What are the factors driving Academy-Industry Linkages? Evidence from Mexican researchers

Arturo Torres (atorresv@correo.xoc.uam.mx),
Noé Becerra (berono@hotmail.com).
Universidad Autónoma Metropolitana- Xochimilco, México

S2.2 Triple Helix study: University-industry-government linkages

Abstract: This paper aims to contribute to a better understanding of the drivers of Academy-Industry interaction from the perspective of the academic researchers. Based on a survey applied to 461 researchers from both Higher Education Institutes (HEI) and Public Research Centres (PRC) in México, individual characteristic as well as those of the groups to which researchers are affiliated have been introduced in a logistic model. The results confirm that factors determining the propensity of the academics to establish linkages with firms are the type of research they perform; gender, and size of the research group they belong to. The probability of AIL is higher when researchers main activity is related with applied science and technological development rather that with basic science. Results suggest that female scientists are less likely to get involved in AI. Finally, the larger the researchers group size, the higher the probability for a scientist to engage in AIL.

Keywords: Academy-Industry Linkages, academic researchers, human and social capital, México

Introduction

Interest in academy-industry links 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 Florida, 2007; Segarra-Blasco and Arauzo-Carod, 2008; Tether and Tajar, 2008). Most of the studies about AIL focus on the firms´perspective (Laursen and Salter, 2004; Eom and Lee,2009), using available data from National Innovation Surveys. Analysis of interactions from the academics perspective is based on ad hoc surveys using different units of analysis (Bozeman and Corley, 2004, Welsh et al, 2008).

Worldwide, and also in developing countries, innovation policy has recently focused on fostering academy-industry interactions, however, it has hardly recognised that academy and firms interact for different reasons. On one hand, firms interact with academy to identify potential employees and access sources of knowledge, which can lead to important industrial applications; on the other hand, academics can get different sources of founding and new ideas for research, and interactions can increase the mobility of researchers and knowledge production and diffusion (Hanel and St-Pierre, 2006). Differences between both perspectives are important to understand the evolution of academy-industry interactions and promote specific policies to strengthen such interactions.

This paper aims to contribute to a better understanding of the drivers of collaboration between academic researchers and firms from the perspective of the researchers in the context of a developing country (México). Determinants will be sought in terms of the individual characteristics of researchers and those of the groups to which scholars are affiliated. It is important to distinguish whether the efforts devoted to creating or nurturing linkages with industry are a function of researchers individual attributes or the result of the individual´s environment (Kenney and Goe, 2004), meaning the institutional setting and the characteristics of their academic community. In prior studies, the set of individual factors includes previous experience, academic status and research fields (Bercovitz and Feldman, 2003; D'Este and Patel, 2007, Boardman and Ponomariov, 2009, Bekkers and Bodas Freitas, 2008), Institutional and research groups (community) characteristics include institutional affiliation (Boardman and Ponomariov, 2009), department characteristics (Schartinger et al, 2001), access to different sources of funding for research (Schartinger et al., 2001; Davis and Lotz, 2006), and type and quality of research (Mansfield and Lee, 1996; Schartinger et al., 2001).

2. Theoretical and empirical background

a) Academy- Industry Linkages (AIL): the researchers perspective

Scholarly studies on AIL have used a number of variables trying to explore differences in the way different characteristics of the researchers could be determining the existence of those linkages and the forms they could adopt. Among them we have a set of researcher's individual and professional attributes such as age, gender, productivity, type of research performed, and scientific discipline. Determinants also have been sought in terms of institutional and collaborative factors, such as the type of institution and group's researchers are associated, networking and other variables akin to these issue. Studies exploring AIL from the researchers perspective can be classified under three main approaches: resource based view; institutional approach and human and social capital approach.

Originally developed for the analysis of the growth of the firms (Penrose, 1959; Prahalad y Hamel, 1990; Barney, 1991), the resource based view (RBV) basic argument is that firms integrate knowledge and other resources to create competitive advantages. The creation of organizational capabilities is at the core of the RBV. Based on this approach, some scholars have tried to explain interactions between university researchers and industry. According to them, just like the firms, academic researchers own a resources stock which can be used to gain competitive advantages. Knowledge and capabilities are developed through their lifetime trajectory, and deployed to perform their research activities. Scholars argue that the RBV can be

a powerful explanatory mechanism for networking among researchers and extra- academic actors such as industrial companies, because through network activity scientist can acquire and assimilate new knowledge (Van Rijnsoever et al, 2008).

Based on this perspective Landry, Amara and Ouimet (2005) analyzed the AIL in Canada for a sample of 1554 active researchers in natural sciences and engineering. They found that researchers in certain research fields were much more active in knowledge transfer to research users. Focus of research projects on users' needs and linkages between researchers and research users are the main variables influencing AIL. Rjinsoever, Hessels y Vandeber (2008) found that researcher networking within one´s own faculty and career development of university researchers are strongly related, while interactions with industry do not.

The institutional approach (IA) highlights the effects that the institutional arrangements of universities, firms and governments have on the interactions among these three agents in order to support the innovative performance of the firms. Three types of institutional arrangement can be distinguished: the National System of Innovation (Lundvall, 1992: Nelson, 1993, Freeman, 1995), the triple helix model (TH) (Etzkowitz y Leydesdorff 1997, 2000), and the new economics of science scheme (Dasgupta y David, 1994). In essence AIL are a consequence of the institutional arrangements, where norms and incentives for the knowledge diffusion drive the dynamic of those linkages.

Human and social capital approach (Bozeman et al, 2001; Youtie et al, 2006; Bozeman y Corley, 2008) gives attention to scientist´s career trajectories and their ability to enhance their capabilities. From this perspective, a researcher possesses individual human capital endowments such as cognitive skills, scientific and technical knowledge and work-related skills. But knowledge creation is not a solitary event; productive social capital network enables the researchers to create knowledge and ideas that otherwise would not be possible. Social capital refers to networks and groups built by researchers through their career trajectory. In addition, Social capital inheres in relations between people and therefore cannot, itself, be owned (Bozeman and Dietz, 2001). Networking with colleagues and other agents constitute the social capital of the researcher. Meyer–Kramer (1998), and Liberman & Wolf (1997) show that the characteristics of the networks help to predict the behavior of the networks members, and presumably to analysis the formation of scientific and technical human capital.

Based on the humans and social capital approaches, this work analyses the effect of the characteristics of researchers as individuals and as members of different groups might have on AIL. We consider human capital as the individual characteristics of academic researchers (professional activity, productivity and gender), and also we use as a proxy of social capital the belonging to a group of research and the size of the group.

c) Hypothesis based on the literature review

Regarding the professional activity of researchers, several studies have showed that applied research and technological development increase the probability to establish AIL (Lee, 1996; O' Shea et al, 2005; Landry et al, 2005). The argument holds that academic researchers involved in applied research and/or technological development get research results that are closer to the firm's necessities than those obtained by researchers dedicated to basic research.

Following this line of research, Lee (1996) analyzed a national survey carried out in the United States in 1990 and found significant differences in the propensity to engage in AIL considering the field of activity. His results point out that scientist from applied disciplines (chemical and electrical engineering, computer science and material science) are more likely to participate in AIL activities than their colleagues from basic sciences and social disciplines. O'Shea et al (2005) by means of econometric analysis observed that researchers of applied fields develop more linkages with industry than scientists in basic science. Finally, Landry et al (2005) examined a questionnaire applied to 1554 researchers from the National Council of Natural Sciences and Research on Engineering in order to identify the determinants of AIL. Their

evidence suggests that the likelihood to establish AIL is higher for applied engineering researchers compared against natural sciences. Accordingly, we propose the next hypothesis:

Proposition 1. Researchers involved in applied sciences and technological development are more likely to build linkages with the industrial sector than the ones devoted to basic science**.**

The relationship between academic productivity, measured by the number of publications, and the activities of AIL has been broadly studied. However, the results are not conclusive. Meanwhile the evidence of Davis and Lotz (2006), Landry et al (2007) and Belkhodja and Landry (2007) found a positive correlation between the rate of publication and the propensity to establish AIL, other scholar detected a trade-off among them (Gittelman y Kogut, 2003; Stern, 2004; Czarnitzky y Toole, 2009). Aiming to contribute in this debate we built the following hypothesis:

Proposition 2. The greater the number of scientific publications, the higher the likelihood to engage in AIL activities.

Another variable used in the analysis of AIL is gender. On this issue, Long and McGinnis (1985) assert that women are less inclined to build links with the industry than men. Leon y Sandoval (2008) got similar results for a sample of academic researchers in Mexico. This kind of outcome is explained by some scholars in terms of the structural constraints that women have to face in the academic environment, for instance less chance to obtain research funding (Fox, 1995). Likewise, the academic departments where female scientists work do not asses properly their role in AIL activities. In this context we derive the following hypothesis:

Proposition 3. The proposensity to establish AIL is less in women than in men.

Recent studies have included the participation of scholars in research groups or in networks of scientist as explicative variables of the establishment of AIL. It is supposed that affiliation to this kind of groups enhances the probability to engage in AIL activities due to the networks influence. For example, Boardman and Ponomariov (2009) found that the larger the social capital, measured by the number of colleagues, the bigger the likelihood to collaborate with firms. Based on this approach our hypothesis states that:

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Proposition 4. Affiliation to a research group or network of researchers increases the propensities to establish AIL.

Most of the studies on AIL have not considered the size of the research team as explicative factor. We assume that the social capital of the individual researcher increases as the size of the team becomes greater and consequently the probability to engage in AIL activities rises. Following this argument, we built the following hypothesis:

Proposition 5. The larger the size of the research group or network, the higher the likelihood to establish AIL activities

3. Data and Methodology

a) Data

This paper is based on a survey applied to 461 researchers working at about 115 different Mexican HEI and PRC in 2009. Responses from individual researchers have been obtained regarding characteristics such as their age, maximum degree obtained, institutional affiliation,

knowledge area, type of research they perform, and affiliation to a research group and to the National Researchers System.[1] The questionnaire also collected data on the characteristics of the research groups such as: size and foundation year of the group, knowledge area, and linkages with other groups.

Wee estimated a logistic regression model to identify the main factors influencing the propensity of the researchers to establish linkages with firms. We grouped the factors driving academy-industry linkages from the researcher's perspective under two categories: individual characteristics and research group's characteristics.

b) Econometric analysis

Dependent Variables

Due that our concern is on analyzing the Academy-Industry Linkages from the researchers' perspective we use as a dependent variable the probability of the researchers to make linkages with firms. To achieve our goal, we built a binomial logistic model which estimates de likelihood of linkages of academic researchers with firms.

Independent variables

The independent variables used in the model are categorized as follows:

Individual factors

Among the individual factors included in the model we have the type of professional activity, productivity of the researcher and gender.

Regarding the professional activity of the researcher we consider three categories: basic science, applied science and technological development, codified as follows:

D_BASIC. Is the category of comparison and indicates that the researcher works in basic science activities and takes 1 in this case and cero otherwise.

D_APPLI. It refers to applied research, and it is a dummy variable. Its value is 1 if the researcher is devoted to applied science and cero in any other case.

D_TECH. It represents the case when the researcher works in technological development. Its value is 1 when the researcher focuses on this activity, cero otherwise.

To measure the productivity of the researcher we have build four categories: non-publications, low, medium and high levels of publication; codification of these categories are as follows:

D_NON. It indicates the case when the researcher does not have any publication and it is the comparison category.

D_LOW. It is assigned 1 when the researcher has from 1 to 5 papers published and cero in any other case.

D_MED. It indicates medium level of publishing and takes 1 if the scientist owns from 6 to 10 publications and cero otherwise.

D_HIGH. It takes 1 if the researcher has more than 10 papers published and cero in any other case.

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[1] The National Research System created in 1984, and grants a pecuniary and status and recognition incentives to researchers based on their productivity and quality of research.

D_GEN. It is a binary variable and takes 1 if the researcher is male and cero if it is female.

Research group factors

As mentioned before we use variables related with research team and networking which are explained below.

D_GROUP. It is a binary variable and takes 1 if the researcher is affiliated to a research group and cero in any other case.

SIZE. This is a numeric variable and indicates the number of members of the research group.

Control variables

We introduced two control variables to make our model more robust: age and affiliation to National Researchers System.

AGE. It is a numerical variable and represents the age of the researcher.

D_NRS. This is a binary variable and takes 1 if the researcher belongs to the NRS and cero otherwise.

We build a binary logistic model to estimate the probability of the researcher to engage in AIL activities. The model estimated is as follows:

$$VINC = \beta_0 + \beta_1 D\_APPLI_i + \beta_2 D\_TECH_i + \beta_3 D\_LOW_i + \beta_4 D\_MED_i + \beta_5 D\_HIGH_i + \beta_6 D\_GROUP_i + \beta_7 SIZE\_G_i + \beta_8 D\_GEN_i + \beta_9 AGE_i + \beta_{10} D\_NRS_i + \varepsilon_i$$

4. The Findings: determinants of the AIL

Based on a logistic binomial model, we have explored the determinants of AI from the researches' perspective. The model estimates the likelihood of the researchers to establish linkages with firms, having as predictor factors the researcher's individual characteristics as well as the characteristics of the research groups to which they are affiliated. Table 1 reports the results.

Regarding the set of variables giving account of the individual characteristics of the researchers, we found that the type of research the scholars carry out as well as the researcher's gender had statically significant coefficient estimates. According to these results, researcher's oriented to applied science and technological development have a higher propensity to interact with firms than those concentrated on basic science. By observing the coefficients (column 2 of the table), we can conclude that the probability of researchers focused on technological development to engage with firms is higher than that of the academics working in applied sciences. Thus, it seems that the likelihood of establishing AIL increases when academic researchers use knowledge to solve practical problems, or for the improvement and development of new process and products. The chances of AIL are lower when scholars carry out research which main purpose is the generation of new ideas and theories, that may not be immediately utilized in the productive sector.

Table 1. Researchers' drivers of Academy-Industry Linkages

Variables	Coef.	prob	
Individual			
D_APPLI	1.684	0.000	***
D_TECH	2.746	0.000	***
D_LOW	0.349	0.339	
D_MED	0.764	0.071	*
D_HIGH	-0.041	0.923	
D_GEN	0.791	0.002	***
Group			
D_GROUP	-0.100	0.733	
SIZE_G	0.300	0.019	**
Control			
AGE	0.013	0.266	
D_NRS	0.267	0.369	
CONST	2.485	0.000	
* p<0.10, **p<0.05, ***<p<0.001			

Gender effect has also been tested by our model. The results obtained are similar to those found in previous studies (Long y McGinnis ,1985; Landry et al, 2005; Boardman y Ponomariov, 2009), were the probability of AIL is higher when male academics are involved. Institutional restrictions as well as the still unequal participation of women in the research system seem to be at the basis of this outcome. Although the impact of sex differences in research productivity and participation of women in science have been analyzed, gender issues require further analysis.

Considering academic productivity, we tested a hypothesis stating that the higher the number of publications of the academic researchers, the higher the probability of them to become involved in AIL. This hypothesis presumes that prolific publications of their works provide academic researchers with an increasing prestige, what in turn increases firm's confidence in academics, all of which increase the likelihood of establishing AIL. However statistically significant coefficients were not obtained in our sample. In fact, there is in the literature a current debate about the relationship between academic researchers productivity and their participation on AIL, that is still unsolved. Analysis such as the aforementioned of Davis and Lotz (2006), and Landry et al (2007), have found a positive association between those variables; while other authors have found the existence of a tradeoff between the participation of academic researchers in AIL and academics productivity levels. More analysis is required about this issue to elucidate the relationship between them.

We tested two hypotheses dealing with researcher group characteristics. The first measured the impact of being part of a group on the researcher's tendency to engage in AIL. The second asked whether or not the size of the group matters to determine the propensity of researchers to collaborate with firms.

According to our results, affiliation to a group is not significant in explaining the likelihood of establishing AILs. However, when this variable is taken together with the size of the group, the model predicts that as the number of academics within research group increases, the likelihood

of a researcher to establish linkages with firms also raises. This could be just reflecting the importance of getting a critical mass of social capital in order to be able to push on the process of linkage with firms. In other words, size of researchers' group matters as long as it reaches a threshold in the number of members.

Deeming the control variables in the model, evidence suggests that they are not significant at least for the sample analyzed. These results indicate that differences in age and belonging to the NRS have no impact in the likelihood of collaboration between academic researchers and firms.

5. Conclusions and Implications

This paper was aimed to contribute to a better understanding of the drivers of collaboration between researchers and firms from the perspective of the academic researchers in the context of a developing country (México). We wish to understand the way in which both, individual characteristics and those of the groups to which researchers are affiliated, determine the existence of AIL. Even though this is an ongoing project, the first results obtained confirms the importance of introducing human and social capital factors into the model, in order to explain why some researchers are more prone to establish linkages with firms.

A body of literature has studied the issue that certain individual characteristics of the researchers matter for the formation of AIL. This line of thought suggests that differences in knowledge skills affect the probability of AIL. Results of the model reported here show that there are significant differences between the type of research academics carry out and the proclivity to link with firms. So, researchers performing basic science tend to connect with firms less than those working on applied research or technological development. It is reasonable to assume that in developing countries like Mexico the contribution of academics to firms innovation does not come from basic research, but from other activities more related to the solving of everyday production problems, and the development of minor technological improvements. Gender is another significant variable explaining the likelihood of AIL to take place. We reached similar conclusions to those form previous studies: evidence points to a higher probability of researchers to engage in AIL when they are male. Institutional and systemic limitations seem to explain this fact. Our sample did not supply evidence to conclude something about the relationship between researchers productivity and AIL, but it is still an issue under debate requiring further analysis.

In our model we have introduced variables measuring in some way the importance of social capital in the configuration of AIL. For the sample of 461 Mexican researchers analyzed we did not find significant relationships between the probabilities of establishing AIL and whether or not the academic researchers are members of a research group. However, when the size of the researchers group is considered, we found a positive relationship between this variable and the probability of the researchers to engage in AIL. Thus, it seems that having a larger group of colleagues interacting and sharing knowledge, creates more possibilities for academic researchers to get involved in AIL; that might be because enlarging one´s own research group increases and diversify networks, both internal and external to the faculty, and that increases the probability of collaboration with firms. Groups and networks are crucial resources for a scientific career; collaboration has useful effects with respect to socialization of knowledge; collective work and cooperation foster the researcher's capabilities, and the ability to develop new network ties and contacts.

Our findings have some policy implications. The importance of gender calls for policies oriented to eliminate institutional limitations that seem to be hampering a more active participation of women in the scientific and innovation system. From the analysis of the impact of different types of research according to the degree of applicability of knowledge to solve practical problems confronted by firms we learned that, in the Mexican case, the probability of researchers focused on applied research and technological development to engage with firms is higher than that of the academics working in basic research. This result seems to reflect the fact

that linkages are related with most profitable activities of firms in the Mexican market in the short term. Policy makers concerned with fostering innovation in firms may find useful to work on this agent perception, showing the potential benefits they could obtain from AIL in both, the short and the long term.

While we were not able to examine other elements and relationships of the human and social capital, such as the effect that different group compositions by research fields, age and degree levels could have on the probability of linking researchers with firms, this first exploration of this type of variables made clear that it is valuable to make further work in that direction. Some additional work has to be done with our data in order to introduce some of those variables to the model.

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