Management of scientific knowledge through an intelligent system

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Abstract

This paper proposes an intelligent system that manages the production of scientific knowledge by actors of the quadruple helix in Honduras (government, business, academy, society), framed in the research of the value and supply chains, consisting of search, creation, storage, transfer and implementation of knowledge within RDI production.

Keywords: knowledge management, intelligent Systems

Introduction

At the end of the 19th century, economists were focused on understanding the economic, political, social, and cultural aspects that determined whether a country was rich or poor, in this regard, statistics was introduced as a tool to study the development phenomena, and economic growth, which formed a new methodical paradigm that allowed to discover the crucial role knowledge plays in a macro context through studying the information that has been gathered, storing and transforming at the macro, meso, and micro social levels, which generate growth in a country's productivity (Fuentes, 2009), thus, knowledge became a topic of academic interest nowadays.

Due to the fast technological growth and the boom of the new Information and Communication Technologies (ICT), the borders of this ever-increasing world have come to be closer. This phenomenon that started at the end of the 20th century brought the necessity to create innovative systems for information management which allowed processing a high-scale volume of data and its consequent transformation in an intelligent product. This technological turn generated a new economy based in knowledge whose main productive component is the intellectual capital, which placed knowledge as a highly valuable asset, thus becoming a fundamental variable of economic analysis.

During the last decades, economy has focused its interest in innovation by considering the investment of resources in the production, application, and transfer of knowledge, information, and technology. Nowadays, an economic agent should obtain, analyze, and process a huge amount of information before taking a decision, which limits the efficiency of economic processes. A solution to this problem should consider 1.- a system that allows to process large amounts of data in a short time, and 2.- links with other economic agents that allow to reduce the necessary resources to perform an activity. This knowledge explosion makes it necessary for the academy, the government, private businesses, and society to integrate in order to improve knowledge transfer and the identification of critical factors that can boost the joint Research, Development, and Innovation (RD&I) of these factors.

This paper contains a short description of the triple, quadruple, and quintuple helix models that emerged in the last decades in order to have a better comprehension of the knowledge-based economies. Subsequently, an analysis of the Honduran context in terms of gobernment-acdemia-society-industry entailment, and finally a proposal of an intelligent system for knowledge management is presented which allows to boost the RD&I in Honduras

Conceptual Framework

Globalization as a phenomenon, the availability of continuing innovations, the constant development of the new ICT, along with the increasing strategic value of knowledge and information, make societies to be in a continuous process of change, due to these facts, it is necessary to think of new models that allow understanding the context of a society. In this regard, Etzkowitz and Leydesdorff (2000) developed a model called the triple helix (TH), which they used to study the relations that emerge among the academy, the industry, and the government under the premise that innovation is the engine that generates wealth, and it comes from the synergy among the main actors of the triple helix: universities, research centers, private business, government institutions, social groups, etc. (González, 2009).

Recent research studies show empirical evidence of the necessity to include more elements or helices to the TH model for a better explanation of a knowledge-based economy; this has generated the creation of a theory that allows extending the TH in an algorithmic way in order to create new models that consist of four, five, or generally more, N-helices (Leydesdorff, 2012). The quadruple helix model (QH) is the result of adding a new dimension to the TH, this fourth helix represents civil society (see Figure 1), which is necessary to have a broader understanding of economy because society is one of the main knowledge and innovation stakeholders, due to this reason, this model suggests that a better entailment of the TH with society is highly important. Likewise, the quintuple helix model is topologically equal to the TH and QH, the difference lays on a higher complexity level, and the addition of a quintuple helix which represents the environment. Such a model dictates that knowledge production and innovation systems should be closely linked to the environment and at the same time aiming at sustainable development from an ecological perspective, since a balance among society, economy and environment is essential for human civilization development (Carayannis and Campbell, 2010; 2012).
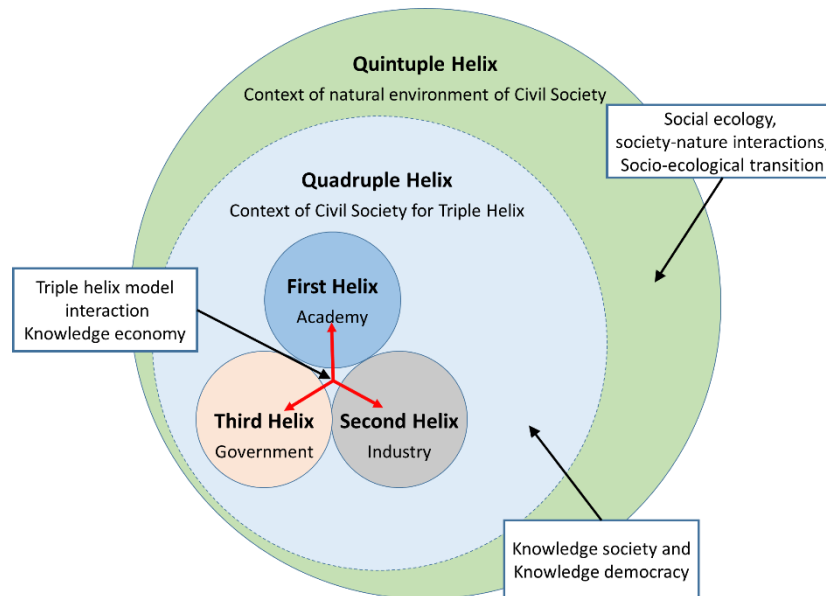
Figure 1 - Models of the Triple, Quadruple, and Quintuple helix.
Source: Adapted from (Carayannis and Campbell, 2013; Saurabh et al., 2014)

As it was previously mentioned, knowledge management is essential for RD&I production in modern economies which has an exponential impact on wealth production and therefore on a country's economic growth, because of that, it is important to deeply understand the meaning of knowledge management. It is important to point out that there are many definitions for the concept of knowledge; it depends on the philosophical perspective from which it is seen. This work does not aim at generating an epistemological debate, its objective is to have a more pragmatic vision and approach its classification as well as the way in which knowledge can be managed. In this regard, knowledge can be classifies as follows (Fuentes, 2009):

- Tacit knowledge: It is the one that can be found in the individuals' minds and due to this reason; it cannot be easily transferred without a common paradigm as well as a set of especial competences between the transmitter of this type of knowledge and its receiver.
- Explicit knowledge: Explicit knowledge is the one that is coded in a formal language. This knowledge is reproduced and transmitted among users in very different ways through channels and communication means such as documents, manuals, instructional materials, reports, etc.

In order for the integrating quadruple helix model to have a sustainable and high advancement through science, technology, and innovation in the different areas of the national development, it is necessary to have a means of knowledge transference that can fulfill the following conditions (Pavez, 2000):

- To formulate strategies of organizational scope for the development, acquisition, storage, transformation, and knowledge application.
- To promote a continuous improvement of business aspects, making emphasis on the generation and use of knowledge.
- To monitor and evaluate the achieved goals through application of knowledge.
- To reduce the cycle times in the development of new products as well as the improvement of already existing products, and the reduction of solution developments to the problems.

- To reduce costs related to errors' repetition.
- To verify the essential factors that can boost or have been able to limit the joint RD&I of these elements that make up the quadruple helix.

Knowledge management's purpose is to transfer knowledge from the place where it was generated until the place where it will be used, Figure 2 shows a way to understand such a way to transfer knowledge through the SECI model (Socialization, Exteriorization, Combination, and Internalization), which explains the different stages of knowledge management, from explicit to tacit and from tacit to explicit (Pavez, 2000; Nonaka and Krogh, 2009).

- Socialization: harmonizes the transfer from tacit to tacit knowledge through a process that consists of exchanging beliefs and experiences, thus generating abilities and knowledge (ex. face to face communication, brainstorming, observation, actions imitation, practice, etc.).
- *Exteriorization:* It conceptualizes knowledge from tacit to explicit through developing concepts and theories that are easy to share to be used by others (ex. Statement in the form of new concepts, metaphors, analogies, hypotheses, models, theorems, etc.).
- *Combination:* It generalizes explicit knowledge complicating it in broader systems of concepts and entities (ex. Association and exchange of documents, creation of e-mails, reports, papers, prototypes creation, etc.).
- *Internalization:* It operationalizes knowledge from explicit to tacit through the transfer and application of explicit knowledge. This implies learning through "learning by doing" (ex. Roles rotation, experimentation, etc.).
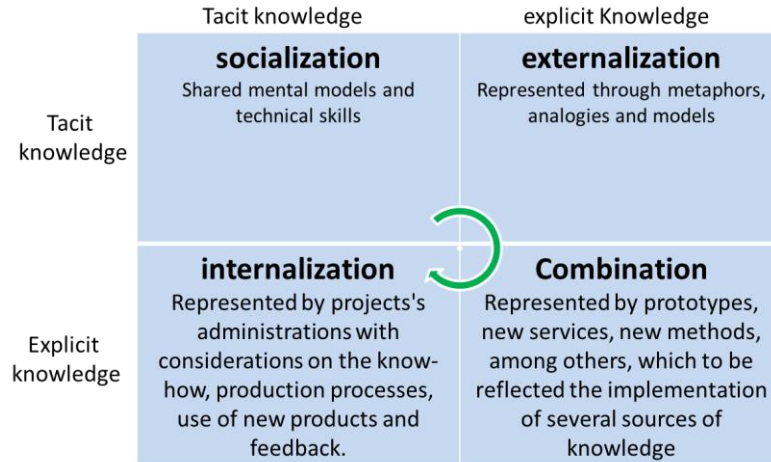

Figure 2 - SECI model for knowledge management
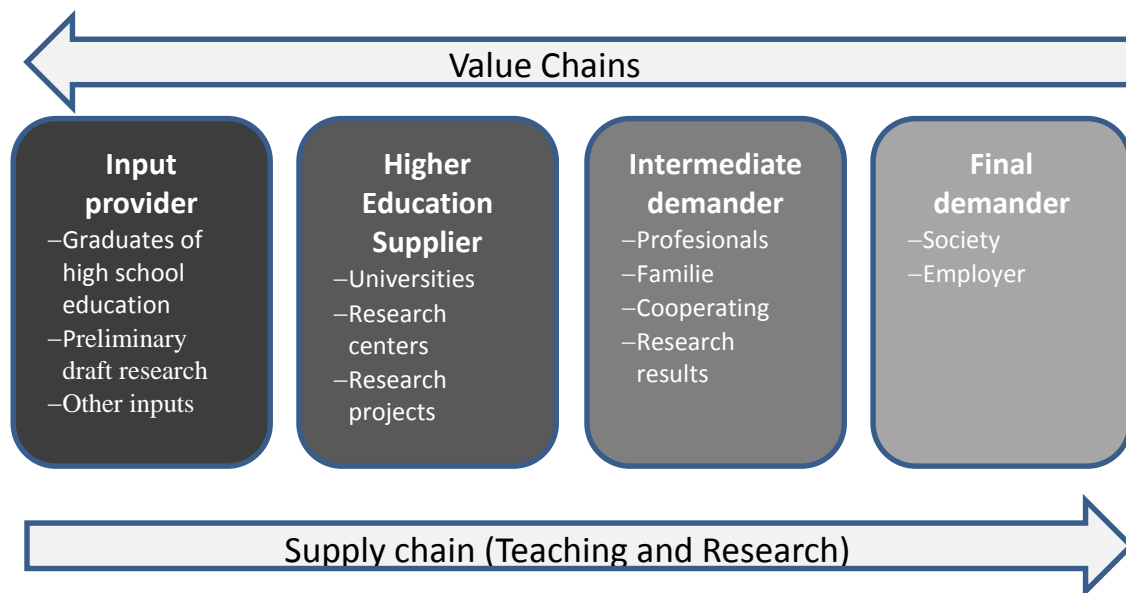*Source: Adapted from (Fuentes, 2009; Pavez, 2000)*

It is evident the SECI model is applied directly or indirectly whenever there is a transference of knowledge between two or more people. However, when research studies are conducted articulated at a macro level, this is, with elements from the academy, industry, government, and society, a considerably high amount of data is used, making it necessary that the economic agents and organizations have innovative information management systems which can allow them to turn the data into an intelligent product that are necessary to develop RD&I relevant results related to the society context. From this need comes the concept of competitive intelligence which aims at

monitoring the organization's environment through the detection and transformation of information into an intelligent product for strategic decision-making (Arroyo, 2005).

The RD&I along with the ICT display an important transition towards a generation of information focused on scientific knowledge, which generates a boom in the coming of intelligent systems and techniques for the boost of Scientific Knowledge Management. These intelligent systems and techniques are based on Mathematics, Logic, and Statistics for the development of intelligent algorithms which can solve practical knowledge management problems when implemented in computer tools (ex. to discover knowledge from a volume of information, discovery of patterns or regularities in information structures, etc.).

Quadruple helix in Honduras

The Higher Education Value and Supply Integrated System (HEVSIS) arises as an initiative of the National University Autonomous of Honduras to understand the interactions between actors of the quadruple helix from the perspective of the university. HEVSIS proposes a study of the national education system and its relevance in the productive sectors of society, through a model composed of a value chain and two supply chains (teaching and research), which consist of the following four links (See Figure 3): 1.- Input provider: inputs entering the higher education (students and research projects); 2. Higher education supplier: consists of all public and private universities; 3. Intermediate demander: composed of the first demanders in the Higher Education (professional, professional schools); 4. Final demander: labor market and Society. (Ortega et al., 2012).

Figure 3 - Flow value and supply model HEVSIS.
Source: Adapted from (Ortega et al., 2012).

Applying the model HEVSIS to the Honduran context has shown that the general perception of people with strategic positions in academy, private enterprise, government and society are aware that exist just a little articulation in the quadruple helix of Honduras, however, seems there are not political (short-term) to establish mechanisms for effective management and transfer of information between organisms belonging to the quadruple helix of Honduras (Ortega, et al., 2014).

A factor that may limit this linkage is that Honduras has allocated few resources to research and his results has not a proper diffusion (Diaz, 2012), this situation is aggravated due to:

- Lack of a mechanism conceptualization of tacit knowledge in Honduras.
- Inefficient transmission channels of information between actors in Honduras quadruple helix.
- Lack of an entity that centralizes the production of scientific knowledge in Honduras.
- Difficulty in retrieving scientific papers
- Lack of an audit mechanism, measurement, administrative and scientific validation and control in the execution of research projects
- Lack of mechanisms to identify good practices in the processes of scientific production in Honduras

Due to this problem in 2014 a research line was established in the National Autonomous University of Honduras called: Knowledge management and intelligent techniques (IIES,2014), this research line aims at the integration of RD&I along with the new ICT and the quantitative methods as a transition towards the information generation focused on scientific knowledge management. That allows monitoring the environment of the society areas through detecting and transforming the information towards intelligent results for strategic decision-making. Such results characterized as individuals or as a part of processes/practices from organizations and/or projects, propose or improve strategies and practices from the organizations or research projects. As a result of this research originated a spin-off of HEVSIS project, leading to the creation of the research project: Intelligence for Scientific Research (ISC), which is described in the next section.

Intelligence for Scientific Research in Honduras

The Project Scientific Research Intelligence (ISC) aims at the systematic and dynamic production of scientific knowledge management in Honduras within the frame of the value chains and research supply which includes the searching, creation, storage, socialization and transference as well as the knowledge practice for the RD&I production. Furthermore, it searches for the centralization of all the processes and results from scientific research which has direct repercussions on the efficiency and efficacy of the flow (transference) of the information among the elements from the quadruple helix through an intelligent system that facilitates the scientific knowledge management and analysis.

The IIC comes from the need to integrate the elements from the quadruple helix (academy, government, private businesses, and society), which is meant to be boosted through a channel that allows to obtain, transfer, and analyze the relevant knowledge, (scientific and tacit) available for the public and obtained legally and ethically, not only for science but also for its implementation and improvement in the decision-making of the elements from the quadruple helix. Thus, there will be an impact through science, technology and innovation in the different areas of the national development.

The ICC Project proposes a mechanism that conceptualizes the tacit knowledge and it frames it within a value chain and research supply, likewise, it considers a scientific knowledge management system in Honduras that is made of a series of data storage modules, information

search and recovery modules, a report generating module, on-line analytical processing and project intelligence models, among others.

Conclusions

Knowledge has become a central theme of modern economies, for this reason, this emergent paradigm of scientific knowledge management requires a readjustment (update) of the communication channels among the elements from the quadruple helix, this is possible due to the technological revolution that has emerged in the last decade, specifically in the ICT. In this regard, the scientific project IIC aims at creating a virtual system that allows an adequate tacit and scientific knowledge management in real time, through a series of "intelligent" modules that contain practices and strategies used to identify (auto-learning), create, store, transfer, and apply ideas and experiences in the form of scientific knowledge. Thus, it is expected at a middle term period to achieve articulated tasks (among the elements from the quadruple helix) through the cooperation, which boosts the scientific and technological areas developing proposals and capabilities of shared spaces of scientific research. It is expected that the academic community can formulate based on the demands and requirements from the productive area in order to achieve a higher local, regional, and national competitiveness.

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