



Legislative environment and others factors that inhibit transfer of Mexican publicly funded research into commercial ventures



Alma Cristal Hernandez-Mondragon ^a, Luis Herrera-Estrella ^{b, 1}, Walid Kuri-Harcuch ^{c, *, 1}

^a Science, Technology and Society, Multi-departmental Interdisciplinary Program, Center for Research and Advanced Studies, IPN, Mexico

^b Laboratorio Nacional de Genómica para la Biodiversidad, Cinvestav Irapuato, Irapuato, Guanajuato, Mexico

^c Department of Cell Biology, Center for Research and Advanced Studies, CINVESTAV-IPN, Apdo., Postal 14-740, México City, 07000, Mexico

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ABSTRACT

In this work we explored some factors that limit technology transfer in the process of innovation from different research institutions in Mexico. We found that one of the main inhibitors for technology transfer is the conflict of interest provision in the Federal Law of Administrative Responsibilities of Public Servants. Since most research and development activities are carried out in public institutions, and funding is mainly derived from Federal and State government programs, scientists are considered public servants in the eyes of the Law. Therefore, according to current norms scientists can incur in conflict of interest for technology transfer and commercialization of their research. From the information gathered from this study, we proposed an amendment to the above mentioned Law to eliminate potential conflict of interest, which derives from the participation of scientists from Mexican publicly funded institutions in the creation of spin-off companies, and hence, to incentivize entrepreneurship, technology transfer and innovation to effectively commercialize the products of publicly funded research. We also discovered other inhibitors of technology transfer that are discussed in this paper.

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1. Transfer technology and legislation

Since the early 1980s, governments paid special attention to the development of public policies supporting the creation and/or expansion of new enterprises or spin offs based on science and technology [1,2]. The knowledge derived from scientific research has become an essential element in product and service development for society [3] and now, is a key for productivity and innovation [4,5]. This “scientification of technology” has occurred in several industries, including biotechnology or microelectronics [2,6].

Society can perceive scientific research through its financial impact and benefit. Hence, for economies to benefit from the scientific knowledge produced by universities and research centers, knowledge needs to be transferred from these institutions to the market, through Technology Transfer (TT) [7]. There are three main forms of TT: 1) licensing contracts or sale, 2) sponsored research, and 3) start ups or spin offs companies [2]. Creating new

enterprises is one of the most visible ways for society to be aware of the scientific research activities carried out by universities and research institutions. Founding new enterprises could even be used to solicit additional public funding [8]. In addition, some studies have shown that creating new companies is more profitable than paying royalties for licensing technologies [9,10].

Flexible policies and the social and cultural environments in a society are important for universities to generate new companies [11]. These policies involve a broad range of issues comprising intellectual property rights, tax deductions on R & D activities, benefits for the institutions and their scientists, policies to avoid conflicts of interest, etc. All these require university-industry relationships in a context of legality and incentive policies. In the United States, a new type of university-industry relationships emerged in the 1980s, centering on Technology Transfer from research institutions to private firms, allowing the discovery of new roles by the researchers and their institutions. This was highly incentivized by the Bayh-Dole Act [4,12–14]. The Organization for Economic Cooperation and Development [15] reported that in Latin America a significant inhibitor for technology transfer is the lack of adequate policies and regulations [15], which seems to be part of the problem in Mexico, as well.

* Corresponding author.

E-mail address: walidkuri@gmail.com (W. Kuri-Harcuch).

¹ These authors contributed equally to this work.

1.1. Public research institutions in México and their role in society

Public research institutions can improve society's perception on scientific research by showing that they can respond to social needs and economic development through the generation of products that meet existing public needs and create jobs and richness for society [16]. Scientific research has a privileged role in today's world as it is crucial for competitiveness and greater technological capabilities for businesses [17]. In fact, some of the current largest companies in their beginnings adopted a brilliant strategy by pursuing R&D combined with the acquisition of key small companies founded by scientists from universities or research centers; Roche, Monsanto or Syngenta are clear examples of this strategy [18]. The birth of spin offs included multiple variables; for example, the researchers culture, personal motivation, human resources, country in which they are developed, organization, network, prestige or infrastructure, and other essential factors such as investment, particularly through seed or venture capital [19–26].

Public funding in public research institutions has an important impact in harvesting new knowledge since it provides scientists with research autonomy to pursue either basic and/or applied scientific projects that are relevant to society, not only through science advancement but also through the development of commercial applications. During the last decades, governments, the main providers of publicly funding for research, have been mandating that public research should achieve scientific and economic impact through technology transfer to industry [27] or to private funding via the creation of new companies. Cunningham et al. (2014) have argued that others factors are important as the role of principal investigator (PI) because "Traditional knowledge, skills and technical know-how of publicly funded PIs are insufficient to deal with the increasing managerial demands and expectations i.e. growing external bureaucracy of public funding agencies". These authors also found that there are inhibiting factors that limit the research autonomy of publicly funded PIs. It has been clear that one of the critical players to ensure technology transfer success of the publicly funded research is the principal investigator [5,28,29,30].

Many studies, during the last 30 years have examined the role of universities as providers of knowledge and technology to industry [31,32]. This has been studied through intellectual property analysis, and it has been argued that patenting increased in universities due to adequate technology transfer policies [32]. Some authors have examined the effect of technology licensing by universities to industry on researchers behavior, showing that "Royalties are typically larger the higher the quality of the faculty and the higher the fraction of licenses that are executed at later stages of development" [5]. It seems that incentives helped the collaboration for partnering and for their successful outcomes [32]. Recently, some authors have re-defined the type of research collaboration. For example, they have defined property-focused research as "research that provides economic benefits (or has the potential to do so) to researchers or research that may provide commercial benefits to industry, with the academic researcher benefiting either directly or indirectly through industry's provision of resources" [32]. Several factors have been perceived that could inhibit this type of research, and one of the most important is the absence of a Technology Transfer Offices (TTOs) [33,34].

In addition to the identified problem of the lack of TTOs in academic institutions, a suitable environment for the development of these enterprises is required [35], including a friendly legislative frame since publicly funded institutions rarely have the autonomy required for this purpose [36]. In developed countries during the 1980's there was great uncertainty to generate spin-off companies from university research that could be funded by the private sector due to potential conflicts of interest (Anderson and Swazey, in

(Louis, 1989 #30)). Several legislative Acts, for example in the United States, solved this potential conflict. However, in Mexico, in 2015, such concern still exists.

1.2. International experience

In more advanced countries legislative action was important to promote technology transfer from scientific organizations to private companies. In the United States, The Bayh-Dole Act (PL. 96–517) allowed universities, small businesses and nonprofit organizations to retain the titles of their inventions developed with federal funds. Before this Act, the federal government retained ownership of all patents obtained through research supported by federal funds [37–41]. Subsequently to the Bayh-Dole Act, a series of laws like the Federal Technology Transfer Act (for Cooperative Research and Development Agreements or CRADA), the Economic Recovery Tax Act (for R&D credit), the Small Business Innovation Research Act (to help small businesses conduct R&D) and the National Cooperative Research Act (to reduce antitrust liabilities of research joint ventures), among others [42–46], helped to create an ecosystem that has supported the creation and growth of knowledge-based industries coming public and private universities in the United States.

Following the changes that were made in the United States by the Bayh-Dole Act and the subsequent new Acts, legislative bodies in several countries promoted changes to foster the transfer of knowledge from universities to society. For example, Nordic countries such as Denmark and Norway promoted the ownership of Intellectual Property Rights (IPR) to be given to institutions, and not the inventors, as it was previously done. In others countries like Italy, the inventor has the ownership of the intellectual property rights [8]. Similarly, some European countries have made legislative changes to encourage and promote the commercialization of the knowledge and technology generated by scientific research funded with public money [13]. These changes are contingent on the cultural and local context and include actions from government and institutions to increase commercialization [8,13]. In Japan, the Government passed the Act on the Promotion of Technology Transfer (TLO Act) and other measures in 1998 to promote university-industry collaborations. One of the major characteristics of the TLO Act was to encourage universities to create Technology-Licensing Offices (TLOs) and grant the intellectual property rights to Institutions. These offices have a role in leading and helping the institution to pursue patent applications, licensing technologies, liaising with companies, etc. Apparently, this process has achieved a similar effect as the Bayh-Dole Act in the United States. The number of patent applications by Japanese universities increased significantly since 1999 [47].

It has been shown that legislative changes can effectively influence technology transfer, mainly from publicly funded research organizations, benefitting institutions and their staff in a university-industry relationship. Institutions can get private money to fund their research, researchers can get extra financial incentives, and students can join new companies, or more easily finding jobs in companies related to their specialty [6]. Consequently, public research institutions should promote policies that encourage researchers and students to pursue commercialization of their attained knowledge [48]. However, several inhibitors can impair the development of these collaborations and entrepreneurship activities derived from scientific research funded with public money. One of such obstacles is the potential conflict of interest.

1.3. Conflict of interest policies

Conflict of interest policies were very broad and generally varied

between institutions, and can create a big hurdle when researchers attempt to pursue entrepreneurial activities. There were no clear guidelines in the institutions since they themselves did not have the autonomy to set policies preventing conflicts of interest, or to set incentives to promote entrepreneurship among their scientists [36,49]. Therefore, it became critical to have clear internal directions and to set up external contracts in order to avoid conflicts of interest between scientists, the university, and external companies since participation of the researchers in all the process comprising technology transfer, founding the company and developing the technology or a new product, is essential and critical for a successful commercial venture [2,10,30,50]. It is important to note that there is strong evidence suggesting that the formation of spin-offs is a high priority area for governments at national level [8].

In Mexico, the process of technology transfer and innovation is very weak [51–53] and it might be, at least in part, due to lack of institutional normative. Since few researchers belonging to public research institutions have pursued technology transfer, which is one of the initial steps for the commercialization of research products, we attempted to study some of the factors that might have discourage scientists to participate in technology transfer. Since most research in the country is publicly funded, we thought that scientists could be subjected to conflict of interest situations since the Law of Administrative Responsibilities of Public Servants (*Ley Federal de Responsabilidades Administrativas de los Servidores Publicos*) stipulated such provision. As we described above, a great inhibitor of technology transfer and entrepreneurship to create new technological companies is precisely the conflict of interest. This is because researchers from the public research institutions are public servants, and they may be subjected to legal action such as administrative penalties, suspension of their research or even imprisonment. This problem has been noticed before [1,52,54,55] but not addressed to reach an adequate solution. Of course, this is not the only difficulty that scientists face in starting spin-offs and increasing their chances of success in the market. However, we believe that it is essential to first lay the foundations for an ecosystem that would be supportive for technology transfer activities and specially for founding spin offs derived from publicly funded research by scientists in the Mexican scientific system.

The approach we followed in our investigation was to gain information in Mexico from scientists in public research institutions. In our investigation we used multi or interdisciplinary methods and techniques [56–58]. We sent a questionnaire containing 4 questions, described in the Methodology next section. We attempted to get an overview of the researchers' interest to participate in technology transfer, and to identify the main obstacles that researchers might encounter when they pursue entrepreneurship activities. We received responses to the questionnaire that helped us identify some of the problems, and then we carried out analysis of policy and of current laws. After we identified that in the R&D ecosystem in Mexico, conflict of interest is a main inhibitor for scientist to pursue technology transfer activities and participating in the creation of new companies, we attempted to develop a legislative initiative to modify the Federal Law regarding this issue. In addition to conflict of interest we also identified other inhibitors that have a significant impact in spin offs creation, and commercialization activities of science and technology.

Finally as a result of this work, we proposed and achieved an amendment in two Federal Laws to eliminate the conflict of interest. This change would enable scientists to be part of a new model for the management and design of public policy on technology transfer and entrepreneurship in the region. Because the problems arising from the conflict of interest is not confined to Mexico, the

vast majority of Latin American countries suffer from the same situation.

We think this investigation might have a significant impact in policies in other developing countries that have similarities to the Mexican situation. For example, countries such as Bolivia, Guatemala, Honduras and Venezuela have not even defined the boundaries between a teacher and a researcher teacher. Others, such as Colombia and Ecuador, have created laws and centers for technology transfer within their research institutions. They recognized that inventors should have an additional economic stimulus but only as part of the university but not as partners of companies created with his inventions. Argentina, Brazil and Chile established some policies few years ago for their publicly funded research, accepting that researchers should receive an additional economic bonus for their inventions; however, in their legislation is not clear whether their scientists may or may not seek to be entrepreneurs without incurring in a conflict of interest.

2. Methodology

We studied some of the factors that would inhibit technology transfer from publicly funded research institutions to the private sector in Mexico, and to contribute to policy analysis. Hence we interrogated scientists from various institutions to establish the context and structure of the problem. Then, in order to define problems and implement solutions we followed the "Assumptinal Analysis" proposed by Dunn (1994). First, we carried out a bibliographical analysis to explore the international experience in legislative amendments. Second, we identified and spoke with the few successful cases from Mexican researchers that had pursued entrepreneur activities. Third, we made a classification of the different types of public research institutions and their regulations under the Mexican federal law. Based on this, we sent out by e-mail an electronic questionnaire to scientists from various Mexican public research institutions and we also carried out multidisciplinary workshops. The questionnaire was sent to 100 researchers selected according to their interest in technology transfer activities (patents) identified in the database from the Mexican Institute of Industrial Property and the database from the Congressional Science and Technology Commission. The time to receive responses to the questionnaire was 3 months (February to April 2014).

We also enclosed in the email a letter of invitation to attend workshops in various scientific disciplines to discuss the problem. This letter of invitation was from Congressman Alejandro Rangel-Segovia who is highly interested in the subject and he was the main driver in Congress for Law amendments. We held two workshops. The first involved researchers from engineering, physics, chemistry and mathematics, and the second involved biological and health sciences researchers. We also invited researchers from the social science and humanities but no one answered the request. We built a list of registration from each workshop. From both meetings, the opinions of the attendees were similar to those we gathered from the questionnaire, and they were videotaped and broadcasted live by Congress Channel television.

The questionnaire included the following questions:

- 1) Do you or your colleagues have results patented from your research?
- 2) Do you or your colleagues have intent to bring them to the market?
- 3) Do you think that the Federal Law of Administrative Responsibilities of Public Servants is an inhibitor for the creation of spin offs?
- 4) What other obstacles exist in Mexico that might inhibit the creation of spin offs?

The answers from the researchers to the questionnaire were classified according to their institution of origin (Public Research, Higher Education Institutions and Entities of the Federal Public Administration). The answers were grouped and counted according to their frequency. After analyzing the answers from the questionnaires and noticing that conflict of interest was one of the problem most frequently identified by the scientists, as it was also suggested by our preliminary investigations, we attempted to structure a proposition to change the Federal Legislation regarding conflict of interest in the pursuit of technology transfer and commercialization activities of R&D products. In order to achieve this goal, we collected and analyzed opinions from different members of the scientific community; we prepared initiatives and lobbied activities, among others. A schematic model of this process is shown in Fig. 1.

All the steps marked on Fig. 1 were made possible through coordination with various government, academic and business entities. The final text for the amendment of the Law was written by a group of lawyers expert in their field, belonging to the National Council of Science and Technology (Conacyt), Ministry for the Civil Service (Secretaría de la Función Pública), Science and Technology Advisory Committee (Foro Consultivo Científico y Tecnológico), and the Ministry of Economy (Secretaría de Economía).

3. Results

3.1. Public research institutions and their relation with the Federal Law

In Mexico, public research institutions are classified into three types, everyone with different regulations and legal framework [28] according to their position in The Science and Technology Act and the Ministry of Public Education (Secretaría de Educación Pública): 1) Higher Education Institutions (HEIs), 2) Public Research Centers (PRCs), and 3) entities of the Federal Public Administration (EFPA) that are not HEI/PRC (Table 1). We also identified the number of scientists belonging to the National Researchers System in its 2014 database (Sistema Nacional de Investigadores, SNI), which is the major database of bona fide researchers in the country (Table 1). The data showed that about 85.5% of the scientists belonging to the SNI are doing research in R&D institutions created and funded by the Federal Government, and only about 15% work in private universities or in companies (Table 1). It is clear from this data that government institutions carry out most of the scientific research in the country, and therefore their scientists are regarded as public servants.

We found that HEIs comprise both autonomous and non-autonomous universities, as well as technological institutes. All HEIs offer Bachelor degrees, and some of them they also offer graduate programs at Master in Science and Doctorate degrees (Ph.D.) or medical specialties. According to the Science and

Technology Act these HEIs can create Technology Transfer Offices with the goal of enabling ecosystems to promote technology development, licensing, consulting and entrepreneurship, etc. All these institutions receive their budget from the Mexican Federal Government through the Ministry of Public Education. Therefore, they are publicly funded institutions and their scientists are subjected to the Federal Law of Administrative Responsibilities of Public Servants.

PRCs are entities that fully belong to the Federal Public Administration and they are recognized as PRCs according to The Science and Technology Act, with the purpose of carrying out scientific and technological research. They are also publicly funded institutions and their budget comes directly from the federal government through the National Council of Science and Technology (Consejo Nacional de Ciencia y Tecnología, Conacyt). These institutions have the privilege of being considered in the Science and Technology Act as a special case for the Federal Law of Administrative Responsibilities of Public Servants. The EFPAs are entities of the Federal Public Administration with R&D activities but in the Law they have different characteristics from HEIs or PRCs.

Since all these public institutions are part of the Federal Government but subjected to different laws, we attempted to study how scientists and researchers are influenced by their respective laws and regulations in pursuing technology transfer activities comprising licensing technology, founding of spin offs, and research translation into new products with commercial benefits. We designed a questionnaire to identify the different factors that might influence their decision to pursue such activities. The questionnaire contained four questions (please see Methodology) and it was sent by e-mail to 100 scientists working in Institutions classified in the three groups that we described above (see Methodology). We received 20 answers from the scientists from these three types of public institutions as described in Fig. 2a. The response rate was 20%; 75% came from researchers (all of them have a Ph.D. degree) and 25% from those individuals responsible for the TTO (all of them have a M.Sc. degree).

3.2. Answers to the questionnaire

The first three questions had a yes or no answer, and few of them had some additional observations that were also taken into account in the analysis. The purpose of the questionnaire was to explore the existence of patents and the interest of researchers to bring them to market through some form of technology transfer, as well as their participation in creating spin offs. We received and analyzed 20 complete responses from different types of research institutions in Mexico (Fig. 2a). The first question was about the existence of patents as a result of their research. All those surveyed answered that they have patents or patent applications protecting their intellectual property (Fig. 2b). The second was about their intent to market their technology or products. The answers showed

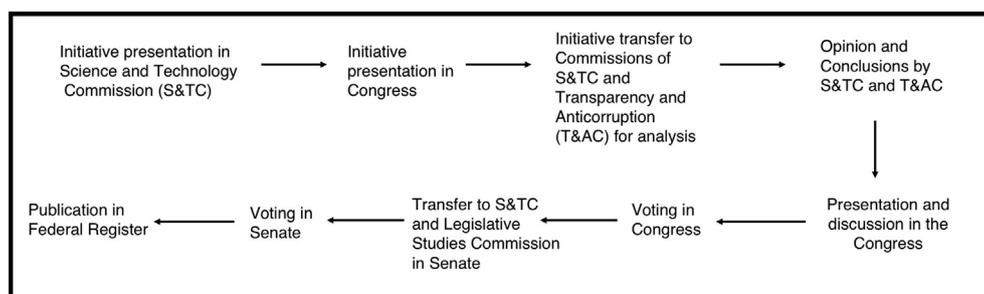


Fig. 1. Schematic process followed for amendment of Federal Law of Administrative Responsibilities of Public Servants regarding conflict of interest provision.

Table 1
Number of R&D institutions and scientists in the SNI, taken from Y2014 database.

Type of institution	Number of research institutions in México	Number and percentage (%) of scientists in SNI
Higher Education Institutions (HEIs) ^a	578	13,773 (64.5)
Public Research Centers (PRC) ^a	32	2450 (11.5)
Entities of the Federal Public Administration (EFPA) ^a	26	3360 (15.7)
Private universities and companies	—	929 (4.3)
Foreign Universities and companies	—	608 (2.8)
Without specification	—	239 (1.1)

^a Public institutions.

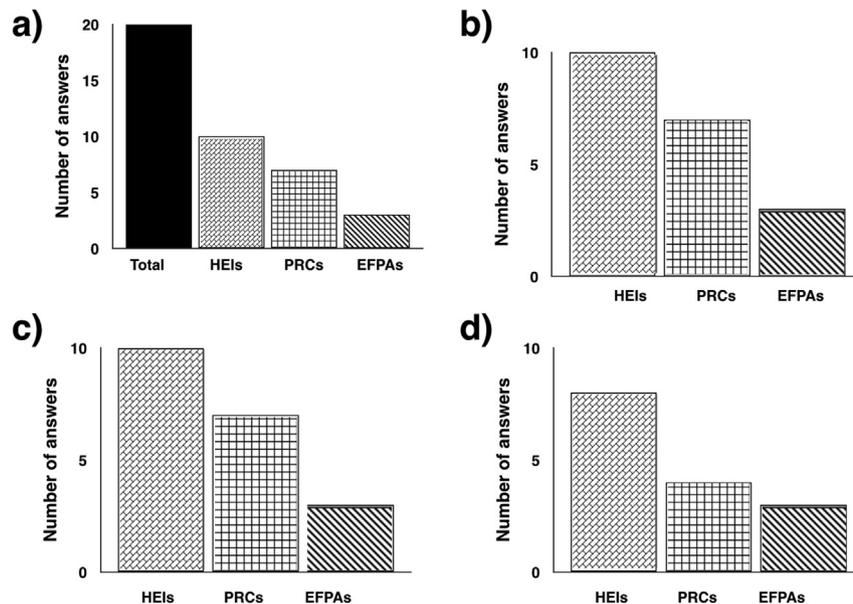


Fig. 2. Distribution of answers received by type of institution. a) Total answers by type of PRI; b) Positive answers from the question, Do you or your colleagues have patents results from your research? c) Positive answers from the question, Do you or your colleagues have intent to bring them to the market? d) Positive answers from the question, Do you think that the Federal Law of Administrative Responsibilities of Public Servants is an inhibitor for the creation of spin offs?

that all the scientists interviewed from the three types of Institutions were interested in commercializing the products of their research (Fig. 2c). In the third question, we asked specifically about the process to create a spin off in view of the Federal Law of Administrative Responsibilities of Public Servants, and whether they thought the Law inhibits such activity (Fig. 2d). Fifteen out of twenty answers confirmed that the Law discourages scientists from founding spin offs and commercializing their research products. Four out of five answers stating that the Law was not an inhibitor came from scientists belonging to the PRCs, which are treated as a special case in The Science and Technology Act. Therefore, since all publicly funded research institutions are subjected to the Federal Law of Administrative Responsibilities of Public Servants, we found that this Law is a significant inhibitor for the creation of new companies and in general, inhibits the pursuance of liaisons with the private sector. This was clear for scientists at HEIs and EFPAs, and less so for scientists in PRCs. Moreover, most scientists in the SNI belong to either HEIs or EFPAs, 15,845 out of 18,280 (85%), and 2435 out of 18,280 (15%) to PRCs. Therefore, 85% of publicly funded scientists would clearly be inhibited by conflict of interest in the Law to pursue entrepreneurial activities with their research products.

In the fourth question, we attempted to identify whether there were any other inhibitors, besides the Law, that might impair activities for founding new companies. Fig. 3a, b shows that major inhibitors were identified by HEIs scientist and PRCs scientists. We identified two other major inhibitors: 1) the lack of financial

resources for technology transfer activities, and 2) the lack of clarity in the institutional regulations regarding the possibility of scientists to become shareholders of the spin off companies they could create. Other answers by the HEIs or PRCs scientists also revealed that the academic evaluation system used in the SNI and other institutional mechanisms are also inhibitors because they undervalue technology transfer activities. Finally, the lack of specialized personnel for technology transfer in the institutions was also noted (Fig. 3).

Before completing this analysis, and since the survey pointed out to the conflict of interest as a significant legislative obstacle, we discussed this problem with Congressman Alejandro Rangel-Segovia, a member of the Science and Technology Commission of Mexican Congress. In collaboration with the Congressman, we organized a Symposium and four workshops with scientists and with political officials to discuss the general concerns of the scientific community and the inhibitors we identified in our work, particularly the Federal Law of Administrative Responsibilities of Public Servants and the Science and Technology Act. Fig. 4 shows the composition of the audience in the workshops.

After analyzing the results of the survey and the opinions of scientists and policy makers that were recorded during the workshops, it became clear that there are inconsistencies and lack of clarity in the Law regulating the role of scientists from publicly funded institutions to found spin-off companies. Therefore, based on our findings, Congressman Rangel-Segovia proposed to Congress an amendment to the Law.

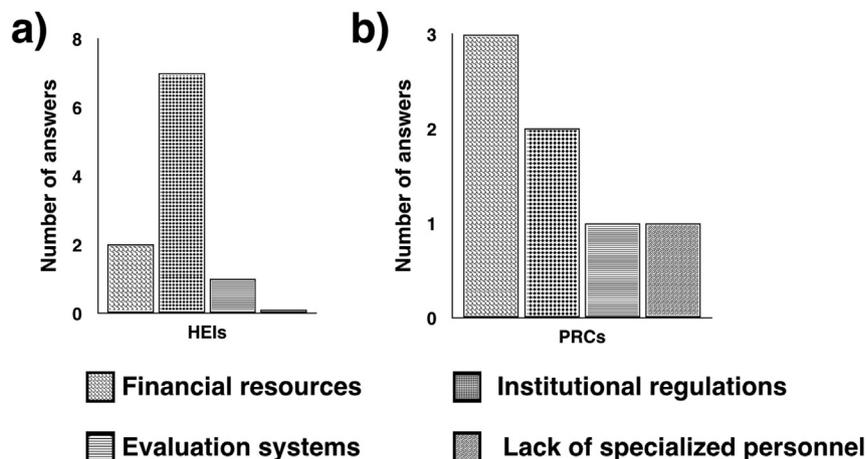


Fig. 3. Answers from scientists and by type of institution. What other obstacles exist in Mexico that might inhibit the creation of spin offs? Financial resources means lack of private money such as venture capital, or public programs from Government to support spin off creation. Institutional regulations means a complicated or nonexistent normative in the institution for technology transfer. Evaluation systems mean the lack of importance of technology transfer in evaluation guidelines for scientific activities. Specialized personnel mean lack of specialized personnel for the creation of spin offs, or some other technology transfer activities.

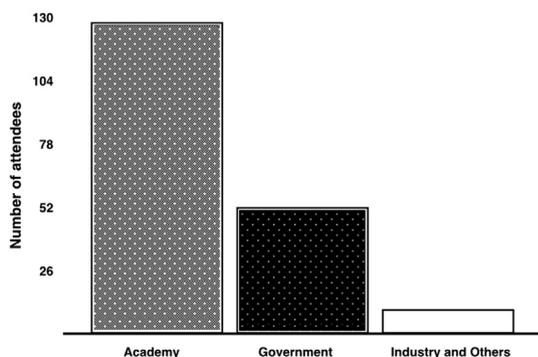


Fig. 4. Attendees to workshops. Academy means researchers and Chiefs of institutions (HEIs, PRCs, EFPAs). Government include members of the Congress, Senate, Ministries of Education, Science and Technology, Treasury, Economy, Public Function, Industrial Property, Science, Tech & Innovation Office from Presidential House, Conuler Organisms and Science and Technology Councils.

3.3. Amending the Law

We identified that the major inhibitors are the provisions of Article 8 of the Federal Law of Administrative Responsibilities of Public Servants which determine the obligations of public servants, and those of Fraction XII that it explicitly describes a conflict of interest when any professional, commercial or industrial activities are directly linked, regulated or supervised by the public sector. These would certainly include start-ups or spin-offs where the scientist would be a founder, shareholder or a person with financial interest in the new company. However, in the case of the PRCs the Act contains a special mention for their members, as follows:

“In the case of the personnel working in public research centers, the governing bodies of such centers, upon previous authorization by its in-house control body, may determine the specific application and exception terms and conditions respect to the provisions of this section, in case of conflict of interests, which may implicate the activities in which such personnel participates or is linked with technological development and scientific research projects related to third parties according to the provisions of the Science and Technology Law; ”

These provisions, yet still quite vague, apply only to the personnel of PRCs but not to the personnel of HEIs and EFPAs. Therefore, only 2435 out of 18,280 (13.3%) publicly funded scientists might partially pursue entrepreneurial activities with their research products without an a priori conflict of interest. In addition, such provisions grant the Governing Body of PRCs the legal capacity to resolve any conflict of interest, creating also a confusing situation for the scientists employed by the PRCs, since the decision process made by the internal Governing Body is discretionary. It must be noted that the Science and Technology Act cites activities with third parties but it does not specifically cite the participation of scientists as shareholder partners of spin-off companies. Clearly, this is confusing for the scientists interested in commercializing their research products.

It was then clear that the described Articles of the Laws are significant impediments for scientists to translate their research findings and discoveries into possible products and technologies, for their benefit and the benefit of society. Together with congressman Rangel-Segovia we wrote a first proposal of amendment of the Law of Administrative Responsibilities of Public Servants to promote the no existence of conflict of interest in the participation of scientists from Mexican publicly funded institutions in creating spin-off companies. With this proposal we lobbied Congressmen to modify the Science and Technology Act, and the Federal Law of Administrative Responsibilities of Public Servants. The initial proposal was improved through information obtained from questionnaires, multidisciplinary workshops and lobbying with key agencies involved, such as CONACyT, Secretary for the Civil Service (Secretaría de la Función Pública), Science and Technology Advisory Committee (Foro Consultivo Científico y Tecnológico), Secretary of Economy (Secretaría de Economía), among others.

On September 23, 2014 Congressman Rangel-Segovia presented the amendment to the Commissions of Science and Technology, and Transparency and Anticorruption, for analysis and ruling. On December 11, 2014 Congress approved this amendment to the Laws with 373 votes in favor, none against and 18 abstentions. On April 16, 2015 the Senate also approved the amendment to the Law with some changes. Due to the legislative process in Mexico, the changes made in the Senate forced the return of the proposal to Congress, and it was finally approved unanimously by it on November 24th,

2015. Finally, on December 8th, 2015, these amendments were published in the Mexican Federal Register (*Diario Oficial de la Federación*) enacting the Law.

4. Discussion

During the last decade, since the need for technology transfer offices in publicly funded institutions has been identified as a significant factor for translating new research knowledge into commercial endeavors in Mexico, the government has promoted the formation of TTOs in several public research institutions in the country [59]. However, our investigations have revealed that in Mexico the lack of a friendly legislative framework has been compounding the difficulties for commercial applications from publicly funded research.

Because scientific research is mainly carried out with public funds and in public research institutions we found that in the current Mexican legislative framework, researchers are public servants and their institution owns the result of their research where it is done. The inventor is entitled to appear as such and might receive royalties or resources resulting from technology transfer (*Ley Federal del Trabajo*) in an amount equal to or less than 70% of the royalties (*Science and Technology Act*). In fact, each institution has its own regulation and in no case that number exceeds 50%. However, scientists have no voice in the decision making process of technology transfer, and they cannot be founders or partners of private companies developing their technologies. This is due to the conflict of interest described in the *Law of Administrative Responsibilities of Public Servants*. It seems clear that at least three factors that inhibit technology transfer activities in the publicly funded scientific community in Mexico are: 1) the conflict of interest provision in the Law, 2) the lack of clarity in the institutional regulations regarding the possibility of the founding scientists to become shareholders in their companies, and 3) the lack of financial resources for technology transfer activities [32,53,55,60].

Although, the *Science and Technology Act* addresses the importance of generating spin-offs and others ways of linking scientific developments and commercialization, there are provisions that prevent it. We found that the types of public institutions engaged in R&D is quite broad and not all of them are ruled only by the *Science and Technology Act*, but they are also ruled by the *Federal Law of Administrative Responsibilities of Public Servants*; therefore, different rules are applied depending on the type of institution concerned (*Table 1*). We attempted to eliminate the conflict of interest provision through changes in both legislative Acts, to regulate the rights and obligations of researchers concerning the conflict of interest regardless of the type of institution to which they belong. We believe this is a fundamental change because it would re-assess the value of researcher's entrepreneurship; helping to create new generations of highly trained students to pursue technological business opportunities in Mexican society.

We know that building a science policy that promotes and encourages innovation requires the sum of wills and coordinated actions of different actors; the scientific community, business and government [61]. The current government is apparently convinced that science and technology are essential tools to achieve a knowledge-based economy less dependent on oil exports. We are convinced that facilitating and promoting the creation of spin-offs is a way to contribute to this goal. The *National Plan of Development (Plan Nacional de Desarrollo)* is the document that guides the government actions for the following years proposed by Mexican government, and in its 4.1 strategy section proposes incentives to create spin-offs [55], but as we saw, parts of the Law are antagonistic to this goal. Mexico is the 10th largest economy in the world and it is ranked 61st of the *Global Competitive Index 2014–2015*

[62], although with low levels of innovation activities. According to the *National Council of Science and Technology* statistics only 5% of companies carry on R&D activities [53]. These facts should invite the government and scientists to set up policies and programs to increase significantly the number of innovative technology companies. We expect that, as a first step, the creation of a favorable legislative framework, regarding the conflict of interest that affect scientists as public servants, would incentivize the commercial applications of research carried out by Mexican scientists. Our work also revealed that other inhibitors for technology transfer, R&D commercialization and the creation of start-ups based on new technologies, are lack of financial resources in the form of angel seed money and venture capital willing to invest in this type of new companies. Therefore, in addition to the proposed change in the legislative framework, other changes are required in the financial and research ecosystem of Mexico in order to achieve a higher number of technology based companies, as it was revealed in another work (*Medina-Molotla et al., 2015; manuscript in preparation*).

We should note that the relationship between academia, the Government and industries are crucial to the innovation ecosystem. In this sense, the *Triple Helix* emerged as a model that involves the relationship between each of the actors in such a way that there is an overlap between the institutional spheres where everyone can take the role of the other [63]. In this model, universities, businesses and government pass new tasks in the development of new technologies, in addition to traditional roles [64]. We believe that actions such as those in this study contribute to the consolidation of the triple helix in Mexico.

It is interesting to note that the *Bayh-Dole Act* in the United States was the first major legislative change made by US Congress on this subject. This change was a response to stimulate the economy through technology transfer, specifically the business activities derived from R&D. In addition, other mechanisms to facilitate R&D commercial initiatives through legislative changes have been compared with the *Bayh-Dole Act*. In particular, Goldfarb identified that the model of the United States (including the participation of researchers) resulted in a more favorable ecosystem to promote the commercialization of R&D by universities than the Swedish model, which also contains legislative changes to business activities in general, but is not completely effective due to the lack of incentives for researchers, despite that the researcher owns the intellectual property rights [2]. Moreover, Gitteman in Ref. [2] suggested that in France the weak success in marketing in a specific area, such as biotechnology, is due to the lack of incentives for researchers. Other studies have suggested that researchers prefer to continue in their laboratory, without leaving the university, to investigate a particular issue with commercial initiative [5].

In conclusion, it is clear that in addition to conflict of interest derived from the legislative environment, the institutional regulations and the evaluation systems to which scientists are subjected are also considered important inhibitors for researchers to begin entrepreneurial R&D activities. Other barriers we found are related to lack of financial resources, lack of highly qualified personnel in IP and TT, lack of instances in the institutions that would be dedicated to the management of technology transfer, and the time devoted by the researcher for various activities, such as research and teaching. However, we cannot disregard the limited availability of seed money and venture capital for investment in technology based new companies.

Based on our work, Mexico passed legislation to eliminate the conflict of interest for its researchers with entrepreneur spirit. This might become a model for the design and management of public policy on technology transfer and entrepreneurship in the region.

The problems arising from the conflict of interest is not confined to Mexico as we described above, since the vast majority of Latin American countries suffer from the same situation. We expect that having solved the conflict of interest through amendments in the Law would be a first solid step in building a path for creation of new technology-based companies by Mexican scientists. There is still a long road for the Mexican society to follow in order to obtain a larger benefit from public funded research and technology transfer activities. The participation of researchers, businessmen and stakeholders was essential for the success of this work. This is the first successful amendment to encourage innovation and economic development in the country since Y2002, when the Science and Technology Act was passed in Mexico.

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