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Artículos Científico

Innovación y transferencia de tecnología en México. Un análisis empírico de datos panel

Scientific Innovation And Transfer Of Technology In Mexico. A factor analysis of data panel

Inovação e transferência de tecnologia no México. Uma análise empírica do painel de dados

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Resumen

La innovación y la transferencia tecnológica en México no siempre se generan en el ámbito empresarial, pues en su génesis intervienen diversos agentes sociales que solo de forma habitual trabajan de manera coordinada, lo que arroja débiles resultados. Por ello, el objetivo de este texto fue analizar el papel que juega la transferencia de conocimientos desde las universidades en la determinación de la innovación tecnológica en México. Metodológicamente, los datos se diseñaron tipo panel, analizados mediante mínimos cuadrados con errores estándar corregidos (MCO), y la base de datos utilizada corresponde al Instituto Mexicano para la Competitividad (IMCO). En tal sentido, los hallazgos indican una relación significativa y positiva entre la innovación y la actividad de las grandes empresas, los posgrados de calidad y los centros de investigación; así como una relación significativa y negativa con las pequeñas y medianas empresas. Por ello, se concluye que

estas características se traducen en importantes áreas de oportunidad en materia de política educativa, su vinculación con grandes empresas y la transferencia del conocimiento generado en universidades del país.

Palabras clave: datos panel, innovación científica, propiedad intelectual, transferencia tecnológica.

Abstract

Innovation and technology transfer in Mexico are not always generated in the business world. In its genesis, various social agents intervene that do not always work in a coordinated manner, obtaining weak results. That is why, the objective of this research is to analyze the role played by the transfer of knowledge from universities in the determination of technological innovation in Mexico. Methodologically, the data were designed as a panel, analyzed using least squares with corrected standard errors (OLS). The database used corresponds to the Mexican Institute for Competitiveness (IMCO). The results indicate a significant and positive relationship between innovation and the activity of large companies, quality postgraduate programs and research centers. As well as a significant and negative relationship with small and medium enterprises. These characteristics translate into important areas of opportunity in terms of educational policy, its linkage with large companies and the transfer of knowledge generated in universities in the country.

Keywords: panel data, scientific innovation, intellectual property, technology transfer.

Resumo

A inovação e a transferência de tecnologia no México nem sempre são geradas no ambiente de negócios, pois em sua gênese intervêm diversos agentes sociais que trabalham apenas de maneira coordenada, o que produz resultados fracos. Portanto, o objetivo deste texto foi analisar o papel da transferência de conhecimento das universidades na determinação da inovação tecnológica no México. Metodologicamente, os dados foram elaborados como um painel, analisados por meio de mínimos quadrados com erros padrão corrigidos (MCO), e o

banco de dados utilizado corresponde ao Instituto Mexicano de Competitividade (IMCO). Nesse sentido, os achados indicam uma relação significativa e positiva entre a inovação e a atividade de grandes empresas, cursos de pós-graduação de qualidade e centros de pesquisa; bem como uma relação significativa e negativa com as pequenas e médias empresas. Portanto, conclui-se que essas características se traduzem em importantes áreas de oportunidade no campo da política educacional, sua relação com as grandes empresas e a transferência de conhecimento gerado nas universidades do país.

Palavras-chave: painel de dados, inovação científica, propriedade intelectual, transferência de tecnologia.

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Introduction

The strengthening of the university-business relationship is a strategy with which some countries have faced the challenges arising from the innovation that economic globalization demands. With this they seek to increase the efficiency of the companies and boost the competitiveness of the economic sectors. Logically, this link between universities and the productive sectors is not recent, since, for decades, formulas have been implemented to strengthen this link, although the results have not been encouraging, either due to lack of flexibility or lack of willingness to the agents to coordinate.

The transfer of technology has been promoted from the public sphere, which has served in Mexico to implement national and local policies that, in general terms, have not offered the expected results. Among these policies are the creation of the National Entrepreneur Institute (Inadem, 2019), the Technological Innovation Fund of the National Council of Science and Technology (Conacyt, 2019a), the National Conference of Science, Technology and Innovation (CNCTI, 2019) or the various support programs for business innovation (Conacyt, 2019b). All these strategies are part of a vertical initiative that seeks the development of installed capacity to increase innovation according to the American Energy & Manufacturing Competitiveness Partnership (AEMC, 2013). The hypothesis

suggests that innovation generates improvements in productivity, which produces an increase in wages and, therefore, in the quality of life of workers. However, these policies fail to integrate all triple helix agents (at least in a collaborative manner), so each of these is aimed at achieving results in isolation, thereby achieving minimal impacts and the country's scientific and productive efforts are diluted.

For this reason, this paper analyzed the role of knowledge transfer from universities in determining technological innovation in Mexico. The actors involved in this process are the government, the education sector and the productive sector. Thus, the variables were grouped into dependent (patents, as tangible of innovation) and independent (companies, large companies, quality postgraduate, research centers and researchers). The analysis period ranged from 2005 to 2017 — in the latter, the most current information offered by the Mexican Institute for Competitiveness (IMCO) was found—.

The main actors in the linking process

Government

Since the beginning of the 21st century, public administration has changed from a neo-public to a neo-managerial vision. This last post-Berber conception transcends budgetary control and focuses on integral efficiency, transparency, access to information and the incorporation of citizenship in government work. In this sense, Cabello and Ortiz (2013) comment that this paradigm shift can be framed in three areas: 1) the level of interference that the State has had on the market, 2) the influence of technocracy on public policy and 3) the separation between theory and practice in the exercise of public management.

Fonseca-Retana, Lafuente-Chryssopoulos and Mora-Esquivel (2016) explain that public policies continue with the vision of a linear model for innovation, since they focus the strategy on increasing the educational offer. However, despite the incentive for the supply of knowledge, the conditions of innovation in research and development (R&D) are not promising. In this regard, Cabrero, Cárdenas, Arellano and Ramírez (2011) point out that the innovation development system in Mexico has serious deprivations regarding specialized

human capital, lack of financial resources in support of R&D activities, as well as an inefficiency in the research productivity of higher education institutions.

According to Licona and Pérez (2018), for a country to stand out on the international stage, it must focus its development strategy on strengthening a highly specialized human capital, because this allows it to increase its workforce and the training of specialized personnel in certain strategic areas for innovation and technological development. In summary, the innovation policy focused on expanding the educational offer only wears out the economy and contributes to the inefficiency of the national economic project.

Therefore, the role of the State must change from a regulatory position to a facilitator to become the bridge that links the process of technology transfer with the productive sector. This would generate an innovation ecosystem through the orientation of vertical policies in strategic areas of science and technology.

Productive sector

The current commercial landscape requires companies to improve their processes and innovate with new products and services. Differentiation, as a competitive strategy, demands a large amount of resources that can be costly for a company. This means that in order to promote an innovation on an individual basis, one must think about the various risks, such as loss of competitiveness and high research and development costs. For this reason, companies must identify market niches in which they can participate with low costs, for which, however, they must know the segment, because that way they will identify development opportunities with innovative products or services.

In other words, for current businesses it is important to know the context in which they operate to carry out strategic planning that allows them to differentiate themselves in products and services and leverage their market positioning. Otherwise, the company would be limiting itself to imitating other leading companies in the sector, which could overshadow its market position.

In this sense, Rautu, Racoviteanu and Dinet (2017) explain that some companies that seek to increase their competitiveness only focus on reproducing what others do, which does

not constitute benchmarking and does not contribute to their survival in the market. Therefore, Welsh, Tullar and Nemati (2016) point out that a key factor of business success is in the training of the entrepreneur, because in this way he can be aware of how he can boost the technological innovation of his company to face the challenges and Changes in the economic environment.

Education sector

The commercial dynamics and the speed with which the transformations in the technology and in certain fields of the scientific work are generated have motivated changes in the conceptions about the educational task and the role that the universities play in the new world scenario. Currently, universities and higher education institutions must remain open, dynamic and willing to change. In fact, the link between universities and the business sector may increase the levels of economic and social development of a state, as this will allow the creation of new lines of knowledge generation and application, as well as evaluation policies on the relevance of research, This will promote quality education and more adjusted to the needs of companies in the region.

In this sense, De Arteche, Santucci and Welsh (2013) explain that the linkage starts from leaderships that promote links between universities and research centers with companies and productive sectors in the region. This idea is based on what is stated by Sharifi Liu and Ismail (2013), who conclude that the establishment of successful linking strategies depends largely on the managers of knowledge transfer offices in universities, whose vision can be vital for The transformation. In other words, the strengthening of this linkage and the effectiveness of transfer strategies depend on relational capital, that is, on how the actors of the institutions and business sectors associate effectively.

For this, universities must support their social responsibility in the work carried out by the transfer offices and strengthen them with the appropriate level in the organizational structure of the institution. Likewise, structuring internal procedures and regulations in relation to companies, as well as specifying the way in which researchers generate

knowledge. In addition, promote intellectual property policies and strategies for entrepreneurship and technological innovation.

In this order of ideas, it is important to emphasize that human capital is a key element in university-business relations. In fact, having highly specialized researchers who develop innovations with student support guarantees a quality education, relevant and focused on the needs of the environment, since knowledge and human capital are the most important factors to integrate any strategy of Innovation and transfer.

In summary, in the changing context of globalization, universities must channel the knowledge generated and direct it to business sectors. In this way, the academy as a social and economic agent goes from having a passive role - focused on the generation of knowledge - to assuming an active role in the economic dynamics of the region, thereby acquiring a strategic position in the economic field and politician.

Materials and methods

The basic structure of the panel data models (MDP) seeks to estimate whether the variations observed in y are related to the variations observed in x, taking into account individual differences:

$$\gamma_{it} = \chi'_{it}\,\beta + \varepsilon_{it} \quad \textit{ecuación}\ (1)$$

Where *Y* is the parameter vector, X_{it} it is a vector of k explanatory variables; *i: 1*, …, *n* denotes the sample units, *t: 1*, …, *T* indicate the periods, *k: 1*, …, β represents covariates, ε_{it} random errors.

In this way, annual data on patents, companies, large companies, quality postgraduates, research centers and researchers were used, during the 2014-2017 period, to estimate an MDP made up of 378 municipalities in Mexico, specified by means of the equation (2):

$$\gamma_{it} = \alpha_i + \beta_1 E_{it} + \beta_2 F_{it} + \beta_3 G_{it} + \beta_4 H_{it} + \beta_5 J_{it} + \boldsymbol{\varepsilon}_i \quad \textit{ecuación}\ (2)$$

where subscript (i) refers to the municipalities of the panel and subscript (t) refers to the period of time. Parameter (d) includes the determining components, such as the intercept, which allows fixed effects between municipalities and trends. Innovation is represented by (y), β represents covariates, which in this case are (E) for companies, (F) for large companies, (G) for quality postgraduate courses, (H) for centers of research and (J) for researchers. Finally, (e) refers to the random error, with zero mean, constant variance and not autocorrelated.

Thus, Figure 1 shows that the estimation design takes patents as a dependent variable as elements of innovation, while the independent variables are the covariates mentioned above.

Figura 1. Variables independientes y dependientes

Fuente: Elaboración propia

Specifically, table 1 defines the variables used based on economic and educational factors.

Tabla 1. Definición de variables

Variables	Definiciones
Patentes	Número de patentes solicitadas
Pymes	Número de registros patronales en el IMSS
Grandes empresas	Número de empresas que están del top 500 CNN
Posgrados de calidad	Número programas de posgrado certificados por Conacyt
Centros de investigación	Número de centros (clave SCIAN 5417)
Investigadores	Miembros del SIN

Fuentes: IMCO (2018)

The data used correspond to the 2018 urban competitiveness index developed by the Mexican Institute of Competitiveness (IMCO). Likewise, the variables are specified in natural logarithms in order to correct problems of scale and variance.

The methodology used in this research corresponds to the grouped regression: ordinary least squares (OLS). This is a simple approach to analyze panel type data, which omits the space and time dimensions of the grouped data. On this point, Cox, Popken and Berman (2013) point out that in the regression equations it is common to present the problem of spurious associations in panel data. For that, it is necessary to determine the order of integration and the balance of the variables that make up the model to know if the variables are balanced or not.

In accordance with this, the Wooldridge and Wald test was applied to the model presented, which allows to determine the existence of autocorrelation and heterocedasticity to detect and control possible problems of this type. The application of the different tests indicated allowed to minimize the heterocedasticity and the unobservable autocorrelation of the data panel. Thus, the estimator that was applied in this investigation was that of standard errors corrected for panel data. (EEECP) (Baltagi y Maasoumi, 2018).

Results

First, a first run of the variables was performed to determine if they were significant with the dependent variable. Thus, the application of the different stages of the OLS methodology allowed us to corroborate the unobservable heterogeneities of the data panel,

trying to control the individual character of each entity and correct, if necessary, the problems of heterocedasticity and autocorrelation that may occur the model.

In this order of ideas, in the search to establish the best estimator for panel-type data from the previous tests, the results shown below were found. Before, it is worth mentioning that this type of estimator has been used in several investigations with panel type data as in time series. In this regard, Kachlami and Yazdanfar (2016) and Yao, Chen, Che, Wang and Guan (2018) demonstrated that this estimator is more accurate for panel data, as shown in Table 2.

Tabla 2. Innovación y transferencia de conocimientos en México

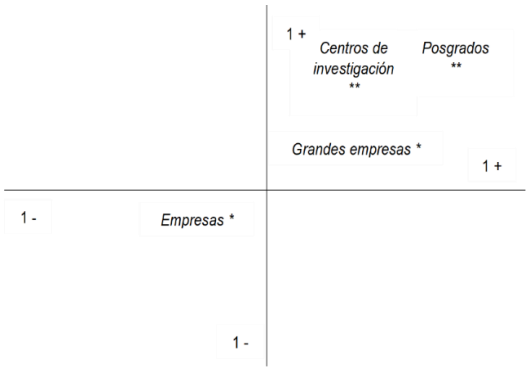
Variable dependiente		
Patentes		
Variables independientes	**Coeficiente**	**Std. Err.**
Empresas	-.0141 **	.0072
Grandes empresas	.1590*	.0392
Posgrados de calidad	.7146**	.3337
Centros de investigación	26.97**	13.4884
Investigadores	-.0114	
Número de observaciones	756	
R-cuadrada	0.8915	

* Significativa 1 %. ** Significativa 5 %. *** Significativa 10 %.
Nota: En los anexos se puede verificar la captura de pantalla del *software* STATA 14.
Fuente: Elaboración propia con base en STATA 14

Discussion

The results show that the most significant variables with positive orientation to the dependent variable were these: research centers, quality postgraduate programs and large companies. On the other hand, companies were the significant variable with negative orientation. The researchers variable had no significant relationship with the dependent variable. Figure 2 shows these relationships more clearly.

Figura 2. Gráfica de tendencias



* Significativa 18 %. ** Significativa 5 %. *** Significativa 10 %.

Fuente: Elaboración propia

Regarding the orientation of the negative sign, it can be argued that an inverse relationship is explained, that is, the lower the presence of the company variable, the greater the possibility of innovation. These results are reinforced with the postulates of Olazaran, Albizu, Lavia and Otero (2013), who studied innovation in small and medium enterprises (SMEs) in the community of Navarra, Spain. In that study they found that while the training and preparation of the staff have an outstanding contribution, the innovation support processes are very limited. In fact, although these companies have an incipient role in innovation processes, the innovation and knowledge transfer system, in general, is disjointed between them and research centers, as well as higher education institutions. These last statements of the decoupling also confirm the data obtained in the present investigation, since it was observed that the variables between research centers, universities, patents and companies were not significant.

Continuing with SMEs, Gligo (2016) points out that these companies have serious problems, such as lower relative productivity, low salaries, lack of qualified personnel, low level of exports and little access to financing. All these factors inherent in this type of companies hinder business innovation, reduce investment in innovation activities and disrupt the link with universities and research centers. In fact, the significant and positively oriented results reinforce what was previously stated by Gligo (2016) and Olazaran et al. (2013), since

the cluster composed of large companies, universities and research centers is the triad of innovation and technology transfer.

Therefore, large companies focus their strategies, generally, on strengthening their competitive advantages through the differentiation strategy, for which they invest in research and development, which results in the generation of patents. In this way, large companies with high development and industrialization in their processes are located in a privileged place above their competitors, thus raising the entry barriers for any new incursion in their market segment. According to Lemley and Feldman (2016) and Zhang and Gallagher (2016), large companies constitute a new economic and financial power, since their innovation activities challenge codification and standardization, which allows them to be knowledge intensive, exclusive in rights of use and exploitation, as well as highly profitable.

On the other hand, globalization allows them to position their power in different countries, by locating their production centers in nations with tax and labor benefits, with less expenses and tax exemption. The effects of this globalization can be seen both positively and negatively, since although advances in computer systems, new technologies, as well as biotechnologies, among others, are unquestionable, the low well-being index and the environmental deterioration of soil and water. Innovation and transfer, therefore, do not always offer a common good, as it should be remembered that innovations have also served to accentuate the negative effects in multiple war conflicts.

An important concept that underlies the results found in this research is that the strong relationship between the innovation triad is through knowledge networks, which transfers what is generated in universities and research centers to companies and productive sectors. region of.

In this sense, in order to explain the development of linkage networks, it is pertinent to retake the concept of assimilation set forth by Dávila (2007). This author points out, within the framework of scientific-technological innovations, that assimilation allows us to observe the speed with which companies and countries incorporate these technological advances around science and technology, which drives research, development and , therefore, innovation.

However, it is not only important to incorporate the innovations into the operations of the companies, since this would only generate the acquisition of technology, which would make them dependent. Therefore, creativity is important for innovation to solve needs with its own elements, without resorting to the imitation of strategies, procedures or techniques. Thus, innovations and technology transfers occur between research centers, universities and large companies, although the transfer is made according to the requirements of these companies, so they are the drivers of knowledge and exercise control according to their own interests.

In summary, the results found by the econometric estimation show that the factors studied are consistent with other research mentioned above and corroborate what is predicted by the technological innovation models, since the greater the relationship between universities, research centers and large companies have effects positive and significant in technological innovation.

Conclusions

The objective of this research was to analyze the role that knowledge transfer plays from universities in the determination of technological innovation in Mexico. For this, an econometric model of OLS was applied, which sought to estimate the function of knowledge transfer; Likewise, panel-type data (in the 2005-2017 period) were grouped with the variables SMEs, large companies, universities, research centers and researchers.

From the results shown in this investigation, it is clearly shown that the postulates posed by the models of technological innovation are fulfilled in a significant and positive way in the case of Mexico. The econometric results of the innovation function provide sufficient empirical evidence of the relevant role of universities, research centers and large companies in the generation of innovations, a situation that is postulated in various referred research.

Finally, based on the results obtained from the empirical analysis of the role of patents, it was verified that the transfer of technology from universities and research centers positively impacts the country's innovation. However, and even when these effects are

significant, technology transfer efforts are still insipient in Mexico, so this path of sustained growth can have an impact on the economy in the country.

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Anexos

Captura de pantalla del análisis MCO, STATA 14

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Linear regression, heteroskedastic panels corrected standard errors

Group variable:   id                            Number of obs      =       756
Time variable:    ao                            Number of groups   =       378
Panels:           heteroskedastic (balanced)    Obs per group:
Autocorrelation:  no autocorrelation                          min =         2
                                                              avg =         2
                                                              max =         2
Estimated covariances      =       378          R-squared          =    0.8915
Estimated autocorrelations =         0          Wald chi2(5)       =    148.14
Estimated coefficients     =         6          Prob > chi2        =    0.0000
```

patentes	Het-corrected Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
empresas	-.0141885	.0072376	-1.96	0.050	-.028374	-3.10e-06
grandesempresas	.1590647	.0392793	4.05	0.000	.0820787	.2360507
posgradosdecalidad	.7146558	.3337598	2.14	0.032	.0604987	1.368813
Centrosdeinvestigación	26.97725	13.48848	2.00	0.045	.5403177	53.41418
investigadores	-.0114595	.0195993	-0.58	0.559	-.0498735	.0269544
_cons	-2.437507	26.33411	-0.09	0.926	-54.05141	49.17639