

The Dynamics of University-Industry Interactions in Peripheral Contexts: Evidence from Brazil

Paulo Aparecido-Tomaz^{a,b}
Assistant Professor, paulo.tomaz@ifmg.edu.br

Bruno Fischer^{c,d}
Associate Professor, bfischer@unicamp.br

Dirk Meissner^d
Professor, Department of Educational Programmes, and Head, Laboratory for Economics of Innovation, dmeissner@hse.ru

Paola Rücker-Schaeffer^e
Post-doctoral Researcher, paolaschaeffernh@hotmail.com

^a Federal Institute of Minas Gerais, Campus Ribeirão das Neves, Vera Lúcia de Oliveira Andrade, 800 – Vila Esplanada, Ribeirão das Neves – MG, 33805-488, Brasil

^b Department of Science and Technology Policy, University of Campinas, Rua Carlos Gomes, 250, Campinas, São Paulo, Brazil 13083-855

^c School of Applied Sciences, University of Campinas, R. Pedro Zaccaria, 1300, Limeira, São Paulo, Brazil 13484-350

^d Institute for Statistical Studies and Economics of Knowledge, National Research University Higher School of Economics, 20 Myasnitskaya str., Moscow 101000, Russian Federation

^e Unisinos Business School, Av. Dr. Nilo Peçanha, 1600 – Boa Vista, Porto Alegre, Rio Grande do Sul, Brazil 91330-002

Abstract

This research aims at addressing the factors that constrain the flow of knowledge between universities and industry when these players are embedded in peripheral contexts. A multiple-case study was carried out in order to describe and understand the limitations of universities as agents of innovation in peripheral ecosystems. Twenty-two semi-structured interviews were conducted with the coordinators of five Technological Innovation Centers (entities equivalent to TTO) of all Federal Institutes (five) located in the State of Minas Gerais, Brazil. The findings show that there are constraining elements associated with the socio-economic environment (the lack of economic dynamism and low

absorptive capacity at firms), with universities (a lack of infrastructure, resources, and available researchers) and intermediary agents (the lack of staff and institutional legitimacy). The observed conditions lead to challenges in fostering dense knowledge flows, thus perpetuating regional economic asymmetries and hindering the institutional evolution of academic institutions toward the notion of entrepreneurial universities. Our research contributes to literature by addressing in detail the limitations of universities in spurring dense innovation networks in laggard ecosystems. Instead, more complex co-evolutionary processes seem to be at play – and “silver bullet” policies are likely to offer disappointing results.

Keywords: knowledge flows, innovation ecosystems; entrepreneurial university; technology transfer; developing countries; Brazil; university-industry interactions

Citation: Aparecido-Tomaz P, Fischer B., Meissner D., Rücker-Schaeffer P. (2022) The Dynamics of University-Industry Interactions in Peripheral Contexts: Evidence from Brazil. *Foresight and STI Governance*, 16(4), 59–69. DOI: 10.17323/2500-2597.2022.4.59.69



© 2022 by the authors. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

Introduction

Innovation and technology transfer have become a priority for universities (Min et al., 2019; Stankevičienė et al., 2017). This focus on knowledge transfer has stemmed from top-down initiatives and has been driven by policymakers who encourage universities to take a proactive stance regarding national and regional economic development (Etzkowitz, 1998). In this sense, these institutions have adopted a dynamic system approach whose main feature is knowledge transfer through activities involving multifaceted interactions with other agents (Schaeffer et al., 2021). This gave rise to institutional changes aimed at encouraging closer connections between universities and industry actors (Fischer et al., 2019).

However, empirical exercises usually analyze their impacts in fairly munificent contexts with a strong presence of complementary actors, a well-established culture of innovation, high economic dynamism, and strong technological activity (Guerrero, Urbano, 2017). Although such studies draw attention to possible outlines, they can hardly be generalized (Sandström et al., 2018). Peripheral regions require a broader concept of innovation systems, especially regarding their actors (Etzkowitz et al., 2005). For example, in addition to what is commonly understood, the university concept also includes contributions to the emerging demands of society that lie outside the scope of traditional technology transfer processes (Bonaccorsi, 2017).

Considering that regions respond differently to development policies – a function of their heterogeneous specificities – there is no guarantee that a successful model in core economic hubs will have similar effects on or produce similar results in peripheral regions (Sánchez-Barrioluengo, Benneworth, 2019). Therefore, this research aims to addressing *the factors that constrain the flow of knowledge between universities and industry when these players are embedded in peripheral contexts*. Our inductive assessment focuses on universities in Brazil, where the typical traits of peripheral regions are largely predominant, and academia and industry evolved separately (Dalmarco et al., 2018). Brazil – like many other developing countries – faces serious difficulties in fostering better quality relationships between the market and academia (Fischer et al., 2019). Such challenges may be related to more basic economic determinants of innovative activity in the country and its regions.

Given the above, the empirical scope of this research includes all Federal Institutes of Education, Science and Technology located in the state of Minas Gerais and higher education members of the Federal Network for Professional and Technological Education, whose mission includes fostering local economic development. The results reveal limitations at the level of ecosystems, institutions, and intermediaries (TTOs). These findings contribute to deepening our

knowledge on the specificities and limits to the entrepreneurial university concept in peripheral regions, especially with regard to knowledge flows and technology transfer processes.

The Role of Universities in the Dynamics of Local Ecosystems of Innovation: The Moderating Role of Context

Benefits accruing from the relationship involving a myriad of actors in the network dynamics of local ecosystems of innovation contribute to the development of new knowledge at universities and companies. Tacit and explicit knowledge are combined in this process, leading to the creation of new products and services (Oh et al., 2016). In this context, the role of universities is closely related to their ability to produce and transfer knowledge, especially through its commercialization, with the potential to drive economic development (Schaeffer et al., 2021). Often, this scientific knowledge spills over onto the market where technological change is rapid and systemic and companies are increasingly dependent upon outside expertise to promote innovation and improve performance (Fernandes et al., 2010).

As knowledge and technologies grow more complex, learning processes at companies depend upon establishing connections with different actors (Schaeffer et al., 2021). Universities become key partners in this context because they often occupy central positions in knowledge networks (Huggins et al., 2019; Brown, 2016; Kempton, 2019). Accordingly, the involvement of universities in such innovation networks provides greater openness and a more substantial flow of knowledge as existing relationships mature and become increasingly productive (Granstrand, Holgersson, 2020; Huggins et al., 2019). In their turn, universities also benefit from new ideas for research projects and access to external funding, which can increase research productivity (Schaeffer et al., 2021, Bonaccorsi, 2017; Fischer et al., 2018).

However, not all businesses or universities are able to take part in networks at various levels. Accordingly, this can likely restrain ecosystem evolution. In this context, universities with fewer resources and less absorptive capacity tend to focus on local linkages, while those with more resources and greater absorptive capacity are involved in broader, interregional networks, thus being able to connect with more diversified knowledge sources (Huggins et al., 2008).

Regional Dynamics and University-Industry Interactions

Peripheral regions are characterized by a lack of economic dynamism, especially when measured by the presence of industrial parks and large companies; low institutional density; scarce innovation culture; and low levels of absorptive capacity (Tödtling et al.

2011; Tödting, Tripl, 2005). These characteristics have a negative impact upon the interaction between universities and companies, since the probability of companies collaborating is strongly related to company size, technological level, and R&D spending (Laursen, Salter, 2004). Likewise, the regional impact of university knowledge depends on internal corporate factors – including entrepreneurial culture – and external factors at the regional level over which universities have no control (Bonaccorsi, 2017; Sánchez-Barrioluengo, Benneworth, 2019).

Thus, the contextual features of regional contexts and their inherent institutional aspects are directly related not only to the companies' ability but also to companies' interest and desire to effectively engage in innovation networks. In this regard, universities' reputations and prestige affect their attractiveness as partners for industry cooperation (Laursen et al., 2011). Companies prefer to cooperate with top-tier universities, regardless of distance, rather than second-tier universities (Bonaccorsi, 2017). On the other hand, cognitive distance has proved to be a serious obstacle for such collaborations to take place (Tödting et al., 2011).

Universities located in peripheral regions might be limited because they experience difficulties attracting high profile research and teaching staff, which potentially results in lower quality cooperative efforts or in less ambitious undertakings. In turn, companies with high absorptive capacity seek universities with greater capacity and a more robust structure for the development of R&D (D'Este et al., 2013). Meanwhile, companies with low absorptive capacity seek partners that are within geographical proximity (D'Este et al., 2013; Laursen et al., 2011), but these relationships seldom involve long-term R&D collaborations oriented toward innovation (Bonaccorsi, 2017). Also, in these regions, low levels of infrastructural quality and industrialization limits the ability of universities to establish productive relationships with partners from industry (Tödting, Tripl, 2005).

Along these lines, while prior research has shown that universities engaged in innovation networks play an important role in a region's innovation culture, such impacts are more prominent in regions with greater economic density (Bonaccorsi, 2017). Their effects are mild in regions without adequate learning and technological capabilities, where the productive system is mainly composed of small and medium-sized enterprises with low-growth trends and fragmented connections with external sources of knowledge (Huggins et al., 2019; Huggins et al., 2008).

Given the above, the role of universities as pivotal promoters of regional development in peripheral regions is questionable, considering that the success stories found in the literature are based on regions that are among the most innovative in the world (Huggins et al., 2019; Tödting, Tripl, 2005). In this sense, the literature focused on regional development has placed

the burden of development on the notion of entrepreneurial universities (Bonaccorsi, 2017). These conditions are bound to generate, at best, lackluster outcomes since regional development depends upon the combination of myriad complementary agents and contextual conditions.

Methodological Approach

A multiple-case study was carried out in order to describe and understand the limitations of universities as agents of innovation in peripheral ecosystems. The option of studying multiple cases, as proposed by Eisenhardt (1989), was motivated by the characteristics of the unit of analysis of this investigation, namely Federal Institutes, since they comprise several features of a university, offering higher education and conducting scientific research and outreach activities. Twenty-two semi-structured interviews were held with the coordinators of five Technological Innovation Centers (entities equivalent to TTO) of all Federal Institutes (five) located in the State of Minas Gerais, Brazil, with at least one researcher from each institute who was somehow related to the TTO, especially regarding intellectual property protection and technology transfer. Furthermore, the interviews were conducted with representatives of companies that had interacted with the TTOs. The surveys were carried out between October 2019 and October 2020. Other techniques were used during case studies to triangulate information (Eisenhardt, 1989; Yin, 2003). These involved direct observations and secondary data on technology transfer activity and contextual features of local economic environments. Table 1 shows that over 16 hours were devoted to the interviews, which were recorded, transcribed, and analyzed.

The transcribed data were used for content analysis based on the analytical categories in the respective interview protocols, defined *ex ante* and supported by dedicated literature (Eisenhardt, 1989; Yin, 2003). This process provided insights into defining the three analytical dimensions – local ecosystem, university research structure, and intermediaries. Ecosystem and university research structure were frequently cited in the interviews with the TTO coordinators, researchers, and company representatives, while TTO structure was strongly perceived in the interviews with their coordinators. The definition of these dimensions is shown in Table 2.

Research Setting

Considering that Brazil is a country of continental dimensions, many particularities can be found in its different regions. There are, therefore, regions with greater economic dynamism and greater capacity to absorb knowledge, such as São Paulo, where leading innovation ecosystems are located. These regions feature a number of successful cases in university-industry relationships (Schaeffer et al., 2021; Fischer et al.,

Table 1. Interviewees by Institute and Segment

Interviewees	Federal institute										Total	
	FI_1		FI_2		FI_3		FI_4		FI_5			
	Int	T**	Int	T**	Int	T**	Int	T**	Int	T**	Int	T**
TTO coordinator	1	57	1	52	1	80	1	*	1	130	5	319
TTO ex-coordinator	—	—	1	45	—	—	—	—	—	—	1	45
Researcher	2	94	3	127	1	*	1	66	2	120	9	407
Company	2	30	2	76	1	72	1	41	1	31	7	250
Total	5	181	7	300	3	152	3	107	4	281	22	1021

*Interviews given in writing (not recorded); ** T= interview time in minutes.
Source: authors.

2018). On the other hand, most other regions across the country face a rather distinct economic reality.

Peripheral regions lack innovation-oriented productive structures and are highly dependent on small and medium-sized enterprises with low-growth trends and specialize in medium-low and low-tech activities. Innovation networks in these regions have fragmented connections, with few external sources of innovation which are also geographically dispersed. The definition of cases in this study is relevant due to the scope of the institutions studied in the State of Minas Gerais, which has regions with heterogeneous economic, social, cultural, and demographic features. Thus, although the cases are relatively concentrated – covering the North, Central, West, Southeast, and South regions of the state - they can offer valuable insights for other peripheral regions embedded in the context of developing economies. In turn, understanding the dynamics of academic-centered innovation in such areas can provide a clearer view of the role (and limits) of universities as pivotal promoters of regional development in peripheral regions.

The analysis centered on the three main outlined dimensions. The first refers to the (peripheral) local ecosystem in which academic institutions are embedded. It is based on the premise that central regions stand for more munificent and complex ecosystems, enjoying a considerable advantage over peripheral regions. The second relates to universities’

research infrastructure. Thus, it is understood that a lack of resources and the unavailability of researchers directly influence the innovation process as well as the ability of universities to interact with external agents. Lastly, an analysis of the intermediary dimension was carried out, more specifically within the scope of the Technology Transfer Offices (TTO) of universities.

Ecosystem Analysis

In the analyzed peripheral ecosystems, companies find it more difficult to implement innovation management processes and to become innovative, mainly due to economic uncertainties and difficulties in terms of scarce human and financial resources. These regions usually lack economic dynamism, absorptive capabilities, innovation culture, and present a low density of complementary elements to foster the formation of knowledge networks.

Economic Dynamism

Laggard regions mostly feature productive structures with low levels of technological capabilities, often involved in traditional sectors (Tödtling, Tripl, 2005). In an attempt to circumvent these obstacles, universities have strived to design their internal innovation policies for technology prospecting by observing the economic frameworks of their respective regions; the level of social development in the region; the qualita-

Table 2. Relationships between the Analyzed Dimensions and the Respective Sources

Dimension	Related topics	Source - Literature	Interviews and other sources
Local Ecosystem	<ul style="list-style-type: none"> Economic dynamism Absorptive capacity Innovation culture Institutional density 	(Bonaccorsi, 2017; Boschma, 2005; Cooke, 2005; Guerrero, Urbano, 2017; Tödtling, Tripl, 2005)	<ul style="list-style-type: none"> Interview with TTO coordinators, researchers and company representatives Economic and social data Institutional Development Plan
University research infrastructure	<ul style="list-style-type: none"> Rapport Facilities and resources Bureaucracy Researchers 	(Bonaccorsi, 2017; Fischer et al., 2018; Huggins et al., 2019)	<ul style="list-style-type: none"> Interview with TTO coordinators, researchers and company Institutional Innovation Policy
Intermediaries – TTO	<ul style="list-style-type: none"> Human Resources IP Protection and Technology Transfer 	(Hayter et al., 2020; Siegel, Wright, 2015)	<ul style="list-style-type: none"> Interview with TTO coordinators and researchers Institutional Innovation Policy

Source: authors.

tive analysis of the level of technological, industrial, and social development of the local economy; the compatibility between the technological demand of the local economy and the institution's expertise; and the possibilities of developing projects in line with the areas of expertise and operation of the innovation hubs. Qualitative data from our research revealed that this socioeconomic environment affects the capacity for integration between universities and the productive environment. This is in line with the perspective that the innovation context differs for a university in a less industrialized region compared to the ecosystem associated with a comparable university in a large metropolitan area (Siegel, Wright, 2015).

As the Federal Institutes operate in economically disadvantaged regions that face different types of problems such as unemployment, poor infrastructural conditions, and a lack of economic dynamism, a research agenda aimed at tackling such problems is required – thus dealing with a much more pressing and urgent agenda than fostering the formation of innovation networks. Corroborating this statement, the TTO2 former coordinator reports that the institution is located in a poor region with sanitation and industrial problems. “If, for example, the institutes acted decisively to truly tackle the problems of those societies and brought them inside the institute in order to solve them, it would be much more efficient” (TTO2 former coordinator). However, such alignment conditions often conflict with the research goals and capabilities of scientists.

Absorptive Capacity

Peripheral regions are mainly characterized by the predominant presence of micro and small enterprises and/or companies with a lack of innovation culture. These organizations are limited in their capacity to absorb complementary knowledge from external sources. This limitation concerns both the acquisition and assimilation of knowledge and the ability to transform and exploit it. Thus, these companies are unable to identify which kinds of knowledge can be absorbed or combined with their own expertise to create new technological opportunities. The effects of such a cognitive mismatch were often mentioned by the interviewees, whether TTO coordinators, researchers, or company representatives, following patterns reported in prior assessments (Crescenzi et al., 2017).

The TTO2 coordinator stresses that many companies have technological capabilities that are distant from those of the Federal Institutes. While this creates possibilities for partnerships dealing with issues that the company is unable to solve internally, the transfer of new technologies and even the identification of economic opportunities is constrained by this cognitive distance. Similarly, the TTO3 coordinator states that the university researchers can only develop research

up to a certain point, being unable to engage in activities such as field testing, depending on the area or type of product. Hence, although there is the possibility of complementarity with reasonable cognitive distance, the low absorptive capacity discourages both companies and universities from establishing links in a context of innovation (Boschma, 2005; D’Este et al., 2013).

Another aspect related to cognitive distance concerns researcher training. In order to reduce this distance and adapt to the companies’ demands, researchers might have to change their line of research, an issue that generates conflict with the autonomy of scientists. One TTO coordinator perceives that sometimes researchers get caught up in scientific endeavors and teaching activities, distancing themselves from market connections (TTO3 Coordinator). While this situation highlights an interest in generating economic development, it is likely to create animosity within the academic community (because it is attached to a loss of freedom in their scientific activities). On the other hand, it is at odds with how performance measurement is undertaken in the academic environment, favoring publications over the development of applied technologies oriented toward addressing market needs.

Innovation Culture

Innovation culture has a strong influence on issues related to university knowledge and learning, especially regarding innovation-related matters. Based on the interviews, it was noted that the TTO coordinators focused on the absence of innovation culture at both universities and companies. In this sense, one respondent states that in Brazil there is no culture of innovating in partnership with universities, with the exception of a few large companies and the pharmaceutical sphere where it occurs more frequently, “but if you look at other areas, it is something very incipient in the country” (TTO2 former coordinator). The (FI5) researcher emphasizes that the specific absence of an innovation culture at Brazilian companies hinders their relationship with universities, a point that was also reported by the coordinator from TTO5. This is corroborated by data from previous assessments and from the Brazilian Innovation Survey, which indicate that less than 4% of innovative companies in Brazil establish cooperative agreements with universities – and only half of that number consists of R&D-oriented projects (Fischer et al., 2019).

Institutional Density

Institutions play a key role in facilitating new opportunities for economic activity and innovation. However, peripheral regions normally lack effective local institutions and are not reached by institutions with a larger geographic scope, especially in countries as large as Brazil, thus creating localized institution-

al voids. In the case of the Federal Institutes, these conditions are expressed in the Institutional Development Plan of FI2, which states that of the nine micro-regions where the institution is present, only two have incubation programs. In addition, the (FI1) researcher stresses the difficulty in developing innovation activities in the region, since they are “in a region that is still poorly developed economically and socially”. Hence, the provision of local-level support institutions that facilitate university-industry connections (Fischer et al., 2018) is often absent in such peripheral contexts.

Universities and Research Infrastructure

Research infrastructure involves both structural and organizational aspects. In this sense, the lack of resources, the limited availability of adequate laboratories for research, the lack of available researchers, excessive bureaucracy, and a lack of rapport with external agents are likely to restrict the integration of universities into an innovation network.

Lack of Rapport

Encouraging closer ties between universities and local companies is challenging. It is difficult to make managers embedded in peripheral ecosystems understand that research can be a driver to transform the company and their businesses. Data from the Brazilian Innovation Survey confirm these results. The share of firms developing joint R&D-oriented activities – instead of technical, training, and consulting forms of cooperation – has not increased despite the intensification of initiatives targeted at increasing the levels of university-industry collaboration in the country. More troubling is that the majority of companies involved in collaborative processes perceive Brazilian universities as agents of low relevance for their innovative activities (Fischer et al., 2019).

According to companies, it is also difficult to have access to universities. The (C4) company representative reports that access is restricted. The main contact the company has with those institutions is through the joint supervision of research theses or hiring of interns. “The company believes that much of the research carried out in universities has no practical application and that the private sector is distant from universities” (C4 company representative). The (C5) company representative also highlights the need to reduce the chasm between universities and society. The respondent points out that a large volume of knowledge produced by universities never reaches society. According to the interviewee, this knowledge should flow to society and generate economic value. For the respondent, the universities do not seek out society’s needs, and those needs are often concealed because the public is not aware of the universities’ potential to contribute to the solution of those problems.

Scarce Research Facilities and Resources

The existence of adequate facilities is a critical element in the research infrastructure of universities. Thus, access to spaces such as maker spaces and laboratories of institutions is highly valued by researchers and academic entrepreneurs. However, not all universities enjoy the privilege of having such spaces. In the case of Federal Institutes, for example, the scarce research infrastructure available is intended for teaching purposes rather than advanced research laboratories, which makes it difficult to set up innovation initiatives with firms.

Likewise, the lack of financial resources prevents the proper maintenance and supply of spaces for technological development. Therefore, this issue is yet another major challenge faced by TTOs. This problem is noticed even by organizations that partner with the institution. In an argument in favor of adequate laboratories for research, the (FI4) researcher argues that “if you have a cutting-edge laboratory for research, you can teach there. The opposite is not true” (FI4 researcher). In turn, these conditions hamper access to research grants, given the inadequate settings to build competitive R&D proposals.

Bureaucracy

At Brazilian universities, the excessive bureaucracy of control mechanisms makes it a challenge to set up collaborative agreements with companies, especially regarding intellectual property protection and technology licensing. The delay in the processes confirms the divergence of expectations between universities and companies (Bodas-Freitas et al., 2013). Companies report that the problem is the delay in getting answers concerning technology transfer processes (C1 company). In this sense, companies complain of the difficulty caused by bureaucracy and suggest that the solution would be to find an alternative that is not tied down by bureaucratic laws. Likewise, the literature reports bureaucracy as a barrier in the technology transfer process. Studies carried out at leading universities both in Brazil and abroad highlight this problem (Bodas-Freitas et al., 2013). In the same sense, the (C5) company representative shows how much bureaucracy can be harmful to the company.

. . . for the company this [bureaucracy] is very bad, because you have a schedule, an expectation, there is market demand, which at that moment you have to exploit, so to speak. When we have this type of gap in research, in support, we have delays in delivering projects and may even lose the timing of the innovation (C5 company).

Even though public management, including with regard to agreements with private actors, requires processes that guarantee legality, morality, and impersonality, such routines cannot be overwhelmed by

rules that hinder the smooth operation of work between partners, since in many cases the window of opportunity of companies for innovation is short.

Researchers

These limitations concern the excessive teaching workload of researchers, legal uncertainty in establishing ties with industrial partners, and the lack of ability to deal with the market. Another challenge found at Federal Institutes concerns their research culture. While regulations stipulate that applied research is a priority of Federal Institutes, many researchers insist on developing basic research, which rarely meets the demands of companies and moves these institutions away from their core objectives. In the perception of both researchers and TTO coordinators, it is very difficult for researchers to carry out applied research in line with local demands, as they have to learn the entire process or even change their line of research. In this sense, the culture of basic research learned at university is strongly present at Federal Institutes. It was noted that researchers such as those from (FI1) and (FI5) reported that their research is basic and does not generate immediate results that can serve the purpose of establishing innovation networks with industrial partners.

Intermediaries

The intermediary dimension features two main challenges that directly influence the flow of knowledge between universities and innovation ecosystems. The first concerns the understaffing of TTOs and the second relates to the protection of intellectual property and technology transfer.

Human Resources

Regarding human resources, staff numbers and turnover are the main critical elements. It is therefore understood that a well-prepared TTO team may significantly influence the results, since an experienced and market-oriented team are essential assets for TTOs to perform to their full potential (Schaeffer et al., 2021). At the investigated institutions, most TTOs operate with one or two employees and one or two interns. However, the employees are civil servants that were not hired specifically for the TTO; they are professors or technicians who are working there temporarily. In the case of TTO1, a single person is in charge of executing all activities, with the position of coordinator. According to this interviewee, he does not work full-time for the TTO. Understaffing discourages TTOs from taking on more complex projects. Sometimes it is even hard to follow through with routine activities. As stated by the TTO5 coordinator: “We need more human resources fast, urgently, to continue with the regular activities.”

The interviewed researchers acknowledge this limitation, stating that the lack of staff at TTOs is a sig-

nificant drawback. The (FI1) researcher stresses that the high turnover of fellows makes it hard to retain knowledge. The (FI2) researcher states that having a multidisciplinary team at TTOs would streamline the process, which could then be totally resolved internally without the need to resort to other departments of the institution. However, even better staffed TTOs, such as the TTO with two civil servants and three interns, believe internship positions should be occupied by regular staff, because “every time the interns leave, it’s like starting from scratch again” (TTO2 former coordinator).

Regarding staff turnover, it was noted that this occurs with both TTO coordinators and interns, which makes it harder to manage knowledge efficiently. As there are few staff members, sometimes the person who leaves is the only one who possesses operational knowledge of the activities undertaken. “Some TTOs have only one employee, so if that person leaves, another arrives that knows nothing about intellectual property, which is a complicated subject” (TTO2 former coordinator). In this regard, researchers stressed the need for TTOs to have fixed employees to ensure the creation of memory and the retention of knowledge. They also highlighted the need for constant training.

These staffing problems at TTOs may be related to a broader structural issue of Brazilian public organizations, which lack flexibility to hire and manage human resources (Fischer et al., 2019). Providing TTOs with sufficient resources and qualified personnel is necessary for them to carry out their work effectively. This perception is in accordance with the early findings that technology transfer professionals should be the drivers of commercialization at research institutions (Bubela, Caulfield, 2010).

IP Protection and Technology Transfer

The TTO activities herein presented are in accordance with what Hayter et al. (2020) highlighted as activities of intellectual property protection, technology transfer, and support for entrepreneurship. Similarly, previous studies also found that the activities performed by Technology Transfer Offices focused on two main dimensions of technology transfer in universities: patenting and licensing (Clarysse et al., 2007; Siegel, Wright, 2015). The other activities aimed at supporting entrepreneurship and technological prospecting are not yet a reality at most TTOs, especially in Brazil (Schaeffer et al., 2021).

Although the main activity of the studied TTOs is the protection of intellectual property, some of them are still deficient in this respect, especially concerning patent registration. The TTO1 coordinator says no patent applications have been filed. In general, protection is done according to demand and covers several categories such as registration of trademarks, patents, software, or cultivars. Although this varies

substantially from one institution to another, most registrations relate to software, trademarks, and patents. Despite the effort to protect intellectual property at the TTOs investigated and the positive results pointed out by some interviewees, the goal and assessment benchmark of universities should be technology transfer, since mere protection of intellectual property without transfer ends up creating a liability for the institution. However, as previously identified, research activities at the investigated institutions are mainly oriented toward basic science, rendering the intermediary role of TTOs limited in this respect. In addition, even the small numbers of intellectual property registered are not commercialized.

An Integrative Perspective on University-Industry Interactions in Peripheral Contexts

Over time, the generation and exchange of knowledge has become an important activity in all industrial sectors, no longer confined to complex R&D laboratories or the ivory towers which for many years housed academic research. Nonetheless, the various forms of knowledge production and exchange, despite being able to contribute to the advancement of knowledge, have considerable limitations. Laboratory research, for example, in striving for basic understanding, may overlook some of the complexities involved in industrial applications. These approaches have underscored several cases of successful relationships between different actors in innovation ecosystems that are considered mature or munificent. However, the literature has largely overlooked its impacts on emerging systems with low levels of absorptive capacity, low institutional density, scant innovation culture, and low economic density, where the main characteristic of the relationship between the actors is fragmentation. In this sense, the following proposition is put forward.

Proposition 1: Ecosystem conditions such as low economic dynamism, little capacity to absorb scientific knowledge, a lack of an innovative culture, and low institutional density moderate the benefits of university-business interaction in peripheral regions.

Different university-industry links can be identified in the context of local innovation networks. Research agreements, consultancy, and joint research are usually the relationships considered most important by several authors, along with patent licensing (Gianpoulou et al., 2010). In this respect, there is a concern about the possibility of attention shifting excessively to intellectual property rights at the expense of publishing research results – despite prior evidence indicating that patenting and publishing are complementary activities (Bourellos et al., 2017).

Notwithstanding the possibility of contributing in different ways to an innovation environment, uni-

versities embedded in peripheral regions face severe limitations regarding the availability of a research infrastructure that meets the needs of business partners. Companies developing research that requires more careful analysis have to set up partnerships with other institutions outside the region to solve industrial and societal problems. As far as research structure is concerned, the workload assigned to researchers often exceeds their ability to execute it regularly, which prevents them from engaging in new and sometimes more ambitious projects.

In addition, other organizational limitations such as excessive bureaucracy, the profile of managers and researchers and institutional culture may influence the decision to engage in innovation-driven linkages. It is also worth noting that not all universities and institution departments possess the characteristics required to contribute significantly to innovation networks (Kempton, 2019; Sánchez-Barrioluengo, Benneworth, 2019). Besides, other elements such as research fields and university size may be closely linked to the possibility of achieving greater or lesser success in relationships. Given the above, the following proposition is presented.

Proposition 2: The organizational conditions of universities, such as the lack of adequate facilities, resources, excessive bureaucracy, work overload for researchers, and the difficulty in joining business networks hinder the interaction of these institutions with the productive sector in peripheral regions.

In the past few decades, the number of intermediary organizations playing a brokering role in innovation ecosystems has increased significantly. In this article, focus has been given to universities' TTOs, which work mainly in protecting intellectual property, supporting innovative entrepreneurship, and interacting with companies. The studied TTOs face severe limitations that constrain their ability to effectively promote further integration between universities and the broader ecosystem. Although some of these limitations are attached to the internal organizational structure of the university, some challenges associated with regulatory frameworks that apply to public entities are also present – thus going beyond the institutional control of individual universities. Excessive bureaucracy, for example, is not only an internal limitation at TTOs, but also affects most universities and public bodies (Bodas-Freitas et al., 2013). Another limitation concerns the staff size assigned to these bodies, as well as their training. Research by Stankevičienė et al. (2017) found a positive relationship between the efficiency of technology transfer offices and the number of qualified staff, motivation systems, and good relationship between TTOs and researchers.

In addition to the above, contextual features directly influence the activities of TTOs, since the regional innovation culture is likely to affect how the academic

community perceives technological activity as part of its mission. Thus, it is more difficult to implement an innovation culture at a university in a context in which such a culture is absent. Other aspects such as the lack of interest in interacting with universities, the lack of knowledge or distrust directly interfere in the performance of TTOs. Therefore, the following proposition is presented.

Proposition 3: The results of TTOs linked to universities in peripheral contexts are negatively affected by the lack of staff, high staff turnover, and the lack of technological prospecting and scarce technology transfer activities. This reveals the fragility of TTOs in supporting university-industry interactions in these regions.

The propositions presented summarize some limitations inherent to university-industry ties in a peripheral context, especially when the focus resides on innovative endeavors.

Concluding Remarks

Our assessment focused on university-industry interactions in a three-dimensional approach, analyzing ecosystems, universities, and TTOs, which act as an interface between universities and the productive environment. It was found that all three dimensions contain elements that constrain knowledge flows between academic and business partners, and these are mostly attached to level of maturity in innovation ecosystems located in peripheral contexts.

Our findings indicated that the entrepreneurial university concept requires a careful reexamination when dealing with academic institutions embedded in such regions. Initiatives ranging from structural public policies to managerial decision-making at the organization or department levels to ensure an improved flow of knowledge and technology are required. However, the solution is not simple, as some

issues lie outside the competence of universities or TTOs. Further involvement of multitudinous local-level stakeholders is necessary so that, in the long run, the ecosystem may become more conducive to the establishment of successful innovation networks. Unfortunately, attempts to develop regions by establishing or promoting universities are often characterized by short-termism. In this regard, our research contributes to the literature by addressing in detail the limitations of universities in spurring dense innovation networks in laggard ecosystems. Instead, more complex co-evolutionary processes seem to be at play – and “silver bullet” policies are likely to offer disappointing results. The heterogeneity between different academic institutions highlights the impossibility of adopting a one-size-fits-all model in terms of education, research, and technology transfer activities (Baglieri et al., 2018; Kempton, 2019).

Our set of propositions highlights key moderators and barriers in this realm, offering academics and policymakers a roadmap to guide the support of entrepreneurial universities when embedded in peripheral ecosystems. Corresponding implications involve a broader comprehension of innovation networks involving universities – rather than simply setting up TTOs. Nevertheless, our assessment does not go without limitations. Our inductive exercise has drawn qualitative information from the specific context of the State of Minas Gerais, Brazil. Thus, further assessments on this topic should address context-specific elements. Deductive assessments based on quantitative data are also due in order to provide academic and policymakers with a clearer perspective on the limits of the entrepreneurial university discourse.

The article was prepared within the framework of the Basic Research Program of the HSE University.

References

- Baglieri D., Baldi F., Tucci C.L. (2018) University technology transfer office business models: One size does not fit all. *Technovation*, 76–77, 51–63. DOI: 10.1016/j.technovation.2018.05.003
- Bodas Freitas I.M., Geuna A., Rossi F. (2013) Finding the right partners: Institutional and personal modes of governance of university-industry interactions. *Research Policy*, 42(1), 50–62. DOI: 10.1016/j.respol.2012.06.007
- Bodas Freitas I.M., Marques R.A., Silva E.M.D.P.E. (2013) University-industry collaboration and innovation in emergent and mature industries in new industrialized countries. *Research Policy*, 42(2), 443–453. DOI: 10.1016/j.respol.2012.06.006
- Bonaccorsi A. (2017) Addressing the disenchantment: Universities and regional development in peripheral regions. *Journal of Economic Policy Reform*, 20(4), 293–320. DOI: 10.1080/17487870.2016.1212711
- Bourellos E., Beyhan B., McKelvey M. (2017) Is the prominent scientist the one who becomes an inventor? A matching of Swedish academic pairs in nanoscience to examine the effect of publishing on patenting. *Research Evaluation*, 26(2), 144–156. DOI: 10.1093/reseval/rvx004
- Boschma R.A. (2005) Proximity and innovation: A critical assessment. *Regional Studies*, 39(1), 61–74. DOI: 10.1080/0034340052000320887

- Brown R. (2016) Mission impossible? Entrepreneurial universities and peripheral regional innovation systems. *Industry and Innovation*, 23(2), 189–205. DOI: 10.1080/13662716.2016.1145575
- Bubela T.M., Caulfield T. (2010) Role and reality: Technology transfer at Canadian universities. *Trends in Biotechnology*, 28(9), 447–451. DOI: 10.1016/j.tibtech.2010.06.002
- Clarysse B., Wright M., Lockett A., Mustar P., Knockaert M. (2007) Academic spin-offs, formal technology transfer and capital raising. *Industrial and Corporate Change*, 16(4), 609–640. DOI: 10.1093/icc/dtm019
- Crescenzi R., Filippetti A., Iammarino S. (2017) Academic inventors: Collaboration and proximity with industry. *Journal of Technology Transfer*, 42(4), 730–762. DOI: 10.1007/s10961-016-9550-z
- D’Este P., Guy F., Iammarino S. (2013) Shaping the formation of university-industry research collaborations: What type of proximity does really matter? *Journal of Economic Geography*, 13(4), 537–558. DOI: 10.1093/jeg/lbs010
- Dalmarco G., Hulsink W., Blois G.V. (2018) Creating entrepreneurial universities in an emerging economy: Evidence from Brazil. *Technological Forecasting and Social Change*, 135, 99–111. DOI: 10.1016/j.techfore.2018.04.015
- Eisenhardt K. (1989) Building Theories from Case Study Research. *Academy of Management Review*, 14(4), 532–550. DOI: 10.2307/258557
- Etzkowitz H. (1998) The norms of entrepreneurial science: Cognitive effects of the new university-industry linkages. *Research Policy*, 27(8), 823–833. DOI: 10.1016/S0048-7333(98)00093-6
- Etzkowitz H., De Mello J.M.C., Almeida M. (2005) Towards “meta-innovation” in Brazil: The evolution of the incubator and the emergence of a triple helix. *Research Policy*, 34(4), 411–424. DOI: 10.1016/j.respol.2005.01.011
- Fernandes A.C., De Souza B.C., Da Silva A.S., Suzigan W., Chaves C.V., Albuquerque E. (2010) Academy-industry links in Brazil: Evidence about channels and benefits for firms and researchers. *Science and Public Policy*, 37(7), 485–498. DOI: 10.3152/030234210X512016
- Fischer B.B., Schaeffer P.R., Vonortas N.S. (2019) Evolution of university-industry collaboration in Brazil from a technology upgrading perspective. *Technological Forecasting and Social Change*, 145, 330–340. DOI: 10.1016/j.techfore.2018.05.001
- Fischer B.B., Schaeffer P.R., Vonortas N.S., Queiroz S. (2018) Quality comes first: University-industry collaboration as a source of academic entrepreneurship in a developing country. *Journal of Technology Transfer*, 43(2), 263–284. DOI: 10.1007/s10961-017-9568-x
- Giannopoulou E., Yström A., Elmquist M., Fredberg T., Ollila S. (2010) Implications of openness: A study into (all) the growing literature on open innovation. *Journal of Technology Management and Innovation*, 5(3), 162–180. DOI: 10.4067/S0718-27242010000300012
- Granstrand O., Holgersson M. (2020) Innovation ecosystems: A conceptual review and a new definition. *Technovation*, 90–91, 102098. DOI: 10.1016/j.technovation.2019.102098
- Guerrero M., Urbano D. (2017) The impact of triple helix agents on entrepreneurial innovations’ performance: An inside look at enterprises located in an emerging economy. *Technological Forecasting and Social Change*, 119, 294–309. DOI: 10.1016/j.techfore.2016.06.015
- Hayter C.S., Rasmussen E., Rooksby J.H. (2020) Beyond formal university technology transfer: Innovative pathways for knowledge exchange. *Journal of Technology Transfer*, 45(1), 1–8. DOI: 10.1007/s10961-018-9677-1
- Huggins R., Izushi H., Prokop D. (2019) Regional advantage and the geography of networks: Explaining global-local knowledge sourcing patterns. *Papers in Regional Science*, 98(4), 1567–1584. DOI: 10.1111/pirs.12423
- Huggins R., Johnston A., Steffenson R. (2008) Universities, knowledge networks and regional policy. *Cambridge Journal of Regions, Economy and Society*, 1(2), 321–340. DOI: 10.1093/cjres/rsn013
- Kempton L. (2019) Wishful thinking? Towards a more realistic role for universities in regional innovation policy. *European Planning Studies*, 27(11), 2248–2265. DOI: 10.1080/09654313.2019.1628183
- Laursen K., Reichstein T., Salter A. (2011) Exploring the effect of geographical proximity and university quality on university-industry collaboration in the United Kingdom. *Regional Studies*, 45(4), 507–523. DOI: 10.1080/00343400903401618
- Laursen K., Salter A. (2004) Searching high and low: What types of firms use universities as a source of innovation? *Research Policy*, 33(8), 1201–1215. DOI: 10.1016/j.respol.2004.07.004
- Min J., Vonortas N.S., Kim Y. (2019) Commercialization of transferred public technologies. *Technological Forecasting and Social Change*, 138, 10–20. DOI: 10.1016/j.techfore.2018.10.003
- Oh D.S., Phillips F., Park S., Lee E. (2016) Innovation ecosystems: A critical examination. *Technovation*, 54, 1–6. DOI: 10.1016/j.technovation.2016.02.004
- Sánchez-Barriluengo M., Benneworth P. (2019) Is the entrepreneurial university also regionally engaged? Analysing the influence of university’s structural configuration on third mission performance. *Technological Forecasting and Social Change*, 141, 206–218. DOI: 10.1016/j.techfore.2018.10.017

- Sandström C., Wennberg K., Wallin M.W., Zherlygina Y. (2018) Public policy for academic entrepreneurship initiatives: A review and critical discussion. *Journal of Technology Transfer*, 43(5), 1232–1256. DOI: 10.1007/s10961-016-9536-x
- Schaeffer P.R., Guerrero M., Fischer B.B. (2021) Mutualism in ecosystems of innovation and entrepreneurship: A bidirectional perspective on universities' linkages. *Journal of Business Research*, 134, 184–197. DOI: 10.1016/j.jbusres.2021.05.039
- Siegel D.S., Wright M. (2015) Academic entrepreneurship: Time for a rethink? *British Journal of Management*, 26(4), 582–595. DOI: 10.1111/1467-8551.12116
- Stankevičienė J., Kraujalienė L., Vaiciukevičiūtė A. (2017) Assessment of technology transfer office performance for value creation in higher education institutions. *Journal of Business Economics and Management*, 18(6), 1063–1081. DOI: 10.3846/16111699.2017.1405841
- Tödtling F., Lengauer L., Höglinger C. (2011) Knowledge sourcing and innovation in “thick” and “thin” regional innovation systems-comparing ICT firms in two Austrian regions. *European Planning Studies*, 19(7), 1245–1276. DOI: 10.1080/09654313.2011.573135
- Tödtling F., Trippel M. (2005) One size fits all?: Towards a differentiated regional innovation policy approach. *Research Policy*, 34(8), 1203–1219. DOI: 10.1016/j.respol.2005.01.018
- Yin R. (2003) *Case Study Research: Design and Methods* (3rd ed.), Thousand Oaks, CA: Sage.