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Preparing for a services economy: an evaluation of higher education in India

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Preparing for a services economy: an evaluation of higher education in India

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Abstract: This report is part of a larger study to examine the role of higher education in India's success in providing globally traded services. In this report, we assess the quality of software engineering education. We find that the institutional structure has the capacity to produce a quality of engineer suited to the current needs of the marketplace. This is a remarkable achievement considering the rapid change in both job requirements and the role of private provision in higher education. While it is too early to assess whether the currently emergent needs, particularly in research, project management and entrepreneurship, will be met by the current structure, we argue that the state's role as regulator will be critical. While the state has so far demonstrated its capabilities of being an effective regulator, we argue that new regulatory capabilities will be needed of the state to address the evolving demands.

Keywords: India, higher education, software engineering, regulation

Preparing for a services economy: an evaluation of higher education in India

Introduction

Even a decade ago, the idea that India would, in less than five years, compete in the global services economy would have seemed farfetched. Although it had by then a recognized and rising (though small) presence in software exports, the Indian services sector was, overall, no different from services in countries at similar stages of development. In such countries, services are largely provided by small, low-technology enterprises catering to the local economy. India was no different as of the late 1990s.

As of 2007, the services sector is both driving economic growth in India and posing to be a formidable global competitor. Services comprise 55% of GDP and have lately been growing at a near 10% rate. Of course, most services remain small, low growth, low-technology services, many of which will reduce in importance as manufacturing grows in the newly reformed environment. But several of the high-growth services are sophisticated services and represent a turnaround from the past. Telecommunications services, for example, were of poor quality and generated negligible revenue a decade ago. Today, India's telecommunications sector is one of the world's most sophisticated, with redundant fiber optic networks that reach almost all settlements, including India's 600,000 villages; a wireless network that adds more customers each month than China; and, a sector that, overall, contributes over 5% to GDP. Airlines and financial services are other such examples that service the domestic markets.

The services sector in which India has made its mark as a global provider is the IT-enabled services sector. From a size of less than 1% of GDP in 1997, India's IT-enabled services exports comprised 3.6 % of GDP in 2006. The value of these exports rose from $1.8 billion in 1997 to $32 billion in 2006, an annualized growth rate of over 35%. (Nasscom, 2007, p.54). With this, India has left other developing and even some developed countries far behind in their ambitions to become leaders in services exports.

The term "IT-enabled services" might not convey to the reader the range of services that are exported from India. They potentially include any service that can be delivered electronically using digital technologies. While, initially, the exports were confined to software programming and, later, call-centers, over the past few years, the range and depth of work has changed dramatically. The list now includes scientific research and development, financial services, market research, data-mining and a host of other services. Largely, the services are located in the vertical termed "professional, scientific and technical services".[1]

The Indian success with remote services provision disproves a widespread belief that Asia is better at manufacturing than services. This shibboleth is based on the evidence that even the advanced economies of Asia, i.e., Japan, Singapore, Taiwan, Hong Kong and Korea, have failed to create globally competitive service industries. In a range of

[1] The US government's NAICS code 54 defines the sector: "The Professional, Scientific, and Technical Services sector comprises establishments that specialize in performing professional, scientific, and technical activities for others. These activities require a high degree of expertise and training. The establishments in this sector specialize according to expertise and provide these services to clients in a variety of industries and, in some cases, to households. Activities performed include: legal advice and representation; accounting, bookkeeping, and payroll services; architectural, engineering, and specialized design services; computer services; consulting services; research services; advertising services; photographic services; translation and interpretation services; veterinary services; and other professional, scientific, and technical services." http://www.census.gov/epcd/naics02/def/NDEF54.HTM June 11, 2007

other key services, such as software, retailing, telecommunications, logistics and insurance, there are no Asian global brand names. The common understanding behind this belief is that acquiring advanced services skills is not an easy or short-term task.

Instead, Asia's economic growth was driven by manufactured goods' exports. This was based on the application of large inputs of physical and financial capital. (Krugman, 1994).

Yet, this is not true of India. Further, Indian firms such as TCS in software services and the Taj group in hotels are beginning to be recognized as brand names. Along with this, the provision of global services is growing in scale, scope and depth at rates that are increasing India's lead over potential competition (Dossani and Kenney, 2007).

This paper examines the contribution of higher education to this success. Before doing so, we briefly examine some other factors that enabled the success of India's global services sector.

The first is the way that the world economy has developed. The previous paradigm of services spatially tied to core nationally-based manufacturing activities has been replaced by one based on the provision of globally tradable services. This advantages countries with advanced services skills. India's turn towards services, in part because of policies that restricted manufacturing, preceded other low-cost countries that were still intensely involved in harvesting manufacturing. This gave India a first-mover advantage that it has continued to capitalize on.

Second, some attribute India's success in providing technical services to technology itself. As documented elsewhere (see Dossani and Denny (2007), Dossani and Kenney, (2007)), the technology for the remote provision of services has changed dramatically in the past decade. The Internet and lower digital storage costs have combined to reduce the capital costs associated with remote service provision; while modularization of software preparation and other services has reduced the operating costs of remote provision.

The impact of the first mover advantage should not be overstated. India was not the first mover in global service provision from a low cost country. Many Asian countries entered global service provision much earlier than India, such as Japanese and Korean banks in the 1980s, with limited success.

Likewise, on the enabling power of technology, many other countries– in east Asia and southeast Asia, for instance, had similar or better access to the latest technologies earlier than India. Their infrastructure, capital access and scale of global trade were far superior to India. Had technological change been the only enabler of services, these would have captured the business a long time before India was even an entrant.

The explanation for India's success is, therefore, unlikely to be a simple one. However, as the foregoing discussion indicates, it is likely to lie in some dimension of human capital rather than physical or financial capital. Unlike manufacturing, where it is possible to produce high technology products by applying relatively unskilled labor to sophisticated machinery, skilled services, by contrast, cannot be provided by combining unskilled labor with physical and financial capital. By definition, the providers of 'just-in-time' skilled services such as IT help desks need to be as skilled as the service provided.[2] Even many 'storable' services such as software code require skilled labor.

There are several skills that appear to be relevant. Indians' most obvious advantage over other low-cost providers is that a relatively large number of people, perhaps as many as 50 million, speak fluent English. Many of them were underemployed till the 1990s due to India's closed economy. Once India opened up its economy in the 1990s, it has been argued, this became an asset.

However, this "late-mover but English speaking" advantage is unlikely to be the only or even the main reason for India's success. There are many countries whose citizens speak equally fluent English, where wage rates are comparable, which globalized earlier than India, and have failed to become global service providers. The Philippines, which opened its economy to global trade two decades before India, is an example.

On the other hand, although it is hard to come by examples in the developing world, there are examples of firms operating in developed countries where English is not widely

[2] I am grateful to Frank Mayadas for this key insight.

spoken and yet have succeeded widely in other western markets. SAP of Germany is one example, but there are several others in services such as IT, retailing and logistics.

A second aspect is higher education, including technical education. The need for such an education is no longer doubted by development analysts and policymakers (World Bank, 2000, p.12) There have been several reports of late that show that India and China are producing a large number of students that are skilled in particular vocations, particularly engineering. Some of these reports also question the quality of the students (Wadhwa, et. al., 2007).

Even if the number is high and the quality is good, it is not obvious that this "scale-and-depth" factor is sufficient for success. As the following table for the software industry shows, neither size nor stage of development are sufficient to explain a country's success.

The table shows that there are countries such as Japan, with a large and high quality software labor force, which have been unsuccessful at global software provision; there are countries, such as Brazil and China, with a large software labor force, and a more uncertain quality of engineer, which have also been unsuccessful. On the other hand, Ireland and Israel have small labor forces, presumably produce a high quality of engineer and are successful.

TABLE 1 Software Exports from Developing Countries, 2001.

Country	Sales ($ billions)	Exports	Labor Force (2000)	Sales per Employee ($)	Primary Work Type
Brazil	7.7	0.1	220	35	P/S = 40/60**
China	7.4 *(15.0)**	0.4 *(2.0)*	186 *(750)*	40 *(20)*	Domestic
EE5 (Bulgaria, Czech Republic, Hungary, Poland, Romania)	0.6	0.5	75	8	Services to Western Europe
India	8.2 *(22.3)**	6.2 *(17.1)*	350 *(878)*	23 *(25)*	Services to U.S. P/S = 25/75
Ireland	7.7	6.5	24	160	Localization of U.S. product software for Western Europe
Israel (2000)	3.7	2.6	35	106	P/S = 70/30
Japan	85.0	0.07	535	159	P/S = 25/75
Philippines	0.2	0.15	0.05	12	Services to U.S.
Russia	0.2	0.1	0.1	13	P/S = 30/70
United States (2002)	200.0	NA	2,600	77	P/S = 40/60

Sources: Arora and Gambardella, 2005 (pp.45, 77, 101); Sahay et al., 2003 (p.17), Nasscom, 2006 (pp.46, 47).

Notes: * Figures in italics are for 2005. **P/S = the ratio between revenue from software products and revenue from software services.

A third dimension is that the type of human capital needed is changing rapidly. In the field of engineering, for instance, the social science aspects of engineering education, such as business and entrepreneurial courses for engineers, may be as important as teaching engineering skills. Merely developing a large number of traditional engineers has much less relevance than in earlier industrial development. Perhaps India has succeeded in a transformation of the nature of engineering and science education so that engineers have "scope" in addition to depth.

Our discussion above implies that India's success is possibly due to some combination of first mover advantages, English-language skills, scale, depth and scope. Examining all of these in sufficient depth is outside the scope of this paper. Instead, this report focuses on one discipline, software engineering, and limits its scope to an assessment of technical education. The questions we pose are whether some fundamental aspects of the education system for technical education, such as governance, have enabled India to succeed as a service provider to date and whether these aspects will enable India to continue to provide the quality of manpower it needs. The fundamental aspects are defined in more detail in Section 3.

This report is divided as follows. In Section 2, we discuss the education system in India – policy, scale of provision, role of different providers, etc. In Section 3, we provide a theoretical model of factors that influence quality. In Section 4, we provide our methodology of assessment and sources of data. Section 5 provides the results of our assessment. Section 6 provides a concluding discussion.

Section 2 The education system in India

The role of the state

India has a federal constitution, under which education is a ‘concurrent’ subject, i.e., a joint responsibility of the federal (central) government in New Delhi and the states. The division of responsibilities is clear in some cases and not as clear in others. The central government, it is agreed, is solely responsible for determining standards for teaching and research. The state governments are supposed to establish universities and colleges that meet these standards, allow private colleges to affiliate with universities, and are responsible for the universities’ funding and management. Note that the university in the Indian higher education system has a different meaning than in America. Indian universities are largely ‘affiliating’ universities at the undergraduate level. They do not offer their own courses but prescribe to the affiliated colleges the course of study, hold examinations and award degrees. The colleges hire teachers, recruit students and educate them.

About 80% of the funding for higher education is provided by the states and 20% by the center through various bodies such as the University Grants Commission (see below). Coordination between the central and state governments is done by the Central Advisory Board of Education (CABE).

The division of responsibilities between the federal and state governments started to overlap when India's first Prime Minister, Nehru, ordered the federal ministry of education to establish universities directly controlled by the federal government. This was because Nehru was keen to speed up the quality of technical education in order to realize his vision of the country as an industrial superpower. He felt that this needed direct supervision from New Delhi rather than by the states. The Indian Institutes of Technology (IITs) were an outcome of that vision. Currently, there are 18 federally run universities of a total of over 300. They offer a higher quality of education than state universities for several reasons, including superior funding. The policy direction of selectively creating new federal universities continues to the present day, because it is still policymaker opinion that the best institutions can only be created by federal-level oversight.

Most university education, however continues to be provided by the states. This creates the lack of the quality continuum mentioned above. The generously-funded central universities occupy the upper quality tier and the state universities are, in general, significantly behind. This feature also restricts the natural flow of the best students to successively higher tiers within state-level institutions. In the U.S., a community college student can end up within two years in a top-tier state university by performing well in community college. This is not possible in India.

The federal government exercises its responsibility for setting and maintaining standards through an apex body, the University Grants Commission, established in 1956, that is “responsible for coordination, determination and maintenance of standards and the release of grants”. http://www.education.nic.in/higedu.asp, downloaded June 6, 2007.

The UGC relies on professional councils set up by the federal government to recognize colleges and universities and courses. The councils also channel UGC grants for undergraduate education, while UGC directly funds other aspects of public higher education, such as research and general budgets. The council that manages IT education is the All India Council for Technical Education (AICTE).

Box 1
The Importance of the IITs

Perhaps the best known Indian engineering institutions, both within and outside India, are the state-owned Indian Institutes of Technology (IIT). These were established by the federal government starting in the mid-1950s. Recruiters around the world recognize the IITs as a global-class brand.

The IIT-system is emblematic of not just the best but some of the worst aspects of the Indian education system. The best is that the seven IITs produce a quality of undergraduate student that is, as noted, of global class. They do this through a four-fold strategy: selective, merit-based recruitment (over two hundred and fifty thousand applicants vie for less than 5,000 seats each year),[1] low tuition costs (tuition costs are less than $1,000 per year),[2] commitment to teaching excellence and adequate infrastructure.[3] The first two strategies lead to a high quality of student admitted, while the latter two strategies cause high value addition in undergraduate education.

These strategies represent a compromise between state and institutional interests. The admissions procedures, for instance, are based on rules that are common across the IITs. The student's prior academic performance and, most important, her performance in a common entrance examination administered jointly by all the IITs determine whether she will get in. The contents of the entrance examination are, however, determined by faculty.

The faculty selection procedures are more flexible, with considerable autonomy given to the departments, although final letters of appointment require the approval of the head of the institution. Departments also determine determine curricula and pursue linkages with the corporate sector.

In all other aspects, the IITs are under the state's control. This has resulted in an overly rules-based and often corrupt administration that stifles academic freedom to pursue research or design new courses.

The worst aspects of the IIT-system are, first, the absence of a second-tier of quality below the IITs. There are the IITs, then about a dozen other state-owned institutions of repute and then a vacuum.[4] The mass of the state-run and private institutions are third-tier. A shortage of funds is the main reason for the quality vacuum. Second, the current dynamics of the higher education system threaten the quality of the IITs. The staff at the IITs and other state institutions are being cannibalized by private institutions due to salary caps (see Box 2), the IITs research output is meager to non-existent (matched by a minimal output of graduate students) due to a lack of academic freedom and incentives, and collaborations with industry for training students are minimal.

The IITs offer important lessons on how a country can provide a high standard of education for a small cohort chosen on merit. First, it can be done quickly. The IITs were begun in the 1950s and achieved excellence within a decade. This was partly due to overseas collaborations in the initial years for the purposes of curriculum and faculty development. The country's best faculty and student applicants turned to the IITs simply because it offered the best students, teachers and infrastructure. Over time, the four strategies noted above emerged.

One lesson from the IITs' success is that while a rules-based process of admissions might not be optimal in a more mature environment, it might make sense in a less mature environment. It protects the institution from misuse that might arise if more discretion is given to the institution. Of course, it raises the question of how an institution is to transition to a less rules-based system that might be desirable as the environment matures.

Another lesson is that so long as the state does not interfere in faculty selection, or in curriculum development, and finances equitable access and infrastructure, its other dimensions of control will not, at least for a time, be a fatal deterrent to the provision of a good undergraduate education.

[1]Source: http://www.hindu.com/2007/04/09/stories/2007040901761300.htm June 11, 2007
[2]Source: http://www.iitm.ac.in/academics/Academic%20Calendar.html June 11, 2007
[3] The general quality of infrastructure, research and university-industry linkages are particularly difficult problems. According to a government report, "obsolescence of facilities and infrastructure are experienced in many institutions … the IT infrastructure and the use of IT in technical institutions is woefully inadequate … the barest minimum laboratory facilities are available in many of the institutions and very little research activity is undertaken … engineering institutes have not succeeded in developing strong linkages with industry … the curriculum offered is outdated and does not meet the needs of the labor market" (Indian Ministry of HRD, 2001, Sections 2.1.2-2.1.6).
[4]http://www.dqindia.com/content/top_stories/2006/106062703.asp June 11, 2007

Degrees

The primary higher education degree is the bachelor's/undergraduate degree.[3] For professional fields, including engineering, this requires four years of study after completing twelve years of primary and secondary school. Some professional fields, such as medicine and architecture, require five years. For other fields, such as arts, commerce and physical and social sciences, the bachelor's degree requires three years of study.

The next higher level is the master's/graduate degree, which requires two years of study beyond the bachelor's degree. In engineering, admission to graduate programs requires taking a standardized aptitude test, the Graduate Aptitude Test in Engineering. Due to the recent high demand for software engineers, the UGC approved an unusual degree course a few years ago, the Master of Computer Applications (MCA). The MCA is a three year graduate program, typically taken by those with non-technical undergraduate degrees. Most upper-tier recruiters such as Google will typically not recruit a student with an MCA because such a student will not have done the fourth year design projects.

The highest level is the doctoral degree which typically requires at least three years of study after the Master's degree and a thesis based on original research.

[3] We shall use American terminology in this paper. A bachelor's education in both India and the US is referred to as an undergraduate education. A bachelor's degree is referred to in the US as an undergraduate degree, in India as a graduate degree. A master's education and degree is referred to as a postgraduate education and degree in India and a graduate education and degree in the US.

Non-degree courses include vocational courses leading up to a diploma. These are typically one to two year courses.

Only a university recognized by one of the central government councils may award a degree. Almost all the country's universities are publicly owned. As noted above, most universities are largely 'affiliating' universities at the undergraduate level. They do not offer their own courses but prescribe to the affiliated colleges the course of study, hold examinations and award degrees. The colleges within a university may be privately or publicly owned. Recently, some colleges that are of high quality have been declared 'autonomous colleges'. In these, the responsibility for proposing and developing courses of study lies with the college, while the university must approve the courses as eligible for degree-level instruction. The degree awarded in such cases is still by the university, although it also bears the name of the autonomous college.

Although private higher education has been a feature of the system from the beginning, it has become important only over the past decade. The change has been policy-driven. Prior to 1991, the state took the view that higher education should only be provided by the state. However, the country has seen low rates of enrollment that have increasingly been attributed to exclusive state provision. India's gross enrolment ratio, i.e., the number of age-unadjusted enrollees as a share of the eligible population that goes to university is, as of 2006, only 9% compared with 35% who complete secondary school. While the absence of private provision has not always led to rises in enrollment in other countries (see Appendix 1) – for instance, the state might reduce its commitment to higher education as a result, in India, it has prompted a policy initiative since 1991 to increase the share of private provision. The other driver of private participation has been the policy decision to reverse the historical bias of the state's education spending in favor of tertiary education. Historically, the government has spent about 3-4% of GDP on education and this accounts for 13% of public spending (Hiromi, p.8). These numbers are comparable to many other developing countries such as China. About 15% of the total budget (equal to Rs.120 bn or $3 bn in 2004) is spent on higher education (Nuepa, p.23). Of this, about a fourth is spent on technical education. (Nuepa, p.5) On a per capita enrolment basis, however, the amount spent on tertiary education is three times that spent on primary and secondary education combined. By contrast, in China, about two-thirds, on a per capita enrolment basis, is spent on primary and secondary education.

About 700,000 students were enrolled in undergraduate degree courses in engineering (all fields) in 2003. This has risen rapidly in recent years. According to Nasscom (2007, p.92), the number of new undergraduates in engineering was expected to be 264,000 in 2006. The IT workforce was further bolstered by those with engineering diplomas (usually a two year course, as noted above) (196,000 new diploma holders in 2006) and those with a Master's degree in Computer Applications (MCA). (35,000 new awardees in 2006).

Box 2

English in India

India is a multilingual country in two senses of the word. First, many Indians speak more than one language, although only one will typically be spoken fluently (most city dwellers are fluent in two). Second, there is no single language that most Indians speak. The most widely spoken language in India is Hindi, spoken as a first language by 180 million persons.[1] Probably no more than 50 million people speak fluent English, most as a second language. Several Indian languages other than Hindi rank above English in the number of speakers, including Bengali, Marathi, Tamil and Telugu.

How important is fluency in English? Indore, the city discussed in Box 1, provides some interesting examples. It has over 50 IT exporting firms, including service firms and software product firms. In my visits to three such firms, I found that the quality of English varied greatly. In most cases, a lead business developer or marketer spoke in sophisticated English while the rest of the staff, including the programmers spoke English in "second-language" quality. This did not seem to hamper success. This suggests that the engineer of today still does not need to have 'scope' (see Section 1), provided such scope exists within his firm. It all depends on who he interacts with.

As an example, consider the case of a successful Indore-based startup, Astute Systems, that produces religious software for mobile phones. It has a staff of 15 engineers and 13 other staff, including business developers, salespersons and support staff. The software allows the user to play video clips of the prayers of most Indian religions, complete with gender-specific rituals and regional variations. The development team does their work in Java 2ME, the industry standard language for mobile applications. Prior to commercialization, the prayers are vetted for both religious correctness by a religious scholar and for script by grammarians in English and several other languages.

The firm's marketing team speaks fluent English and travels to various export markets. The software is widely exported, primarily to the Middle East and the rest of Asia. However, the primary market is in India. The main clients are the telecom service providers, all of whom conduct transactions in English.

The programming team is different: their standard of English is well below the Queen's English; yet, this did not impair their capability to program in Java 2ME. As I observed their work, I noted that they converse with each other and with the business development and marketing teams in Hindi while all their work on the computer (programming, tech support, emails, etc.) was either in Java 2ME or in English.

The success of firms like Astute Software raises questions about the importance of English for India's success. While the marketing and business development team of Astute would not have succeeded, even in domestic markets, without an adequate command over the English language, most of the team did not have to know any more English than is common among second-language English speakers in many countries around the world. India, for instance, has several hundred million who speak English as a second-language.

[1] http://www.ethnologue.com/show_language.asp?code=hin, downloaded June 6, 2007

Private providers

The impact of private provision can be seen in the following data: from a negligible presence upto 1990, as of 2005, they accounted for half of total undergraduate enrolment of about 10 million students and over 60% of the number of degree-awarding institutions (see Appendix 1). In more commercially lucrative fields such as engineering, they accounted for over three fourths of the number of institutions.

Accredited private providers must, by Indian law, be organized as non-profit institutions. They can be of two kinds: self-funded or government-aided. The latter forces them to offer government pay scales to teachers and charge government tuition rates for admission.[4]

The legal requirement of non-profit status for private institutions means that they are invariably established as trusts. This allows them to make profits provided these are ploughed back into the institution. Of course, in practice, given India's murky record with tracking and disciplining malpractice, many, probably the vast majority (Nuepa, 2006, p.43), suck large sums away through devices such as charging upfront 'capitation' fees that are not tracked, employing family members of the trust's founders at enormous salaries and so on.

[4] A recent trend is the private provision of foreign degrees in India by foreign universities operating in India. This, being outside the Indian education system, is little documented although its impact is believed to be small. It consists largely of little-known institutions in the western world charging high fees for degrees awarded by the foreign universities. By many accounts, most of these are 'fly-by-night' operations.

The private providers have focused on the more lucrative fields such as engineering and management education, as noted above. As a result of their presence, the Indian higher education system has become increasingly differentiated. The private providers tend to specialize in only a few fields for which demand is high. By contrast, the state providers offer a wider range of studies.

Box 3
The role of private institutions

The town of Indore in the state of Madhya Pradesh might seem an unlikely place to be the site of fierce competition between the private and public sector. Indore, with a population of 2 million, relies primarily on soybean trading for its sustenance. It is a poor city with a volatile economy. Yet, apart from the state-run Devi Ahilya (DA) University, there are at least four private colleges that offer a four-year degree program in computer sciences. The faculty in the computer science department at DA University, as of end 2006, consisted of 7 full-time faculty. The full strength of the department is 12, but the department has been unable to recruit faculty to recover its full strength, which was last achieved in 2004. Two faculty members resigned in 2006.

What has changed? Until a few years ago, DA university attracted Indore's best faculty, while the private colleges were staffed by part-timers and lower quality faculty. But, a sea-change in the remuneration offered by private competition has affected DA's ability to retain faculty. Salaries at DA are capped by federal government rules that limit the maximum wage to Rs.50,000 per month (about $1250 at current rates of exchange). This is an attractive salary in Indore – the university also provides housing, so it should be possible for a typical earner with a family to save at least 20% of that salary. However, private colleges in Indore start junior faculty at Rs.100,000 ($2,500) per month and typically, pay Rs.200,000 ($5,000) per month for the best faculty. In addition, universities in the Middle East and Far East regularly raid universities like DA with offers of at least 2x the best private university salaries. In consequence, retaining faculty is a problem. According to the head of the CS department at DA university, the CS department expects to continue losing 1-2 faculty every year.

The federal and state governments are, of course, well aware of the problem. Their ability to fight back is limited by a lack of resources and a need to be equitable. The salary cap of Rs.50,000 is applicable across all university departments nationally.

One way in which they are fighting back is by offering better research facilities. For example, even at DA university (and most other public sector universities that were interviewed), bandwidth is adequate and research is adequately supported. Typical research budgets enable a faculty member to have one research assistant, buy lab equipment, travel domestically several times a year for conferences and fieldwork and travel internationally once a year. The university subscribes to JSTOR and other archiving services, thus enabling faculty and students similar electronic access to research as is available to faculty and students in any American university.

On the other hand, the private colleges offer meager research facilities. They focus on teaching. Some of them are developing high teaching standards, although this is not generally true. There are several fly-by-night operations. Even so, the salary differential a significant attraction. The private colleges can afford to pay higher salaries because they are not as restricted as the public colleges on tuition.

The story of DA university's faculty loss is repeated across all public colleges and universities in India, from the top-tier IITs to the lowest rung of state universities. At the upper level universities, the loss is augmented by faculty wishing to do research who tend to migrate overseas. While the upper level universities we interviewed, such as Banaras Hindu University and some of the IITs, boast an excellent infrastructure for research (bandwidth, generous soft budgets for research assistance and local and international travel, etc.), the shortage of critical mass of faculty in particular sub-disciplines or disciplines and the near absence of university-industry collaboration is a barrier to research. The last-named is also a concern for undergraduate education. The final year design project that the engineering student is required to undertake is overwhelmingly designed and implemented within the ivory tower. By comparison, in most U.S. universities that are at least middle-tier, such as the California State University system, the fourth year design project invariably has an industry component to it.

Section 3

The quality of education: a theoretical framework.

The role of the state

The quality of a nation's higher educational system reflects a complex partnership between the nation's state and its citizens. For instance, we have earlier discussed examples where the corporate sector takes on roles that the state is either unwilling or incapable of doing, or needs partners. In some cases, the state takes a leading role, such as in determining budgets for higher education and allocating responsibilities between the federal and state governments; in other cases, such as determining research goals, both the state and non-state sectors may help to determine outcomes.

Even in an environment in which private provision thrives, as in the U.S., the state's role is critical. The ways that the state plays a critical role include the financing of education for efficiency and equity, directing science and engineering courses towards problem solving and creative thinking, and organizing the policy environment, governance structures and institutional administration to produce higher quality training (Martinez, 2002).

The policy decisions primarily concern the mix of teaching and research and the focus on accessibility by targeted student populations. Depending on the charter of the institution and the environment (including competition), the role of the state in determining policy can vary.

The governance structures indicate the formal and informal arrangements allowing higher education institutions to make decisions and take action on strategic variables that influence the outcomes of these policies, such as setting fees and managing costs (World Bank, 2000, p.83). The state, in many cases, not only determines policy priorities but may tightly govern the institution as well. For example, it may limit the freedom to pursue research, or regulate fees and costs. We term such a state role as 'regulatory'. In other cases, the state does not take an active role in defining policy, controlling the strategic variables or ensuring that these are met. However, it may still finance deficits. We term such a state role as 'advocatory'. In between the advocatory and regulatory states, the 'steering state' helps to set policy priorities but leaves it to the institution to establish and manage the governance structures that will help to realize those priorities. This may happen even while the state finances deficits.

The administrative structures refer to rules and regulations that create the incentives for meeting the strategic choices. Examples are the rules for resource mobilization or terms of tenure. These may be bureaucratic, i.e., rules-based, or, if not, subject to faculty influence or other influences such as donors and trustees. The state's role, if present, is usually higher when the administrative structures are bureaucratic and lower otherwise.

Obviously, the role of the state in a particular institution is constrained by the dependence of that educational institution on the state for resources and on the charter of the institution. In general, private institutions will be different from state institutions.

Within state institutions, the role of the state tends to focus more on advocacy for upper-tier institutions, whereas lower-tier institutions are usually more tightly regulated in order to improve access to less-privileged populations.

The following table provides examples of the different roles of the state. It is intended to be illustrative rather than comprehensive. The state's role may be more complex than shown below. For example, the state may play a regulatory role in some aspects of governance, eg., tuition, while playing a steering role in others, such as faculty salaries.

Table 2
Differing roles of the state in higher education

Note: Terms like 'higher' and 'lower', 'more' and' less'in the table below are used with reference to the type in the previous row.

Type	Policy	Governance	Administration	Role of state	Examples from US and India
2-year state-run programs	Equitable access	Controlled tuition, salaries and class sizes (TSC)	Bureaucratic, i.e., rules-based, set by the state	Regulatory	Foothill Community College, CA; Govt Polytechnic, Pune
2nd-tier state university	Higher teaching standards	Less controlled TSC; higher student & faculty standards (SF)	Less bureaucratic; some faculty influence	Steering	CA State Univ; Regional Engg Colleges, India
1st-tier state university	Higher teaching standards & research	Less controlled TSC; higher SF; freedom to pursue research	Less bureaucratic; faculty, alumni and donors also exercise influence	Advocatory	University of CA system; IITs
2nd-tier private university	High teaching standards	Flexible TSC	Faculty, alumni and donors exercise influence	Advocatory	Menlo College, CA; P.E.S. Inst of Tech, Bangalore.
1st-tier private university	Higher teaching standards & research	Flexible TSC; freedom to pursue research	Faculty, alumni and donors exercise influence	Advocatory	Stanford University; BITS, Pilani

In mature environments such as in many developed countries, it is found that the quality of students graduating from an institution (though not necessarily from the educational system as a whole) will be lower if: (1) state policy favors student accessibility (equity) over merit, (2) state policy favors teaching over research. (3) governance structures focus more on managing tuition costs than admission standards. (4) governance structures focus more on managing salaries than faculty selection criteria, (5) administrative structures are more bureaucratic. (6) administrative structures exclude non-state stakeholders such as faculty and alumni (McDaniel, 1996, World Bank, 2000).

We hypothesize that the impact of a higher role of the state might be different in some respects in India. This is because the system has dramatically changed in respect of the share of private provision, as noted above. Most of the new providers are new and in the private sector. In some other respects, the role of the state should be similar to more mature environments.

One area of difference could be in the state's role in faculty selection. A common criticism of the newer private institutions in India is that they employ faculty of poor quality. For example, M. Anandakrishnan, Chair of the state-owned Madras Institute of Development Studies, a division of the National Institute of Social Science Research, has argued that the quality of faculty in private institutions is below that of public institutions. He argues that this is because "They (the self-financing private institutions) generally treat the faculty somewhat like bonded labor in matters of salary and service conditions (Nuepa, p.43)."

Similarly, the private institutions often waive their admission norms in favor of those willing to pay more.

The private institutions get away with such behavior because of poor regulation and the newness of private provision. As a result, it is argued, students cannot easily distinguish good from bad private institutions (World Bank, 2000). On the other hand, the state-owned institutions, which are more rules-based, ensure that faculty selection and salaries, and admission criteria meet minimum standards, even if suboptimal (see also Box 1 for a discussion of this with regard to the IITs).

Hence, in an immature environment like India, we would expect that a responsible state will play a role that is more intrusive than in a more mature environment. For instance, if there is an excess demand for software engineering courses and if students are unable to distinguish good from bad institutions, the state may lay down minimum standards for faculty selection in new institutions (both private and public), such as possession of a graduate degree in engineering.

By contrast, there would be other respects in which the newness or immaturity of the system would not lead to differences between India and more mature environments. For instance, we would expect that high state involvement in determining which research projects to undertake would reduce quality even in a new institution. Shared governance between the state and other stakeholders such as faculty should also always be a positive contributor to quality.

Note that, sometimes, an immature state might be an obstacle to institutional maturation. Although the overall environment for software engineering education is immature, there are several mature institutions. For the latter, the state ought to have different standards. In practice, a common complaint of the Indian higher educational system is that the state is intrusive even when it is not needed. One of the goals of this paper is to identify areas where the state has not been responsive to the evolving institutional environment.

We now turn to our detailed hypotheses, methodology and data.

Section 4

Methodology and Data

Methodology

The variables that are most reliably observed are administrative variables, such as the rules for setting tuition or eligibility requirements. Governance structures and the underlying policies can be inferred from these, although we also use qualitative questions, eg., asking whether the institution focuses on cost management rather than faculty quality, in order to make more direct, if less reliable, assessments on governance structures and policy.

The hypothesis we study is:

H1: $y = c + b_1x_1 + \ldots + b_{11}x_{11} + e$

Where y = quality of graduate

x_1=role of the state in influencing entrance requirements

x_2=role of the state in influencing teaching

x_3=role of the state in influencing research

x_4=role of the state in influencing faculty selection

x_5=quality of curriculum

x_6=politicization of the administration

x_7=quality of faculty who apply for jobs

x_8=quality of student intake

x_9=quality of infrastructure

x_{10}=quality of research

x_{11}=quality of university-industry interaction

e = residual term

x_1, the role of the state in influencing entrance requirements, is measured by its role in setting fees, eligibility requirements, the number of students to be admitted and selection of students. In each case, respondents were asked to rank the role of the state from 1-5, where 1 was the least centralized and 5 the most centralized. The average of these rankings for the four categories was taken as the measure of x_1.

Given India's institutional immaturity, we expect that the state will play an important role in influencing entrance requirements in most institutions. Within the immature environment, we expect that the mature state will offer greater freedom to more mature, higher quality institutions. Hence, we expect that the mean value for x_1 will exceed three, while the sign of the regression coefficient will be positive. The predicted regression coefficients for this and subsequent variables are shown in Table 3 below.

x_2, the role of the state in influencing teaching, is measured by its role in starting a new discipline, starting a new disciplinary specialization, determining the course syllabus, selecting textbooks, and assessing the quality of teaching. Respondents were asked to rank the role of the state from 1-5, where 1 is very low and 5 is very high. The average of these rankings for the five categories was taken as the measure of x_2. The expected value and sign are similar to x_1.

x_3, the role of the state in influencing research, is measured by its role in determining research projects, on university-industry interaction and revenue-sharing between faculty and department for outside work, such as consultancy projects. Respondents were asked to rank the role of the state from 1-5, where 1 is very low and 5 is very high. The average of these rankings for the three categories was taken as the measure of x_3. As discussed above, the state should play a hands-off role in research regardless of the maturity of the system. Hence, we expect that the mean value will be less than 3 and that the role of the state will not vary with institutional rank, i.e., the predicted sign of the coefficient is zero.

x_4, the role of the state in selecting faculty, is measured by its role in determing the categories of faculty, the required qualifications of faculty and faculty salaries. Respondents were asked to rank the role of the state from 1-5, where 1 is very low and 5 is very high. The average of these rankings for the three categories was taken as the measure of x_4. The expected value and sign are similar to x_1.

A set of independent variables was used as control variables. These were the quality of the curriculum, the quality of student intake, the quality of faculty, the quality of physical infrastructure (libraries, electronic media, bandwidth, etc.), the quality of research, interaction between academia and industry, and the politicization of the administration. Of these seven variables, the first six were ranked from from 1-5, where 1 measured the best quality and 5 the lowest quality. In all six cases, we expect that higher ranked institutions will have higher quality, i.e., the coefficient sign should be positive.

The mean values are likely to be less uniform. Curricula are likely to be less demanding in a weaker institution; given the newness of most providers, we expect that the mean value will be greater than 3. A similar argument applies to the quality of faculty, quality of physical infrastructur, quality of research and the quality of university-industry interaction. However, the quality of students depends on many other factors, including the options available in other fields and the quality of the secondary and primary education system.

The seventh independent variable, politicization, was ranked from 1-5, where 1 measured high politicization and 5 low politicization. Note that politicization refers to the intrusion of policymakers into the day-to-day functioning of the institution. This can happen in both state-owned and private institutions. We expect politicization to be high on average (mean value < 3) and to be worse for lower-ranked institutions (negative sign).

The table below summarizes the conditions for predicted values and signs of the coefficients on the independent variable, as discussed above.

Table 3: Expected range of values and sign of the independent variables.

Indep variables	Predicted mean	Predicted coefficient sign
Entrance (x_1)	> 3	+
Teaching (x_2)	< 3	+
Research (x_3)	< 3	0
Faculty (x_4)	> 3	+
Curriculum (x_5)	> 3	+
Politicization (x_6)	< 3	-
Faculty intake (x_7)	> 3	+
Student intake (x_8)	NA	+
Infrastructure (x_9)	> 3	+
Research (x x_{10})	> 3	+
Univ-industry interaction (x_{11})	> 3	+

Data

The data was collected from a questionnaire that was administered face-to-face to 19 institutions. In each institution, either the head of the institution or the head of the computer science (or equivalent) department responded. Most of these are in or near Bangalore (12), with four in Chennai and three in Hyderabad. The institutions were chosen randomly after stratifying the population into private colleges, state-run colleges and centrally-run colleges.

Three institutions that recruit software engineers, the Indian Institute of Management, Bangalore (for graduate management studies), Wipro and Google were asked for to rank the 19 institutions relative to best global standards. The institutions were ranked from 1-5, where 1 is the highest rank, 3 the middle rank and 5 is the lowest rank. These ranks were averaged to obtain the dependent variable.

Other data was collected by administering the same questionnaire nationally to a number of institutions. We also interviewed three American institutions using the same questionnaire and also to assess the quality of Indian undergraduates who apply to graduate programs in the United States. However, this data was used to corroborate the findings of the Bangalore survey and is not part of the sample regression analysis below. The full list of institutions is provided in Appendix 2.

Section 5

Findings

The average rank of the institutions sampled is provided in the table below.

The table below provides information on the average ranks of each tier.

Table 4 Sample rank of institutional quality

Type	1st-tier state	2nd-tier state	1st-tier private	2nd-tier private	Avg state	Avg private	All
Number	4	3	3	9	7	12	19
Avg Rank	1.4	2.9	2	2.9	2.1	2.7	2.5

Note: 1 is highest rank, 5 is lowest rank.
Note: 1st-tier institutions were those ranked 2 or higher.

The sample shows that Bangalore produces a somewhat better than average quality of students, with a rank of 2.5. The gap between first and second tier state institutions is higher than between first and second tier private institutions. This confirms our discussion in the introduction wherein we noted that focusing on the upper tier institutions had led the state to neglect the second tier.

Table 5 Sample ranks of independent variables

Indep var	Mean	Predicted mean	Mean for state institutions	Mean for private institutions	Rank of differences*
Entrance (x1)	3.7	> 3	3.9	3.5	8
Teaching (x2)	2.9	< 3	1.8	3.6	1
Research (x3)	1.8	< 3	2.1	1.7	10
Faculty (x4)	4.2	> 3	4.3	4.1	7
Curriculum (x5)	1.5	> 3	1.1	1.8	3
Politicization (x6)	3.6	< 3	4.6	3.0	11
Faculty intake (x7)	2.2	> 3	1.9	2.4	4
Student intake (x8)	1.9	NA	1.4	2.2	2
Infrastructure (x9)	2.1	> 3	2.3	1.9	9
Research (x10)	3.5	> 3	3.1	3.7	5
Univ-industry interaction (x11)	2.5	> 3	2.3	2.6	6

* Rank of differences is measured by ranking the ratio of the mean for state institutions to the mean for private institutions.

A comparison of the actual means with the predicted means indicates the following:

1. The role of the state (x_1- x_4) is generally high. The exception is the research function. These values confirm our hypothesis that the state plays an important corrective role where it can, given the immaturity of the system, while staying out of functions which it cannot influence, such as research. In addition, the state plays a more intrusive role in setting teaching standards for private institutions than for state institutions. The former are the newer, more immature institutions, so this role appears to be appropriate.

2. The mean values of the independent variables are consistent with the hypothesis of mature state intervention in the context of an immature environment, particularly due to private provision. The quality of curricula, faculty, students, infrastructure and university-industry interaction are higher than expected, suggesting that the quality of the system is better than would be expected. This may be an outcome of appropriate governance within the institution (despite active state involvement) or it might indicate that the state is playing an appropriate role. The high mean value of politicization suggests that the system is less politicized than expected. However, this is due largely to the low politicization in state-owned institutions, whereas politicization in the private institutions is higher (though not intrusive), as the next two columns show. This confirms the hypothesis that the private institutions' policymakers interfere more in the day-to-day functioning of their institutions relative to the state, which plays a more appropriate, hands-off role in state-owned institutions.

3. The unexpectedly high quality of the independent variables even among the private institutions (which are newer and less mature) suggests that quality for the system

as a whole will improve further as the system matures. Meanwhile, the state-owned institutions currently offer a higher quality of education.

4. The low quality of research, despite limited state interference, suggests that other factors might be at work, such as private incentives. In our interviews, we found that the research function at even the highest ranked institutions is generally neglected. This is despite relatively generous allowances for research. Even in the smaller state-run institutions, it was found that faculty can relatively simply obtain funds for domestic travel, materials and assistance. In some of the larger state schools, even international travel for conferences is funded. The might improve if the state instituted rules that required, for instance, that a certain proportion of research funding needs to come from industry or if rules of tenure included a research evaluation (this factor is mostly missing even in the highly-ranked institutions). As the table above shows, the private sector ranks even more poorly than the state institutions on research, as may be expected given our discussion above.

We now turn to the sign of the coefficients

Linear regression	
	Number of obs = 19
	F(11, 7) = 5.99
	Prob > F = 0.0128
	R-squared = 0.7710
	Root MSE = .6001

Table 6: Table of coefficients

Independent variables	Coeff	Predicted coefficient sign
Entrance (x_1)	.44*	+
Teaching (x_2)	.07	+
Research (x_3)	-.32	0
Faculty (x_4)	-.21	+
Curriculum (x_5)	.36	+

Politicization (x_6)	-.07	-
Faculty intake (x_7)	-.19	+
Student intake (x_8)	-.04	+
Infrastructure (x_9)	-.18	+
Research (x_{10})	.28	+
Univ-industry interaction (x_{11})	.11	+

Note: * denotes significance at 5%

Table 7: Correlation matrix

	x_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	x_{10}	x_{11}
x_1	1										
x_2	.45	1									
x_3	.58	.26	1								
x_4	.82	.54	.54	1							
x_5	-.16	.24	-.2	.11	1						
x_6	.02	-.57	.14	-.14	0.47	1					
x_7	.43	.22	-.01	.26	.14	-.33	1				
x_8	.05	.23	-.16	-.02	.26	-.31	.52	1			
x_9	.29	.11	-.06	.17	-.06	-.31	.55	.21	1		
x_{10}	.2	.34	-.17	.36	.32	-.4	.18	.39	.38	1	
x_{11}	.2	.1	-.13	.05	-.07	-.19	.6	.52	.6	.52	1

Due in part to the small sample size, the regression coefficients are largely not significant. The only significant independent variable is the state's influence on entrance. A higher influence is associated with lower ranked institutions. In the context of the system's overall immaturity and overal high quality, we interpret this to mean that the state is playing a needed role, as discussed earlier.

Section 6

Concluding Discussion

As with any system undergoing rapid change, the rate of change makes it hard to rate the quality of engineering graduates. It is common for software firms in India to express fears about the quality of manpower relative to costs. This is attributed by them to the high demand for IT engineers relative to the supply. However, the data show that, at least for the near term, there is adequate supply. For example, in 2006, the number of new engineering graduates, MCAs and engineering diploma holders was expected to be 495,000 (Nasscom, 2007, p.92). The growth rate of graduates is about 20 % per annum. This should have comfortably met the software exporting industry's need for an additional 200,000 employees in 2006, a figure that is growing at about 30% per annum.

The difference in growth rates helps to explain why there is a perception of falling quality of recruit despite a rising average quality of graduate. Even though average quality of the graduate is rising, the average quality of recruit at the firm level can fall. Whereas in earlier times, only the best engineers found jobs in the export sector, more recently, even poorer quality engineers find jobs.

It is important to note that the quality of *work done* may be higher even if the quality of the recruit is lower. This is because many of the leading IT firms in India provide their own training to supplement a university education. These include the leading Indian software service firms. Others work directly with educational institutions, providing curriculum and teaching kits. For example, Texas Instruments claims to have over 400 such collaborations with institutions in India.

In this report, our intent was to provide the beginnings of a framework for analyzing the Indian higher education system's readiness for a services economy. We argued that several conventional arguments about the advantages of the Indian education system, such as knowledge of the English language, technical excellence and scale of supply needed to be reassessed in the light of changes in the type of engineer needed and the changes within the Indian education system. The former set of changes required a consideration of the creative and managerial competences of engineers, while the latter was needed because of the dramatic change in the role of private provision.

For purposes of this introductory analysis, we considered only one discipline, software engineering, and limited our scope to an assessment of technical education. We first showed that India's greatest success was in establishing certain elite institutions, such as the IITs. The elite institutions like the IITs are managed and funded under a different organizational model than the overwhelming majority of state-owned institutions. They are run by the federal government with levels of funding that would be unaffordable were these to be generally applicable to all state-owned institutions. This means that, under the present environment, the "IIT-model" is not widely replicable within the country.

Nevertheless, elite institutions like the IITs offer some important lessons. The first is that the policy goal of achieving excellence for a small cohort of students chosen entirely on a rules-based criterion of merit and funded primarily by the state can achieve the strategic target of attracting the country's best students and faculty into a small number of institutions. This sets the conditions for a rapid establishment of high quality. Certain minimal other conditions need to be fulfilled, such as a hands-off approach by the state to the educational core of faculty selection, curriculum development and minimal infrastructure. But, beyond this, even an intrusive state that otherwise runs a bureaucratic, even a corrupt administration, can co-exist with a high quality education.

Nevertheless, the elite institutions are under threat. The primary threat is to faculty retention. The state caps salaries at its institutions (currently to Rs.50,000 per month, or about $1250), at levels significantly below what private institutions can afford. The recent proliferation of private provision with higher budgets has allowed them to poach the best faculty and has already led to considerable erosion in faculty quality across the board from leading to smaller state-owned institutions countrywide. The state has tried to be responsive, offering better infrastructure and research budgets, but it remains insufficient when the private providers can offer salaries that are several times what faculty in the state-owned institution currently earn.

The overwhelming majority of state-owned provision is by individual states. This is an outcome of India's constitution where the central (federal) government assumes responsibility for setting standards while the state governments take responsibility for funding and provision.

The institutions run by the individual states are generally of significantly lower quality than federally-run institutions. This is largely an outcome of funding and results in a serious quality gap. In software engineering, for instance, there are about a dozen institutions, mostly federally-run, that offer a high (1^{st}-tier) quality education, then a large gap, followed by lower-tier (3^{rd}-tier) state-run institutions. The absence of a quality continuum at the second-tier disadvantages students who fail to enter the elite institutions and must settle for a third-tier institution.

The state began to recognize this problem in the 1990s and responded with encouraging private provision. The private providers have, in turn, responded energetically. Though they are required to be legally organized as non-profit trusts, private provision offers enough opportunities, given the immature environment, for personal gain. In engineering, over three fourths of the providers are now private, a dramatic turnaround from a decade ago, when their presence was negligible.

The private providers are key to the system's future. Although they currently occupy the lowest tiers of quality, over time, as they mature, they, more than state-owned providers, are going to provide the scale, depth and scope of the system. There are already signs that some private providers are maturing into high quality providers.

Nevertheless, the state remains a critical player. Its institutions set the current benchmarks for standards, of course (as well as providing fertile ground for recruiting faculty!). But its primary influence is through its role as the system's regulator. The system allows it to be as intrusive as it wants. This is because the law allows the state to set institution-specific admissions standards; standards for faculty recruitment; funding standards for research; and to shut down those institutions that fail to meet these standards.

Hence, there is now a complex environment that characterizes the higher education sector. The state as regulator, provider and financier must interact increasingly with the private sector as provider. What sort of outcomes have resulted? Do they meet the needs of the nation?

To assess this, we surveyed institutions that are important suppliers of software engineers to India's software capital, Bangalore. We considered the role of the state through the assessment of its influence on fundamental aspects of an institution, such as entrance requirements, teaching, research and faculty selection. The influence was evaluated through three layers: influence on institutional policy (such as the focus on teaching versus research, equity versus merit, etc.), influence on governance structures (such as the rules for selecting or compensating faculty) and influence on the administrative structures (how flexible are the rules for admission? Do policymakers influence admissions directly and waive standards in return for higher fees?). These influences and quality outcomes such as the quality of research and the quality of curriculum were evaluated against the quality of the institutions as ranked by recruiters, both commercial and academic.

We found that the average quality of the institutions that supply Bangalore with software graduate is high and that the public sector is of better quality than private institutions. The state owned institutions are superior in certain key variables: curriculum, students and faculty. Nevertheless, even the private providers score well in these respects and score better than the state-owned providers on infrastructure. At the operating level, the state-owned providers tend to be less influenced by policymakers.   By contrast, the private providers are more politicized. In one key respect, research, the weakness of quality cuts across all types of institutions.

The unexpectedly high quality of the independent variables even among the private institutions (which are newer and less mature) suggests that quality for the system as a whole will improve further as the system matures.

Second, we found that influence of the state is generally high on teaching, entrance and faculty selection. The exception is the research function, where the state plays a hands-off role.   These findings confirm our hypothesis that the state plays an important corrective role where it can, given the immaturity of the system, while staying out of functions which it cannot influence, such as research. In addition, the state plays a more intrusive role in setting teaching standards for private institutions than for state institutions. The former are the newer, more immature institutions, so this role appears to be appropriate.

The low quality of research, despite limited state interference, suggests that other factors might be at work, such as private incentives. In our interviews, we found that the research function at even the highest ranked institutions is generally neglected. This seems to reflect poor university-industry linkages for research, even though they appear to be satisfactory from a recruiter's viewpoint. Even the final year design project of the student is typically done within the university rather than at a commercial enterprise.

This weakness in research is despite relatively generous allowances for research. Even in the smaller state-run institutions, it was found that faculty can relatively simply obtain funds for domestic travel, materials and assistance. In some of the larger state schools, even international travel for conferences is funded. The might improve if the state instituted rules that required, for instance, that a certain proportion of research funding needs to come from industry or if rules of tenure included a research evaluation (this factor is mostly missing even in the highly-ranked institutions). The private sector ranks even more poorly than the state institutions on research.

In summary, the education environment we studied shows that the institutional structure seems to have the capacity to produce a quality of engineer that is suited for the present needs of the workplace. Interestingly, all institutions, from the lowest to the highest ranked, seem to aim to produce technically competent engineers rather than a creativity-driven quality continuum.

As the demands of the marketplace evolve, certain weaknesses, particularly in the research and project management functions, will need to be addressed. We have argued that the role of the state will be critical. So far, the state has demonstrated its capability of being an effective regulator. To address evolving demands, new capabilities will no doubt be needed by the state. In particular, the state needs to address the issue of the quality gap at the second-tier and the absence of research capabilities at the first tier. It also needs to increase autonomy to first-tier institutions, particularly in administrative structures. Towards private providers, the state currently plays a more intrusive role than it would in a more mature system. This reflects the immaturity of the private provision system, as evidenced by politicization and generally lower quality outcomes. The challenge the state's role raises is how the state ought to fashion its regulatory role so that it can transition to a less rules-based system as the environment matures. This is a transition that it has not achieved even in the best state-owned institutions and remains, therefore, a challenge.

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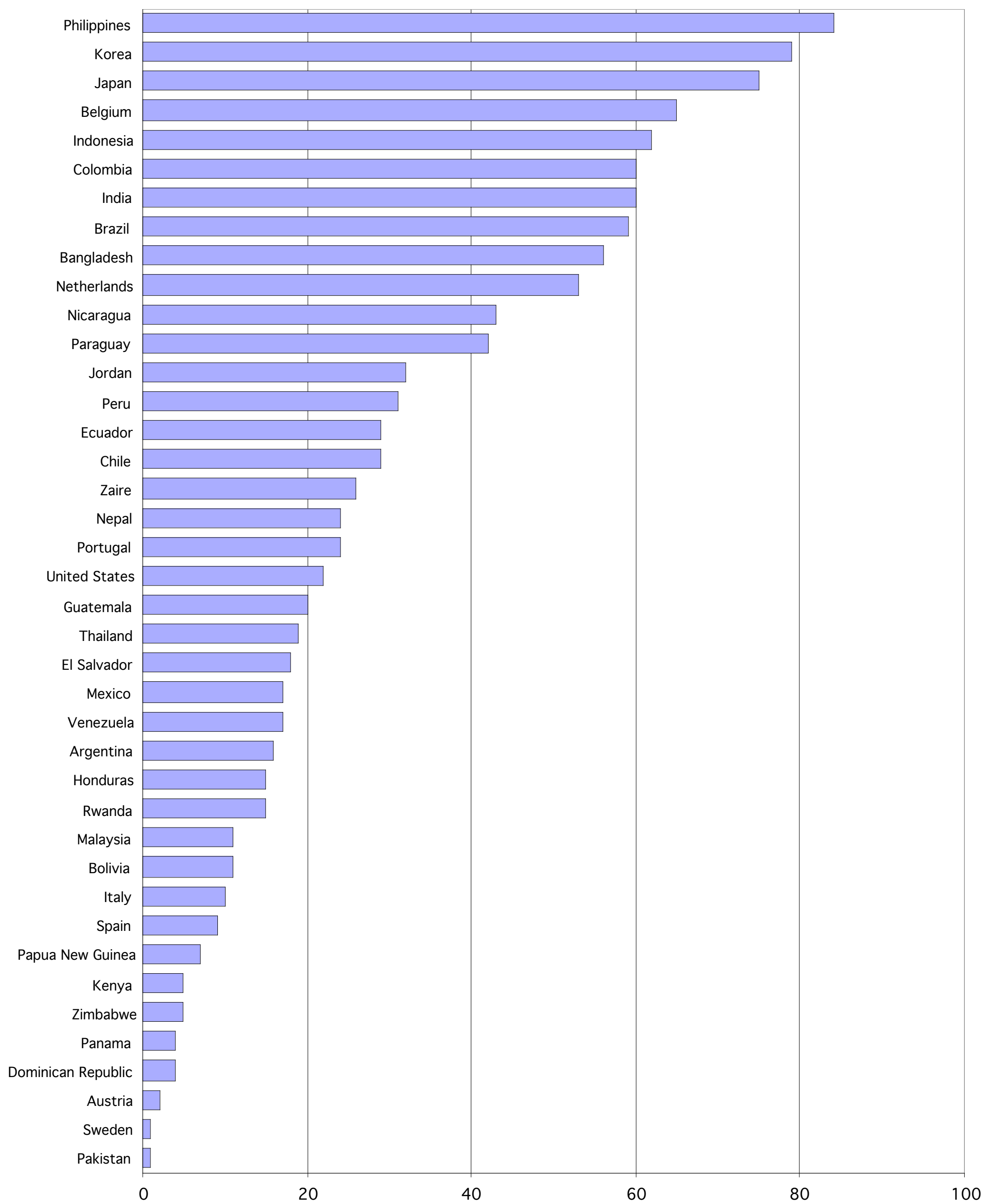
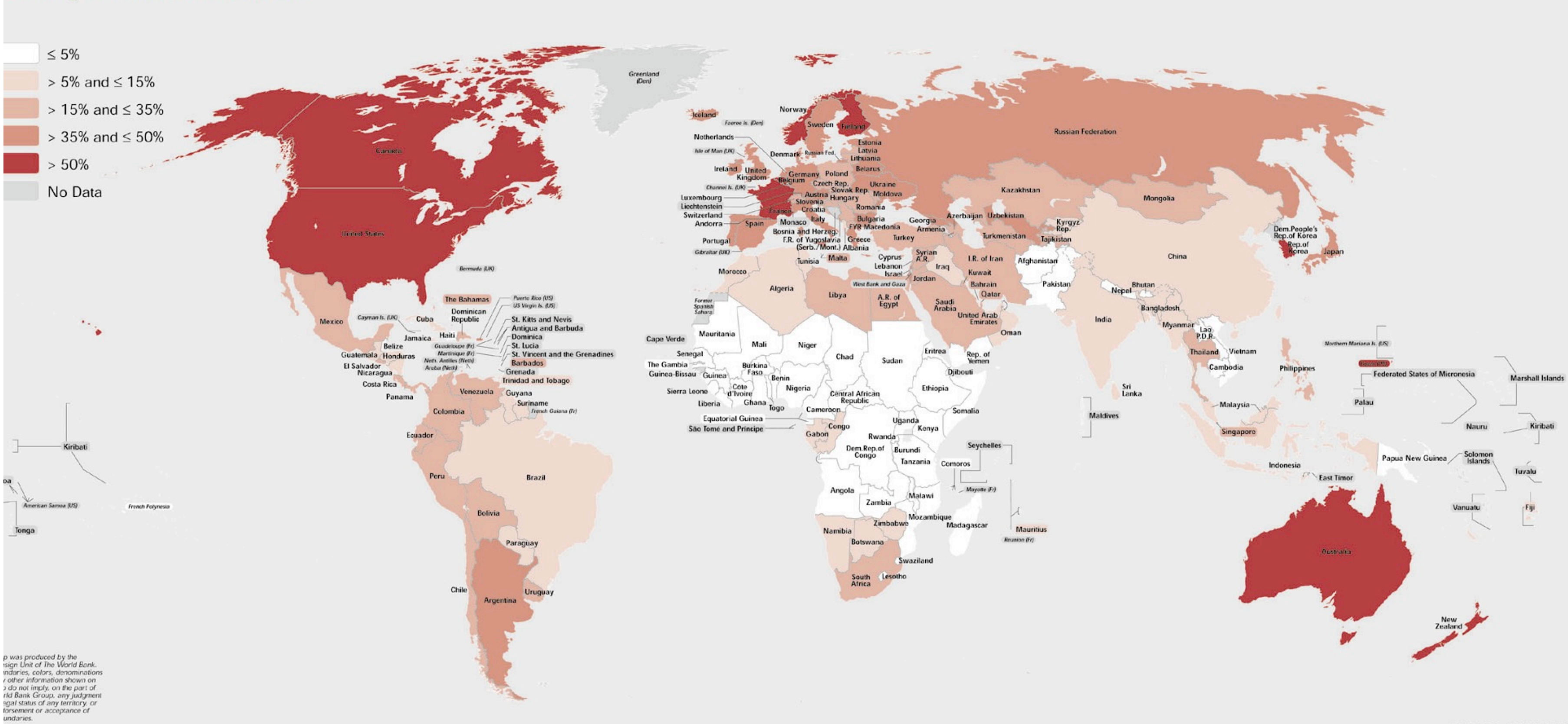
Appendix 1

Share of enrolment in private higher education & enrolment rates
(Source: World Bank, 2000, p.39)



gure 1

Tertiary Enrollment Ratios, 1995



ap shows the variation in tertiary enrollment ratios across the countries of the world. In general, people in countries that are more ped economically are more likely to be enrolled in higher education. Nevertheless, there are also regional trends, and numerous es have different enrollment ratios than might be expected on the basis of per-capita income.

Appendix 2

List of institutions in sample (in Bangalore, unless otherwise noted)

Acharya Polytechnic
Bellary Engineering College
BMS College of Engineering
College of Engineering, Guindy (Chennai)
Dayananda Sagar College of Engineering
Government Polytechnic for Women
IIT Madras (Chennai)
International Institute of Information Technology (Hyderabad)
Indian Institute of Science
Jawaharlal Nehru Technological University (Hyderabad)
JSS Academy of Technical Education
MSR Institute of Technology
Madras Institute of Technology (Chennai)
Nizam Institute of Engineering and Technology (Hyderabad)
P.E.S.Institute of Technology
SJ Government Polytechnic
SRM Institute of Science and Technology (Chennai)
VVS Polytechnic
Vijaynagar Engineering College

Other institutions interviewed (not used for sample tests)

India:
Allahabad University, Allahabad
Banaras Hindu University, Varanasi
Devi Ahilyabai University, Indore
IIM, Calcutta
IIT, Bombay
JSS Mahavidyapeeth, Delhi
US:
Illinois Institute of Technology, Champaign-Urbana, IL
San Jose State University, San Jose, CA
Stanford University, Stanford, CA