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**Proceedings of the 7th International QMOD Conference Management Challenge of the New Millenium in Monterrey, Mexico, August 4-6, 2004**

Citation for the published paper:

Alänge, S. ; Ardila, A. ; Scheinberg, S. (2004) "The Quality of a Regional Innovation System - the case of Querétaro, Mexico". Proceedings of the 7th International QMOD Conference Management Challenge of the New Millenium in Monterrey, Mexico, August 4-6, 2004 pp. 21-37.

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# The Quality of a Regional Innovation System - the case of Querétaro, Mexico

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The purpose of this study is to identify innovation patterns and to explore barriers/facilitators to innovation in a regional innovation system. One major problem identified was a lack of connectivity between the stakeholders. Hence, this regional innovation system on one hand produces quality products but on the other hand it is fragile and built on weak links and misperceptions. These weak links stands as a threat for its future ability to develop product and process innovations.

Keywords: Innovation System, Research, Network, Quality, Product Development

## Introduction<sup>1</sup>

The Querétaro region of Mexico has five major public and private universities, several national research institutes, many large manufacturing companies and a substantial number of small and medium-sized companies. The automotive industry is strong in Querétaro and suppliers to the car industry have received several quality awards as world class suppliers to the North American automobile industry. Still, there is very limited product and process innovation in the local industry, although a considerable amount of research is being conducted, both in universities and in research institutes.

The focus of the quality movement is gradually shifting towards managing for innovation, agility and focus on the future (Baldrige 2004). Still the focus of enquiry has primarily been directed on the individual firm, although there has been an understanding that without excellent suppliers there is no possibility to offer world class performance (Alänge 1994). However, in parallel fields, an awareness has emerged that in order to develop an understanding of innovation processes there is a need of looking at the firm in a system or network perspective (e.g. Freeman 1987, Håkansson 1987, Lundvall 1992, Etzkowitz & Leydesdorff 1995, Edqvist 1997, Alänge & Lundgren 2000).

This study is based on an innovation system perspective. Data was collected through interviews with different types of stakeholders such as firms, universities, public research institutes, banks and government organizations in order to explore their participation in the development of new products and processes. The purpose is to identify innovation patterns and to explore barriers/facilitators to innovation.

There are six sections in this report. Section 2 presents a brief overview of the theoretical underpinnings for the importance of innovation and entrepreneurship for the economic development of a country. It also points to the importance of not only considering the development of individual firms, but that firms develop in relationship to other firms, universities, financial organization and in a context regulated by laws and culture, i.e. in what conceptually can be described as an innovation system. In section 3, the research methodology

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<sup>1</sup> We would like to thank all the interviewees for their openness and readiness in supporting the study. Also we would like to thank Concepción Bernal, Cecilia Bustamante, Manuel Espinosa, Roberto de Holanda, Alejandro Lozano and Gilbert Munoz for their participation in the main study (Alänge et al. 2001 and 2004), and Alexandra Noriega, ITESM, for her input during the analysis sessions. We would also like to thank Chalmers, CONCYTEQ, ITESM, Recomate AB and STINT for financing different phases of data collection and research cooperation.

and research questions are outlined. Section 4 presents the empirical findings followed by the discussion section 5. Finally, the conclusions are presented.

## Innovation Systems and Local Research

A characteristic of developed industrial nations is the capacity to innovate and create new products, new production processes, and new ways of organizing operations and distribution. The importance of innovation for economic development and job creation has long been recognized and in this context, the specific role of the entrepreneurs and the start-up of new companies have been emphasized (Schumpeter 1911 and 1934). The first half of the 20<sup>th</sup> century saw the gradual development of in-house research capabilities in the large corporations and the R&D laboratories of large firms assumed an important complementary role in the creation of knowledge needed for innovations (Schumpeter 1942). However, firms typically develop in relationships with other firms and organizations, including universities and research centers: this has been expressed in terms of concepts such as “development blocs” (Dahmén 1950), clusters, networks or systems. Specifically, the concept of “innovation system” has been used when studying the participants and their environment, including the regulatory mechanisms (institutions such as laws and culture), involved in creating and diffusing new technology and innovations. Innovation systems have mainly been studied on a national level (Freeman 1987, Alänge & Jacobsson 1992, Lundvall 1992, Nelson 1993, Carlsson 1997, Edquist 1997, Alänge & Lundgren 2000, Lundgren & Alänge 2000), but they can also be of a more local level, as well as transcend national borders (Alänge et al. 1992, Lundgren 1996, Rickne 2000, Holmén 2001, Lindmark 2002). The industrial network approach shows considerable similarities to the innovation systems approach in its focus on the role of interaction among industrial actors in technological development (Håkansson 1987, 1995, Bångens 2001). A further parallel research flow has developed around the ‘Triple Helix’ concept, emphasizing the dynamic cooperation between industry, academy and government (Etzkowitz & Leydesdorff 1995, 2000, Casas & Luna 1997) and the increasingly entrepreneurial role of universities in technological innovation (Etzkowitz et al. 2000, Etzkowitz 2003).

Technological change can be seen as a learning process which is mainly gradual and cumulative in nature. Firms build upon their existing knowledge base when they search for new opportunities, which means that innovation processes often are rooted in the present economic structure, i.e. they are path dependent (David 1988) and largely local in nature (Alänge et al. 1998). This means that there is a risk that firms and other actors in the innovation system risk to become ‘locked-in’ to the ‘old technologies’ (Cohen & Levinthal 1990). There is also a risk that the soft institutional factors, such as values and norms, may block innovation processes, both in individual firms and in networks of firms and other stakeholders. Hence, there has been a growing interest in researching the effect of values and culture on innovation and diffusion processes (Scheinberg 1989, Miconnet 2001). The importance of culture and institutions has also been emphasized by researchers within the area of innovation systems (Lundvall 1992, Lundgren & Alänge 2000)

Innovation processes consist both of the development of new products, services, processes or ways of organizing activities and their further diffusion among the stakeholders of the innovation system. However, the gradual and cumulative nature of technical and organizational change makes it misleading to make a clear-cut distinction between innovation and diffusion, instead a characteristic is that the innovation typically alters in the course of the diffusion process (Alänge et al. 1998).

While the national system is a natural unit of analysis, providing an identical context in terms of rules for economic activity, innovations are often created through interplay of participants from different nations. Hence, innovations are developed in open systems, and there is a need of considering the inputs to and outputs from the system when analyzing an innovation system, as the system borders have always been set through an arbitrary process, based on what makes sense for the aim of the analysis. Correspondingly, a regional open innovation system often has considerable contacts outside the region, but typically the focus of analysis is on the vitality of the cooperation among the participants inside the system.

As mentioned above, a characteristic for developed industrialized nations is the existence of an innovation system where different actors co-operate to create new innovations. This co-operation consists in a dynamic

interplay between knowledge creating organizations, such as universities and research centers, the industry developing and commercializing the knowledge into new products and processes, the financial institutions providing capital, and the governing structures, including the creation of laws and incentive structures. However, this is not typically a characteristic for economies striving to catch-up. Rather, these economies show less signs of integrated innovation systems, more dependency on the external world for knowledge production and technology, and a more fractional structure, sometimes expressed in terms of a “dual economy” (OECD 1999).

Put into a regional context, there are many examples of local growth areas, often built around a specific technology area, including local knowledge production and innovation. The dynamic interplay between university research, entrepreneurship and company formation has been emphasized (Lundqvist 2001), e.g. in Silicon Valley (Rogers & Larsen 1984, Saxenian 1994) or in a new “emergent” form of cooperation in Mexico (Casas and Luna eds. 1999), or in the close cooperation between different small companies, e.g. in industrial districts in Italy (Pyke et al. 1990) or in the Swedish “Småland” small scale industry intensive area (Johannisson 1985). This kind of dynamic cooperation contributes to the creation of employment and to an increased attractiveness of the local region, both for the location of new companies and for established units to remain and expand. Among measures on local level can be mentioned: the development of excellent educational institutions and research institutions, the establishment of incubators for new company creation, the development of communications, the provision of land and facilities. Of specific importance is the creation of meeting places for communication and interchange between industry, academia and government, contributing to the establishment of a culture of innovations. It has to be emphasized that these local growth areas are never totally self-sustained - the contacts outside the local system (including less frequent “weak-ties”, Granovetter 1973) can be of immense importance for its continued development - i.e. it is an open system. Rather, the connectivity locally is the base, i.e. a good information and knowledge flow between local actors, but it is as important that some actors have connections outside the system with excellent research units, suppliers of technology, or market competence. These links outside, which typically can be international, can in a well functioning local innovation system be essential for the development of many companies and local economic activity, provided that there are local arenas or meeting places (Alänge 1987). However, developing countries do not typically show these characteristics of well integrated local innovation systems. Instead, both essential actors may be missing and in addition essential links between the existing actors could be missing, a condition where the local innovation system can be seen as an “infant local network” (Alänge 1987, p. 238-239).

The scientific field of innovation systems has recently grown in importance but the research has primarily been focused on western industrialized countries, and only a few on developing countries (Intarakamnerd et al. 2001). The relationships between globalization and national/local systems seem to be relatively under-researched (Johnson & Segura-Bonilla 2001). Also, the role and implications of large multinational corporations’ activities on regional innovation systems needs to be further explored, as these MNCs in one sense function as semi-autonomous innovations systems, only loosely connected to local innovations systems in host countries. In an even more limited sense research has considered the interplay between different innovation systems in industrializing and industrialized countries.

Recent Mexican studies of innovation processes and networks include Corona Treviño (2001, 2002), Casas & Luna (1999), Casas et al. (2000), Santos Corral (2000), Muñoz et al. (1999, 2001) and Alänge et al. (2001). Corona Treviño (2001) has made a thorough empirical and mainly descriptive study of innovative firms in a regional perspective. The focus is on the “Polo de innovación” (innovation pole) consisting of technology based companies, incubators and science parks, universities and research centers, units for information and technology transfer, and risk capital sources. The empirical data is from the El Bajío region, consisting of parts of the Querétaro and the Guanajuato states. Corona Treviño points out that the appearance of technology based company start ups is a recent phenomena in Mexico and that it shows a cyclic behavior (pp.99-100). Corona Treviño (2002) provides an overview of theories on technological innovation and presents one chapter on Latin American contributions. This book briefly presents the concept of innovation systems, but does not build upon recent contributions in the field (pp.281-282). Casas & Luna (1997) is an edited volume focusing on how Mexican companies evolve over time in relationships with government and academy, and several contributions are based on the Triple Helix approach. They claim that these spatial relations are new and emerging in Mexico. Casas et al. (2000) present an empirical study of the material sciences, biotechnology

and telecommunications sectors and introduce the concept of “emergent knowledge spaces”. They emphasize the importance of regional research institutes for the development of knowledge spaces that possibly can lead to the development of a complete Triple Helix model. Santos Corral (2000) makes an anthropological analysis of how new technology is affecting the behavior of companies and in doing so she makes a comprehensive description of how modernization and technology is affecting telecommunication companies in Mexico. Muñoz et al. (1999) studied how micro and small suppliers to the automotive industry evolved over time. They concluded that the small suppliers showed a clear development during the time span 1991-1999 in all technology related dimensions investigated: machinery and equipment, process technology and product technology, from a weak or medium stage into a medium-high stage. However, they pointed out that the product and process development primarily concerned improvement and not real innovations. Muñoz et al. (2001) studied the problems of establishing relationships between academia and industry in the Querétaro region. They found that larger and medium sized companies were more willing to establish relationships with academia than micro and small firms. They also made a test of actively approaching companies with a portfolio of project proposals and found that this type of active intervention was a door opener leading to the establishment of joint projects between firms and academia. Finally, our pre-study (Alänge et al. 2001) was a first attempt to map the innovation system of Querétaro and to identify weaknesses in the relationship between different stakeholders, leading to the identification of further areas for research.

## Research Questions and Method

This paper is based on a study conducted in the Querétaro region in 2001 (Alänge et al. 2001) with additional interviews in 2003. Five main questions were driving this study (Alänge et al. 2004): 1) What types of innovations take place in the various stakeholder groups within the Querétaro State today, e.g. product, process and organization? 2) What activities are followed and resources allocated to support the innovation process (research and development) in the various stakeholder groups in the Querétaro State? 3) What types of links exist between the various stakeholders to the innovation process? 4) What obstacles hinder the links between the stakeholders and interfere with the innovation process and what supports, mechanisms or resources exist that support these links between the stakeholders? 5) What are the future opportunities and trends regarding innovation and stakeholder cooperation in the Querétaro State? This paper is focused on question 3 and 4.

The following stakeholder groups were identified as being potential parties of the innovation process: 1) Industry: a) Multinational companies (companies that belonged to an international group and had Headquarters abroad), b) National advanced group (large Mexican owned companies), c) National intermediate group (small and medium sized Mexican owned companies), and d) Micro Firms; 2) Public Research Institutes; 3) Universities; 4) Banks; 5) Government Agencies (setting policy for innovation, practically supporting innovation, and funding innovations). Data was collected through 27 interviews in 14 industries, 2 universities, 5 public research institutes, 2 banks, and 3 Government institutions. In addition, existing documents and studies conducted on innovation activities and processes in the region were reviewed.

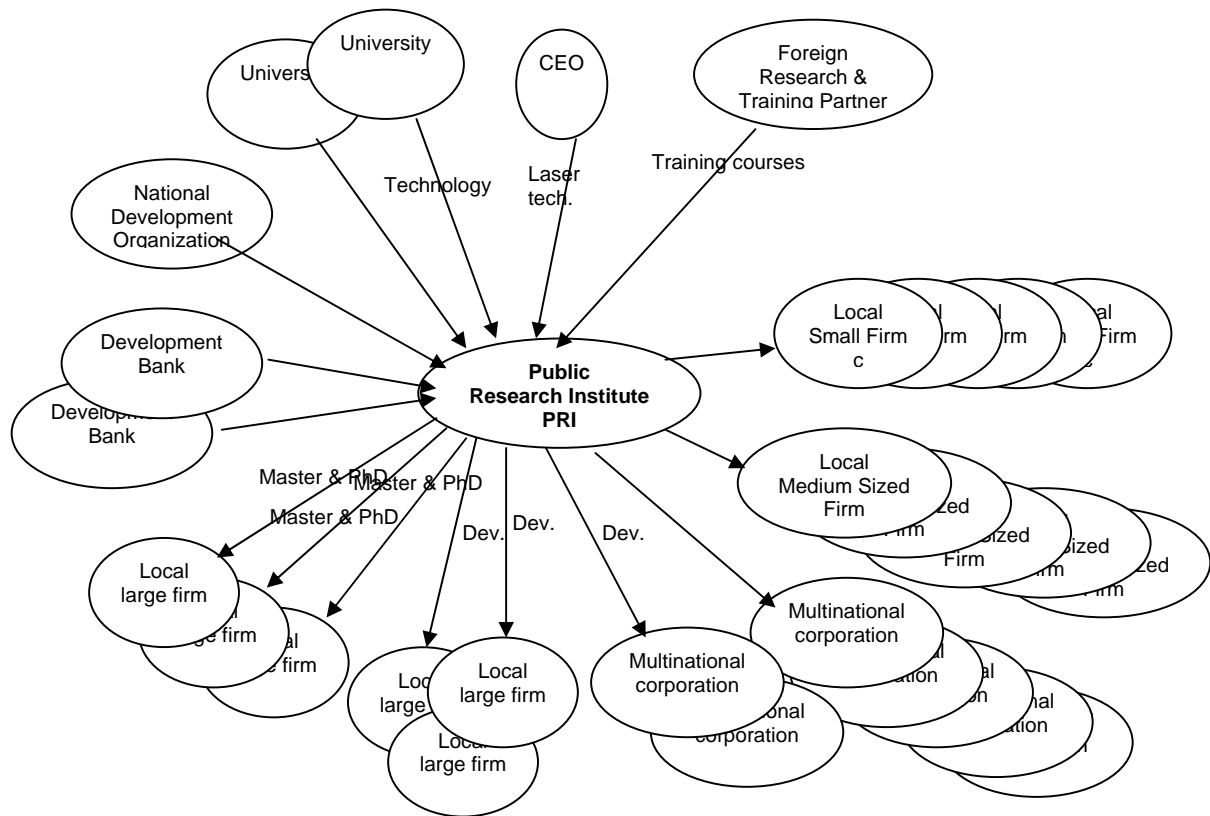
Each interview lasted approximately, 2 to 3 hours. Most time during the visit, was allocated to conducting an in-depth interview. Some time was also used to walking around the organization, in order to observe some aspects of the innovation or production process. To facilitate that similar interviews were conducted in each of the organizations, a series of 3 questionnaires were developed. One interview guide was developed for private organizations, another for universities and research institutes and the third for government agencies and funding organizations.

Each questionnaire was designed with two main sections concerning the current working situation and future possible cooperation. For example, questions were developed to explore the way work, cooperation and innovation was taking place today and how each stakeholder would like to work with innovation and the various stakeholders in the future. For both sections, the stakeholders were asked additional questions, including: a) to explain the process of innovation; b) to describe their relations with the other stakeholders, i.e. industry, universities, research institutes, and Government; c) to describe trends in the business environment;

d) to present barriers and opportunities to cooperation and innovation; e) to make recommendations to the other stakeholders that could strengthen the cooperation

Each interview was led by a research leader, who asked most of the questions, and supported by a research assistant, who asked supplementary questions. The remaining team members were responsible for taking notes and to observe the process. Directly after each interview, the team spent at least 60 minutes to reflect on the interview and to summarize their main impressions. One person was chosen from each team to type up a draft version of the notes in English, which would then be reviewed and approved by the other team participants. A summary case report was written for each company or institution and included the following aspects from the interviews: a) Goals and facts about the organization; b) Innovation process – innovations and evaluation of process; c) Links between the actors; d) Barriers to cooperation between actors; e) Recommendations for a better cooperation between actors; f) Environmental trends; g) Needs for the future.

A four-step strategy was used for analyzing the interviews. The first step was to review the reports that were written, simply in order to get familiar with the various interviews, in order to have an overview of the key issues discovered in each of the aspects, defined above. As a result, a review included evaluating the characteristics of the companies or institutions, type and process of innovations being conducted, level and quality of cooperation with other stakeholders, perceived barriers to cooperate with other stakeholders, awards received, level of internationalization (imports and/or exports), views and needs of the future, etc. The second step was to draw a stakeholders diagram for each organization, see figure 1.



**Figure 1: A stakeholders diagram of a Public Research Institute**

In this way, a map was developed for each organization illustrating the current relations between each core organization and the other stakeholder groups. Each of these maps was analyzed to identify which links existed (to which stakeholders), what types of links were used and not used (e.g. types of cooperation) and what mechanisms supported or hindered these links (e.g. resources, contacts and laws). The third step was to combine each of the above aspects for each stakeholder group. In this way, an analysis could be conducted to

explore the patterns and properties affecting each stakeholder group. Hence an overview was created and portrayed for each of the stakeholder groups. The final step focused on defining the main conclusions that can be drawn from this pilot study. In addition the team also tried to determine what information they were still missing, and what the limitations were for this study. A sketch of the final report was prepared and each member of the research team was responsible for the writing a specific part of it (in Mexico and Sweden). The integration of the final report was carried out by e-mail between Sweden and Mexico, and also by means of a series of coordinating meetings conducted in Mexico in connection with the SEP/STINT seminar in October 2001, held in Querétaro and again in Querétaro in July 2003.

This explorative study is based on a relatively limited number of interviews with stakeholders in the local innovation system. For example, only a few micro and small firms were interviewed and among these firms no professional service providers or consultants were included. This is important to consider due to the fact that these kinds of firms are typically important providers of applied knowledge. There are five major universities in the area, but the findings presented above are based on a limited number of interviews at only two of these universities. Also no interviews were conducted at the federal level, although decisions and actions at this level have a major impact on the local innovation system. Hence, there is an obvious need of supplementary data collection from these categories of stakeholders. Given the limitations provided by the data collection, we still believe that the findings presented here provide a starting picture of the local innovation system.

## The Querétaro Innovation System

Some preliminary findings on what is taking place in the Querétaro innovation system will be presented below. It is based on interviews conducted with stakeholders supplemented by first hand data from within the research group as well as by some secondary data. These findings should primarily be seen as an explorative starting point for continued research.

### Industry

A first observation is that there are large differences in the way innovations are being developed and introduced depending on company type. We found it useful to divide the firms in four different groups, representing some broad common characteristics. The decisive variables used are ownership and size and we decided to use the following groupings: multinational companies, national advanced large companies, national small and medium sized companies, and local micro companies. The multinational companies in Mexico are 51% owned by a foreign multinational corporation, while Mexican owned firms can be from 51% (with 49% foreign capital) to 100% Mexican owned. All in all, we interviewed 8 multinational, 3 large advanced local firms, 3 medium sized, and one micro firm. Additional data concerning the small and the micro firms was obtained through the interviews with the governmental organizations for support of small and micro firms (SEDESU and CCC) as well as through recent studies by members of the research group (Munoz et al. 2001, Espinosa et.al 2001, Espinosa et al. 2003). The two latter reports provided specific insights into the banking sector and the financial situation for small and micro firms.

According to our findings, the *multinational firms* get their new technology and product/process innovations from abroad, and they have a big advantage in being able to finance their investments internationally. In some of the multinational corporations there is a recent tendency that the Mexican units get the responsibility to do local product design and product development. This is visible in the form of a locally developed product range being sold at both the Mexican market and for export, or in the establishment of local research laboratories. However, the multinational firms are not strongly linked to local research resources. Rather they use the public research institutions for simple testing assignments, because of their modern equipment, and they use the universities as suppliers of trained labor and in a few cases for continued training.

In contrast to the multinational firms, the *large advanced national corporations* were found to be the integrators who connect different actors in the local innovation system. They all have in-house resources for product and process development. But among these firms are also the pioneers who commission research projects by universities, and they use the public research institutions not only for testing purposes, but also to

do joint projects or for specified product development assignments. They also use university resources, professors and students, and public research institutions in order to develop their production processes. However, the main cooperation with universities is still focused on their role as suppliers of trained labor, engineers and technicians. A very recent step has been to include the possibility for employees to do their PhD in a program managed by one of the research institutions. In general, however, these large advanced local firms do not yet hire PhDs for their development work.

There is a group of *relatively advanced local small and medium-sized firms* (SMEs) who at present are in a difficult situation, being squeezed by demands from their customers and the difficulty of arranging competitive financing on the local Mexican market. These firms are active on the export market as suppliers and subcontractors, or are directly feeling the competition from imported products after the lowering of import duties. Some of these firms have had a "maquiladora" position, which now is being threatened because there are other countries where the wage level is considerably lower than in Mexico, and hence, their customers are leaving. Among this group of companies are some who have contacts with universities, but the majority, they are working in an independent way without linking up to universities, government or industry associations.

The *local micro firms* are in a very difficult situation mainly trying to survive from day to day. The thought of product development requiring substantial development time is far beyond their reality. Capital is very expensive on the Mexican market (2-3 times more expensive than at the international market during in 2000-2001) and these small firms have very limited possibilities to obtain any kind of loans. There are still some minor programs for product/process development from the Federal Government or Development banks - but these programs are not known to most of the firms in this group. The micro firms are not well connected to universities. There are a few examples of programs geared towards this group from both the private universities and from the public universities, but it is very limited in comparison to the contacts with the larger local firms.

## **Public Research Institutes**

The public research institutes (PRI) interviewed in this study, claim that their financing, which has historically been financed by the Federal Government, is now shifting towards private sources. This is a direct effect of a Government decision to gradually cut the federal financing in order to make the research institutes more market oriented. It remains to be seen if this new market focus will lead to short-term problem solving rather than more long-term joint research. From all of our interviews, both with industry and the research institutes themselves, one PRI stood out as already now being more market oriented. They have been able to focus and finance 98% of their projects based on expressed needs by industry. However, in general, industry representatives were not satisfied with the PRIs response time, and most projects financed, are short term oriented.

Looking into both the PRI's own maps and the maps of different industrial firms we found that a few PRI's can be found in almost all industry maps, i.e. the contacts are shown as reciprocal, both parties interviewed have identified the contacts. Other PRI's seem to have considerably less frequent contacts with the firms interviewed. Looking into the content of the contacts we see that they differ considerably. Some PRI's are primarily sites where industry can test products, as the PRI equipment is advanced, while a few are involved in a steady flow of product development/testing activities for commercial interests. Another important task of PRIs is professional training activities, which in one case also includes a PhD program. The map of one of the more active PRIs was shown in figure 1.

Upon reviewing the PRIs cooperation with universities, there has been virtually no cooperation with private universities, and relatively limited cooperation with public universities. One reason found was that Government funding does not normally go to private universities (in strong contrast to the government financing received by the PRIs). A second reason found was that the research institutes can issue PhDs by their own right, as they are entities directly under the Ministry of Education, and hence do not need to cooperate with universities around PhD education and pure research activities.



## **Universities**

*Private universities* are seen by industry primarily as training facilities and suppliers of trained labor force. The cooperation with industry limits itself to the supply of labor, courses for continued education, and different kinds of training assignments for students on industry sites. Research cooperation between universities and industry is virtually non-existent. The result has been that private universities excel in training activities while their research activities are very limited. This has been further reinforced by the traditional Governmental policy of not making research funds available for private universities.

*Public universities*, on the other hand, receive more Governmental funding for research and hence, there is a certain volume of research going on. However, due to the specific incentive structure in academic world, most activity is still inwardly focused on academic achievement and publication in scientific journals. This inward focus is often condemning any outside oriented focus, where working with industry and solving their problems as applied research is involved. However, we saw some interesting examples of applied research projects directly designed to solve problems for small agricultural and industrial entities. The university unit responsible for these applied projects even saw it as a natural step to form university spin-off companies.

In summary, there have not been many initiatives, from either private or public universities, to establish research cooperation with industries or public research institutes. In our interviews it was an almost uniform view expressed by all interviewees, that universities have to do more, to go out and visit Mexican industry, in order to developing an in-depth understanding of the conditions and problems facing industry today in Querétaro.

## **Development Banks**

There are some Government initiatives geared towards SMEs, but general credit schemes to promote their development seem to belong to history. In general, credits to SMEs are expensive, and in the present economic situation many small and micro companies do not consider loans as a viable means towards development and growth. One of the development banks interviewed, today plays a very limited role, as it has no direct access to funds for providing loans, but instead functions as an intermediary to other funding institutions.

## **Government Organizations**

According to our findings, Government organizations complained about the lack of industry participation in most of the programs they are organizing (e.g. training, consulting, promotion, productivity and quality certification). This lack of industry participation has been defined as being due to a number of factors, including: lack of information, lack of interest, lack of promotion, inadequacy of products offered, inappropriate portfolio of products and activities being offered, or fear of working with Government officials. In addition, Querétaro, with both federal and state agencies dedicated for development, runs a risk of having non-coordinated efforts to promote industry development. There appears to be a large overlap in the services being offered by the various agencies. And it was hard for these agencies to differentiate themselves and their profile from the other agencies. However, an interesting example of the activity of a state level agency was found, where it worked to promote the contacts between micro companies and existing federal support funds. It was also found that Federal government institutions are more concerned with innovation than state agencies, but both federal and state institutions have scarce resources for innovation. In addition, there is a general lack of both state and national policies, which promote the development of innovation systems and which consider innovation as a vital component for the creation economic development.

According to traditional Government policy in Mexico, national development programs and public funding have been directed towards solely supporting national companies. Hence, the 51% foreign ownership rule, which defines a non-Mexican company, also puts an end to the participation of this kind of firms in national development programs. However, this rule might also have a detrimental effect on national company development, as it might form a barrier towards a needed increase in cooperation and connectivity in the local innovation system, where foreign owned companies could be a vital component.

## **The Querétaro Innovation System – today and emerging**

Why is the Querétaro regional innovation system, which produces high quality products for export, characterized by limited R&D in industry and poor research connections between industry, academia and government? A characteristic of the Querétaro innovation system is the missing trust between most of the stakeholders. Part of an explanation can be found in that the participants, with some exceptions, typically have a very limited knowledge and understanding of what the other parties are doing and could be offering. In addition, there is a deep mistrust of universities by industry, mainly because of the time conflict expressed by industry's "we want it done yesterday" in comparison to university's need of time for the development of new knowledge. This has been further aggravated by earlier experiences of universities' long vacations as well as labor disputes resulting in frequent strikes at public universities.

Hence, the Querétaro innovation system is characterized by a low connectivity and mistrust between the potential cooperation partners. The driving force to connect has been limited as there has been a limited understanding of the value of research among the business community, at the same time as the academic representatives, both at research institutes and universities have been motivated primarily by incentive systems promoting an inward looking focus on academic publications.

However, there are clear signs of a qualitative shift in the perception of Querétaro as a source for future research and industrial development. The region's traditional strength of being a cheap producer and quality supplier primarily for the automotive industry is quickly fading. In its place is an increased awareness of the critical mass of world-class business leaders and engineers that now exists in Querétaro. Hence, Querétaro region is now perceived as able to offer qualified engineering capability. For example, large companies are now in the process of establishing software laboratories in Querétaro. And at our visits to the larger companies, both the foreign owned and the Mexican, we saw many examples of local product innovation and process improvement. Furthermore, this engineering resource in the region is growing as a result of the substantial number of local universities and public research institutes. This is further enhanced by the fact that Querétaro is seen by professionals as a healthy place live in and therefore attracts many people to move there.

## **Discussion**

In literature (OECD 1999, xx ) it has been pointed out that many countries outside the Western industrial economies share the characteristic of having one modern foreign owned industrial sector internationally connected and another less developed and local, i.e. a dual structure. However, our study shows that the view of a dual character is an over-simplification. Instead of a dual characteristic (OECD 1999), the Mexican industrial sector can, according to our study, be seen more as a system with at least three different groups with distinct characteristics: the multinationals which are poorly connected to the University research, the large domestic firms which are strongly connected but only recently has started to build research ties, and the small and medium sized firms that mainly strive for survival and typically have poor ties to University. In addition, we can add the micro firms, which although being different from the small and medium sized firms, still share their characteristic of not being connected to the universities. One of the main limiting factors for SME and micro firms is that they lack access to financing sources outside the internal Mexican capital market. As capital in Mexico has been considerably more expensive than international capital, this has been a major barrier for the development. This also includes those SMEs, which are based on advanced technology.

As mentioned earlier, a characteristic of dynamic innovation systems is that new technology-based companies are started in order to commercialize the technology. This is, however, not a typical characteristic for the Querétaro region (Corona Treviño, 2001). In our interviews different reasons were brought forward, including the financial system and the focus among capital owners on very short pay back time. It was also pointed out that earlier or existing programs to promote entrepreneurship at universities or in incubators initiated on state level, have recorded very limited success. However, in the Government plan for Science & Technology in 2001 it has been very clearly spelled out the importance of new technology-based business development, which indicates a shift in policy towards new company start-ups.

The "entrepreneurial university", which plays an enhanced role in technological innovation, and which according to Etzkowitz et al. (2000) is a global phenomenon, is not yet visible among the Querétaro

universities. In Querétaro, the development of innovations which could result in commercialization and new company formation is primarily the result of efforts of a few dedicated individuals, working in an academic environment which only to a limited extent appreciates these efforts. However, this resistance from traditional academia is not only a Mexican phenomenon, but exist elsewhere as well, although there the “momentum towards the emergence of the ‘entrepreneurial university’ is exceptionally strong” (Etzkowitz et al. 2000, p.314).

Advanced industry in Mexico has long been under foreign dominance, sometimes being started based on foreign technology and financing, other times being acquired by foreign interests. However, if local corporations are being acquired by foreign multinationals there is a clear risk that essential research areas at universities will lose their cooperation partners, due to other logics of economy in the large foreign-owned multinational corporations, which strive to optimize their R&D activities world-wide. For example, Mexico used to be the world leader for a specific medical product (contraceptives) but the leading local firm was acquired by a large US multinational, which moved their R&D from Mexico to the US (synthetic contraceptives), and hence, the local innovation system was considerably weakened and Mexican research lost its leading position (Larsson 2001). However, in our study we also found examples of the opposite, i.e. that acquired local companies got access to a very strong source of research, which also led to an improvement of the local research competence and activities.

One measure being used to describe an innovation system is its connectivity, i.e. how well different stakeholders within the system are linked. An indication of a low connectivity came from our interviews, where it strongly came out a lack of trust between different stakeholder groups. As is reflected in the federal-state-community structure, a characteristic of the Mexican society is that local or state level organizations are linked to strong centers, typically "Mexico City", in what can be described as a pyramid structure. Hence, as was brought up in the interviews, this has a tendency of leading to a structure where the contacts across different local organizations are less well developed, which may negatively affect the local innovation system.

There were several instances at our interviews where the reasons for actions taken or lack of action was referred to as being cultural. In a more general sense, the lack of innovation and the lack of relationships and cooperation in developing new knowledge, was blamed on “culture” or “our habits”. Other research has shown that culture can have an importance for business formation as well as for what is possible to change in an existing firm (Scheinberg, 1989, Miconnet, 2001). The willingness or rather lack of interest among Mexican company leaders to cooperate and share experiences has been interpreted as a cultural phenomenon. Also the perception among company representatives of research, and then specifically university research has as well been described in cultural terms during our interviews. However, this general reference to culture has to be further substantiated. While it was clear from our interviews that there commonly is a belief in public institutions that all policies, improvements and support programs must come from the “top”, it has to be further investigated to what extent this belief influences the way decisions are made and actions are taken. Several interviewees pointed out that the Mexican work force lack the ability to work in teams in the way required by many multinational companies working according to some form of TQM approach. At the same time, the role of social groups, e.g. the family, has been emphasized. Hence, there is a need to further clarify the role and relative importance of different social groups, including teams and family groups, in the innovation process. We have found many references to the value system in Mexico or traditions, but a thorough analysis of the role of these soft institutions in relation to the influence of hard institutions such as laws and regulations, remains to be made.

## Conclusions

One major problem identified in the analysis was a lack of connectivity between the stakeholders. A majority of the interviewees expressed a lack of trust in other stakeholders, disinterest in cooperation and/or a lack of awareness of the competences and activities of other stakeholders. Hence, the present study examines an existing regional innovation system, which on one hand produces quality products, but on the other hand is fragile and is built on weak links and misperceptions. These weak links stands as a threat for its future ability to develop product and process innovations.

Looking across different company categories, it is clear that there is a considerable difference to what extent and in the way in which innovations are being developed and commercialized. Multinational companies have an advantage in their supply of technology and financing from a global base, but are poorly connected to the Mexican university and research institute system. Larger advanced Mexican firms are beginning to create R&D links with Mexican universities and research institutes, although the major part of their relationships still takes place in terms of supply of trained labor, student assignments and continued education. Medium sized firms, as well as micro firms, are in difficult positions as regards innovation and long-term investment, and as a general pattern, most of these firms are poorly connected to local research and development units. A general impression is that the connections between university research and industry innovation is relatively limited and one major reason mentioned by representatives from different stakeholder groups is the lack of trust.

In an innovation system, the way knowledge is being appropriated plays a key role. However, as of now, proprietary knowledge and patents have not been a primary question on the agenda for most of the potential partners, but they will need to address it in the near future. Another important issue that is barely visible in Querétaro while very prevalent in most industrialized economies is their understanding of the critical role of new company start-ups and university spin-offs. This can be seen as a complimentary road for university research to become commercialized and to contribute to the vitalization of the economy.

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***Appendix: Summary of Stakeholder Organizations Interviewed in Study***

<b>Type of Stakeholder</b>	<b>Name of Organization</b>
Universities	<ol style="list-style-type: none"> <li>1. ITESM</li> <li>2. UAQ</li> </ol>
Public Research Institutes	<ol style="list-style-type: none"> <li>1. CENAM</li> <li>2. CIDESI</li> <li>3. CIDETEQ</li> <li>4. CIVESTAV</li> <li>5. IMT</li> </ol>
Multinational Firms	<ol style="list-style-type: none"> <li>1. Cronstrulita</li> <li>3. Johnson Matthey</li> <li>4. Kostal</li> <li>5. New Holland</li> <li>6. Tetra Pak</li> <li>7. TRW</li> <li>8. Valeo</li> </ol>
National Advanced Firms	<ol style="list-style-type: none"> <li>1. Condumex</li> <li>2. Tremec</li> <li>3. Velcon</li> </ol>
National Intermediate Firms	<ol style="list-style-type: none"> <li>1. EXPOHORT</li> <li>2. Manufacturas Nieto</li> <li>3. Maquinados Numéricos</li> </ol>
Micro Firms	<ol style="list-style-type: none"> <li>1. Galvelec</li> <li>2. Government sources</li> </ol>
Government Agencies	<ol style="list-style-type: none"> <li>1. CONACYT</li> <li>2. Secretaría de Economía</li> <li>3. SEDESU</li> </ol>
Banks	<ol style="list-style-type: none"> <li>1. BANCOMEXT</li> <li>2. NAFIN</li> </ol>