

# What are the factors driving Academy-Industry linkages in Latecomer Firms: Evidence from Mexico

## DRAFT

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## 1. Introduction <sup>1</sup>

It is now widely recognized that Universities can play a fundamental role on the performance of the firms' innovation activities, because they are the main producers and transmitters of knowledge (Narin, Hamilton and Olivestro, 1997; Cohen, Nelson and Walsh, 2002; Arocena and Sutz, 2001). In the pursuit of innovation, firms interact with other organizations to gain, develop and exchange various kinds of knowledge, information and other resources (Edquist, 1997, 2001). In the context of the so called "Knowledge Based Economy", the reliance of firms on knowledge built in the Universities has become even more important than in the past (Etzkowitz et al, 2000; Brundenius et al, 2008). A major reason for this is an enlargement in the complexity of production (Howells, 2000). So that, many governments of both, developed and developing countries have introduced an increasing range of policies encouraging the involvement of Higher Education Institutes and also Public Research Centers (HEI/PRC) in technology transfer to firms (D'Este and Patel, 2007; Arocena and Sutz, 2001).

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In the case of developing countries, HEI/PRC might be a vehicle through which technologies and organizational forms of advanced countries can be absorbed locally. They have also the potential to generate appropriate technological inputs in close interaction with local firms.

Despite the growing interest among academics and policy makers, there are a number of gaps in our understanding of academy-industry linkages. In particular, most of the literature on this issue has centred on developed countries, and the academic capacities of HEI/PRC. Much less has been written regarding in detail the state and characteristics of academy-industry linkages looking at the firm's perspective, particularly in latecomer countries.

This paper aims to contribute to a better understanding of the modes of Academy-Industry interaction and the factors explaining them in the case of latecomer firms. Structural and innovation effort related factors have been introduced in a logistic model (logit binomial and multinomial models), in order to analyse a sample of Mexican manufacturing firms. Linkages with HEI and PRC are distinguished looking for different interaction paths.

The paper is organised as follows: after this introduction, section 2 reviews basic literature on this issue, section 3 describes the data and methods, section 4 discusses the findings, and finally section 5 contains some reflections.

## **2. Theoretical and empirical background**

### *a) Academy-Industry Linkages (AIL)*

Interest in academy-industry links, particularly university-industry, has been object of a vast amount of research (Mansfield, 1991; Narin et al, 1997; Cohen, Nelson and Walsh, 2002; Laursen and Salter, 2004; D'Este and Patel 2007; Brimble and Richard, 2007; Segarra-Blasco and Arauzo-Carod, 2008; Tether and Tajar, 2008). Some contrasting views on what should be the role of the universities and the ideal university-industry relationships have emerged from those works. Scholars under the "Triple Helix" thesis (TH) (Etzkowitz and Leydesdorff, 1995; Etzkowitz et al, 2000) argue that academia should be closely integrated with industrial firms to maximize the capitalization of knowledge. This view is expressed in the entrepreneurial university model focused on the commercialization of the academy knowledge in the form of patenting, licensing, industry collaboration and the creation of spin offs. In contrast with this thesis, scholars advocating the so-called "third mission of universities" (Bell, 1999; Arocena and Sutz, 2005; Gulbrandtsen and Slipersaeter; 2007) have expressed their concern about the entrepreneurial model of academy, because it could jeopardize one of the most important roles of universities, named their contribution to social change and development.

These contrasting views referred above have some important implications for developing countries. As some authors have suggested (Eun, Lee and Wu, 2006; Sutz 2003), to the extend that the TH assigns a heavy importance to the nature of knowledge in newly emergent industries, such as biotechnology and other similar highly innovative activities, it

has minimum relevance for the vast majority of developing countries characterized by the predominance of mature industries producing low-tech products.

As regarding the empirical studies applied from the advanced countries perspective, research on AIL has tended to focus on the academic capacities of IES and PRC to exploit intellectual property rights via patent ownership agreements, academic spin-offs, licensing, and collaborative research projects with industrial firms (D'Este and Patel, 2007). Much less has been explored on the process of knowledge transfer between university and industry through other channels, such as personnel mobility, informal contacts, consulting relationships, informal information exchange and human resources training (Brimble and R. Florida, 2007; Mathews and Mei-Chih, 2007). These channels seem to be more important for the case of developing countries.

Drawing from the third mission perspective and from the literature on late industrialization, we argue that the analysis of academy-industry relationships should take into account the differences between the context in the developed and developing countries world.

*b) Late industrialization and the role of the technological/ innovation effort*

As regarding the characteristic of late industrialized countries, we know that a key feature of this group of economies is the absence of new technology, even in leading firms (Amsden, 1991, 2001; Amsden and Hikino, 1993, 1994). Late industrializers have initially not had the competitive asset of pioneering products and processes, which is what differentiates them from earlier industrializers. The absence of pioneering technology means that latecomer firms are more concerned with shop floor productivity and quality than firms that evolved as innovators. Latecomer firms depend on learning; they borrow technology from innovators. In practice, such a characteristic is related to a relatively poor research and educational infrastructure.

The relationships between firms and IES/PRC in latecomer countries are conditioned by that different setting, outside sources of knowledge, are essential to the firm's innovation process. The ability to exploit external knowledge is a critical component of innovative capabilities at the firm level. But it is not costless or a by product of their everyday activities. It implies an effort, meaning an intention, which finds expression in a purposive investment in human and physical resources, and in the time committed to activities aimed at technology mastery (Dahlman and Westphal, 1981; Tremblay, 1998; Romijn, 1999; Wignaraja and Ikiara, 1999; Jonker, Romijn and Szimai, 2004). Technological/ Innovation effort (TIE) of the firms can be measured by variables such as number of employees sent for external training courses, educational levels of the personal, the setting up of R&D facilities and other activities intended to use, create, upgrade, improve and/or strengthen the firms technological/ innovation capabilities (Tremblay, 1998; Wignaraja and Ikiara, 1999; Jonker et al, 2004). One of the main reasons why latecomer firms invest in R&D is that this effort provides them with the abilities to identify, assimilate and exploit outside knowledge.

The intensity of TIE shapes the propensity of firms to interact with HEI and PRC, that is the degree to which firms seeks to draw on new knowledge and to re-use existing knowledge from external sources such as HEI and PRC.

Research has tended to focus on the impact of “structural factors” (such as size of the firms, age, ownership kind and localization) and industry characteristics (such as technological intensity and intellectual property regimens) on the propensity of firms to establish linkages with HEI and PRC. These studies have dealt with very valuable issues bringing about important insights for the analysis of AIL; they have emphasized factors over which firms have a narrow scope to make choices. We presume that structural factors should be complemented with variables giving account of the internal efforts of the firms to develop technological/innovative capabilities. The argument behind this conjecture is that TIE variables could contribute to our understanding of how decisions or deliberate actions around innovation made by firms might be determining the likelihood and the mode of AIL formation. Both, structural and TIE variables have been introduced in our model. A set of hypothesis are advanced below in order to explore the impact of them on the propensity of firms to engage with HEI and PRC to carry out innovation related activities, and whether or not they drive firms to different modes of interaction with HEI/PRC.

*c) Hypothesis emerging from the literature review*

As we have just argued, a significant amount of the research on AIL has centred the analysis on structural variables (Lauren and Salter, 2004). Scholars have analyzed the effect of firm size on AIL. However, the evidence is not conclusive. While Acs et al (1994) found that small firms have a comparative advantage to exploit the knowledge produced in HEI/PRC, Link and Rees (1990) state that larger firms are more likely to establish AIL. Similarly, Cohen et al (2002) and Tether and Tajar (2008) have claimed that large firms have a stronger propensity to establish AIL than the small ones. In the case of the Mexican manufacturing firms, previous studies (Casalet and Casas, 1998) found that between 1995-1998 larger firms tended to engage in AIL in a bigger percentage that the smaller ones. Drawing from earlier studies and facts, a hypothesis regarding size of the firms and probability of AIL can be stated as follows:

**Hypothesis 1.** The propensity of firms to establish linkages with HEI/PRC increases with firm size.

Just few researchers have examined firm’s ownership as a determinant of AIL (Guliani and Arza, 2008). They have found a positive relation between ownership and the appearance of “valuable AIL” for Chile and a negative relation for the case of Italy. In the case of Mexico, bearing in mind the characteristics of foreign firms, we have stated the hypothesis as follows:

**Hypothesis 2.** The higher the percentage of foreign ownership of the firm, the less likely the establishment of linkages with HEI/PRC (taking for granted that most of the R&D projects would be developed in the foreign R&D facilities).

A trend of literature has studied the impact of technological intensity on the propensity to establish AIL. Segarra-Blasco and Arauzo-Carod (2008) found that low tech manufactures were less likely to have AIL. Similar results were obtained by Tether and Tajar (2008). Consistent with the previous research, a hypothesis might be stated as:

**Hypothesis 3.** Firms operating in technology intensive sectors will be more willing to establish linkages with HEI/PRC than firms operating in low technology sectors (It is assumed that the demand of knowledge from HEI/PRC would be higher for the high tech sort of industries).

Several scholars have stressed the major role that R&D activity and R&D intensity play in the likelihood of establishing AIL. They claim a positive effect (Eom and Lee, (2008; Tether and Tajar, (2008; Segarra-Blasco and Arauzo-Carod, 2008).

One of the main reasons latecomer firms invest in R&D is that this effort provides them with an in house ability to identify, assimilate, and exploit outside knowledge. A firm that already has invested in R&D, and has developed in-house capabilities will be more prompted to engage in HEI/PRC linkages than those that haven't. An important factor determining interaction between firms and universities is the technological/innovation effort of the former. Hence, hypothesis can be stated as:

**Hypothesis 4.** The higher the R&D activity of the firm, the higher propensity they will have to establish linkages with academic institutions (it is assumed that this kind of firms would need the knowledge created in the Academy).

The innovative performance of firms has been analyzed for many researchers. The argument is that firms' innovation process would need knowledge created in HEI/PRC (Tether and Tajar, 2008; Segarra-Blasco and Arauzo-Carod, 2008). Consequently the hypothesis might be stated as:

**Hypothesis 5.** The higher the innovative activity of the firms, the higher their willingness is to establish linkages with HEI/PRC (we presume that innovation performance depends heavily on the advance of knowledge from academic institutions).

In the models we introduce two control variables related with the dependent variable according to the literature on AIL: Age of the firm (Giuliani and Arza, 2008; Tether and Tajar, 2008) and membership to a group (Tether and Tajar, 2008; Eom and Lee, 2008).

### **3. Data and Methods**

#### *a) Data Survey Description*

This paper is based on a survey applied to firms operating in Mexico's manufacturing sector in 2008. The survey was designed by the international team. Responses of 334 firms from 19 out of the 32 states integrating the Mexican Country were obtained. A variety of factors were considered in selecting the firms sample such as: size, ownership, geographical location, principal activities and products, firm technological dynamics, R&D and non-R&D performer firms, firms with and without governmental incentives for innovation activities, and firms linked with both HEIs and PRCs.

Eighteen channels of information and types of interactions between firms and HEI/PRC were included at first in our questionnaire. They were grouped into four categories, each one meaning to hold interactions having a similar purpose (e.g the Information category includes publications and reports, conferences and meetings, and other linkages which purpose is the diffusion and exchange of information). Table 1 show the taxonomy used.

**Table 1. Modes of interaction with HEI/PRC**

<b>Information</b>	Publications and reports
	Public conferences and meetings
	Informal information exchange
	Participation in networks that involve HEIs/ PRCs
<b>Human Resources</b>	Recently hired graduates with advanced degree
	Integration of students to research groups
	Short stays of student groups in firms
	Training
	Temporary personnel exchange
<b>Research Services and Products</b>	Licensed technology
	Patents
	Contract research with HEI or PRC
	Consulting with individual researchers
	Joint or cooperative R&D projects
<b>Firm's setting-up</b>	Incubators
	Science and/or technology parks
	Firms owned by a HEI or a PRC
	Spin-off firms from HEI/ PRC

## *b) Statistical and Econometric analysis*

### ***Dependent variables***

Since we are interested in the kind of AIL according to the structural and TIE variables, our dependent variable is the AIL modality. A first model was constructed in order to estimate the probability of manifestation of linkages. Following the four modes of academy-firms interaction taxonomy described in Table 1, our second model estimates the propensity of establishing any of them.

### ***Independent variables***

We classify the variables used in the model in the following way:

### Structural variables

Size of the firm (SIZE), is the total number of employees of the firm.

National ownership (NATION\_OWN), measured by the share (%) of the social capital owned by nationals

Technological intensity (TECH\_INT). We use the OECD taxonomy and it is a dummy variable: 1 if the firm is in a sector of medium-high and high technology, and 0 in other case.

### Technology & innovation effort variables

R&D activity (R&D). It is a binary variable: 1 if the firm performs R&D activities and 0 if it doesn't.

R&D Intensity (INTENS\_R&D). It measures the intensity of R&D activities calculated as the proportion of employees in R&D activities on the total personnel of the firm

Innovative activity (INNO). It is a dummy variable and takes 1 if the firm has introduced product/process innovations in the last three years, 0 otherwise.

### Control variables

Age of the firm (AGE). It is the number of years accumulated since the opening of the firm till 2008.

Group Membership (GROUP). It is a binary variable, Takes 1 if the firm is part of a group or firms, 0 in other case.

### The models estimated

This paper uses logit binomial and multinomial models. Binomial models were estimated in order to explore the likelihood of the firms to establish AIL with HEI and PRC respectively. Multinomial models were built to estimate the relationship between the firms characteristics (structural, TIE, and control variables) and specific categories of AIL with both, HEI and PRC. As already explained, four modes or categories of interaction were used. The principal findings are analyzed in the section below.

## **4. The Findings**

The determinants of AIL

Based on logit binomial and multinomial models, we explore the determinants of AIL. In models 1 and 2, the dependent variable measures whether the firms establish AIL as a function of the independent and control variables. Models were estimated for both, HEI and PRC.

Table 2 reports the results of the two binomial models estimated. Model 1 (AIL with HEI) shows that among firm's characteristics, LnSIZE, R&D and INNO are statistically significant. The negative LnSIZE means that larger firms tend to engage in AIL less frequently than small ones. Both R&D and INNO are positive, implying that R&D, as well as other innovation activities performed by firms encourage the probability of setting AIL. On the other hand, all the other variables are no significant, which means that none of them are deterministic, at least in our sample. The second binomial model estimates the likelihood of establishing AIL with PRC. Results of the estimation show that LnSIZE, R&D, INTENS\_R&D AND GROUP are statistically significant. From Table 2 we know that the coefficient of LnSIZE is negatively related to AIL. In other words, we find similar results than in the HEI case, the larger the firms, the lower is their propensity to engage in AIL. Similarly, the negative sign of the GROUP variable implies that there is a lower probability of a firm to make connections with PRC when the firm belongs to a group. By contrast, R&D and INTENS\_R&D variables are positive, meaning that firms performing in house R&D activities tend to use AIL more than those firms who do not have R&D facilities. A similar relationship derives from the consideration of intensity of R&D activities; the highest the R&D intensity is, the highest the probability of linkages with PRC to appear.

One, in some way, unexpected result is the negative relationship between size of the firms and their tendency to engage in AIL. According to this, large firms will be less prompted than smaller ones to establish AIL. Some factors could contribute to explain these results:

- Large Mexican firms are largely followers, so they carry out R&D to follow the leaders and do not invest to move the technological frontier. They have to solve technological problems but they do not require relying on knowledge generated in HEI/PRC for it. They also have greater resources than small firms, including R&D activities, so that they are able to develop their own projects and to solve by themselves the technological problems that arise.
- Most of the large subsidiaries from multinationals do not require establishing AIL with HEI/PCR from host countries because technological solutions come from foreign corporative R&D centres.
- It seems that we need to take into account not only the size of the firms, but the technological dynamics of their activities.

Table 2. Linkages with HEI and PRC (logit binary model)

Linkages with HEI			Linkages with PRC		
	Coef.	Std. Err.		Coef.	Std. Err.
LnSIZE	-0.425	0.165 *	LnSIZE	-0.314	0.1621 **
TECH_INT	-0.037	0.048	TECH_INT	-0.037	0.0452
NATION_OWN	-0.004	0.004	NATION_OWN	0.006	0.0035
R&D	0.278	0.077 *	R&D	0.198	0.081 *
INTENS_R&D	2.353	1.758	INTENS_R&D	3.632	1.9373 ***
LnAGE	0.221	0.181	LnAGE	0.102	0.1732
INNO	0.168	0.076 **	INNO	0.006	0.0749
GROUP	-0.027	0.055	GROUP	0.1647	0.0536 *

\*p < 0.01, \*\*p < 0.05, \*\*\*p < 0.10

As mentioned in the section on data and methods, we grouped the different types of AIL (18) according to their purpose. The aim is to find relationships between firms characteristics and specific categories of AIL. For that purpose, two multinomial models were estimated; the first for the case of HEI, the second for PRC. Table 3 reveals the likelihood of AIL categories with HEI and PRC respectively

The first multinomial model analyzes the appearance of AIL in the case of HEI . According with our estimations, we find that interactions implying flows of Information presents a negative relationship with LnSIZE. So that, we infer that smaller firms tend to establish more information links with HEI. On the other hand, R&D has a positive coefficient, meaning that more effort in firms R&D activities result in more linkages related to information flows with HEI.

Linkages aimed to develop Human Resources have a negative association with LnSIZE and NATION\_OWN. Therefore, larger size of the firms and larger participation of nationals in the ownership of firms relates with lower frequency of linkages related to human resources with HEI. On contrast, R&D and INNO variable impact positively the appearance of AIL related with human resources.

INTENS\_R&D has a positive relationship with linkages related to Research Services and Products, implying that the intensity of R&D increases the probability of this kind of linkages with HEI.

Firm's Setting-up category refers to those academy activities that can help in the foundation of new firms and facilities. According to the estimations reported, this category has two significant coefficients. The positive sign of NATION\_OWN variable means that national ownership increases the probability of AIL related with this category. Meanwhile LnAGE, with negative coefficient indicates that older firms establish less AIL of this kind.

The second multinomial model analyzes the emergence of AIL in the case of PRC. Information linkages have a positive relation with R&D, INTENS\_R&D and GROUP, implying that the frequency of AIL related to gathering of information increases with R&D activity, intensity of R&D and the membership to a group. Conversely, LnSIZE impacts negatively that sort of linkages.

The propensity of AIL related to Human Resources diminishes with size of the firm (LnSIZE) and technological intensity (TECH\_INT), according to the coefficients estimated.

Links of Research Services and Products have a positive relationship with INTENS\_R&D and GROUP, meaning that R&D intensity and firms belonging to a group increases the probability of this kind of linkages.

Firm's Setting-up has two significant coefficients. NATION\_OWN affects positively the appearance of these AIL, so national ownership rise this sort of links. However, INNO has a negative effect on this category. This implies that innovative firms do not engage in this kind of bonds with PRC.

Table 3. Categories of AIL with HEI and PRC (logit multinomial model)

<i>Linkages with HEI</i>					<i>Linkages with PRC</i>				
Multinomial logistic regression Num obs = 308					Multinomial logistic regression Num obs = 308				
LR chi2 (8) = 81.33					LR chi2 (8) = 71.01				
Prob > chi2 = 0.0001					Prob > chi2 = 0.0001				
Pseudo R2 = 0.0966					Pseudo R2 = 0.0900				
	HEI Category	Coef	Std. Err.			PRC Category	Coef	Std. Err.	
<b>Information</b>					<b>Information</b>				
	LnSIZE	-0.8421	0.3124	*		LnSIZE	-0.5384	0.244	**
	R&D	0.5158	0.2066	*		R&D	0.3581	0.158	**
<b>Human Resources</b>					<b>Human Resources</b>				
	LnSIZE	-0.4229	0.1933	**		LnSIZE	-0.4614	0.2770	**
	NATION_OWN	-0.0087	0.0043	**		TECH_INT	-0.1386	0.0854	**
	R&D	0.2674	0.0928	*	<b>Researching Products and Services</b>				
	INNO	0.1610	0.1610	***		INTENS_R&D	4.4970	2.2066	**
<b>Researching Products and Services</b>						GROUP	0.2725	0.0762	*
	INTENS_R&D	3.8934	2.0991	***	<b>Firm's Setting-up</b>				
<b>Firm's Setting-up</b>						NATION_OWN	1.3539	0.0195	*
	NATION_OWN	0.3004	0.0404	*		INNO	-0.3682	0.2244	***
	LnAGE	-2.6166	1.4134	***					

\* p < 0.01, \*\*p < 0.05, \*\*\*p < 0.10

We can sum up the results regarding the hypothesis stated as follows:

**Hypothesis 1.** The propensity of firms to establish linkages with HEI/PRC increases with firm size.

This hypothesis is not satisfied. Contrary to what was predicted, we found a significant but negative relation between size and the willingness of firms to engage in AIL.

**Hypothesis 2.** The higher the percentage of foreign ownership of the firm, the less likely the establishment of linkages with HEI/PRC

Although the direction of the relationship was rightly predicted, foreign ownership is not a significant variable in determining the engagement of firms with HEI or PRC.

**Hypothesis 3.** Firms operating in technology intensive sectors will be more willing to establish linkages with HEI/PRC than firms operating in low technology sectors.

This hypothesis is satisfied partially because technological intensity (TECH\_INT) was positive and statistically significant for explaining linkages with HEI, but not for CPRs.

**Hypothesis 4.** The higher the R&D activity of the firm, the higher propensity they will have to establish linkages with academic institutions.

The hypothesis is largely satisfied for both, HEI and PRC. Firms performing R&D will tend to use AIL more than those firms who do not.

**Hypothesis 5.** The higher the innovative activity of the firms, the higher their willingness is to establish linkages with HEI/PRC

This hypothesis is partially satisfied, because it works quite well at explaining the case of HEI, but not for PRC.

## 5. Conclusions

This paper began by observing that despite the enthusiasm of researchers for Academy-industry linkages, there are still a limited number of studies searching in detail this issue from the perspective of late industrializing countries. As acknowledging the contributions done to the analysis of AIL by scholars centered on the case of developed countries, we have claimed that some of the results they have found might be misleading when analyzing the case of latecomer firms. Bearing in mind that gap, we decided to focus on structural variables to explore the factors determining the propensity of firms to engage in AIL and the type of linkages they build. We also proposed the introduction of a set of variables capturing the technological and innovative effort (TIE) of the firms. The conjecture underlying this proposal was that the TIE effort allows latecomer firms to be aware of external sources of knowledge, and to be able to use it, and that matters for the establishment of AIL.

Even though this is an ongoing project, the first results obtained in this paper confirms the importance of technological/ innovation efforts (TIE) factors in explaining why some firms establish linkages with HEI and PRC to carry out innovative activities. It appears that whether or not R&D is performed by firms from late industrialized countries like México is important for the establishment of AIL. A similar role is played by the intensity of in-house R&D and innovation activities implemented by the firms. From the logistic models estimated, we found that there is a positive relationship between TIE variables and the propensity to establish AIL with both, HEI and PRC. TIE resulted also significant in determining the likelihood of specific types of interactions with AIL. Thus, the existence of R&D activities within the firms is positively related with the establishment of Information related linkages with PRC and HEI. Intensity of R&D relates positively with Information related linkages in the case of PRC, and with Research Services and Products linkages for both, HEI and PRC. The performance of innovative activities (INNO) has a positive effect

on Human Resources linkages for the case of PRC, and a negative effect on the Firm's Setting Up category.

As regarding the structural factors, we found that size is important. As the literature review showed, this is still an issue under discussion. Ownership and group membership were found also significant. A negative relationship between the GROUP variable and the probability to make connections with PRC emerged from the binomial model. Group memberships have a positive relation with Information linkages. So that, firms organized within groups of business are more enthusiastic about AIL. The same logic applies for the case of linkages involving Research Services and Products. Concerning national ownership of the firms, this variable is positively related with AIL. It seems that national companies are more prompted to use PRC services related to the setting up of new firms and facilities.

This paper makes a plea for more research on how the characteristics of latecomer firms might be affecting the AIL. Overall, we suggest that much more attention should be paid to the role of Technology/Innovation Effort factors in order to explain different AIL paths in developing countries. We see this paper as a first exploration in that direction.

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