



Productive articulation model as a regional innovation system

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Abstract

This paper presents a productive articulation model that serves as the basis for developing and enhancing regional innovation systems. The main objective is to generate a process of linkage between the industrial sector, academia, and government within which specific regional problems can be solved through the effective intervention of each of the actors. Also, a success story is present in the State Guanajuato, Mexico, which serves to visualize as a clear and defined process of articulation that allows between the actors a transfer of knowledge. Among the main results, be seen how the process proposed in the document serves to generate positive interaction between industry-academia-government, and in the present study solution feasible to the problem was obtained of the case.

Keywords: Productivity articulation model; regional Innovation system; triple helix.

JEL Classification: L38, O18

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Modelo de articulación productiva como sistema regional de innovación

Resumen

Este documento presenta un modelo de articulación productivo que sirve de base para desarrollar y mejorar los sistemas regionales de innovación. El objetivo principal es generar un proceso de vinculación entre el sector industrial, la academia y el gobierno dentro del cual se puedan resolver problemas regionales específicos mediante la intervención efectiva de cada uno de los actores. Además del proceso, se presenta una historia de éxito del Estado de Guanajuato, México, que sirve para visualizar como un proceso claro y definido de articulación que permite una transferencia de conocimiento entre los actores. Entre los principales resultados, se observa cómo el proceso propuesto en el documento sirve para generar una interacción positiva entre industria-academia-gobierno, y en el presente estudio se obtuvo una solución factible al problema del caso.

Palabras clave: Modelo de articulación de productividad; sistema regional de innovación; triple hélice.

Códigos JEL: L38, O18

1. INTRODUCTION

The literature on regional innovation systems (RIS) has grown impressively since 2000 (Doloreux, 2002; Fornahl & Brenner, 2003; Todtling & Trippl, 2005; Isaksen & Trippl, 2017; Asheim, Grillitsch & Trippl, 2016; Isaksen, Todtling & Trippl, 2018; Berman, Marino & Mudambi, 2020). The Regional Innovation System (RIS) is one of the complementary approaches to innovation systems. The idea of a Regional or even local Systems of Innovation, in contrast to the traditional National Innovation Systems (NIS), has taken a lot of attention due to the increase in regional imbalances and inequalities. Also, each region has its unique characteristics that affect economic transformation and evolution (Howells, 2002; Iammarino, 2005; Coletti & Di Maria, 2015; Dhewanto et al., 2016; Guimon, 2017). Therefore, the combination of national policies is not sufficient to address specific regional needs (Riahi, & Fard, 2019).

The idea of RIS is presented by Cooke (1992), and since then, many contributions made to evolve the concept and the importance of it (Cooke 2004; Doloreux, & Porto Gomez, 2017; Makkonen et al., 2018). For example, it can be conceptualized as the set of companies, organizations, and institutions that influence innovative behavior and economic performance at the regional level (Cooke et al. 2004; Asheim & Gertler, 2005).

Regional Innovation Systems (RISs) usually focuses on the comparative performance of different regions and analyzes how each region is utilizing its resources own. Also, the available resources can be shared by many firms that are grouped by industry, just as universities collaborate with many firms in many industries (Avilés-Sacoto, Cook, Güemes-Castorena & Zhu, 2020).

Among the main components of a Regional Innovation Systems (RIS) are the geographical space, networks among the enterprises, appropriate financial

institutions, the presence of effective innovation policies, technical agencies and research and development (R&D) public infrastructure, among others (Borrás & Edquist, 2013; Evangelista et al., 2002). Policies include supporting the development of human capital through education and training policies, supporting the promotion of new network organization companies, developing infrastructure (Audretsch & Feldman, 1996; Wolfe & Gertler, 2006).

The RIS models make a great emphasis on the interactions between the private and public sectors to guide and sustain innovation (Mason, Castleman & Parker, 2005). The key to generating innovation is centrally based on the relationships and mutual influences among the actors in the system (Carlsson et al., 2002; Sleuwaegen & Boiardi, 2014). In this sense, the interaction between the industry and different corporations, such as academia, government, and financial systems, is needed to provide knowledge, skills, and an innovative solution (Wolfe, 2011). Among the examples of frameworks that implement the RIS approach are the European Commission-funded RIS/RITTS initiatives (Landabaso & Mouton, 2002), VINNOVA regional policies (Coenen & Moodysson, 2009), and the Norwegian VRI program (Asheim, 2012).

This paper aims to contribute to the understanding of the phenomenon of RIS in emerging economies by presenting a productivity articulation model (PAM). The PAM has been used in the Government of Guanajuato, Mexico in connection with the Guanajuato State Science and Technology Council (CONCYTEG, acronyms in Spanish) and prove to be a successful model to generate new solutions using as a base the triple helix model. Also, the paper presents an

example of a successful process to solve a plague of the *Phytophthora capsici* fungus in chili producers of the State.

The rest of the document is as follows: Section 2 will review the studies carried out on RIS and the triple helix model. Section 3 will explain the methodology detailing the Productivity Articulation Model. Section 4 discusses and presents an example of a PAM model success story. Section 5 presents the conclusions of this document and provide related recommendations.

2. THEORETICAL REVIEW

2.1. *Regional Innovation Systems (RIS)*

The innovation systems that define innovation must be an evolutionary, non-linear, and interactive process that requires intense communication and collaboration between different actors. The actors include universities, educational institutions, innovation centers, financial institutions, regulatory bodies, industrial associations, and government agencies (Edquist, 1997, 2001). These actors include other companies, research institutes, training organizations, and intermediary organizations (Doloreux & Porto Gomez, 2017).

Therefore, the innovation system of a company is made up of a multitude of actors who participate in the innovation process and interact with each other. The interactions between the actors have been studied from different perspectives, as well as the role that each institution plays in the system (Kwon & Motohashi, 2017). Although several authors study innovation systems based on case studies, for example, they have analyzed how institutions have managed to promote the establishment of a RIS in disadvantaged areas (Dantas & Bell, 2009; Clò, Florio, Pellegrin &

Sirtori, 2018), RIS have been studied for specific industries such as tourism (Anne-Mette Hjalager, 2010). Also, they examine the relationship between universities and industries in a RIS (Wang, Vanhaverbeke & Roijakkers, 2012).

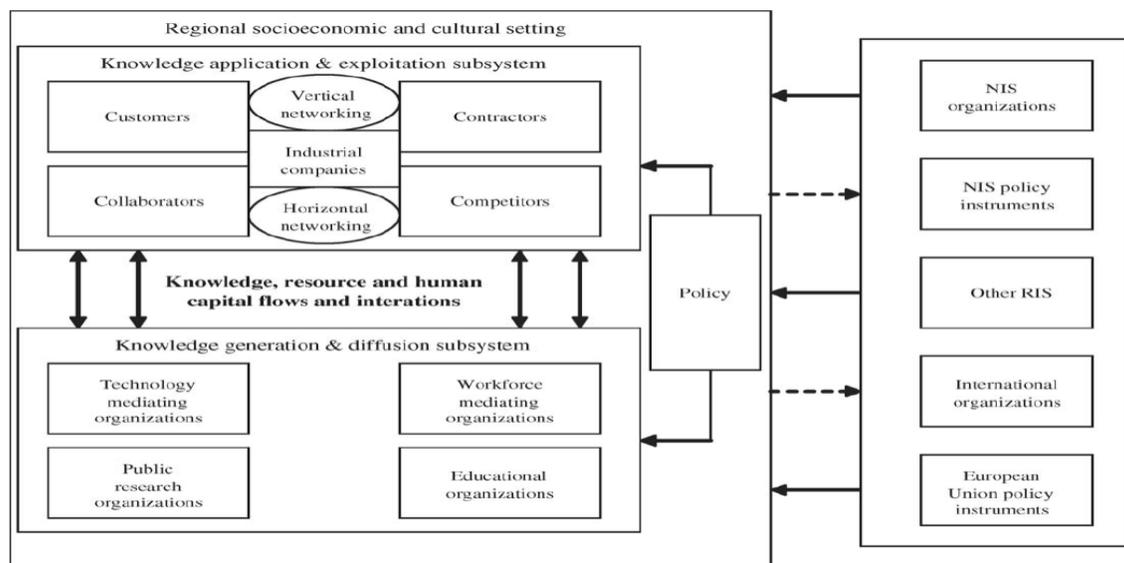
Likewise, other studies have investigated the determinants of RIS, and the processes necessary for an innovation system to grow at the local or regional level, such as networks between companies, universities, regional culture as well as governance (Chen and Guan, 2011). Also, the national innovation system (NIS) literature has revealed vast differences between countries in attributes as Research and Development (R&D), economic structure, institutional set-up, and innovation performance (Edquist, 1997). This concept of innovation system has been applied to the national level (Nelson, 1993; OECD, 1999).

Taking the approach to a regional level, RIS is an interaction between private and

public interest, formal institutions, and other organizations that function according to the organization and institutional arrangements that conduct to the generation, use, and dissemination of knowledge (Doloreux & Parto, 2005).

In accordance with Braczyk, Cooke & Heidenreich, (1998) and Cooke, Boekholt & Tödtling, (2000), the regional innovation system (RIS) approach provides a useful framework to the firms, institutions, and clusters, of an innovation system. This RIS approach emphasizes social and economic interaction between agents – from both the public and private sectors – as a critical channel for the diffusing of knowledge within regions, which are, in turn, embedded in more extensive national and global systems of innovation (Asheim, Boschma & Cooke, 2011). It shows a schematic illustration of the structuring of regional innovation systems provides by Autio (1998). (See Figure 1)

FIGURE 1. THE MAIN STRUCTURE OF REGIONAL INNOVATION SYSTEMS (RIS)



Source: Tödtling & Trippl (2005), based on Autio (1998).

Regional innovation systems are far from being self-sustaining units. They usually have various links to national and international actors and innovation systems. It can be seen in two essential dimensions: First, to the innovation networks of firms, there is a widespread consensus nowadays that local connections do not suffice to sustain innovativeness. In the context of intensifying international competition and accelerating technological change, extra-regional contacts that complement local ones are of much signification. External links provide access to ideas, knowledge, and technologies, which are not generated within the limited context of the region (Bunnell & Coe, 2001; Camagni, 1991; Mytelka, 2000; Oinas & Malecki, 1999, 2002). Second, in terms of public intervention, it becomes apparent that regional, national, and European policy actors and organizations can shape the development and dynamics of regional innovation systems (multi-level governance) (Tödtling & Trippel, 2005).

2.2. *The Triple Helix Model*

Academics and policymakers have long attempted to depict innovation systems from different angles to understand the foundations and developmental paths of innovation (Li, He & Zhao, 2019). A popular framework is the Triple Helix model of university-industry-government collaboration (Etzkowitz 2003; Etzkowitz & Leydesdorff 1997, 2000).

The triple helix model is a knowledge-based innovation tool with the interdependent principal parts of government, university, and industry. For Fu & Jiang (2019), the mechanism of the model is to optimize the regional innovation environment through the promotion of

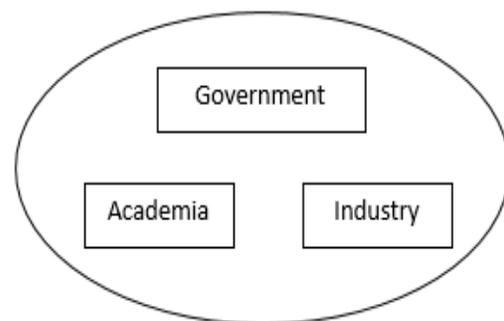
regional cooperation and fostering a feedback loop to act on the innovation efforts of different participants.

Therefore, a Triple Helix innovation system is a spiral model of innovation that captures multiple reciprocal relationships at different points in the process of knowledge capitalization (Leydesdorff, 2000).

The existence of the university, the company, and the interactions of the government can also be identified as a critical factor in regional development (Etzkowitz & Klofsten, 2005). As a result, according to Mueller (2006), nations fostering connections among these three types of institutions often enjoy a competitive advantage in terms of better knowledge creation and utilization.

The model proposed by Etzkowitz establishes the evolution of innovation systems, and the current conflict about which path to take in university-business relations is reflected in institutional arrangements other than academia-industry-government. First, you can distinguish between specific historical situations that you may want the "Triple Helix I" label. In this configuration, the government embraces the academic world, and the industry directs the relations between them (Figure 2).

FIGURE 2. TRIPLE HELIX MODEL I

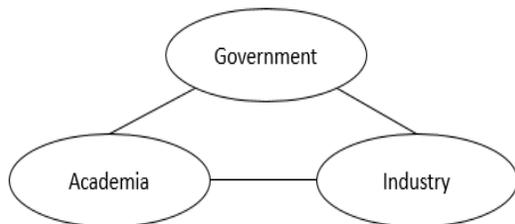


Source: Etzkowitz & Leydesdorff (2000)

The robust version of this model can be found in the former Soviet Union and European countries under the "existing socialism." Weaker versions were formulated in the policies of many Latin American countries and, to a certain extent, in European countries.

A second model (Figure 3) consists of different institutional areas with strong frontiers, divided, and delimited relations between the spheres. The integrating vision of the model is the one that develops the problem of linkage; Etzkowitz & Leydesdorff (2000) propose a conceptual process as an evolutionary consequence of the innovation process, which is put into action in an integrating response between the academia, industry, and government participation. Thus, academia is involved in activities specific to innovation and the factors that determine a link between the two remaining helices.

FIGURE 3. TRIPLE HELIX MODEL II

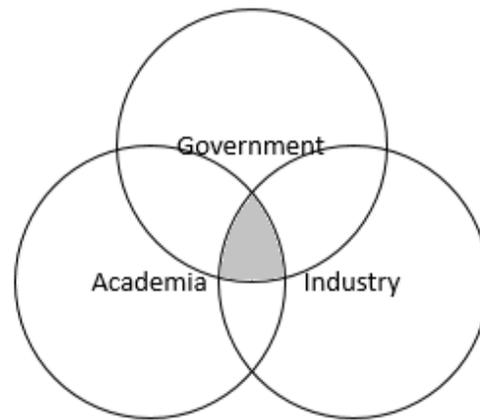


Source: Etzkowitz & Leydesdorff (2000)

Finally, triple helix III is creating a knowledge infrastructure in terms of overlapping institutional spheres, where each takes on the role of the others and with emergent hybrid organizations in the interfaces (Figure 4). In the study of the relationship between university-business-government, it is important to mention the transition to a knowledge society since it is the basic premise of the Triple Helix model.

On the one hand, the university is an institution of medieval origin that has played a feudal support role, and the industrial society moves to center stage. At the same time, industry and government constitute the frame of reference for the post-industrial era of knowledge-based societies (Etzkowitz & Klofsten, 2005).

FIGURE 4. TRIPLE HELIX III MODEL



Source: Etzkowitz & Leydesdorff (2000)

For Etzkowitz and Klofsten (2005), the model of the Triple Helix consists of three basic elements that are the following:

- It assumes greater importance in the role of the university in innovation, along with industry and government based on the knowledge society.
- There is a movement towards collaborative relationships between institutional areas in which the policy of innovation is increasingly a result of interaction and not a recipe for the government.
- Each institutional area also takes activities of others, which operate in an axis of their new role.
- A business university, which makes the conventional parts of industry and

government, which is the central institution for innovation in the regions.

In one way or another, most countries and regions are currently trying to apply the Triple Helix III model properly.

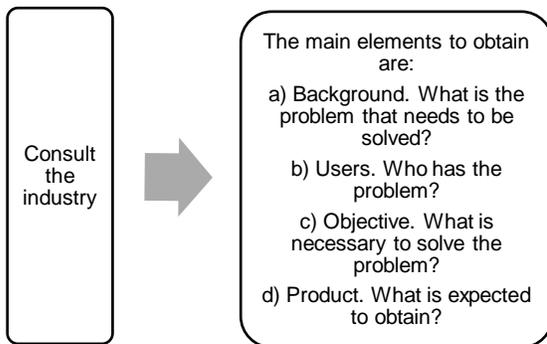
3. METHODOLOGY

This section presents a description of the phase's productivity articulation model. The main idea is to show the steps (Phases) different that need following to generate the articulation process between the industry-academia-government, and also the figures that are present in this section serve as basic questions to obtain the information to progress in the process.

Phase 1. In this phase, a questionnaire is made to the companies or business chambers to identify their wants or demands. In this way, it is possible to have a portfolio of requirements or needs of the business sector, and that will allow identifying if in the environment there is human capital necessary to solve the identified need or if it is required to search for intellectual capital outside the region.

The graphical idea of this phase is the following.

FIGURE 5. PAM PHASE 1

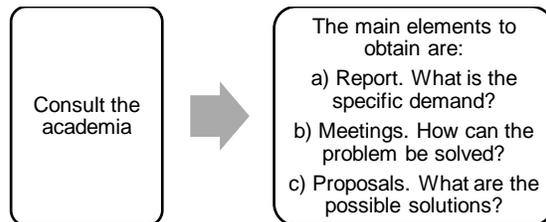


Source: Own elaboration

Phase 2. Consist of convening all the researchers of the different institutions of the State, organized in worktables, located according to the business demands, explaining what the information matrices consist of and how they were elaborated. Understood the mechanism, investigators are asked to select within the needs or demands that they believe can be addressed or resolved by them.

After this, we continue with the next step of phase 2, which is to bring together in the same space entrepreneurs and researchers to agree on how to carry out the research and development project that will solve their demand. Here the team of government officials plays a significant role since they must be the interlocutors or translators of the dialogue between academia and the industry. This phase can be seen graphically in Figure 6.

FIGURE 6. PAM PHASE 2

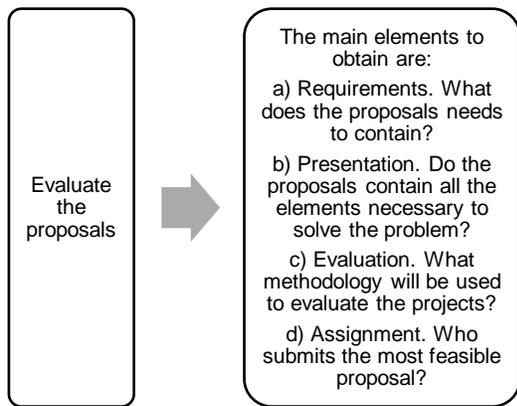


Source: Own elaboration

Phase 3. In this phase, the evaluation of the proposals will be carried out based on the specific characteristics of the demand or need. The industry will indicate the main points to evaluate and the weights for each of these. Also, the government must, in turn, specify are the main elements that the proposal must contain to obtain governmental resources and support. In the next step, the academia must present its proposals considering the characteristics of the industry and the government so that

later, they are evaluated by a committee composed of members of the three sectors (academia-industry-government). Each proposal should be evaluated; in this part, many different techniques can be used; some recommended would be weighted averages, ordered weighted average (OWA) operator, or any other aggregation operator (Blanco-Mesa *et al.*, 2019). Once calculated, the project with the best result will be assigned to be carried out and will be the one attached to the government resource. The graphical presentation of this phase can be seen in figure 7.

FIGURE 7. PAM PHASE 3.

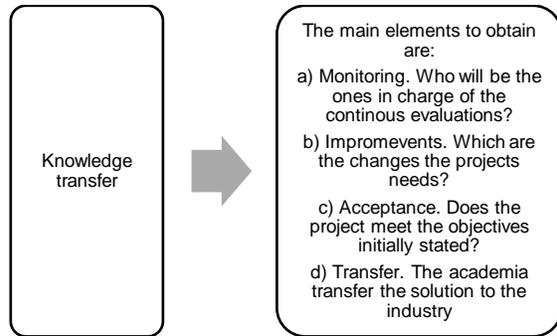


Source: Own elaboration

Phase 4. Academia develops the project and works with the industry and government for the monitoring and evaluation. The purpose of these reunions is that academia does not deviate from the purpose of the project. On the other hand, the industry is satisfied with the advances presented in the project, and the government verifies the correct transfer of the knowledge. Any problem presented can be solved in the different reunions that academia-industry-government will have. In this way, the PAM

concludes. In a simplified form, this phase is presented in figure 8.

FIGURE 8. PAM PHASE 4



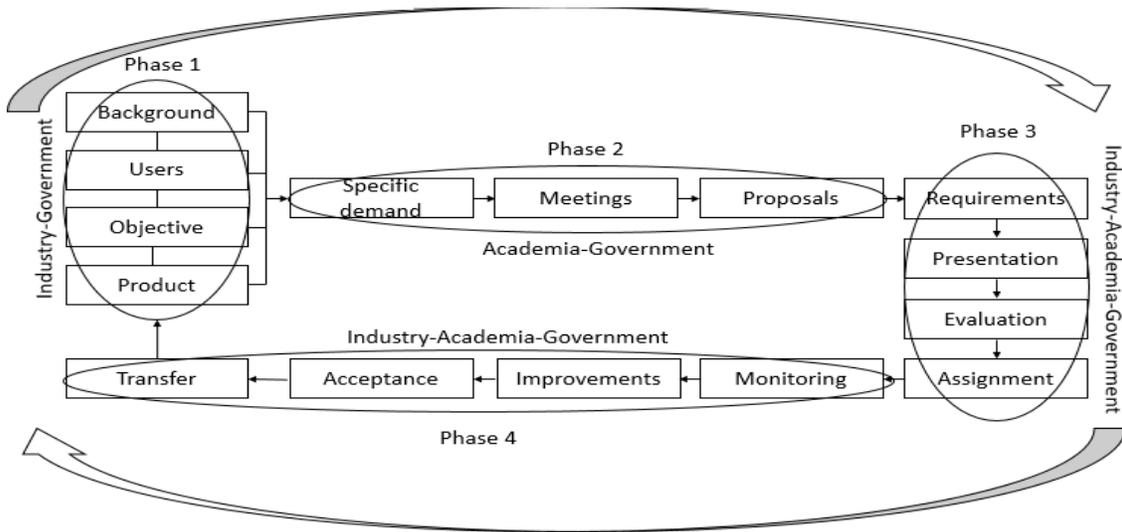
Source: Own elaboration

The whole idea of the PAM model is presented graphically in figure 9. As can be seen, it is possible to achieve knowledge transfer with the PAM and, at the same time, including government, industry, and academia in the proposal, becoming a good strategy as a RIS. PAM model is cyclical since once a problem or need has been solved, the industry can ask for more support, the academia will be linked efficiently with the productive sector, and the government will effectively provide support and resources.

4. SUCCESS CASE OF THE PAM MODEL

The case to be analyzed will be that of the chili producers of the State of Guanajuato, who, suffering a plague of the *phytophthora capsici* fungus in their product, caused it to wither once it matured and disabled its possibility of a sale, generating significant losses in the sector. Hence, they met with the Governor of the State of Guanajuato Juan Carlos Romero Hicks to raise their need, and he informs the Director of Science and Technology of the State of Guanajuato (CONCYTEG) who started the application of the PAM model.

FIGURE 9. PAM MODEL



Source: Own elaboration

The following describes how each of the different stages of the model was given.

Phase 1. A meeting is convened by CONCYTEG (a government agency) and those affected (industry) to determine if the problem is presented clearly. At this stage, the questions in Figure 5 are used as the basis, and the need to develop a planting process that includes the pesticides needed to combat the phytophthora capsici fungus is detected. Once clearly identified, the need is taken to the next phase.

Phase 2. In this stage, the director of CONCYTEG (a government agency) makes a call to all researchers and universities (academy) who knew the product (chili), whether production, genetics, management, pest control, and other related. This call was attended by researchers from the Center for Research and Advanced Studies (CINVESTAV) Irapuato unit, National Institute of Forestry, Agricultural, and Livestock Research (INIFAP), Faculty of Agronomy of the University of Guanajuato,

Instituto Tecnológico de Roque, State Committee of Plant Health of Guanajuato (CESAVEG) and the Institute of Technology of Celaya. Once the problem was explained, the researchers began to work in their laboratories for possible solutions. After six months, the first approach of the experimental planting process was taken to combat the phytophthora capsici fungus within which the use of certain chemicals and processes was intended to eliminate the appearance of the fungus. It is then moved to phase 3.

Phase 3. Once the process to be followed by the academy had been presented, pilot tests were carried out on specific hectares of cultivation. At this stage, it was a farmer who oversaw using the experimental planting process to visualize the effectiveness and feasibility of the project. Once applied, adjustments were made to the method according to the time, soil type, temperature, and other specific characteristics of the area needs of the industry. Once this is done, it was determined what the process should be

followed to avoid this problem. It is from this part that you move to phase 4.

Phase 4. Once the planting process was validated, CONCYTEG (government), researchers (academy), and producers (industry) began the process of knowledge transfer. In this case, academia supported by the farmer who lent their land for the testing process was the ones who brought that knowledge to the other producers. It is important to mention that this process began two years after the first stage. As can be seen, in the case analyzed, there is a real transmission of knowledge applied from the academy to the industry, all articulated with the active government management carried out, in this case, by CONCYTEG.

Finally, is important to note that the process is consistent with the three basics elements that Etzkowitz and Klofsten (2005) propose. First, the university has a role important in innovation because it was the academia that solves the problem presented by the industry and focused on present a new plating process. Second, the industry-academia-government made an effective collaboration with different interactions among the process, generating successful communication between them, and generating better results based on the interaction. Finally, each institution took activities that helped to improve the final solution and helped to have the knowledge transfer process between academia to the industry. By doing these, it is possible to see that process can provide a methodology interesting to activate the Triple Helix at a regional level.

5. CONCLUSIONS

The paper presents a productive articulation model (PAM) based on the experiences obtained by work carried out within the State of Guanajuato, Mexico, through CONCYTEG. The objective of the model is to present the clear and precise stages in which problems can be solved between industry, academia, and government, allowing knowledge transfer and, in turn, developing effective regional innovation systems according to the needs of each State.

The PAM is a 4-phase model that begins with the identification of the problem by the industry; the above is generated by a link with the government (in this case the CONCYTEG) who detected the needs would look for the academy to present to them the needs of the industry and can propose different solution alternatives (phase 2). Within phase 3, the various options are analyzed and evaluated to select the one that is most appropriate based on previously determined elements, such as the necessary resources (economic, human, and raw material), time of development of the solution, among many other that is considered relevant. Finally, the implementation of the proposal is developed, and it is here that the academy transfers knowledge to the industry. It sees its problem resolved, all under the intermediation of the government.

Also, a success story about the plague of the fungus *phytophthora capsici* is presented. The main contribution was to link academia with problems of the industry, supporting the economy of the industry through a solution to the pest problem in their crops and allowing efficient articulation between actors

by the government. The above, as shown in Figure 9, will enable solutions to problems to be developed in a continuous way, which significantly improves the relationship between sectors and develops regional innovation systems through environment-specific solutions.

The methodology proposed to generate the PAM is important because is based on the main ideas of the Triple Helix (Etzkowitz & Klofsten, 2005) and also prove to be a successful way to generate RIS that provide solutions to local problems based on the knowledge and ideas that all participant has (industry-academia-government), being a RIS based on the interactions among the participants (Kwon & Motohashi, 2017). Also, it is important to note that the different 4 phases present some basic questions to start the obtention of information and that will serve as a base to upcoming projects.

Within the future lines of research will be specially considered how each of the phases can be better developed and allows to improve the survival possibilities of companies within their specific region (Leon-Castro, 2019) different decision-making tools under uncertain and diffuse environments (Alfaro-Calderon, Zaragoza, Alfaro-García & Gil-Lafuente, 2020; Alfaro-García, 2019; Alfaro-García, Gil-Lafuente & Alfaro Calderón, 2018; Alfaro-García et al. 2017) such as the use of the forgotten effects methodology (Kaufmann & Gil, 1988), information aggregation operators (Blanco-Mesa et al., 2019; Báez-Palencia et al., 2019), among others.

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