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Identification of key factors of academia in the process of linking in the triple helix of innovation model in Mexico, a state of the art matrix

Identificación de factores clave de la academia en el proceso de vinculación del modelo de la triple hélice de la innovación en México

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Resumen

Introducción: La innovación es reconocida como una actividad esencial para aumentar la competitividad de un país Etzkowitz define el modelo de la triple hélice para el proceso de innovación en el cual se describe la relación entre la interacción industria-academia-gobierno en una institución, región o país. En las últimas dos décadas México ha adoptado gradualmente un enfoque tecnológico, mediante el cambio y la implementación de políticas tecnológicas, que incluyen la transformación del a industria, el gobierno y la academia. Una de las mayores dificultades ha sido la implementación de esas políticas dentro de las instituciones académicas debido a su organización y estructura.

Método: Se usó la metodología de matrix del estado del arte (SAM) con el objetivo de colectar, compilar y analizar la literatura disponible sobre el tema de innovación y triple hélice en México. La selección de la literatura se realizó buscando artículos de revistar científicas, libros, conferencias relacionadas con el modelo de la triple hélice, en bases de datos digitales y libros impresos en México. Posteriormente se codificaron los artículos encontrados y usando diagramas de afinidad (matrices) y se clasificaron en tres tipos de factores: internos, estructurales y ambientales.

Resultados: El principal objetivo de la academia en México es la educación, la cual carece de una visión innovadora. Esto tiene como consecuencia que a pesar de los esfuerzos para lograr la vinculación, el número de proyectos de vinculación entre la academia y la industria sea mínimo.

Conclusión: En los últimos 20 años ha habido un incremento en el número de investigaciones sobre el modelo de la triple hélice de la innovación en México, debido a la desarticulación de los actores en México. Los investigadores han estudiado la situación y descrito las áreas de oportunidad, experiencias y mejores prácticas, con la finalidad de compartir, trasmitir y promover los cambios para cada actor del modelo. Es necesario determinar los factores clave que retrasan y/o promueven el involucramiento de la academia en el modelo de la triple hélice de innovación en México, con la finalidad de generar y promover ideas, acciones y políticas que tengan un impacto positivo en el desarrollo tecnológico.

***Palabras Clave*:** Innovación; triple hélice; México; academia; factores clave; análisis SAM

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Abstract

Introduction: Innovation is recognized as an essential activity for increasing competitiveness in a country. Etzkowitz defines a triple helix model for innovation process that describes the relationship between industry-academia-government interaction and innovation in an institution, region or country. In the last two decades Mexico has adopted gradually a technological approach, by changing and implementing technological policies which include industry, government and academia transformation. One of the main difficulties has been the implementation of these polices within academic institutions due to their organization and structure.

Method: Fot the methodology, it was use a state of the art matrix (SAM) in order to colect, compile and analyze the available literature about innovation and triple helix in Mexico. The selection of the literature was made by finding journal papers, books and conferences related to triple helix model in digital database and in books printed in Mexico; Afterwards, the articles were codified using affinity diagrams (matrices) and were classified in three types of factors: internal, structural and environmental.

Results: The main objective of the academy in Mexico is education, which lacks of an innovative vision. This has the consequence that despite efforts to achieve linkage, the number of projects linking academia - industry is minimal.

Conclusion: In the last 20 years there has been a growth in the research of triple helix model of innovation in Mexico, due the disarticulation of the actors in Mexico. Researchers have studied the situation and described the opportunity areas, experiences and best practices, in order to share, transmit, and promote changes in each actor in to the model. It is necessary to determine the key factors that delay and/or encourage the involvement of academia in the triple helix model of innovation in Mexico, in order to generate and promote ideas, actions and policies that have a positive impact in technological development.

Keywords: Innovation, triple helix, Mexico, academia, key factors, SAM analysis

Introduction

The innovation process in a country is determined by the linkage of three main actors: academia, industry and government. Some authors have conducted research on how such interaction should be to achieve a competitive level of the country. In the last 20 years, Mexico has adopted gradually, an approach on the development of the triple helix model of innovation linkage. Several authors have conducted local studies in order to obtain a diagnosis of the involvement of the three actors in the innovation process. This article presents a SAM analysis of the key linking factors of academia in the triple helix model. This paper, besides proving a literature analysis on academia, covers the following objectives: (1) identifying the main factors, (2) classification of literature, (3) describing each factor according to an affinity diaggram and (4) proposing general recommendations.

This article presents a qualitative study to enumerate and to analyze the key factors that inhibit and facilitate the linkage process within academy across Mexican literature, to determine the relation among them, in order to propose structural, internal and political changes in academic and industry institutions that increase interaction among actors and generate a third stage of triple helix model in the future.

State of the art matrix

A State of the art matrix (SAM) analysis was used by Beruvides and Vincent Omachonu (2001) to manage research information, this method uses matrices in order to compile and classify the literature about a specific subject. In this research, 36 publications were analyzed (see Annex I) for the purpose to compile research-made related to the topic, and then classified into different factors. The publications are divided as follow: 11 book articles, 14 journal articles, 9 conference proceedings, 1 book and 1 white paper. All of the publications are from the Mexican perspective of the situation of the triple helix model, covering 25 years of literature. Figure 1 represents a distribution graph of the type of documents studied across time (see Figure 1).

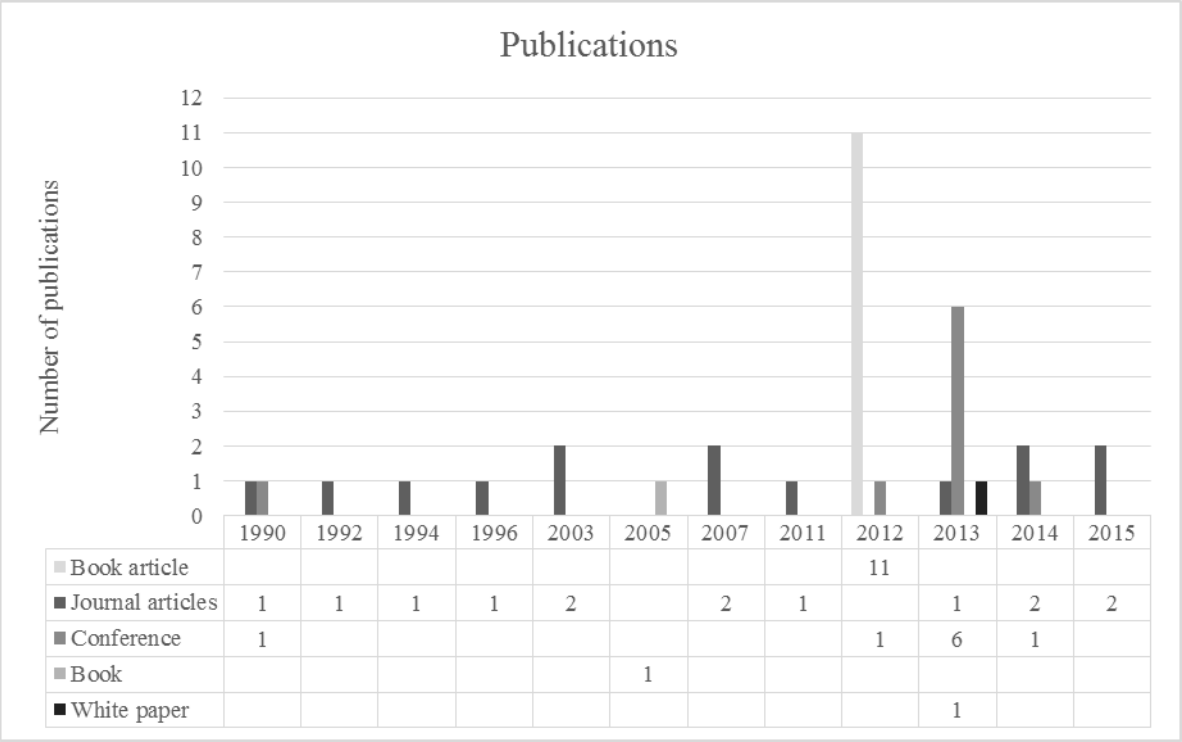


Figure 1. Literature classification (own elaboration)

From the publication analysis can be notice that in the last decade (2005-2015) there has been more research on the topic of innovation and triple helix model in Mexico, this reveals that the importance of innovation in the country has emphasized in the last decade. The recommended steps for SAM are:

1. List all subject-areas related to the research topic.
2. List the critical terminology, key words used by researchers in the area to define and describe the research.
3. Do an extensive/ exhaustive literature search.
4. The search should be done using Internet
5. Select data management software.
6. Begin to compile the research into binders or files.
7. Develop a schedule for reading and reviewed each piece of research and develop the classification scheme that best describes the area of research. Finally, it is the time to define and codify critical graphical data.
8. After completing the review process the construction of the matrices and other analyses are conducted to try to decipher information from the research.

Conceptual issues in technology transfer and triple helix

Technology transfer can be defined as "the successful adoption of a technology package by a new organization i.e. when technology is purchased or licensed between companies" (Boer, 1999). Khalil (2000) defines technology transfer as a process that permits the flow of technology from a source to a receiver. Seen from conventional perspective, technology transfer is referred to the sell or concession made with lucrative objective of technology (Escorsa Castells & Valls Pasola, 2005). Technology transfer process implies some sub-process and interactions with other institutions; they can be other firms, customers, stakeholders, etc. As Pedroza & Suárez (2003) mentioned, technology innovation is a complex technical, economic and social process that denotes complex net of interactions between the enterprise with other enterprises, government, academy, and society.

Innovation is a social process which is successfully developed with the construction of networks, with a strong interaction between stakeholders and buyers of goods, services, knowledge and technology. The triple helix model determines the multiple relationships of the knowledge capitalization process. The model is formed by three main actors:

(1) Academia, defined as public research centers, universities, technological institutes of high education, etc.

(2) Industry comprise of big, medium and small enterprises, and;

(3) Government as the structural and political environment where academia and industry develop.

Etzkowitz (2002) defines four stages of the model. The first stage consists in the internal transformation of each helix, intersecting developments, second stage is determined by the influence of one helix over another, third stage is the creation of an overlay of trilateral networks and the last stage is the relationship between academia-industry-government as an association among equals, working in synergy. The main purpose of the linkage between them is to stimulate economic development based on knowledge.

One of the main theories for regional innovation is the national innovation systems (NIS). A NIS is defined as a model that comprises a production structure and institutional network. The production structure are the consumers, enterprises, institutions and organizations, while the institutional network are the policies, strategies, programs, actions and supports to develop innovation (Guzmán & Brown, 2013; Merrit-Tapia, 2012). In the NIS, distance is an

important factor for the interaction between different actors in innovation process (Fuentes, C. de, & Dutrénit, G., 2014). NIS model has been used to explain innovation process in small countries but with high technological development. (Saldaña Rosas, 2014)

According to Jun (2008) "the interaction among university, industry and research institutions will produce a synergistic effect, greatly enhancing the capability of national innovation system". This means that the triple helix is a model that simulates in a macro way the national innovation system of any entity, as city, town or country. Also Jun (2008) concludes that by stablishing a triple heix model the national level of competitivness can be increased.

The role of academia is the education of human resources with the purpose of acquiring and developing knowledge necessary to work in area of interest. The main functions of academia have been: teaching, research and extension services (Acuña, 1993). Academia has to interact with industry in order to solve technical problems that arise within the social, industrial and governmental needs. Also, Academia needs to have a close relationship with government to promote, encourage and develop necessary policies for technological development (Merrit-Tapia, 2007).

Diagnosis of the innovation situation in Mexico

In the last two decades, Mexico has increased efforts in science and technology themes, in order to reverse the low economic development. In the last decade, Mexican government has proposed the implementation of new policies corresponding to technology transfer between firms and academy. Even though the efforts and the arisen of new policies, they have not been sufficient to make the transformation of the country needs towards an innovative culture. Mexico has a problem in its evaluative and adaptive capacity of its universities to understand science and technology importance in country development and competiveness (Arechavala Vargas, R., 2011). The problematic has many reasons, but mainly the disarticulation of triple helix actors.

The environment is characterized for a low spending in science, technology and innovation, lack of innovative culture, poor linkage between academy and industrial sector, low production of specialized human resources and little amount of specialized financial instruments for the innovation process. According to National Council of Science and Technology in Mexico (CONACYT [for its acronym in Spanish])(2013), in 2012 the national expenditure in Science and Technology was distributed as follows: 55.1% from public sector;

41.6% from private sector, and 3.3% from Superior Education Institutions. According to Mendoza Rojas (2011) the federal spending in education has increased from $207,006 thousand MXN to $512,112 thousand MXN corresponding to a 60% increase in 11 years, this means an average of 8% per year. This shows that the importance of education has increased in federal perspective, as shown in Figure 2.

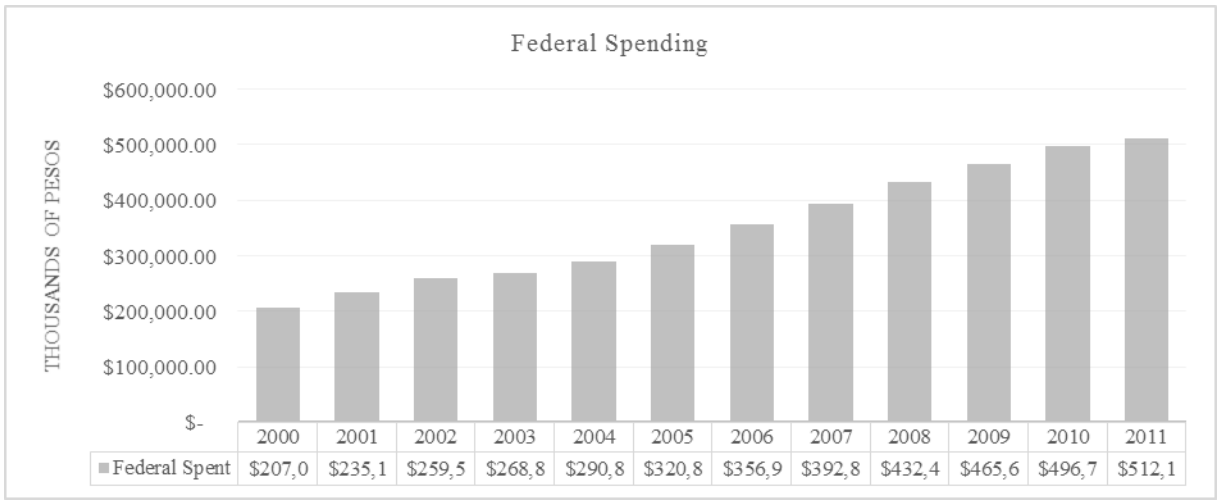


Figure 2. Federal spending in education in Mexico from 2000 to 2011 (own elaboration)

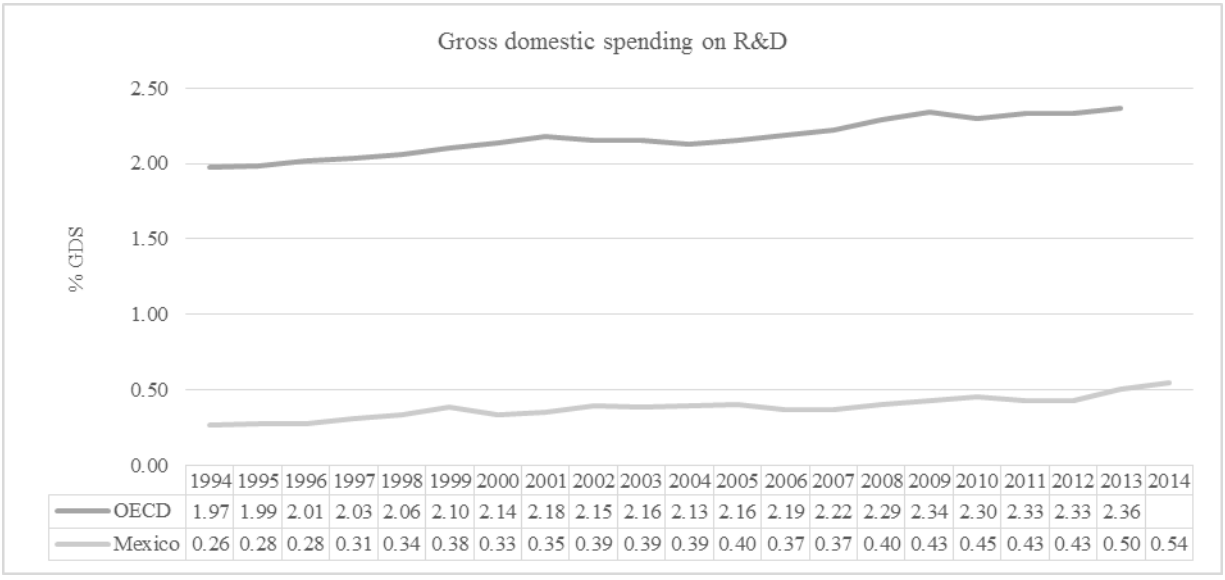
Mexican research has failed to fully develop technological innovation model, this can be seen in the number of patents obtained by Mexican companies and/or Mexican researchers, in 2014 of 9,819, only 305 were of Mexican origin. (Instituto Mexicano de la Propiedad Industrial , 2014) This means that only 3.1% of total are from Mexican origin. According to Forbes (2014) from 2009 to 2014, 93% of patents are from firms, 6% from independent researches and only 4% from universities. This shows the lack of a poor intellectual property culture from universities in Mexico.

The impact factor of scientific publication in Mexico in the last year is 4.25, representing a low impact factor compared with the impact factor of developed countries as USA or Germany, 7.70 and 7.47 respectively (INEGI, 2016). Further, according to Soto Flores and Fregoso Falcón (2012) 19% of technological parks are not associated with any enterprise or industry.

One of the main problems of education research in Mexico is researcher's training (OECD, 2013), nowadays there are a total of 44,769 specialty programs, 155,077 masters programs and 29,355 doctoral programs in Mexico ([SEP], 2013). But only 230 specialty programs, 1,067 masters programs and 579 doctoral programs are recognized in National Registry of

Postgraduates in CONACYT([CONACYT], 2015), these represents that only 0.82% of all graduate programs are registered.

Another important indicator is the gross domestic spending (GDP) on R&D. According to OECD (2015) in the last 19 years (1994-2013), Mexico has spent an average of 0.36% of GDP on R&D; this percentage is the overall average of the OECD countries as it can be seen in Figure 3. This shows that the GDP on R&D is not stuffiest to develop an innovative culture and increase Mexico's competitiveness Rodríguez, Leopoldo et al. (2013).



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OECD	1.97	1.99	2.01	2.03	2.06	2.10	2.14	2.18	2.15	2.16	2.13	2.16	2.19	2.22	2.29	2.34	2.30	2.33	2.33	2.36	
Mexico	0.26	0.28	0.28	0.31	0.34	0.38	0.33	0.35	0.39	0.39	0.39	0.40	0.37	0.37	0.40	0.43	0.45	0.43	0.43	0.50	0.54

Figure 3. Gross domestic spending on R&D. Mexico and Average of the OECD countries comparison

Methodology

According to SAM analysis the following steps were conducted.

1. List all subject-areas related to innovation and triple helix model in Mexico. In this paper the subject areas were: industrial engineering, economics, technology management, technology transfer, innovation and triple helix model.

2. Then the key words were defined: "innovation", "triple helix", "technology transfer", "Mexico"; "linkage", "academy" and "industry". Also, it is important to signalize that the search was made using the keywords in English and in Spanish.

3. Afterwards and extensive literature search using Emerald, IEEE and ProQuest database were used; articles from Altec (Asociación Latino-Iberoamericana de Gestión Tecnológica), ISPIM International Society for Professional Innovation Management),

and Asociación Nacional de Universidades e Instituciones de Educación Superior (ANUIES) as well as books printed in Mexico were conducted. The literature research was done till July 2015.

4. The literature was compiled using a excel spreadsheet. All the information from literature was filled in the spreadsheet (author, title, year, type of publication, etc.)

5. The literature was ordered chronologically and then alphabetically by author.

6. After reading and analyzing some articles, it was decided to classified the literature using the Freeman (1987); Rothwell and Dodgson (1991); and Barceló (1994) classification's (Pedroza Zapata & Suárez Núñez, 2003) to determine de key factors of successful innovation in firms. The classification method was chosen because despite having few elements, broadly defined innovator structure of any institution. The characteristics of each type help to describe more completely each definition thereof, making it easier and practical to sorting therefore easier to interpret and understand. The classification is described as follows (see Figure 4):

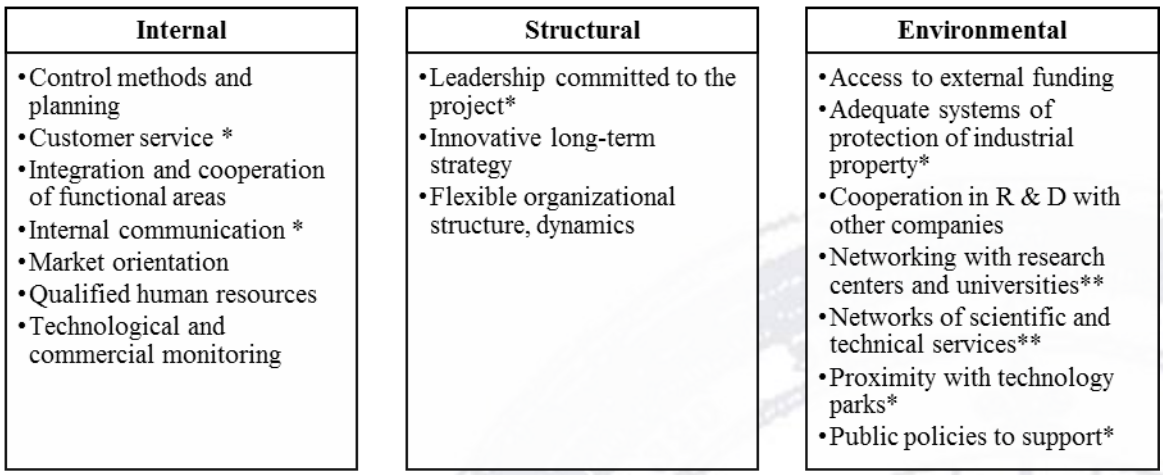


Figure 4.- Factors classification according Freeman (1987); Rothwell and Dodgson (1991); and Barceló(1994) (Pedroza Zapata & Sárez Núñez, 2003)
**Factors that were not found in academia SAM analysis*
***These two factors were join in one named Networks of scientific and technical services*

7. After completing the review process there were found a complex list of main factors, 157 factors in total. The SAM analysis proposed the use of matrices but in this paper affinity diagrams were used instead of matrices. An affinity diagram is an organizing procedure to sort or to group issues or items into categories for analysis (Yen, 2009).

   Each factor (internal, structural and environmental) is divided in one or more characteristics (described in each of the boxes shown in Figure 4) that help describe

the situation of each one according to the objective of the article. To facilitate the understanding of each element found in the analysis, a detailed description of each of the factors is performed.

For example, it was found that four authors mentioned intellectual property as key factor (see Table 1), and then this factor is described as "Poor intellectual property culture" and can be localized as Control methods and planning within internal factors in Figure 4. In this way, all the factors were classified into 32 key elements, separated in 12 factors divided in three types.

Table 1. Factors defining Poor intellectual property culture

Factor /Author(s)				
4) Guadarrama, V. H., & Woolfolk, C. A. (2013)	*11) Solleiro, J. L., Ritter, E., et al (2012)*	*17) Vázquez Lombera, J., & Vázquez Pérez, A. (2012)*	*27) Meza Olvera, E. (2012)*	*31) Vera Salazar, P., Álvarez Suescun, E., et al (2013)*
Poor intellectual property culture	Lack of attention in intellectual property issues	Lack of legal information in linkage process	Need of involvement of lawyers in the realization of linking agreements	Need to implement intellectual property policies

Internal factors

Internal factors are described as operating and organization characteristics of the institution needed to build and develop activities with an innovative approach. From the SAM analysis, the following table was obtained (Table 2):

Table 2. Internal factors of academia in linking process of triple helix in Mexico

Characteristics	Elements	References
Control methods and planning	Institutional prestige	López Martínez, R. E., Medellín, E., et al. (1994) Castañeda Santibáñez (1996) Torreblanca Rivera, L. G., & Trujillo Corona, C. S. (2012)
	Poor intellectual property culture	Vázquez Lombera, J., & Vázquez Pérez, A. (2012) Meza Olvera, E. (2012) Solleiro, J. L., Ritter, E., & Castañón, R. (2012) Guadarrama, V. H., & Woolfolk, C. A. (2013)
Integration and cooperation of functional areas	Insufficient infrastructure	Sánchez Puentes (1990) López Martínez, R. E., Medellín, E., et al. (1994) Soto-Velázquez, R., Castaños-Rodríguez, H., et al (2007) Guadarrama, V. H., & Woolfolk, C. A. (2013)
Market Orientation	Capital human profiles away from business demand	Sánchez Puentes (1990) Villarreal Gonda (1990) Llorens Báez (1992) Castañeda Santibáñez (1996) Fernández (2003) Schorr Wiener, Valdez Salas, & Hernández-Duque Delgadillo (2003) Soto-Velázquez, R., Castaños-Rodríguez, H., et al (2007) Guillén Guzmán, F. (2012)
	Academic service offer	Solleiro, J. L., Ritter, E., & Castañón, R. (2012)
Qualified human resources	Individual prestige	López Martínez, R. E., Medellín, E., et al. (1994) Torreblanca Rivera, L. G., & Trujillo Corona, C. S. (2012)
	Human resources mobility	Sánchez Puentes (1990) Villarreal Gonda (1990) Schorr Wiener, Valdez Salas, & Hernández-Duque Delgadillo (2003) Meza Olvera, E. (2012) Guadarrama, V. H., & Woolfolk, C. A. (2013)
	Innovation focus of the academics	Sánchez Puentes (1990) Soto Velázquez, R., Castaños Rodríguez, H., et al (2007) Vázquez Lombera, J., & Vázquez Pérez, A. (2012) Torreblanca Rivera, L. G., & Trujillo Corona, C. S. (2012) Meza Olvera, E. (2012)
Technological and commercial monitoring	Technological monitoring	Villarreal Gonda (1990) Castañeda Santibáñez (1996) Schorr Wiener, Valdez Salas, & Hernández-Duque Delgadillo (2003) Vázquez Lombera, J., & Vázquez Pérez, A. (2012) Torreblanca Rivera, L. G., & Trujillo Corona, C. S. (2012) Solleiro, J. L., Ritter, E., & Castañón, R. (2012) Guillén Guzmán, F. (2012) Amaro-Rosales & Villavicencio-Carbajal (2015)

Integration and cooperation of functional areas

According to the authors (López Martínez, 1994; Soto Velázquez et al., 2007), Mexican academic institutions lack the necessary industrial and laboratory equipment to put into practice the theoretical knowledge acquired in the classroom. This problematic leads the linkage between academia and industry through professional practices of students, thereby students can uses industry facilities and have real-world environment approach. Academic institutions do not have sufficient economic resources to stablish and implement industrial-like laboratories in order to complement theoretical knowledge.

Control and planning methods

Most of the academic institutions in Mexico are more focused on achieving and increasing the institutional prestige through research excellence, than in developing research for innovation. In spite of Torreblanca Rivera, L. G., & Trujillo Corona, C. S.(2012) mentioned that academic institutions have more emphasis in professional development and prestige of researchers; they said that this search-for-prestige conduct results in a poor linkage process with industry. Even though academic institutions generate knowledge, they do not involve in the process of technology transfer.

The lack of involvement in technology transfer process of the academic institutions is related with the poor intellectual property culture. Most of the academic institutions lack of explicit policies and regulation about the linkage process with private sector (Solleiro et al., 2012). In most of the linkage contracts there is a little involvement of counsel from academic institutions. According to Meza (2012) the National Polytechnic Institute (IPN, for its acronym in Spanish) has the Attorney General Office ("Oficina del Abogado General") to manage, conduct and review linkage conventions between IPN and industry. This has favored positively technology transfer process between projects and industry.

Market Orientation

Market orientation refers to the capacity of the institutions to study and diagnose market needs in order to restructure or modify internal organization to satisfy those needs. According to the authors, one of the main problems in the linking process in Mexico is that academic institutions do not take into consideration the requirements and/or needs of neither the industry nor the government for the design and operation of curricula, causing that graduates from technological institutes and universities lack necessary technical skills to develop

activities within firms. Guillén Guzmán, F. (2012) mentions that formation of academic alliances are needed to develop curricula attached to industrial and social requirements. According to Schorr Wiener, Valdez Salas, & Hernández-Duque Delgadillo (2003) technological universities may offer a high quality superior education that responses to productivity sector.

Added to this, most of the firms do not look forward to associate with academic institutions because most of the time, they ignore about additional services that academics have to facilitate, support and develop innovation activities. Academic institutions need to search and link with firms that involve technology, this key activity helps stablishing relationships with industrial sector. It means that academic institutions not only have to promote their services but also to detect industrial needs with the aim of develop university projects (Solleiro et al., 2012).

Qualified human resources

Skilled human resources enable a company or institution to perform the activities necessary for the proper operation thereof. Academic institutions are characterized for having more researchers than industry. That why the linkage is necessary, to make those researchers work altogether with industrial technicians to solve industry problems. It was found three factors that affect the linkage process in these category, they are: individual prestige, human resources mobility, and innovation focus of the academics (Solleiro et al., 2012).

According to López Martínez, R. E., Medellín, E., et al. (1994) and Sánchez Puentes (1990) most of the academics and researchers in Mexico are motivated to research with the intention of obtaining a patent and increase their individual perspectives that also generates additional revenue and increase their prestige, but they are not aware that their patent can be transfer latter. Also Torreblanca Rivera, L. G., & Trujillo Corona, C. S.(2012) mentioned that researchers are focusing on publishing in order to increase their level in national institute of researchers (SNI, for its acronym in Spanish). So the technology transfer process is delayed because of this. In the last decade CONACYT has stablished the project named “Avance” that is a program focus on promote training and acquisition of methodologies to the consolidated offices of technology transfer and support researcher´s patent in the process of commercialization.

Students, teachers and academics´ low mobility between academic institutions, and low levels of public-private sector cooperation affects the linkage process because they slow down the development of technical capacities of academic actors (Guadarrama & Woolfolk, 2013). As seen before, academic institutions do not have sufficient infrastructure to put into practice theoretical knowledge, but for example if one institution has the necessary equipment needed by students researching in other institute, they could access to that institution or industry to experiment and continue with his or her investigation.

Most universities and academic institutions are more focused on academic activities like teaching, forming and tutoring, rather than research and innovation activities; however research in academic institutions requires organization, policies, full-time researchers and economic support (Sánchez Puentes, 1990). Vázquez Lombera, J., & Vázquez Pérez, A.(2012) mentioned that the academic institutions that reach linking in industrial projects leave students work alone; it means that teachers are not really involved in the projects, and students completed the project in order to pass the subject. Because of this Torreblanca Rivera, L. G., & Trujillo Corona, C. S.(2012) say that it requires a conviction by the researchers of the importance of technology transfer and benefit to society, the educational institution and the researchers themselves.

Technological and commercial monitoring

Most of the studies show that firms do not look for linking with academic institutions because most of academic project do not consider industrial needs. Academic institutions projects are focus on theoretical problems and do not reveal industrial reality(Guillén Guzmán, 2012; Torreblanca Rivera & Trujillo Corona, 2012). Academic institutions need to implement activities that allow access to information, methodologies, practices and needs of industry and environment to generate innovation projects, recommended Vázquez Lombera, J., & Vázquez Pérez, A.(2012). It means the creation of structured technological monitoring techniques within academic institutions.

Structural factors

The structural factors are related to the ability of an organization to develop a project according to the established strategy. From the SAM analysis, the following table was obtained (see Table 3):

Table 3. Structural factors of academia in linking process of triple helix in Mexico

Characteristics	Elements	References
Innovative long-term strategy	Technological approach	Llorens Báez (1992) López Martínez, R. E., Medellín, E., et al. (1994) Arechavala Vargas (2011) López Parra, M., Borja Ramírez, V., et al (2012) Solleiro, J. L., Ritter, E., & Castañón, R. (2012)
	Commercial exploitation of knowledge	Sánchez Puentes (1990) Castañeda Santibáñez (1996) Torreblanca Rivera, L. G., & Trujillo Corona, C. S. (2012) Solleiro, J. L., Ritter, E., & Castañón, R. (2012)
	Entrepreneurial culture	Castañeda Santibáñez (1996) López Martínez, R. E., Medellín, E., et al. (1994) Castañeda Santibáñez (1996) Arechavala Vargas (2011) Torreblanca Rivera, L. G., & Trujillo Corona, C. S. (2012) Solleiro, J. L., Ritter, E., & Castañón, R. (2012)
Flexible organizational structure, dynamics	Linkage process and mechanisms	Sánchez Puentes (1990) López Martínez, R. E., Medellín, E., et al. (1994) Soto Velázquez, R., Castaños Rodríguez, H., et al (2007) Arechavala Vargas (2011) Vázquez Lombera, J., & Vázquez Pérez, A. (2012) Guillén Guzmán, F. (2012) Meza Olvera, E. (2012) Solleiro, J. L., Ritter, E., & Castañón, R. (2012) Amaro-Rosales & Villavicencio-Carbajal (2015)
	System of incentives and stimuli	Sánchez Puentes (1990) Llorens Báez (1992) Torreblanca Rivera, L. G., & Trujillo Corona, C. S. (2012) Meza Olvera, E. (2012) Solleiro, J. L., Ritter, E., & Castañón, R. (2012)
	Financial resources	Llorens Báez (1992) López Martínez, R. E., Medellín, E., et al. (1994) Guadarrama, V. H., & Woolfolk, C. A. (2013) Amaro-Rosales & Villavicencio-Carbajal (2015)

Innovative long-term strategy

The authors highlight the importance for academic institutions to have programs that encourage students to generate innovative ideas for the creation of technology-based companies. Furthermore, within academic institutions it should be a promotion of relationships with external clients and partnerships, such as with other academic institutions, firms, and government to encourage applied research. According to Solleiro, J. L., Ritter, E., & Castañón, R. (2012) in Mexico exist little experience in linking process with academia, so

it is necessary to increase the number of successful cases in order to promote the linkage process, and encourage firms to link with academia.

As mentioned above, many academics create patents without the aware that they can commercialize it, that's why Torreblanca Rivera, L. G., & Trujillo Corona, C. S. (2012) point out that most of universities and investigation centers lack personnel with commercializing abilities to achieve technology transfer process. Similarly, academic institutions do not focus on the economic aspects of linking process, according to Guillén Guzmán, F. (2012) this is a paradigm that working with companies prostitutes academic activity. Academic institutions role is education and they should not have relation with entrepreneurial activity. However, the academy should leverage their resources and knowledge to generate income through investment in technological activities.

Supported by López Martínez, R. E., Medellín, E., et al. (1994) and Castañeda Santibáñez (1996) there is a cultural gap between academic and industrial sectors. Academics need to change the perception of academia, and start including academic activities in the linking process with external actors through the creation of entrepreneurship culture within the research activities (Solleiro et al., 2012). It is necessary to generate academic activities that encourage students to create their own enterprise and to highlight their benefits.

Flexible organizational structure, dynamics

According to the authors (Sánchez Puentes, 1990; Amaro-Rosales & Villavicencio-Carbajal, 2015), one of the main factors that affect linking process with academia is bureaucracy to consolidate innovation projects. As Soto Velázquez, R., Castaños Rodríguez, H., et al (2007) industrial sectors require fast responses to meet their needs but academia has many process and procedures to stablish linking contracts. Authors agree that it is fundamental for academia to make radical organizational changes in order to create policies, framework and organization that facilitate linking process. In the study made by Meza (2012), he noticed that an academic institution with well-implemented strategy increases the level of confidence with firms, and increases its participation in linking projects. It can be determined that academic institutions need interaction structures that reduce the administrative, operational and management barriers related to generating projects and agreements of linkage in academic institutions with industry and/or government projects.

Mexican universities lack explicit policies and regulations to manage linkage projects with private sector, in most of academic institutions incentive and stimuli systems have no direct relationship with research and technology transfer (Solleiro et al., 2012). Torreblanca Rivera, L. G., & Trujillo Corona, C. S. (2012) and Meza Olvera, E. (2012) signalize that it is necessary to generate and stablish a system of incentives and stimuli associated with technology transfer in academic institutions in order to motive research groups within academic institutions. According to Amaro-Rosales & Villavicencio-Carbajal (2015) there are many incentive mechanisms but due the complex policy environment they represent an innovation barrier.

Instability of public universities is one of the factor inhibiting linking process between academic institutions and industry, due the deficiency of financial resources (López Martínez, 1994). As it was pointed before there is a low budget allocation related to research and technology transfer activities, causing that financial resources are not sufficient to generate new projects and to ensure the financial supports of the actual ones. These mean that is necessary the implementation of policies of assuring financial resources for activities related to technology transfer in academic institutions, not only to promote technological activities but to ensure the completion of innovation projects.

Environmental factors

Environmental factors are external conditions given by the government and industry that directly and indirectly influence the interaction of academia with the other actors within the model of the triple helix. These factors influence in the linkage process but they do not determinate the degree of linkage between academia and industry or government. In Table 4 are the characteristics of the environmental factors found in the SAM analysis.

Table 4. Environmental factors of academia in linking process of triple helix in Mexico

Characteristics	Elements	References
Access to external sources of financing	Financial public support	Guillén Guzmán, F. (2012)
Cooperation networks	Innovation poles	López Martínez, R. E., Medellín, E., et al. (1994) Robles-Cárdenas, S. A., & Ballinas-Ríos, F. (2012) Meza Olvera, E. (2012) Micheli Thirión, J., & Armendáriz Torres, S. (2012)
	International collaboration	Solleiro, J. L., Ritter, E., & Castañón, R. (2012)
	Strategy alliances	Castañeda Santibáñez (1996) Solleiro, J. L., Ritter, E., & Castañón, R. (2012) Guillén Guzmán, F. (2012) Guadarrama, V. H., & Woolfolk, C. A. (2013)
Networks of scientific and technical services	Exposure of students to industrial environments.	Sánchez Puentes (1990) Villarreal Gonda (1990) López Martínez, R. E., Medellín, E., et al. (1994) Castañeda Santibáñez (1996) Vázquez Lombera, J., & Vázquez Pérez, A. (2012) Guillén Guzmán, F. (2012)
	Technological extension services.	Corona Treviño, L. (2005) Sampedro H., Becerra, Dutrénit, & Torres (2012) Saldaña Rosas, A. (2014).

Access to external sources of financing

As seen in structural factors, one of the most important factors that inhibit linkage projects with academic institutions is lack of access to financial resources. In Mexico, federal-spent in education has increased in the past 10 years but it has not been sufficient to cover research demands in academics institutions to accomplish successful performance in triple helix model. According to Guillén Guzmán, F.(2012) one of the motivation for the academic institutions to collaborate with industry is access to public financial resources. Academic institutions need to establish mechanisms for pursuing funding and public support for technological projects and stimulate network collaboration. On the other hand, some researchers (Rodríguez, Rosa Ibarra, Torres Vargas, Guillén G, & Woolfolk, 2013) point out that the evaluation commissions have a crucial role in assigning public resources in research project, that means that criteria, processes and practices must be clear and transparent. This means that the main problem of seeking public resources has its roots in the definition of government policies.

Cooperation networks

The location of an innovation pole does not only rely on the firms -or on the firms´ clusters - located in the territory but rather in the complex ecosystem of innovation dynamics that takes place between different actors (Capdevila, 2014). Innovation poles encourages regional innovation systems, competitive and technological development through successful linkage process (Robles-Cárdenas & Ballinas-Ríos, 2012). Academic institutions require the creation of spaces, projects, activities and events that facilitate communication and interaction with business, government and society to the realization of development of innovation activities in academic institutions. For example, IPN has created an interface to accomplish the integration of society and industry with academia; the purpose of the interface is to ensure efficient mutual beneficial relationships with the environment, that contributes to improve institutional functions and social development (Meza Olvera, 2012).

In Mexico most of the international collaboration is related to student exchange programs in bachelor degrees. But for postgraduate programs the exchange programs are limited to academic institution with programs registered in the National Register of Quality Graduate Program, that is limited to only 0.82% ([CONACYT], 2015) of total postgraduate programs. It is important to increase international collaboration in order to complement researcher knowledge and collaborate with international projects and researchers (Solleiro et al., 2012). For example in a research performed to study advantages in international cooperation with "Grupo Lala", Rodríguez Díaz (2012) concluded as advantages: (1) complement leaders' role, (2) efficient knowledge transfer, (3) combination of capabilities to solve project problems, and (4) identification of wining strategies and best practices.

Academic institutions should been seen as a part of a complex system of academic, entrepreneurial, social and public entities, to stablish a strategy that impacts their own environment (Guillén Guzmán, 2012). It is necessary to develop and implement policies for collaboration research with industry and government sector for creating, developing, monitoring innovation projects in academic institutions. According to Guadarrama & Woolfolk (2013), one of the limitations of innovation strategies in Mexico is that institutional objectives are not aligned to national-innovation objectives because of a lack of communication between different actors; therefore, it is required to promote communication and collaboration among academia, industry and government in order to develop a success triple helix model.

Networks of scientific and technical services

As it can been seen, one of the internal factors is the insufficient infrastructure in academic institutions, this can be overcome by creating academic programs that foster business linkage acquiring work experience to students. This requires stablishing channels of communication and collaboration between academic institutions and industry and/or government. For example in the case of study of Vázquez Lombera & Vázquez Pérez (2012), where a group of students of "Universidad Nacional Autónoma de México [UNAM]", collaborated with Jersa Industry; they noticed a variety of benefits from this linking process as access to industry methodologies, information and practices, also allowing students to know internal business development processes, and to study the industry behavior, markets, needs and priorities.

Academic institutions´ role in triple helix is scientific development and technological capacities (Corona Treviño, 2005) but most of the times industry and government have no awareness of academic activities available and the process of technology transfer support. Sampedro H. et al. (2012) recognized 18 linkage channels between academic institutions and industry, known as technological extension services; and they grouped them in 7 categories as follow: (1) information, (2) property rights, (3) human resource training, (4) R&D cooperation and contract, (5) company formation, (6) networking and (7) consultancy. Academic institutions require to publicize their activities in order to allow external actors to have access to knowledge and combine experiences and ideas (Capdevila, 2014). It is important to academic institutions to acquire and develop staff with skills, knowledge and experience to develop work and support linkage-project activities.

Key findings

The internal key factors of academy are related to activities that are conducted within academic institutions. The main objective of the academy in Mexico is education, which lacks of an innovative vision. This has the consequence that despite efforts to achieve linkage, the number of projects linking academia - industry is minimal. Academy should aim to prepare competent professionals that are required to the economic development of Mexico (Sánchez Puentes, 1990)

Academic institutions absence necessary resource to carry out research and development, however, the academy has not exploited its capabilities and expertise to promote links with industry and government. For example, the academy does not have the infrastructure capacity to implement the theoretical knowledge, but through linkage with industry, it can develop in

students and academic staff theoretical knowledge in industrial laboratories. Similarly, academic institutions can promote their skills and knowledge to industry and conduct linking activities.

As can be seen, the structure of academic institutions does not allow the interaction of academics and students with the industrial environment of the region. Likewise, the academy does not meet the needs of the environment, it can be seen that the curricula of universities do not match labor field demand. It may also notice a lack in activities related to technology transfer activities, it is required that academic institutions involved in the processes of industrial property and contract performance linkage.

Moreover, it can be recognized the importance of prestige, both institutional and individual. In Mexico most universities focus their activities to attract more students through institutional prestige. Also scholars engaged in research and connections with companies have as priority increase their individual prestige in order to increase their personal income and expand individual perspectives. Most scholars conducting industrial projects prefer to work outside the academic institution, due to the lack of organization and structure of the academic institution in relation to development linking projects.

On the other hand, the structural key factors of academy are related to the organization of the academic institutions. According to Vera Salazar, Álvarez Suescun, & Angulo Cuentas (2013), innovative leadership is required to address academic institutions into an innovative culture. In Mexico, most of the academic institutions have cultural barriers about innovation, obstructing the linkage with industry and government.

One of the most mentioned factor is the linkage process in academic institutions. The organizational structure of academic institutions require bureaucratic process of selection, monitoring and support of linking project, causing the linking process with other institutions or actors to take longer than estimated. So, it is necessary to make structural modifications within academic institutions, in order to facilitate the linkage process. These modifications include policies, programs, and activities that support the linking projects and increase its number.

Many of the structural factors are related to the academic institutions´ vision. The main goal of the academy is forming and educating their students; however, in order to become part of

the triple helix model of innovation requires a change in the culture of academic institutions towards a technological approach and knowledge culture.

Financial resources, are other key factor, most of the universities in Mexico do not have enough financial resources for linking process, causing academics to participate in innovative project externally of academic institutions. Also, academic institutions do not have stablished a policy for incentives and stimuli for the academics and/or students participating in linking project. These polices may guarantee financial resources for participants, hence promoting and increasing participation of scholar members.

Finally, environmental factors determine conditions that promote linking process in academic institutions. In the case of Mexico, it appears that academic institutions lack the financial and materials resources to carry out research and development activities, making it necessary to search for external financing sources and strategic alliances with both industry and government.

Environmental factors are mostly related to innovation poles, geographical network structures that allow the heterogeneity of the actors and the relationships between them in order to generate and share knowledge (Corona Treviño, 2005). Join to innovation poles are strategy alliances, both are related to the capacity of each actor to develop and stablish relationships through innovative projects. Without a side that projects should be carried out in environment that promotes formal and informal relationships between academia, industry, government and society. As Capdevila (2014) mentions places, spaces, projects and events facilitate activities to develop innovation process.

On the other hand, it is important that academia exposures students to a real world environment, in order, to generate applicable ideas to solve daily problems. This can be done by stablishing links with industry and government. To achieve this academia requires producing the necessary structure to facilitate and promote collaboration projects. Academic institutions as an actor of triple helix model should be seen as partner of the industry, government, and society in developing innovation projects (Weisz & Carvalho de Mello, 2013). Also the industry requires doing structural changes to receive students and to offer them an opportunity to collaborate with real problems Pacheco, V., & Mejía, G. (2013).

Conclusions

In the last 20 years there has been a growth in the research of triple helix model of innovation in Mexico, due the disarticulation of the actors in Mexico. Researchers have studied the situation and described the opportunity areas, experiences and best practices, in order to share, transmit, and promote changes in each actor in to the model. In this paper a SAM analysis of literature was performed in order to synthetize key factors in the process of linking in the triple helix of innovation in Mexico from the academy point of view.

In the last decade Mexico has experimented changes in public policies in science and technology, but despite the efforts the correct implementation of these polices have had deficiencies. Across the analysis of literature it was found a list of key factors; which were synthetized and classified in internal factors, structural factors and environmental factors, for a better understanding.

Internal factors of the academy are related mainly with the operation and organization of thereof. Most authors agree that the organization of academic institutions do not allow the interactions in technological network. Academic institutions need to restructure their policies, process and organization with an innovative focus; that means that they have to consider human, financial and infrastructure resources that permit academics and student the interaction with industry and government for developing industrial projects.

It is also required a culture change within academic institutions, from the teaching-learning perspective to learning-innovating perspective. Academics need to consider a practical application for their research results, and not only generate patents that later cannot been transfer and/or commercialize. Moreover students should be more involved in real world problems in order to generate ideas that create applicable technology. For this, it is necessary a change in the academic strategy to generate and spread a more innovative and entrepreneur culture.

Regarding the structural factors, authors did not mentioned the leadership role in innovative process, but as Vera Salazar, Álvarez Suescun, & Angulo Cuentas (2013), innovative leadership is required to change the actual learning culture into an innovative culture. It is important that each academic institutions look for stablishing internal leaders that promote academics and students to generate, participate and interact in technological projects with industry.

Finally environmental factors are determined by external conditions. In Mexico, government has reformed technological polices to facilitate access to financial resources for academic institutions and enterprises, and to promote linking projects between them. Even though, access to financial resources is one of the most mentioned factors across literature, academic institutions need to link projects as a way to obtain financial resources to develop technological solution and promote academics and students collaboration. Some authors recommend changes to those policies and increase surveillance in implementing them.

In conclusion, it is necessary to determine the key factors that delay and/or encourage the involvement of academia in the triple helix model of innovation in Mexico, in order to generate and promote ideas, actions and policies that have a positive impact in technological development. However, it is also important to consider that the results of these changes are not immediate and requires a continuous process of transformation to see tangible results in a given period of time. As Saldaña (2014) mentioned successful innovation is the result of elements that facilitate the creation of a favorable environment.

Also, it is important to highlight that this study is based in the first stage of the triple helix model; it is intended to conduct a study of each actors separately to make a deep research of each. As Etzkowitz (2002) pointed it is impossible to advance to second stage if one of the actors has not made the internal and structural changes to interact with the other actors.

As can be seen through the study of literature, many factors are constant over the years, especially in internal and structural factors, concluding that there is still required for internal and structural changes within the academy to achieve the first stage of the triple helix model, and then can seek interaction with other actors to reach the further stages of the model, and obtain the final stage: association among equals.

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Annex I – SAM analysis literature

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