OPEN INNOVATION FROM THE UNIVERSITY TO LOCAL ENTERPRISES: CONDITIONS, COMPLEXITIES, AND CHALLENGES

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ABSTRACT

The paper aimed to analyze the open innovation model from the Latin-American public university and the main factors that influence it. The interaction between the university with its ecosystem, its innovation and technology management, the profile of the academic community, and innovation policies were studied. The research methodology had a qualitative approach. And the process was integrated into three phases to identify the categories of open innovation, categorized the interaction between the university with the innovation ecosystem in four Mexican public universities, and triangulate the Latin-American behavior through semi-structured interviews to six academics. The main findings showed that open innovation is a feasible platform to link the Latin-American University with local enterprises despite the peculiar heterogeneous and unequal context of the ecosystem; furthermore, four collaborative flows between the university and the ecosystem were identified –inside, outside, mixed and hybrid-. In conclusion, the interdisciplinary approach, the techno-institutional networks, and the institutional policy influence open innovation from the university to the ecosystem, where the academic community is a mediator variable. Finally, it is highlighted that new re-institutionalization of innovation policies based on digital transformation and environmental sustainability are required; thus, Latin-American Schools of Innovation Taught are needed to encourage them.

Keywords: open innovation; university open innovation; knowledge transfer from university; university-enterprise linkage; collaborative strategies.

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Innovación abierta entre universidades y empresas locales: condiciones, complejidades y retos

RESUMEN

El objetivo del artículo fue analizar el modelo de innovación abierta de la universidad pública Latinoamericana y los principales factores que influyen en éste. Se estudió la interacción entre la universidad con el ecosistema, políticas de innovación, la gestión de la innovación y tecnología, y el perfil de la comunidad académica. La metodología de investigación fue cualitativa, y el proceso se integró en tres fases para identificar categorías de innovación abierta, categorizar la interacción entre la universidad con el ecosistema de innovación en cuatro universidades públicas mexicanas y triangularlo con el comportamiento universitario latinoamericano a través de entrevistas semiestructuradas a seis académicos. Los principales hallazgos mostraron que la innovación abierta es una plataforma factible para vincular a la universidad con empresas locales a pesar de su contexto heterogéneo y desigual; se identificaron cuatro flujos colaborativos entre la universidad y el ecosistema –desde dentro, desde afuera, mixto e híbrido-. En conclusión, enfoques interdisciplinarios, redes tecno-institucionales y la política institucional inciden en la innovación abierta universitaria, y la comunidad académica es una variable mediadora. Finalmente, se destacó que es necesaria una nueva reinstitucionalización de políticas de innovación universitaria con base en transformaciones digitales y sostenibilidad ambiental para incidir significativamente en el ecosistema.

Palabras clave: innovación abierta; innovación abierta universitaria; transferencia de conocimiento desde la universidad; vinculación universidad-empresa; estrategias de colaboración.

Introduction

Literature has shown that local enterprises need to interact with other actors in their ecosystem to accelerate their innovation processes and to improve their competitiveness (Leckel, Veilleux & Dana, 2020; Anicet, Carneiro & Prévot, 2019; Han & Gao, 2019; Feldmann, Jacomossi, Barrichello & Scabim, 2017). Their strategic management directly influences the process of improvement of the competitiveness of companies and technological innovations (Han & Gao, 2019); these innovation processes involve managing the flow, exchanging, and mixing knowledge in open processes for the organization (Cheng, Huang, Zhao & Wu, 2019). According to Chesbrough (2006; 2017), open innovation (OI) facilitates innovations through a mix of endogenous and exogenous knowledge, which encourages a dynamic flow between the organization and its ecosystem. This organizational openness implies productive interactions with other organizations such as universities or research centers, which accelerate the assimilation, the transformation, and the application of knowledge (Schepis, Purchase & Butler, 2021; Anicet, Carneiro & Prévot, 2019).

The relevance of the university interaction with the ecosystem has been highlighted by several studies (Etzkowitz, 2018; Subtil, Soares, Nogueira & Colini, 2017). The university is recognized as a primary actor in the innovation ecosystem. Thereby the creation of new knowledge flows outwards and has multidimensional and multi-temporal impacts (Etzkowitz,

2018). Further, the public university is considered an actor capable of energizing local ecosystems to transform the territory and strengthen the general welfare. Since the university innovation has as a central purpose the innovation in and to the society (Álvarez & Palacios, 2018). The university is linked to the ecosystem through the social relevance of its educational offer, the exploitation of its research results with social impact, and their innovation processes with social, public, and productive sectors (González & Álvarez, 2019). Since over 30 years ago, the linkage between the university and other actors in the ecosystem has had a strong upward trend from a classical to an open innovation model (Kuwashima, 2018).

In Latin America, the interaction between the actors of innovation ecosystems has been insignificant and weakly systematized (Casas, 2020; Giraldo, 2019). Latin America has been tagged as an unequal territory, has grown based on a productive and export structure. Which has been focused on sectors of low productivity and low technological dynamism; it has been highly vulnerable to the fluctuations in the external sector, and its development has had an unstable behavior (ECLAC, 2019; RICYT, 2020).

Although there has been evidence of a series of incentives for innovation activities in Latin America, they have not been disruptive enough to systematically contribute to a productive development in the region (Palacios, Estrada & Álvarez, 2016). In Latin America, technological change has demanded more efficient adaptation of technological processes and more dynamic processes of innovation diffusion as a structural condition of the ecosystem. However, they have not been accomplished yet, and it is the fundamental responsibility of the State of its institutions and the dynamic capabilities available in the ecosystem (Giraldo, 2019; Palacios, Estrada & Álvarez, 2016).

According to Palacios, Estrada & Álvarez (2016), most Latin American scientific reports about innovation and its limitations are directed towards two aspects. The first one is the absence of a strategic, organizational, and operational framework, which has shown it as an abstract phenomenon and not a mechanism that operates and has defined functions. The second one is the reductionism in selecting strategies by the actors and institutions involved in the ecosystem. Notwithstanding that scientific and technological research is the basis of university innovation which is a key platform that contributes to territorial competitiveness and social welfare in the ecosystem, in Latin America, the level of linkage between universities and local enterprises have been inconsistent (Casas, 2020; RICYT, 2020).

Most Latin-American countries have recognized that the link between their academic institutions and companies is one of the greatest weaknesses in the innovation ecosystem and one of the greatest operational challenges (Giraldo, 2019; RICYT, 2020). Organizations ought to involve different internal and external actors to accelerate their innovation processes, creating value in the organization and their ecosystem. The management of the actors involved in innovation processes from inside and outside an organization and in the interactions with the ecosystem is imperative because it is the moderator between innovation and competitiveness (Schepis, Purchase & Butler, 2021; Pustovrh, Rangus & Drnovšek, 2020; Feldmann et al., 2017).

In this tessitura, the study of open innovation in the Latin-American public University is border research because OI has contributed to explaining the linkage between an organization and its environment to create new knowledge and implement new ideas. Further, OI approach has been widely studied and researched on its behavior, although studies in heterogeneous territories or traditional productive sectors are still under construction (Chesbrough, 2017). The

object of study in this research was analyzed in the framework's social, environmental, and productive complexity of Latin America; this has contributed to close the gap in the literature. The general assumption in this research is that the university is a strategic actor in innovation ecosystems. Besides, open innovation is a viable linking platform for the Latin American public University to collaborate with local enterprises to create social, economic, and environmental value. Nevertheless, this is a complex multifactorial and multidimensional process, which is not limited by policies of public resources' allocation, neither by technology development but rather by the social-institutional arrangements of the ecosystem.

The contribution of this paper is theoretical and methodological because it analyzed the linkage between open innovation and the university with local enterprises in the Latin American reality, which is characterized by its high heterogeneity and social inequality. Likewise, this paper is added to the discussion in this special issue, "Latin America School of Business Taught," which lectures the Latin American academic contributions since the open innovation study, to the role of the university in the process of linking with other actors in the ecosystem, challenges, and future opportunities. The results could have practical implications if the inputs were to be provided to policymakers for the design of policies under local and heterogeneous conditions. Furthermore, local Latin-American enterprises could have inputs to motivate knowledge transfer under an open innovation approach. Finally, these results provide direct and indirect inputs for the academic discussion fostered by the six questions posed by the call that motivated this special issue.

Methodological framework

The research was explanatory through a qualitative approach divided in three phases; thereby, the internal validation was guaranteed by data triangulation, and the external validation by analytical generalization (Yin, 2009).

In the first phase, academic publications were reviewed to elucidate the construct of open innovation. In addition, two sets of combined keywords were searched in the Web of Science database. The first set of keywords was about open innovation restricted by the publication date –last three years-. The second set was based on *open innovation + Latin America* without restrictions on the publication date. In the trend of publications about open innovation in Latin America, 10 991 publications were identified from 1997 to 2021, from which 7 828 were scientific papers (figure 1). Based on the relevance, a first selection was performed by examining 171 abstracts. It was performed a skim lecture of around 61 articles, from which 15 were review articles. These scientific publications could be stratified into two general groups: politics and economics of innovation, and strategies from the perspective of the different actors in the innovation ecosystem. The publications on the successful or unsuccessful experience of specific Latin-American cases were scarce.

Figure 1. Trend of publications
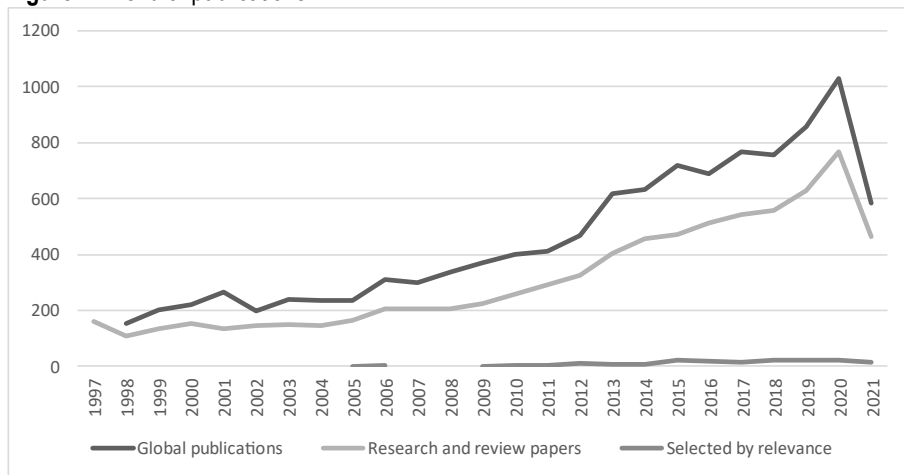
Source: by the authors based on bibliometric analysis.

In the second phase, four local public universities of Mexico –Guadalajara (U1), Guanajuato (U2), Nuevo León (U3) and Yucatán (U4)- were analyzed to identify their behavior pattern and activities of open innovation. The selection of these institutions was through intentional sampling (Patton, 2014) for two reasons. On the one hand, these institutions were ranked into the five public universities of federative entities in Mexico with the most patent titles until 2016 (García, 2017); these patent titles granted provided information of the profile of their institutional priorities linked with productive sectors. On the other hand, the complex context of these universities has had highlight features; Guadalajara, Guanajuato, and Nuevo León have had a strong industrial vocation and have prioritized foreign direct investment as the basis of its development policy (Álvarez, Estrada & Palacios, 2018; Pérez, 2015; García & Chavez, 2014). Yucatán has been acknowledged as an innovation pole and has occupied the eighth national place for its scientific productivity (Porto-Gomez, Zabala-Iturriagagoitia & Leydesdorff, 2019). Furthermore, these entities have based their policy on science and technology and have been designed to articulate the economic and social welfare balance (Porto-Gomez, Zabala-Iturriagagoitia & Leydesdorff, 2019). The dense description (Clifford, 2003) was integrated with available information from their official websites and some scientific papers on the linking with the productive and social environment of the analyzed universities; besides, the basic innovation indicators of the four local ecosystems are shown in table 1.

Table 1. Context of the local studied ecosystems

	Profile local ecosystem			
	U1	U2	U3	U4
Scientific and innovation capabilities index	48	34	49	23
Coverage rate in higher education	38,0	35,6	53,2	43,8
Researchers' rate /100 thousand inhabitants	34,95	33,54	42,94	56,94
Doctoral, master and specialization students /1 000 of	4,336	3,846	5,834	4,249

economical active population				
Companies registered in the National Registry of Scientific and Technological Institutions and Companies/10 000 employers	44,3	39,3	81,8	85,3
Patents applied /one million inhabitants	68,8	41,3	95,8	33,5
Proportion of households with broadband Internet	59,5	40,7	67,4	59,0

Source: by the authors based on IPLANEG (2021); SIICYT (2021); SIIES (2021); IMCO (2020); SIEGY (2020).

In the third phase, the semi-structured guide was focused on four axes as follows: the University structure and its interaction with the ecosystem (Pustovrh, Rangus & Drnovšek, 2020; Kuwashima, 2018; Rauter *et al.*, 2018; Lenart, 2016); the innovation and technology management and the stimulus to generate applied science and targeted technology (Han & Gao, 2019; Feldmann *et al.*, 2017); the university processes of open innovation and features of the academic community (Cheng *et al.*, 2019); the factors that inhibit or facilitate open innovation from universities (Sivam *et al.*, 2019; Subtil *et al.*, 2017). The academics interviewed were from Argentina, Chile, Colombia, Mexico, El Salvador, and Venezuela. Their knowledge areas were sustainability science, social science, social innovation, entrepreneurship, engineering, and digital economy, respectively; one of them had a master's degree and the rest had PhDs. The interviews were recorded, transcribed, and systematized to analyze the hermeneutic unit.

The collected data were analyzed with ATLAS.ti v.7.0. First, the frequency of use of the key terms was analyzed through the word cloud counting technique. Then, codes were associated with the most representative categories through frequency tables. Finally, the network of categories was built based on holistic analysis.

Analytical framework

A collective creative structure –from its ideation stage to its interaction with the ecosystem-, the accumulation of capabilities –regardless of their results- and the high degree of uncertainty –at each stage of the process- characterized the open innovation (Chesbrough, 2017). Open innovation has been adopted by several types of organizations due to its high frequency of staff turnover –scientists, engineers, knowledge managers, or technicians-; the mobility of these internal actors affects the innovation processes since it causes an imbalance in the knowledge flows and in the knowledge capital of the organization (Barbic, Jolink, Niesten & Hidalgo, 2021; Schepis, Purchase & Butler, 2021; Chesbrough, 2017). Furthermore, OI has rapidly developed due to the digital transformation through which the environment has undergone in recent years; this facilitates access to external knowledge generators, which could shorten innovation cycles, optimize resources, and intensify the research (Issa *et al.*, 2018).

The organizations incorporate their knowledge stocks into continuous interaction flows with external knowledge to maintain a high level of innovation generation (Leckel, Veilleux & Dana, 2020; Cheng *et al.*, 2019; Santoro, Vrontis, Thrassou & Dezi, 2018). According to Chesbrough (2017), OI is multidirectional and is based on collaboration since the various knowledge inputs and outputs generated by innovation are multiple. The environment is an intense force that pulls organizations to combine their internal knowledge with the one generated in the environment to respond faster to its demands (Hu, Wang & Li, 2017). Open innovation

motivates the organization to create transdisciplinary solutions that respond to the social requests of the environment (Chesbrough, 2017). However, the main challenge is selecting and involving the different actors in the environment to share their knowledge (Schepis, Purchase & Butler, 2021; Brockman, Khurana & Zhong, 2018); besides, the property of this knowledge is fairly negotiated (Grimaldi, Greco & Cricelli, 2020).

The process of OI is an increasing quotidian platform in university settings due to the digital transformation in which it is immersed (Issa *et al.*, 2018). Digital transformation is considered a dominant technological pattern capable of influencing the principles of innovation and the dynamical interaction of the actors in the innovation ecosystem (Escott, Palacios & Cruz, 2020). Open innovation allows the strengthening of relational activities to share information, generate knowledge (Lenart, 2016), increase alliances that transmit knowledge to the ecosystem (Xie & Wang, 2020), and achieve meaningful interuniversity knowledge (Wang, Phillips & Yang, 2020). The university open innovation is based on three key factors: the soft and hard inputs of the process of linkage –innovative culture, knowledge management, and technological infrastructure-; the support processes such as research management, relational capital or strategic alliances; the tangible and intangible results of research and their technological services (González & Álvarez, 2019). University open innovation is strategic to generate interdisciplinary solutions to the social, public, and productive sector's problems (Rauter, Globocnik, Perl-Vorbach & Baumgartner, 2018).

The open innovation construct has incorporated the category of collaborative networks based on the knowledge; it flows with multidirectional interactions, and the categories of social capital and knowledge capital are based on the strength of knowledge stocks within (Lenart, 2016). Open innovation has the challenge of reconciling heterogeneous interests of the different actors involved in the linking process of the university with its environment (Grimaldi, Greco & Cricelli, 2020; Pustovrh, Rangus & Drnovšek, 2020). Moreover, the OI process facilitates the construction of active and value-generating networks for the organizations involved, and it allows the construction of valuable knowledge in the process of collaboration (Schepis, Purchase & Butler, 2021; Sivam, Dieguez, Pinto & Silva, 2019). It also allows the organizations to strengthen their knowledge networks, share scientific-technological risks, explore new innovation-niches in open innovation ecosystems, among others linkage actions; moreover, the collaborative learning curves accelerate and create competitive advantages (Xie & Wang, 2020).

Open innovation as a mechanism for linking the university with its ecosystem has grown based on the combination of internal and external knowledge (Vicente-Saez, Gustafsson & Van den Brande, 2020), and this influences the flexible construction of knowledge networks that respond to the environmental requirements (Prieto, Montes, & Taborda, 2019). The construction of capabilities to create collaborative knowledge with other organizations has been considered indispensable because the ecosystem demands dynamic capabilities to increase its functionality (López, Fernández-Mesa & Edwards-Schachter, 2018). The processes of open innovation and the new technologies increase the complexity of the knowledge management process in the organizations involved, which requires greater organizational flexibility and a faster response speed in the decision making (Santoro *et al.*, 2018). The open innovation process is consolidated based on the strength and flexibility of the associative relationships of the organization's management model –innovation and technology management- and its innovation

policy (Barbic *et al.*, 2021; Kuwashima, 2018). Based on the literature review, table 2 shows the basic elements that conceptualize the open innovation from the university.

Table 2. Conceptualization of open innovation from the university

Interaction with the ecosystem	- University structure - Collaborative networks - Digital transformation - Interdisciplinary solutions - Flows of knowledge: inside; outside; mixed.	(Pustovrh, Rangus & Drnovšek, 2020; Xie & Wang, 2020; Robaczewska, Vanhaverbeke & Lorenz, 2019; Kuwashima, 2018; Rauter *et al.,* 2018; Lenart, 2016)
Innovation and technology management	- Generation of applied science and targeted technology - Interdisciplinary interaction - Multidirectional flows of the knowledge generation - Creative processes based on collaboration - Intellectual property	(Wang, Phillips & Yang, 2020; Han & Gao, 2019; Feldmann *et al.,* 2017)
Profile of the academic community	- Innovation capabilities - Institutional and social capital - Knowledge capital - Interuniversity knowledge	(Schepis, Purchase & Butler, 2021; Cheng *et al*., 2019; González & Álvarez, 2019; López, Fernández-Mesa & Edwards-Schachter, 2018)
Innovation policy	- Process of linkage (soft | hard inputs) - Support processes (research management, relational capital, strategic alliances, among others) - Measured and valuation of tangible and intangible results of research and technological services	(Barbic et al., 2021; González & Álvarez, 2019; Sivam *et al.*, 2019; Hu, Wang & Li, 2017; Subtil *et al.,* 2017)

Source: by the authors.

Thereby, open innovation requires new models of knowledge generation, new interaction platforms that involve multiple key sectors in their processes (Robaczewska, Vanhaverbeke & Lorenz, 2019). Based on the above, the assumptions of the paper are the following:

1. OI encourages transdisciplinary interaction between the university and the innovation ecosystem. It is energized based on the profile of the academic community to impact the business environment of the university context.

2. OI triggers the multidirectional effectiveness of collaborative networks. It strengthens the institutional capital of the university to increase the interaction with its environment, to raise awareness of its socio-productive demands, and intervene.

3. OI is an instrument for the coherent and efficient adaptation of the university to the digital transformation.

4. The institutional policy facilitates or inhibits open innovation and the level of linking between the university and the business environment; besides, it contributes to increasing the interactions between the actors of innovation ecosystems and impacts the university model of innovation and technology management.

Analysis and discussion

Countless discussions have coincided that the university has been transformed and has evolved from an institution that responds to industrial development to an innovative institution that responds to sustainability, climate change, and digital transformation (Leal *et al.*, 2020; Escott, Pérez & Palacios, 2020; González & Álvarez, 2019). The university has sought to achieve that science, technology, and innovation strengthen social welfare in each stage. Table 3 shows the results of the co-occurrence analysis to characterize the institutional infrastructure and knowledge capital that trigger open innovation in the ecosystem.

Table 3. Main integrated codes and keywords of university open innovation

Ecosystem profile	Research and innovation as State policy. State institutions organize the academic communities and boost productive innovation through the communication between the university and the education system. Intermediate organisms trigger the ecosystem –different natures such as innovation, technology, and science-. Scientifical-Technological Park such as the shared space for OI. Programs of basic education to train scientific vocations (scientific roots). Programs of university scientific impulse.
University structure	Technological Labs: Robotics, IoT, embedded computing systems, bioengineering… Science Labs: Basic and applied math, medical physics, bioinspired algorithms, evolutive computing… Sustainable Labs: Intercultural development, environmental science, earth science, bioinformatic… Social science: Territorial smart, cities networks, socio-ecological systems, mobility and logistic, social innovation, inclusive technology, audiovisual ethnography. Public and private resources to trigger OI based on technology.
Innovation and technology management	Main strategy: open innovation as the interface in the ecosystem with different scale of intervention –flexible, effective, and responsible-. Main approach: functional connections to solve complex issues, and social and business challenges. Main aim: encourage institutional capabilities such as autonomy and collaboration. Main features: OI collective projects based on the priorities of the state and management based on challenges.
Innovation capabilities	Quality accredited programs of undergraduate and postgraduate. Researcher National System consolidated by knowledge areas. Technological development priorities: data science, automation of knowledge and electronic.

Source: by the authors.

The word cloud frequently referenced these integrated codes: physical and virtual networks for the creation and transfer of knowledge; collaborative tools for information exchange; high telecommunications technology; urban infrastructure integration; incubation and financial resources to promote technology-based companies. Digital transformation and social innovation were identified as two general groups that encourage OI from the university to the business ecosystem. The different university areas showed that bidirectional knowledge flows with the ecosystem; each area has used different paths and has specific linkage objectives. The level and type of linkage depend on the productive sectors' features and the academic community's profile. Table 4 shows institutional singularities correlated with features of the studied local ecosystems.

Table 4. Singularities of the local ecosystem

U1	U2
Model based on educational innovation and new digital pedagogies -its main goal was to increase the digital competences of the teachers-.	Model based on logistic infrastructure to link actors in the ecosystem and transfer knowledge.
Platform of OI aimed to train practice communities through a governance model based on a technological and social innovation approach.	Complex and interdisciplinary thinking, research through teaching, linkage, and intensive use of digital technologies were identified as open innovation axes applied to healthcare projects.
Technological specialization area: information technologies and electronic.	Technological areas priories business ecosystems.
U3	U4
Model based on action-research approach to transform the ecosystem.	Model of proactive capabilities development; its design has used inputs from the ecosystem to calibrate competences.
Model of governance that promotes a participative business ecosystem in the social issues to manage public goods.	Transversal higher education through university networks.
Decentralization of activities to train communities of practice in urban contexts based on knowledge.	Technological specialization area: information technologies and communications.

Source: by the authors.

The analyzed universities showed similar potential behavior for open innovation. These universities have made continuous efforts to implement policies that promote systematic linkages with the ecosystem during the last decades. However, their results have been insufficient. Therefore, it is inferred that the low demand for scientific and technological knowledge of the local productive sectors (Giraldo, 2019) causes an open innovation model by supply, which is a complex challenge due to the heterogeneous characteristics of the business ecosystem –most of their companies had low technological level (RICYT, 2020)-.

Based on the frequency of co-occurrence in the hermeneutic unit, the first factor in the university process of open innovation was external collaborative networks of the academic community (34,39 %). These interactions with the research, technological, productive, social, and public sectors have allowed them to mix external and internal ideas to design innovation projects. Moreover, it is unpostponable to strengthen –learn and re-learn- multidisciplinary

collaboration. This was very relevant because the multidisciplinary collaboration facilitates OI, which boosts the flows and stocks of technological, social, or academic knowledge towards the ecosystem (Wang, Phillips & Yang, 2020). In as much as the university is the key to trigger ecosystems and strengthen productive and local development, and its flexible structure could meet the demand for ecosystem knowledge (Leckel, Veilleux & Dana, 2020; Robaczewska *et al.*, 2019; Álvarez & Palacios, 2018; Kuwashima, 2018). This dynamical interaction will be the differentiator of the open innovation functionality; however, the greatest challenge is to generate trust for the linkage to happen. Furthermore, four collaborative flows from the university to the ecosystem were identified.

1. Inside flow. Academical communities use the knowledge available in the environment but do not create it with other organizations of the ecosystem; the level of social participation of the university is low; the direction of the knowledge flow is from the outside to the inside of the institution.

2. Outside flow. Academical communities supply knowledge towards the ecosystem but do not create it with other organizations; the level of social participation of the university is medium; the direction of the knowledge flow is from the inside to the outside of the institution.

3. Mixed flow. Academical communities use and share the knowledge with the ecosystem; the university's social participation level is medium-high. Additionally, interactions and flow of knowledge are bidirectional.

4. Hybrid flow. Academical communities use and share the knowledge with the ecosystem and create it with other organizations the university's social participation level is high; there are multidirectional interactions and bidirectional flow of knowledge.

The second co-occurrence referred to the institutional infrastructure as a facilitator or inhibitor for open innovation –tangible (13,23 %) and intangible (12,98 %)-; the individual decisions of the academics and the informal channels of networking have been the key to do applied research or technological development, useful in the university context. Moreover, the equity relevance between knowledge protection –copyright, patents, utility models, open source, among other strategies and paths-, and its social diffusion and appropriation were remarkably highlighted. In this sense, OI is a political and managerial mechanism that mixes closed and open innovation with external and internal knowledge (Barbic *et al.,* 2021); however, intellectual property management is the essential strategy for sustainable university linkage (Grimaldi, Greco & Cricelli, 2020).

The institutional policy is part of the intangible infrastructure, and it has a high correlation with the development of the university innovation (Leckel, Veilleux & Dana, 2020; Kuwashima, 2018). On the one hand, innovation policy defines the public resources –time academic, teaching labs, among others- that the OI may use. On the other hand, this policy also stimulates academic communities to strengthen the relational capital of the university in the ecosystem (Sivam *et al.*, 2019; Lenart, 2016). The hermeneutic analysis showed a relation between the motivation for linking and the university's organizational structure, which is also defined by the institutional policy.

The third co-occurrence was innovation capabilities of academic communities to interact dynamically with the ecosystem (10,39 %); competencies and skills about valuation and protection of the university knowledge; in gradual stages were emphasized. The public communication of science was mentioned as a weak competence; it should be strengthened to

facilitate communication with the different ecosystem actors. Furthermore, the academic profile was significantly mentioned as a facilitator/inhibitor of OI. On the one hand, its background and networking allow them to prospect the potential supply of knowledge and opportunities due to demand; on the other hand, its attitude was related to its decision and motivation to link with the ecosystem.

In the next step of the systematic analysis, it was found that there is a university perception about the lack' interest of companies to interact with academic communities to generate innovation. Since companies believe that it is impossible to have a commercial relationship with the university to develop OI due to the institutional bureaucracy; however, it was considered essential to boost this link to meet and re-meet. It was recognized that the university must have more flexible structures, a new action-oriented research approach, and more participation in networks to socialize the bidirectional flow of knowledge socially pertinent. These would configure another type of institutional capital directly related to the functionality of open innovation in Latin-American universities (González & Álvarez, 2019).

The functionality of university OI endogenously depends on its level of institutional priority because it requires operating new models of public-private investment and knowledge production linked directly to the fundamental functions of education and research. Which implies a positive correlation with its institutional policy and its systemic operative innovation strategy; exogenously, an innovation policy is required with decisive intervention of the State (Mazzucato, 2016). This demands a new relationship of trust and credibility of the Latin-American University ecosystem based on more interaction with the ecosystem and a knowledge production model that prioritizes applied research and an open innovation approach oriented to a specific purpose.

In Latin American, the open innovation operability from the university to innovation ecosystems was not considered fruitful because their interactions have been invaded by exogenous intrusions and techno-structural institutional discourses that do not coincide with daily humanist discourse typical of its local culture, heterogeneity, and social inequality. In the last 20 years, this region has experienced an improvement in its trade for rising commodity prices and has had a positive impact on the available income in the region. However, its productive local sectors have not been more innovative, and despite the great resilience of the region, its slowdown has continued until now (ECLAC, 2020; 2019).

It was highlighted that OI would be functional if and only if an operational innovation policy strengthens the interaction with the ecosystem to respond to local demands. Thereby, the profile of the university community influences, directly and indirectly, OI mediated by the institutional policy, collaborative networks, and transdisciplinary approach. Based on the holistic analysis, figure 1 shows the network of latent and manifest categories of open innovation from Latin-American public universities to explain this complex phenomenon.

Figure 1. Categories of Latin-American open innovation
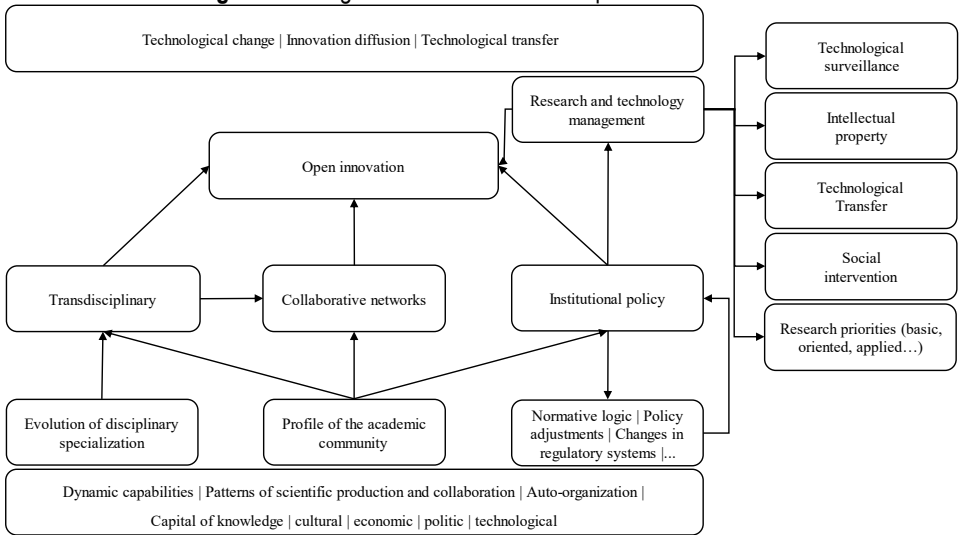
Source: by the authors.

Conclusions

Based on the findings, the open innovation process is influenced by endogenous factors –institutional policy, interdisciplinary approach, and institutional capital-. As well as exogenous related with the nature of the ecosystem; it has four paths for the collaboration University-Enterprise –inside, outside, mixed and hybrid-; the profile of academic communities influence directly and indirectly the open innovation as a mediator variable. Thus, general assumption in this research was confirmed. In conclusion, OI is a viable platform to connect the Latin American public university to local enterprises to create social, economic, and environmental value, despite heterogeneous and unequal conditions of its ecosystem. Nevertheless, this is a complex multifactorial, multi-temporal, and multidimensional process limited by the socio-institutional arrangements of the ecosystem.

The results reinforced the idea that the Latin-American company has a peculiar heterogeneous and unequal context. However, the open innovation is a platform for the Latin-American enterprise to collaborate with the University based on new public-private approaches, which would allow them to move towards a sustainable, social, and digital appropriation of knowledge. Thereby, the open innovation from Latin-American universities could be the path to encourage the social appropriation of knowledge as a public good.

A new re-institutionalization of innovation policy based on digital transformation and environmental sustainability is required. Hence, the development of new programs or instruments is needed. For instance, sustainability innovation thinking units or Latin-American Schools of Innovation Taught to monitor and strengthen the new dynamics of the network of actors in the ecosystem, its digitalization, and environmental responsibility. These could have more success

probabilities than a big change or leapfrog based on the creative destruction of the Schumpeterian approach.

The aforementioned establish the structural basis for the relationship between the university and the enterprise in an innovation ecosystem. Moreover, it represents the basis for the adaptation of the innovation ecosystem to digital transformation. Thereby, the ecosystem-based on IO approach should have the capacity to increase the level of innovation capacity of enterprises and universities as a whole unit in digital transformation and environmental sustainability and strengthen the collaboration based on technological and climate approaches.

The practical implications are viewed in three axes; the first is aimed at local enterprises. It was showed that the viability of business linkages with universities in two pressing issues are the digital transformation and crisis recovery. The second is aimed at innovation policymakers of the University and the State, which should strengthen the dynamic capabilities and stimulate the intervention of academic communities into the ecosystem. Finally, the main points put on the debate table of business taught were the following:

a) The behavior pattern of Latin American publications on the categories studied showed an idea about when this area of knowledge arose and how it has behaved in Latin America.

b) The study of innovation in Latin America has had theoretical and empirical contributions as an abstract approach rather than an operative mechanism with defined functions to contribute to local development. Besides, the Latin-American countries have recognized that the university's interaction with the innovation ecosystem is one of their greatest challenges, which has implications in research and university teaching of innovation.

c) The conditions and complexities involved in strengthening the IO in this region were raised. Hence, it becomes increasingly relevant the discussion about the functionality of a Latin-American school of innovation, and its cultural, institutional, and social obstacles, and consequently, the challenges to face of research, teaching, and linkages with the ecosystem. Thus, future opportunities in Latin America for innovation were envisioned.

The research design and the profile of the units of analysis allowed the contrast and identification of categories in complex conditions; thus, the next research line will have to explain this phenomenon from the productive sector's perspective and analyze the mediating effects between the categories identified. The management of the University-Enterprise linkage is a challenge due to the complex conditions of the Latin-American ecosystem, which needs to experiment with the development of new theoretical approaches that address the complexity and the new dynamics of technological change. This would allow that new types of relationships between universities and companies could be built.

Building interactive networks to develop specific programs and collaborative projects is a path to boost this new linkage. Furthermore, a theoretical foundation for this new dynamic ought to be built based on the characterization of the influences of technological patterns such as digital transformation, and then these patterns should adapt to the geographic and regional reality to develop innovation capabilities of the actors that supply and demand knowledge. Consequently, the ecosystem should promote dynamic interactions between innovation authors and other actors of the ecosystem. Thus, this paper contributes to advancing the theory of management and to the discussion that is fostered in this special issue.

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