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A new role for leading universities in emerging economies: Building the local capabilities to develop knowledge-based STPs

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Building local capabilities to develop STPs

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Executive Summary

The building of local knowledge-based capabilities is a central issue in the development of Science and Technology Parks (STPs). Whether universities should assume an active role in building these capabilities has received a great deal of attention in the last few years. Several scholars propose that leading universities have to balance traditional roles in teaching and basic research with new societal demands involving the creation of suitable conditions for the growth and development of the regions where they are located. Based upon dominant perspectives in the literature on university-industry linkages, the present study analyzes the role of UNICEN, an Argentine publicly-funded university, in creating the conditions that gave rise to a successful software-based STP in the relatively small city of Tandil, in Buenos Aires Province. The case provides evidence of the entrepreneurial role that a university can play as a central actor in the start-up phase of developing a STP.

Keywords: University roles, regional development, university-industry linkages, knowledge-based capabilities, STP, software industry, emerging economies, Argentina.

Introduction

The building of local knowledge-based capabilities is a central issue in the development of Science and Technology Parks (STPs). STPs promote economic development and increased competitiveness of regions and cities by creating new business opportunities and adding value to mature companies, by fostering entrepreneurship and incubating new ventures, by generating knowledge-based jobs and building attractive spaces and workplaces for creative workers.

Discussions regarding whether universities should assume a new role as active agents in building of these local capabilities have received a great deal of attention in the last few years. Several authors propose that leading universities face an important challenge in balancing their traditional roles of teaching and basic research with new societal demands requiring an active involvement in regional economic development (e.g., Berglund & Clarke, 1999; Florida, 1995; Florida, 2000; Gunasekara, 2006b; Schiller, 2006). To meet the challenge, leading universities around the world have started to perform what is widely known as the "third role" or the "new role" (e.g., Chatterton & Goddard, 2000; Gunasekara, 2006b; Tornatzky, Waugaman & Gray, 2002), emphasizing how innovative universities commit to the creation of suitable conditions for the growth and development of the regions where they are located.

Performing such a role has become particularly important for universities in emerging economies. In the absence of other decentralized agencies and institutional interfaces capable of dealing with the complexities of the knowledge-driven economy, universities – especially those publicly-funded – are expected to be actively involved in creating the essential infrastructure required for regional economic growth and development. In a context where the role of higher education becomes much more critical all for industries (and particularly for those technology-driven), STPs and related mechanisms (entrepreneurship

programs, technology transfer offices, career centers) are likely enablers of productive partnerships between universities and firms.

Previous research conducted in developed countries has shown that universities respond to societal demands by applying similar sets of mechanisms and practices; however, the way of implementing those mechanisms and practices differs considerably across universities and contexts (Tornatzky et al., 2002). Differences in both internal competencies and contextual forces shape the way in which each university performs the third role and their likely outcomes (Arocena & Sutz, 2001). Moreover, little evidence exist examining the role of leading universities in the context of emerging economies and their contributions in terms of building the local knowledge-based capabilities (for exceptions, see Cabral & Dahab, 1998; Chaminade, Coenen & Vang-Lauridsen, 2007; Liefner, Hennemann & Xin, 2006; Schiller, 2006).

The purpose of this paper is to analyze the role of UNICEN, an Argentinean publicly-funded university, in building the local capabilities that gave rise to a successful software-based STP in the relatively small city of Tandil, Buenos Aires province. The case provides evidence of the entrepreneurial role that a local university can play as a central actor in the start-up phase of developing a STP as well as in the building of the regional innovation system and infrastructure required to support sustainable growth and development.

The following section presents the conceptual framework highlighting how universities can perform the third role, in addition to the traditional roles of teaching and research. A review of the literature on regional innovation system enhances the understanding of how universities engage in building the local knowledge-based capabilities required for the economic growth and development of their regions. Subsequently, we introduce the context in which the case unfolds, highlighting salient features of the software industry in Argentina and its recent evolution. We analyze the role performed by UNICEN in the initial phases of developing the Tandil software-based STP using the framework and perspectives presented in the review. Finally, we conclude by discussing the implications of this case for theory and practice.

The third role of universities in the context of emerging economies

The regional innovation systems (RIS) framework is a suitable approach to analyze the role of universities for regional innovation in both developed and developing countries (Schiller, 2006). Regional innovation systems stand for the intersection of both systems of innovation and cluster approach (OECD, 1999a). Moreover, RIS have also been defined as a "constellation of industrial clusters surrounded by innovation supporting organizations" (Asheim & Coenen, 2005).

It is worth noting that the framework adopts a broader definition of innovation, which encompasses not only R&D related activities, but also competence in building and upgrading different activities to a higher level of value-added (Chaminade et al., 2007). Universities are central to the development of a regional innovation system; however, its specific contributions differ in developed and developing countries. University-industry linkages focus primarily on industry-sponsored research, patents and technology transfer in developed countries (Tornatzky et al., 2002); yet, the focus shifts towards human capital development, adjustment of innovations, and technological dissemination to local firms in developing countries (Schiller, 2006).

A key factor in which the RIS approach stands is the capacity of the local environment to provide interactive learning, continuing improvement and innovation (Chaminade et al., 2007). According to Schiller (2006), two dominant strategies have been applied in developing countries to upgrade their local capabilities: (1) increasing the embeddedness of foreign-

owned or multinational companies within the region to tap into advanced knowledge and technologies, and (2) increasing local knowledge sources and endogenous innovative capacities by supporting universities and other research-oriented organizations and improving their responsiveness to regional technological demands.

Although universities have always been regarded as a key component of innovation systems, there has been lately a rising interest in their specific role towards regional economic development (Chaminade et al., 2007; Lundvall, 2002). Two general approaches have been identified concerning the role for universities in RIS. The first one is the triple helix. This approach points out the emergence of hybrid, recursive and cross-institutional relations between university, industry and government. In addition to performing their traditional functions, each of these institutional spheres assumes the roles of the others. Specifically, the approach asserts that universities generate economic development mainly through knowledge capitalization and other boundary spanning mechanisms like business incubation, spin-off formation and scientific parks (Etzkowitz, 2002). In this sense, universities collaborate with the economic development of a region when they adopt an enterprising format (Etzkowitz, Webster, Gebhardt, Cantisano Terra, 2000). The triple helix approach suggests that entrepreneurial university is a response to the increasing importance of knowledge as a production factor in any innovation system and the recognition that the university has an undisputable leadership in the creation of new knowledge and its transfer to the broader society.

The second approach is called “university engagement”. Authors supporting this view emphasize the way in which higher education institutions are responding to regional needs in terms of teaching, research and community service. They focus attention on how universities adapt their teaching and research missions and, on consequence, engage with their regions, but not necessarily linking it to capital formation projects or entrepreneurial activity (Gunasekara, 2004). According to this literature, teaching activities take a greater regional engagement by following actions such as the attraction of the best students to the region (student recruitment), the efforts to increase graduate retention, the creation of specialized and locally-oriented courses drawing upon regional characteristics, and the promotion of lifelong learning and continuing professional development and training (Chatterton & Goddard, 2000; OECD, 1999b). In the same way, research activities become more oriented towards regional engagement by drivers such as the production of knowledge by strategic alliances with other regional knowledge producers (think tanks, research centers and STPs), the promotion of industry research linkages and technology clusters at a regional level, and the efforts to adopt and diffuse cutting-edge technological development throughout the region. Nevertheless, advocates of the engagement approach recognize the existence of different barriers, including, for instance, nationally-driven accreditation standards affecting the teaching engagement efforts at the regional level as well as nationally-driven priorities and funding affecting the regional engagement of research efforts (Chatterton & Goddard (2000).

More recently, researchers have sought for ways of integrating these two approaches to reflect more broadly universities’ real efforts in the contribution to regional development. In this direction, Gunasekara (2006b) and Tornatzky and colleagues (2002) propose two frameworks, which describe the elements and actions that must be present when analyzing universities’ roles in the building of the local capabilities required for regional innovation, economic growth and development.

Guansekara’s (2006b) framework first introduces four major components as central elements of a regional innovation system, to analyze later how universities contribute to the development of these elements. These elements include the regional agglomeration or clustering of firms in a specific domain; the availability of specialized assets including the

stock of human and physical capital; the associative governance structure leading the ongoing development of the regional innovation system; and lastly, the development of supportive shared institutions defined as cultural norms promoting of openness to learning, trust and cooperation between firms (Chaminade et al., 2007; Cooke, 1998; Gunasekara, 2006b).

Regional agglomeration or the clustering of firms is the first element of a regional innovation system. A cluster is defined as "a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities." (Porter, 2000: 16) The geographic scope of clusters can range from a single city or neighborhood to a whole region, but typically, the boundaries and domains of regional clusters continually evolve as new firms and industries emerge, shrink or decline over time and related institutions develop and change (Porter, 2000).

The availability of specialized assets is a second key element of a regional innovation system. Cooke (2002) has defined it as "proximity capital", which includes different types of infrastructures sustaining the activities of innovative organizations. Specialized assets include the development of human capital as the critical factor of production in this knowledge-based economy. Universities have always play a crucial role in human capital formation; moreover, in recent years, some of them have redesign their teaching and research programs in order to make them responsive to regional knowledge demands (Gunasekara, 2006b).

As the third element, the associative governance structure plays an important role in the context of regional innovation and economic development. It refers to a "networking propensity whereby key regional development agencies interact with, and are and inclusive of, other bodies of consequence to regional innovation and development" (Cooke, 2002: 135). Increasing associativeness encourages the embeddedness among core actors (universities, governmental agencies, local firms, and so on), which in turn can lead to the creation of sustainable strategies for economic growth and development (Chatterton & Goddard, 2000).

The fourth key element of a regional innovative system is the development of shared norms supporting trust, cooperation and reciprocal learning among members that comprise the cluster. Institutional norms shape the regional innovation system by affecting the ways in which actors in the cluster create, exchange, and exploit 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 (Chaminade et al., 2007). Cultural norms that support the openness to learning and interactive innovation, also indicate to the degree of embeddedness of a region, that is the extent to which the regional cluster or agglomeration operates based on shared norms of cooperation, trustful interaction, and untraded interdependencies (Cooke, 2002).

In the analysis of universities' contributions towards the development of these four elements, Gunasekara's (2006b) framework attempts to explore "what" universities do and "why" they do it that way. The author suggests that universities can support these elements through two different approaches, drawing on the literature on triple helix and university engagement. Following these ideas, universities take on a generative role when adopting an entrepreneurial-based approach, or take on a developmental role when focusing on the adaptation of teaching and research activities. These two roles are not incompatible but differences exist across the actions taken by universities to develop RIS's elements depending on the approach adopted. These are summarized in Figure 1.

Figure 1: University roles in a knowledge economy: A framework at the RIS-level

Key element of regional innovation system	Generative role	Developmental role
Regional agglomeration, or clustering, of firms	Knowledge capitalization centered on firm formation and co-location of new and existing firms near the university	Regionally focused teaching and research, but not necessarily linked to firm formation projects
Human capital formation	Integration of knowledge capitalization activities, through firm formation, spin offs, and industry research partnerships	Stronger regional focus on student recruitment and graduate retention. Local adaptation of new technological developments
	Development of advanced research and training programs to support entrepreneurial activities and cutting-edge technology creation and transfer	Training and research programs developed or adapted to meet regional demands. Learning processes regionally informed
Associative governance	Driver of the regional innovation strategy, centered on knowledge capitalization and firm formation projects; analyzing strengths and weaknesses and bringing together industry and government to forge innovation strategy	Shaping regional networking and institutional capacity, through staff participation on external bodies; provision of information and analysis to support decision-making and knowledge brokering between external and local actors
Regional cultural norms	Institutionalization of shared norms. Tradition of university-industry linkages, involving knowledge capitalization	Shaping shared norms with other key actors. University-industry linkages, involving various forms of collaboration

Source: Adapted from Gunasekara (2006b).

Finally, Gunaseka (2006b) proposes a number of factors shaping the role – generative or developmental – that universities perform in the development of regional innovation systems. These explanatory factors include the university orientation to regional engagement, the history of university-region linkages, the complementarities of technological fields, the existence of champions of innovation, the nature of regional industry base, and finally, the external political and economic conditions.

Shifting from the regional system to the university (i.e., individual organization) level of analysis, Tornatzky, Waugaman and Gray (2002) develop a framework orientated towards understanding how universities can play a larger and more effective role in fostering regional economies. The authors note that high-technology regions typically contain a leading university, but not all leading universities are surrounded by innovative regions, and thus not all graduates (knowledge workers) stay around to develop their universities' local sphere. Based upon these facts, they examine the distinguishing elements that make certain universities active agents in building the local capabilities to develop knowledge-based

regions. They identify three domains regarding universities' interactions with industry and local developmental agencies (including the local government), as well as the organizational characteristics that enable these interactions. These three critical domains are: the institutional enablers, the boundary-spanning structures and systems, and the mechanisms and facilitators of partnerships and economic development.

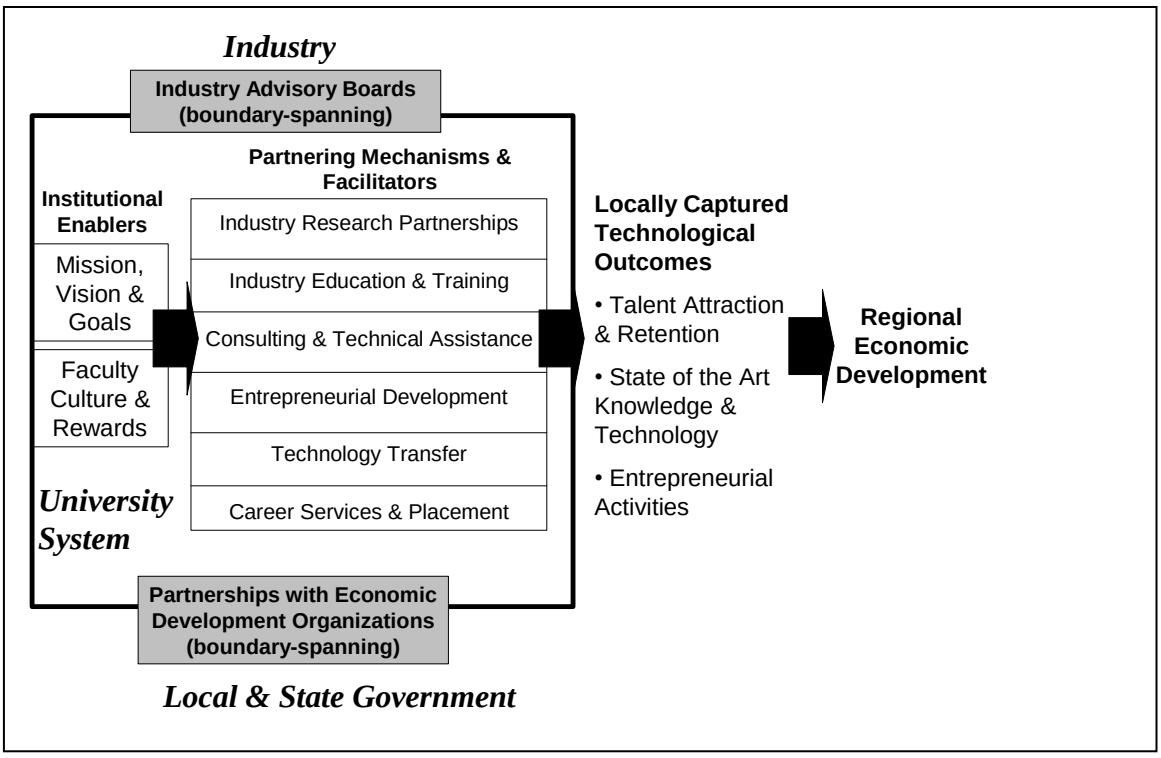
The institutional enablers refer primarily to university culture and reward systems. If a university is engaged with its region, this will be evident in the alignment of its values, beliefs, norms and behaviors towards this goal. The language of the mission, vision, goal statements, press releases and speeches can assess the type of culture. As well, culture must be reflected in rewards systems, which in turn should compensate and promote staff members based on this criterion in order to gain credibility and effectiveness.

Boundary-spanning structures and systems consist of formal partnerships and linkages with economic development organizations as well as industry-university advisory boards and councils. The authors propose that universities engaged with their regions create new structures to advance in this direction by influencing the regional strategy and developmental programs and by facilitating mutual learning among the core institutional spheres.

Finally, the mechanisms and facilitators of partnerships refer to the specific activities by which different departments, units, or individual staff members interact with the local industry. The authors identify six types of partnering activities: (1) industry research partnership, which refers to the co-production of research outcomes, (2) technology transfer, which accounts for firms' utilization of universities' research results including patents, (3) consulting and technical assistance, in which firms' apply knowledge and expertise available at the university, without necessarily implying new discoveries, (4) entrepreneurial development, including activities such as new business incubation, entrepreneurship education, and the organization of venture forums, (5) industry education/training partnerships, which refers to teaching activities oriented directly to the needs of local firms or created in order to increase the availability of human capital within the region, and (6) career services and placement, which focus on staffing solutions for local firms and talent retention at the regional level.

The framework proposes that through these types of interactions and organizational characteristics, universities can better address local industry's needs and improve innovation capacities. These efforts help the region achieve higher levels of talent attraction and retention, cutting-edge knowledge and state of the art technology, as well as growth of entrepreneurial activities. Subsequently, these outcomes can lead to local economic development (see Figure 2).

Figure 2: University roles in the knowledge economy: A framework at the organizational-level



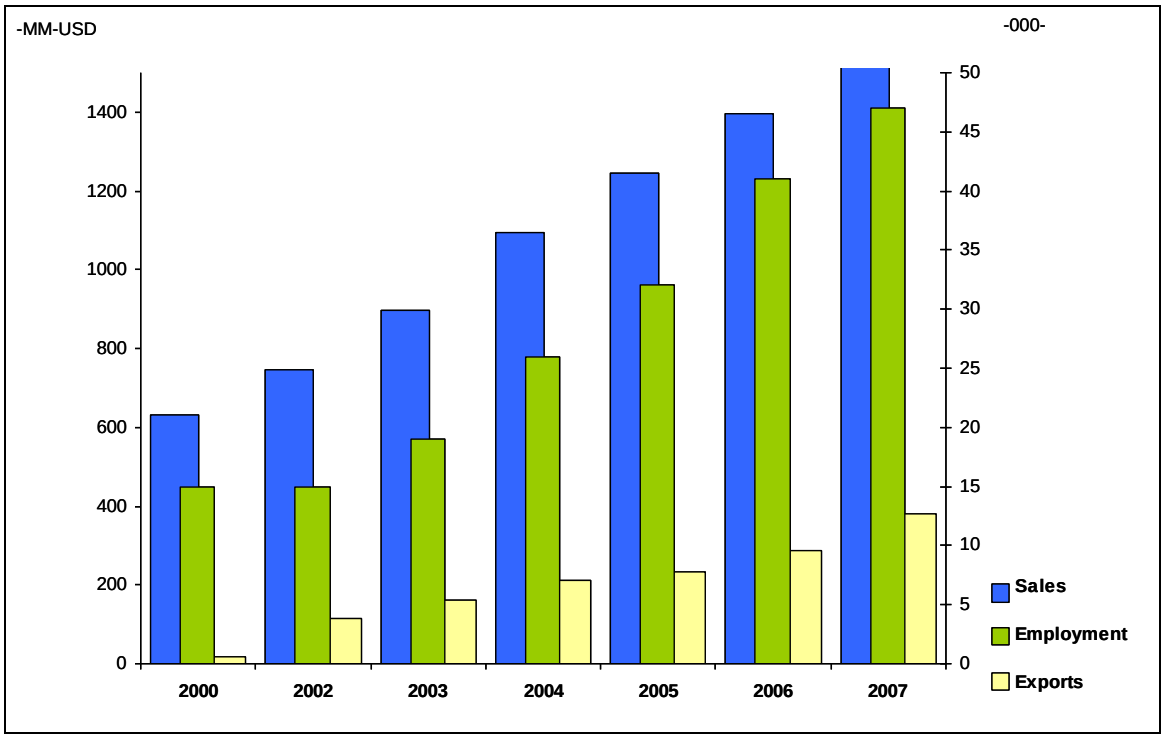
Source: Adapted from Tornatzky, Waugaman & Gray (2002).

The present study builds on these frameworks to analyze the role of UNICEN in the building of local knowledge based capabilities that facilitated the emergence of Tandil software cluster in Argentina. Whereas Tornatzky and colleagues' (2002) framework guides the analysis of UNICEN's organizational characteristics and activities towards the interaction with local firms, Gunasekara's (2006b) framework is used to explore both generative and developmental roles of UNICEN in shaping the regional innovation systems.

The Software Industry in Argentina

The software industry has shown a significant growth in Argentina during recent years, reaching an annual growth rate of 20%, a rate that is expected to be sustained for the next three years (CESSI, 2007; see Figure 3). Total revenues have reached an approximate of U$S 1,500 millions, representing 0.75 % of Argentinean GDP in 2007 (CoFeCyT, 2006), whereas exports have grown at an average of 46% annually since 2001, occupying the world fourth place for years between 1995 and 2004 (OECD, 2006). At the same time, several multinationals have established their subsidiaries in Argentina, including Motorola, IBM, Intel, Accenture, Oracle, Siemmens, EDS, among others (López & Ramos, 2006).

Figure 3: Evolution of Employment, GDP and Exports in Argentine Software Industry



Source: CESSI (2007)

The Argentine software industry is primarily comprised by approximately 1,000 small and medium enterprises (SMEs). With a firm birth rate of 20% per year, software has become the second most dynamic sector of the national economy since 2003 (López & Ramos, 2006). It employs more than 40,000 people, 55% of them in companies with less than 25 employees. The formal employment rate in the sector has grown at an annual average of almost 30% between 2002 and 2006, while the country's rate did it at only 6% (López & Ramos, 2006).

Two key factors explain the recent evolution of the software industry in Argentina. The first factor is the availability of a critical mass of well-qualified human resources. Argentina has a long tradition in educational matters, with prestigious universities and good reputation in hard sciences as well as some advantages in all human capital indexes compared to other nations in the region. The second factor is the relative low costs, compared to other providers of software products and services. During the crisis of 2001-2002, Argentina abandoned the one-to-one parity against the American dollar (USD), devaluating its peso (ARS). The new exchange rate made Argentine software development considerably cheaper for international markets, a reason that also help explain why multinational firms opened subsidiaries in this country. Other factors include the rapid economic recovery after the crisis, the increasing technological demands, the existence of technological infrastructure, and some natural factors like language, time zone, and cultural advantages, which facilitated software exports and multinational operations.

Following the crisis, some governmental agencies started to envision the importance of the software sector for national economic recovery (e.g., in terms of GDP, new qualified jobs, technology adoption for SME, and exports). The three nodes of the triple helix – government, academia and industry – combined to work together on a nation-wide strategic plan trying to generate new policies for the development of the software industry. The main goal is to position Argentina in a prominent player among peripheral (or non-central) countries in the

information technology and software industries (SICPME, 2004). As a result, governmental initiatives in several areas, but particularly education, science and technology started to make clear an active role of the state and federal government in promoting the national innovation system (Yusuf & Stiglitz, 2001). It is worth remarking the cooperative effort among diverse actors with different interests within the industry, considering that innovation systems in most developing countries are characterized by a fragmentation of actors and their linkages (Intarakumnerd, Chairatana & Tangchitpaiboon, 2002).

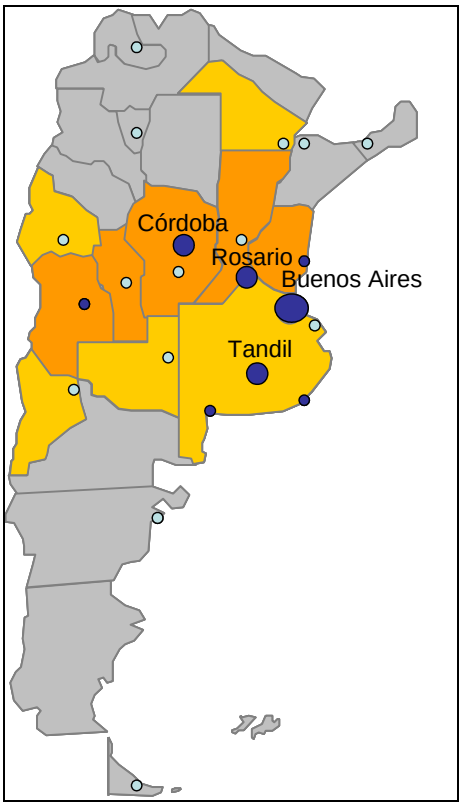
Reaching some basic-level of agreements among government, academia and industry was an initial milestone assuring more coordination in future action nationwide; however, as the strategic plan pointed out, the software sector faces a number of important challenges down the road. One of the challenges consists of the low internal demand of technological solutions. An overwhelming proportion of Argentine SMEs across different sectors have yet not realized the importance of adopting new technology to their operations. Likewise, the government has yet to adopt new information technology to increase transparency of public information and efficient management of public services. In general, software firms cannot count on local demands to foster competitiveness.

Other set of challenges are more closely related to the knowledge intensive nature of the software industry. Among them, a key challenge is the need for more research and development (R&D), given both the infrequent partnerships between firms and the scientific system and the scarce investments in R&D by private firms. This challenge has promoted, among other things, the creation of a nationwide R&D center integrating decentralized competences and capable of functioning as an effective think tank or consultancy agency in areas where the industry has the highest impact (Clarín, 2007). Other initiatives have stimulated industry research partnerships, technology-based entrepreneurship, technology transfer through specific programs funded by the Argentine National Science and Technology Agency (e.g., Fontar, Foncyt and Fonsoft). In general, these programs require some significant level of investment from each of the key actors of the triple helix: government (financial resources), universities (research results), and industry (effective development).

Increasing interests in fostering university-industry partnerships has called the attention to the priorities of publicly-funded research endeavors. National funding agencies have started to look more carefully at the relevance of the research conducted in universities. University-based research teams are expected to interact more frequently with firms in an effort to increase the potential research impact on the regional innovation system. At the same time, software has been defined as the quintessential knowledge-intensive industry, which continuously demands a critical mass of well-trained professionals. In this sense, universities are expected to play an important role attracting and educating talented students.

Talent retention is another important challenge that both the software industry and the regional innovation systems face. Clusters, STPs, and other forms of agglomeration among software firms have been proven crucial for creating “thick labor markets” capable of attracting and retaining large pools of talented workers within a geographical area. In Argentina, software firms historically clustered in Buenos Aires, the largest city of the country that concentrates one third of the population and the bulk of economic activity. However, in recent years, new clusters and STPs have emerged in other cities, being Córdoba, Rosario, and Tandil the most salient (see Figure 4; CESSI, 2007). In some of them, local universities have played a key role by providing highly qualified workers, relevant research, appropriate services and technological infrastructure needed for their initial development. As Schiller (2006) pointed out, in most regional innovation systems of developing countries, universities are the only endogenous knowledge source. Thus, universities have to take wider responsibility for the process of regional economic development.

Figure 4: Location of Software-Based Clusters in Argentina



Source: CESSI (2007)

Argentine software industry's strategic plan reaffirms the need to continue promoting and supporting initiatives towards firm agglomeration in clusters and STPs, which would allow companies to gain competitiveness, articulate production chains and generate value-added and innovation. The plan indicates that STPs are optimal spaces in which industry, government and universities can come together in order to synergize their contributions (López y Ramos, 2006).

The development of the software industry has become a country's strategic priority. In fact, its internal cohesion among diverse actors, levels of agreement, and alignment towards a shared strategic vision has distinguished the sector (compared to other industries in the country). Partnerships between software firms, universities and supporting institutions have given rise to a number of successful experiences that contribute to explain, in part, the recent evolution of the software industry in Argentina. In the following section we examined the emergence of Tandil software cluster as well as the essential role played by its local university, UNICEN, in building the essential knowledge-based infrastructure required for the start-up phase of developing an STP.

UNICEN and the emergence of Tandil software-based STP

The National University of the Center of Buenos Aires Province, popularly known as UNICEN is an established research oriented-university located in the southeast of Buenos Aires province in Argentina, with campuses in the cities of Tandil, Azul and Olavarría. Founded in the sixties and nationalized in 1974, UNICEN can be characterized as a medium-size university in the context of the nationwide university system, with more than 13,000 students and 2,000 faculty and staff members.

There is a strong tradition at UNICEN to conduct research through organized research units, such as centers or institutes. As a result, there are currently more than 30 research units at different developmental stages, including research institutes, research centers and small-groups. Typically, these units concentrated around disciplinary projects (interdisciplinary endeavors are rare, though increasing in number during the last few years). UNICEN is considered one of the nation's premier research universities in the areas of Software, Physics, and Veterinary Science, all of them located in the campus of Tandil. It also has a strong reputation, both at graduate and undergraduate programs in the Schools of Agriculture (Azul campus), Engineering (Olavarría campus), Business and Humanities (Tandil campus). UNICEN's recent initiatives include the Schools of Arts (Tandil campus), Law (Azul campus), Social Science and Medicine (Olavarría campus)

Specifically related to the software industry, the most popular undergraduate degree at UNICEN's Computer Science Department is in the area of Systems Engineering, with a total enrollment of about 1,500 students and an incoming class of about 300 new students each year, on average, over the past ten years. More than a 125 faculty members, with different rank from teaching assistants to full professors, teach in this program. The Department developed its initial research capabilities during the nineties, where UNICEN made substantial investments in areas with weak local research traditions such as computer science, management, social sciences. The goal was to achieve a critical mass of qualified scientists with the training required to perform high quality research. The university created special programs to educate young scientists, often by supporting their graduate education abroad. Once these scientists returned to UNICEN upon achieving their doctoral degrees abroad, research activities started to grow and improve rapidly in the Computer Science Department.

Research activities organized in two major research units: (1) the Computer Engineering Institute, dedicated to data storage and embedded systems, and (2) the Software Engineering Institute, dedicated to software architecture, multi-agent systems, and computational modeling. This latter institute, in particular, was able to achieve high levels of research productivity measured by the traditional standards associated with (quantity and quality of) publications in referred journals, research grants scientists accrued to the institute, number of scientists holding doctoral degrees, and number of scientists holding an affiliation to the major nationwide agency for science. Based on these competences, the Computer Science Department was subsequently able to pass the accreditation standards required for both master and doctoral degrees. It became one of the first Academic Departments to offer advanced graduate degrees in the field of Computer Sciences.

Mission, Vision and Goal Statement

UNICEN has enhanced its national reputation in both teaching and research domains while stepping up its activities in and impacts on regional economic development. Through its focus on research, teaching and community outreach, the university creates, conveys and applies knowledge to expand personal growth and culture, advance social and community development, and foster regional economics competitiveness. Although these goals existed since the founding days, UNICEN increasing commitment to regional socio-economic development became much more convincing in the Strategic Plan of 2002: As a publicly-funded institution, UNICEN has the mission of teaching, researching, and supporting public interest, and moreover, of fostering the economic development of its region of direct influence (i.e., where it is located).

In the aftermath of one of the country's worst economic crisis of 2001-2002, UNICEN initiated a major transformation effort to increase the university's impact on regional economic development. Defying established norms and standards for assessing research productivity,

the Board of Governors at UNICEN called for greater research relevance and challenged the value of research conducted in isolation from broader societal concerns.

UNICEN issued a new set of policies regulating the internal funding allocation among research units as a means of stimulating active involvement in university-industry partnerships. The policies' major goals included: (1) to actively engage in the identification of opportunities with high potential impact on the local community, (2) to promote productive innovation by means of entrepreneurial activities and collaborative partnerships with industrial firms and local organizations, and (3) to stimulate interdisciplinary research required to address complex issues of special interests for the local economy.

At UNICEN, the 2001-2002 national crisis emerged as a recurrent reason for justifying change in the internal policies regulating research funding and scientific activities. In particular, results of a content analysis revealed the crisis was cited in 95 percent of the cases where Board members expressed a rationale for change, though it was often accompanied by other reasons of strategic, academic, political, or administrative nature. The crisis was also cited as a reason for change in multiple internal reports prepared by UNICEN executives. Here is an example:

> In times of crisis, there is a need for new incentive systems so that the knowledge generated and available within the university can more readily have an impact on region's welfare. To date, scientists' performance appraisals have focused only on number of publications in referred journals… Other indicators assessing the extent of technology development and transfer, outreach programs, productive innovation should also be taken into account. Universities have to redefine their mission and goals in the context of their regions… Accreditation standards and external evaluations have to consider university's impact on its region (Internal Report on the Incentive System, Associate Dean of Science and Technology, September 2003).

During the last few years, UNICEN has notably increased its commitment to regional economic development by stimulating a variety of outreach programs and university-industry partnerships – in addition to enhancing both its educational and research performance. Although the transformation efforts have not yet been worked out completely, initial results suggest that the case offers a remarkable example of how cultural and structural change can be instrumental to accommodate the new priority of increasing the university's impact on regional economic development.

One of UNICEN major initiatives was the initial development of a local STP, launched in December of 2003 to consolidate university-industry partnerships in the area of software. Ten SMEs software firms joined the university with the goal of promoting innovation, technology transfer and knowledge-based entrepreneurship in association with the university. In particular, UNICEN committed: (1) to generate conditions conducive to the creation of new ventures (spin-offs and start-ups) and the attraction of knowledge-intensive organizations to the region, and (2) to facilitate the process of knowledge sharing and technology transfer between university and industry. Since then, the university has started to put in place new infrastructure, facilities and services (on- and off-campus) required to foster synergies and productive interaction with the associated software firms. In this process, UNICEN employs an array of partnering mechanisms and facilitators:

Industry research partnerships

UNICEN external sources of research funding have grown up to 30% of the total resources and funding it annually receives from the federal government. This percentage, that situates the

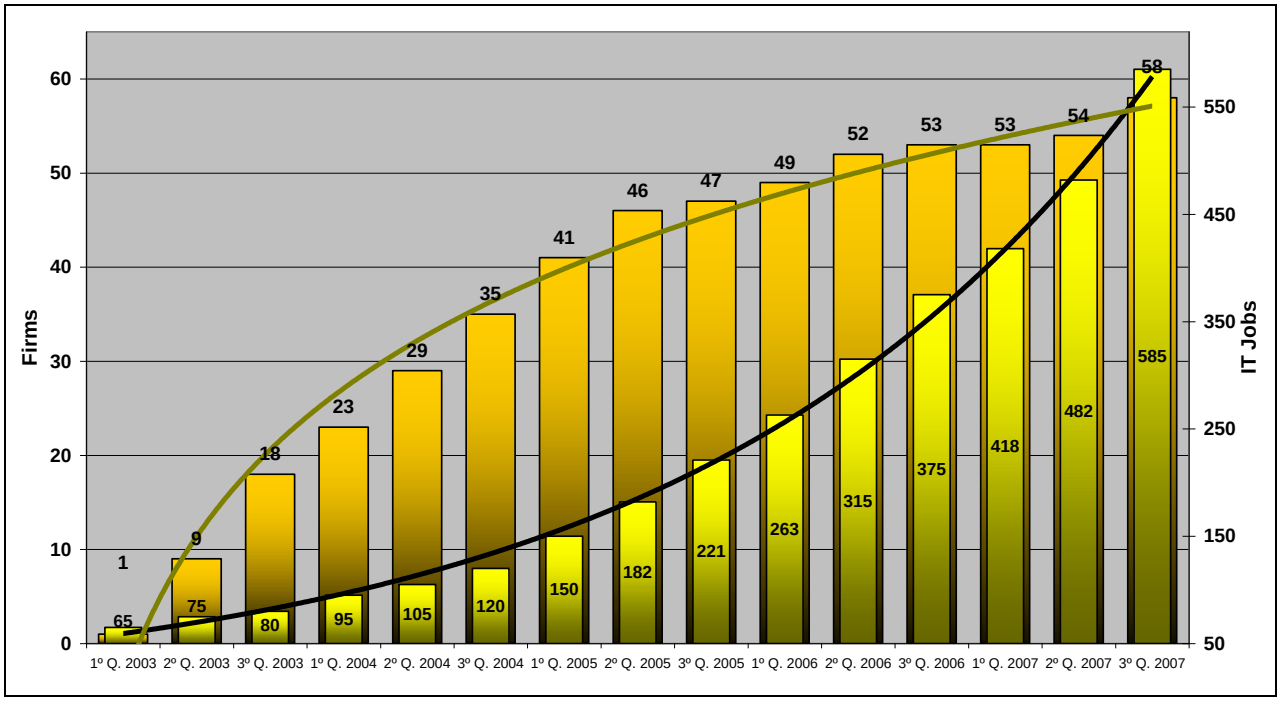
university well above the national average, includes both agency-based and industry-sponsored research funding. A number of factors appear to have contributed to UNICEN increasing performance in university-industry partnerships. First, UNICEN, particularly at Tandil campus, has historically emphasized programs that appeal to national industry, such as veterinary science for the animal production sector, physics for the metallurgical industry, computer science for the emerging software industry, and business with high potential impact across economic sectors.

Second, the fact that UNICEN has provided space, infrastructure and services for technological and innovative firms at early stages of development makes it easier for firms to quickly become research partners of the university and its research institutes. STPs and clustered organizing in areas contiguous to the campus encourage permanent and ongoing relationships between faculty researchers and firm's managers and technical staff.

Likewise, prior knowledge from the classroom in formal educational programs or in-company training provides firms with an enhanced understanding of the university logic (and vice versa). In turn, this prior knowledge allows both parties to anticipate the potential benefits of entering a new industry research partnership.

Regarding the software industry in particular, more than 55 SMEs have associated with the software-based STP and 35 of them have established software factories or project groups in the region, creating more than 600 qualified jobs in the region in the past five years (see Figure 5). Until now, no more than 20 firms have engaged actively in an industry research partnership, however, given the increasing dynamic of the software sector, the number of partnerships is expected to increase in the near future. In addition, UNICEN and local software firms have taken advantages of new federal programs aimed at stimulating industry active engagement in research partnerships (e.g., PAE-Foncyt).

Figure 5: Firm settlement and new job creation in Tandil software-based cluster (2003-2007).



Industry education and training

At UNICEN, most formal educational programs at both the undergraduate and graduate level have been designed with a professional orientation to meet the needs of the industry. In the last five years, however the most important innovation has been the emergence of executive and other in-company training programs. For the most part, these programs are designed to broaden the perspective of local firms' top management teams and technical staff. Members from almost all of the local companies established in Tandil have participated in a wide variety of programs addressing topics such as, quality assurance, project-based management, leadership, information technology, human resource management, and so on. The programs are typically organized by the university but run by a combination of tenure-track faculty and non-faculty instructional staff. As new firms establish and the cluster sustains its growth and development, there is an increasing demand of both formal education (particularly, MBAs and IT Master's degrees) and executive programs.

Consulting and technical assistance

UNICEN does not have a permanent or formal extension service in the area of software (though it does have extension services in other areas, such as advanced materials and business). However, many faculty members in the Computer Science Department are heavily involved in providing technical assistance and consulting services on an ad hoc basis. The university offers the possibility to formalize the assistance, but it does not enforce the process (faculty members can articulate it as a personal professional service). Consulting and technical assistances have grown considerably in recent years as new software firms established in the cluster. In most cases, consulting and technical activities emerge as a by-product or a continuation of industrial research partnerships. Once the term of the research contract comes to an end, researchers who participated in a successful project often continue their involvement with the firm on the basis of an open-ended consulting or technical assistance agreement.

Entrepreneurial development

UNICEN increasing emphasis on productive innovation has created a fertile terrain for entrepreneurial activity among different actors of the university environment (faculty members, technical staff members, advanced students, and alumni who remain connected to the university system). Moreover, the Federal Government has designed and implemented several programs promoting technology-based entrepreneurship and stimulating scientists to commercially pursue new venture creation. Although traditional academic standards remain high (particularly in more advanced schools or departments, such as Physics, Veterinary Science and Computer Science), new university policies and programs have embraced the idea of supporting faculty members in their entrepreneurial endeavors.

Five new software projects led by faculty members and technical staff received formal support at UNICEN in the last three years. The type of support can take many forms, including additional funding for prototype development, support for preparing the business plan, paid leave of absence to pursue entrepreneurial projects, specific assistance during investment rounds, networking with both local business angels and institutional investors. Finally, it is worth noting that entrepreneurship does not result solely from university spin-offs, but also from the dynamic interactions among members of the established software firms.

Technology transfer

Argentina and its university system lack a strong tradition in terms of licensing, patents and intellectual property, which is one of the major weaknesses in entering university-industry linkages. Specific agreements regarding intellectual property are negotiated on a case-by-case basis. University lawyers assist faculty members and interested parties during the process. The flow of knowledge, however, is much broader than what can be captured through the technology transfer procedures. For instance, more than 60% of the software firms established in Tandil since the creation of the STP can trace their origins back to the work or efforts of UNICEN faculty, students, or alumni. The vast majority of these companies were started after the crisis of 2001 and 2002. Since 2007, UNICEN has started to develop new competences in this area with the goal of creating a formal Technology Transfer Office capable of assisting in the creation of university-based spin-offs and in the protection of the intellectual property developed within the university.

Career services and placement

Based upon its nationwide reputation, UNICEN used to attract employers from all over the country (including SMEs and multinationals) to recruit UNICEN new graduates. In the last few years, however, the university has taken a number of initiatives to help meet the staffing needs of local and regional employers. This is particularly true in the case of software, and more consistent with its current focus on regional economic development. The software-based STP runs its own Career Center which offers differentiated services to software firms associated with the cluster. These services include candidate referral services and pre-screening, job-listing services, on-campus interviews, institutional presentations, internship agreements, performance appraisals, reports about the state of the local and national labor market. The Career Center hosts a number of events annually, such as job and career fairs, seminars with invited speakers, social hours, and other events that serve to the purpose of connecting potential employers and students. Through the Career Center webpage students can submit their resumes and employers can submit their requests. All services are oriented to make the resume search and the selection processes much more effective for both firms

and candidates. Although educational programs do not require students to complete an internship, all the students who actively sought an intern position in the software industry using the Center's services during 2007 received at least one competitive offer within the first month of initiating the search.

Formal partnerships with economic development organizations

Following Tornatzky and colleagues' framework, it is also important to assess whether the university is embedded in its region via boundary-spanning structures, formal partnerships, and linkages with economic development organizations. Over the past few years, UNICEN has increased its level of institutional embeddedness at all levels: national, provincial and local spheres. For instance, UNICEN sponsored the creation of the University-Industry Foundation, which offers the grounds for the associative governance structure of Tandil software-based STP, promoting cooperative action for the benefit of the cluster and each of the associated firms. At the local level, it has also form alliances with the municipal government, local chambers and councils, and non-for-profit organizations promoting socio-economic development. At the state and national levels, UNICEN has permanent representations at the core federal or provincial committees in the areas of education, science, technology and productive innovation. It has also formed networking alliances with key actors in the software industry including the national chamber as well as technology-based clusters emerging in other regions of this country. Finally, the university is well-connected internationally via cooperative agreements with different research centers and universities all around the world as well as with international associations in the area of regional economic development (e.g., IASP-LA).

Generative and Developmental Roles

As Gunasekara (2006b) suggests, UNICEN seems to perform both roles, generative and developmental, in shaping Tandil regional innovation system. In the early stages of the Software STP, the university adopted a generative role, manifested in its actions as main champion of the initiative. These include the clustering of firms, human capital formation and the provision of the associative governance structure. In this first stage, UNICEN was the responsible for giving birth to the cluster and establishing the guidelines for future interaction among actors involved.

More recently, as the cluster evolved and other key actors (firms and local government) became more actively engaged with STP development. This led UNICEN to prioritize a developmental role to accompany more mature stages of clustering of firms and associative governance structure. This meant concentration on human capital retention, shaping of shared norms with other key actors and regional learning. Actually, the university does not institutionalize actions by its own, but gives support and promotes optimal conditions for the ongoing development of the STP.

Conclusion

The study calls on the important role that leading universities play in the creation of the local knowledge-based capabilities for the start-up phase of developing an STP in the context of emerging countries. In these contexts, universities emerge as the main endogenous knowledge source, which gives them greater responsibility for the process of economic development. In a practical level, UNICEN case presents a wide array of actions and organizational characteristics that universities can perform to effectively encourage knowledge creation and firm formation in their regions. In a theoretical dimension, the

review and results suggest that the generative and developmental roles of universities seem to interplay in order to be effective in the support of regional economic development. Both roles are complementary. The generative role integrates knowledge capitalization activities through firm formation, spin offs and industry research partnerships. The developmental role focalizes on the creation of optimum conditions for this to happen, through pertinent teaching, research and graduate retention. Future studies can build on these results to analyze universities' contributions in other developing countries and sectors of the economy.

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