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The University as an Engine of Innovation: Critical Case Studies from Brazil and the U.S.

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1. Introduction

Universities today are increasingly viewed as essential contributors to innovation and economic growth. Whether as a partner with industry and government (Etskowitz, 2000) or more recently, as part of an entrepreneurial ecosystem (Audretsch, 2012), the university's role now extends well beyond just research and education to more applied and translational work with industry as well as more entrepreneurial activities that support new venture formations among students and faculty. Transferring technology from the university to the market place through firms and industries has become a central focus of the university, even for those that have epitomized the "ivory tower."

How universities have evolved and aligned themselves with these goals very much depends on the internal workings of the institution and the ways in which the rules, regulations, and incentives shape the behavior of faculty, researchers and students. Specifically, these help determine the formal and informal channels through which technology transfer occurs. Before successful partnerships can be formed or startups created, the university must create the conditions that encourage such behavior. While much has been written about tech transfer channels (Link, 2007; Grimpe and Fier, 2009), there has been less attention paid to the internal conditions that set the stage, or not, for greater translational work. The premise of this paper is that these conditions are critical to the successful fostering of tech transfer.

This paper compares two critical cases of top universities and their tech transfer mechanisms in a developed and emerging economy, the U.S. and Brazil, to identify key factors that shape both formal and informal channels of technology transfer between universities and industry. Informal channels, such as consulting by faculty, and formal channels, through industry-sponsored research or through patenting and licensing, are three of the most important ways that university-industry interactions occur. The cases are different in several respects. The U.S. case, MIT, is one of the premier private science and engineering universities in the US and a leader nationally, if not globally, in working with industry and also patenting and licensing new companies from faculty and student research. The second, Unicamp, is one of the top public general purpose state universities in Brazil and Latin America, and a leader in Brazil in terms of patents and startup companies. It goes without saying that these two institutions are very different in their history, missions, and funding among other key points.

Despite these differences, there is much to learn from each case about how the university supports industry collaborations and commercialization at their respective stages of development in this dimension. As leaders in their countries with respect to industry collaborations, patenting and new firm formation, each sit on a continuum, with MIT perhaps at one end, exploring and experimenting with ways to enhance translational work. As corporations generally have reduced their R&D capacity internally and looked externally toward universities and startups for building their innovation capacity, universities have likewise had to create new capacity to support and encourage greater translational and entrepreneurial activities. This is true for universities at every stage of the translational continuum.

Since the early 2000s in Brazil, public policies have actively encourage and pushed universities to become more central in driving growth and innovation in the country by supporting more university-industry interactions as well as commercialization. As this paper suggests, this first wave of new rules, regulations and incentives at universities has made some positive changes while still facing some friction in their implementation. The comparison between MIT and Unicamp highlights some of the important foundational and cultural differences between the schools that are important to understand in determining the possibilities and limitations for each institution in terms of industry collaborations and commercialization pathways. For all universities, there is no doubt a threshold where the university's main missions of education and research are at risk of being compromised if commercial interests play too great a role in shaping the university's goals.

The paper is organized as follows. Section 2 provides a brief overview on the evolving role of universities in society. Section 3 provides an overview of both institutions in terms of their history, staffing and funding models. Section 4 discusses compensation and incentive systems including a discussion on industry-sponsored research. Section 5 looks at supporting the entrepreneurial ecosystem through offices such as the Technology Licensing Office. In section 6 we offer a conclusion and thoughts on future research directions.

2. The Role of Universities in Society: The U.S. and Brazilian Context

Much has been written about the changing role of the university in society. It has evolved through many stages: from their early origins as medieval institutions that acted largely as extensions of religious institutions, to the introduction of a liberal conception of the university in the early 19th century that focused on freedom of thought and the combination of the arts and the sciences (the Humboldtian tradition), to a 20th century model that progressively saw the university as an engine for economic growth engaged in commercial applications that would benefit society, to more recently, an entrepreneurial model that sees the university as a driver of knowledge creation and innovation that actively works to translate its activities into entrepreneurial pursuits, pursued through both formal and informal channels (Audretsch, 2012).

The tension between preserving academic freedom and the pursuit of knowledge for its own sake, versus pursuing research that has commercial value and direct relevance to industry and the economy has existed at least since the middle of the 19th century. As technology began to play an increasingly important role in the economy, including with the Industrial Revolution and through two world wars, the university's role as an engine for economic growth increased. This shift can be seen as early as the 1860s in the U.S. as land grant colleges and universities emerged under Abraham Lincoln and the Morrill Act. Land grant colleges were established in several U.S. states expressly to support the creation of agricultural and mechanical colleges that would generate economic benefit to their state (MIT is one of these). For these institutions, there was little tension for them in fulfilling their mandates and pursuing commercial applications of their research.

World War II also contributed in a very direct manner of universities engaged by government and working directly with industry to pursue explicit commercial applications that had a direct bearing on the war (e.g., radar). Post-war, the importance of government funding of basic science and technology, and the close partnership with industry in developing commercial applications was established such that it became an accepted model of the modern university in the second half of the 20th century (Bush, 1945; Hart, 2010).

Perhaps the most important development that changed the incentives of universities toward translational work and commercialization was the passage of the Bayh-Dole act of 1980 (Kenney and Patten, 2009). The Act allowed universities title to patents arising from federally funded research. It allowed licensing, including exclusive licensing, and allowed universities to collect royalties while also insisting that inventors also receive a share of royalties.

These incentives to spur universities toward greater invention and innovation aligned with research into economic growth that emphasized the importance of knowledge creation (Romer, 1986) in driving long-term growth. Thus, the university was not only critical to developing the talent through education, but also the critical input to economic growth through new knowledge creation and innovation. The university thus became to be seen as a central mechanism for fostering economic growth, both regionally and nationally.

Since this time, universities have been actively engaged in promoting the commercialization of their inventions and spurring on entrepreneurial activity among faculty and students alike. As the rise of proof of concept centers and incubators suggests, engaging just in basic and applied research and developing a patent is not enough to bring ideas to the marketplace. Thus, universities have actively engaged in supporting the commercialization of ideas through activities on and off campus. The rise of the "entrepreneurial university" can be said to have started in the 1990s but gained significant steam since the beginning of the 21st century. Today, places like MIT boast over 80 different organizations that foster entrepreneurship.

2.1. The Brazilian Context

Some indicators, such as patents by universities, suggest that university-industry interaction in Brazil has increased over the last few years, although many specialists think that this is one of the major bottlenecks in the Brazilian innovation system. Several new policies with this objective were also created or improved during that time. Maybe the first policy explicitly aimed to foster research projects at universities in partnership with industry had been the Sectoral Funds, created in 1999. These funds provided grants to research projects conducted by universities and research institutions and focused on the technological challenges of several economic sectors, such as energy, oil and gas, health etc.

The growing recognition of the relevance of innovation and of the importance of strengthening the linkages among Universities and companies to leverage innovation resulted in the creation several other policies during the following years. The most important one with this regard was the Innovation Law, enacted in 2004. This law intended, among other things, to improve the regulatory framework regarding joint projects between Universities and companies, allowing public universities and institutions celebrate research contracts with companies. The Law also provided guidance for intellectual property rights on joint projects and created different kinds of compensations for the researchers and institutions involved in such projects. Even before this law, however, the Brazilian Intellectual Property Law, from 1996, guaranteed that Universities or research institutions, and not the researchers, would be the owners of the patents generated inside them. Beyond that, the Innovation Law allowed and provided the tools for the commercialization of such patents, being, in this aspect, similar to the US Bayh-Dole Act.

It is important to notice, however, that even after the Law, the research funding agencies had different policies regarding IP and, in some cases, these policies could foresee a share of the agency in the royalties. The Projects Funding Agency (Finep), since 1999, have decided that would no longer be the owner of any property rights resulting from research projects funded by it. The CNPq, in turn, maintained the practice of owning any patent created as a result of the research projects funded by the Agency up to 2008. Currently, the Agency still preserves the right to receive a share of the "economic gains" obtained by the patent. The regulations of these and other agencies regarding IP rights have to be observed in parallel with the innovation law.

The Innovation Law also imposes that every public university and research organization in the country should constitute, by their own or in association with other institutes, a Technology Transfer Office (TTO). The TTO would be responsible for research and licensing contracts between the university and research institution and the company. The TTO would also be responsible for making transparent the internal rules and regulations of the university regarding technology transfer.

Other laws and regulations effect, directly and indirectly, the relationship between private companies and universities in Brazil. One major example is the regulation regarding R&D in sectors such as oil and gas and electricity. In these sectors, the regulatory agencies enforce companies to invest a share of the turnover in R&D and part of this investment has to be done in universities and research institutions in Brazil. These regulations probably are one of the factors inducing a big investment of electricity and oil and gas companies in Brazilian research system. The informatics law also requires that companies invest a certain amount in R&D in order to get the fiscal incentives foresee in the law. Part of this investment has to be made in partnership with universities or research institutions in the country. Besides that, there are the grants provided by agencies such as Finep and BNDES that could induce that the awarded company have to develop a partnership with Brazilian research institutions in order to be able to get the grant.

According to De Negri and Rauen (2017), besides looking at patent activities at the universities, the Innovation Law also specifies other formal channels through which Universities and Public Research Organizations (PROS) could interact with firms in order to create "cooperative environments of innovation". The article 4, for instance, establishes how the universities and PROS can share laboratories and facilities with companies, while article 6 focus on tech transfer and IP licensing contracts. The law also foresees how these institutions could provide technical services to private firms as well as celebrate research agreements.

Professors interviewed for this paper, however, argue that the most common channel by which the university connects to the companies in Brazil are the informal ways, such as fairs, publications, qualified people etc. Following these informal channels, comes consultancy by professors. Licensing and research contracts come after as important ways in which university can spread the knowledge and transfer technology to the business sector.

In spite of all the possible channels in which a company could contract or buy technologies from universities, consultancy provided privately by researchers is probably the most common way for a company to approach from the university. In this regard, the Innovation Law also allowed researchers from public institutions, even those who are contracted in the so called "exclusive dedication regime"[1] to perform paid consultancy for companies, since approved by the employer institution or university.

Regarding the incentives for the staff the Innovation Law states that both institutions and researchers could be compensated by firms for working on projects in partnership with companies. This compensation could be an additional variable payment in the monthly salary of the researcher or through a so called "innovation stimulus scholarship".

Maybe the most critical issue regarding the university-industry interaction in Brazil is the ability of public institutions such as universities or research organizations manage private resources. Inasmuch as being part of the direct public administration, they have several constraints in receiving and spending money from other organizations. Public institutions in Brazil have solved this problem by using the services of private non-profit entities, called support foundations, that were created in 1994 (Law 8958/94) to help the public organizations to raise and spend funds from funding agencies or private organizations. The Innovation Law has improved the basic regulations for the operation of these type of entities in supporting research and innovation projects.

Although the Innovation Law has represented a major improvement in the Brazilian regulations regarding the university-industry interaction, some issues still remain unresolved even after the law. The excessive bureaucracy, uncertainty about the application of the Innovation Law and the overlapping of legislations in Brazil regarding the subject were some examples. Because of that, a New Science and Technology Law (Law n. 13.243/2016) has been enacted to consolidate several pieces of legislation affecting innovation and to "reduce the constraints to the implementation of university-industry partnerships (De Negri and Rauen, 2017).

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[1] This regime of contracting professors and researchers is most common in Brazilian universities. By this regime, the professor/researcher used to be obliged to have full dedication to the university and was not allowed to work for others. This obligation was to a certain extent reduced by the Innovation Law.

3. Overview of MIT and Unicamp

The following provides an overview of the two institutions, their history, size and funding model.

3.1. Brief History of the Schools

MIT

Established in 1861 as a land grant college by the Commonwealth of Massachusetts, with its first students attending class in 1865, MIT was conceived of as a polytechnic school by its founder, William Barton Rogers that would emphasize “the inculcation of all the scientific principles which form the basis and explanation of them, their leading processes and operations in connection with physical laws.” Its motto, *mens and manus* (mind and hand), underscored the importance of applied research and learning. Land grant colleges at the time, introduced by Lincoln during the early stages of the Industrial Revolution, were meant to help foster the region’s farming and emerging manufacturing industries as expressed in its mission: “a school of industrial science [aiding] the advancement, development and practical application of science in connection with arts, agriculture, manufactures, and commerce.” The novel introduction of laboratories where students would experience hands-on learning ensured that the work of the institution would be applied and translate to solve the societal challenges of the time.

By the early decades of the 20th century, MIT had established its close interaction with industry through the engagement of leading businessmen at the time on advisory committees and the like and also made a commitment to marry its strengths in engineering with excellence in the basic sciences.

The outbreak of World War II was a critical chapter in MIT’s history, as the university became a direct engine of innovation for the purposes of the war. Under President Roosevelt, the Office of Scientific Research and Development was created and its first director was Vannevar Bush, an MIT professor and former dean of MIT’s School of Engineering. Bush engaged MIT’s resources, as well as other universities, and established working partnerships with industry to solve critical challenges facing the Allies including the invention of wartime radar, guidance systems, and microwave technology. After the war, Bush made the case in his report, 'Science: Endless Frontier" (1945) for the active and continued investment by government into the basic sciences to ensure US prominence in innovation and technological advancement and to foster economic growth.

Post WWII, MIT was involved in key scientific milestones including the NASA space mission to the moon in the 1960s and the emergence of the biotechnology industry in the 1970s with the development of recombinant DNA. During this time and into the 1980s, MIT made significant investments into the life sciences with the creation of the Center for Cancer Research (now the Koch Institute for Integrative Cancer Research) and the Whitehead Institute for Biomedical Research.

After decades of being a bit of a wasteland (due in part to federal decisions not to use land for NASA in Cambridge), Kendall Square revived by the 1990s and MIT and the surrounding area became a hotbed of entrepreneurial activity creating one of the top "innovation ecosystems" in the country, rivaling to some extent, Silicon Valley. While this began in the life sciences, today it has expanded to several industries including clean energy, software development, material sciences, and medical devices to name a few. MIT's entrepreneurial engine has only accelerated on campus (with over 80 organizations engaged in entrepreneurial efforts) as well as off campus as fully 15 percent of alumni found new companies within 10 years of graduating (Roberts, et. al., 2016).

Unicamp

The University of Campinas (Unicamp) is one of the largest Brazilian research universities and certainly one of the most relevant in both academic and technological terms. Located in one of the most dynamic and innovative regions of the country in Campinas, the University is still very young, even in Brazilian scenario where the first universities were created in the 1920s. It was founded in 1966 firstly as a response of the State of São Paulo to the aspirations of the population in the region for a Medical school. Indeed, this was the first undergrad course at Unicamp. The creation of the University was also intended to meet the demand for qualified human resources in the state of São Paulo State, responsible for around 40% of Brazilian industrial production at that time. The University was installed in an area of 110 hectares donated by the Almeida Prado family and located in Barão Geraldo, suburb of Campinas.

Campinas is located around 100 km far from the city of São Paulo, where are the biggest industrial companies in the country. Indeed, the state of São Paulo, mainly the regions of Campinas and the city of São Paulo, are responsible for more than 30% of the Brazilian GDP. Campinas had a population of more than 1100 thousand and a per capita GDP around R$ 44 thousand (or US$ 27 thousand using the ppp conversion rate of 1.65) in 2013. The human development index is one of the biggest in the country, around 0.805.

Unicamp was the first Brazilian University that was planned as a University from the beginning unlike other ones that were constituted by the combination of several different colleges already existents. This planning was conducted in close connection with the demands of society and in response to concrete market needs, which at the time required engineers, chemists, physicists, biologists, mathematicians and economists, among other professionals[2]. Zeferino Vaz was the first president of the University and the person responsible for outlining and implementing the project.

Over the years, the existence of the University was one of the factors to attract to Campinas high tech industries from several sectors such as chemical sector, electronic and communications as well as other research institutions such as the Telecom Research and Development Center (CPQd) and the Center for Research in Energy and Materials (CNPEM). One of the reasons for its capacity of attracting other research institutions and private R&D centers is that, since the very beginning, the University had a strong emphasis on research. Indeed, more than 40% of its alumni are graduate students as can be seen in the table 1 next.

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[2] Source: Jornal da Unicamp, nº 672, 2016. Available in http://www.unicamp.br/unicamp/ju/572/um-projeto-organico-e-coeso

Currently, Unicamp is the second in the country in terms of academic publications, according the Simago ranking[3] and the first one in terms of number of patents applied at the National Institute of Industrial Property (INPI).

3.2. Students, Faculty and Staff

Below we outline some comparative information about the schools regarding students, faculty and staff as well as areas of study.

Table 1. Number of students and, staff and faculty members at Unicamp and MIT: 2015 (Unicamp) and 2016 (MIT).

	MIT (2016)	Unicamp (2015)
STUDENTS		
Undergraduate students	4,524	19,001
Graduate students	6,852	16,655
STAFF		
Total employees	**12,109**	**10,473**
Health /clinical / medical staff	144	3,679
Other academic and research staff	5,193	271
Administrative and support staff	4,900	4,656
Teaching staff*	1,872	1,867
*Number of post-doctoral researchers ** *	*1554*	*271*

*Source: Unicamp Statistical Yearbook (2016). Obs. In these figures are not included the staff and the students at the Unicamp Technical High School (COTUCA). *At MIT, this number includes professors and other teaching staff, such as senior lectures, instructors and adjunt faculty. At Unicamp, all the teaching staff is formed by professors (there is no other teaching staff than professors). **The post-doctoral researchers were included in the "other academic and research staff" figures, although at Unicamp are not accounted as the University's staff.*

The first point to note is that Unicamp is a much larger school, with four times the number of undergraduates and two and a half times the number of graduates, although Unicamp has just 20% more employees than MIT. More interestingly, they have a similar size teaching

3 http://www.scimagoir.com/index.php

staff and administrative support. In fact, the greater number of employees at Unicamp is related to the staff of the University's hospital.

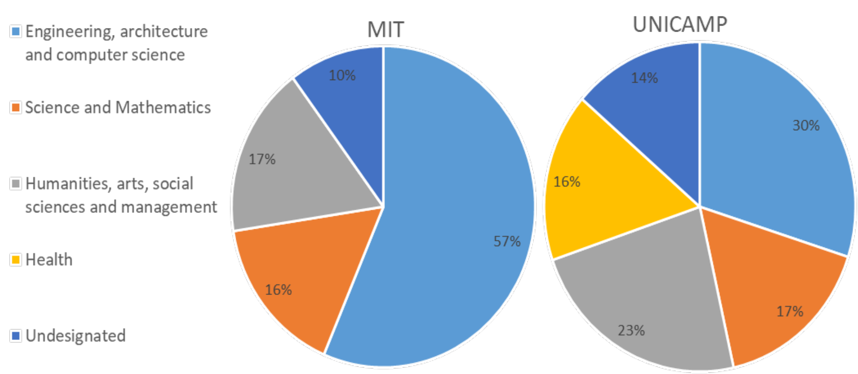
For the purposes of this research, an interesting difference between the schools is the category of "Other Academic and Research Staff." At MIT, research staff, including postdocs, play an important role on campus in providing non-student additional research resources. As of 2016, there were 1,550 postdocs at MIT. This compares to approximately 270 at Unicamp. Postdocs spend a year or two working in a lab or center with a professor on particular research projects. Postdocs are treated as staff and paid a salary (though some have suggested the value they provide relative to their pay makes them more like "slave labor.") In theory, postdocs are spending a good portion of their time getting their recent dissertation work ready for publication and preparing for going on the job market. At the same time, they can provide critical support in research as well as managing projects, labs and external relationships. In many cases, postdocs are the conduit between academic research and the establishment of startup companies, becoming the first employees within a new venture.

In addition to postdocs, MIT established the Research Scientist position, a research staff position that does not lead to tenure. Currently there is approximately 3,600 such research staff at MIT. Research Scientists can be promoted to Principle Research Scientist and Senior Research Scientists, which both have Principal Investigator status and thus can develop and raise funds for research proposals. They often focus on particular research areas and in many cases run research centers or programs on campus. Importantly, they are funded by "soft money", that is money that is raised from external sources to cover their costs. In the case of both postdocs and Research Scientists, the resources needed to cover their costs is significant and must cover both salary and benefits, the latter which run to almost 90% of salary expenses. These additional members of the MIT research community help in the overall research enterprise through their research as well as project or center management and relationship building.

In Brazilian public universities, such as Unicamp, there are no other career paths for researchers or other sort of academic positions that are not tenure track professor positions. After a relatively brief initial period of evaluation (two years), university teaching staff are provided tenure so there are few levels of professorships. Thus, all teaching staff have some tenure track position.

In terms of fields of study, both institutions cover similar disciplines, though Unicamp has a School of Medicine that comprises 17% of the student body, which does not exist at MIT. Not surprisingly and given its history, MIT has almost twice the number of students concentrating in engineering and computer science (57% compared to Unicamp's 30%). Since the engineering is probably the area with more interaction with companies, this fact might make a difference in terms of the potential of interaction with the business sector at Unicamp and MIT. Distribution across other disciplines is relatively similar.

Graph 1. Distribution of Unicamp's and MIT's students according scientific areas: 2015 (Unicamp) and 2016 (MIT).



Source: Unicamp Statistical Yearbook (2016) and MIT registrar's office (http://web.mit.edu/registrar/stats/yrpts/index.html)

3.3. Funding model

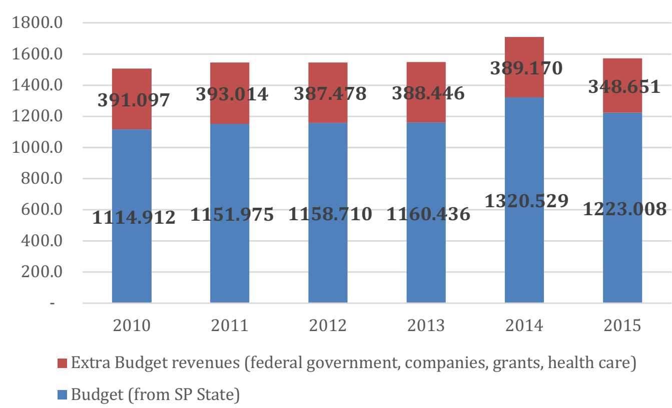
MIT, a private university, and Unicamp, a public university, are clearly funded in fundamentally different ways. Most of Unicamp's annual funding is provided by the state of São Paulo whilst MIT's funding is much more diversified, coming from a range of public and private sources.

Indeed, since Unicamp is a public institution from the State of SP, most of its revenue comes from the State as a basic funding for maintaining the University. In 2015, the University received a budget of U$ 1.2 b from the State, which is around 80% of the total revenues of the Institution. The budget from the State of SP is not related to projects or to any performance metrics and most of it is spent in paying the staff of the University. This funding has become relatively flat over the last few years, except for a slight increase in 2014.

The other 20%, or around US$ 350 million, called extra-budget revenues, came from services, health care, grants from public funding agencies, sponsored projects with companies or project based funding from the State of SP itself. Indeed, the most significant part of the extra-budget revenues (30% of them) is the payments from the Brazilian Health Care System to the University Hospital. The second most relevant share is the project based funding from the State of São Paulo Research Foundation (FAPESP), a public funding agency for R&D.

Since public institutions in Brazil do not charge fees from their students, there are no tuition revenues at the University. In the same way, public universities in Brazil are not allowed to receive and manage donations from companies or individuals, making this kind of revenue as well as the endowment funds not relevant in the Brazilian scenario.

Graph 2. Revenues of the University of Campinas: 2010 to 2015 (in US$ million *PPP*)



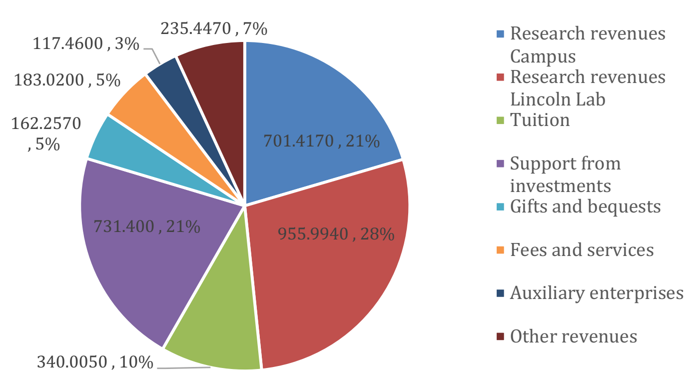
*Source: Unicamp Statistical Yearbook (2016) and World Bank for R$-US$ ppp conversion factor (*http://data.worldbank.org/indicator/PA.NUS.PPP?locations=BR *)*

MIT

As seen in Grapn 3, 49 percent of MIT's revenues are generated through funded research, 28 percent of that just from the US Department of Defense for the Lincoln Lab. This significant source of revenue from the DOD is relatively unique and represents MIT's management of Lincoln Labs, one of DODs research and development centers. An additional 21 percent of the school's revenues come from returns on investments, 10 percent from tuition, and 5% come from gifts and bequests.

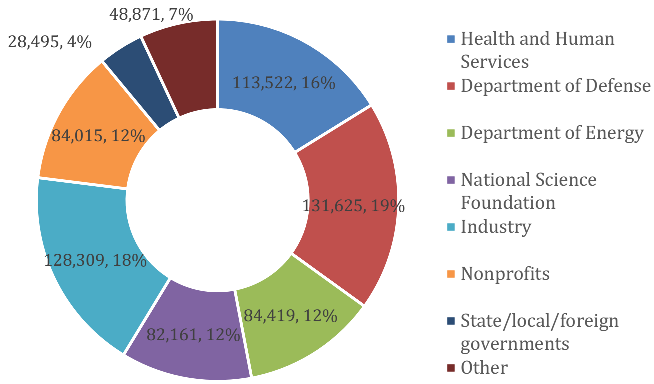
If one looks at the sources of revenue within research on Campus (not considering Lincoln lab), over half come from federal government department and agencies. Non-profit institutions represent an additional 12 percent of funding. Importantly, funding from the private sector (industry) has been increasing steadily over the past decades. Whereas industry sponsored research represented just three percent of research revenue in 1970, 35 years later it had climbed to 12 percent, and just a decade later in 2016 it represents approximately 18 percent of total research revenue. This acceleration in the last decade perhaps reflects the increasing reliance by industry on external sources of R&D.

Graph 3. Revenues of the Massachusetts Institute of Technology: 2016 (US$ million)



Source: MIT's Report of the Treasurer: 2016.

Graph 4. Research Revenues on Campus (except Lincoln Lab) - Massachusetts Institute of Technology: 2016 (US$ million)



Source: MIT's Report of the Treasurer: 2016.

There are, indeed, significant differences regarding the funding model at the two institutions. However, the role of industry in funding university research is sometimes overstated by academics and policy makers. In fact, even at MIT, industry on the whole is not one of the most important sources of funding for research.

Table 2. Revenues, research expenditures and contracts with companies at MIT and Unicamp (US$* and %)

	Unicamp 2010 (US$ ppp)	Unicamp 2015 (US$ ppp)	MIT 2010	MIT 2016
Total revenues (US$ million)	2,087.3	2,932.7	2,663.1	3,427.0
Research expenditures/revenues (US$ million)*	1,011.7	1,671.6	1,369.6	1,690.2
Contracts with companies (US$ million)	49.1	43.2	93.0	128
As a share of total revenues (%)	2.4%	1.5%	3.5%	3.7%
As a share of research expenditures (%)	4.9%	2.6%	6.8%	7.6%

*Source: Unicamp Statistical Yearbook (2016) and extra-budget revenues report; MIT Report of the Treasurer for 2016 and 2010; World Bank for R$-US$ ppp conversion factor (*http://data.worldbank.org/indicator/PA.NUS.PPP?locations=BR*). *At MIT, this figure represents research revenues. At Unicamp, the research expenditure, which is estimated by the Ministry of Science and Technology based on the Frascatti Manual.*

Commented [D1]: Liz, 138 was the number in 2015 and these figures are from 2016, so I changed. I've also completed the table for 2010.

In fact, the contracts with companies represent approximately 4 percent of all revenues of MIT and 7.6 percent of the research revenues. At Unicamp, industry sponsored research represents approximately 2.6% of the total budget and 1.5% of the all research expenditures. However, this figure has been declining over the last few years due to the economic crisis in the country. In 2010, industry funding represented 2.4% of the research expenditure at Unicamp. According to calculations from Brito Cruz (2012) this figure is even higher, reaching around 5% of research resources[4]. If one takes these higher numbers into consideration, Unicamp's ability to attract industry sponsored research appears relatively robust, somewhere between 30 to 60 percent of MIT's industry-based research.

[4] Brito Cruz (2012) used different methodology (with data not accessible to the authors of this paper) to calculate the research revenues at Unicamp and got a greater share of the research funded by companies in the total research revenues at Unicamp.

4. Compensation and Incentive Systems

The most important resource at any university is its faculty. Their ability to educate and inspire the next generation and in many cases, generate path-breaking research, is essential to the economic and social development and general prosperity of regions and countries.

The rules, regulations, norms and incentives within which faculty work can profoundly shape their interest and ability in developing partnerships with industry or in commercializing their research.

Indeed, the incentive systems are one of the most important elements to leverage a deeper engagement in different activities. One of the hypotheses that might help to explain why some universities are less innovative or less likely to interact with the business sector is the incentive system.

The following provides some of the key parameters that impact faculty in these dimensions. In the case of MIT, these points reflect practices at the School of Engineering (SOE) and may differ from other schools.

MIT has approximately 1,000 faculty, a number that has hardly fluxuated over several decades. With no mandated retirement age, the opening of new positions in departments is relatively rare. Faculty are divided among four tiers.

MIT has a four-step process toward tenure that typically takes eight years. New faculty are hired as Assistant Professors and after three to five years, they are promoted to Associate without tenure. This is a relatively sure promotion and is considered the "dress rehearsal" for the next promotion, which is Associate with Tenure. This first promotion can also be part of an "up and out" strategy that allows faculty who will not make the next step to have time to transition to another institution. Approximately two-thirds of faculty are promoted to Associate with Tenure, a percentage that has increased over time and potentially reflects the increasing quality of the junior faculty. Once faculty are made Associates with Tenure, the next step to a Full Professor is basically ensured.

Promotions are based on the impact of a faculty member's work on society as judged by their peers, both those in their department as well as outside reviewers. This is measured in part in terms of publications and citations but also their leadership in the field, their teaching capabilities as well as leadership at the Institute. Interestingly, patents are considered, but are not perceived as being that important. There importance was described by one Department Chair as "negligible…when it comes to promotion, [patents] are not a factor." While some faculty at MIT start new companies which may have a significant impact on society, it is usually tenured faculty that work on startups since starting a company can be a distraction from developing one's tenure case early on. "You don't get anywhere on the academic ladder" by starting a company according to one administrator.

Faculty obligations at SOE are relatively minimal, with faculty required to teach one course per semester as well as supervise masters and PhD students. Faculty are not allowed to "buy time from teaching" through research funds but might be able to double up for a semester to free up time in another semester.

Before the 1990s, faculty were required to raise approximately 50% of their salaries from external research funding. To provide more support and freedom to faculty, in the 1990s MIT moved to "harden" faculty salaries and cover 100% of salaries for a 9-month period. Faculty are still responsible for covering their summer salary, which creates incentives for seeking outside funding. Salaries ranges for starting professors begin at $100,000 and can increase significantly for tenured faculty. The outside range of salaries is kept confidential.

Faculty are free to consult one day a week. MIT requires faculty to report to whom they are consulting and how many days during the academic year they are engaged in consulting (faculty are allowed up to 39 days during the academic year) but not about their pay. In theory, faculty are required to report all paid and non-paid outside work, for example, acting as an editor to a journal. Each department head has oversight over the consulting reporting of his or her department. In general, this area of activity is considered "fuzzy" without a lot of uniformity in practice and reporting. For faculty who start companies, they may work in theory one day a week on their startups and then might take a leave of absence to dedicate more time to the venture. Leaves of absence are granted for up to two years and only beyond that with special permission of the Provost.

With respect to new enterprises founded by faculty, faculty at MIT are allowed to own unlimited equity within a company but may not hold a position in the company as an employee. Most founders will play an advisory role to their company. Faculty also receive royalties from the licensing of their patented technology. This is usually divided (after patent costs and TLO costs are taken into account), as a third to the faculty members, a third to their department and a third to MIT.

At Unicamp faculty are civil servants and selected through a public and competitive selection process. There are three types of employment: i) full-time dedication; ii) part time (12 hours per week) and iii; part time (20 hours per week). More the 90% of the faculty are full time employees. In each of these categories, there are 8 career brackets with different requirements and pay levels. The upper 6 brackets require PhD level.

The professors can join the University in any of these career levels, depending on the University needs. However, there is also the possibility of career progression for faculty hired in the lower levels. The specific criteria for advancing in the career can vary slightly according the School, although the main parameters remain very similar. Faculty can request a promotion and, to get it, they are evaluated by several academic criteria such as publications, guidance to students, courses provided among others. The overall involvement in institutional and administrative tasks, such as being the department or school head, is also considered in the evaluation. Generally, leveraging external funds for the University or conducting contracts or agreements with companies are not considered in the promotion criteria. In the full-time scheme, the salary range goes from around 43k for masters to US$ 63k for professors in the higher career level. Once hired by the University, faculty go through two year probation time, after which they become tenure. In this sense, all professors selected by the public selection become tenure.

Faculty obligations can vary from one School to another but, generally, include at least one course by semester and provide guidance for students. The department meeting is the responsible for the allocation of faculty among the courses and for distributing the tasks of the department among all faculty.

Regarding the specific incentive regime for partnerships with companies, faculty in a full-time scheme are allowed to consult one day a week. However, it is necessary the approval from the department and the School meeting. The earnings from the consultancy activities are subject to an overhead charge from the University. So, faculty have to pay a share of their earnings obtained with external consultancy for Unicamp, even if they don't use the research infrastructure from the University.

Besides that, however, faculty can also be compensated by working in sponsored research projects. This payment could reach up to two times the professor salary. Above this threshold, the University can charge an overhead tax of around 26%.

Box 1. Salary, consultancy policies and incentives at Unicamp and MIT.

Faculty Parameters	Unicamp	MIT
Salary range for faculty (annualy)	US$ 43K to $63 (not ppp)	Starting at $100K for 9 mths
Process to tenure track	All faculty are hired as tenured after a period of evaluation of two years	8 years
Time allowed for consultancy	1 day a week	1 day a week
Limits to outside consultancy income	Need authorization of the department University can charge overhead over the professor income with consultancy	none
Overhead over university's research projects with companies	up to 26% (total)	54.70%
Teaching requirements	One course per semester plus guidance	Once course per semester
Additional compensation through industry sponsored research?	Yes, up to 100% of the annual salary (above that threshold the University can charge overhead)	Summer salary costs (up to 3 months)
Ability to own equity in a company started by prof.	Faculty can be a shareholder but cannot be the single owner or the manager.	Yes but cannot be an employee; can advise

Source: Author's analysis based on internal rules and regulations of MIT and UNICAMP.

A few points should be highlighted from this comparison. First, while salaries are higher at MIT, the tenure track involves more risk to the individual as well as more reward in terms of compensation if they make it through. There are opportunities for faculty at both MIT and Unicamp to consult, though Unicamp professors must channel their consulting through the university which will charge overhead on the consulting income. This would seem to create a significant disincentive to consulting practices. While Unicamp professors are paid relatively modestly, they also may double their salary through compensation provided by outside funding such as industry sponsored work, a significant incentive. With respect to starting companies and ownership, MIT has no limits to equity ownership (though cannot negotiate a license with a faculty member so there must be a partner in any venture). Unicamp also has few limits on equity ownership though a faculty members may not own 100 percent of a company.

These incentive structures matter greatly when trying to encourage technology transfer. Significant research has examined the ways in which knowledge developed in universities is transferred to society at large, and more specifically to the business sector (Jaffe, 1989; Boseman, 2000; Friedman and Silberman, 2003). The interactions that support technology transfer from universities to industry occur through several different channels, both informal and formal. Informal channels include consulting, publications, conferences and the hiring of students for employment post graduation. Formal tech transfer comes in the form of industry sponsored research or through patents and licenses to new technology.

Research in the US as well as in Brazil suggest that informal channels are the most prevalent ways in which tech transfer happens between universities and industry (Link et al., 2007; Agarwal and Henderson, 2002; Póvoa, 2008; Póvoa and Rapini, 2010; Castro et al, 2014). Link et al (2007) found that among the U.S. scientists and engineers surveyed engaged in working relationships with industry, the most prominent channel was through consulting (18%) followed by joint commercialization of technology (16%) and joint publications (15%). Similarly, Agarwal and Henderson (2002) found that MIT faculty perception about the relative importance of different channels for knowledge transfer put consulting first and foremost. The percentages broke down as follows:

- Consulting (26%)
- Publications (18%)
- Recruiting graduates (17%)
- Collaborative research (12%)
- Co-supervising (9%)
- Patents and Licensing (7%)
- Conversations (6%)
- Conferences (5%)
-

Informal channels represent the top three responses, while the formal channels of collaborative research and patents and licensing are fourth and sixth respectively For all of the interest in commercializing IP out of universities, relatively few companies end up doing this and the perception is that is it not the most important means for transferring knowledge to industry. These results from MIT also align with our research on Unicamp. According to interviews with professors and researchers, Unicamp has a similar pattern of interaction with the business sector. Although the University does not have consolidated information about all the agreements or contacts made with the business sector, interviews suggest that the informal channels are, indeed, the most common way of technology transfer. Interviews at both MIT and Unicamp underscore the importance of consulting as often the first contact between the university and a company through a university professor or researcher that then may be leveraged into a broader, more formal relationship through sponsored research.

While these informal channels are clearly critical, they are also very difficult to track or analyze. In the remaining part of this paper, we focus on the more formal channels for university-industry partnerships, namely collaborative research and patents and licensing.

4.1. Industry Sponsored Research

Industry sponsored research is the most important formal channel for university – industry tech transfer. Below we outline the process by which these collaborations arise. While of course it is critical to have compelling research, dedicated teams and well managed projects to developing a successful partnership, we focus here on the internal regulations and processes, which help facilitate these collaborations. Certainly, in the case of Brazil, the challenges of these types of relationships are often considered to be more about process than the actual substantive research that is conducted.

MIT

As outlined earlier, MIT's share of research funded by industry has been steadily increasing since 1970 when it was three percent to today at 19%. This reflects the increasing interest by companies in being close to the disruptive and cutting edge technologies being developed at MIT. As described by MIT's head of the Industrial Liason Program, a membership organization for companies interested in an affiliation with MIT, most of the sponsors want to fund targeted research with specific PIs rather than consortium models. In the end, it is "all about relationships – long-term, trusting relationships." By working with MIT, companies can be "first in line" in terms of insights and access to new technologies and emerging industries. This is what excites companies rather than complementary research to their own.

These collaborations with industry requires a significant capacity within the Institute to facilitate these contracts and ensure they provide clarification about roles and responsibilities, intellectual property and liability. Having said this, industry sponsored contracts likely represent just a fifth of all of the proposals generated annually by MIT faculty and researchers (estimated at approximately 1,000).

While there is little vetting by the administration on the substantive nature of industry sponsored research, it does make sure that what is agreed upon represents fundamental research with which academic publications can be derived. The Office of Sponsored Programs (OSP), which oversees and approves all of MIT's research contracts, is careful to ensure that MIT is not being hired for "product development." If a PI is interested in helping with product development, they must engage through consulting arrangements and cannot use MIT facilities. Given many of MIT's buildings have been built with tax exempt bonds (a practice that is progressively being faded out) work conducted in the buildings must be considered in the public interest.

The Office of Sponsored Research reviews contracts between PIs and industry (as well as with government entities) to ensure PIs aren't overcommitting the Institute in any way (resources, space, intellectual property etc) or promising unrealistic deliverables. In general, OSP is described as "very conservative" with respect to taking risks, sticking to certain principles and positions. Industry often pushes back and wants certain terms and to date, MIT has held a strong line about its willingness to take on too much risk with respect to collaborations with industry. MIT is self-ensured and thus, if it were to take significant risks it could put its endowment at risk. MIT tries to avoid escalating confrontations with industry in their negotiations and because the Institute has bargaining power given its highly qualified faculty, it is often in a position to hold its ground.

The OSP Process for Approving Industry Sponsored Research

The process of negotiating a contract with industry is relatively straight forward. The concern from MIT's side is not the nature of the research but the liability and risk for the Institute. Importantly*, liability in case of any malfeasance or breach of contract is held by the Institute*, not by individual faculty. The Institute is the party with which the industry partners enters a contract (of course, in the case of something like academic fraud, the PI can be sued directly). MIT's concerns lie in both what is promised (in terms of human capital resources, space and deliverables) but also how intellectual property is treated. MIT insists that they own any IP developed at the Institute. An industry sponsor can be given an exclusive option to negotiate an exclusive license after the IP is created, but licenses can't be prenegotiated ahead of time. This helps ensure that the IP is actually used and not necessarily "sat upon" by large companies. MIT is exploring ways to create some flexibility in this area but it is difficult to negotiate special terms with one partner and not all of them.

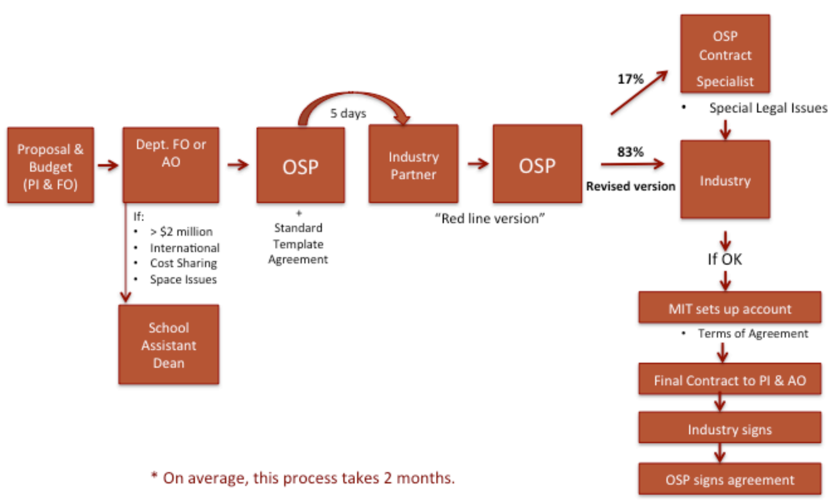
Engagement with PIs

MIT has a long and successful history of working with industry and thus can often dictate the terms of the agreements with industry. Sponsorships can be modest, from helping support a couple of graduate students in a lab, to supporting an entire lab. PIs must be clear with sponsors about how much overlap there may be in their lab with work supported by other sponsors. Research is inherently "messy" and thus it may be difficult to determine what exactly was invented with what sponsorship money. Because of the nature of the research, and because of students also being involved, there is only so much of the process that PIs can control. Typically, PIs promise to keep findings confidential and will show work to sponsors before anything is published to ensure they are not publishing any confidential information or patent disclosures (if you publish your findings before you file for a patent, you lose your patent availability.) The nature of research also often involves multiple researchers and multiple labs/departments so again, hard to absolutely pin down exactly what has been funded by whom. Thus, the general rule is that exclusive licenses are provided subject to any other 3rd party rights (another researcher or lab). In general, faculty have to be careful about any promises they make to sponsors. If a sponsor is funding research it expects to be solely sponsored by them, "there can't be another corporate sponsor within shouting distance of the project." Often, PIs will make clear they do not want confidential information from the industry sponsor because it complicates matters (PIs must officially accept or decline confidential information). Often an NDA is part of the research agreement so there is no need to come back to OSP to negotiate these separately.

Process of Approval of Contract with Industry

The process for finalizing an industry-sponsored agreement primarily involves three key participants: the PI, the Department Financial Officer, and the OSP contract administrator. While there may be other important approvals in the process, these three people are essential. The figure below provides a graphic schemata of the process. The various step are outlined below.

MIT Industry Sponsored Research Agreement Process



At the outset, the PI develops a research proposal that has usually been discussed with the industry partner to outline research of mutual interest (in theory the PIs proposal should be sent to OSP before discussions with industry but this rarely happens). The first step for the PI is to get approval from the Department Financial Officer (FO) to get an approved budget along with any additional requirements outlined in the proposal (use of space at MIT, for example). Once the FO and PI are in agreement with the proposal, it is sent to the OSP officer who has five days in which to review, adjust in concert with the PI or FO if necessary, and then send a cover letter and standard research contract template to the industry partner. If working with industry partners in which there is some history, or if they know there will need to be "special treatment" (particular clauses related to visiting researchers or use of materials), then adjustments are made to the standard template.

In specific cases, the contract will have to be sent from the FO to the Assistant Dean of the School for approval before it heads to OSP. These cases include:

- A contract worth more than $2 million
- An international agreement
- Where there is cost sharing
- Where commitments to space are involved

Cost sharing refers to research sponsorships where MIT makes exceptions regarding the payment of standard overhead costs (which are at 54.7%). Many foundations and others will not pay such a high percentage of the agreement to overhead and in these cases, MIT must agree to cover some of the overhead.

When the template is returned in a "red line" form to OSP, the clock is said to begin in terms of the negotiation timeline between MIT and the industry sponsor. A certain percentage of the industry sponsored contracts (approximately 15%) require the attention of "contract specialists", a team of lawyers that focus on key legal issues raised in the negotiations. The vast majority of the time this involves the negotiation of IP. This focus on IP may be appropriate and necessary, but it results in "arguing about stuff that never happens." Industry-sponsored research results in protectable IP in only 20-25% of the time, and of this IP, only a fraction of the sponsors end up taking licenses. It is estimated approximately 7-8% of industry sponsors ultimately take exclusive licenses of IP generated by their support.

On average, OSP states that it takes approximately two months from the time they receive a redlined version of the agreement to the time that the agreement is signed by the parties. Two or three of the senior leadership at OSP have the authority to sign on behalf of the Institute. There are final approvals that are needed with respect to export control as well as the use of human subjects, but those do not hold back a process and can be finalized after the signing of an agreement.

In terms of how industry funds may be used, MIT overhead costs run at 54.7% for all MIT sponsored research, though there are exceptions to this through a "cost sharing" model where for some sponsors that refuse to pay such high overhead, MIT covers the difference. The terms of research funding are negotiated upfront but can ususally be used to purchase equipment and pay for student stipends, postdocs as well as consultants if they are called for. It may also be used to cover up to three months of faculty summer salary (which the university does not cover). It may not exceed the equivalent of 12 months of their monthly salary.

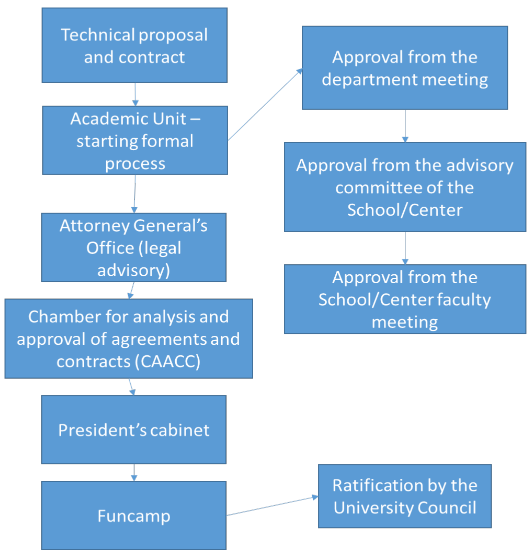
UNICAMP

The Figure 1 shows the process by which a research contract or agreement has to go through in order to be firmed by the University in a timeline that can reach up to 90 days. Several researchers, however, mentioned that the process could last even longer. The first step in the process below is to prepare the research proposal and contract, where the Funcamp agreement is necessary, in case the Foundation is responsible for managing the contract. The researcher/professor is the responsible for preparing the contract and can count on the help of the Inova Agency[5] or the Funcamp. The University also provides some templates and standard contracts that could be followed by the researcher. In other words, the process outlined in the flowchart below is about the approval of the contract by the several forums responsible for it.

[5] People interviewed at Inova mentioned that the Agency helped to elaborate 26 from a total of 30 contracts signed last year.

The contract and the terms of negotiation with the company are already concluded before the formal approval process begins.

Figure 1. Flowchart for the Unicamp contracts and agreements approval process



Source: Flowchart sent by Inova/Unicamp.

Once the proposal and the contract are completed and agreed by the researcher, the company and by Funcamp, the researcher must send it to the Department. In accordance with the University's general rules[6], the process must pass through three different committees and boards within the School for approval: the department meeting, the School advisory committee and finally, the School faculty meeting. The general rules of the University state that these forums should evaluate the merit and the interest of Unicamp on the proposal. However, according to several researchers interviewed it is not likely for a project to be rejected by these forums. After the Unit approval, the contract goes to the Attorney General's Office for legal advice and reformulation if needed. A reformulation of the contract, in this stage, should probably to be submitted again to the contractor.

There is still one last committee for approval, which is the Chamber for Analysis and Approval of Agreements and Contracts, which is responsible for review and approve all the contracts of the University. This Chamber was created in 2013 to accelerate the process for approval contracts, which had to go through several different instances previously in a process that could take several months. So, the chamber put together several different actors of the University who were supposed to review and approve the contracts separately one at a time before the Chamber.

After the approval of the Chamber, the contract goes to the President's cabinet for signature and still has to be confirmed by the University Council, which is the top council of the University, comprised of professors, students and administrative employees.

After the signature, the contract goes to Funcamp, which will manage the contract. Funcamp is a non-profit organization responsible for the administration of external revenues coming from contracts and agreements made by Unicamp. It was created in 1977 to provide administrative support to the University on the management of contracts and agreements. Currently, most of the agreements made by Unicamp are managed by the Foundation. In 2016, for instance, the Foundation was responsible for managing 98 new contracts and agreements summing circa R$ 72 million (or around US$ 21 million).

One issue that arises from the analysis of this process is the high number of committees and councils that are supposed to approve the contract. Since several of these groups meet each 15 days or more, it means that the time for go through all of them can take up to 2 months. Besides that, there is clearly a redundancy in having so many commitees evaluating one single proposal, especially if one takes into account that all these comitees should evaluate the merit of the proposal. Another related issue is tmat there is no objective criteria for this evaluation, be the budget, the availability of resources at the department, the number of laboratory hours used or any other.

The support for the researcher in terms of negotiation and of preparing the contract and the budget also seem to be reduced. The researchers are the main responsible for the negotiation and even for the preparation of the formal contract, which is obviously not their specialty. Finally, compared to other universities around the world, the need for the president to sign any contract firmed by the University is a highly centralized process that could sometimes be inefficient.

One important issue on the contracts that how the University uses the resources coming from contracts and agreements. These resources can be used for several different purposes but primarily they are used to hire students and researchers, especially in the last couple of years when the federal resources available for scholarships have been reduced. However, the resources can also be used for buying equipment, research inputs, building facilities and to complement faculty salary. Regarding the uses of the resources for complementing the faculty salary, there are some regulations and limits to this[7]. The professors can be compensated by their participation in a contract up to a maximum of twice their salary. Of the amount that exceeds this threshold, the Unicamp can charge 20% as an overhead reimbursement.

The overhead reimbursement at Unicamp is around 20% but could vary slightly among the different departments. This total is distributed as follow:

- ✓ 6.5% goes to cover administrative expenses of the Funcamp Foundation;
- ✓ 8% to a program called Integration, development and socialization, whose objectives are mainly to share the earning with sectors of the University not so likely to raise money from external sources.
- ✓ 3% to a University fund aimed to support research at the University.
- ✓ A minimum of 3% to the department or center where the project was performed.

[7] The President's Cabinet resolution number 23/2008 says how the revenues from contracts and agreements can be applied and sets the limits for faculty compensation.

5. Supporting Entrepreneurship

5.1. The Technology Licensing Office/Technology Transfer Office

The other formal channel through which universities transfer technology to industry besides sponsored research is through the patenting and licensing of technology. Technology Licensing Offices (TLOs) or Technology Transfer Offices (TTOs) are the offices through which this occurs. While MIT has had the equivalent of a TLO since the 1940s, the establishment of TLOs generally did not occur until late in the 20th century after the Bayh-Dole Act was enacted. As outlined earlier, in many countries it was not until the beginning of this century that policies were established for the rights of universities to own IP on their inventions and the creation of TLOs. Below we highlight the role the MIT TLO plays at the Institute and some of the key learnings that have emerged over the years. We also review the role of Inova, Unicamp's TTO, one of the most established in Brazil, though still a relatively young institution founded in 2003.

MIT

The Technology Licensing Office is one of the key entities within MIT's innovation ecosystem. It is the formal channel through which inventions developed at MIT are patented and then possibly licensed to industry.

From the outset, the primary goal of the TLO has always been to extend MIT's impact on society by "midwifing the technology into the real world where it could make a real difference," according to the former director of the TLO. MIT, along with Stanford, are considered national (and international) leaders in their work licensing technology coming out of the university as well as creating new ventures based on the technology. The goal of MIT's TLO has always been impact and despite the impression by some universities that the licensing of new technologies is a path toward revenue generation for the university, on the whole, tech transfer offices do not make money "unless you get lucky." It is unlikely that a university even with a mature tech transfer program will make more than 2-3% of its overall budget from technology transfer. Having said this, there is the occasional big success such as MIT's investment in Akamai, a web services company and the HDTV algorithm that runs most modern TVs, which is owned by MIT. For example, in 2012, the TLO realized $145m in income.

The mission of MIT's TLO is three-fold. First and foremost,

- *To transfer research results into commercialization utilization by licensing companies to promote, develop and market the technology*

Also:

- *To promote economic development through the introduction of new technologies into industry*
- *To create a fair return to MIT and its inventors on licensed IP*

The role of the TLO has evolved over the years, both narrowing as other entities emerged at MIT to support entrepreneurs, but also expanding as MIT engaged with more industry partners with whom IP issues and licensing became part of the negotiations. Today, TLO officers (approximately 45 of them) are engaged in three primary activities. First, a technical hat. The TLO officers must be sufficiently technically knowledgeable in their fields to be able to determine whether disclosures have merit for patenting and eventual commercialization. Second, a legal hat in which they are well-versed in patent law and how the process works. Third, a business hat because TLO officers are responsible for developing their own agreements and negotiating licenses. While agreements are standardized to reflect best practices, they are also highly customized.

Importantly, TLO officers have significant discretion and authority with respect to the patenting and licensing process. Typically, TLO officers have spent 15-20 years working in industry and have a technical specialty. They both determine whether a new technology is worthy of patenting and also make the final recommendation to the head of the TLO regarding licensing agreements. Discretion among the TLO officers is important according to the former head, because each case is different. The Director of the TLO has the authority to sign off on all licensing agreements and does not need to seek approval from higher authorities at the Institute. Thus, TLO officers are highly autonomous, reflecting as one TLO officer said, MIT's culture of

“900 CEOs.” Having said this, the Vice President of Research does co-sign all equity licenses, since the Institute feels it is important to keep abreast of MIT employees (especially faculty) with equity related commitments.

Briefly, the process at the TLO begins with disclosures, where professors (or students) disclose innovations that they believe have commercial potential. The TLO officer works with the professor to understand what the invention is about and how it might relate to previous inventions by the individual. The officer will conduct a “prior art” search and search consultants at the TLO try to understand its patentability. If a patent is filed, it might take years for it to be issued, but commercialization activities can begin immediately. MIT assumes patents will be granted. TLO officers must make a judgement as to whether something that is patentable has a real chance of being licensed. Patenting technology just for patenting’s sake does not fulfill the TLO’s mission. As one TLO leader said, “A patent without a license is worst of all worlds. You spend money and tie up technology.” Most IP created at MIT is in the form of patents, but the TLO also works with copyrights (software), trademarks.

If the inventor is interested in starting a company, the TLO must negotiate with a partner and not the MIT employee. The TLO will provide advice on structuring the venture vehicle, provide introductions to potential funders, and direct the nascent company to business mentoring services as well as discuss conflict of interest issues with the inventor. As the services for entrepreneurs have evolved and increased at MIT, the TLO’s role as a coach has decreased and other organizations have stepped in. The TLO does not, for example, provide money, physical space, management, business plan writing, or formal guidance to the company.

It should be mentioned that all MIT research must be published and thus when an inventor has a disclosure, he or she must publish their findings before they file for a patent. If the disclosure is based on research funded by a research sponsor, they must inform the sponsor. The sponsor has 30 days to review disclosure documents to determine if there is any proprietary information included in the disclosure or anything they would like to patent as well.

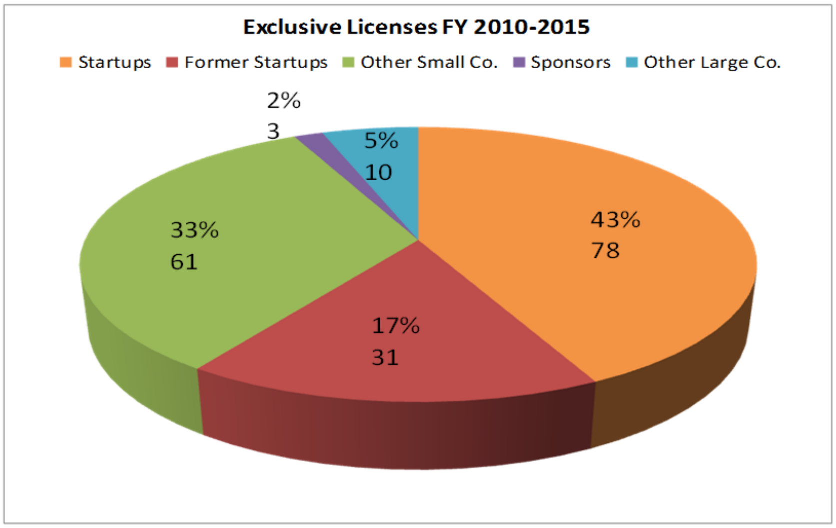
In 2016, the TLO output was the following:

- 795 invention disclosures
- 314 patents issued
- 91 license agreements
- 33 option agreements
- 28 startups

TLO officers suggest an increase in the overall numbers over the years is due to both an increasing interest in entrepreneurship on campus as well as outreach efforts by the TLO. Instead of a self-selecting group of "repeat commercializers", the TLO is seeing an increase in the number of new faculty who are initiating contact.

As mentioned before, inventors receive one-third of the net royalties from inventions. The other two-thirds is divided between their department and the Institute. Patent costs and licensing issue fees are covered by the licensee and might be paid to MIT in the form of equity investments or royalty agreements. The royalties are a percentage on product sales. As stated before, faculty may have unlimited ownership as a founder of a licensed startup company but may not be an officer of the company while also employed by MIT. They may also not receive any research funding from a company in which they have ownership.

In terms of licensing, very few of the licenses issued by MIT go to large companies. In general, the IP that comes out of a university (if it is a fundamental research university) is too early to be of interest to them because of its long development time and high risk. According to TLO leaders, even the companies that sponsor research and have first rights to an exclusive license on a patent do not usually take it. Of the licenses issues by MIT, about 40 percent are to new startup companies, and another 17% are to small companies that used to be startups. A third go to small companies and the remainder go to sponsors and other large companies.



When MIT takes an equity stake in a company, it is usually below five percent. This reflects the Institutes emphasis on providing pre-company nurturing and not on forming companies *per se*. MIT "retreats"l as inventors and investors step forward. In other countries, where there are fewer investors, the TLO might play a larger role and thus take a larger equity stake in a new venture. The TLO's formal role is to provide a license agreement for the IP and little more.

With the rise of the "entrepreneurial university," the TLO has become one of many nodes in the innovation ecosystem at MIT. Its work is supported by the Deshpande Center, which provides early stage funding and guidance to faculty and student entrepreneurs during a technology's proof of concept stage. MIT's Trust Center for Entrepreneurship as well as Venture Mentoring Services are also important nodes in the system. The former director of TLO suggests that this emphasis on entrepreneurship has reinforced the TLO's second mission around economic development, given entrepreneurial companies have an impact on the economy and job creation. This is reflected in the development of the entrepreneurship curriculum at MIT, including the new creation of an undergraduate minor in entrepreneurship as well as new entitites like the Engine, a for-profit incubator created by MIT in June of 2017.

The Industrial Liason Program

There is one other organization at MIT that deserves mention because of the important role it plays in terms of industry relationships at MIT. The Industrial Liason Program (ILP) was created in 1948 at the request of a major U.S. corporation that wanted to develop closer ties to the Institute. The ILP has since grown into a membership organization with over 200 company members and a department of 30 full-time Liason Officers. The purpose of the ILP is to facilitate relationships between MIT faculty and staff with industry to create a greater exchange and fostering of ideas and build explicit research partnerships between them. The ILP offers annual memberships at $75K and provides members, through a dedicated ILP officer, a tailored introduction to the Institute and its faculty and researchers whose work might be of interest to them. They also hold regular conferences on particular leading edge research topics and technologies that provide opportunities for networking with other ILP member companies. Finally, more recently, they provide introductions to MIT-related startups in a range of industries and technologies through the MIT Startup Exchange. Approximately half of the ILP members end up sponsoring specific research at MIT.

ILP members have become progressively international. Current membership breaks down as follows: 30% US headquartered companies; 30% Western Europe and 40% in Asia (with a few companies from Latin America). As countries and companies globalize, they tend to expand their partnerships internationally. Places that have a strong institutional history with applied research and technical universities, such as Germany, may lead to fewer ILP members because of the rich environment they can draw from in their own country. But in countries that don't have this tradition, for example, Japan and China, the ILP is appealing. Whereas Japanese companies were joining the ILP in the 1980s and 1990s, today Chinese companies are expanding their relationships. In general, ILP members tend to reflect global GDP.

INOVA- UNICAMP

The agency responsible for technology transfer at Unicamp, the Innovation Agency, Inova, was created in 2003, one year before the innovation law established that all public universities should have a Technology Transfer Office (TTO). But in fact, Unicamp was involved in issues related to IP several decades beforehand. It created a Permanent Committee for IP in 1984 and in 1990 had an early version of a tech transfer office. In 1998, the office transformed into a range of knowledge and technology services and became Inova in 2003. The mission of the Agency is to identify opportunities and promote activities to stimulate innovation and entrepreneurship.

In fact, Inova is not only a TTO, since besides being responsible for licensing the technologies produced by Unicamp, the Agency also develops several activities related to entrepreneurship and innovation at the University. Its role includes the traditional roles of a TTO such as i) helping the researchers to apply for a patent in the National Institute for Industrial Property (INPI) and ii) licensing those patents. But Inova also has several other roles including iii) stimulating entrepreneurship at the university; iv) managing the technological park and Unicamp's incubator; and v) creating challenges and events about innovation and entrepreneurship.

Commented [D2]: Liz, as we talked, I think Flavia is confusing consulting with sponsored research. What I heart is that Inova has been trying to manage the sponsored research contracts for professors, even it is not mandatory.

According to the Inova's annual report, in 2016, Unicamp applied for 80 patents in Brazil and 7 abroad, reaching more than a thousand of patents in total since its inception. Among these patents, 87 have been licensed. It is unclear how many startups have come directly from this licensing, but Inova has registered over 400 new companies that have been founded by alumni or by professors of the University. The Inova patenting team is comprised of several lawyers as well as five technology specialists. This has grown since the founding of Inova when the team was relatively small and professors were essentially filing patents themselves. They follow a similar pattern as MIT in terms of first understanding a disclosure, then determining patentability. Sometimes a third party is involved in the patent process, for example when funding for the technology development came from an outside entity such as FINEP or FAPESP, who often are co-holders of the patent.

Commented [D3]: Liz, I'm really not sure about this. Maybe we should check this out before writing in the paper. I will try to find out how is the negotiation process but, until the next version of the paper, I would suggest we drop this part off.

As discussed earlier, in terms of royalties and equity ownership in startups, Unicamp faculty are designated a third of any royalties from licensed technology, and are allowed an equity stake in a company but not allowed to be majority owners.

Commented [D4]: Yes, that is correct.

Inova spends time educating the faculty and students about patenting technology. They teach classes to incoming students at different departments, explaining what sorts of technologies can be patented, and what sorts of articles shouldn't be published before a patent is deposited. They also visit professors at his/her laboratory to understand the research that they're doing, and see whether there is potential for patenting.

Inova is interested in bringing money into the university through the commercialization of technology coming out of the university. However, one of the challenges they face is spreading the word about their patents to attract potential licensees but as in the case of MIT, the patented technologies are at a very early stage and not yet developed enough for commercialization. They use websites, LinkIn, Slideshare, newspapers, TV and other channels for communicating about their patent portfolio. There isn't a large investor community in Brazil so they don't have many investors looking into their portfolio.

In terms of the other activities of Inova, the Unicamp's Scientific and Technological Park, located on the campus, was created in 2010 and is administered by the Inova. Currently, it has 350 thousand m^2, with 100 thousand m^2 of urbanized area already available for construction of new buildings. Pre-incubated and incubated technology-based companies and company laboratories with collaborative research projects with Unicamp are eligible for locating at the Park. A primary benefit to the companies located in the park is that they can employ students, as if they were paying them regular student scholarships. While companies may approach Inova about finding professors or students, they often interact directly with them and Inova's role is more like a real estate agent.

The incubator was created in 2001 and incorporated in Inova in 2003. It is also located at the campus and has around 20 incubated companies and more than 40 graduated companies. Companies can stay for up to two years and don't necessarily need to be associated with Unicamp. The companies have access to all of Unicamp; equipment, researchers, whether they're associated with Unicamp or not. There are two Inova staff that work with the Tech Park and Incubator.

Thus, the Unicamp model for supporting innovation and entrepreneurship is more centralized than MIT, organized under one umbrella, Inova, and engages in significant interaction with industry and startups not just through research, patenting and licensing, but also through the provision of physical space and access to university resources. This no doubt creates synergies between the different set of activities and helps with the funding of them, whereas at

MIT, each of the entrepreneurial organizations (Deshpande, Ventor Mentoring Services, Martin Trust Center for Entrepreneurship) determines its funding separately. They rely significantly on private donations by alumni and must conduct rigorous evaluations of their work annually to make the case for additional funding.

6. Conclusion

As stated from the outset, these two cases are very different one from the other for a number of reasons including their histories, disciplinary emphases and funding structures. Nevertheless, they are each a the leading institutions of higher learning in their respective countries, both actively pursuing partnerships with industry in applied research as well as commercialization pathways. A comparison between them is not meant to compare them like for like, but rather to set them on a continuum with respect to these two dimensions of translational work.

The cases have highlighted several important points.

1) Autonomy, Discretion and Liability

First, as is evident in the case of negotiating university-industry sponsorship agreements, greater autonomy and discretion is given to the PI and OSP leadership at MIT than to the PI and others at Unicamp. While in many cases, essentially three people can sign off on an industry partnership agreement at MIT (the PI, the department financial officer and an OSP officer), the Unicamp system involves not just the PI, but three separate committees, who are reviewing both the terms of the agreement and the nature of the research as well. This may be tied to the question of liability at Unicamp, which can rest with an individual, whereas at MIT, the institution is liable for any breach of contract.

2) Bureaucracy

This lack of autonomy and discretion necessarily leads to a more bureaucratic process, which slows down negotiations. By increasing the number of approvals that are needed, by individuals and committees, a cumbersome process is created creating what one academic called a “management” problem. As we heard from one international multinational company, negotiating successful contracts with a Brazilian university takes a long time, and equally, contracts that don’t transpire take a long time to fail as well.

3) Incentives Around Patenting

Another issue that needs further attention is the issue of patenting. Brazil made a significant effort to increase its patenting output, though it still remains far behind other comparable countries. Beginning this century, with the passage of the Innovation Law in Brazil, academics were encouraged to patent (one patent was equivalent to 1.5 publications according to the rankings done by CNPq) and TTOs were set up to facilitate this. However, almost 15 years later, it is possible that the focus on patenting has created a bottleneck. Less than 10% of Unicamps total patents have been licensed (compared to on average 30% at MIT). Industry and other research partners suggest that patent negotiations with universities can be cumbersome. As was stated earlier, a stockpile of patents that are not licensed is “the worst outcome” because of the cost and the tying up of technology. Patenting without a transfer to the marketplace misses the ultimate goal. At the same time, Brazil has fewer of the startups and smaller companies that tend to license this technology at MIT so potentially has fewer potential licensees for its patents.

4) Entrepreneurial Ecosystem Organization

Finally, it is worth reflecting on how innovation-related and entrepreneurial efforts are organized at both institutions. MIT’s model is highly decentralized with over 80 different organizations, most of which stand independent of one another. Unicamp’s more centralized model under Inova clearly has benefits in terms of synergies and coordination. At the same time, it may also exacerbate bureaucratic tendencies. The separate entities at MIT underscore the vibrancy of entrepreneurship on campus, but also create a highly fragmented ecosystem in which many key organizations in the ecosystem are required to raise funds independently and are not coordinated in their efforts.

This paper has touched upon some of the key factors that influence tech transfer between universities and industry and how they differ in two different institutions in a developed and emerging economy. Further research could shed more light on the tensions and questions raised in this paper by looking more closely at actual partnerships, how they are structured and how they progress over time.

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