7

Brazil

FERNANDA DE NEGRI AND CRISTIANE VIANNA RAUEN

7.1 Introduction

It is widely recognized that the knowledge production of universities and research institutions is one of the foundations of economic development. The experiences of countries such as Japan, the Republic of Korea, the United States of America (U.S.), and, more recently, China have shown that successful development results from a combination of good policies, a sound research and education infrastructure, and productive interaction between that infrastructure and enterprises.

Brazil does not have a strong tradition of interaction between universities/public research institutes and businesses, but the situation has changed greatly in recent years. The lack of interaction used to be one of the most frequently noted characteristics of the Brazilian innovation system. Sutz (2000), for instance, observed a very low level of contact between the country's universities and companies. Data consolidated by De Negri et al. (2009) show that only 14 percent of all research projects supported by the main source of public funding for science and technology (S&T) in Brazil, the so-called Sectoral Funds, counted companies among the beneficiaries. Although these projects represent around 35 percent of the resources invested by the Sectoral Funds, that is probably not enough since the aim of the Funds is to support innovation.

However, there has been a notable increase in efforts to support innovation and facilitate interaction among universities, researchers, research institutions, and companies in Brazil in recent years. The 2000s witnessed the creation of several policies that transformed the scenario for innovation in Brazil. From new policies to support R&D investments by companies to a new regulatory framework for university–industry interaction, several initiatives were implemented during this

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period. And several new pieces of evidence suggest that these policies probably did increase the level of interaction between universities and companies.

This chapter aims to analyze the conditions and policies framing the interaction between public research institutes and universities and the business sector in Brazil. Our analysis is based on: (1) a review of the scholarly literature and Brazilian legislation regarding innovation policies and university–industry interactions; (2) data on IP and related indicators in official Brazilian government reports; (3) information gathered through questionnaires sent to eighteen Brazilian universities and research institutions; and (4) in-depth interviews with four selected Brazilian knowledge transfer offices (KTOs).

The chapter is composed of five sections including this introduction. The second section briefly reviews the key literature on knowledge transfer in Brazil. The third section gives an overview of the historical role of universities and public research institutes in the Brazilian innovation system as well as the main policy instruments and mechanisms in relation to science, technology, and innovation. Section 7.4 analyzes the main policies and practices adopted by institutions and companies for knowledge transfer in the country, while the fifth and final section presents our concluding remarks.

7.2 The Literature on University–Industry Relations in Brazil

University–industry interactions are considered an important element of any national innovation system (NIS) as they are one of the engines of technological progress and of competence building at the regional and national levels (Chaves et al. 2015). In Brazil, the view is often advanced that academia is too remote from the needs of industry.

Albuquerque (1999), for instance, argues that the channels of knowledge transfer are weak in Brazil, impairing the frequency and quality of university–industry interactions in the country. A combination of two main factors may explain the weakness of knowledge transfer mechanisms in Brazil: the historical backwardness of Brazilian industrialization and the relatively late creation of universities and research institutes in comparison with developed countries (Suzigan and Albuquerque 2011).

Several authors have sought to explain the low level of interaction between universities/public research institutes and business. Rapini et al. (2009) argue that it reflects a poor pattern of demand from industry. Indeed, Britto et al. (2015) show that, in comparison with other

countries, the majority of Brazilian companies – especially the internationalized ones – still do not look to universities to establish any kind of knowledge transfer in order to promote their innovative activities.

Dutrénit and Arza (2015) argue that although linkages between universities and firms in Brazil are fragile, there have been successful cases of knowledge transfer, including in the steel, petrochemicals, aircraft, and agro-industry sectors. But despite these success stories, Brazilian NIS is lagging behind other countries, since there remains a mismatch between the scientific side of the system and its productive structure.

Recently, several authors have argued that the level of university–industry partnership has increased, based on new data from several sources. Brito Cruz (2015), for instance, found that the volume of research revenues flowing from companies to some universities in São Paulo was similar to the average for US universities (around 5 percent of their research revenues). De Negri and Squeff (2016) also found that around 43 percent of Brazilian laboratories and research facilities among a sample of almost 2,000 said they provided some sort of services to companies.

Several studies have focused on other aspects of university–industry interactions, such as the main channels and kinds of knowledge transfer, the main technology areas of transfer, patent statistics, firm profiles, and the overall incentives and barriers to cooperation.

Póvoa (2008) identified that the vast majority of Brazilian knowledge transfer occurs in areas related to engineering and agrarian sciences (70 percent), and that the companies that received most of the technology generated by universities and public research institutes belong to what he called the "processing industry" sector (47.1 percent) – mainly the manufacturing of food products, chemical products, and machinery and equipment.

A survey by Chaves et al. (2015) of 1,005 research group leaders at Brazilian universities showed that firms do not usually seek interactions with these institutions in order to obtain high-level research and experimental development. According to them, the most common channels of knowledge transfer from universities to firms are training of human resources, consulting activities, and the provision of routine services such as measuring, testing, and quality control. Patents and other institutional knowledge exchange channels such as incubators and technology parks still seem to feature rarely in knowledge exchange between universities/public research institutes and firms.

In fact, as observed by Livesey (2014), the belief that patenting is the best way to transfer new knowledge from universities to companies is no longer dominant in Brazil, since other routes including spinouts and consultancy are also now highly regarded.

Based on a survey of 178 leaders of research groups affiliated to Brazilian universities and public research institutes, Póvoa (2008) also established that the main channels for knowledge transfer in Brazil are informal. In fact, more than 70 percent of knowledge transfers are based on "publications and reports," 46.5 percent are based on "informal exchange of information," 43.5 percent on "training and consulting," and only 13.7 percent on "patents and licensing." This emphasis on informal channels has also been observed in many developed countries (Mowery et al. 2004).

The same results were reached by de Castro et al. (2014) through a survey applied to 314 Brazilian firms that had already established channels for knowledge transfer with universities and public research institutes. The majority of respondent firms said that the most important knowledge transfer channels for their innovation activities were informal, including publications and reports (68.9 percent), informal information exchanges (62.4 percent), and conferences and seminars (61.1 percent). Fewer companies (33 percent) considered licensing an important channel to foster innovation.

Póvoa and Rapini (2010) have shown that, as might be expected, the type of transfer channel varies according to the type of knowledge transferred. Patents showed a high correlation with the transfer of knowledge aimed at obtaining new products, equipment, prototypes, and materials. However, mechanisms such as consulting and hiring of personnel were more correlated with new processes and techniques. This analysis corroborates the conclusions of Póvoa (2008), who found that the main kinds of technology transferred by universities and public research institutes to companies were new processes (44.6 percent), new techniques (43.5 percent), and new products (28.4 percent).

The results of the studies presented here confirm that, in Brazil, patenting is not the most relevant type of knowledge transfer between universities/public research institutes and enterprises, and that informal channels as well as the regular forms of "open science" are more important than formal ones. Póvoa (2008) showed that the only enterprises able to manage formal mechanisms of knowledge transfer such as patents were those with a pre-established capacity to absorb these technologies,

for example R&D departments and well-trained personnel, and most Brazilian companies lack such capacity.

De Castro et al. (2014) also argue that patenting is not an important knowledge transfer channel in Brazil due to firms' low capacity to absorb this kind of knowledge. They believe that firms prefer to access cheaper kinds of knowledge such as knowledge in the public domain (e.g., seminars and reports) as well as forms of collaborative research that could complement their relatively weak R&D.

By way of contrast, Dos Santos et al. (2009) emphasize the importance of KTOs associated with universities and public research institute in guaranteeing the professionalization and success of the transfer of knowledge and technologies between these organizations and interested companies.

The Brazilian literature on knowledge transfer also emphasizes the importance of implementing policies to encourage a strong patenting culture in universities and public research institutes. Póvoa (2008), for instance, showed that between 1999 and 2003, the top fifty patent applicants in Brazil included eight Brazilian universities and four Brazilian public research institutes – accounting for nearly one-quarter of those top applicants. The main technological domains in which universities and public research institutes patented during this period were measurement and control (14.2 percent), organic chemistry (9.3 percent), and biotechnology (7.5 percent), which Póvoa saw as demonstrating a significant contribution of universities to "science-based" sectors.

Póvoa also showed that between 1996 and 2004, the total number of university patent applications increased by about 700 percent. He thinks this rise is in large part attributable to the introduction of the Industrial Property Law in 1996 (Brasil 1996), which brought significant changes to patenting activities in Brazil. In addition to expanding the range of patentable inventions, the Law allowed researchers to share in the economic gains derived from the exploitation of university patents.

Some scholars believe that the Brazilian Innovation Act 2004 (Brasil 2004) also spurred the increase in patenting activities by universities and public research institutes, especially by formalizing the KTOs associated with these institutions, charged, among other things, with managing patenting activities. According to Pereira and Mello (2015), the main reason for the increase in the number of patenting activities by universities in recent decades is the professionalization of the industrial property management carried out by the KTOs.

On the other hand, a survey of thirty-three Brazilian KTOs by Livesey (2014) revealed that they tended to be small structures with just seven staff on average, only two of whom have advanced degrees and one of whom is an IP specialist. Less than one-third (29 percent) of the KTOs surveyed believed they had the technical skills required to manage knowledge transfer, compared to nearly half (45 percent) who did not. The largest deficit was found in commercial skills, with only 13 percent of respondents saying they had the necessary skills in this area to be effective.

Livesey (2014) considers that KTOs should be more integrated into universities in order to better perform knowledge transfer to enterprises. In fact, his study showed that KTOs felt marginalized and disconnected from the organizations they were trying to serve. Over half of respondents (54 percent) did not believe they had the necessary support and funding, and nearly two-thirds (63 percent) did not believe that knowledge transfer was an established part of their university's strategy.

The confidence of KTOs that they had the skills required to manage technology varied by region. Livesey's survey revealed that, while only 20 percent of KTOs in the northeast of the country believed they had the necessary legal skills, this figure reached 60 percent among KTOs in the southeast and almost 40 percent among those in the south. In relation to technical skills, none of the northeastern respondents thought they had the necessary skills to manage knowledge transfer, whereas almost 40 percent of their southern counterparts and 20 percent of those in the southeast expressed confidence. Finally, regarding commercial skills, KTOs from the southeast showed the lowest level of confidence (10 percent), followed by those from the south (over 10 percent), and the northeast (20 percent).

Regional differences are also noticeable as regards KTOs' preferred knowledge transfer routes. Broadening the discussion on knowledge transfer from licensing and consulting, Livesey (2014) found that half the KTOs in the south agreed that spinouts were the best way to transfer a technology, whereas those from the northeast and southeast were less likely to endorse this view (20 percent and 30 percent, respectively). Livesey noted that his survey showed that the south was also the region with the largest number of links to venture capital.

Regarding patenting activity, Pinheiro-Machado and Oliveira (2004) revealed that patenting by Brazilian universities increased twice as quickly as in US universities in the period 1990–2001. However, they argued that the performance of Brazil's universities was impaired by poor

performance on the part of the KTOs: "[A] significant fraction of Brazilian academic patent applications remains abandoned due to the lack of specialized staff to help in writing and to shepherd the application through the patenting process in universities."

Along with the launch of the Industrial Property Law (1996) and the Innovation Act (2004), Chaves et al. (2015) consider that the Brazilian government has implemented other important measures to stimulate university–industry interactions since the mid-1990s, including the establishment of new lines of S&T funding such as the above-mentioned Sectoral Funds and the use of tax breaks for firms that propose joint R&D projects with universities and public research institutes.

Undeniably, these institutional changes have become important mechanisms to encourage patenting activities by Brazilian universities, as observed in statistics for recent decades and in the results of the interviews presented in Section 7.4. But while the performance of universities and public research institutes in recent years represents a remarkable achievement of Brazilian S&T and industrial policies, Albuquerque (2003) argues that the relative strength of these institutions in patenting activities exposes the comparative fragility of Brazil's industrial structure, especially as regards business investment in R&D activities.

According to Póvoa (2008), patents owned jointly by universities and companies represented around 6 percent of patent applications by universities in the period 1979–2004. While this proportion may seem small, it is close to that observed in several European countries in the period 1978–2002: 11.5 percent in the case of German universities, 10.2 percent in the case of French universities, and 9.4 percent in the case of UK universities (Ruiz 2005, cited in Póvoa 2008).

Póvoa (2008) also showed that most of the patents jointly owned by Brazilian universities in this period were deposited by three universities based in São Paulo State: USP (thirteen joint-ownership patents), Unicamp (twelve), and Universidade Federal de São Carlos (UFSCar) (eleven). The main technological fields for joint patenting were optical technologies and telecommunications. Petrobrás was the company with the largest number of patent applications made jointly with universities in the period.

An analysis of patent filings by public universities in São Paulo State from 1995 to 2006 by Amadei and Torkomian (2009) confirms that the number of joint filings was not significant. According to them, during this period the universities were the sole patent holders of more than

80 percent of their total filings. They argue that given the considerable contribution made by the patent indicators in the construction of national innovation policy, there is a need for a more user-friendly national patent database with the possibility to consult more up-to-date indicators integrated with existing ones to help interested firms identify the technologies available at universities.

These statistics represent the evolution of an important formal channel of knowledge transfer in the last decades, but as noted earlier, not all kinds of knowledge transfer from universities to companies result in an attempt to obtain a new invention. According to Rapini (2007), such formal transfers represent only a small portion of the possible university–industry interaction: "[N]ot every invention is patentable or patented."

Curiously, in spite of what is traditionally expected from this kind of interaction, Póvoa (2008) showed that in Brazil, a significant number of the knowledge transfers analyzed (slightly more than one-third) were motivated by the leaders of universities' research groups interested in private funding opportunities for new lines of research.

Póvoa (2008) also showed that universities, as opposed to public research institutes, were responsible for 88.1 percent of the total number of technologies transferred to enterprises. The only area in which the public research institutes stood out was agronomy, which accounted for 24 percent of all knowledge transfers, especially due to the prominent role of Embrapa in national agronomy research.

Telles (2011) identified that public research institutes were responsible for presenting new applied research to companies. In the cases he analyzed, it was public research institutes that proposed new technological projects to companies as well as financing many project expenses using their own resources. Public research institutes thus also emerge as institutions inducing knowledge transfer in Brazil. Telles attributes the proactivity of the public research institutes in their interactions with firms to the fact that governments usually use these institutes as an instrument to promote the development of specific national sectors.

But while universities and public research institutes are responsible for determining the research agenda for cooperation with companies, according to Porto et al. (2011), most university–business interaction in Brazil is focused on short- and medium-term technological development aimed at solving firms' technological problems.

In fact, university and industry partners express divergent interests and perceptions about their interaction and relationship. Bearing this

in mind, Closs and Ferreira (2012) aimed to identify the factors that facilitate university–industry interactions in Brazil and those that jeopardize them. From a review of the literature on knowledge transfer in Brazil from 2005 to 2009, they concluded that among the motivations for university–industry cooperation, the ones related to financial resources stand out. On the one hand, universities increasingly need private resources to finance new areas of research in the face of a reduction of public resources in recent decades. On the other hand, firms want to save costs in implementing new technologies by accessing infrastructure and professional consultancy provided by universities.

The importance of cost concerns in motivating university–industry cooperation is also corroborated by Porto et al. (2011), who analyzed information from 2,623 Brazilian companies and 1,663 research groups – distributed in 193 research organizations (universities and public research institutes) – that carried out joint technology projects in 2003 and 2004. According to the authors: "[T]he increase in R&D spending by companies and research institutes leads to the search for cost dilution instruments and, consequently, encourages cooperation between companies and universities."

Rauen and Turchi (2017) found that access to public funding is important to stimulate companies to look for university cooperation. As will be discussed in Section 7.4, they found that there is a seasonal component in the companies' demand for support from public research organizations which correlates with the periods in which development agencies publish funding notices.

As regards barriers to the promotion of university–industry interactions, Rapini et al. (2009) emphasize some noted above, such as excessive bureaucracy and legal uncertainty, difficulties in establishing contractual agreements with firms, and a lack of staff with specialized knowledge transfer skills.

The studies analyzed by Closs and Ferreira (2012) highlighted a range of problem factors from the firms' point of view, such as legal uncertainty and excessive bureaucracy, noncompliance with project deadlines, a lack of information security, and a lack of project management skills. From the universities' point of view, challenges included the need to establish reward mechanisms for researchers and teachers to engage in projects with firms, excessive university bureaucracy, backwardness in the execution of contracts or the registration of patents, and the fact that the evaluation of researchers and teachers is still based on their record of

scientific publication, not on patents or any other kind of knowledge transfer to firms.

7.3 The Role of Universities and Public Research Institutes in the Brazilian Innovation System

As noted earlier, Brazil has undertaken several actions and introduced new policies to reinforce its scientific and innovative capacity over the last two decades. One of the most important policies was the creation of the Sectoral Funds in 1999, to be operated and managed by the innovation agency Finep. The Sectoral Funds were designed to have several different revenue sources in order to ensure stable long-term public funding for S&T. These revenues included a share of royalties from the oil sector, a special levy on gas and other sector-specific taxes. At the time they were introduced, instability was considered one of the most serious problems in S&T funding in Brazil, and the creation of the Sectoral Funds was seen as a promising attempt to overcome this challenge.

Besides assuring stable S&T funding, the Funds were also intended to foster innovation in the Brazilian economy, focusing on research projects related to technological challenges in specific sectors. This objective was prompted by the low level of interaction between universities, research institutions, and the country's productive industry. The revenues of each fund were intended to support R&D related to the sector for which that fund was created. These sectors include oil, mining, health, infrastructure, agriculture, aeronautics, biotechnology, information, and communication, and there are also funds designed to foster cross-sectional projects and research facilities.

In the early 2000s, growing recognition of the economic importance of innovation resulted in a series of new policies intended to create incentives for R&D investments and a more up-to-date framework for S&T and innovation. The Innovation Act (Law no. 10,973 of 2004) was introduced to improve the innovation system and empower linkages between different actors. One of the major breakthroughs of the Act was the possibility for the government to provide grants[1] to companies for investments in innovation, which was not previously allowed under Brazilian law. The Act also established a clear regulatory framework for

[1] Grants are nonrepayable money given by the government to a recipient to perform a specific research project. The recipient may be a nonprofit entity, an educational institution, a business, or an individual. To receive a grant, it is often necessary to submit a proposal or application in a competitive process.

the interaction between universities/public research institutes and companies, and for the IP rights arising from such interaction.

Finally, in 2005 the so-called Good Law (*Lei do Bem*, Law no. 11.196, of 2005) implemented tax breaks for firms that invest in R&D in the country. Such tax incentives could reach up to half the total amount invested in R&D by companies.

Both the Innovation Act and the Good Law were implemented in the context of the first industrial policy of President Lula's government in 2003: the PITCE (Industrial, Technological, and Foreign Trade Policy). After the PITCE, two new editions of this industrial policy were launched: the Productive Development Policy in 2008 and the Greater Brazil Plan in 2010, right after the global financial crisis. In these two last versions, the main measure adopted to encourage innovation was the Innovate Company Program (*Programa Inova Empresa*), introduced within the Greater Brazil Plan (*Plano Brasil Maior*), taking advantage of a small share of the resources meant for the Investment Maintenance Program (PSI).

These various new policies together created a relatively comprehensive framework of innovation policies in terms of the diversity of instruments (see Table 7.1). Currently, the country can count on many of the instruments used in most of the developed world to foster innovation, such as subsidized credit/loans,[2] tax incentives, grants for companies, and grants for research projects and individuals at universities and research centers, among others.

Regarding direct public investments in S&T, according to the Brazilian Ministry of Science, Technology, and Innovation,[3] in 2012 the Brazilian public sector (federal and subnational governments) spent around BRL 40 billion (around USD 20 billion) on science and technology. About 40 percent of the S&T public investment is attached at maintaining postgraduate courses and institutions at federal and state levels. Of the remaining BRL 25 billion (USD 13 billion), about BRL 18 billion (or USD 9.4 billion) was invested by the federal government.

An important share of public S&T investment is devoted to building and maintaining the country's research infrastructure and facilities. In the last few years, Brazil's S&T infrastructure has received substantial resources from several sources, notably the Infrastructure Sectoral Fund,

[2] Loans for innovation at below market interest rates are provided by both the National Development Bank (BNDES) and by the Brazilian Innovation Agency (Finep).

[3] Indicators available at www.mctic.gov.br/mctic/opencms/indicadores/indicadores_cti.html (only in Portuguese).

Table 7.1 *Main policies and instruments for S&T funding in Brazil in 2012*

	Policies and instruments	Value in 2012 (current BRL)	Current USD (USD 1 = R$1.95)
Tax incentives for innovation		**6,423**	**3,294**
Public credit/loans for innovation (disbursements in the year)	Finep	1,800	923
	BNDES	2,200	1,128
	Total (public credit)	**4,000**	**2,051**
Public investments in S&T	States (excluding postgraduate programs)	7,034	3,607
	Federal government (excluding postgraduate programs)	18,388	9,430
	Total (excluding postgraduate programs)	**25,422**	**13,037**
	Total (with postgraduate programs)	**40,045**	**20,536**

Sources: Ministry of Science, Technology and Innovation (MCTI) – www.mctic.gov.br/mctic/opencms/indicadores/indicadores_cti.html; National Bank for Social and Economic Development (BNDES) – Annual Report/2013; Brazilian Innovation Agency (Finep); Electricity Regulatory Agency (ANEEL); National Petroleum Agency (ANP) – Statistical Yearbook/2013. Extracted and adapted from Zuniga et al. (2016)

also known as CT-Infra.[4] Significant resources have also been provided under the Coordination for the Improvement of Higher Education Personnel (Capes) program of the Ministry of Education (MEC), by

[4] CT-Infra was created to enable the modernization and expansion of the infrastructure and support services of all the Brazilian higher education and research institutions. Its resources are earmarked for the construction and renovation of laboratories, and the purchase of equipment, among other actions.

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Table 7.2 *Number of research infrastructures in Brazil by launch period*

Period	Number of infrastructures launched	Number of infrastructures launched as a share of all infrastructures (%)
Pre-1970	50	2.8
1970–9	110	6.3
1980–9	193	11.0
1990–9	410	23.3
2000–9	654	37.2
2010–12	343	19.5
Total	1,760	100

Source: IPEA/CNPq/MCTI – Research Infrastructure Mapping in Brazil (2013). Extracted from De Negri and Squeff (2016)

state foundations that support research, and by companies such as Petrobrás (De Negri, Cavalcante, and Alves 2015).

In fact, it is safe to say that the country's research infrastructure[5] is now much more up to date than it was few years ago. De Negri and Squeff (2016) show that most laboratories and research facilities (56.7 percent) began operation since 2000 (Table 7.2) and argue that this fact could be related to an increase in investments in science, technology, and innovation from the middle of the 2000s until 2014.[6] The authors conducted a survey with around 2,000 researchers in charge of research laboratories at Brazilian universities and research institutions in 2012. More than 70 percent of respondents said they had received significant investments in the five years preceding the survey, and many reported significant investment within the past year.

However, according to De Negri and Squeff (2016), most of the research facilities in Brazil are small laboratories scattered across the

[5] For the purposes of this chapter, the concept of research "infrastructure" refers to "the set of physical facilities and material conditions of support (equipment and resources) used by researchers to carry out R&D activities." The term thus covers everything from laboratories to biotools, high-performance computer networks, specialized libraries, observatories, telescopes, research vessels, experimental stations, and so on (De Negri and Squeff 2016: 17).

[6] De Negri and Squeff (2016) is based on a pioneering survey carried out in 2013 by Ipea, CNPq, and the MCTI which collected information about 2,000 research facilities in more than 130 universities and research institutions in Brazil.

Table 7.3 *Number of universities, research universities, and federal technological institutions in Brazil in 2015*

	Research universities*	Universities (university centers)	Federal technological institutions	Total
Federal institutions	63		40	103
State institutions	38	1		39
Municipal institutions	6	8		14
Private institutions	88	140		228
Total	195	149	40	384

Source: National Institute for Educational Studies and Research – INEP (2016)

* Research universities are universities obliged to perform research and some sort of social activities as well as teaching. The universities (in Portuguese, "university centers") are not obliged to perform research, and there are also 1,980 colleges in Brazil (not listed in the table) which teach but do not research. The federal technological institutions focus on professional and technological education.

departments of the big Brazilian universities. Although the country has some important research institutions, they are few and most of them are small when compared to the national laboratories or similar large scientific facilities of some other countries. There are 7,090 researchers working in Brazil's 1,760 research infrastructures, an average of just four per laboratory.

Brazil has more than 2,300 higher education institutions, including universities, schools, and federal institutes, as well as several research centers. While there are roughly as many private education institutes as public ones, the importance of the latter in science and technology production is much greater than that of the former.

The number of higher education institutions has grown sharply over the last decade, from fewer than 1,400 in 2000. Between 2000 and 2013, the Brazilian federal government and the states created eighty-nine new higher education institutions, mostly research or technical universities – growth of more than 150 percent in the number of public institutions within fifteen years.

It is widely recognized in Brazil that the most relevant research universities in the country are public, although the number of good private

universities is believed to have grown in recent decades. Among the country's higher education institutions, 193 can be considered research universities, most of which are federal or state ones. The private sector is mostly present in colleges and in so-called university centers, where there is no obligation to perform scientific research.

To identify the biggest public research universities in the country, Table 7.4 shows the amount of R&D investments performed by these institutions. The three biggest universities in São Paulo are responsible alone for more than half of all R&D investment by the country's fifteen biggest public research universities. The University of São Paulo, besides being Brazil's biggest university in terms of budget, is also its main university in terms of academic publications as well as the best placed in several national and world rankings.

Public research institutes also play a very important role in the Brazilian S&T system and the biggest ones, based on their budget information in 2014, are shown in Table 7.5. The two biggest are also the most important public research institutes in the country. The Oswaldo Cruz Foundation is a public research institution attached to the Ministry of Health and is responsible for a range of activities such as R&D, production of vaccines and drugs, education and training, hospital care services, and quality control of products and services. The institution was created in 1900 and today has over 11,000 employees and health professionals.

The Brazilian Agriculture Research Corporation (Embrapa) is also very important within the Brazilian innovation system. Embrapa is a public company created in 1973 under the stewardship of the Ministry of Agriculture with the objective of developing science and technology applied to the Brazilian farming sector. Today, it has more than 9,000 employees and about 2,400 researchers working in more than sixty units around the country.

The Butantan Institute (Instituto Butantan), created in 1901, is linked to the State of São Paulo. Today, the Institute is the main producer of immunobiologicals in Brazil and responsible for a big share of the national production of vaccines and hyperimmune serums used by the Brazilian Ministry of Health. Besides producing immunobiologicals, the Butantan Institute also maintains zoological scientific collections and performs basic and applied research on venomous animals and pathogenic agents, and the production and control of immunobiological products. The Institute is currently involved in the research and development

Table 7.4 *R&D investment by the main public universities in Brazil in 2012*

	Name	R&D investments (USD million)*	Ownership	State
USP	Universidade de São Paulo	1,715.71	State	SP
UNICAMP	Universidade Estadual de Campinas	634.59	State	SP
UNESP	Universidade Estadual Paulista "Júlio de Mesquita Filho"	415.31	State	SP
UFRJ	Universidade Federal do Rio de Janeiro	371.48	Federal	RJ
UFMG	Universidade Federal de Minas Gerais	251.58	Federal	MG
UNB	Universidade de Brasília	235.89	Federal	DF
UFRGS	Universidade Federal do Rio Grande do Sul	224.63	Federal	RS
UFSC	Universidade Federal de Santa Catarina	191.23	Federal	SC
UNIFESP	Universidade Federal de São Paulo	177.42	Federal	SP
UFC	Universidade Federal do Ceará	136.05	Federal	CE
UFPE	Universidade Federal de Pernambuco	126.79	Federal	PE
UERJ	Universidade do Estado do Rio de Janeiro	125.97	State	RJ
UFPR	Universidade Federal do Paraná	125.30	Federal	PR
UFF	Universidade Federal Fluminense	116.93	Federal	RJ
UFBA	Universidade Federal da Bahia	103.27	Federal	BA

Source: Ministry of Science, Technology, Innovation and Communications www.mctic.gov.br/mctic/opencms/indicadores/indicadores_cti.html, accessed September 2016

* Exchange rate: R$/USD = 2.04, 31/12/2012.

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Table 7.5 *Budget or revenues of the main public research institutes in Brazil in 2014*

Public research institute	Budget/revenues (USD thousands)
Oswaldo Cruz Foundation (Fiocruz) [1]	1,609,803
Brazilian Agriculture Research Corporation (Embrapa)	1,076,427
Butantan Institute	411,370
Brazilian Center for Research in Energy and Materials (CNPEM)[2]	78,631
IPT – Institute for Technological Research[3]	63,712
National Institute for Pure and Applied Mathematics (IMPA)	42,580
National Institute for Space Research (INPE)	40,909
Center for Natural Disaster Monitoring and Alert (CEMADEN)	31,420
National Institute for Amazonian Research (INPA)	13,989

Source: http://odimpact.org/case-brazils-open-budget-transparency-portal.html Brazil's Open Budget Transparency Portal (www.portaltransparencia.gov.br/) and Ministry of Science, Technology, Innovation and Communications (MCTIC), accessed September 2016
About half this budget is not spent on R&D.

[1] Includes not only research but also teaching and manufacturing of medicines.
[2] Data from 2015 (exchange rate BRL/USD = 2.65). Includes the budget for investment in a new synchrotron light source (around USD 31 million in 2015) and other special projects. The normal budget for the institution is around USD 30 million.
[3] Includes the baseline public budget (about 35 percent) and revenues from technological services (65 percent).

of a vaccine for Dengue fever and the Zika virus. Last, it offers graduate courses in its areas of expertise.

The Brazilian Center for Research in Energy and Materials (CNPEM) is a quasi-public organization, very similar to the federally owned and privately operated National Laboratories in the U.S. It is linked to the Ministry of

Science, Technology, Innovation, and Communications[7] (MCTIC) and has seventy-five in-house researchers. The facilities of CNPEM were used by almost 2,000 researchers in 2014. Probably the most used facility is the synchrotron light source, which is used by researchers from all over the country as well as other countries. MCTIC has other quasi-public research organizations attached to it, for instance the National Institute for Pure and Applied Mathematics (IMPA) and the National Education and Research Network (RNP).

The organizations mentioned above – universities and public research institutes – are the most important research institutions in the country and are responsible for a large share of Brazilian scientific publications, as one can see in the Scimago ranking of Brazilian universities and research institutions.

The public universities and research institutions are also very relevant in terms of patenting. By way of context, in Brazil, as in other middle-income countries, most patent applications come from non-residents (80 percent).[8] Applications from residents are distributed almost equally among private individuals – independent inventors, university researchers, and professors, and so on – and institutions, comprising companies including foreign-owned subsidiaries, universities, public and private research institutions, nonprofit organizations, and so on.

The institutions account for around 10 percent of total patent applications, of which around 30 percent are filed by the public sector or by teaching or research institutions. Indeed, Brazilian universities and research institutions have increased their share of patent applications to the National Institute of Industrial Property (INPI) sharply, from 0.6 percent in 2000 to 2.7 percent in 2012 (Table 7.6).

As we noted earlier, some authors argue that this growth was encouraged by the Industrial Property Law in 1996 (Póvoa 2008), particularly the possibilities it offered for researchers to share in the economic gains from patents. Others believe that the Innovation Act of 2004 is mainly responsible. Most likely, both laws as well as other, more minor

[7] Since May 2016, when the Ministry of Science, Technology, and Innovation was merged with the Ministry of Communications.

[8] The concept of non-resident and resident application is as used by the World Intellectual Property Organization (WIPO) and available at www.wipo.int/ipstats/en/statistics/glossary.html. According to WIPO, a resident application is "an application filed with an IP office by an applicant residing in the country/region in which that office has jurisdiction." In that sense, an application to the Brazilian patent office by a foreign subsidiary installed in Brazil would be considered a resident application and an application from its headquarters would be a nonresident one.

Table 7.6 *Number of patents filed by Brazilian universities and research institutions at the National Institute of Industrial Property, 2000–12*

University/institution	2000	2002	2004	2006	2008	2010	2012
Universidade Estadual de Campinas – UNICAMP	36	55	49	53	48	45	67
Universidade de São Paulo – USP	6	11	15	26	53	47	58
Universidade Federal de Minas Gerais – UFMG	6	21	18	30	38	59	64
Universidade Federal do Rio de Janeiro – UFRJ	2	23	24	14	29	27	16
Universidade Federal do Paraná – UFPR	1	1	7	12	17	21	68
Universidade Federal do Rio Grande do Sul – UFRGS	5	11	10	4	9	23	30
Serviço Nacional de Aprendizagem Industrial – SENAI	1	0	2	1	3	20	20
Fundação Universidade de Brasília – UNB	2	0	4	4	7	6	21
Universidade Federal da Bahia – UFBA	0	0	0	0	4	16	22
Universidade Federal de Pelotas – UFPEL	0	0	1	1	1	0	17
Total patent applications by universities and research institutions (A)	115	219	264	318	440	590	904
Total patents filed at INPI by residents (B)	6,449	7,052	7,701	7,194	7,711	7,244	7808
Total patents filed at INPI (C)	20,854	20,334	20,431	23,152	26,641	28,099	33,569
Universities and public research institute filings as a share of total filings (A/C) (%)	0.6	1.1	1.3	1.4	1.7	2.1	2.7
Resident filings as a share of total fiings (B/C) (%)	31	35	38	31	29	26	23
Universities and public research institute filings as a share of resident filings (A/B) (%)	2	3	3	4	6	8	12

Source: National Institute of Industrial Property (INPI): http://www.inpi.gov.br/estatisticas/anuario-estatistico-de-propriedade-industrial-2000–2012-patente1#patente

institutional improvements are important in explaining the increasing role of universities and public research institutes in patenting.

In any case, one of the consequences of this growth is that the list of the twenty leading patent applicants in Brazil in 2015 featured fifteen public universities, only four companies, and one private research institution: the Telecom Research and Development Center (CPqD in the Portuguese acronym).

This once again highlights the importance of public institutions in the Brazilian innovation system. Indeed, in Table 7.6 one can see that among the ten leading universities and research institutions applying for patents in Brazil between 2000 and 2012, there is only one private research institution. The Brazilian National Service for Industrial Training (SENAI) is a nonprofit organization funded by industry organizations that originally aimed to train workers for industry. In recent years, it has become increasingly concerned with innovation, having established several research institutions across the country. As a result, it increased its number of patents filings from around two per year to around twenty per year between 2010 and 2012. According to Table 7.6, the most prominent universities in terms of patent filings are UNICAMP, USP, UFMG, UFRJ, and, more recently, UFPR. Pereira and Mello (2015), analyzing the period from 1979 to 2011, reached the same conclusions.

However, a large number of patents registered by universities and research institutions does not in itself prove the market value or relevance of the knowledge they produce. Many of the patents filed and registered by universities may never be transferred to companies. For instance, although Unicamp is one of the country's major patent applicants, it has licensed only eighty-seven of its 1,000+ patents in the past two decades. At MIT, by contrast, around 40 percent of the patents obtained are licensed every year (Reynolds and De Negri, 2017).

The latest Brazilian Innovation Survey (PINTEC/IBGE 2014) reveals that only 2.3 percent of innovative firms consider interaction with universities and public research institutes, and, in particular, the existence of cooperation agreements with them, to be highly important for innovation (Table 7.7).[9] The industries that are the leading users of knowledge produced by universities and research institutions according to the Survey are: research and development (44 percent), electricity and gas services (33 percent),

[9] Wunsch-Vincent (2012: Figure 3) provides data on collaboration between private companies and universities or public research institutes in several countries. Brazil emerges as one of the countries with the lowest rates of collaboration.

Table 7.7 *Firms that innovated using a cooperation agreement with a university or public research institute in 2014*

Sector	Innovative firms	Firms with cooperation agreements with other organizations	Firms that rate cooperation with universities/PROs as highly important	
Total	47,693	7,300	1,098	2.3 percent
Research and development	18	15	8	44 percent
Electricity and gas services	137	75	45	33 percent
Manufacture of computer equipment	156	72	38	24 percent
Manufacture of chemical products	196	80	37	19 percent
Manufacture of pharmaceutical products	204	91	36	18 percent
Manufacture of computer, electronic and optical products	1,053	317	117	11 percent

Source: Brazilian Innovation Survey (PINTEC – 2014). Brazilian Institute of Geography and Statistics (IBGE)

manufacture of computer equipment (24 percent), manufacture of chemical products (19 percent), manufacture of pharmaceutical products (18 percent), and manufacture of computer, electronic, and optical products (11 percent). Importantly, most firms that consider interaction with universities and public research institutes to be highly important belong to sectors with a medium or high technology intensity. In addition, firms from regulated sectors such as electricity and gas services must comply with rules established in the concession agreements, for example contractual

R&D clauses,[10] which oblige them to invest a percentage of their revenues in R&D activities in partnership with universities and research institutes in Brazil.

7.4 Policies and Institutional Practices for Knowledge Transfer in Brazil

This section is based on several interviews with researchers and KTOs and on questionnaires sent to more than ten KTOs in Brazil. The interviews and questionnaires were intended to collect information in order to identify the types of procedure and practice used by the institutions and KTOs to transfer knowledge.

7.4.1 Legal Framework

The main regulation regarding the relationship between public research institutes, universities and companies in Brazil is provided by the Innovation Act (Law no. 10,973 of 2004). This law aims to promote partnerships between such institutions and companies in order to foster innovation in the country. As regards IP rights specifically, prior to the Innovation Act, the Brazilian Intellectual Property Law approved in 1996 guaranteed that universities and public research institutes would own patents generated inside the institution.

However, the Innovation Act goes much further in regulating and fostering knowledge transfer between universities, public research institutes, and companies. For the first time in Brazil, this law allowed public institutions – public research institutes or universities – to sign knowledge transfer contracts with companies, and established some basic rules for such contracts. These include rules regarding exclusive licenses, which the original version of the Act required be preceded by an open call. Recently, the Science and Technology Act (Law no. 13.243 of 2016) has changed some of the requirements for public research institutes and universities signing exclusive agreements with companies. Exclusive agreements originating from a prior partnership with a specific company

[10] By way of example, the Resolution of the Oil National Agency (ANP 2005) establishes that oil and gas concessionaires must invest in Brazil the equivalent of 1 percent of their gross revenue in carrying out R&D, and at least half this amount must be expenses incurred in R&D partnerships with universities and research institutes previously accredited by the ANP for this purpose. A similar Resolution established by the National Electric Energy Agency (Aneel) applies to concessionaires of the electrical sector.

have been simplified. However, this law has also introduced a series of new requirements that reduce the autonomy of a public research institute or university in negotiating such contracts.

The emphasis of the Innovation Act on fostering knowledge transfer is revealed by seven chapters dedicated to promoting the so-called "cooperative environments of innovation." A special role is accorded to public-based research organizations – universities and public research institutes – in the cooperative production of new technologies with firms.

To ensure such engagement, the Act sets out the specific formal channels through which universities and public research institutes are expected to support firms in the production of new technologies:

- Article 4 provides for (a) sharing university and public research institute laboratories and facilities with SMEs in incubation activities, and (b) granting private companies access to laboratories, equipment and facilities for R&D activities.
- Article 6 allows universities and public research institutes to sign knowledge transfer and IP licensing contracts based on technologies developed by the institution or in partnership and establishes the basic rules for those contracts.
- Article 8 foresees the provision of technical services by universities and public research institutes to private firms engaged in R&D activities, such as tests, trials and calibrations, as well as technical reports.
- Article 9 allows universities and public research institutes to enter into partnership agreements with firms aimed at developing new technologies together.

To encourage university and public research institute staff (mostly government researchers) to engage in such interactions, the Innovation Act states that these institutions may be financially compensated by firms for such activities, and any of their staff involved may also be financially compensated through an additional variable payment or an "innovation stimulus scholarship."

The Act also stipulates that each research organization should establish its own knowledge transfer and innovation policies creating guidelines for entrepreneurship, innovation, knowledge transfer, and so on. Indeed, the existence of a KTO in each public research institute or university is a requirement of the Act and it sets out the basic competences of a KTO. This was controversial, since even universities with a low technology focus were obliged to establish a KTO. The requirement was relaxed

recently and the law was modified to allow KTOs to be created in association with other universities or public research institutes.

The Innovation Act represented a major change in the Brazilian landscape for innovation. However, there are still a lot of improvements to be made and a lot of uncertainty regarding its application. Prompted by concerns about uncertainty, excessive bureaucracy and overlapping laws in the Brazilian legal framework for innovation, the New Science and Technology Act (Law no. 13.243 of 2016) was recently enacted to consolidate several different pieces of legislation affecting innovation. This new act aimed to promote the modernization of the legal framework as well as reducing constraints on the implementation of university–industry partnerships.

The possibilities and stimulus mechanisms established by the Innovation Act in 2004 notwithstanding, university–industry interaction remains low in Brazil. One oft-cited barrier is the legal uncertainty that surrounds the Brazilian innovation legal framework (Rapini et al. 2009; Closs and Ferreira 2012; Rauen 2016). Three particular aspects of legal uncertainty in the Innovation Act should be highlighted: (1) the management of private resources received by universities and public research institutes as compensation for their involvement in innovation activities (since they are part of central government administration, universities and public research institutes do not enjoy autonomy in managing private resources); (2) the difficulty of implementing financial compensation for university and public research institute researchers involved in innovation activities, since the law does not clearly state how such benefits should be granted; and (3) the still-limited role of KTOs – a situation that undermines their capacity to generate and implement new university and public research institute partnerships.

Recognizing the legal uncertainty in these areas, the 2016 Science and Technology Act introduced significant reforms to the Innovation Act. As regards university/public research institute–enterprise interaction, it aimed to strengthen and empower KTOs and establish clearer processes for managing private resources to reward institutions engaging in innovation activities. However, it has not clarified the law on compensation for public researchers, and so it seems unlikely to succeed in reducing the difficulties faced by universities and public research institutes in managing rewards for researchers involved in such activities.

In sum, there is still scope to improve the Brazilian Innovation Act and complementary laws and practices in order to further reduce legal uncertainty within the Brazilian innovation legal framework as regards

university–industry interaction. But in any case, fostering public–private partnerships in Brazil requires changes that go beyond the modernization of innovation legislation. The solutions needed are many, but all of them are connected – at least in some way – with the creation, diffusion, and application of protocols, internal processes, and rules of conduct in government organizations, and with the capacity of government agencies to deal with conflicts of interest and risk.

7.4.2 The Main Channels of Knowledge Transfer

The most common channels for knowledge transfer are probably informal ones such as technology fairs, workshops, conferences, and seminars. Based on informal networks and contacts, these channels play an important role in the innovation landscape in many countries, not only Brazil. However, our analysis here focuses mainly on formal mechanisms for knowledge transfer, even though these are likely to be preceded by an informal approach.

The Innovation Act established the formal channels for knowledge transfer. One of the obligations of universities and public research institutes in this context is to inform the Ministry of Science, Technology, and Innovation about licensing contracts and the overall intellectual property policies of the institution. This information is collected by the Ministry every year and published in a report that contains basic information about knowledge transfer in Brazilian public research institutes and universities – the so-called FORMICT[11] reports. For instance, these reports contain the number and type of knowledge transfer contracts undertaken by public organizations in the country.

Based on this information, Table 7.8 shows the most common formal channels for knowledge transfer used by the 264 public research institutes and public universities that responded to the MCTIC survey in 2014. Licensing contracts seem to be the most common knowledge transfer channel among the sample, representing more than 42 percent of total contracts signed by respondent institutions, followed by R&D agreements (25 percent) and know-how contracts (9 percent).

According to the MCTIC data, most of the licensing contracts were made with companies from Brazilian manufacturing, which represented around 30 percent of total contracts. Within manufacturing, the

[11] Acronym for "Form for Information on the Intellectual Property Policy of the Brazilian Scientific, Technological and Innovation Institutions."

Table 7.8 *Knowledge transfer contracts undertaken by Brazilian public research institutes and public universities by type of contract in 2014*

Type of contract for knowledge transfer	Number of universities and public research institutes that reported having this kind of contract	Number of contracts	Contracts as a share of all knowledge transfer contracts (%)	Total amount (BRL million)	Total amount (USD million)
Licensing contract	30	823	42	34.40	10.62
R&D collaboration agreement / collaborative R&D	34	485	25	221.70	68.43
Contracts for knowhow, technical assistance and other services	15	159	8	108.00	33.33
Confidentiality agreement	12	133	7	–	–
Co-ownership agreement	13	84	4	2.60	0.80
Contract or agreement for access to research facilities	4	76	4	2.10	0.65
Contract or agreement for the use of intellectual human capital in R&D projects	5	45	2	58.00	17.90

Contract or agreement to share research facilities with small companies in incubation activities	5	27	1	6.90	2.13
Biological material transfer agreement	6	19	1	–	–
Contract to assign IP rights	2	2	0	–	–
Other	13	104	5	3.90	1.20
Total		1,957	100	437.60	135.06

Source: FORMICT Report 2016 (MCTIC 2017)
Note: Data from 2016 (exchange rate USD/BRL = 3.24).

pharmaceutical and chemical industries were the sectors with the largest number of knowledge transfer contracts.

It is important to note, however, that the figures are distorted by the fact that the information comes from KTOs. KTOs are most likely only reporting on those contracts and agreements for which they are responsible. Since the involvement of a KTO is only mandatory in the case of licensing contracts, this channel is probably overestimated in the official data.

For the same reason, our own interview data from KTOs also probably overstate the importance of licensing. Four interviews were undertaken with major KTOs in Brazil as part of the research project for this book. We identified three main formal channels of knowledge transfer: licensing and commercialization of IP, software, and knowhow; non-disclosure agreements; and technological partnership agreements. Of these, licensing emerged as the KTOs' main activity.

This contrasts with the results of the interviews we conducted with researchers, which identified consultancy performed by academics personally rather than agreements on the part of their universities as the main knowledge transfer channel, followed by research agreements (sponsored research) between universities and companies. The literature on knowledge transfer also emphasizes the importance of academic consultancy.

All the interviewees – KTOs and individual researchers – agreed that data management was crucial to control and improve KTOs' activities and knowledge transfer processes. They also noted the importance of data management in enabling KTOs to comply with their obligations under the Brazilian Innovation Act, which requires them to "monitor the processing of applications and the maintenance of the institution's intellectual property rights" and "promote and monitor the University/PRI relationship with companies."

Despite the importance of their data management function, KTOs may hold incomplete information about universities' knowledge transfer activities. For instance, at Unicamp the KTO (called Inova) may support the process of signing a new sponsored research contract with a company, but this is not necessary or mandatory. In fact, the internal regulations on this process do not foresee a role for the office. As a result, in 2016 Inova had information about fewer than thirty research contracts with companies undertaken by Unicamp, according its annual report.

The same thing happens in several other universities, explaining why licensing contracts appear in the official statistics as the main formal channel for knowledge transfer. But all the other evidence suggests that

consultancy and research contracts are the most important channels, although there are no consolidated data to confirm this.

7.4.3 Institutional Knowledge Transfer Practices

In general, the knowledge transfer activities of the institutions whose personnel were interviewed are based on: (1) the innovation policy of the universities to which they are linked, (2) their university's internal regulations on research and graduate activities, (3) the Brazilian Innovation Act and related regulations, (4) federal law on supporting agencies, (5) laws on academic employment, and (6) implicit policies of innovation (the "culture") adopted by researchers and university academics.

In order to stimulate university/public research institute–enterprise interactions, the Brazilian Innovation Act obliged all public research institutes and public universities to establish their own innovation policies covering, among other things: (1) strategic objectives and guidelines for innovation; (2) entrepreneurship; (3) technological services; (4) laboratory-sharing procedures; and (5) IP rights and knowledge transfer. The Act also stipulated that universities and public research institutes should have their own KTOs fulfilling the role of intermediate agents responsible for managing the institution's innovation policies (Brasil 2004: art. 16).

All the institutions answering our research questionnaire said they had an IP policy. The requirements of the Innovation Act are probably responsible for that in many cases, but some institutions had already established their IP policies or created KTOs before the Act. For instance, Inova, the KTO at Unicamp, was created in 2003, and UFMG has had an IP policy since 1998.

While every public university and public research institute in the country is required to have a KTO, the Innovation Act allowed institutions to share a KTO. This is probably a unique feature of the Brazilian KTOs: several of them serve more than one research organization.[12]

It is rare for Brazilian universities and public research institutes to use other kinds of agency to support knowledge transfer or entrepreneurship. For example, liaison offices to promote partnerships with companies are not common in Brazilian institutions, and neither are funds or specific agencies geared to supporting entrepreneurship. Therefore, the KTOs

[12] NIT Mantiqueira and NIT Rio are examples.

sometimes take on these kinds of responsibility. For instance, some interviewees mentioned actions taken to stimulate faculty and graduate students to get involved in technology partnerships with companies and entrepreneurship, and at Unicamp the incubator and technology park come under the umbrella of Inova.

However, several authors argue that the role of Brazilian KTOs is still very limited, and, in certain cases, research institutions do not include them in the management of innovation activities (Pinheiro-Machado and Oliveira 2004; Dos Santos et al. 2009; Closs and Ferreira 2012; Pereira and Mello 2015; Rauen and Turchi 2017).

The explanation for the limited role of Brazilian KTOs may in part lie in their staff profile. According to the MCTI (2017), more than 50 percent of KTO staff are public servants with no previous experience in the private sector, which might be of great help in evaluating the commercial potential of or market interest in a given technology. The others are fellows, students or support employees (interns constitute almost 10 percent of all KTO staff).

Regarding KTOs' intended role as a contact point for companies at public research institutes, this is also not so relevant since companies' approaches to public research institutes tend to be informal or motivated by other concerns. Rauen and Turchi (2017) consulted thirteen public research institutes and over sixty public specialists in the management of public–private R&D interaction to identify, among other things, common business practices in accessing public research institutes' knowledge transfer channels. Their interviewees reported that companies tend to approach public research institutes in four different ways to seek their R&D support:

- spontaneous demand (motivated by previous informal contacts with public research institutes' technicians and researchers);
- response to public funding notices (especially those notices that prioritize research activities and technological development through public–private partnerships);
- contact with public research institute alumni; and
- response to support advertised by public research institutes themselves, which occurs mainly in the case of institutions that provide open-access laboratories for many different users.

In fact, several studies (Porto et al. 2011; Closs and Ferreira 2012; Rauen and Turchi 2017) have shown that public funding announcements aimed at building partnerships between business and universities/public

research institutes are very important in fostering interest among companies in formalizing partnership agreements.

Nevertheless, KTOs undertake several activities to promote university–industry interaction. All the KTOs at larger universities, for instance, release a list of their institution's technologies that are available for licensing so that companies can find the most suitable ones for their interests.

Other activities, such as pricing technical services, agreeing the number of public research organization staff who will consult on R&D projects or the number of hours of private access to laboratories, tend to be led by public research organization researchers and technicians themselves. The role of the KTO at this negotiation stage is minimal or nonexistent.

While KTOs have limited participation in most of the public research institutes' innovation management activities, they do make an important contribution to managing IP activities, especially drafting, registering, and filing patents. Rauen and Turchi (2017) reached this conclusion from interviews with specialists in knowledge transfer and researchers at several public research institutes in Brazil in which they asked about the role of KTOs, among other things. The identified two main reasons why KTOs have little participation in and limited influence over public research institutes' innovation management activities. First, KTOs have limited managerial and budgetary autonomy, as they depend largely on fund transfers from and strategic decisions by public research institutes. Second, they suffer from high staff turnover and a dearth of qualified or specialized staff, because their link to government institutions obliges them to rely on public tenders in hiring new staff and they do not offer competitive salaries.

In sum, although the KTOs were expected to play an important role in mediating innovation activities with the private sector, they lack the recognition and operational flexibility necessary to carry out their tasks.

As regards incentives, the Innovation Act and subsequent legislation did provide financial incentives for universities and academics to work with companies, and, in consequence, it is now very common for both institution and individual staff to receive financial and nonfinancial compensation for their participation in innovation activities.

All the institutions we surveyed reported that professors and researchers can undertake consultancy activities for companies and can also receive additional remuneration for participating in research contracts between universities and companies. Finally, they can also receive

one-third of any royalties received from licensing technologies that they helped to develop.[13]

Regarding nonfinancial compensations, interviewees affirm that, in collaborative projects, the standard procedure is that any remaining research assets such as equipment tend to be donated to the university.

In spite of all the difficulties faced, in particular by public universities, the institutions were unanimous in reporting that these compensation mechanisms are important in stimulating engagement among teachers and researchers in developing technologies in partnership with companies. Interviewees believe that KTOs helped to empower researchers to seek new innovation projects with companies, because they felt there was a support structure in place for identifying, negotiating and managing projects.

7.5 Final Remarks

There has been increasing concern among researchers, specialists, and policymakers about the need to narrow the gap between the scientific knowledge production in universities and the requirements of the business sector. To some extent, such concern lay behind the development of a brand-new framework of public policies fostering university–industry interaction in Brazil in the last fifteen years.

Thanks to these new policies, a lack of interaction between companies and universities is no longer the main bottleneck in the Brazilian innovation system. Today, most of Brazil's major universities and research institutes have a knowledge transfer office to support knowledge transfer to the business sector. Furthermore, there are financial incentives for universities and for academics personally to work in partnership with companies, through sponsored research at the university or consultancy.

Brazilian legislation is now much more akin to the rules in place in several developed countries in terms of managing intellectual property rights. The KTOs have primary responsibility for filing patents on behalf of Brazilian universities, and universities are now the main institutional applicants at the National Institute of Industrial Property.

However, some problems clearly remain unsolved. Excessive bureaucracy is always mentioned as a concern when it comes to the

[13] One-third of the royalties goes to the university and the remaining third covers laboratory costs.

relationship between universities and research institutes and the business sector. Bureaucracy is a big issue in the public sector, and most of Brazil's universities and public research institutes are part of the public sector.

When it comes to patenting, although the share of universities and research institutes in Brazilian patenting activity has increased, few of the patents they own are, in fact, licensed to companies. This underlines the importance of informal knowledge transfer channels in university–industry interaction in Brazil. So one of the main conclusions in terms of future policy is that it should aim to reinforce such channels.

Of course, it is also necessary to look at the demand side. The overall business environment is also important in explaining why university–industry interaction is not stronger in Brazil. This chapter has not examined the private sector as such in detail, but a lack of competition should be acknowledged as an important reason why Brazilian companies show little interest in the knowledge produced by the country's universities. Brazil is one of the most closed economies in the world, and so the motivation to innovate is low.

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