Globelics

Technology Transfer from UNAM's Research Centers to Industry: impacts of its organization and knowledge profile[1].

Leonel Corona Treviño[2]
Javier Jasso Villazul[3]

Background

In some contemporary societies knowledge has become an intensive factor of production. The term "knowledge economy" is used to reflect this fact. One of the characteristics of knowledge economies is their capacity to innovate and diffuse innovations. This depends on the idea, invention or technology at hand and also on a number of other factors including human resources, incentives, funding and management[4]. This depends also on the *milieu* where this takes place with its agglomeration of innovative firms, research universities[5] and research centers (RC), especially important for those innovations that are more scientific and technology intensive.

Research centers are engaged in scientific research (Sc), technology development (Tech), the offer of technical services (S), and teaching activities (t) in domains related to their scientific and technological capabilities. So RCs can be oriented to mainly, scientific,

[1] This paper to be presented in Gobelics (Mexico City September 22-24th) is part of a current research done for WIPO (World Intellectual Property Organization). Therefore, it would be possible for conclusions to differ as it planned to compare performance of UNAM research centers with that of other universities and public research centers.

[2] Facultad de Economía, UNAM, leonel@servidor.unam.mx

[3] Facultad de Contaduría y Administración, UNAM, jjasso@correo.fca.unam.mx

[4] To characterize a country as knowledge society a set of 80 variables has been developed and aggregated in for pillars: innovation, economic incentives, information infrastructure and education. ("The Knowledge Economy, the KAM Methodology and World Bank Operations" Derek H. C. Chen and Carl J. Dahlman, The World Bank Washington DC 20433 October 19, 2005)

[5] "Research" universities are those which "offer a full range of baccalaureate programs, are committed to graduate education through the doctorate, and give high priority to research" There are 88 US universities in 1994. (The Boyer Commission on Educating Undergraduates "Reinventing Undergraduate Education: A Blueprint for America's Research Universities" (http://www.physics.ohio-state.edu/~jossem/REF/144.pdf).

technology or service, depending on their goals and orientations and also the management style. There is no optimal mix of these four functions as the profile of each RC depends on its specific role but it is generally expected that university research centers will be biased towards scientific activities.

OBJECTIVE AND RESEARCH QUESTION(S)

Focusing on the research centers the objective of this paper is to find answers to the following questions:
How the different profiles are related with the Technology Transfer activities of each RC?
How the intensity of technology transfer is changing the RC's organization? The answers to these questions can give some light on the manner in which internal RC's functions are related, and how they are linked externally with the users of their technology. Technology Transfer activities in each RC could contribute to the understanding of the behavior and strategies of RCs for TT activities.

PATENTS AND RESEARCH CENTERS IN THE KNOWLEDGE SOCIETIES.

Nowadays there is a polarised debate between the academic and the economic role of universities and research centers. "The issue of what aspects of academic research should be public – and what private – lies at the heart of each of these debates. The movement of academic scientists into commercialisation of discoveries and inventions has been extolled by some as a new model of academic research, one which facilitates economic and social returns from universities. At the same time, this trend has been criticised by others as representing a socially inefficient 'privatisation' of academic research and as a threat to the ethos of science itself." (Sampat, Bhaven N. 2006).

Therefore a central theme is the conflict that arises on intellectual property rights in relation to scientific research of the research centers and universities, on the boundary relations with the research performed by firms and individuals in the private sector (David, Paul A. and Bronwyn H. Hall,2006).

In general, the patent system is considered an incentive to innovate through the disclosure of the technical details of the innovation. However, for university and research centers' patenting facilitates the commercialization of the discoveries produced by scientific research (Arora et al. 2001). This scientific research performed in universities and RCs is to solve the public good type of market failure through a publicly financed system of research (Arrow, 1962; Nelson 1959; David, 1993, 1998).

Patents become incentives to disclose and to publish scientific discoveries are generated by the priority reward system in science. As a result, the main economic argument for patenting by universities and RCs is not the incentive to invent or disclose, but the incentive to transfer to private firms and to commercialize the generated knowledge. So, in this transfer process patents allowed firms to have the incentives to invest additional R&D in

product and technology development to bring such a product into the market. (Bacchiocchi, E., Montobbio, F. 2007).

As the object of study is the UNAM[6]'s RC, subsequently the commercialization of technology is embedded in the University-industry linkages which occur in a wide variety of forms and appear to be an increasingly important phenomenon that has received widespread attention (Bonaccorsi and Piccaluga 1994). Because of their respective science bases, university technologies are likely to be radical in nature, therefore commercializing scientific research outputs can be an important means by which firms can expand their innovative capabilities.

Therefore, the exclusivity agreement, given by patents, is a useful tool to protect the firm's investment and help ensure that value is appropriated through the commercialization process.(Larry van den Berghe Æ Paul D. Guild, 2008).

Are the Intellectual Property Rights (IPR) working in this direction in Mexico, and in particular in the UNAM`s RC's patents?, or which are the economic basis that motives the process of patenting by the RCs in Mexico? Is the absence of institutions similar the Bayh-Dole Law[7] an important piece for dynamic change in patenting in the Mexican public research institutions? These are questions that orient this paper.

METHODOLOGY

Hypothesis: The degree and ways of the technological transferences depend on the profile of the research center and its management style or type which gives room to technology development activities.
For the comparative analysis the target population is the 29 UNAM's scientific research centers[8].
Surveys will be applied to the Research Center's directors and key personnel to indentify the RC's knowledge profile, in terms of its relative participation of Scientific, Technological, Service and teaching activities (Sc-Tech-S-t). Then the activity profile is correlated with the RC's outputs: publications, thesis, services and patents.
Data sources used are the annual reports of the RCs as well as questionnaire and interviews to people related with the technology transfer activities of the selected RCs. The patent

[6] UNAM stands for the Spanish acronym of the Mexico National University.

[7]The Bayh–Dole Patent and Trademark Amendments Act of 1980 allowed US universities to receive patents and grant licenses, even exclusive licenses, on patents resulting from research funded by the federal government. (Rafferty, M, 2008).

[8] The 29 UNAM's RC are under the Coordination of Scientific Research, CIC (Spanish acronyms). The 17 social and humanities research centers which are under the Humanities Coordination (CH) are no considered in this study. Also there are other research groups in the UNAM's teaching entities, mainly in the graduate programs. So there are other sources of UNAM's patents, beyond the scientific research centers. (UNAM stands for the Spanish acronym of the Mexico National University).

databases will give additional information of the RC´s identified patents: IMPI (BANAPA), USPTO.

Patents are well established indicators of innovation in the literature, but they do not give the whole picture of the technology transfer and unfortunately, the number of UNAM´s patents involved is rather small.

In order to complement the patent indicator of the technology transfer to industry, some RCs cases will be selected in order to find out, through interviews, some other indicators to better capture what is going on between the UNAM's research centers and the productive sector in Mexico. So, 3 research centers out of UNAM's 29 scientific research centers have been selected for specific interviews, considering different levels of patenting: Engineering (23 granted patents), Materials (4), and Chemistry (1)[9].

The knowledge profile and the technology transfer of UNAM`s RCs.

The number of the UNAM patents is small[10]. First this can be explained at national scope by the relatively stagnant number of the Mexican residents patents compare to the foreign patenting in Mexico (Fig 0). Second by the agents involved, as must of the patents are made by individuals 64%, second the firms 30% and only 6 % is coming from research institutions (Data for 565 patents in 2004, Aboites J. 2008). But to have a more detail picture, a focus RCs survey is necessary, considering that the scope of the patents coming or related to science are expected to have a larger impact on society. But there is a different profile of the RC functions, -scientific research (Sc), technology development (Tech), the offer of technical services (S), and teaching activities (t)- which change from RC to RC.

These RCs can be ordered by its relative scientific and technology activities. Then, a first group with strong scientific activities captured half of the research centers

A second group with 5 centers has both science and technology lower profiles.
A third group of 6 research centers have a higher technology profile. Next is the case of the Energy Center which has a technology as well as a scientific profile slightly over the

[9] The interviews are on their way. So the results are not included.

[10] In 2005 the 10 top US universities have 115 patents each on average, from 390 for the University of California to 57 Columbia University, (ipfrontline.com "Top 10 Universities Receiving Most Patents in 2005", Thursday, April 06, 2006 by: USPTO Press Release), meanwhile UNAM had only 5 patents granted (La Ciencia en la UNAM, 2007).

UNAM average (1.4; 1.1[11], respectively). Then this, nearly empty, one research center fourth group profiles needs to be developed at UNAM (Table 2, Fig1).

Table 2 Scientific and Technology profiles of UNAM`s Research Centers (24RC)

	TECHNOLOGY	
	Low	High
High Scientific activity.	GROUP I (12 RC) **Cellular Physiology** Biomedicine, Atmosphere, Nanoscience and nanotechnology, Materials, Chemistry, Biology, Physics, Geosciences, Geophysics, Ecology,and Environmental Geography.	GROUP IV (1 RC) Energy
Lower Sc Activity	GROUP II (5 RC) Geography, Applied physics and advanced technologies, Radioastronomy and astrophysics, Nuclear, *and* Ecosystems.	GROUP III (6 RC) **Engineering** **Biotechnology**, Applied science and technology development, Astronomy, Physical Sciences, *and* Neurobiology.
RC, patenting (number of patents): **High** (5->), Medium (2-4), Low (1) RC with no patents (0).		Source: author elaboration base on CIC-UNAM 2007

e

Although, the small number of RC's patents there are large differences between them. In fact, the 24 UNAM Research Centers[12] can be also grouped considering those with highest (3RC), medium (5RC), and low number of patents (7RC), or even no-patenting, either requested or granted (14RC) (Table2).

[11] The specialized values are calculated for the UNAM RCs, which are mainly scientific. As a matter of fact the scientific average is 58% percentage with a range of up to 85% (Geophysics) down to 30% (CECADET. Meanwhile the technology profile average is 11%, in a range up to 40% (CECADET) down to 0% (Ecology, Geophysics, Environmental geography, and Radio-astronomy and astrophysics. Therefore when a center is classified with a high technology profile means that it is over the UNAM RCs average. In a next research step, adding other RCs profiles these values will differ.

[12] Until July 15th 2008, 24 directors answered the profile question about their research centers activities. The pendant 5 RC`s profiles are: Sea sciences and Limnology (with 1 patent), Genomics, Applied mathematics and systems, Mathematics, and Geology (these research centers with no patents).

Looking both classifications, profile and patenting, 2 out of 3 RCs with high patenting have as expected high technology profile; 4 out of 5 RC with medium patenting have high scientific profile. However, both calcifications give no clear grouping. This is consistent with the correlation analysis that follows for patenting.

Scientific activities lead to the publication of "papers" (pub). So, there is a positive correlation between publications and the number of researchers. Then the size of the UNAM's scientific research centers, measured by its researchers (Inv), increased the publication yield by about 11% (coefficient 1.11). The explanation of the relationship is up to 74%, which is reached with a log-log function (FIG 3):

$$\mathbf{pub = 0.77 * Inv^{1.11}\ ;} \qquad \mathbf{R^2 = 0.74}$$

Similarly, teaching activities measured by the total RC´s finished thesis (either of bachelor, master or PhD levels) are positively correlated that is a 30% scale gain comes from the Research Center size, measured by the number of researchers (Inv), (Fig 4):

$$\mathbf{Thesis = 0.15 * Inv^{1.30}\ ;} \qquad \mathbf{R^2 = 0.71}$$

Services (S) are problem oriented, solving short term industry's organization, and product and process problems, through short studies or routine laboratory practices. Services activities are poorly related with the RC profile indicating that these activities are relatively independent of the others (See Table 3, "Serv" column). This fact shows that the research centers have room for explicit service policies that could be related with their core scientific, teaching and technology activities.

On the other hand**,** as mentioned above**,** patenting (**Po**, granted patents by RC) is not a systematic output of the RCs[13]. However, only a 35% variation is positively correlated with the Technology profile (**T**) and with the creation of an office for technology transfer activities (**Of**). A third (0.3) of the increase on Technology activities gives one additional patent and 1.3 patents, in ten years, with the establishment in the RC of a Technology Transfer Office:

$$\mathbf{Po = -1.20 + 0.32T + 1.3\ Of\ ;} \qquad \mathbf{R^2 = 0.34}$$

Then for explaining the rest variation (66%) other more specific indicators are needed. Some explanation could be found looking at the inventors as it has been observed that patenting is, generally, concentrated in some few researchers[14].

[13] The Mexican RCs have few intellectual property protection cases. Solleiro JL (2004).

[14] Two example of this concentration are: In the case of the Engineering Institute 4 researchers out of 84 invented 10 out of the 15 patents granted. The 2 patents granted to de Atmospheric Center are of one researcher.

Research Center´s organization type.

The UNAM RC's organizations are the kind of a central structure based on research areas grouping researchers and its research projects. There are slightly variations between them, regarding the way of including laboratories either by area or functioning horizontally as an input for the research projects demands (as it is the case of Chemical and Atmospheric RCs). Then, mainly the organization structure made no difference to its technology transfer or patenting. However, the 29 Unam's research centers have an explicit policy for linking its research activities to the production or societal demands, but only half have a Technology Transfer Office (TTO)[15].

The degree and type of technological transference depend on the profile of the research center and the management style or type. Thus, the scientific RCs have a high and medium transference, the technological ones a medium and associated to consultancy, tests and resolution of problems transference and the teaching activities have a low and associated to courses that have little impact in the innovation transference of technology. In addition these profiles are associated to administration styles and organization in each RC. Thus the RCs with a higher degree of technological transference are those in which the administration style is closest to the demand (sector) and to the drive that the director provides to obtain additional resources to the budget granted by UNAM (entrepreneurship style). In contrast those RC in which the "non entrepreneurship" management style is embedded in the Scientific organization the technological transference activities are not impelled. The expected results are summarized in the following table 4.

Table 4: Management Style and Technology Transfer

Center Profile	Management Style-Type	Grade of technological transference	Cases
Technological	Entrepreneur	High	Engineering, Biotech
Scientific	Mixed Scientific-Entrepreneur	Medium	Materials, Biomedicine
Scientific	Non-entrepreneur	Low	CECADET IIMAS

[15] Astronomy is an exception, as its external office is more oriented to divulgate astronomy scientific knowledge to society. However it is doing important technology research which is related to astronomy instruments requirements.

Conclusions

There is an stagnate context for patenting in Mexico as the residents maintain an average flow of about 500 patents per year in the period 1990 to 2006. Because foreign patents increased, the resident patenting participation drops from 13% in 1990 to 4 % in 2006.

Mexico's Research centers patenting match with this low numbers. Then a diagnosis is necessary, as research centers technology transfer is important in the context of the knowledge society. A first approach is to relate the RC profile - in terms of its relative participation of Scientific, Technological, Service and teaching activities. The findings for the UNAM's RCs are the followings:

UNAM has a low number of patents than other research universities in other countries (See note9). This small patenting is partially explained, up to 34%, by the RC technology profile and the establishment of an Office of technology transfer. So, other more specific indicators are needed. One line of research will be to look at the concentration on patenting in few researchers (See note 12).

Services activities are weakly related with the RC's core activities, which could be explained by a casuistic pattern service demand behavior. As an alternative it is possible to consider explicit RC's policies of offering services that could be related with the scientific, teaching and technology activities.

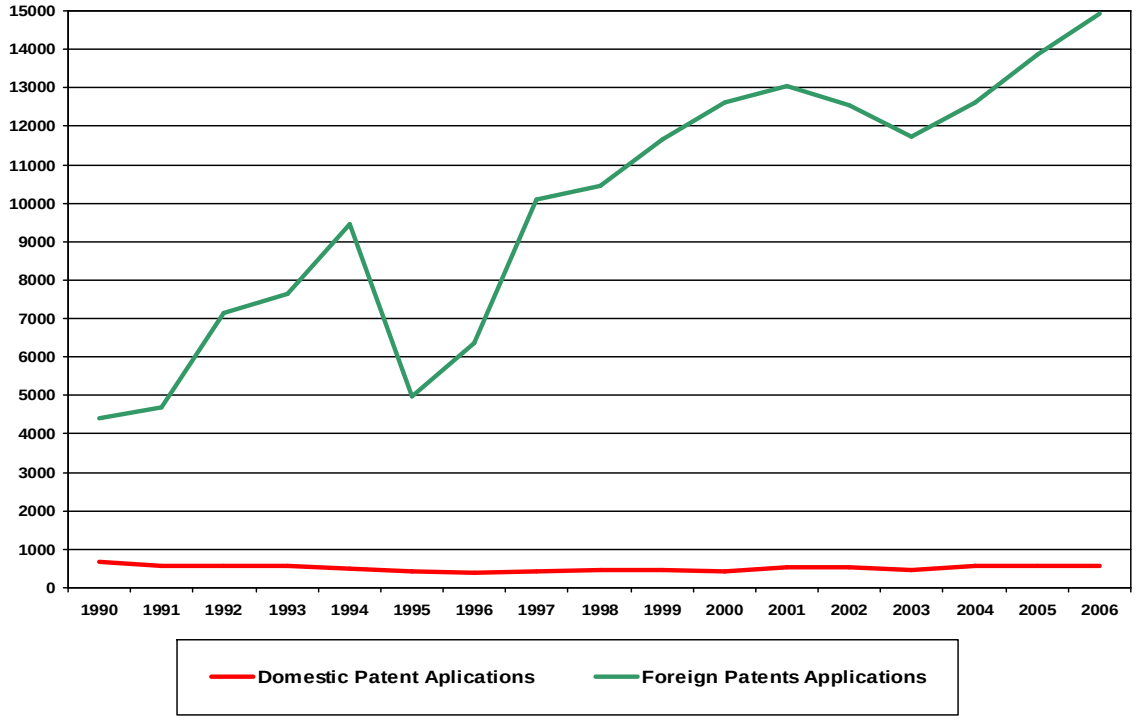
Scaling up RCs, measured by its researchers, has a low impact on the numbers of publications (11%) and a medium impact on the number of thesis (30%).

Even though the UNAM RC's organizations have a central structure based on research areas grouping researchers and its research projects, the orientation towards an entrepreneurial attitude related with applied science and technology has a positive impact in the transfer of technology activities.

A twofold research is necessary in order to complement these conclusions: one at institutional level for capturing both the incentives and barriers for technology patenting and the position of the technology transfer relationship in the context of the RC´s pattern of linkages; and, second a particular study of selected RCs, interviewing their research inventors.

NOTES: CNyN, IQ , IF share the point (0.5;1.2); CCADET , II share the point (3.7;0.5)

Fig 1 Applied Patents in Mexico 1990-2006



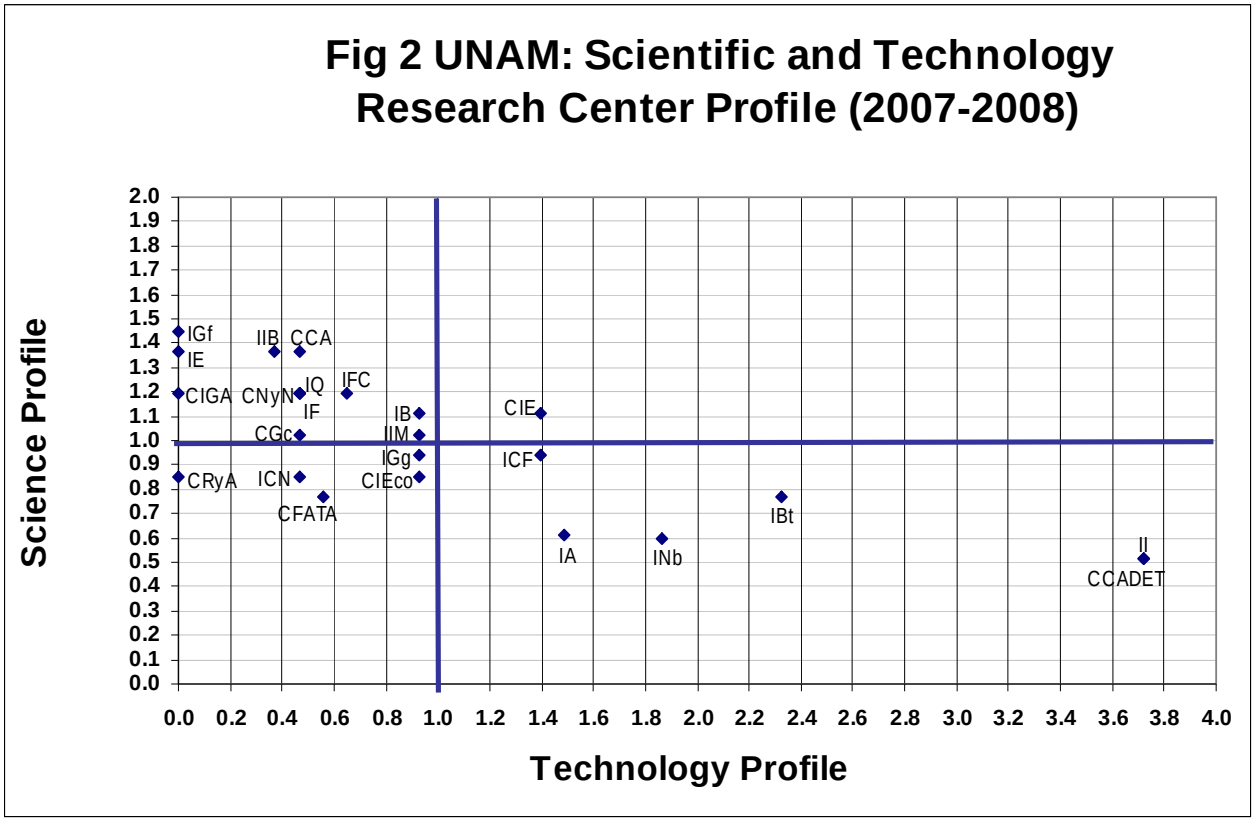
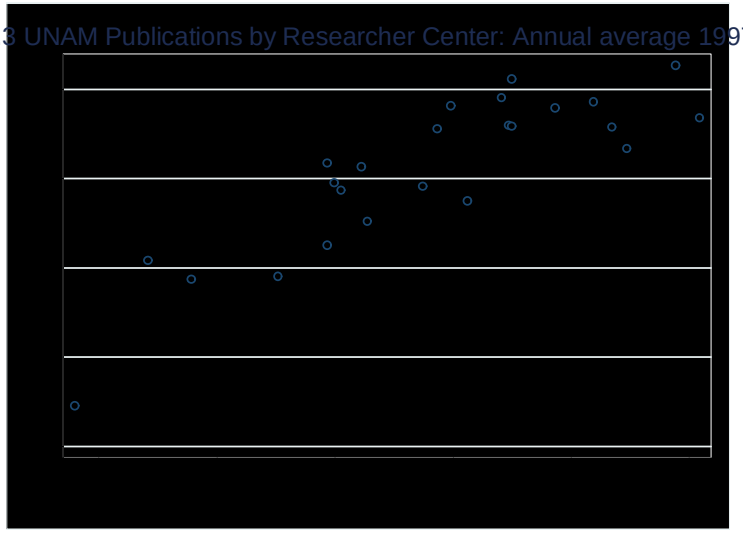
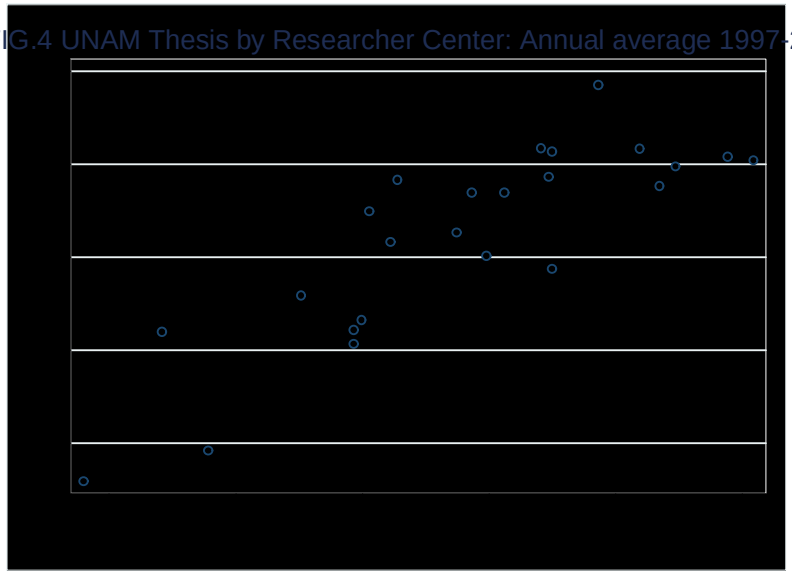


FIG.3 UNAM Publications by Researcher Center: Annual average 1997-2006



Log-Log correlation: **pub= 0.77 * Inv $^{1.11}$;** **R^2= 0,74**

FIG.4 UNAM Thesis by Researcher Center: Annual average 1997-2006



Log-Log correlation: **Thesis = 0.15 * Inv $^{1.30}$;** **R^2= 0,71**

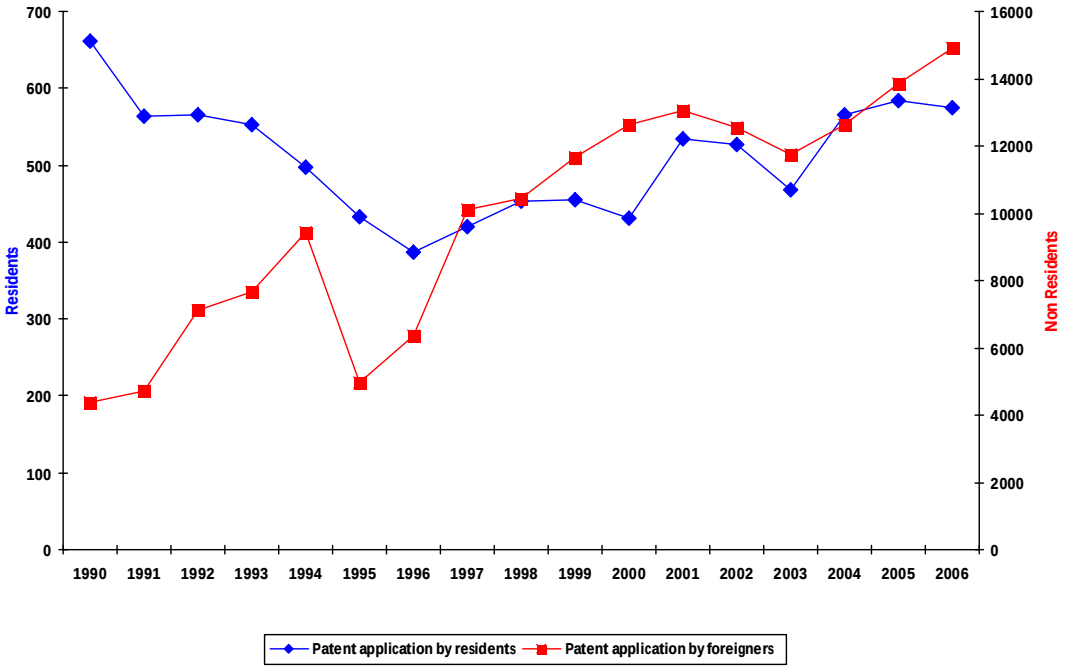
Table 3. Correlation matrix of UNAM`s Research Centers Variables: 24 RC

	RC PROFILE (1)									
	Sc	Tech	Serv	Teaching	Pat	inv	pub	thesis	foundat	office 01
Sc	1.0000									
Tech	-0.7553	1.0000								
Ser	-0.4494	0.0551	1.0000							
Teaching	-0.5005	-0.0287	0.0476	1.0000						
Patenting	-0.3236	0.5764	-0.2147	-0.1214	1.0000					
inv	0.2041	0.0869	-0.3135	-0.2918	0.4359	1.0000				
pub	0.1559	0.0941	-0.2064	-0.3058	0.2207	0.7355	1.0000			
thesis	0.1103	0.2975	-0.4141	-0.4405	0.6231	0.6403	0.6603	1.0000		
foundation	0.1463	0.0182	0.0317	-0.3293	-0.0665	0.5338	0.7191	0.4593	1.0000	
Office 01	-0.0606	0.2725	0.1133	-0.3772	0.2556	0.0872	0.0612	0.2638	0.1979	1.0000

1. Profile: Science, Tech, Services and Teaching make the profile of 100% of the whole Research Centers activities.

2. The following variables are for 10 years: 1997-2006
   Pat, Patenting.
   Inv, number of researchers by RC
   Pub, publications by research center, RC.
   Thesis, bachelor, master or PhD levels.
   Foundation, is the age of the research center until 2008.
   Office 0-1, Office for external relationships, mainly Technology Transfer: 0, none, 1 if there is an Office.

Fig 1 Patent Application by Residents and Non-Residents 1990 - 2006



REFERENCES:

Aboites Jaime (2005) "The inventing activity in Mexico seen thought patents" Presentation WIPO National Roundtable on Economics of Intellectual Property, Mexico, UNAM 28-29 January 2008.

Arechavala-Vargas Ricardo and Claudia Diaz-Pérez (2006) Environmental demands and strategy construction in Mexican Research and Development Centers, PICMET '06 Conference

Arora, A., Fosfuri, A. and Gambardella, A., (2001). Markets for Technology: The Economics of Innovation and Corporate Strategy, The MIT Press, Cambridge MA.

Arrow, K. (1962). Economic Welfare and the Allocation of Resources for Invention, in The Rate and Direction of Inventive Activity edited by Richard Nelson. Princeton University Press, 609-625.

Asomoza, René (2008) "Estrategias de articulación para el fomento a la competitividad", Congreso ADIAT 2008, México Acapulco Gro

Bacchiocchi, E., Montobbio, F. (2007). Knowledge Diffusion from University and Public Research. A Comparison between US, Japan and Europe using Patent Citations. Journal of Technology Transfer.

Bonaccorsi and Piccaluga 1994

CIC-UNAM (2007) La ciencia en la UNAM 2007, a través del subsistema de la Investigación Científica, UNAM México.

Cooper H. Langford "Measuring the Impact of University Research on Innovation" University of Calgary Canada.
http://www.utoronto.ca/isrn/publications/WorkingPapers/Working00/Langford00_Measuring.pdf.

David, Paul A. and Bronwyn H. Hall (2006) Introduction: Property and the pursuit of knowledge: IPR issues affecting scientific research, Research Policy 35 p767–771

David, PA (1998) Common Agency Contracting and the Emergence of "Open Science" Institutions. The American Economic Review, Vol. 88, No. 2, Papers and Proceedings of the Hundred and Tenth Annual Meeting of the American Economic Association. (May, 1998), pp. 15-21.

Nelson R. R. (1959) The simple economics of basic scientific research. Journal of Political Economy, 67:297–306.

Sampat, Bhaven N. (2006) "Patenting and US academic research in the 20th century: The world before and after Bayh-Dole" Research Policy 2006, Volume 35, Issue 6 Pages 772-789

Solleiro, José Luis (2004) "Gestión del capital intelectual en centros de I&D". Economía Informa, Num. 330; Octubre 2004.

Rafferty, Matthew (2008) "The Bayh–Dole Act and university research and development" Research Policy 37, 29–40.

Van den Berghe, Larry and Æ Paul D. Guild (2008) "The strategic value of new university technology and its impact on exclusivity of licensing transactions: An empirical study" J Technol Transfer 33:91–103