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Latin American Universities and the Third Mission

Trends, Challenges and Policy Options[1]

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1 Introduction

Rising demand for knowledge and highly skilled labor has changed the role of universities in Latin America. Universities are increasingly considered instruments of social and economic development and face rising expectations in terms of training qualified 'knowledge workers', creating insights of direct relevance to society, and engaging in commercial activity. The new role of universities as entrepreneurs and contributors to social and economic development has been characterized as a *third mission*. This role comes in addition to the traditional functions of universities as institutions of advanced education and research.

Firms both in developed and developing countries have only imperfect knowledge of relevant technological options, and research demonstrates that they generally look for new solutions around their existing competencies (Fagerberg and Godinho 2005). In less advanced economies, the circle of competencies is likely to be further from the knowledge frontier, and therefore the pool of considered options may be limited. Moreover, the possibility of introducing new products and processes depends on research and development (R&D) capabilities and skills that are often not there. Therefore, in order to avoid being trapped on an inferior development path, low- and middle-income countries are in particular need of 'institutional instruments' that enhance access to cutting-edge technologies, supply needed skills, services and other inputs, and strengthen local innovation networks. Universities are well positioned to meet this challenge to the extent they are at the technology frontier and are responsive to the needs of firms.

Universities make up a prominent part of all national innovation systems. In Latin America this is particularly the case as universities are the primary employers of researchers and receive the bulk of public subsides for research. In countries such as Argentina, Brazil, Colombia and Mexico more than 60 percent of all researchers are employed by universities. Due to lack of tradition and incentives, universities in Latin America have unrealized potential for putting this research capacity to productive use. The importance of university education and research is particularly prominent in technology-based industries. However, due to skill-based technology change universities are becoming increasingly important also to other industries, traditionally not considered as knowledge-intensive.

This paper discusses trends and challenges within Latin American universities, as well as policy options available for strengthening their contributions to social and economic development. It is not intended to provide an exhaustive analysis, but focuses on some of the key issues confronting universities in the region. The third mission of universities is often equated with knowledge transfer narrowly defined as licensing and commercialization of research. This paper adopts a broader approach and explores how the new role of universities affects all aspects of academic practice in Latin America, including advanced education and research. The paper begins with a discussion of how universities contribute to national innovation systems. Section 2 overviews the production of advanced human capital in Latin America and its relation to industrial needs. The quality and relevance of academic research is the focus of Section 3. Section 4 addresses mechanisms for the transfer and diffusion of new knowledge. Section 5 discusses the challenges that commercial activity places on university governance structures and management and Section 6 concludes.

1.1 From the 'ivory tower' to the 'triple helix'

The role of universities in economic development has been on the policy agenda for decades. In the post-World War II United States, a seminal report *Science – Endless Frontier* (1945) shaped modern US science policy and had a strong influence around the world. The report emphasized that innovation starts with fundamental research, which through applied research and experimental work develops into product design and marketing. Such model determines that universities and industry have independent, but complementary tasks. Universities produce fundamental research and industry uses the results for practical application and product development. This model also prescribes appropriate government support. Due to market failure, basic research is underprovided in the market. Research results are non-rivalry – the number of users does not increase the price and therefore wide dissemination is socially beneficial. It may also be non-excludable, which causes a free-rider problem. Most importantly, the practical value of fundamental research is unpredictable and return on investments often has a considerable time lag. All this makes basic research an unattractive investment option for private companies.

The linear model from basic research to a new process or marketable product does not adequately reflect contemporary innovation processes. Research is not only a foundation for technological application, but is informed and inspired by it. Much scientific advancement has been driven by a strong interest in practical solutions. New technologies and interaction between different fields of knowledge have also led to the development of entirely new academic disciplines – such as computer science and biotechnology. Strong linkages between industry and science are therefore beneficial both in terms of the relevance of science and technological advancement in productive sectors.

A rise in applied research in fields such as agricultural research, materials science, and medical research has stimulated interaction between universities and industry. Especially in OECD countries, the contribution of universities has developed well beyond applied and contract research. Universities and industry are not only in close interaction, but their borders, roles and division of tasks have become increasingly blurred. Universities establish spin-off companies and collaborate in research parks; they create technology transfer offices in order to actively seek knowledge diffusion and business opportunities; and they work as equal partners in the incubation of new technology-based businesses. Hence, the relationship between three main partners – university, industry and government – is marked by close multidirectional interaction and overlapping roles, as prominently symbolized by the triple helix model (Etzkowitz and Leydesdorff 1997).

1.2 Universities and natural resource based economies

The importance of research and advanced human capital is usually discussed in the context of highly innovative sectors, and studies often demonstrate that university-industry cooperation is particularly prominent in knowledge-intensive industries (e.g. Meyer-Krahmer and Schmoch 1998). However, this should not divert attention from economies heavily reliant on the export of natural resources, Latin America included. Due to skill-based technology change universities are becoming increasingly important also for industries that typically are not considered research-intensive (Tunzelmann and Acha 2005).

Evidence suggests that science and technology policy can be effectively used to add value to traditional production. There may be high returns to upgrading strong, existing industries by adding value to existing processes and products. In Latin America perceived superiority of

manufacturing compared to natural resources-based activities has constrained countries from realizing the full potential of their natural advantages. As demonstrated by De Ferranti et al. (2002), natural resource-based activities in the region can be converted into knowledge-based industries and lead growth for long periods of time.

Even if economies see their challenge not in creating new technology, but transferring and adopting existing technologies, they cannot afford not to develop a domestic R&D capacity. Sufficient capacity is necessary to identify scientific and technological options, to adapt existing technologies to local needs, and to create technologies that are unique to the country (Fagerberg and Verspagen 2002). As suppliers of advanced education and dominant players in research, universities in Latin American play a central role in developing such a capacity.

1.3 University-industry linkages in Latin America

Data from recent innovation surveys conducted in Argentina, Chile, Colombia and Mexico suggest that considerable benefits can be accrued from increased university-industry collaboration. An analysis of firm-level data from Chile finds that collaboration with universities increases the propensity of a private enterprise being involved in patenting by 35 percent, keeping all other explanatory variables in the model constant. Collaboration also increases the likelihood of company involvement in product innovation, whereas the analysis finds no significant effect on process innovation (Table 1).

Table 1. Marginal effect of company characteristics on innovation

	Patents	Product innovation	Process innovation
Firm Characteristics			
Export active	**0.34	0.21	0.08
Firm age (ln age)	0.02	0.00	0.02
Firm size (ln size)	0.07	0.10	0.01
Collaboration with			
Universities	**0.35	**0.30	**0.20**
Consultants	-0.02	0.12	0.16
Suppliers	**0.09	**0.32	**0.35
Other firms	0.01	-0.02	0.06
Absorptive capacity			
Internal R&D department	**0.06	**0.19	0.12
Human capital			
Innovation related training	**0.09	**0.27	**0.23
Observations	4,570	4,570	4,570
Pseudo-R-square	0.22	0.30	0.37

Note: ** Significant at 5% level. The three models are based on probit estimation of binary dependent variables. No sample selection bias is found using Heckman's two-stage method. The table is an extraction from the full models counting 25 explanatory variables including controls for economic sectors.
Source: Mark et al. 2006

Despite potentially significant returns from collaboration, evidence suggests that linkages between universities and private companies are quite weak in Latin America. One of the reasons is low regard among entrepreneurs in the region for the quality of university education and research and lack of capacity among private companies to absorb knowledge. Yearly competitiveness surveys conducted by the International Institute for Management Development consistency show that universities in the region are perceived not to be sufficiently responsive to the needs of industry, emphasizing academics over commercial applications in their research orientation (IMD 2005).

A low level of university-industry collaboration is also evident in firm-level innovation surveys. Universities and public research institutes are among the least employed counterparts for private companies when it comes to innovation projects in Latin America. In Mexico, only 6 percent of

surveyed companies had established cooperation agreements with universities and about 5 percent had done so with public research institutes (Melo 2001). Similarly, an Argentine innovation survey from 2002 shows that the most important external partners for firms involved in R&D are suppliers, clients and consultancies. Universities and training institutions, public and private laboratories, technology transfer offices (TTOs), and government S&T promoting agencies are much less the partner of choice for private innovators (SECyT 2003).

In addition to real or perceived low relevance of academic research, cooperation is hampered by lack of incentives for public researchers to address private sector knowledge needs. Experience from Latin America suggests that the inward orientation of academia is reinforced by hiring and promotion rules, which put extensive stress on academic publications (Lundvall 2002). Reward structures in the region generally do not recognize the value of non-academic collaboration, and faculty who take part in industry-sponsored projects risks weakening their academic career prospects. Moreover, bureaucratic rigidities make inter-sectoral mobility and public-private partnerships cumbersome and costly.

Experience from the OECD shows that knowledge and technology transfer is often driven by personal entrepreneurship and initiative (BHEF 2001). Hence, strengthening university-industry linkages in Latin America hinges to a large degree on the ability of policy makers and university leaders to make it more attractive for individual faculty members to engage in outreach activities and partnerships with industry. One of the most important challenges in this regard is to update hiring, promotion and reward structures to fully recognize factors such as participation in public-private research projects and effectiveness in attracting external funding.

1.4 Tension in university—industry relationship

Interaction between universities and industry raises the concern to what extent such activities are consistent with the public service function of universities. Universities and industry have fundamentally different missions, values, and cultures, and face different financial and temporal constraints. In academia, open scrutiny of research results, techniques and methodologies by peers is considered a critical element in upholding high quality standards. Moreover, university researchers generally engage in long-term research projects and are expected to push the knowledge frontier forward by making results publicly available. Firms, on the other hand, tend to focus on short-term, specific research activities and have an interest in concealing new knowledge from potential competitors at least until the research is evaluated and a patent application has been filed (Dasgupta and David 1987).

For university leaders in Latin America conflicts of interest are a legitimate concern. While universities can obtain external financial support and broaden the experience of students and faculty by working with the productive sector, they must also guard against devolving into contract research organizations indebted to their sponsors. Nonetheless, evidence suggests that the concern at this point is too little collaboration rather than too much. The majority of universities in Latin America are still in the early phases of opening up to partnering with private businesses. As will be discussed in section 4.2.5 it is important to develop clear internal regulation in this process to protect the ability of universities to produce unbiased knowledge in the public interest.

2 Advanced education

The production of highly skilled human capital is undoubtedly the main contribution universities make to national innovation systems. Efforts to upgrade the technological infrastructure and

stimulate innovation are unlikely to yield a high return if not complemented with a sufficient stock of advanced human capital (De Ferranti et al. 2003). Therefore, educational systems need to be of high quality and ensure that graduates have skills relevant to the labor market.

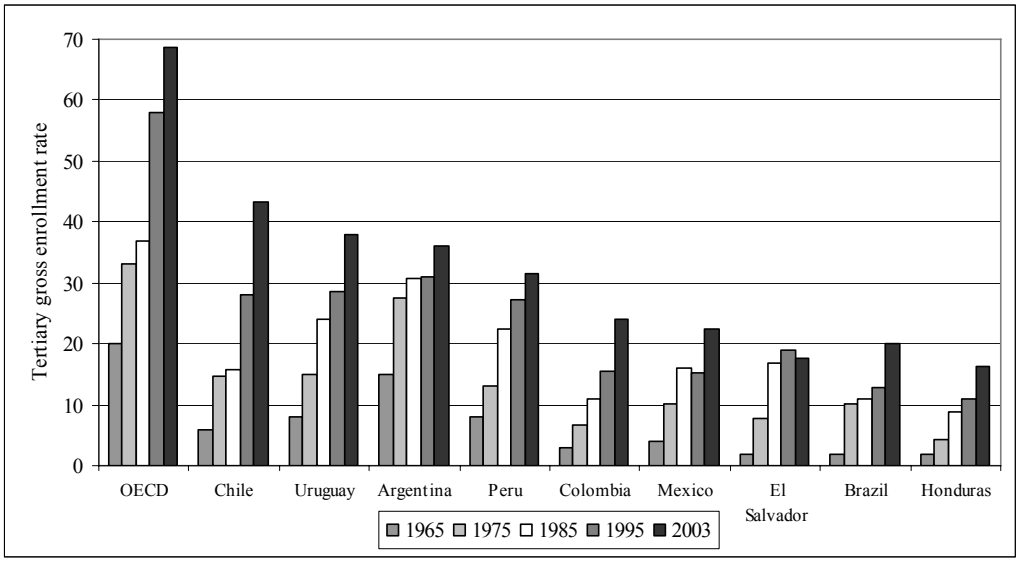
Human capital formation may be a strategic priority even before a country faces unmet demand from industry. Evidence suggests that technologies not only increase demand for skills, but new technologies are adopted more extensively in organizations with a high share of skilled workers (Doms et al. 1997). Large increases in the supply of workers with university training in the 1970s contributed to the rapid technological change of the time and accelerated the demand for skills (Acemoglu 1998). South Korea, for example, started to expand higher education significantly in 1960s, which not only enabled but also contributed to the rapid progress in later years (World Bank 1999).

2.1 University education in Latin America

Evidence suggests that jobs presupposing university education have grown faster than jobs requiring lower skill levels in Latin America. Moreover, new technologies have increased the relative productivity of educated workers in the region. As a result, the relative wages of workers with higher education are on the rise everywhere in Latin America. In Argentina, for example, returns to university education rose 50 percent between 1992 and 2002, while returns to primary and secondary education remained largely unchanged (Patrinos and Vegas 2005).

Countries in Latin America have responded to increased demand for advanced skills by expanding and diversifying the supply of university education. In 2001, 23 percent of Latin Americans 18-24 were enrolled in postsecondary institutions. This represents an annual growth rate in enrollment of more than 2 percent since 1985. Uruguay, Argentina and Peru and notably Chile are among the regional leaders, with enrollment rates of more than 30 percent. Despite impressive growth, however, Latin America still lags behind leading economies. Among the OECD countries the average higher education enrollment rate is currently 69 percent (Figure 1).

Figure 1. Gross higher education enrollment in Latin America and the OECD, 1965-2003

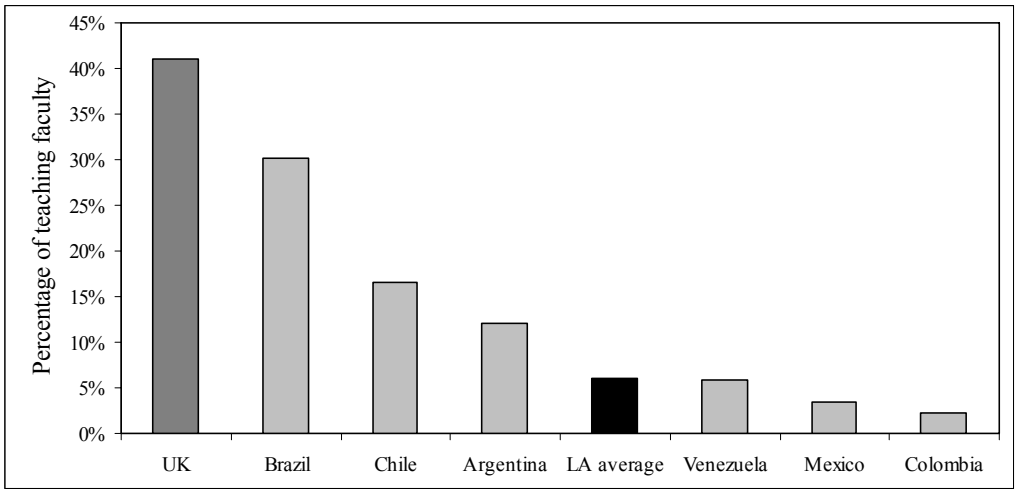


Source: World Bank (2006) and for Argentina: INDEC (2003) and SPU (2003)

It is not only the quantity of skilled labor that is important for a well-functioning innovation system. Education has to be relevant for industrial needs and provide skills that enhance technological change. Evidence suggests that employers increasingly value higher order skills such as finding, analyzing, and applying knowledge, instead of passive subject knowledge (World Bank 2002a). Therefore the development of new pedagogical approaches such as problem-based learning and reflective practice are becoming increasingly important.

Rapid expansion and diversification of the higher education sector has caused significant variation in the quality of higher education services in the region. Many universities struggle with outdated teaching materials and lack of laboratory equipment. In the hard sciences it is often difficult for students to engage in experiments and practice in real-life circumstances. The ability of universities to supply society with high quality advanced education is also challenged by low qualifications of university teaching staff in Latin America. Only a small proportion of academic staff in the region holds doctoral degrees and is actively involved in research. For example, less than 4 percent of faculty in Mexico and Colombia has a PhD degree. The only exception to the generally low level in the region is Brazil, where 30 percent of the staff in federal universities has doctoral level qualifications (Figure 2).

Figure 2. Proportion of professors with doctoral degrees, 2001



Source: World Bank (2002b)

While coverage has increased in undergraduate university education, expansion of graduate education has been less pronounced in Latin America. Master and Doctoral level programs constitute roughly 3 percent of tertiary enrollment in the region (Holm-Nielsen et al. 2005). As a consequence, the number of completed PhD degrees is quite small in Latin America and the number is only slowly increasing (RICyT 2006). This challenge is also reflected in relatively low stock of researchers. Brazil – a regional leader in science & technology – has about one full-time equivalent researcher per thousand people in the work force which should be compared to 6 and 7 in Spain and the Republic of Korea, respectively (RICyT 2006). The low number of researchers has negative implications for the region's ability to build critical mass, provide advanced skills to knowledge-intensive companies, and provide training for the next generation of researchers.

2.2 Policies promoting educational productivity

2.2.1 Responding to labor market needs

Discrepancy between the qualifications of tertiary graduates and productive needs arise in part from insufficient information about shortages and opportunities in the labor market. Most countries in Latin America do not collect data on labor market outcomes on a systematic basis. A promising exception is Colombia where the Ministry of Education has established a labor market observatory to monitor and analyze the professional performance of university graduates. Accurate data about skill shortages and labor market outcomes of university graduates provides invaluable input for the future planning of curricula and course offerings.

Greater interaction between universities and companies is vital to ensuring a better match between educational output and the need for human resources in the economy. OECD countries in particular have begun to collaborate with employers when designing curricula and defining skills. Although still on a small scale, several countries in Latin America are also introducing competency-based curricula in tertiary education with clarity on the skills that students are expected to acquire. In the Tuning Latin America project, for example, 120 universities from across the region collaborate in defining competencies for eight fields in partnership with employers.

The interaction between industry and education can also take a more immediate form. Student internships in companies and involvement of practitioners in teaching are especially relevant in vocational tertiary education, but can also be used in many professional fields. In addition to training students to be employees, universities may prepare them to generate employment. A number of universities in Latin American have included courses in entrepreneurship in the curriculum. For example, engineering students at the Catholic University of Rio de Janeiro in Brazil are required to complete training in entrepreneurship and business management (Etzkowitz et al. 2005).

2.2.2 Quality enhancement

Ensuring high academic quality in advanced education is another challenge faced by countries in Latin America. Quality became a public issue in the region especially in the context of rapid expansion of the private higher education sector. As a response, governments give high priority to establishing or strengthening accreditation and evaluation procedures. In recent years, accreditation agencies for undergraduate programs have been created in Argentina, Belize, Bolivia, Chile, Colombia, Costa Rica, El Salvador, Mexico, and Nicaragua (Hom-Nielsen et al. 2005). Methods used for quality evaluation vary among countries but generally include a combination of self-evaluation, external peer review, quantitative performance indicators, and student assessment. The first generation of quality assurance was heavily focused on inputs and process aspects of education. Over time, quality assurance has evolved to place increased emphasis on learning outcomes and acquired competencies.

Many Latin American countries have started to address deficiencies in teaching quality by experimenting with new funding instruments. Argentina and Chile, for example, have used competitive funding to encourage quality improvements in higher education programs by supporting projects developed and proposed by universities. This approach has been most effective when linked to quality assurance. Program and institutional accreditation allow institutions to identify weaknesses and appropriate remedies. Funding for quality improvement, in turn, provides the means by which corrective action can be taken. Hence, the combination of the two instruments ensures that funding targets key weaknesses and that quality assurance becomes

a meaningful exercise with a direct operational impact. Quality can also be stimulated by rewarding performance and increasing accountability at the teacher level. For example, teaching awards have been established in a number of countries, aiming to increase visibility of good practices and encourage excellence in teaching. Regardless of the controversies, course evaluations by students are also becoming a more common practice.

2.2.3 Strengthening doctoral and professional education

Graduate education remains underdeveloped in Latin America. Most countries do not produce enough PhDs to fill the vacancies at tertiary institutions created by retiring professors let alone build a knowledge base in industry and public research institutions. With more than 8,000 doctoral graduates per year, Brazil is the best example of a successful attempt to strengthen graduate education in the region. This achievement rests on the combined and long-term support from the Ministry of Education, Ministry of Science and Technology and State institutions. Moreover, support from the federal agency CAPES has allowed graduate programs to recruit PhD holders educated abroad as faculty members (Schwartzman 2002).

Chile provides another interesting case of how expansion of graduate education is feasible within a short period of time. Since 1999, Chile has made targeted investments in the learning infrastructure for existing and new doctoral programs coupled with efforts to strengthen student demand by making PhD scholarships available to talented students. Moreover, cross-institutional networks have been supported to mitigate some of the disadvantages of low numbers and geographical dispersion. Although Chile still has a low production of doctorates, the results achieved in recent years are impressive. Between 1999 and 2004, the number of PhD graduates increased from 75 to 244 students (Thorn 2005a).

The link between graduate education and industry is at the center of efforts to strengthen national innovation systems in Latin America. Graduate education in the region is often plagued with lack of incentives and tradition for pursuing collaboration with industry and a career outside academia. Interaction with industry promises to promote industrially relevant research, improve students' competencies, and create relationships that continue after graduation. A number of initiatives have been taken in the region to bring private companies and PhD students together. One option is to provide incentives students to undertake their thesis work in collaboration with industry. Chile, for example, is developing a program where a proportion of doctoral students are assigned a thesis advisor in both academic and a private company. The objective is to strengthen applied research and encourage mobility of advanced human capital between sectors.

3 Academic research and innovation

Academic excellence is a critical factor for knowledge production, commercialization and university-industry linkages. Low quality research does not serve students, private companies or the country at large. Preliminary data from Chile suggest that academic quality is in fact a good predictor for the ability of universities to commercialize research. Universities with better qualified staff and higher publication rates are more likely to produce patents and be involved in university-industry research partnerships (Kawax 2006).

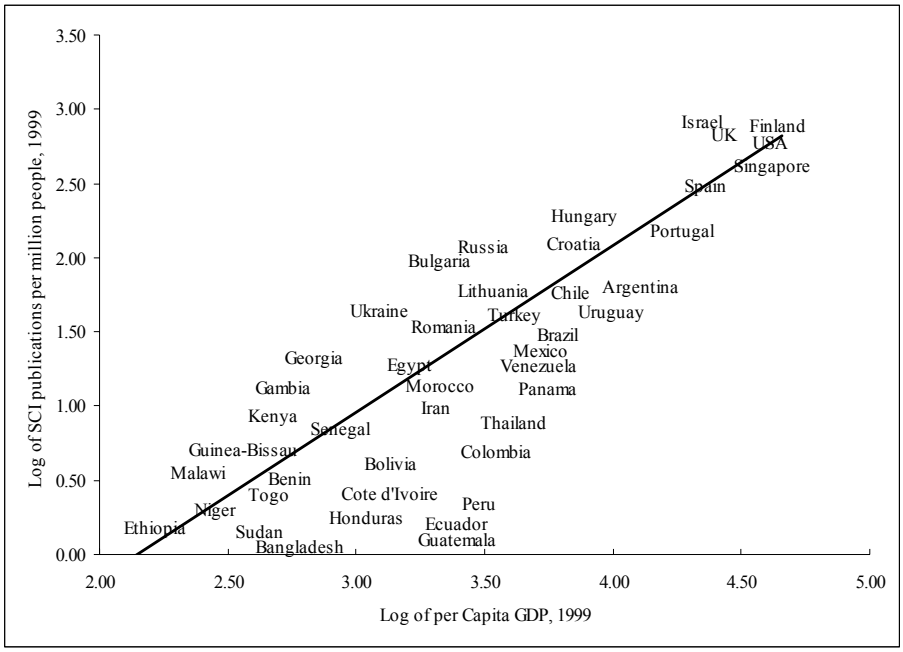
Academic research is expensive, and increasingly so. Even leading research countries have seen the need to prioritize fields, acknowledging that it is not feasible to achieve excellence in all areas of science (e.g. NAS 1995). Such prioritizations generally direct resources to fields with high economic potential where the necessary research infrastructure and human resources exist. When allocating resources there is a need to maintain a balance between fundamental and applied

research in universities in a way that builds intellectual capability and encourages long-term and high-risk research projects. The comparative advantage of universities vis-à-vis industry is clearly their solid academic competence. Hence, the importance of high quality research in universities should not be underestimated even if the link between academic research and industrial application is often ambiguous.

3.1 Academic research in Latin America

The quality of research in Latin American universities is not uniformly good, particularly considering the funds allocated them (Holm-Nielsen and Agapitova 2002; Lundvall 2000). Figure 3 shows scientific publications relative to the level of income for a sample of 123 countries. The estimated trend line reflects the expected log of ISI publications per million people when a linear regression is performed on the log of per capita GDP. The data indicate that all countries in Latin America publish below what is expected based on their level of income. Researchers in countries such as Argentina, Brazil and Mexico produce on average an international peer-reviewed article only every five years. Moreover, the quality of research, as indicated by the citation impact factor is low in the region. Articles published by researchers in Argentina, Brazil and Mexico are cited roughly 1.3 times, which should be compared to 2.7 and 2.0 times for articles published by their colleagues in Finland and Spain, respectively (Thorn 2005b).

Figure 3. Publications per million people relative to GDP per capita, 1999



Note: Some country names have been omitted to make the graph more legible
Source: Thorn 2005b

Research production and quality is dependent on various factors. As noted earlier, the insufficient qualifications of academic research staff is an issue facing most countries in Latin America. University professors often see their main role in instruction rather than research, which is the heritage from the old university model in Latin America where universities were primarily teaching institutions. A low emphasis on research is particularly evident in private universities, which generally have a high proportion of part-time staff and tends to be specialized in less research-intensive fields. Moreover, major universities enjoy great independence of public oversight and maintain incentive structures that do not reward excellence. Despite these challenges, there are pockets of quality research in Latin America, even if the average level does

not compare well with high-income countries (Cetto and Vessuri 1998). Argentina, for example, features several Nobel prizewinners.

3.2 Policies promoting research quality and productivity

3.2.1 Incentive mechanisms

Direct subsides for university research can be used by governments to provide incentives for quality research and to shape cooperation between researchers and industry. The traditional system of research funding in Latin America is in the form of annual institutional grants, negotiated on the basis of the previous year's allocation. The problem with the traditional system is twofold: first, the system is not based on research output and therefore does not encourage quality research, and second, the system tends to be bureaucratic and inflexible.

Competition-based research funding is gradually gaining legitimacy and popularity in the world due to a number of positive effects. Competing for research grants has proven to encourage high quality research and channel funds to the most productive researchers, thereby making maximum use of available talent. Moreover, yearly competitions allow governments to prioritize research areas by targeting eligibility and selection criteria. Hence, competitive funding promises to increase the efficiency of research funding. Competition based research funding is now widely used by national science and technology commissions in Latin America. In addition, many universities assign internal research funds based on open competition and peer review processes (Urzúa 2002). The University of the Republic in Uruguay, for example, has set up a commission that allocates about 15 percent of funds for R&D on a competitive basis. One of the priorities is projects fostering linkages to the productive sector (Bértola et al. 2004).

Another drawback of the traditional funding system in Latin America is its fragmentation. Due to low availability of large-size research grants, principal researchers are required to draw on a number of sources to fund different aspects of a project: e.g. participation in a conference, hiring PhD students, and purchasing equipment. This takes time and effort of scientists away from their research and makes long-term planning difficult. Moreover, as the funding system is not always transparent and predictable, the system discourages undertaking ambitious, large-scale projects. Countries such as Brazil, Chile and Mexico have begun to introduce larger grants, which not only integrate various aspects of a successful research project, but the project team is given a fairly high level of autonomy in allocating project money.

Large research grants have an additional value – they stimulate researchers to cross institutional boundaries and bring together teams for specific projects. Creating networks of scientists from different institutions and different disciplines can help overcome some of the problems that stem from a lack of "critical mass". Networks, however, do not always emerge spontaneously. At their inception, networks may need an external impetus as well as supportive conditions, incentives and infrastructure. Several countries in Latin America have created Centers of Excellence, and on a smaller scale Science Nuclei, in order to bring together some of the best researchers and scientists. Evidence suggests that these centers have improved the quality and relevance of research by concentrating research efforts (Yammal and Thorn 2005 and Shrivastava et al. 2002).

3.2.2 Retaining talented researchers

Developing countries face an additional challenge when attempting to strengthen their research capacity — their best talent is often drawn away by more advanced countries. An obvious reason for 'brain drain' from Latin America to mainly the United States and Europe is the unfavorable wage-differential.

The wage level, however, is not the only reason why talented researchers choose to leave the region. OECD countries, and especially the US, are attractive to scholars from the entire world for two additional reasons: because of the research infrastructure (laboratories, technology and facilities), which gives important professional opportunities, and because of merit-based, transparent career structures, which provide professional opportunities and high personal motivation. To retain talent, countries in Latin America have to face both of these issues (Thorn and Holm-Nielsen 2005).

Efforts are underway to transform traditional seniority based career structures in Latin America by increasing the visibility of good practices and encouraging excellence in research. Mexico, for example, has a program that links salary increases and career progression for public researchers directly to a number of measures for academic performance. In addition to improving the quality of research, evidence suggests that the program has been successful in reducing brain drain by providing opportunities for talented young scholars (Holm-Nielsen et al. 2005).

4 Transfer and commercialization of knowledge

Besides teaching and research, universities are increasingly expected to make a direct contribution to economic development and to the wellbeing of society. This new role requires universities not only to produce but also commercialize knowledge, i.e. to use research results to create intellectual property and contribute to new processes and products tradable in the market. A number of universities in Latin America have taken up this new challenge by transforming incentives structures, engaging in public-private research partnerships, establishing spin-off companies and patenting research results.

4.1 Promoting university-industry linkages and knowledge commercialization

The majority of universities in Latin America have unrealized potential for exploring the wide spectrum of university-industry collaboration ranging from informal interaction to the establishment of new businesses. Formal relationships (e.g. spin-offs, patents, science parks) are most visible and therefore subject to considerable attention in S&T policies. However, in many cases informal contacts and contract research may correspond much better to the needs of industry. In the US, for example, only few universities generate substantial revenues from their patented research and the vast majority, including MIT for example, earn less than 10 percent of their research budgets from licensing intellectual property (OECD 2003). Moreover, at least 70 percent of all licensing income earned by universities is generated by one research area - patents in the life sciences (Canton 2004).

4.1.1 Informal contacts and contract research

Evidence suggests that the overwhelming majority of knowledge flows from academia to industry through informal linkages and small-scale collaboration (Senker, Faulkner and Velho 1998). There are several reasons for this. First, most knowledge requirements are specific, of limited scope and arise suddenly in the course of research and development. Second, there is a considerable tacit and skill-based element in the expertise industrial researchers seek and obtain when they interact with academia. Finally, mutual respect and understanding are vital prerequisites for success in formal partnerships, and these are most easily built up informally (Senker, Faulkner and Velho 1998).

Informal linkages and university contract research have grown substantially in recent years in Latin America. In part, this reflects efforts by universities to adjust to falling per student public subsidies and meet a rising demand for tertiary education. In Peru, for example, self-generated revenue in public universities rose from 16 to 38 percent of their budget between 1995 and 2003 while maintaining a policy of no tuition in undergraduate education. A significant proportion of this income was generated through contract research and consultants' services (ANR 2005). A similar pattern is found in Argentina, Brazil and Mexico.

Strengthening cross-sectoral research collaboration in Latin America is a matter of building trust, improving communication and strengthening incentives. One of the key obstacles is lack of private sector confidence in the quality and the relevance of academic research. Stimulating excellence when funding research and, notably, changing incentives at the level of the individual researcher would go a long way in addressing this challenge. With few exceptions, universities and research agencies in Latin America have unrealized potential for changing personnel policies and practices to encourage faculty members to collaborate with external partners and pursue their entrepreneurial interests. Researchers associated with the National Council of Scientific and Technological Research (CONICET) in Argentina, for example, are evaluated by peers based entirely on traditional academic criteria such as publications and citations. Hence, a researcher working with industry risks not being formally recognized for this effort (Thorn 2005b).

4.1.2 Mobility of advanced human capital

An effective way to boost the transfer of tacit knowledge and build company R&D capacity is to facilitate mobility and the exchange of researchers and company staff. Data from the 2005 Colombia innovation survey, for example, suggest that the presence that at least one PhD employee has a significant positive impact on company success in obtaining a patent (Mark et al. 2006). Nonetheless, the overwhelming majority of researchers in Latin America work in public universities and government research laboratories, spending their entire career in academia. Hence, stimulating the mobility of advanced human capital between sectors could lower barriers for cross-sectoral collaboration, increase the relevance of academic research, and boost the capacity of the private sector to absorb knowledge.

There are many reasons underlying low mobility of researchers in Latin America. Business careers are often not sufficiently attractive for young researchers, and industry does not perceive graduates as adding enough value. In addition, deep-rooted views that a career in industry is an abandonment of academic values still exist among academics in the region (Mullin et al. 2000). Hence, programs targeted at enhancing mobility, may be an effective mechanism for building mutual trust for further collaboration.

The most common approach is to encourage researchers to seek employment and work part-time in industry. For example, professors can be granted the right to remain on the faculty or have reduced teaching loads while working in industry. Another approach – currently used in Chile and Argentina – is to co-finance scholarships to young researchers working in industry. These scholarships are temporary and decline in value of time, with the company financing an increasing share of the researcher's salary. A 2001 evaluation of a researcher insertion program in Canada – surveying 360 young researchers and 100 participating companies – found that 77 percent of scholarship holders were still employed in industry after the public support had ended (NSERC 2003), indicating that the program had long-lasting results.

Reverse mobility of advanced human capital – from industry to universities — could also bring benefits to both companies and universities in Latin America. Options include encouraging

industry researchers to team-up with university professors in carrying out research or hiring entrepreneurs as part-time staff, using their knowledge of the private sector to prepare the next generation of researchers for a career outside academia.

4.1.3 Research clusters, science parks, and public-private R&D partnerships

Approaches to university-industry relationships can also take a large-scale and structured form. The success of Silicon Valley and other famous high-tech hubs has heightened public interest in Latin America of how to support cluster formation. Clusters comprise firms, research centers, universities, suppliers and investors that work together in close physical proximity to design and commercialize new technologies, products and enterprises (Porter 2003). Although the most successful clusters have developed spontaneously, instruments such as science parks and public-private research partnerships may give an impetus to innovation processes, which in turn encourages co-operation between different parts of the R&D system, attract investors and cross-fertilize the rest of the economy.

Latin America features a number of 'proto-clusters', notably in Argentina, Brazil and Mexico. The State of São Paulo in Brazil is home to one of the very few mature clusters in the region. São Paulo's manufacturing industry is among the largest and most diverse in Latin America. While the reasons behind the success are many, investments in advanced education, science and collaboration between public and private researchers have undoubtedly contributed to the State's economic success (Plonski 2000). São Paulo is the country's intellectual centre featuring the largest universities and research centers in Brazil and most of Brazil's scientific publications. The University of Campinas, for example, boasts the highest number of top-rated graduate programs in Brazil. In addition, for several decades a fixed percentage of state tax revenues has been earmarked to science and technology and concentrated in state-of-the-art research laboratories. The stability in funding has allowed the State to build a strong science base and attract highly-qualified researchers. A key factor in the success of the region is the strong ties between universities, public research institutions and industry. According to Quandt (1997), two-thirds of technology-based firms in the city of Campinas mentioned universities and public laboratories as the dominant providers of research and new knowledge. Firms also refer to local universities as the predominant source of highly skilled employees.

A number of countries in Latin America are establishing or considering science parks in order to promote industry-university research collaboration. Among others, the *Polo Tecnólogica Constituyentes* (PTC) in Buenos Aires, Argentina is an attempt to stimulate clustering. The PTC is made up of several public research institutions, including the National University of San Martín. Industry outreach activities include a program to stimulate new technology-based enterprises, courses in entrepreneurship, and technical assistance. The PTC also emphasizes collaboration with research clusters and science institutions around the world.

Science parks in Latin America are often overshadowed by the fact that the clusters are heavily publicly subsidized. PTC, for example, depends almost exclusively on public funding, which indicates low private sector commitment (Cassin 2001, Bortagaray 2000). Public sector dominance is not only a financial problem, but may have a negative effect also on the efficiency of science parks. Government-led initiatives are likely to be less responsive to actual industrial needs, less able to promote collaborative relationships, and may lock a region into an industrial specialization, which will eventually face decline (De Ferranti et al.2003).

Another instrument adopted in some Latin American countries is support for university-industry research partnerships. Companies can benefit in a number of ways from such partnerships. In

many industries, technological developments are occurring too rapidly and traverse too many disciplines, to be managed effectively with in-house R&D staff alone. At the same time, partnerships with university researchers may be a way for small and medium-size companies to leverage their own limited resources (AICUM 2003).

In Chile and Mexico a new initiative brings together universities and industry to work together in consortia on research issues of common interest. Consortia are partially supported with public funding, but all participants—including universities—are required to make cash and in-kind contributions. Research partnerships differ from science parks in their bottom-up approach. Partners need to come together and formulate a proposal in order to obtain funding. Collaboration is based on clearly formulated projects whose success or failure depends on the ability of the partners to conduct research together. Hence, strong incentives exist to make the cross-sectoral communication and collaboration work.

4.1.4 Intellectual property regulations and direct commercialization

Instead of trying to diffuse knowledge, universities may be directly involved in commercial activities. One option is for researchers and students to bring their ideas to the market by creating spin-off companies in a legal framework outside the university. Universities can also capitalize knowledge through patents and licenses and thereby sell research results to private businesses.

University-level regulations on technology transfer can provide researchers a powerful incentive to pay attention to possible practical applications of their work, and to cooperate in efforts to realize that potential. Research on the landmark Dayh-Dole act in the United States shows that universities sharing a high proportion of royalty revenue with staff generate more patents and licensing income (Lach and Schankerman 2003). This implies that universities can significantly affect knowledge transfer by revising incentive structures. Universities in Latin America in most cases have not regulated how rewards from intellectual property are shared between individual researchers, academic departments, and the institution. Rather, intellectual property is dealt with on a case-by-case basis (Mullin 2004). As commercial activity develops further, universities in the region will face the need to explicitly regulate how generated income is shared.

A newly arising phenomenon within the context of university-industry linkages is academic entrepreneurship: researchers – as individuals or in conjunction with their university – commercializing research results through the creation of spin-off companies. Academic spin-offs are increasingly seen as important means for enhancing local economic development, generating income to universities and encouraging successful scientist to become innovators. Moreover, academic ventures may fill a critical gap in cases where technologies remain unlicensed. University involvement in business creation implies a new role of scientists. In addition to the role of innovators and advisors, they are now required to be members of entrepreneurial teams; hence, play an important role in identifying and developing business opportunities, acquiring resources, and organizing the venture (Norden 2005).

Despite much attention in recent years, there are only few examples in Latin America of university staff setting up technology-based companies. The School of Engineering at the Catholic University in Chile has one of the most extensive experiences in the region. Since 1992 the university has supported the creation of five spin-off companies which involved university academics and students (Mullin 2004). Further stimulating the establishment of university spin-offs in Latin America requires governments and universities to clearly define polices on the matter and establish appropriate support structures to spin-off companies in their formative years. Academics and students typically have little private sector experience and may need assistance on

how to package a technology into a marketable product, establish a viable business model and grow a company. Moreover, dedicated efforts to increase the size of private seed and venture capital markets in Latin America would likely contribute to the creation of new technology-based enterprises.

4.1.5 Managing conflicts of interest in university—industry relationships

Universities and private companies have different priorities in regard to the disclosure of results arising from joint research projects. Academics are rewarded for publishing results while companies have an interest in gaining a first mover advantage by concealing new knowledge from potential competitors. Hence, it is important that the bargaining process that leads to contracts for research collaboration brings clarity on the issue of confidentiality. A common solution is to agree on a maximum time-span that may constrain a university researcher to withhold publication (Hernes and Martin 2000). Most collaboration agreements permit companies to delay submission of an academic paper for two or three months, to secure intellectual property protection. When PhD students are involved in a joint project it is important to guard against the situation where thesis research becomes unpublishable due to corporate secrecy constraints. Students should be informed at the outset of any confidentiality and intellectual property expectations (BHEF 2001).

The clash between traditional values of universities and profit-making firms may emerge also in the case of university spin-offs. Vestergaard (2005) illustrates how creating a venture in a Finnish university raised questions about the boundaries between the duties of researchers as academics and employees in a spin-off company. In most countries in Latin America, such as Mexico and Brazil, academic staff has specific employment conditions which indicate their tasks and the length of time they are expected to spend on teaching and research. Such employment conditions provide a frame of reference for the time that can be dedicated to private work. The University of São Paulo in Brazil, for example, has established that a staff member is allowed, under certain circumstances and with the permission of the head of the institution, to take one day of leave per week for private consultancy, under the condition that the work should complement the research interest of the academic and of the department (Polonski 2000).

Cooperation with industry may also cause a direct conflict of interests for university researchers in cases where firms offer them financial rewards via royalties and equity in companies while also funding their research. Especially in the field of medicine, evidence suggests that researchers who cooperate closely with industry are less likely to disseminate their research results (e.g. Blumenthal et al. 1997) and are more likely to publish results favorable to the sponsor (e.g. Cho and Bero 1996). Conflicts of interest are thus a justified concern as they may lower the quality of research and diminish public perception of and trust in universities and researchers. The US Government, for example, obliges researchers to disclose financial interests when applying to certain public research funding (Cho et al.2000).

Universities may often need to support academic values with internal regulations in order to protect their position in society. As university-industry collaboration intensifies in Latin America, the current case-by-case treatment by most universities will likely be insufficient for protecting their core values and universities will face the need to establish and review their internal regulations.

5 University Governance

Adaptation to the needs of national innovation systems has prompted universities to revise not only their traditional functions, but also their governance structure.

5.1 Increased flexibility in university management

Traditionally, higher education systems in Latin America have been characterized by bureaucratic and inflexible public sector management rules. In many Latin American countries, the Ministry of Education used to determine budget allocations, student admission policies, and the content of curricula; and institutions had little influence on the number of staff and positions, the level of salaries, or promotions (Schwartzman 2002). The traditional rigid state oversight model has become ineffective in the new reality, notably in regard to resource management.

As universities increasingly are held accountable for external funding, academic productivity, and teaching quality, universities must have greater freedom to maneuver and be in control, so that they can truly take responsibility for their success and failure. As a consequence, the relationship between government and university is changing in many Latin American countries. In Venezuela, for example, the 1999 constitution guarantees the largest universities greater freedom regarding budget, governing, personnel policy, and academic programs (World Bank 2002a). Several governments in Latin America are currently contemplating how to balance institutional autonomy with accountability for results. Colombia for instance is allocating a fixed percentage of the annual public budget for tertiary education based on results, and Chile is in the process of introducing performance agreements negotiated between the Ministry of Education and publicly subsidized universities (Thorn et al. 2004). Such instruments hold significant potential for stimulating universities to increasingly take societal needs into account in teaching and research.

The trend of decentralization in Latin America extends from the university-government relationship also to individual departments. Top-down university management, where all decisions regarding external contracts and funding allocations require approval from the rector, is too cumbersome in the new environment. In an increasing number of universities in Latin America, external contracts and decisions about funding allocations can now be managed at a lower level. Many universities retain the legal practice that the rector's approval is needed for any financial commitments, but in cases where central approval is still needed the procedure has generally been revised and simplified (Mullin 2004). Higher level of autonomy in sub-units sets higher demands on managerial capacity at the decentralized level. This changes most prominently the role of department heads and deans from merely a representative of fellow academics to a leader and manager of an organization (Amaral et al. 2003).

5.2 Managing linkages through TTOs

As university-industry relationships become an important component of every-day activities, many universities try to actively support collaboration and commercialization. Technology Transfer Offices (TTOs) can track potential industrial research opportunities, support commercialization processes (i.e. dealing with patents, licenses and contracts), and develop general guidelines for university-industry collaboration.

Universities in Argentina, Brazil, Chile, and Mexico have been active in creating TTOs, while most other countries in the region are lacking behind in this aspect (Mullin 2004). Successful knowledge transfer depends on the available of personnel experienced in business management, capital markets, and the handling of intellectual property. Moreover, TTO staff needs to have

knowledge of academic research and potentially interested business partners. One of the key challenges of TTOs in Latin America is a lack of personnel with adequate skills and experience to carry out such tasks. Argentina has tried to address this problem by providing training to TTO personnel and supporting the establishment of inter-institutional TTO networks.

5.3 Opening governing structures to external stakeholders

Universities are increasingly open systems in close interaction with public and private employers, research partners, national, regional and local authorities, students and parents, international partners, and other stakeholders. As a result, there is a growing need to ensure that university governing structures are inclusive and place universities in a strong position to manage their new role as direct contributors to social and economic development.

The majority of public universities in Latin America are governed by internally elected academic leaders represented in academic councils. In Brazil, for example, federal universities rely on collegial decision-making processes and elected leadership in each department or institution (Schwartzman 1998). Such an arrangement is a central component of a vital and creative academic community. It does, however, run the risk of politicizing and decelerating necessary management decisions. In addition, internal elections do not provide a solid basis for professional leadership, as academic leaders are rarely trained in the management of large, complex institutions (Altbach 2003).

In recent years, OECD countries have acted to ensure involvement of external stakeholders in university management. Stakeholders have potential not only to increase institutional legitimacy, but to make universities more responsive to societal needs. Stakeholders can be involved at various levels. From the perspective of a national innovation system, industry representatives can add value to curriculum development, the evaluation of university education, and the setting of research priorities. External stakeholders can also play a formal role as appointed members of institutional governing boards. Ensuring participation of individuals with, for instance, business exposure in strategic decision-making processes facilitates an increased focus on the relevance of education and research and may give universities access to valuable managerial expertise and network.

6 Concluding comments

Universities in Latin America are well positioned to become full-fledged partners in national innovation systems and contribute to economic development. From being largely institutions of advanced education and basic research, universities are increasingly expected to contribute directly to commercial activity and economic development. The so-called “third mission” of universities is a relatively new phenomenon in Latin America but is expected to evolve in scope and complexity as countries in the region face the challenge of developing into knowledge-based economies.

Due to the novelty, visibility, and explicit impact, university-industry research partnerships and university spin-off companies have received considerable attention by policy makers and university managers. The two traditional missions of universities – advanced education and research – are, however, equally important to national innovation systems and are under similar pressure to adapt to new realities. Highly skilled individuals are the backbone of the knowledge economy and education is a key element in efforts to boost economic growth. The challenge in Latin America is to ensure that higher education is inclusive, of high quality and well aligned

with the needs of the private sector and that young researchers find employment outside academia.

In regard to research, academic excellence underlies both university-industry collaboration and high-quality education. If universities are not able to deliver quality research there will be no demand for their services from the private sector. Nonetheless, university research can never be a substitute for research activities in industry and – as a matter of high priority – efforts should be made in Latin America to boost the capacity of firms to absorb knowledge. Policies on university-industry linkages can add to this objective, i.e. by stimulating mobility of advanced human capital, providing services and encouraging research partnerships.

Helping universities develop their "third mission" could unleash a significant innovative capacity in Latin America. The paper has pointed to a number of instruments that are used to stimulate cross-sectoral linkages and the commercialization of university research. In undergraduate and, notably, graduate education students can be encouraged to practice in real life circumstances and work on projects in collaboration with industry. The impact of university research could be increased by converting pioneering technology into intellectual property. Moreover, countries in Latin America have unrealized potential for using public research funding to stimulate cross-sectoral research collaboration and commercialization. In a challenging global environment universities in Latin America should not expect to find "silver bullet" solutions. Whatever approach adopted, it is indispensable that institutions monitor results and adjust instruments based on lessons learned.

One of the most important challenges for policy-makers and university managers is defining a legal framework, sound management procedures and incentive systems that stimulate entrepreneurship while recognizing the distinct but complementary roles of universities and industry. It will undoubtedly require high powered incentives for cross-sectoral research, commercialization, and mobility to transform deep-rooted academic cultures in Latin America and demonstrate to the private sector that gains in productivity, value added and market shares can be achieved by collaborating with universities.

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