Theme: Universities as interactive partners

Title: Technology transfer in Mexican Universities: a new approach in the context of open innovation

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Introduction.

During the last decades, university-company relationships have become a focal theme due to the fact that technological progress is essential for economical development in countries preoccupied with generating better competitive conditions in an international scenario. The emergence of an innovation system supported by different participants,

academy-industry being one of them, has triggered several forms aimed at optimizing the interface between science, technology, and economical development.

In addition, Open Innovation presents a model in which new products come from both internal and external company sources. Open Innovation concerns itself with the promotion of a bidirectional flow of ideas, technology, and skills through institutional boundaries using multiple interface and collaboration methods aimed at speeding-up internal innovation processes and establishing new marketing routes for their results

For open innovation, the collaboration between universities, companies and government constitutes one of the best pacts to link technology with economical development (Raymand and Nichols, 1996; Chesbrough, 2003). But managing this collaboration is a complex task mainly because of the different nature of universities and firms. It is more difficult in countries where the innovation ecosystem is immature and unarticulated as it is in the case of Mexico.

In order to put these arrangements or institutional relationships in motion, universities have created specific methods with the objective of stimulating and facilitating their relationships with the other agents in innovation systems: industry and government.

Technology transfer has become a relevant issue for Mexican universities but important limitations in terms of institutional policies and technology management establish obstacles to technology transfer.

Based on consultations to technology transfer officers of research universities as well as to industry's representatives, this paper's objectives are to draw some recommendations for technology transfer from universities to industry in countries with weak innovation ecosystems, based on the analysis of Mexico's Universities cases.

The analysis shows Mexican ecosystem for innovation is not supportive because very little resources are devoted to R&D and the institutional setting lacks integration and the proper continuity. It is therefore that we present different recommendations for the improvement of technology transfer activities at Mexican universities.

State of the art

In an Open Innovation context, universities should be conceived as knowledge-based organizations where knowledge management and innovation are essential in order for the processes of creation and learning to become more efficient and flexible, and so the transformation of knowledge into intellectual capital become more frequent; increasing the likelihood of generating economical and social benefits (Solleiro *et al*., 2009).

From a theoretical point of view, coordinating university, industry and government has been the objective of different analysis that vary from a macro perspective to the establishment of conceptual models for technology transfer from university to industry.

Sábato and Botana (1968), perceived the importance of the interrelationship between these agents and argued that in part, Latin America's possibilities of overcoming

underdevelopment resides in including science and technology into the different countries' development processes. This relationship, graphically represented as a triangle, where the government occupies the vertex and the other elements occupy the base angles, is known as "Sabato's Triangle". One of its main characteristics is the emphasis on the role of the government as regulator of the actions between the other agents of innovation.

Nelson and Rosenberg (1993), also tackle this subject with a central preoccupation on innovative performance of national companies. In this context, the authors develop the concept of "National Innovation Systems", covering institutions and private companies, including institutions such as universities, which are dedicated to the production of scientific and technological knowledge, and governmental programs. According to this concept, private companies constitute the nucleus of the whole system.

Leydesdorff and Etzkowitz (1996), using the same central elements of the National Innovation Systems and of Sabato's Triangle (without referencing it), propose the concept of the "Triple Helix" which incorporates the evolution of the relationships between universities, industry, and government, pointing out the new roles that these institutional spheres carry out in today's society. In addition to the traditional roles, universities, industry, and government now assume new tasks in the development of new technologies.

Based on the Triple Helix, companies transmit demands to basic research forcing academy to get involved in industrial innovation, and at the same time reinforcing the performance of basic research. This is why universities have started to assume economic development as an academic function, along with teaching and research. This strengthens the role of universities as basic agents in the innovation process (Ritter dos Santos, M., 2005).

Articulating universities with economical development based on relationships with industry is a well-known phenomenon. According to Betz (1996), it was science, technology, and economy as a group that provided and continues to provide a basis for global progress and industrialization. At the beginning of the XVIII century, technologies developed from scientific knowledge, and then were used by the industries to promote economical development. Since then, universities have become the main generators of scientific progress, industries have become the main producers of new technologies and economic growth, and governments have become the main sponsors for science.

As technology transfer processes increased from universities to the productive sector, and as relationships between them evolved, new institutional arrangements appeared. According to Solleiro and López (1994): "Collaboration between research institutions and companies has shown an evolution of their processes affecting both organizations and countries; beginning with traditional activities such as human resource development, going up-to provision of minor services, carrying out hired research and licensing, and

finally, giving way to developing structures that promote much more complex forms of cooperation".

There are many options for transferring knowledge but also difficulties in carrying them out. Structural problems and current uncertainties demand new solution alternatives and an impulse into a new cycle of innovation that brings together basic and applied research (Rothwell 1993). In fact, there are conceptual proposals that point towards a new paradigm in scientific and technological knowledge production, characterized by this gradual coming together of science and technology culture with academy and industry (Brooks 1993). Thus, knowledge production occurs more and more in an applications context. This brings deep transformations in inter-institutional relationship patterns, breaking first with the linear model for explaining innovation in order to give way to one that explains knowledge production as a continuous exchange of information between different social parts, with random –and even accidental- appearances of new ideas, and an increasingly important role of learning and capitalization of technology. Therefore, we speak of a socially distributed knowledge production system (Gibbons, 1994).

In this manner, innovation tends to be the result of the activity fulfilled in a context of network production and knowledge diffusion, with a special emphasis on high technology sectors with elevated R&D expenses, forming part of the network and being able to exploit the information that circulates within it has become more valuable than having the ability of autonomously generating knowledge (Gambardella 1992). In this framework, universities and research institutions have to face the challenge of generating new forms

of interaction to achieve synergies rather to trying to replace firms in their leading role in innovation (Del Bello 2007).

These conceptual advances are fundamental in understanding the tension, uncertainty, and conflicts that have an influence on university-industry technology transfer. According to Rappert and Webster (1997), there are three areas that determine knowledge production and reproduction as interchangeable merchandise:

1. The appropriation process by which social actors capture economical income derived from innovation.
2. The framework in which academics are motivated to achieve the marketing of the results of their research.
3. The organization strategies and procedures used by the actors to manage the context in which knowledge is produced, interchanged, and disseminated.

Specifically, this means that marketing academic research results requires some attention: to an appropriation regime, that refers to the ability of innovators to capture profits generated by an innovation; to policy definition, parameters of research evaluation, financial regulations, and management practices that form the governance framework so academics can be involved in activities oriented towards commercialization; and to regulatory methods for emerging social relationships between producers and users of knowledge.

Methodology:

This paper is based on following activities:

- To review international experiences regarding university-industry linkage in order to define benchmarks.
- To review Mexico's legal and regulatory framework for technology transfer.
- Workshop with liaison officers from 40 public Mexican universities located in Mexico City and the State of Mexico to analyze strengths and weaknesses of institutional policies for technology transfer. The policies considered are showed in **Table 2.**
- A survey to 18 technology managers of 13 Mexican research universities to identify the main gaps at carrying out their activities
- Workshops with 147 representatives of Small and Medium Enterprises (SMEs) in the metropolitan area of Mexico City to evaluate strengths and weaknesses of collaborative innovation[1]. An overview on the needs and strategies to foster effective technology transfer was generated.
- To analyze the experience of the authors of this paper in technology transfer, because they have been involved in managing technology transfer at the largest research university of the country (UNAM) from 2008 to 2012.

These activities were address to answer following questions:

[1] Workshops were organized between July and September 2011 in following sectors: advanced manufacturing, logistics, information and communications technologies, food processing, chemicals, plastics, pharmaceuticals, textiles, and flower production.

1) Is the international experience applicable to Mexican Universities?
2) Is Mexican Institutional Environment conductive for technology transfer (TT)?
3) What are the main gaps for different Mexican universities?
4) What are the expectations and actions of industry regarding TT?

Findings and interpretation:

a) International institutional approaches for technology transfer.

With the objective of understanding the differences in approaches to innovation technology management in public research institutions in different countries, we analyzed some relevant experiences of institutional promotion of technology transfer (see **Table 1**). Some important conclusions can be made from the analysis of this table:

- The existence of a legal instrument that mandates that the protection of intellectual property and technology transfer are legitimate activities in public research institutions, and that academics may establish relationships of external services, is a fundamental element in the advancement of technology transfer formalization. This makes it clear that the institutional base is a key for successful technology transfer activities. This justifies the assessment of institutional policies conducted in this study.
- All countries have promoted the existence of organizations dedicated to technology transfer management. This promotion includes office financing.

- It is well accepted that technology transfer is a new and complex subject that is supported by research, documentation, and diffusion of good practices in such a way that offices become involved in a dynamic of learning and perfecting.
- All analyzed countries have had positive results in terms of the increase in the number of patents, amount of research and licensing contracts, new companies, job creation, and income obtained from the transfer.
- Technology transfer from universities to industry is treated as a State Policy. Hertog et al. (2003) recognize that intellectual property rights are constituted in the structural condition that is fundamental for innovation, and confirm the argument that, in order to stimulate innovation, national policies and suitable structures are also necessary in order to perfect the links between industry and science.

Table 1. Relevant international experiences in academy-industry interactions.

Country		
United States	Legislation	Bayh-Dole Act (1980). Allows institutions to hold ownership of inventions developed with federal resources. National Cooperative Research Act (1984). Promotes I+D cooperation.
	Technology Transfer	Liaison offices Technology transfer offices

	Organization	Business incubator Business accelerators Science parks
	Promotion of Good Practices	The association of University Technology Managers (AUTM) offers training, information on contracts and experiences.
	Financing	Universities and centers sponsor the offices. There are important federal and state resources for cooperation projects.
	Observations	In 2003, AUTM had 3,200 members. From 1993 to 2002, universities obtained 28,093 patents Between 1980 and 2002, 4,320 new companies were created based on university technology licenses.
France	Legislation	Innovation and Research Policy (1999). Favors transfer of developed technology in public institutions for the private sector and the creation of innovating businesses.
	Technology Transfer Organization	Research networking National centers for technology research Teams of technology research Technological resource centers for SMBs Business incubators Scientific parks Transfer offices

	Promotion of Good Practices	ANVAR (National Agency for Research Appraisal) CRITTs (Regional Centers for Innovation and Technology Transfer) Réseau CURIE
	Financing	Risk capital Fiscal incentives
	Observations	Since the issue of the law, more than a hundred institutions have been benefitted. From 1999 to 2002,1,451 projects were promoted with 2,300 new jobs, 30 new incubators, and 344 new companies. Accumulated 40 years of experience in appraisal.
Spain	Legislation	Policy for the Promotion and General Coordination of Scientific and Technical Research (1986) and Policy for University Reform (1983) that allows professors to take jobs by contract with a third party.
	Technology Transfer Organization	Office for the Transfer of Research Results (OTRI) Incubators Science parks
	Promotion of Good Practices	OTRI (network) COTEC foundation Madri+d
	Financing	Project funding

		Risk capital Fiscal incentives
	Observations	In 2004, 9,804 I+D contracts were signed, with a profit of 282 millions of Euros; 307 patent applications; 143 license contracts generated profits for 1.9 millions of Euros. Spin-off of 90 new companies
Germany	Legislation	Employees' inventions policy (2002) Commercial exploitation regulation for project results financed by the Department of Education and Research
	Technology Transfer Organization	Technology Transfer Offices Patent Marketing Companies (PMCs) Public research institutions
	Promotion of Good Practices	National external service organization network Foundations Network of technology alliances
	Financing	Federal program for university funding Organization clusters Funding for protection costs for SMBs
	Observations	In 2006, 200 institutions and 100,000 researchers collaborated with PMCs, with a portfolio of 2,000 patents

Sources: Prepared by the authors based on the following sources: Ritter dos Santos, M. (2005), Office of Science and Technology Embassy of France in the USA (2002), Summary on the measures and assessment on 31 December 2002; Ignacio Fernández de Lucio (2006), "Repensando las Relaciones Universidad-Entorno" (*Re-thinking University-Environment Relationships)*, Annual OTRI network conference,

Barcelona; Technology Transfer in Germany, (http://astp.wikia.com/wiki/Technology_Transfer_in_Germany)

Technology transfer activities are promoted through different institutional and contractual forms. Stal (1998), suggested an evolution in the forms of collaboration between universities and industry that follows this trajectory: 1st, Personal informal relationships (in this case, the university is not involved as such)[2]; 2nd, Formal personal relationships (agreements between university and industry); 3rd, Involvement of an intermediary institution (liaison office); 4th, Formal agreements with defined objectives; 5th, Formal long-term agreements without defined objectives; and 6th, Creation of special structures.

Some of the institutional experiences from developed countries serve as important lessons for the definition and management of promotion units for company-university technology transfer.

In first place, it is important to point out that the evaluation of interface units must not be compared to a business simple based on generated utilities or the portion of the market they have reached. A big part of the investment in said units are public expenditures with a long-term vision. In this way, success should be evaluated in function of criteria that combine the unit's energy, the relevance for industry, its contribution to national science and technology infrastructure, creation of value, industrial appreciation, ability to

[2] Generally speaking, formal arrangements require legal acts or instruments, while informal arrangements are given by personal relationships for the provision of technical services, analysis and tests, individual consultancy, participation in seminars and workshops, etc.

generate profit, development of innovative organizational approaches, management effectiveness, and measurable scientific and technological results (Rush et al., 1995).

The existence of partial government funding is important both in the form of direct contributions, as well as through contestable research programs and contracts. Beyond providing funds, government has an active involvement in the promotion of the relationships between universities and industry in industrialized countries.

The construction of a knowledge appropriation regime in universities, with the objective of promoting technology transfer might have, in a long or middle term, a limiting effect on the general knowledge transfer rate from universities. Protection through patents in universities might involuntarily commit knowledge with private sector agents and induce bias, and even menace the university's vision of knowledge diffusion. That is why it is essential that there are explicit policies to manage delicate matters such as the possibility of an industrial secret, defense patents, and the incidental conflict of interests with academics participating in companies.

Regarding intellectual property, it is important to point out that, in industrialized countries, **technology transfer from universities is mainly a system of disclosure, patenting, licensing and patent and license control**. The technology transfer office is obliged to guarantee that the registration of intellectual property of the invention be carried out in accordance to federal and university policies. Once the deposit is made, the

TTO starts the search for the invention's marketing in the industry. A non-confidential summary is sent to the potentially interested companies. If a company expresses its interest, it is invited to sign a confidentiality agreement (to protect information and future patent rights) before receiving confidential information from the university. If the company is still interested, an agreement is reached to continue with the invention project in the university. University inventions are almost all in embryonic stage, and require further research and development before they are ready to go to market. There is a great risk for the license holder; this has to be taken into consideration when negotiating the license (Mehlman et al., 2010).

b) Technology transfer from universities to industry in Mexico.

Mexico has made considerable efforts in the last years to promote the relationships between universities and companies. The forces that motivate the different initiatives oriented towards strengthening these relationships are found, on one hand, in the need of Mexican companies to elevate their competitiveness, and on the other hand, in the need of universities to diversify their funding sources because recent government policy changes tend to rationalize public spending destined to scientific and technological activities. Particularly in Mexico, in addition to these reasons, we have to add the fact that most of the research is carried out in university centers which makes them almost the only domestic source of scientific knowledge (Solleiro and López1994; Foro Consultivo 2011).

Unfortunately, very few universities in Mexico have consolidated competitive research programs and groups that could face the challenge of developing technology for an industry that has to compete in ever more demanding markets. This establishes a clear barrier in the service supply and support that most universities can offer to companies in this region, which end up focusing on continuing education activities and offering simple technical services.

In the case of the universities that do carry out research, it is not uncommon to find that researchers are not familiarized with the quality requirements a technology needs to be competitive at an industrial level. This lack of information creates serious problems for eventual commercialization of university technology, because businessmen don't want to invest in technologies with doubtful performances. The majority of the contracts celebrated between industry and academy in Mexico, have the purpose of providing services or technical assistance; contracts directed at specific research are scarce. The international models we described are not applicable to Mexican universities, mainly because they do not have patent portfolios to license. Intellectual property management is just in the early infancy.

Another problem worth mentioning has to do with the low level of culture and will of university academics to build links with industry. At present, the evaluation of academic staff in most Mexican universities is still based, almost exclusively, in conventional academic criteria. Institutions we analyzed do not have internal policies to recognize technological solutions for industry as legitimate academic results. This factor was

qualified as one of the main gaps by the managers participating in our consultation (**see Table 3**).

Our consultation has shown that most Mexican universities still do not have a suitable institutional structure for marketing their services and technologies. All the liaison officers of teaching universities we consulted stated that their main activity concentrates in opening spaces in industry for internships of students. Under this circumstance, sales strategies for these services are based on the personal effort of academic researchers, who generally don't have the experience or the time needed to negotiate with companies. Research universities have created TTOs that centralize marketing activities, but they do not have enough qualified personnel with basic knowledge of technology transfer management. Finding qualified personnel in this specific area is very difficult because technology management is a new discipline in Mexico

Another limitation that is still found in most Mexican universities, deals with the lack of explicit policies and regulations for improving institutional interface with the private sector. Despite the fact that more than 30 years have passed since the first industry-university relationships were formalized in Mexico, there is still a lot of work to do in order for academic institutions to count on regulations and efficient and agile methods to respond to the demands of industry, to avoid bureaucratic management of funds produced by an interaction with the private sector, and most importantly, for the correct distribution of economical benefits among the institution and the participants. As result of our consultation we have observed that only the most advanced research universities have

internal guidelines to manage extraordinary income derived from tech transfer activities and only three out of them have explicit rules to share that income with participating staff. If this limitation is not overcome, according to the opinion of liaison officers of our consultation, it will be practically impossible to attract funding and participation from the private sector, and worse of all, impossible to motivate academics into participating in contract projects. In addition, it's fair to say that when a university tries to establish a relationship with companies without any defined strategy or policies, what generally happens is that the relationship is informal, based on simple and not challenging projects.

Table 2. Assessment of institutional policies regarding technology transfer.

Policy item	Documental support	Main features	Assessment on alignment with technology transfer objectives	Recommendations for improvement
Technology transfer policy	No university has a documented policy		Great obstacle	Development and implementation of explicit policies
Management of self-	Experience is based on		Limitation to attract income	Clear rules for the use of

generated income	organization of training courses		from services, consultancy and contract research	extraordinary income and rapid response
Policy to share income with participating academic staff	No provisions		Lack of incentive for academic staff	Explicit rules to share income and reward participation
Academic evaluation of technological solutions for industry	Evaluation based on teaching and research results.	Economic incentives for productivity (class-hours, graduation and published papers)	Lack of incentives for actual solutions to industry's problems	Implementation of an evaluation system considering a diversity of outputs including technology transfer
Participation of students in contract research	No provision yet		No incentive to get students involved in projects with industry	To develop guidelines to promote projects with students' participation with emphasis in strengthening

				quality of education and share of IP
Conflict of interest	No explicit provision		Doubts and lack of confidence	
IP and trade secret management	Only one institution has an IP policy	Emphasis on patent application procedures	Lack of resources and culture for IP management	Promotion and reward of creativity and inventiveness

Table 3 shows the main results of the consultation to TTOs' staff members. We can conclude that, from their perspective, technologies developed at their universities do not face industry's evaluation standards and reach only the prototype stage in the innovation process. It is quite interesting that TTOs use to face a problem of definition of their institutional role and functions. It is common to find that such offices deal with managing not only relations with industry based on transferring technology and co-operative research and they are also asked to get involved in academic cooperation. This represents a problem of work overload, conflict of priorities and performance evaluation too.

Government does not support scaling-up and pre-commercial development of technologies unless a firm acts as leader of the project[3]. This is a limitation because most firms are not willing to invest in these stages. SMEs have little experience in leading this kind of projects and this leads to decreasing effectiveness of these incentives. Under these circumstances, large Mexican firms and multinationals take the greatest part of the benefit of these funds.

From the firm's perspective, another important obstacle to technology transfer is the lack of alignment of teaching and research at universities with industrial needs and priorities. This has created a context characterized by the lack of trust.

Table 3. Main gaps[4] for technology transfer from the TTO's perspective.

University		**Government**		**Firms**	
Factor	**Gap***	**Factor**	**Gap***	**Factor**	**Gap***
Technology offer deals with prototype without industrial tests	4.2	Economic rewards to academics working in technological	6	In-house staff trained on technology innovation	6.2

[3] Mexico's CONACYT has a program to support industry's innovation with an incentive to those projects in which universities and public research organizations are involved. Total budget of the program used to be around 200 million U$ and has been decreasing over the last two years. This has implied a rate of rejection of industry's proposals of 90%.

[4] Calculation of gaps is based on a scoring method. Participants in this consultation were asked to give the different factors a weight depending on their relative importante (from 0 to 10) and then to assess the actual importante given to each factor at their institution. The differences are the gaps from which mean values were then calculated

		development activities.		management	
Basic knowledge about management of technology	4.8	Financial support for prototypes and scaling-up of processes	5.4	Use of methodologies for assessing technologies	6.7
Budget to operate the TTO	5.1	Training programs and promotion of a culture of technology management at firms and universities.	5.9	Firm's liaison office to work with other actors of the innovation system	6.1
Empowerement of TTO´s employees for decision-making regarding university – industry linkage	5.3	Financial support for technology transfer offices	5.5	Incentives for staff members' technological developments	6.1
Clear definition of TTO's objectives and institutional role	4.9			Explicit technology plan	6.3

				Formal structure to manage R&D	5.9

Source: Authors' work. Gaps were qualified from 0 to 10.

When interface obstacles are analyzed between universities and the productive sector in Mexico, it is unavoidable to consider the role that the productive sector plays in this process as the final user of university services and innovations.

Mexican companies in general, consciously or unconsciously, neglect their technological supplies and they resist defining and implementing technological strategies. Therefore, we can see that the typical Mexican firm is a passive follower of technology with a slow response to technological change.

The workshops with representatives of 147 SMEs made it clear that small firms are rather conservative and only propose incremental innovations. This confirms the results of Mexico's innovation survey 2006, in the sense that 95% of the firms considered their innovation projects were successful (CONACYT 2006). This only happens in the case of low-risk incremental innovations.

Mexico's industry has highly dispersed and heterogeneous innovation capabilities. Although there is in place a small amount of exporting companies, most of them controlled by foreign and highly qualified firms, just a few of them carry out modest

domestic R&D activities, but the prevailing model is the acquisition of technologies from abroad since their processes are easier to incorporate into innovations, but that severely reduce the possibility of organizing collaboration among institutions aimed at reinforcing innovation systems. Even worse is the case of other companies that not only resort to purchase external technologies, but rather prefer the spare parts and inputs supply from another country, and thereby breaking the value added networks and incentives for local supply.

This is the profile of the typical client for university technologies in Mexico. In order to commercialize their technology services, universities have to start by convincing companies on the strategic value of the technology and the importance of innovating. Just a few firms have units dedicated to R&D and technology management. This represents, without doubt, a serious problem for commercialization and a major cultural challenge. Therefore, one must assume the additional and difficult work needed to influence in the forming of a culture of technology and innovation in an industry. In general, companies in developed countries are aware of the strategic importance of accessing advanced technological knowledge in order to strengthen their competitiveness and there are government incentives that promote the relationship between industry and universities but the number of actual cooperative projects is still low.

Government policies to promote technology transfer.

In contrast with the experience of technologically advanced nations, in Mexico the incentive provided by governments for promoting relationships between universities and industries is truly marginal and unstable. This last characteristic has forced several institutional methods to be canceled or transformed exclusively in accordance to political criteria, diluting the obtained knowledge on technology transfer.

The case of Mexico's policy shows that among policy instruments implemented in the country the Science and Technology Act stands out. This law establishes basic framework conditions for R&D and technology transfer including the possibility for universities and research centers to create technology transfer units (even as private entities) but it **explicitly prohibits the use of fiscal funds to support the operation of such units**. This is clearly a limitation. The Special Science, Technology and Innovation Program (PECYTI, Spanish Acronym) aims to coordinate nation- and state-wide efforts in S&T particularly in priority areas. PECYTI has failed to result in specific intervention instruments and such fact makes it difficult to realize remarkable S&T efforts. The quintessential instrument implemented by the Mexican government for S&T are mixed funds (Federal government-states of the Republic), and sector funds (Federal government-State secretariats); these funds finance S&T research and development-related activities, and the development of specialized human resources; also they finance the design of innovation to deal with regional and sector priorities and requirements. Private sector access to these funds has been very complex and for that reason most of the money has been devoted to academic research with little actual industrial and economic impact.

It is very important to clearly point out that the resources allocated to conduct scientific and technological activities represent a fundamental limitation. As regards national R&D expenditure it represents 0.4% of the GNP, whereas the private sector allocates less than 40%. The degree of involvement by companies in innovation activities is still very low, basically due to the reduced efficacy of promotion instruments. Such fact is mainly due to a lack of resources and a certain coordination deficiency. The weak organization among the System stakeholders is also evident, and such fact has been evidenced by the 2006 National Innovation Survey, which revealed that only less than 5% of the companies carrying out innovation activities have collaborated with universities and research centers. This leads us to conclude that expectations of most Mexican firms regarding technology transfer are extremely low. This is another marketing challenge for universities.

This summarized picture of the environment of university-industry technology transfer illustrates, in sharp contrast with the cases of advanced countries, the fragility of the system and the lack of actual support to this important activity.

Critical needs for sound technology transfer: Institutional policy.

Policies are strategies derived from decision-making processes when faced with determined public problems. When correctly stated, a policy will contain a description of

the desired condition and a group of instruments needed to lead the system to its goals. A policy might imply regulations, distribution of different kinds of resources, selective intervention, or the creation of positive framework conditions.

In the case of institutional technology transfer policies, according to the opinion of the liaison officers participating in our consultation, success will rest upon the pillars illustrated in Table 4.

Table 4. Institutional policies for technology transfer.

Element	**Supporting document(s) (e.g. regulations, guidelines, etc.)**
Interface Policy	Rector's guidelines, rector's linkage plan, internal regulations for technology liaison and transfer
Extraordinary income management	Regulations on extraordinary income, agreement on distribution of economical resources derived from technology transfer activities
Additional payments to academic staff members participating in collaborative projects	Regulations on extraordinary income, internal rules on payment of compensations to academics, rules for distribution or surplus
Academic evaluation of participation in technology	Declaration of promotional activities and academic promotions, scheme of recognized points for solving

transfer projects	private sector problems, special evaluation commissions
Participation of students in projects interfaced with external sectors	Regulations on intellectual contributions from alumni, regulations on intellectual property for alumni, agreement on distribution of economical resources for alumni, regulations on management of confidential information in theses, agreements to facilitate graduation of alumni that develop hired technologies
Conflicts of interest management	Internal regulations on participation of academics and university staff members in company activities, regulations on the use of hired time, guidelines for the authorization of participation of companies
Trade secrets and confidential information.	Confidential information management for academic staff, alumni, and administrative staff; regulation of maximum time limit for keeping secrecy on information of commercial and academic interest

Just some institutions have internal regulations to deal with intellectual property and royalty-income distribution. Students' inventions are not involved in intellectual property laws, because they are not employees, but this translates in a lack of support for students' innovations in most institutions.

It is still very common that managers and academic staff at public universities do not consider that commercializing knowledge is fair. Heated debates appear when a faculty member gets extraordinary fees for consultancy or royalties or when he creates a start-up. There is a generalized perception that making money from knowledge represents conflicts of interest. This has as a consequence that, in absence of the proper regulatory framework, decision-making on income distribution and creation of new firms by faculty is very complex and time-consuming.

There are no rules to manage confidential information and academic institutions do not have policies or guidelines to establish in which cases and for how long scientific and technical information generated at university settings can be hold as secret.

The main results founded in the research are:

- Most universities in Mexico do not have enough research capacity to offer technological solutions for industrial problems
- It is not uncommon to find that researchers are not familiarized with the quality requirements a technology needs to be competitive at an industrial level
- A low level of culture and will of university academics to build links with industry.
- Most Mexican universities still do not have a suitable institutional structure for marketing their services and technologies.

- Technology management is a new discipline in Mexico so is very difficult to find qualified personnel in this specific area.
- Another limitation that is still found in most Mexican universities, deals with the lack of explicit policies and regulations for improving institutional interface with the private sector.
- Technologies developed at their universities do not face industry's evaluation standards and reach only the prototype stage in the innovation process.
- Government does not support scaling-up and pre-commercial development of technologies unless a firm acts as leader of the project.
- From the firm's perspective, another important obstacle to technology transfer is the lack of alignment of teaching and research at universities with industrial needs and priorities. This has created a context characterized by the lack of trust.
- Mexican companies in general, neglect their technological supplies and they resist defining and implementing technological strategies
- Small firms are rather conservative and only propose incremental innovations.
- Mexico's industry has highly dispersed and heterogeneous innovation capabilities. Although there is in place a small amount of exporting companies, most of them controlled by foreign and highly qualified firms, just a few of them carry out modest domestic R&D activities, but the prevailing model is the acquisition of technologies from abroad since their processes are easier to incorporate into innovations, but that severely reduce the possibility of organizing collaboration among institutions aimed at reinforcing innovation systems.

- In order to commercialize their technology services, universities have to start by convincing companies on the strategic value of the technology and the importance of innovating.
- In Mexico the incentive provided by governments for promoting relationships between universities and industries is truly marginal and unstable.
- The resources allocated to conduct scientific and technological activities represent a fundamental limitation. As regards national R&D expenditure it represents 0.4% of the GNP, whereas the private sector allocates less than 40%.

Conclusions

Most Mexican universities are within Stal's first three stages of evolution in their forms of collaboration with industry, mainly dominated by informal and ocassional provision of technical sevices and some consultancy.

Introducing a business strategy is therefore imperative for the university to participate in the technology market. This involves preoccupation for results and a research quality control system focused on knowledge users; client relationship management; and a service marketing strategy.

Successful experiences in institutional methods for technology transfer reveal that one of the strong points has been the introduction of business practices in management to effectively meet goals in the university-company-government interface. In this context,

good management practices require a high degree of professionalization, mainly to be able to correctly link knowledge management with intellectual capital management.

Among the most important organizational factors, the definition and stability of institutional policies has proven to be critical to foster collaboration between universities, productive sector and the government. However, it is not enough that policies be translated into laws and regulations, they need an organizational structure to be implemented and to be known by the university community, and be connected with all operational levels.

Institutional policies must consider technology transfer in performance evaluation of faculty as well as clear guidelines to deal with sharing extraordinary income, management of conflict of interest and promotion of faculty's start-ups. Organization performance is the product and reflection of how people perform when they get involved in start-up activities.

In Mexico, there is a lot of work to do regarding professionalization in the execution of technology transfer activities. This is why it is necessary to make an effort to document experiences and good practices. This will help with professionalization and the construction of a regional management theory for technology transfer, adapted to the conditions of the country and its institutions. There are interesting cases of national institutions that have been successful in technology transfer and implementing sound policies. This could be the base for a system of good practices fully adapted to local

conditions as well as for training programs for technology transfer officers. Currently, some training efforts and government programs are oriented to bring models from countries such as Great Britain, Israel and USA to Mexican organizations. Success of these training efforts requires a blending approach in which adaptation to local conditions should be properly considered.

Taking universities' business strategy into consideration, there are still niches unexplored by universities that could become additional income sources by broadening their service portfolio. There are many options and a suitable management must be linked to selective and systematic exploitation, based on own characteristics and on actual market demands. Mexican universities need to develop plans to foster the evolution of their forms of technology transfer giving emphasis to developing research capacities aligned with local industrial needs.

We can't put aside the role of the State. In all the successful cases, public policy has been decisive for the progress and consolidation of institutional models for technology transfer. Public performance should not be limited to defining laws. Legal frameworks should be accompanied by actions for institutional capacity building, promotion and financing of cooperative activities between universities, R&D centers, and companies.

References.

Betz, F. (1996) "Industry/university centres in the USA - Connecting industry to science". Industry & Higher Education 10 (6), 349-54

Brooks, H. (1993), "Research Universities and the Social Contract for Science" en "Empowering Technology. Implementing a U.S. Strategy", MIT Press, Massachusetts

Chesbrough, H. (2003), "the logic of Open Innovation: managing Intellectual Property", California Management Review vol. 45; pp. 33-58

CONACYT (2006), Encuesta nacional de innovación, Consejo Nacional de Ciencia y Tecnología, México, D.F.

Del Bello, J.C. (2007), "Gobernanza de los institutos públicos de investigación en América Latina y el Caribe", I Reunión Hemisférica de la Red de Ciencia, Tecnología e Innovación, April 16-17, Washington, D.C. Inter-American Development Bank

Fischer, R. (2008), "*Innovation and Excellence Clusters: Experiences and Solutions from Fraunhofer Institutes*". Innovation and Development Forum, Chile (http://www.expoalemania.cl/docs/presentaciones/ForoInnovacion/FischerFraunhofer.pdf)

Foro Consultivo (2011), Ranking nacional de ciencia, tecnología e innovación, Foro Consultivo Científico y Tecnológico, México, D.F.

Gambardella, A. (1992), “Competitive advantages from in-house scientific research: the US pharmaceutical industry in the 1980s”, Research Policy Vol.21, pp.391-407

Gibbons, M. (1994), “Innovation and the Developing System of Knowledge Production”, The Trinational Summer Institute on Innovation, Competitiveness and Sustainability, Whistler, B.C. Canada.

Hertog et al. (2003) “Introduction and Overview. In: OCDE, Turning Science into Business – Patenting and Licensing at Public Research Organizations”. Paris, Francia.

Leydesdorff, L. and Etzkowitz, H. (1996). "Emergence of a Triple Helix of University-Industry-Government Relations," *Science and Public Policy* 23, 279-86

Mehlman, S.K., Uribe-Salcedo, S., Taylor, R.P., Slowinski, G., Carreras Ed & Arena, C. (2010). “*Better practices for Managing Intellectual Assets in Collaborations”. Research Technology Management,* 53(1): 55-66.

Nelson, R. and Rosenberg, N. (1993) “Technical Innovation and National Systems”, en Nelson, R.R. (editor), National Innovation Systems: A Comparative Analysis. Oxford University Press.

Rappert, B. and Webster, A. (1997), "Regimes of Ordering: The Commercialization of Intellectual Property in Industrial-Academic Collaborations", Technology Analysis & Strategic Management 9(2) 115-130

Raymond, S, and Nichols, R. (1996) "Partnerships linking Technology to Economic Growth: Case Experience from around the Globe". In: Linking Technology to Economic Growth and Development. New York Academy of Sciences. .

Ritter, dos Santos M. (2005), "La Gestión de la Transferencia de Tecnología de la Universidad al Sector Productivo: Un Modelo para Brasil" . Facultad de Contaduría y Administración, Doctoral Thesis . UNAM, México.

Rothwell, R. (1993), "The changing nature of the innovation process" paper presented at the conference on New Technology-Based Firms in the 1990s, Manchester Business School, 25-26 June.

Rush, H. et al. (1995), "Strategies for best practice in research and technology institutes: an overview of a benchmarking exercise", R&D Management 25, 1, 17-31

Sábato, J. and Botana, N. (1968) La Ciencia y la Tecnología en el Desarrollo Futuro de America Latina (*Science and Technology in the Future Development of Latin America)*. Paper presented at "The World Order Models Conference", in Bellagio, Italy, September 25-30, 1968

Solleiro, J:L. y López, R. (1994), "La experiencia reciente de vinculación universidad-empresa en México" (*Recent experiences in university-industry interface in Mexico)* in Plonski.A. "Cooperacao Universidade-Empresa" (*University-Industry cooperation)*, CYTED Program, Sao Paulo

Solleiro, J. et al. (2009) "Informe narrativo final" (*Final narrative report)*, project: Gestión del conocimiento y creación de valor en centros de I+D (*Knowledge Management and value creation in I+D centres)*, FLACSO-IDRC, México, D.F.

Stal, E. (1998) "Centros de Investigación Cooperativa y las motivaciones de las empresas" *(Cooperative Reasearch Centers and company motivation)* XX Simposium on Technology Innovation Management. São Paulo, SP. November 17 to 20.