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Learning from the Bangalore Experience: The Role of Universities in an Emerging Regional Innovation System

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Abstract

This paper is concerned with the role of universities and public research organizations initiating and sustaining the development of regional innovation systems in developing countries, focusing the discussion on the Bangalore software cluster. Innovation systems research has paid significant attention to the importance of universities and other publicly financed research institutions as engines of growth and innovative performance in regions. With noble exceptions these papers tend to ignore the specific context in which this interaction between the university and the industry takes place, that is, the specific competences and capabilities of the universities and the firms' specific needs, particularly in developing countries. This papers aims at reducing this gap by making an empirically-based analysis of the role that universities can play in initiating, sustaining and deepening Bangalore's regional innovation system for the IT-service and software industry embedding the discussion on the specificities of the strategies of the firms and the universities located in the cluster.

Keywords: university, regional system of innovation, software industry, developing countries, Bangalore

Learning from the Bangalore Experience: The Role of Universities in an Emerging Regional Innovation System

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1. Introduction

This paper is concerned with the role of universities and public research organizations in initiating, maintaining and sustaining the development of regional innovation systems in Asian countries, exemplified by Bangalore, India. Over the past two decades researchers and policy-makers have increasingly acknowledged the importance of universities and other publicly financed research institutions as engines of knowledge-based growth and enhanced innovative performance in developed economies. Especially in the context of regional economic development and fuelled by the Silicon Valley success story, expectations on the presence and contribution of universities to regional high-technology agglomerations have been high (OECD, 1999).

Universities are conceptualized as creators and providers of knowledge spillovers for industrial innovation and thus as key actors in the national and regional innovation systems. Particularly the triple helix narrative has been widely heralded as the new policy paradigm that puts universities at the heart of knowledge-based regional economic development (Etzkowitz and Leydesdorff, 2000; Jacob, 2006). It explicitly seeks to reform academia into entrepreneurial universities and to strengthen industry-university-state interaction. Under this paradigm, it is believed that in order to harness scientific knowledge for innovation, industry-university linkages have to be stimulated through various mechanisms such as the promotion of academic entrepreneurship, the establishment of science parks and incubator centers and the set-up of a technology transfer support infrastructure.

The discussion on the third task that was grounded in experiences in California, or the US more generally is swiftly disseminating to other regions, such as Asia. Policy makers all over the world are now discussing the importance of the entrepreneurial university as an

engine for growth, particularly in high-tech regions. Similar debates are increasingly taking place in policy circles and documents in India. We argue, however, that this envisaged function of universities runs the risk of misplaced policy-learning by ascribing universal truths to Western practices (Amin, 1989, Said, 1993, Yeung, 2003) ignoring the specific context - including the historical trajectories - in which this interaction between the university and the industry has taken place. This paper attempts to contribute to the current discussion in India about the role of universities in the development of high-tech clusters, particularly IT. As the flagship of the IT industry in India, Bangalore is often referred to as the Silicon Valley of Asia. This chapter therefore scrutinizes the role played by universities and research institutes for the emergence of the Bangalore IT cluster. As such we critically discuss the adequacy of readily-imported, one-size-fits-all models on the role of universities in stimulating high-tech regional clusters. Instead we endorse a non-deterministic evolutionary perspective that emphasizes firms', regions' and nations' degrees of freedom in strategizing, i.e. contextually shaped strategy in action (Nygaard, 2001). Bangalore has been chosen as it represents one of the few cases in Asian countries which has come close to having constructing a full-scale regional innovation system (Chaminade and Vang, 2006b, Vang and Chaminade, 2006a).

The structure of the reminder of the chapter is as follows. First, we introduce the dominant perspectives, positions and findings on the role of universities in (regional) innovation systems. Then we turn to the case, Bangalore, where we analyze the different roles of universities and publicly funded research in the different phases of Bangalore's development into an immature software regional innovation system (Chaminade and Vang, 2006b) and for the different groups of firms that are co-located in the cluster. The paper is rounded off with more general conclusions from the study and the challenges they pose to established insights on the role of universities in innovation systems research.

2. Universities in innovation systems: the current debate

While having its bedrock in OECD economies, innovation systems research has become increasingly interested in Asian, Latin-American as well as African economies. This has entailed a stronger focus from innovation narrowly defined as R&D related activities to a broader perspective that also encompasses competence building and upgrading to higher value added activities in global value chains (Chaminade and Vang, 2006; Vang and Asheim, 2006). Central to the innovation

systems approach is the claim that upgrading is possible when there is *an environment* that supports interactive learning and innovation. Firms' isolated efforts to make this transition tend to fail in the longer term. The literature argues that the interaction often takes place with other firms and organizations co-located in the same regional area (Lundvall and Borras, 1999). The importance of the local interactions for firms, particularly, SMEs holds for developed (Asheim et al., 2003; Cooke and Morgan, 1998; Cooke and Will, 1999; Schmitz, 1992) as well as developing countries (Albu, 1997; Giuliani, 2004; Giuliani and Bell, 2005; Pietrobelli and Rabellotti, 2006; UNIDO, 1997 and 2004). Firms located in a region might benefit from static and dynamic externalities supporting their ability to compete in local and global markets.

The paper departs from the regional innovation systems (RIS) approach. RIS are defined as a "constellation of industrial clusters surrounded by innovation supporting organizations" (Asheim and Coenen, 2005). The approach puts the emphasis on the systemic dimension of the innovation process; being the dynamic interaction between the different elements of the system. Four related system-elements can be identified (Doloreux, 2002):

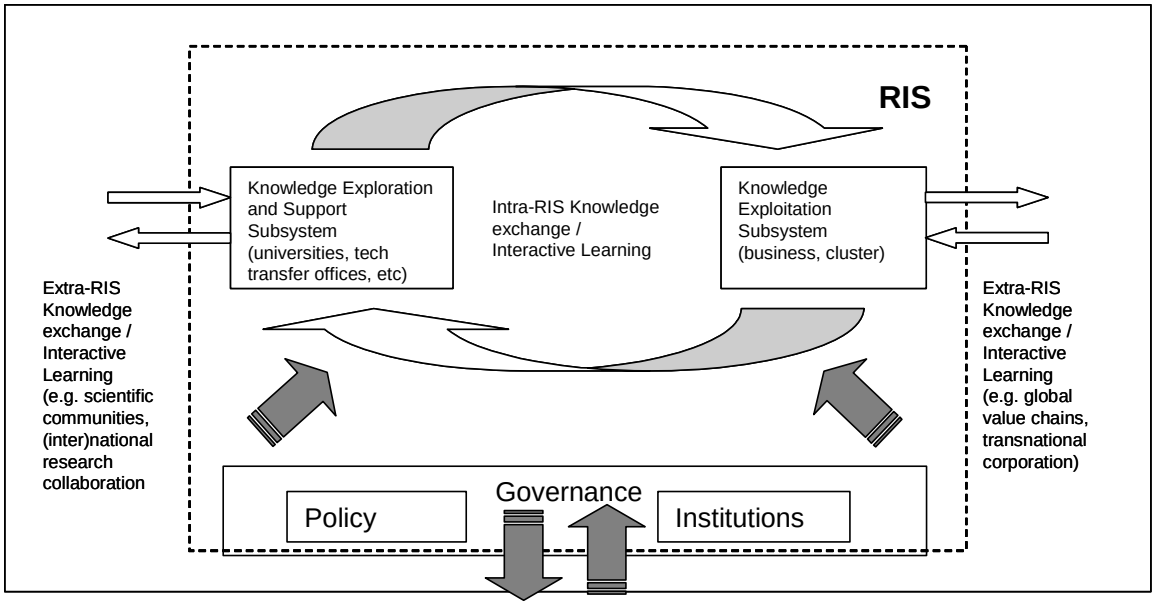
- Firms within a cluster (constituting the knowledge exploitation subsystem)
- Knowledge infrastructure (constituting the knowledge exploration subsystem) in which Universities are included
- Institutions (the 'rules' regulating the behavior of the actors in the RIS and their interaction)
- Policy (intended to improve the overall innovative performance of the RIS)

Thereby, the regional innovation system is boiled down to two main knowledge-related sub-systems, the interactions between them as well as a governance system underpinning it (see figure 1). The first type of sub-system, involved with knowledge exploitation, concerns the companies in the region's main industrial clusters, including their customers and suppliers. Industrial clusters are defined as the geographic concentration of firms in the same or related industries (Porter, 1998; Pietrobelli and Rabellotti, 2004; for a critique, see Martin and Sunley, 2003). In this sense, industrial clusters represent the production component of the regional innovation system. The second sub-system, involved with knowledge exploration and support, includes research and higher education institutes (universities, technical colleges, and R&D institutes), technology transfer agencies, vocational training organizations, business associations, finance

institutions, etc (Asheim and Coenen, 2005). It provides the infrastructure backing up the innovative performance of the first type of actors. The knowledge creating and diffusing organizations bestow the resources and services (knowledge, capital, etc.) to support innovation among the local firms.

As a third element, institutions are an important factor that shapes the territorial context of the RIS and, thus, the ways that actors in the region create, exchange, exploit and forget knowledge. As formal regulations, legislation, and systems as well as informal societal norms, they produce (and are reproduced by) the structures and meanings that regulate (but not wholly determine) the actions and interactions of firms and other organizations (Gertler, 2004; Hollingsworth, 2000; Nooteboom, 2000; North, 1990). Fourthly, policy plays an increasingly important role, not the least due to the rising popularity and diffusion of the RIS concept into policy-making circles. However, the functioning of the RIS is also influenced by policy frameworks and decision taken outside the boundaries of the region (Isaksen, 2003), for example through national science and technology policy and central decisions about the extent and level of regional administrative devolution. On a general level, RIS policy seeks to improve the overall system by increasing learning capabilities and knowledge diffusion (Doloreux, 2002) but the way this policy is specifically shaped can take different forms dependent on the region's characteristics (Asheim and Isaksen, 2003).

Figure 1



Although Universities have always been considered a crucial element in the system of innovation, there has recently been a rising interest in the specific role that they should play supporting the development of different innovation systems (Lundvall 2002, Asheim et al, forthcoming) where special attention has been placed on the so-called 'third task' or mission (Goddard and Chatterton, 2003). The third task (after teaching/education and research) refers to direct interaction between universities and society. This can be interpreted in a variety of ways. University third tasks range from creating new high-technology firms, consulting for local industry, delivering advice to politicians and policy-makers and informing general public debates and shaping the national spatial distribution of social opportunities and services. Although, historically, universities have been engaged with society in a variety of manners (Benneworth and Arbo, 2006) most innovation system researchers tend to privilege direct economic engagement over other potential roles (Molas-Gallart et al., 2002). Thus, the third task often refers to direct collaboration between university and the industry. Such direct interaction between actors in the knowledge exploration and the knowledge exploitation subsystem fits very well in a RIS framework. It should therefore not be seen as a surprise that university's third task often is advocated from a regional innovation policy perspective.

However concern has also been raised that this emphasis on direct collaboration with industry, might divert attention and resources away from university's core activities, i.e. (public) research and teaching (Lundvall, 2002; Martin and Etzkowitz, 2006). This debate has resulted in polarized views on the role(s) of universities in regional systems of innovation which tend to ignore the territorial and historical context in which the university is embedded. Such contextualization is especially important when discussing the role of university in Asian regional innovation systems and the case of Bangalore in particular. Below this debate shall be outlined and an effort is made to propose a more nuanced framework to understand the role of universities in RIS in Asia, taking Bangalore as a flagship example. It appears that the discussion has been split in two camps that either emphasize university's generative or developmental role (Gunasekara, 2006). While the generative role mainly refers to knowledge creation, diffusion and exploitation processes, the developmental role is more pre-occupied with the governance dimensions that regulate the interaction of university in the regional innovation system.

2.1. The generative role of universities

The generative role of universities underlines the contribution of academia to knowledge-based regional development through the production of advanced basic research and trained personnel. The knowledge outputs that are produced can take different forms for example as scientific and technological information, equipment and instrumentation, skills or human capital, networks of scientific and technological capabilities and prototypes for new products and processes (Mowery and Sampat, 2005). Such discrete outputs have varying potential across industry to become commodified knowledge. It is not the objective of the generative role to supply the industry with knowledge solutions (in the sense of applied knowledge) but to produce science (basic knowledge) and to train human resources.

Obviously, science-based and high-technology industries benefit more from industry-university linkages compared to, for example, service providers. The generative role of universities is often couched in terms of knowledge spillovers. Academic knowledge spillovers, measured by the location of inventors citing university patents, have a tendency to be localized in the university's region (Adams, 2002; Trajtenberg et al., 1997). Such measurements do not say very much about the mechanisms by which knowledge spillovers are realized. Zucker and Darby (1996) have highlighted the role of so-called 'star scientists' that drives the commercialization of break-through discoveries. Others find that the average level of human capital conditions the ability to develop and implement new technology (Glaeser et al., 1992). This, in part, relates to Cohen and Levinthal's (1990) argument that the appropriability of new knowledge by a firm is dependent on its absorptive capacity, i.e. the firm's level of prior related knowledge and related intensity of efforts in acquiring new knowledge. The consensus in the literature seems to be that "knowledge spillovers are geographically bounded within limited space over which interaction and communication is facilitated, search intensity is increased, and task coordination is enhanced" (Feldman, 2003). While the localization of knowledge spillovers often is explained through institutional similarities, this literature remains rather silent about which institutions matter and how, as well as how firms or regions located outside these areas can access and benefit from the localized knowledge spillovers.

Many (national) innovation system researchers and particularly its early proponents subscribe to the generative role of university in innovation systems. They tend to treat universities as a more or less

autonomous systems adhering to norms of academic research and teaching. Their research supports the claim that university research plays a small role in industrial R&D projects (Cohen et al, 2002; Fagerberg, 2004). It implies that the importance of direct, purposeful industry-university interaction, in other words the third task, should not be exaggerated. Lundvall (2002) even goes so far to state that university's "most significant contribution to society and the economy will remain well-educated graduates with critical minds and good learning skills" (2002, p…). He acknowledges that universities can be involved in 'third task' activities but sees it both as dangerous and mainly relevant for specific industries such as science-based industries biotech and software production. While skeptical of the constraints implicated in direct co-operation with industry, he stresses the importance of openness to the environment or surrounding society "to ensure that the long-term, creative and critical aspects of academic research can survive". In sum, the generative role of universities in innovation systems ascribes to traditional activities in the Universities, i.e. scientific research and teaching. In contrast, the developmental perspective takes a broader perspective on university's contribution to innovation.

2.2. The developmental role of universities

While acknowledging the knowledge generating and disseminating activities underlined in the generative role, the developmental role puts a stronger emphasis on university's impact in the governance of the regional innovation system and in the close interaction between university and industry in the development of what has been called "economically useful" knowledge. As such it conceptualizes the university not only as an autonomous player strictly involved in knowledge generation but also as an actor that participates, both formally and informally, in shaping regional institutional and social capacities through close interaction with the industry, as Table 1 summaries. While having been a central concern in regional studies for quite some time, this perspective has lately been increasingly dominated by the triple helix model.

Table 1

	Generative role	**Developmental role**
Role of university	Supply of qualified human capital and basic research	Driver of regional growth. Entrepreneurial university
Research type	Basic research and non-industry specific applied research	Prominently applied research, although some basic research also takes

		place
Functions	Education and research	Third task (but also training and research)
Networks with local actors	Weak. Independent institution.	Strong. Blurring boundaries in the role of the different organizations as knowledge providers
Equivalent mode	Mode 1	Mode 2
Theoretical influences	Research policy, (national) innovation systems, standard economics	Triple helix, regional innovation systems
Advantages	Research excellence. Autonomy in research and training and focus on basic research. Clear boundaries between roles of the different organizations. Long-term orientation of research	Coordination between the different actors in the generation of knowledge and its transformation into commercial outputs
Inconveniences/Critics	Research might be disentangled from industry and thus never turn into new products and services that impact growth	The university might lose its core "competence" resulting in an identity crisis. There is a risk of concentrating too much efforts in applied research and abandon basic research (for which firms have less incentives). Potential problems of recruiting researchers if they become reduced to cheap consultants.
Policy implications	Emphasis on basic research and education	Emphasis on applied research that suits industry needs

The triple helix finds its foundation in a spiral model of interaction between university-industry-government where knowledge production and innovation transcends organizational boundaries (Etzkowitz and Leydesdorff, 2000). According to Etzkowitz (2002) it refers to a move towards a new global model for the management of knowledge and technology. In this model, universities should be rethought in ways that allow for new interfaces with industry and, even, a shift towards roles that were traditionally allocated to private industry such as the exploitation of intellectual property rights, technology transfer, the establishment of science parks and spin-off firms. In fact, Etzkowitz

criticizes the innovation system approach for adopting a static, essentialist perspective deeming triple helix superior:

> "The National Systems of Innovation (NSI, [read: generative role]) approach is especially well suited to analysis of bounded phenomena, within nations or individual firms. Although other sources are taken into account, incremental innovation is viewed as primarily occurring within the firm, through various forms of learning (Lundvall, 1988). A different model of the sources of innovation is required to account for discontinuous as opposed to incremental innovation". (p. 1, Etzkowitz 2002)

While the generative role treats universities as more or less independent units, the triple helix model emphasizes the emergence of hybrid, recursive and cross-institutional relations between university-industry-government. In other words, the institutional boundaries between university and industry are blurring. According to Etzkowitz and Klofsten (2005) this has three resulted in three fundamental changes in the role of universities in stimulating innovation. First of all, universities have become one of the drivers of innovation in a knowledge-based economy, not only through its research activities. Secondly there is a shift towards purposeful, collaborative relationships between university and industry, as well as government. Thirdly, each sphere has started to take the role of the other. This has lead Etzkowitz and Klofsten (2005) to argue that the entrepreneurial university is *the* core institution in an innovating region. The triple helix model seeks to spur innovation of the more radical kind by conceptualizing the university as an incubator or seedbed that provides support structures for overlapping networks of academic research groups and start-up firms.

In contrast to the generative role, the developmental role is mainly concerned with how university-industry interaction in a regional innovation system is organized. As a result, it has a stronger focus on novel associative structures and modes of governance (Cooke and Morgan, 1998) compared to research that deals with the generative role of universities.

The triple helix approach has been rapidly disseminated worldwide and it is increasingly being used in policy circles, including several Asian countries, as the new paradigm for the design of innovation policies. However, in the dissemination process the ideas have been de-contextualized. The model is based on studies conducted in the Boston region with MIT (Massachusetts Institute of Technology) as the exemplar case of an entrepreneurial university. While case studies

have been conducted in other regions and universities, the triple helix model has been criticized for its totalizing framework. Very little has been reported on the disadvantages and conflicts of interests related to academic entrepreneurialism (Gunasekara, 2006) or on the adequacy of the model to the specific territorial and historical context of the RIS.

This issue is particularly relevant for developing countries. As recent research has pointed out (Saad, 2004, Juma et al, 2001 cf Sardana and Krishna, 2006; Turpin and Martinez-Fernandez, 2003) the use of the triple helix concept in a developing context is problematic. In most of the cases, the interaction between the government, the university and the industry does not materialize due to the lack of resources, power and the weaknesses of the different actors involved in the system. Despite the relevance of their critique, what this literature tends to implicitly assume is that a more proactive role of the university and a closer interaction with the industry is desirable (Krishna, 2001, Basant and Chandra, 2006) and that policy makers should be more actively supporting the transition from the generative role to the developmental role of the university (Sardana and Krishna, 2006). This is a special critical issue when discussing the future of high-tech clusters in India, such as the Bangalore cluster. Hence, attention is now turned to analyze the role played by the Indian universities – especially those in Bangalore – in facilitating the emergence of the IT cluster in Bangalore.

2.3. Contextualizing the debate

The first step in this process is contextualizing the debate on the role of universities in (regional) innovation systems. In this sense, the following three dimensions need to be taken into account.

Time matters: Firstly, there is abundant documentation supporting that most Asian countries (apart from Japan) – or rather their firms – should be conceptualized as imitators, as they tend to rely on second or 'third' mover advantages. That is they compete on producing cheaper products than their competitors in the developed world by copying, reengineering and imitating the first movers products without having to host the R&D costs or they simply serve as sites for outsourcing or offshoring production because of Richardian or absolute cost advantages. This challenges the notion of firms in both dominant approaches to the role of universities in systems of innovation. Both assume that innovation per se is pivotal. However, the literature on developing countries emphasizes the importance of imitation. It is by

no means clear that universities are important when innovation is not so crucial among the clustered firms nor has the literature provided systematic answers for when which of the three different university tasks (training, research and third task) become relevant in the evolution of the industries in the developing countries. It does not provide clear answers to whether there are generic evolutionary propensities attached to respectively generative and developmental roles (for example, whether generative activities are more important earlier that later). In this context the importance and trade off between different types of interaction with universities for Asian countries has not been investigated (see Mowery and Sampat 2005 for an attempt in the US).

Position in the value chain matters: Secondly, the sectoral and regional innovation systems literatures emphasize the industry specific dimension of innovation. However, most of the studies often ignore that firms in the developed and developing world tend to operate in different segments of the value chain of the same industry. Most of the studies tend to focus on the knowledge-intensive (read R&D intensive) activities in the value chain and thus one cannot mechanically generalize their findings to other parts of the value chain (i.e. the role occupied by Asian firms). The identified sector specificities are thus not unlikely to reflect industry differences but specific positions in the value chain. Hence the different roles of universities discussed in the developed world might not be relevant in Asian countries.

Strategy matters: In the same vein it should be emphasized that the literature ignores the importance of the specificities of firm strategies. It assumes that all firms pursue the global leadership in a certain segment of an industry. Hence, applies a hierarchical concept of knowledge that is detached from firms' strategic aims and visions. Alternatively, one could think of 'knowledge-levels' as context and strategy specific. In other words the demand for particular types of public knowledge provision (i.e. the role of public universities) is contingent on firms' strategies. Public knowledge provision can both support existing strategies and create the conditions underpinning new alternative strategies. In other words, whether universities should aim at becoming developmental or generative reflects a balance between developmental goals, institutional resources and firm's strategies and capabilities. Hence, it is not *a priory* assumed that supporting global leadership based on a developmental university should be privileged compared to a strategy - based on generative universities - exploring the advantages of, for example, targeting southern markets (D'Costa, 2006).

While other dimensions could have been emphasized the pivotal importance of these dimensions illustrate the need for an inductive study that discusses the role of the university taking into account the specificities of the regional innovation system.

3. The role of universities and public research in Bangalore's software 'RIS'

Bangalore has emerged as one of the largest and fastest growing software clusters outside the US (Nadvi, 1995; Parthasarathy, 2004a). Bangalore is not only a hub for software-related industries but also houses several high-tech clusters (e.g. defense, aeronautics) and is considered to be the scientific and engineering centre of India in terms of research and training and partly manufacturing. Despite the weight of the TNCs in the Bangalore IT sector, the large majority of firms are SMEs (NASSCOM, 2005).

Bangalore has attracted the attention of scholars around the world for its impressive software growth export rates, superior to those of competing IT hubs such as Israel, Brazil or China (Arora and Gambardella, 2004, Athreye, 2005). The value of export, for example, typically grows more than 30% annually while revenues grow at 30-40% (www.bangaloreit.in). The growth of the software industry in India is based on exports to global markets, mainly to the US. This export-led development trajectory or model has important implications for the industrial structure of the RIS and the possibilities for upgrading of the indigenous firms (D'Costa, 2006). India has an estimated share of 65 percent within the global IT services off-shoring segment and around 46 percent of the global BPO market (NASSCOM-McKinsey Study, 2005a).

Bangalore is considered to be a successful story and, as such, is receiving an increasing attention by Indian policy makers that are currently discussing how to support the growth of the IT sector through a variety of policies in the education, science and technology realm (Indian Ministry of Human Resource Development, 2006). As in many other countries the open debate is whether to support a more generative role of the university or a more developmental role. To understand what of the two options is more adequate for Bangalore it is necessary to analyze how the RIS evolved over time and what the different needs of the firms located in Bangalore are.

3.1. The emergence of the RIS and the gradual fragmentation of the knowledge exploitation subsystem

There is a heated debate on the role of public research in the initial phase of Bangalore development. As many authors have acknowledged (Arora and Gambardella, 2004, Athreye, 2005) the early development of Bangalore as a specialized hub in the software industry was due to the location in the region of some of the best educational institutions such as the world renown Indian Institute of Science, the Indian Institute of Information Technology, Raman Research Institute, National Institute of Mental Health and Neuro-Sciences, Central Food Technological Research Institute, Indian Space Research Organisation, National Aeronautical Laboratory, etc. The high concentration of knowledge providers in the region resulted in critical mass of highly qualified yet cheap labor force which could explain the initial interest of the US firms in locating their outsource activities in the region. Direct research spillovers from university research seem somewhat unimportant.

Instead the interaction between the indigenous firms and the TNCS seems to be major driver behind the development of certain firms, such as TCS, Wipro or Infosys in the early phase[1]. Through the interaction with the TNCs, these firms became more familiar with the work organization and requirements of the US firms (delivery times, quality, reliability) while the US firms started to gradually outsource tasks to be performed entirely in Bangalore. Cooperation was facilitated by the role of the Indian transnational community in the US (Saxenian, 2001), particularly those that held important positions in US firms (Vang and Oberby, 2006).

As the Bangalore software RIS matured both Bangalore and US firms improved their competences in managing outsourcing and off-shoring, build up inter-cultural competencies and created their own local networks. Employee attrition and wage increases forced the firms to introduce advanced management techniques (Arora et al, 1999; Athreye, 2003) alluding to the importance of managerial education as an added value to the existing engineering training capacity. The broader knowledge base combined with the existence and gradually building of reputation as reliable suppliers in the US market plus an aggressive certifying strategy among most Indian firms have permitted a handful of firms to move up the global value chain (to the provision

[1] Yet, it should be acknowledged that especially changes in the domestic banking sector also played a central role in fuelling the development of the IT-industry.

of R&D services for TNCs) and, even in some cases, develop their own innovation strategy and enter new niche markets with their own final product. (Parthasarathy and Aoyama, forthcoming).

Only a small group of firms has benefited in terms of knowledge spillovers from the interaction with the TNCs and has effectively moved to higher added value activities. As acknowledged by D'Costa (2006) most of the SMEs located in Bangalore provide standardized services, therefore, the incentives for the TNCs to create long-term arrangements with the indigenous SMEs are low.[2] Their absorptive capacity also remains low. Only the small group of firms that has been able to build an absorptive capacity and create distinctive capabilities are benefiting from the interaction with TNCs. The growth model that the indigenous firms have adopted (i.e. export- and TNC-driven) has created a fragmented industry with very weak local linkages (D'Costa, 2006). Table 2 plots the distribution of the industry by segments. Basically the top 15 Tier I and Tier II companies account for 70% of the IT services software revenues. The vast majority of firms (emergent players) are still responsible for only 15% of the IT services. Furthermore, while the market share of the Tier I firms has increased from 32% in 2001-02 to 45% in 2004-05, Tier II lost ground from 35% to 16%.

Table 2.

Category	**No. of players**	**Share of India's total IT/BPO export revenues**	**Performance**
Tier I Players	3-4	• 45% of IT Services • 4-5% of BPO	Revenues greater than USD 1 billion
Tier II IT Players	7-10	• 25% of IT Services • 4-5% of BPO	Revenues USD 100 million-USD 1 billion
Offshore operations of Global IT majors	20-30	• 10-15% of IT Services • 10-15% of BPO	Revenues USD 10 million-USD 500 million

[2] TNCs seem more concerned with protecting intellectual property rights. This applies not only in respect to external alliances but also on by applying highly modular R&D research strategies with minimum knowledge dissemination to their Indian subsidiaries.

Pure play BPO providers	40-50	• 20% of BPO	Revenues USD 10 million-USD 200 million (Excluding top provider with USD 500 million)
Captive BPO units	150	• 50% of BPO	Revenues USD 25 million-USD 150 million (top 10 units)
Emerging players	>3000	• 10-15% of IT Services • 5% of BPO	Revenues less than USD 100 million (IT) Revenues less than USD 10 million (BPO)

Source: NASSCOM-McKinsey (2005a)

The question that these numbers pose is if it is possible to talk about the role of the university for the whole Bangalore system of innovation with such a fragmented and polarized industry.

3.2. The knowledge exploration subsystem

The situation of the universities in India is extremely heterogeneous in terms of performance and tasks undertaken. Four Indian universities are listed in the top 50 universities in the world (THES-QS, 2006): The Indian Institute of Technology, the Indian Institute of Management, the Indian Institute of Science and the Jawaharlal Nehru University. Those universities are considered to be world-class in both training and research, as well as in terms of the collaboration with the industry (Basant and Chandra, 2006).

In a recent report on the IT industry, the Indian Ministry of Human Resource Development classifies the IT-related higher education institutions into 3 categories (2006):

- Category I embraces the 6 IITs (Indian Institute of Technology), the Indian Institute of Science, 2 IIIT (Indian Institute of Information Technologies) and 6 IIMs (Indian Institute of Management). Of the 15 institutions, 3 are located in Bangalore (IIIT, IIS, IIM). Category I institutions supply post-graduate education and advanced research.
- Category II includes the 17th Regional Engineering Colleges and 33 other established universities and technical institutions. The REC provide undergraduate education in the IT field. One of them, the University of Vishveshvariayya is located in Bangalore.
- Category III: Other government institutions and self financing institutions (include approximately 200 government support IT

training institutions and 550 self financing institutions). This is a extremely heterogeneous category embracing both low-end II academies and the corporate training centers, as Infosys training center, which is the largest IT training institution in Bangalore. The two top IT service firms located in Bangalore (Infosys and Wipro have established their own training centers)

If one eliminates the handful of world-class technical institutions, the picture is one of shortages of high quality staff (Arora and Gambardella, 2006; NASSCOM-McKinsey 2005a, 2005b), and under-investment in research facilities. According to the last NASSCOM-McKinsey report (2005a) only one forth of the technical graduates and 10-15% of the general college graduates are suitable for employment in IT and BPO activities. This fragmentation of the university system, together with a shortage in the supply of human capital explains why some TNCs and also local firms have increasingly started to build their own training centers in Bangalore as the recent examples of Infosys, Wipro or TCS show.

The shortage of human capital is also reaching the university. Almost 25% of the IT and computer science faculty positions remain vacant, due to the heavy demand from industry and the high salaries offered by the industry (Indian Ministry of Human Resource Development, 2006). With few exceptions universities are almost exclusively devoted to the provision of (qualified) manpower to the local firms (Basant and Chandra, 2006). Research is often more basic research and, as a consequence, universities are not playing a significant role in supporting innovation and generating research results for the local firms. Faculty with postgraduate education is hard to find (Indian Ministry of Human Resource Development, 2006). As Basant and Chandra (2006) indicate, only a handful of institutions provide both high-quality undergraduate and postgraduate teaching and research. Those are the universities considered as Category I which are actively engaged in research in collaboration with the industry.[3] Table 3 provides some examples of research collaboration between the top 5 IT service firms and a selection of universities located in Bangalore and outside the region.

[3] Not all universities are present in Bangalore. The Indian firms need to develop subsidiary strategies that facilitate physical proximity to the relevant universities when the nature of the university-industry collaboration requires this. The strategies should also encompass subsidiary R&D mandate.

Table 3. Sample of collaboration in research

Top 5 IT services companies located in Bangalore	University Partner in Bangalore (area of collaboration)	University partner elsewhere (area of collaboration)
TCS	IISc (Advance product design and prototyping)	IIT Delhi (Lab for intelligent internet research) IIT Chenai (Computational engineering) University of California (Internet quality of service) University of Wisconsin (Business components) Carnegie Mellon University (Center for the Study of the Software Industry)
Infosys	IIIT Bangalore (Banking, C-BIT center)	
Wipro	Institute of Bioinformatics and applied biotechnology (Bioinformatics)	
HCL Tech	--	IIT Delhi (Supercomputing facility for bioinformatics and computing biology)
Satyam		Center for cellular and molecular biology (Hydebarad) (Bioinformatics) John Hopkins University (Health care)

Source: information compiled from the firms and universities website www.tcs.com, www.infosys.com, www.wipro.com, www.hcltech.com, www.satyam.com, www.iit.com, www.iitb.com.

As an example the Indian Institute of Information Technologies (IIIT) located in Bangalore hosts research labs from different companies such as Honeywell, Intel, HP or Siemens as well as several research centers such as C-Bit (research on banking systems), C-Ait (research on automotive software) or C-Hit on healthcare and IT. Similarly, the Indian Institute of Science has contributed significantly to the growth of the biotech cluster in Bangalore, generating some important spillovers in terms of bioinformatics research for the IT industry (Basant and Chandra, 2006). But outside those top high-education institutions, interactive learning with universities is thus weak (D'Costa, 2006).

In sum, the Bangalore system of innovation is fragmented with large disparities in both the knowledge generation (universities and research institutions) and exploitation subsystems, with organizations that are competing globally coexisting with low-quality education institutions

and firms operating in the low end of the value chain. Under these circumstances, the discussion on whether to invest the scarce resources in improving the general IT education of a larger majority of population (generative role), to invest in more elite institutions that can better support the research requirements of the most advanced firms is or to maintain the current distribution is a crucial albeit highly complicated one. The analysis of the possible future scenarios in Bangalore might shed some light to the issue.

3.3. A dual university-industry system?

The combined analysis of the potential future strategies for the knowledge exploitation subsystem as well as the type of university and education institutions available to the Bangalore firms, might illustrate the open debate between the generative and developmental role of the university. There are five possible strategies for the IT firms located in Bangalore (NASSCOM-McKinsey, 2005a; D'Costa 2006):

- **Global Champions:** Become global IT service and software players, competing in the same market segment as IBM, Accenture, and so forth.
- **IT specialist in a segment:** Become an IT specialist in 3 or 4 major industry verticals or cross-industry service lines, targeting OECD markets.
- **IT specialist in secondary markets:** Become an IT specialist targeting niche markets (such as Japan, Latin America or other Asian countries)
- **ADM specialist:** Turn into an ADM factory (specialized in advanced design manufacturing), providing low-cost application development and service maintenance, linking with smaller business consulting and system integrators.
- Or become a **BPO specialist**, focusing on process reengineering, chip design or other BPO services.

The selection of one or another strategy is a function of the previous capabilities of the firm. It follows that the most advanced IT firms will be the ones prepared to adopt the first strategy, while the others will be more or less compiled to adopt a different one.

Table 4.

STRATEGY	Actors(1)	Number	Role of University	Possible potential University partners
Global Champions	Tier I Indian firms (TCS, Wipro, Infosys, Satyam and HCL Technologies)	5-7	Developmental university: Training, advanced research and third task	Category I (ex. IISc, IIT IIIT. Total 15 institutions in the country)
IT specialist in a segment	Tier II suppliers (ex. Patni computers, NIIT, Mastek, i-flex, Polaris, CMC, Birlasoft, Mindtree)	10-15	Generative role (training and specialized research)	Category I (ex. IISc, IIT IIIT. Total 15 institutions in the country)
IT specialist in secondary markets (ex. Other Asian countries, Latin America)	Emerging players	>3000	Basic generative role (training of HR). Language training required!	Category II - Regional Engineering Colleges (17 institutions) and other University or Technical colleges (33)
ADM (advanced design manufacture)	Emerging players	>3000	Basic generative role (training of HR). Language training required	Regional Engineering Colleges
BPO specialists	Pure play BPO providers	2000	Basic generative role	REC and other government and self-financed institutions aprox 50 in total)

One thing that emerges clearly from this table and the historical evolution of Bangalore is that initially the leading institutes had only a positive indirect spillover to the private industry and even today the provision of high-quality specialized research will benefit only a small proportion of the firms. These are the firms that are performing better in terms of exports and revenues. The long-term derived spillovers on the regional innovation system obviously remains to be seem. Different scenarios are possible. On one hand the university-industry collaboration can turn out to be successful and support the general upgrading of the cluster by generating spillovers into the SMEs and spin-off's from the global champions. These spillovers might even

support other strategies (i.e. **IT specialist in secondary markets**, for example) and reduce the entry costs for firms to upgrade and change strategy in this direction. This might be needed due to the increased global competition from other low-cost countries and/or labor shortage and increased salaries in Bangalore. Positive spillovers to firms aiming at becoming **IT specialist in a segment** are likely to be limited. Due to their technological gap and lack of absorptive capacity, spillovers into **ADM**- and **BPO-oriented** firms are not likely to happen either. In a less optimistic scenario the investments in a developmental role of the universities will either lead to further technological diversity among the indigenous firms in the cluster or mainly benefit the TNCs.

Extrapolating the experience of Bangalore suggests that at best the increased technological inequality among the indigenous firms is the most likely outcome. Lack of social capital and absorptive capacity (Chaminade and Vang, 2006 and Vang and Chaminade, 2006) does not support the idea that we might expect great spillovers to SMEs (albeit successful collaboration in embedded software suggests that it might be possible). Currently, the TNCs located in Bangalore (and firms in the OECD-countries) attract the almost all the IT-candidates from the best universities. Hence, the construction of localized knowledge spillovers from universities to indigenous firms – especially SMEs – is an uncertain process and requires policy measures targeting these challenges.

Investing in increasing the quality of a greater number of training institutions (thus supporting the generative role of the university) could impact a larger number of firms in the regional innovation systems, thus contributing to a general upgrading on the RIS. Important to say that, for example, for the 3rd strategy, there is a need to invest in Languages. Apparently, one of the reasons that India is losing market to China and Easter Countries (even Mexico) is their lack of knowledge of Japanese, French or Spanish. Yet, the uncertainty with respect to this strategy is the future competitiveness of the Bangalore firms as their competitiveness is likely to be gradually eroded by increased wages and/or competition from other countries. While Tier I continue to grow, Tier II and the rest are losing markets. This suggests that the traditional generative role of the universities at least requires to be complemented by other policy-measures supporting and creating incentives for the upgrading of the non-first tier firms. Upgrading for these firms – at least from third tier and down – is not likely to emerge from without public support. One particular task generative universities should focus on in education and research

is innovation management as this might provide the competencies needed for upgrading in the indigenous SMEs.

Seen from a policy perspective one might also argue that the discussion on generative versus developmental universities is mainly interesting from a 'distribution-perspective'. Meaning focusing on 'how many of each' as opposed to 'either or', is the main question. While being explorative in nature our arguments above suggest that attention should increasingly be paid to upgrading the promising mid-level universities with the highest direct contact with indigenous SMEs. This could imply a modified developmental role (i.e. applied research of relevancy for SMEs upgrading). This, however, requires fundamental changes in budgets, internal incentive structure, salaries and formalized competency building.

4. Conclusions

Innovation systems research focusing on the role of universities in generating economic development is divided into two camps with radically opposing claims: proponents of the generative versus the developmental university. The current debated is based on experiences of the developed world and hardly translated to the reality of developing countries and regions, such as Asia. In this vein the particularities of the firms' strategic choices (for upgrading and global expansion) and derived requirements for university-based support are often neglected. The literature draws on a hierarchical knowledge concept which is less relevant for the strategies applied by catching-up Asian countries. Finally, the positions are polemic and constructed as 'either or'-positions that seldom take into account the specificities of different innovation systems.

Translating the discussion to the Bangalore regional system of innovation provides some interesting insights into the discussion. First, the case suggests that in the initial phases, when the regional system of innovation is still in its emerging phase, it is sufficient for the universities to focus almost exclusive on the supply of qualified human resources with general and industry specific skills (i.e. generative role). In the later phases universities roles become more complex and tied to the specific strategic choices by the firms (their strategies are again conditioned by the innovation system and changes in the global competitive landscape).. The IT-firms located in Bangalore should follow one of these five different –strategies if they want to stay in the market: aiming at becoming global champions, IT specialist in a

segment, IT specialist in secondary markets or specialized in ADM or BPO. The different strategies require different responses from the universities and call for different types of corrective policy measures. Firms aiming at becoming global leaders are most likely to benefit from universities taking a developmental role. Yet, it is not unlikely that the TNCs will harvest the main benefits unless targeted policy measures are implemented. Second tier firms and SMEs in general are not likely to acquire benefits. Generative universities can mainly support the upgrading of the firms in Bangalore by focusing on specific types of education of relevancy for their upgrading (i.e. innovation management). A reliance of generative universities is increasingly likely to require alternative supportive policy measures for third tier firms. Second tier firms are likely not to encounter major problems as competitiveness even among industry leaders within their field (i.e. IT services) is based on 'innovation without research'. Global leaders can maintain their current position and expand in IT-service but is not likely that they will be able to compete in the science-based parts of the industry if the leading universities maintain a generative role. Concerning the distribution of different types of universities we suggest that focus should increasingly be paid to the 'generative' role of mid-level performing universities. This is likely to lead to lead to most spillovers for the indigenous firms and especially the SMEs. Yet, much research remains to be done in this respect.

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