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# KNOWLEDGE COMMERCIALIZATION FRAMEWORK: FACTORS AFFECTING DEVELOPING COUNTRIES

MARCO DE COMERCIALIZACIÓN DE CONOCIMIENTO: FACTORES QUE AFECTAN A LOS PAÍSES EN DESARROLLO

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## ABSTRACT

Amid economic pressure and inclination for independent financing, universities tend to commercialize knowledge, a growing trend emerging as an entry gate for the privatization of scientific advancements and the development and transfer of technology from universities. Numerous studies have been conducted on the commercialization of knowledge. This article aims to integrate previous studies and develop a comprehensive model out of the factors cited in those studies. Therefore, 57 relevant articles were analyzed to identify the indices of knowledge commercialization within the framework of a systematic review literature guideline. In addition to guideline validate criteria, three university professors were interviewed for conceptual model include the subjects (contextual, individual, organizational, institutional, and environmental), and components.

## KEYWORDS

Knowledge commercialization, Commercialization performance, Antecedent of commercialization.

## RESUMEN

En medio de la presión económica y la inclinación por el financiamiento independiente, las universidades tienden a comercializar el conocimiento, una tendencia creciente que emerge como una puerta de entrada para la privatización de los avances científicos y el desarrollo y la transferencia de tecnología desde las universidades. Se han realizado numerosos estudios sobre la comercialización del conocimiento. Este artículo tiene como objetivo integrar estudios previos y desarrollar un modelo integral a partir de los factores citados en esos estudios. Por lo tanto, se analizaron 57 artículos relevantes para identificar los índices de comercialización del conocimiento en el marco de una guía de revisión sistemática de la literatura. Además de los criterios de validación de la guía, se entrevistaron tres profesores universitarios para que el modelo conceptual incluyera las áreas (contextual, individual, organizacional, institucional y ambiental) y los componentes.

## PALABRAS CLAVE

Comercialización del conocimiento, Desempeño de la comercialización, Antecedente de comercialización.

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## 1. INTRODUCTION

Due to the change in governmental policies and monitoring systems, universities pay great attention to their economic roles and tend to appear more effective in order to be able to have access to governmental budgets (OECD, 2002; Finardi & Breznitz, 2017). According to a report by the Organization for Economic Co-operation and Development (OECD, 2002), many countries have modified their academic systems, as part of efforts to become more independent, competitive, and cost-effective via the commercialization of research results (Davari et al., 2018). In addition, universities have significantly boosted their policies propping up commercialization and Technology transfer. Etzkowitz et al. (2000) recommend that a pattern is emerging in different geographical locations, signaling a change in entrepreneur universities. The change results from developments inside universities, external factors impacting academic structures, and maybe the increase in the classification of innovation at a regional level. According to Zhou (2008), the Entrepreneur University models are emerging (Park & Ryu, 2015; Salamzadeh et al., 2017).

Etzkowitz & Leydesdorff (1997) believe that the changes in universities' missions have enabled many of them to secure budgets that are greater than non-governmental sources. Generally, universities can contribute to economic development by interacting with the existing industries and via commercialization of knowledge which in turn helps open up business opportunities. Many universities take their opportunities to guarantee and develop their activities in society by proving to be effective (Etzkowitz & Leydesdorff, 1997; Wu et al., 2015).

In most countries, governments are reducing their role in financing universities. Therefore, universities should envisage financial independence and find ways to finance their activities without any prejudice to their mission, assignments, norms and values. With knowledge having become the main competitive advantage, world nations are pushed to pay due attention to the centers of development of knowledge and its transfer to other sectors, while embarking on essential reforms in processes, missions and performances (Siegel et al., 2004).

With a more precise look into the factors presented in various research, one may conclude that there has never been a comprehensive conclusion by a researcher or institute on the driving forces and all aspects have not been taken into consideration for the development of knowledge commercialization, therefore leaving a void for a proper model. For instance, Muir et al. (2005) classified knowledge commercialization factors under inputs, outputs and outcomes (impacts), thereby ignoring many driving indices.

Studying the commercialization of research and technology and its various dimensions are of great significance, as such analyses provide managers and policymakers with essential insight for efficient decision-making (Min et al., 2019; Rothaermel et al., 2007; Salamzadeh et al., 2017). Therefore, it is critically important to determine which factors can significantly affect the development of academic

companies, licenses, and technical knowledge. It is also necessary for national brokers, research and development managers, and technical managers to consider such factors. The present study's central question is: "What is the conceptual framework of the Antecedent of Knowledge Commercialization?"

## 2. THEORETICAL FRAMEWORK

In the present study, Phan & Siegel (2006) classification was used to establish a theoretical framework, comprising three main subjects: institutional, organizational, and individual ones. The mentioned subjects were used as the criteria for designing and collecting the required data. Although the components of this framework were developed after holding systematic analysis, the researchers took the theoretical framework into the account in order to deepen their knowledge of the study.

**Individual factors:** They deal with the factors related to individuals and the researcher's individual qualities, which affect the commercialization function of academic studies.

**Institutional factors:** They refer to a set of factors connected to rules, regulations, authorizations, norms, and public beliefs and are related to the commercialization function of academic studies.

**Organizational factors:** They highlight the potential importance of organizational factors and refer to the considerations about the structures, processes, and other organizational factors affecting Technology Transfer from universities to industries.

**Knowledge commercialization performance:** In this research, the knowledge commercialization performance follows the definition presented by Phan & Siegel (2006), factoring in faculty members and academic researchers who seek to benefit from their research results through receiving patent, obtaining license and partnership in the ownership of university spinoffs. It is important to note that every academic thought aligned in the value chain of knowledge can become an integral part of the commercialization performance. Therefore, in this research, the performance of knowledge commercialization comprises any activity by faculty members that would lead to development of products and services with the focus being on its direct or indirect effectiveness in economic and social development.

## 3. METHODOLOGY

The research method used in this article is qualitative and, more specifically, a Systematic Literature Review. This method is proper specifically when the research literature is rich in content about the subject of study, in which case, a systematic method may be applied to identify, classify and summarize the underlying components of the phenomenon studied (Okoli & Schabram, 2012). The Okoli & Schabram (2010) guide in the systematic literature review with eight steps has been applied:

### 3.1. Purpose of the literature review

The main objective of this research is to study the identification of precursor factors in knowledge commercialization. The critical point is that these factors have not been studied in previous research in terms of a comprehensive model. Also, antecedent factors concerning interrelation can help the right decision between science policymakers and research directors. The main question of this research is to know the antecedent factors of performance of knowledge commercialization and how they are interrelated based on previous studies.

### 3.2. Protocol and training

The Whole review is entirely governed by one of the authors in each step. This strategy helped researchers to simultaneously validate the research and operational steps of the systematic review literature. The authors trained Note-taking techniques and Reviewing techniques to be clear and in agreement about the detailed procedure to be followed.

### 3.3. Searching for the literature

In order to search through related works, in this systematic review study, the articles published in English between 1991 and 2019 were searched on Web of Science Core Collection (<http://www.webofknowledge.com>) for such keywords as knowledge commercialization, innovation commercialization, commercialization of academic knowledge, university commercialization and commercialization in the titles, abstracts and keywords. By applying search strategies as well as AND/OR operators, 3179 articles were found in the first phase.

### 3.4. Practical screen

Authors conducted the search in the databases. Therefore, the keywords mentioned above were searched in the title, abstract and full text of the articles. Furthermore, other commercialization-related materials as well as effective commercialization factors were considered as criteria for the study input. The studies whose title and abstract were not related to innovation and knowledge commercialization or did not match organizational criteria were excluded. The Practical screen is precisely focused on the “knowledge commercialization”. The articles found in more than one search were excluded, leaving 3070 articles. The articles’ consistency was determined with

the research subject, contents (topic and variables), the abstracts, and the keywords. Based on the title and abstract of the articles, a total of 2453 unrelated articles that had studied commercialization without knowledge commercialization were excluded. Based on this criteria, the abstract and full text of the remaining 617 articles underwent an in-depth review, which led to the exclusion of articles not matching necessary criteria or not being fully available.

### 3.5. Quality appraisal

Date of publication: Due to the inclusive and extended meaning of “commercialization” and “knowledge”, only research published after 1991 and in English was reviewed.

Type of Study: Due to the topic of the research, only quantitative, qualitative or combined quantitative-qualitative studies whose results had been presented at various organizational, national and international levels were reviewed.

Therefore, after excluding unrelated and duplicate articles, screening, qualitative assessment and exclusion of fully unavailable articles (the articles published in English journals, but unavailable free of charge), of a total 3179 articles obtained in the initial search, only 57 articles were selected to match the current study’s criteria, which underwent a final analysis.

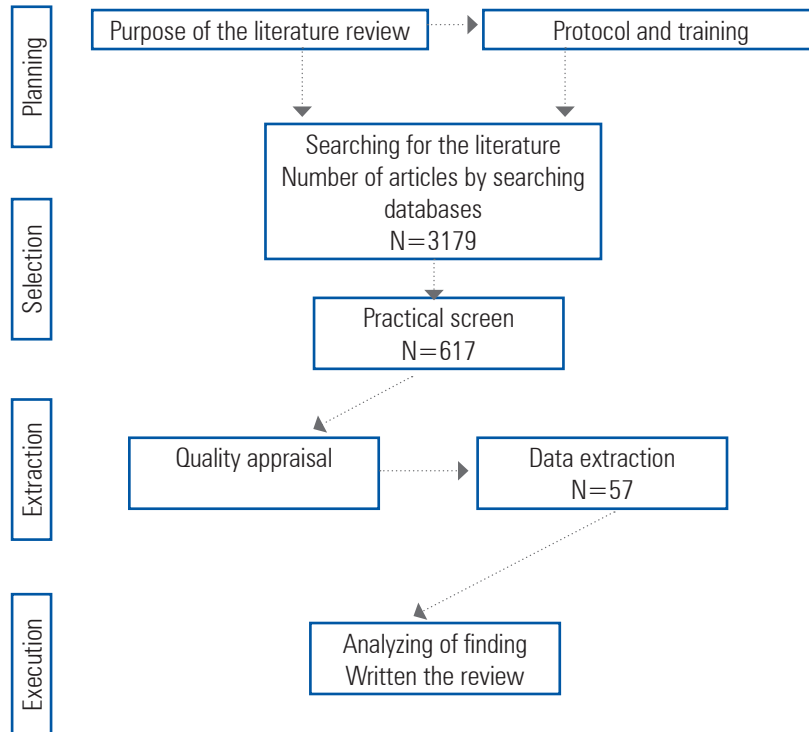
### 3.6. Data extraction

In order to mine data, a researcher-made checklist was used and information related to the research, including the article’s title, the author’s name, the year of publication, the type of study, the research objective, crisis factor/effective factor in crisis, and method or solution proposed for crisis management were mined for final assessment and inserted into an EXCEL table. The researcher conducted the search. Ultimately, necessary information for analysis was classified in five tables (Tables 1-5) for final analysis after completing information related to the article’s title, year of publication, effective antecedent factors and the relationship between these factors.

### 3.7. Synthesis of studies

In order to assess the studies effectively and choose the best articles in a critical process to evaluate the quality of research methodology and the obtained results, all articles were reviewed by researchers, based on which the studies were either used in the systematic review or excluded. The selected articles were processed by ENDNOTE.

Figure1: research method



### 3.8. Writing the review

The search and selection strategy of research is illustrated in figure 1 and to be reported in adequate detail that the results of the review can be separately replicated. The findings were presented in five sections and a conceptual model in the conclusion. Finally, three professors who had carried out at least 10 research studies on commercialization and contributed to 3 relevant research projects were received final draft and validate the dimensions, components and model.

## 4. DATA ANALYSIS

In the following table, the subject mentioned in previous studies have been categorized into five main groups: organizational, individual, institutional, contextual, and environmental. In the case of organizational subject and components, as table 1 shows, many organizational researchers intend to combine the economic models of scientific discoveries with factors pertaining to organizational success.

Markman et al. (2005) reviewed the significance of organizational structure and concluded that the most attractive combinations of technology stage and licensing strategy for new venture creation-early-stage technology and licensing for equity-are least likely to be favored by the university (due to risk aversion and a focus on short-run revenue maximization) and will even lower the likelihood of its application. That is explained by the fact that universities and TTOs focus on liquidity maximization in the short-term and seriously avert financial and legal risks.

Lockett et al. (2003) realized that universities with most spinoffs have transparent and precise strategies about the formation and management of spinoff companies. Such universities prefer to hire second-degree (external) entrepreneurs rather than academic entrepreneurs for process management. Furthermore, it seems that more successful universities have more specialties and larger social networks, which help them launch new spinoff companies. However, the role of academic inventors is not significant enough when it comes to the accomplishments of more successful and unsuccessful universities. Furthermore, spinoff company staff at more successful universities had bigger assets.

Lockett & Wright (2005) have highlighted the existence of sufficient experience and skill at universities that used to be in fully non-commercial environments as the source of capability for gaining revenue from spinoff companies. They insist that separating the role of the input sources of universities from everyday trends in their capabilities is instrumental in creating spinoff companies. They also found that both the number of spinoff companies created and those created with equity investment are positively correlated with the expenditure on intellectual property protection, the business development capabilities of Technology Transfer offices and the number of years these offices were active in the field.

Markman et al. (2005) developed a model indicating that for-profit University Technology Transfer Offices (UTTO) structures and licensing in exchange for equity are most positively related to new venture formation, but licensing for cash is the most common strategy used to transfer technologies. Although licensing for equity is more likely to drive new venture emergence, the UTTO motivation to maximize cash flows and minimize financial and legal risks often leads to a strategic choice that does not support new venture creation.



Table 1: Organizational subject and components affecting the knowledge Commercialization

Subject	Component	Previous Studies
Organizational	Supportive Structures (Incubators, science and technology park), Processes of Supportive Structures, Employees, Rights and Rewards for employees)	(Bali & Zarea, 2018; Ensley & Hmieleski, 2005; R. A. Jensen et al., 2003; Lockett & Wright, 2005; Rothaermel & Thursby, 2005; Thompson et al., 2018)
	Structure (Complexity, Formality, Control)	(Boehm & Hogan, 2013; Markman et al., 2004; Markman, Phan, et al., 2005; Moray & Clarysse, 2005; Su & Zarea, 2020)
	Process (Speed up the process of commercialization of research, Formulation and process design and Commercialization standards)	(Baldini et al., 2006; Markman et al., 2005)
	Strategy, Mission, Vision, Goals, Policy	(Bercovitz & Feldman, 2006; Breznitz et al., 2008; Friedrichsen et al., 2017; Lockett et al., 2003; Siegel et al., 2004)
	Revenues from the Commercialization	(Hohenberg & Homburg, 2019; Powers & McDougall, 2005; Read, 2004; Wright et al., 2007)
	University Resources (Assigned Revenue Budget for the Commercialization of Research, Technical Support, Physical Infrastructure, Communications)	(Lauzikas et al., 2016; Phan & Siegel, 2006; Wright et al., 2006)
	Organizational Incentives (Commercialization Revenue Split between the Research Team and University, System of Credit and Promotion)	(Debackere & Veugelers, 2005; di Gregorio & Shane, 2003; Leisyte, 2011; Lim et al., 2017; Markman et al., 2004; Markman, Gianiodis, et al., 2005)

In the case of institutional subject and components, qualitatively analyzing five European universities excelling in technology transfer, Clark (1998) concluded that entrepreneurial norms, standards, and culture contribute to academic entrepreneurship and enhance commercial activities in academic studies. Therefore, institutions' factors play the greatest role in forming entrepreneurial universities. Table 2 presents the discussed subjects and components drafted through the institutional approach.

Moray & Clarysse (2005) maintain that an institutional view for launching university spinoffs in rapid succession poses a risk to research commercialization. The main question they pose is to know if resource endowment to science-based entrepreneurial companies during budget allocation would be affected by the method of Technology Transfer by parent companies. They insist on the point

that any change in the internal structure of the organization (and particularly in the technology transfer policy) would result in a general change in the method of resource endowment to science-based entrepreneurial agencies. In portraying significant changes in the organization in terms of Technology Transfer policy, they identified three generations of companies and also showed the specificities of resources during the budgeting process.

Degroof & Roberts (2004) examined the significance of university policies regarding establishment of spinoffs in the area where environmental factors (like Technology Transfer and entrepreneurial infrastructure) are not favorable to entrepreneurial activities. They have classified spinoff policies under four categories: absence of policies to launch new companies, minimum activity for the purpose of launch and minimum supporting policy, medium activity for the purpose of launch and medium supporting policy and finally all-out activity for launch and maximum supporting policy in favor of companies. They concluded that formulation of supportive policies by universities at a higher pace may be helpful given the impact they have on the possible growth of ventures.

Table 2: Institutional subject and components affecting knowledge commercialization

Subject	Components	Previous Studies
Institutional	Culture and Behavior	(Bercovitz & Feldman, 2006; Clark, 1998; Franklin et al., 2001; Hohenberg & Homburg, 2019; Mustar et al., 2006; Siegel et al., 2003)
	Norms for the Protection of Products and New Technologies and Intellectual Property Protection Legislation	(Bercovitz & Feldman, 2006; Ensley & Hmieleski, 2005; Louis et al., 1989)
	Rules and Regulations for the Protection of Products and New Technologies and Intellectual Property Protection Legislation	(Bercovitz et al., 2001; Yadoolahi Farsi et al., 2011; Lim et al., 2017; Link & Scott, 2017; Markman, Gianiodis, et al., 2005)

In the case of individual subject and components, given the fact that the success of academic technology commercialization depends on individual intentions (i.e., risk-taking and academic entrepreneurs' skills), it is imperative to bring the individual analysis level into account to draft a more comprehensive model to facilitate an effective technology transference (Emami & Klein, 2020; Ismail & Sidek, 2019). In Table 3, the individual factors affecting the commercialization function of academic studies have been presented.

Markman et al. (2004) analyzed bioscience faculty members' interest in engaging in various aspects of Technology Transfer like commercialization and studied the

individual aspects and characteristics. They insist that regional groups' norms can largely impact commercialization of university research, regardless of the form and structure of the university.

Vohora et al. (2002) concluded that university spinoffs should go through regular steps in order to become successful. For them, academic entrepreneurship is a nonlinear iterative process that passes through several key nodes. Specific barriers or junctures are also identified that must be overcome in order to move from one stage to the next: opportunity recognition, entrepreneurial commitment, threshold of credibility and threshold of sustainability.

Table 3: Individual subject and components affecting knowledge commercialization

Subject	Component	Previous Studies
Individual	Age	(D. Audretsch et al., 2003; D. B. Audretsch et al., 2017; Baldini et al., 2006; Boehm & Hogan, 2013; Thompson et al., 2018)
	Commercialization of education and skills	(Chang et al., 2009; Lim et al., 2017)
	Experiences and Skills of Research Commercialization, Quality of Professor in University, Specialization	(R. A. Jensen et al., 2003; R. Jensen & Thursby, 2001; Mustar et al., 2006; Thompson et al., 2018)
	Access time	(Chang et al., 2009; Do, 2014; Friedrichsen et al., 2017)
	Characteristics of Entrepreneurs (Proactiveness, Risk-Taking, Dissatisfaction of Work, Motivation, Commitment)	(Leisyte, 2011; Mustar et al., 2006; Vohora et al., 2002; Zucker & Darby, 2001)

In the case of contextual subject and components, Nicolaou & Birley (2003) see social networks of university entrepreneurs as determinants of university spinoffs. For them, social networks of entrepreneurs including communications with venture capitalists, colleagues and researcher's personal communications as instrumental in the commercialization of university research.

Link & Scott (2005) investigated the conditions when a research joint venture (RJV) will involve a university as a research partner. They hypothesized that larger RJVs are more likely to invite a university to join the venture as a research partner than smaller RJVs because larger ventures are less likely to expect substantial additional appropriability problems to result because of the addition of a university partner and because the larger ventures have both a lower marginal cost and a higher marginal value from university R&D contributions to the ventures' innovative output.

Table 4: Contextual subject and components affecting knowledge commercialization

Subject	Component	Previous Studies
Contextual	University Context (History and Traditions of the University), University of Abilities and Capabilities	(Bercovitz & Feldman, 2006; Lauzikas et al., 2016; Link & Scott, 2017; O'Shea et al., 2005)
	Networks Within and Outside the University, Professor of University Active in the Industrial Sector, Industrial Relations, Business Partners, Proactive Companies in other Industries, Government Companies, Competitors, and Experts Outside the Company	(Lim et al., 2017; Rothaermel & Thursby, 2005; Zucker & Darby, 2001)

In the case of environmental subject and components, Siegel et al. (2003) realized the inconsistency between the motivational system of faculty members and the objectives of commercialization of Technology Transfer at universities. This inconsistency covered both cash and non-cash rewards like credit for professorship and promotion. They developed a model of productivity for 113 TTOs. In their model, licensing activity is treated as the output and invention disclosures, full-time equivalent employees in the TTO, and legal expenditures are considered to be inputs.

Link & Scott (2017) found that the university royalty distribution formula determining the fraction of the licensing revenue that is allocated to the faculty member who developed the new technology. It may also lead to development of technology licensing. However, they make a distinction between this issue and the formation of new companies.

Ensley & Hmieleski (2005) studied the difference between high-technology university-based and independent start-ups in order to draw definitive conclusions worthy of use toward informing university business incubator and technology park related policy. In so doing, they adopted the view that university-based firms will institutionalize themselves toward the norms of the university and the successful ventures that have been launched through their nurturing, rather than toward their own industry. To that end, they painted a picture of what the term "localized" isomorphic behavior.

Audretsch et al. (2017) see the startup's choice of location as a strategy for benefiting from the knowledge spillover at universities. They say that proximity to universities is subject to various mechanisms of knowledge spillover (human research and capital) and various types of knowledge spillover (natural sciences and social sciences). They concluded that knowledge spillover mechanisms and types

are all non-homogenous. More importantly they realized that university spinoffs (at least in science and high-tech) are affected by local economic conditions as well as accessibility to knowledge developed by universities.

Table 5: Environmental subject and components affecting knowledge commercialization

Subject	Components	Previous Studies
Environmental	Effects of Collaboration, Cooperation with Scientists Oldest	(Baldini et al., 2006; Bercovitz & Feldman, 2006; Zucker & Darby, 2001)
	Market and Marketing Factors (Identification of Market Opportunities, Good Marketing, Market Pressure)	(Boehm & Hogan, 2013; Siegel et al., 2003; Vohora et al., 2002)
	Geographical Location (Overflow Knowledge)	(D. B. Audretsch et al., 2012; Breznitz et al., 2008; Do, 2014; Zucker & Darby, 2001)
	Campus, Corporate Concentration in One Area, and Their Choice	(Friedrichsen et al., 2017; Hohenberg & Homburg, 2019; Powers & McDougall, 2005)

## 5. DISCUSSION AND CONCLUSION

Studying knowledge commercialization from various aspects may indicate the complexity of the process and the grounds for the materialization of commercialization. Therefore, commercialization performance has its own complications. For instance, Nicolaou & Birley (2003) and Mustar et al. (2006) have studied social networks of academic entrepreneurs and researchers, but they have not precisely provided an assessment of these networks and they have mainly focused on the significance of social networks and their formation. That is while in the Muir et al. (2005), it has been noted that the high number of measures may lead to disruption in the commercialization system, pushing WG to reduce the number of its initially proposed factors from 40 to 14.

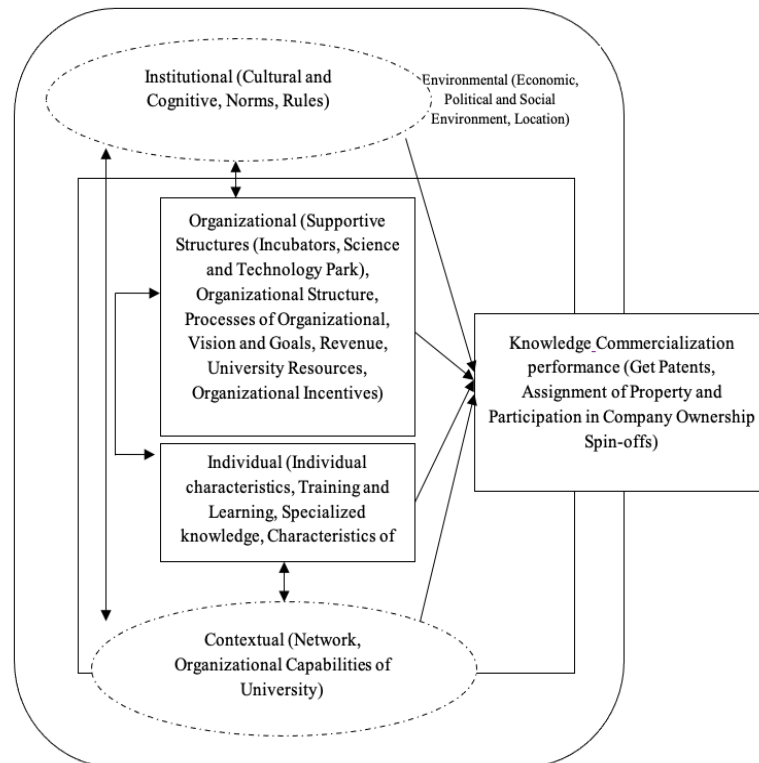
All researchers and institutes have chosen factors based on the circumstances under which the research has been done and studied them within the domain of research. For this reason, each subjects and components are significant and prioritized based on the domain of research. Some scientists have chosen subjects based on the history of the academic value system (Degroof & Roberts, 2004), the technical depth of institution (Phan & Siegel, 2006) while some have factored in cultural circumstances (Clark, 1998) to study relevant components. Of course, numerous researchers have embarked on a comprehensive study of subjects and have either pointed to a single classification or failed to provide any suggestion on the proper use of the components. For instance, Agrawal (2001) has a comprehensive review of the literature of technology transfer between universities and industries. Based on

his findings, problem was stated that many of existing criteria naturally cast doubt on the uniqueness and specificity of the route. He dismisses the idea of the components being unsuitable, saying they need to be interpreted correctly. For him, each of these has to be studied within the framework of the stated problem.

In this article, we take into consideration the subject and components cited in the conceptual model research on development of knowledge commercialization performance as shown in figure 2.

The present study expanded contextual, institutional, and environmental factors contributing to the knowledge commercialization, remarkably influence the processes and activities of knowledge commercializing. The review of the related literature and the results of experts interviews reveal that environmental factors can serve as a platform and facilitate other effective factors. It can be concluded that contextual and institutional factors are present inside and outside universities, and scholars and faculty members consider them as instruments for enhancing entrepreneurial behaviors and setting up entrepreneurial universities. For example, many scholars use unofficial networks formed by industries to gain the necessary financial support to fund their research projects. Here, as organizational factors, universities have no effect on the improvement of the commercialization function of academic studies.

Figure 2: Antecedents knowledge Commercialization Conceptual Framework



It should be noted that these factors, including those inside and outside universities, affect the performance commercialization and will fail to yield expected results unless the environmental factors are considered.

As a matter of fact, contextual factors reinforce networks, improve internal interactions of the researchers and faculty members, and boost organizational capabilities. Holding short-term training courses can help improve the researchers' commercialization skills and other capabilities, including marketing, project management and product development.

Finally, it is recommended that policymakers and managers change commercialization policies in relation to encouragement and motivation to synergize the potentials of researchers and faculty members. Failure to modify the current policies would instead lead to researchers' motivation loss and the rejection of more commercialization studies. It is recommended that other researchers test the framework through quantitative methods and factor analysis tools. It is also recommended that researchers study technology commercialization.

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