

University-Industry Collaboration. An Exploration of An Entrepreneurial University in Mexico

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Abstract: This research aims to explore the university-industry collaboration in a public university in Mexico. This research considers the researchers' perception of organizational factors and the researchers' characteristics as drivers of the university-industry collaboration. The research design of this study was quantitative. Findings indicate that the researchers' participation in innovation projects is low. The researchers' perception about some organizational factors to collaborate with industry is negative. Data shows that researchers consider it complicated to establish a relationship with industry that is mainly related to organizational factors. In addition, important findings of this study suggest that researchers' gender influence the university-industry collaboration.

Keywords. University-industry collaboration; technology transfer; entrepreneurial university; innovation; Mexico; researchers.

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1. Introduction

Latin American countries, including an emerging economy like Mexico, still face critical social challenges: extreme poverty, malnutrition, high infant mortality, low life expectancy rates and low-quality indicators in schooling. These problems can be related to economic, political, social and other factors that exacerbate this situation, such as the limited investment in science, technology and innovation (Corona et al. 2014). In a NIS is essential the construction of a network of interaction channels between higher education institutions, public research centers, researchers and firms, if not, the entire system does not develop capabilities to enhance innovation, technology and competitiveness (Dutrénit et al. 2010). In Mexico, research projects and the transfer of their outcomes, deal with structural and organizational barriers that arise from a bureaucratic management in universities with low interaction between researchers and productive sector. In addition, knowledge supply and demand are still weak and whereby as limited number of agents participate in knowledge exchanges (Casalet 2013). Therefore, this research aims to explore the university-industry collaboration in a public university in Mexico. This research considers the researchers' perception of some organizational factors and the researchers' characteristics as drivers of the university-industry collaboration. This research is based on data retrieved through a survey applied to researchers affiliated to a public university in Mexico. Our research provides evidence of the key factors influencing the activities of collaboration and transfer of knowledge and technology in the context of a public university in Mexico. In addition, our research contributes with relevant evidence of gender influence to the field of university-industry collaboration.

This paper is organized as follows. In section two we present university-industry outcomes of collaboration, the entrepreneurial university concept, and factors associated to the university-industry collaboration. Section three presents the methodology applied. In section four relevant findings are stated. Section five discusses and identifies

implications according to the university-industry collaboration findings. In addition, this section offers the conclusions of this study indicating the contributions to the field of university-industry collaboration.

2. Literature Review

2.1 University-industry collaboration outcomes

The main competitive advantage of universities in the knowledge market is their competence in generating new discoveries and new approaches to solve problems of productive sector and society (Debackere and Veugelers, 2005, Arocena and Sutz, 2005). The university has been transformed from a teaching institution, to an institution that combines teaching with research (Etzkowitz and Leydesdorff, 2000). In addition to research and teaching, universities have a third role developing more specific tasks such as technology transfer, patenting and commercial outputs (Fichter and Tiemann, 2018). University scientists are seen as agents providing new knowledge for industrial purposes, like innovation (Hsu et al., 2015).

Following Arvanitis et al. (2008) knowledge and technology transfer between academic institutions and the business sector is understood as any activities aimed at transferring knowledge or technology that expect to generate benefits for the parties involved in the transfer activity. D'Este et al. (2019) classify university-industry interaction in four modes of university-industry interactions: firm creation (academic entrepreneurship), technology transfer (licensing of IP), co-production (research partnerships), and response mode (research services). University-industry interactions occurs through diverse activities, these activities include spin-offs (prototypes, licensing), start-ups, contract research, consulting (Wright et al. 2008), collaborative research, exchange of research staff between companies and research institutes, training and the number of Ph.D. theses and the number of Masters theses, jointly supervised with firm members or carried out at firms (Scharinger et al. 2002; Debackere and Veugelers 2005; Wright et al. 2008).

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2.2 Entrepreneurial university

Firms and universities collectively advance proposals for solutions and create value through their collaborative projects (Lascaux 2019). The concept of the entrepreneurial university cannot be limited to the context of research-intensive institutions only (Abreu et al. 2016). An entrepreneurial university is the one supporting and encouraging innovation and entrepreneurship culture, helping technological innovation centers to reduce the bureaucracy within their activities, paying attention to the market and developing research based on technology, helping to generate new companies and, consequently, leading to technological impact (Chais *et al.*, 2018, p. 36). An entrepreneurial university needs an infrastructure to behave as an entrepreneur, therefore it reduces bureaucracy and rework in the activities (Chais *et al.*, 2018). Individuals, organizations or networks are critical in the development and implementation of new proposals (Fichter, 2013).

2.3 Factors associated to the university-industry collaboration

University-industry collaboration involves factors driving and hindering this relationship. This section presents these factors since the university and researchers perspective.

Researchers perceive benefits from research publication, such as promotion and tenure; in addition, researchers expect that collaborative research can increase the practitioners' adoption of their research results for that reason researchers find university-industry collaboration attractive (Rajaeian et al. 2018). On its behalf, university seeks to retain new knowledge co-created in collaboration with the purpose of recombining, enriching, and advancing this knowledge in subsequent research projects (Lascaux, 2019).

Nevertheless, this relationship deal with some structural factors hindering the collaboration. First, researchers may feel pressure through their work colleagues, as well as the confidence on their expertise (Arzenšek et al. 2018). Another sources of pressure are related to the lack of time to prioritize interaction, lack of knowledge of how to get in contact with industry, lack of encouragement to interact with stakeholders, lack of knowledge of how to successfully conduct stakeholders interaction, and lack of funding for interaction (Knaggård et al. 2019), university support scarcity, such as lack of internal rules, weak management process, lack of emphasize of communication and activities to encourage knowledge transfer (Olaya Escobar et al. 2017). Second, universities need to improve the professionalization of internal processes related to innovation and entrepreneurial behavior, and to create policies to be efficient in the transfer and protection of knowledge and technology (Siegel et al. 2004; Bercovitz and Feldmann 2006; D'Este and Patel 2007; Callaert et al. 2015; Ávila et al. 2017; Chais et al. 2018; Fichter and Tiemann 2018). In addition, universities require personnel with expertise in determining the commercial value of research results and in managing research results (Decter et al. 2007; Bozeman et al. 2015; Aragonés-Beltrán et al. 2017; Barletta et al. 2017). Another relevant obstacles are related to financial resources and the lack of an entrepreneurial orientation and intention (Fichter and Tiemann, 2018) and with resources availability (for example: technology) and institutional culture (Ávila *et al.*, 2017). Is important to increase the academics' awareness and understanding of

business' needs. Academics need to know how to develop investment funds, how to apply knowledge, added value, and to speak the same language as businesses (Rivera et al. 2011; Ramírez and Cárdenas 2013; Díaz 2014; Bozeman et al. 2015; Aragonés-Beltrán et al. 2017).

3. Methodology

Our research explores the university-industry collaboration to better understand the influence of organizational factors and researchers' characteristics. This research is based on relevant findings obtained in previous studies discussing the factors driving and hindering collaboration between university and industry. This research implements a descriptive, exploratory and quantitative approach. Our primary unit of analysis are researchers affiliated to a public university in Mexico and participating in university-industry projects. For data collection methods, it was carried out a survey, which was sent by email to our primary unit sample. The data collection was carried out from March to May 2016, obtaining a response from the entire sample (177 researchers).

For accomplishing the objective, this research shows the descriptive data about the researchers' characteristics, organizational factors and the university-industry collaboration. In addition, it was carried out an Analyze of Variance (ANOVA) with the purpose of answering the next question: Is there any difference in the university-industry collaboration according to the researchers' gender, age and seniority? This research is particularly interested in knowing the influence of the researchers' gender, age and seniority.

4. Findings

Findings regarding the university-industry collaboration, organizational factors and researchers' characteristics are presented below.

4.1 University-industry collaboration

Regarding the activities in collaboration with industry carried out in the last 5 years, the most reported were research projects, publishing, training services, technological services, and research residences. Largely, women tend to involve in training services. On the contrary, men participate more than women in technological services and consultancy. According to the obtained data, the researchers' participation in innovation projects of products, processes and services, is low. Even, there is a difference between women's and men's participation in these projects, and the involvement of men is greater than women.

The main researchers' incentives to collaborate with industry are the knowledge and information exchange, publishing, obtaining ideas for further research, and the exchanging of equipment and tools. Researchers suggested that their projects allowed mainly the solution of a problem and the improvement of products and services. With these projects, researchers expect to help in the regional development needs.

To carry out their projects, researchers use some ways to contact with industry. They mentioned that the first way is personal relationships, and subsequently by conferences, academic events or through work colleagues. The Technology Transfer Office is the least way used.

Is important to note that in table 1 the knowledge area of the project is an internal category.

Table 1. Knowledge area of the project.

Knowledge area of the project	%
Technology and Engineering Sciences	31.1%
Natural and Exact Sciences	22.8%
Health Sciences	17.8%
Agriculture Sciences	13.9%
Economic-Administrative Sciences	11.1%
Education Sciences	2.8%
Social Sciences	0.6%

The research projects are related to the strategic areas of the innovation schedule of the state, that is i.e., fishing, agriculture, construction, information technology, medical products, automotive industry and manufacture of wood products. Is important to consider that the project's scope, since the geographical point of view, is mainly regional, and in a little less percentage is national. The 60% of the researchers pointed out that they sought the potential user to carry out the project.

4.2 Organizational factors

Regarding the organizational factors, mainly researchers perceive a weak management of knowledge and technology transfer. They pointed out the lack of information about the functions of the Technology Transfer Office (TTO). Is important to highlight that in terms of managing research results, for example: commercial value and intellectual property rights licensing, approximately 50% of researchers consider that the TTO can support them. In addition, there are some reasons for which researchers consider complicate to establish a partnership with industry. First, the lack of time. Second, the lack of internal and external funding. Third, the excess of administrative procedures (bureaucracy). Other factors are related to geographical distance, training difference between researchers and practitioners, technical aspects and the relationship between the project participants.

4.3 Researchers' characteristics

Researchers' characteristics show that the involvement of women in collaborative projects with industry is a little fewer than men. In addition, findings suggest that researchers tend to affiliate to a research team.

Table 2. Researchers' characteristics.

Variable	
Gender	
Men	56.1%
Women	43.9%
Age (years)	47.3
Seniority (average years)	16.3
Affiliation to a research team	
Affiliated	78.3%
Not Affiliated	21.7%
Affiliation to the National System of Researchers (SNI)	
Women	36.8%
Men	50%

4.4 ANOVA

As we mentioned above, this research has a particular interest of investigating the influence of researchers' gender, age and seniority in the university-industry collaboration. It was conducted an ANOVA with the purpose of answering the question: Is there any difference in the university-industry collaboration according to the researchers' age, gender and seniority?

The hypothesis are the following:

Ho: There is not difference in the university-industry collaboration according to the researchers' age, gender and seniority.

Ha: There is a difference in the university-industry collaboration according to the researchers' age, gender and seniority.

Table 3 reports the results of the ANOVA for university-industry collaboration according to the researchers' gender. Due to the p-value (sig.) is less than 0.05, the hypothesis of equality of means (Ho) is rejected, and Ha is accepted, i.e., it exists significant differences between groups. Researchers' gender influence in the university-industry collaboration.

Table 3. ANOVA UIC-Researchers' gender.

	Sum of squares	Df	Mean square	F	Sig.
Between groups	3292.219	1	3292.219	6.021	.015
Within groups	97334.731	178	546.824		
Total	100626.950	179			

On the contrary, owing to the p-value is greater than 0.05 in the ANOVA results for UIC-Researchers' age, the hypothesis of equality of means (Ho) is accepted, i.e., there is not significant differences between UIC-Researchers' age groups (Table 4).

Table 4. ANOVA UIC-Researchers' age.

	Sum of squares	Df	Mean square	F	Sig.
Between groups	1871.581	3	623.860	1.081	.359
Within groups	97526.281	169	577.079		
Total	99397.861	172			

Additionally, it was carried out an ANOVA for UIC-Researchers' seniority. According to the p-value (sig.), i.e., is greater than 0.05, the hypothesis of equality of means (Ho) is accepted; there is not significant differences between groups (Table 5).

Table 5. ANOVA UIC-Researchers' seniority.

	Sum of squares	Df	Mean square	F	Sig.
Between groups	1124.846	6	187.474	.326	.923
Within groups	99502.104	173	575.157		
Total	100626.950	179			

Contrary with the study conducted by Boardman and Ponomarev (2009) and Giuliani *et al.* (2010), the researchers' age and seniority do not influence their collaboration with industry.

5. Discussion and conclusions

Each university community is unique and its attitudes are shaped by a combination of factors such as entrepreneurship education, teaching methodologies, role models and reward systems (Guerrero and Urbano 2012). Researchers need an environment of continuous collaboration with public and private sector, as well as society, in order to understand their needs, and to develop innovative solutions for them.

In response to these calls, this research presents data related to the university-industry collaboration of a public university in Mexico. In terms of university-industry collaboration, in this study, the most reported activities of collaboration were research projects, training services, research residences, technological services and publications. Nevertheless, the researchers' participation in innovation projects of products, processes and services, is low, and to a greater extent, they seek the recipients of their research results (knowledge supply). In addition, researchers' incentives to collaborate with industry are related to the knowledge and information exchange, publishing, obtaining ideas for further research, and the exchanging of equipment and tools. In the particular case of Mexico, publishing research results is an important performance indicator for individual researchers. For example: universities and the SNI evaluate researchers' production and grants according to quantity and quality benchmarks. According to Díaz and Alarcón (2018), researchers in candidate level (the lowest) and researchers in level three (the highest) have a relevant effect in the innovation capacity of a region. Researchers in level 3 of the SNI explain to a large extent the patenting, followed by candidate researchers. Their publications are important to produce new ideas liable to patent, especially in engineering and related sciences (Díaz and Alarcón 2018). Nevertheless, Rivera *et al.* (2011) highlight that the number of papers in scientific reviews is a poor indicator of productivity, owing to the broad variety of professors' outcomes focused to solve problems. In this sense, science, technology and innovation policy should evaluate policies to contribute and award collaboration outcomes. On the other hand, researchers suggested that with their involvement in projects with industry, they expect to help in the regional development needs. In this sense, is important to highlight that a challenge for universities is to support and emphasize researchers in engaging with international organizations, and not only in the creation of local networks (Zhang *et al.* 2016).

Regarding the organizational factors, mainly researchers perceive a weak management of knowledge and technology transfer. The involvement of high qualified personnel is imperative in the planning of activities to encourage the researchers involvement in innovation and technological projects (Aragonés-Beltrán *et al.*, 2017; Bozeman *et al.*, 2015; Díaz, 2014; Ramírez and Cárdenas, 2013; Rivera *et al.*, 2011), as well as in managing research results including determining their commercial value (Aragonés-Beltrán *et al.*, 2017; Barletta *et al.*, 2017; Bozeman *et al.*, 2015; Decter *et al.*, 2007; Siegel *et al.*, 2003). On the other hand, researchers also face the lack of time to do research, the lack of funding and bureaucracy. Is important to note that the organizational factors are critical to ease the researchers' collaboration with industry (Callaert *et al.*, 2015; D'Este and Patel, 2007;

Fichter and Tiemann, 2018). The type of collaboration carried out by researchers allows to identify their connection to the entrepreneurial context (Etzkowitz, 2017; Debackere and Veugelers, 2005). For these reasons, it is important to encourage an appropriate innovation culture in universities with the purpose of exceeding its primary mission of teaching and research (Carayannis and Campbell, 2012). Knowledge and technology transfer between university and industry expects to spur innovation (Rajalo and Vadi, 2017).

Relevant findings regarding the researchers' characteristics are related to the researchers' gender. According to the ANOVA results, researchers' gender influence in the university-industry collaboration. In their study Shubert *et al.*, (2014) suggest that some personality characteristics influence and shape the university-industry collaboration. Our research results are in the line with Boardman and Ponomariov (2009). In their study, Boardman and Ponomariov (2009) identified that there is a difference in the activities carried out by men and women. Women tend to link in training services, and men in consultancy services. In addition, a study conducted by Miranda *et al.* (2017) confirms that the collaboration intention is greater for men compared to women. Miranda *et al.* (2017) suggest that if women had, on average, the same characteristics as men, they would continue to show lower collaboration intention. This effect suggests that the lower collaboration rate for women is because of non-observable influences directly linked to gender. These non-observable influences could be caused by discrimination among customers and investors, cultural aspects, social differences or differences in family roles or preferences (Miranda *et al.*, 2017). In their research, Giuri *et al.* (2020) conclude that the university support could facilitate women's participation in academic patenting, which is a factor that spurs commercialization of research results. On the other hand, findings suggest that researchers seek their affiliation to a research team, might they are influenced by the perception of getting economic or other type of benefits, for example: getting funding for research projects. In some public universities of Mexico, this form of affiliation is common and it intends to increase the research productivity.

Researchers deeply expect that collaborative research can increase the practitioners' adoption of their research results (Decter *et al.* 2007; Berggren 2017; Rajaeian *et al.* 2018). If age and seniority do not influence the researchers' collaboration with industry, universities could take advantage by facilitating the processes and encouraging researchers to collaborate with firms. A pathway to encourage researchers involvement are incentives, is important to remember that they are key factors of success with the potential to contribute to technology transfer and innovation (Bercovitz and Feldmann, 2006; Debackere and Veugelers, 2005). Considering the effect of the environment in the researchers' behaviors to engage in university-industry partnership (Callaert *et al.*, 2015; D'Este and Patel, 2007) the TTO should define a strategic agenda driving the active participation of university for successfully engage in innovation projects.

5.1 Theoretical contributions

Theoretically, this research contributes to the existing literature about the university-industry collaboration. Our research highlights that

gender is a factor influencing the university-industry collaboration. On the contrary to previous studies (Boardman and Ponomariov, 2009; Giuliani *et al.*, 2010), age and senior do not influence the university-industry collaboration, that is, researchers engage in collaborative projects with industry independent of their age and seniority, they are might influenced by another internal or external factors to engage in collaborative projects with industry. In addition, findings suggest that research teams appear to play a relevant role in the researchers' involvement in university-industry partnership.

5.2 Managerial implications

The findings of this research have implications for different agents involved in the university-industry collaboration, that is, university and government. First, the university need a qualified team focused to develop the structure and frame conditions to actively collaborate with industry and to commercialize the research results. The industry as recipient of university knowledge and as an agent pursuing different goals (innovation or catching up) need the conditions to acquire and assimilate the outcomes of the collaboration. As we mentioned above, the university-industry collaboration is based more on the supply of knowledge than on the demand for knowledge. Second, government needs a science, technology and innovation policy driving the university-industry collaboration. In other words and more specifically, government needs to evaluate the policies, programs, strategies, etc. implemented (Guerrero *et al.* 2019) with the purpose of assessing their impact on the university-industry collaboration outcomes. Last, this study contributes in understanding the challenges faced by researchers and universities in their trajectory to be an entrepreneurial university.

5.3 Future research

Our study suggests areas for further research. Future work can investigate how internal and external factors influence the researchers' decision to engage in collaborative projects with industry. For example: in Mexico, the firms' technological capability is characterized by only have capabilities to use and operate existing technologies, they do not invest in any innovation activity (Dutrénit *et al.* 2019). In their study Guerrero *et al.* (2019) show that Mexican innovative enterprises are more likely to collaborate with universities in the development of radical innovations than in the development of incremental innovations.

Another promising research avenue is to examine the relation between the affiliation to research teams and the researchers' engagement in innovation projects. Another area in need of further research is to examine if there are differences in academic innovation outcomes according to the research area and researchers' gender, in order to explore the factors that frame this condition. It would also be interesting to repeat the study in a private university to identify if the nature of this type of university shows similar or different results.

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