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Authors

Jefferson, David J
Maida, Magali
Farkas, Alexander
[et al.](#)

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Technology transfer in the Americas: common and divergent practices among major research universities and public sector institutions

David J. Jefferson¹ · Magali Maida² · Alexander Farkas¹ ·
Monica Alandete-Saez¹ · Alan B. Bennett¹

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Abstract The present article presents the results of a qualitative study whose purpose was to compare the structure and operation of the programs for intellectual property management and technology transfer, and the mechanisms through which to foster entrepreneurship, in five high-profile research institutions across the Americas. The institutions of focus included Stanford University and the University of California, Davis in the United States; the Universidad Católica and the Universidad de Concepción in Chile; and the National Scientific and Technical Research Council in Argentina. The purpose of the study was to elucidate commonalities and differences among these institutions with respect to their technology transfer practices, and to distill methodologies that could be used to establish or refine technology transfer offices in American regions. Research revealed common goals and core activities, shared and implemented in similar ways among all five institutions. However, the analysis also identified divergent areas within the structure and operation of the various technology transfer programs, representing significant differences between the five institutions.

Keywords University technology transfer · International technology transfer practice · Intellectual property management · Entrepreneurship · Start-up creation

JEL Classification O3

✉ David J. Jefferson
djjefferson@ucdavis.edu

¹ Department of Plant Sciences, Public Intellectual Property Resource for Agriculture (PIPRA), University of California, Davis, Plant Reproductive Building, One Extension Center Drive, Davis, CA 95616, USA

² Technology Transfer Unit, Catholic University of Chile, Avenida Alemania 0211, Casilla 15-D, Temuco, Chile

1 Introduction

The performance of university technology transfer offices (TTOs) has historically been evaluated through quantitative measures. Tseng and Raudensky (2014) describe several of these conventional performance metrics, which include the number of invention disclosures received by the TTO; the number of patent applications filed; the number of granted patents obtained; TTO income (e.g., from royalties); the number of licensing agreements executed; and the number of start-up companies formed. Similarly, Friedman and Silberman (2003) evaluated several TTOs by operationalizing their practices and examining the impact of these activities on the generation of licenses and income. Multiple other studies have been conducted to quantify TTO success (e.g., O'Shea et al. 2005; Siegel et al. 2004, 2007).

Here, we sought to focus instead on a comparative analysis of the policy environments in which particular research centers from three countries in the Americas are situated, as well as the nature of the human resources associated with the efficacious TTOs located within these institutions. Our means of data collection included scrutinizing the technology transfer policies of each of the TTOs studied, reviewing case studies of technologies transferred from these institutions into the marketplace, and conducting interviews with TTO staff at all five institutions (Table 1).

The analysis described in the present article is divided into four sections. Section One focuses on the core components common to the technology transfer offices located within the institutions studied. This part also highlights certain practices such as mission definition; description of the activities in which the program may engage; and human resources required to establish the technology transfer office's team. Section Two explores two broad types of policies that institutions commonly approve and implement for the purposes of promoting innovation and facilitating technology transfer. These policies primarily included provisions for (1) management of intangible assets protected by intellectual property; and (2) navigation of conflicts of interest and commitment.

Section Three relates the institutions' practices associated with intellectual property management, marketing of inventions, and technology licensing, and analyzes key differences between the five programs studied. Finally, Section Four reviews the practices in

Table 1 Characteristics of the institutions studied

Institution	Country	Sector	Year founded	Student body size	Year TTO founded
Stanford	USA	Private	1885	16,000	1970
UC Davis	USA	Public	1908	34,000	1978 ^a
U Católica	Chile	Private	1888	23,500	2014
U Concepción	Chile	Private	1919	23,700	2012
CONICET	Argentina	Public	1955	N/a ^b	1985

^a The system-wide University of California Office of Technology Transfer was established in 1978. However, the system later decentralized and the campus-specific UC Davis technology transfer office, InnovationAccess was founded in 2004

^b CONICET is a national research institution and does not train students in structured academic programs. However, the institution has over 7800 researchers and over 9000 research fellows

which the institutions engage to foster entrepreneurship and support the creation of start-up companies, toward the end of local and regional economic development.

The results of this study could inform administrators and technology managers in universities and research institutions seeking to establish their own policies and programs for intellectual property management and technology transfer. The authors note that the establishment of a TTO should not undermine the primacy of basic research in academic institutions, nor compromise other academic activities. Indeed, technology transfer activities should complement the research and teaching missions of academic institutions. The transfer of technologies protected by intellectual property rights form only a small subset of transactions through which academic knowledge and discoveries migrate from university to society. Publications, exchange of students and faculty, consulting, conferences, research collaborations and other scholarly activities are arguably all more important than formal technology transfer (Merrill and Mazza 2010).

Nevertheless, a robust technology transfer program can bolster an institution's capacity to conduct relatively more applied research, while still supporting exploratory scientific activity. Ultimately, the observations reported in the present article could complement quantitative data on TTO performance. The hope is to provide a comparative and holistic understanding of how institutions can best commercialize their research results while remaining faithful to their academic and public interest missions.

2 Technology transfer office (tto) foundation

University and non-profit technology transfer offices (TTOs) are generally designed to mobilize academic knowledge and discovery, so that the products of scholarship and research may have a broad impact in society at large. A myriad of benefits have been attributed to successful academic TTOs, including more productive relationships between the academy and industry; greater willingness by governmental funding agencies to provide support for joint university-industry research proposals; and royalty income from license agreements covering institutional research results and intellectual property (Nelsen 2007).

However, notwithstanding the potential financial benefits derived from technology transfer, income from these activities rarely if ever generates sufficient revenue to recoup the initial investment required to conduct the research that resulted in the technologies in question. For instance, one recent survey found that over half of the United States technology transfer programs studied bring in less money than the costs of operating the program, and only 16 % are financially self-sustaining (Abrams et al. 2009). Thus, it is the "social" function of a TTO that arguably comprises its most important contribution. In this sense, an important measure of TTO success is the impact that the technologies generated in the host institution have in society at large. This impact may be difficult to quantify, but can be examined in dialogue with the vision of faculty and staff, in the context of the institution's mission.

Ideally, technology transfer offices emerge organically in response to the needs and desires of the academic and scientific community within a particular research institution. While it may be difficult or undesirable to circumscribe all forms of academic knowledge dissemination—including publications, conference presentations, and consulting—in an institutional technology transfer policy, the motivation underlying all knowledge transfer activities may be captured in the institutional mission statement.

2.1 Mission statements

The mission statement represents the concrete articulation of institutional values, based on which TTO officers decide how to best transfer technologies developed within their organization. This document should be congruent with the overarching ideals and goals of the institution. Nevertheless, it may have diverse objectives covering a range of themes, including provision of social benefit (via development of technologies for the marketplace); generation of income (via technology licensing); and economic development (via creation of start-up companies) (Nelsen 2007).

The prioritization of one or more of these objectives has a direct impact on the daily operation of a technology transfer office, as well as its policies and procedures. Prioritization of objectives should be clearly specified, in order to avoid the emergence of conflicting operational choices and policies. Discriminating primary, secondary, and even tertiary goals can enable the TTO to clearly identify its priorities and objectives, and also to clarify the metrics of success that will inform future developments (Sharer and Faley 2008).

Societal benefit and support for research are central objectives in the mission statements of all five of the TTOs studied. In addition, all institutions except Stanford explicitly emphasize the promotion of economic development in the local region or beyond as a central objective. This includes active participation in the creation of new ventures. Interestingly, revenue generation is only expressly included in Stanford's mission statement. However, interviews with personnel at the other four institutions revealed that each perceives generation of income to be a key TTO objective (Table 2).

Table 2 Excerpts from the language of the mission statements or institutional policy objectives from the five institutions studied

Institution	Mission statement/institutional objectives
Stanford	"...promote the transfer of Stanford University technology for society's use and benefit while generating unrestricted income to support research and education"
UC Davis	"...[to be a] catalyst for the creation of partnerships that advance, for public benefit, the dissemination, utilization and commercialization of discoveries made in research at UC Davis"
CONICET	"...[to] serve the public interest by providing procedures through which the results of the scientific research technology may be used by the society due to the granting of licenses or transfers of patents or other rights to intellectual or industrial property that allow transformation of these research results into innovations that aim to advance science and technology in the country, develop the national economy and improve the quality of life"
U. Católica	"...to encourage and assist faculty to increase the applied research made at the University; to promote, facilitate and enhance the identification of research results and creative work with transferable potential; and to protect and transfer those research results and/or creative work to companies willing and able to evolve them into commercial products or services which can be later transferred to the public"
U. Concepción	"...build upon the university's inventor and innovator base to increase the number of inventions and opportunities for commercialization, and benefit the community and the public by managing and transferring the University of Concepción's complete Intellectual Property and expertise to third parties capable of delivering new products and services to the market"

2.2 Staff

People form the core component of successful technology transfer (Vinig and van Rijbergen 2009). Because technology transfer activities are interdisciplinary in nature, a TTO must be comprised of personnel who balance technical, business, and legal skills. This is particularly important because of the diverse—and sometimes conflicting—demands that technology transfer officers must face. TTO personnel may be asked to undertake multiple tasks including scouting and evaluating inventions, drafting patent applications, marketing IP rights to potential licensees, mediating contracts between their institution's personnel and external investors, and monitoring and enforcing licensing and research contracts (Graff et al. 2002). These various activities require wide-ranging skill sets, and thus the proportion of personnel with particular types of training will influence the areas of strength and weakness of the TTO.

In addition to these specialized proficiencies, a technology transfer manager should generally be able to understand and reconcile the positions and interests of both the institution and the academic community on the one hand, and industry partners on the other (Bennett and Chi-Ham 2012; O'Kane et al. 2015). Recent research has uncovered that at least in the United States, the vast majority of OTT staff time—approximately 74 %—is typically devoted to pre-licensing and commercialization activities including soliciting ideas, evaluating inventions, and assessing the economic potential of technologies (Castillo et al. 2016). Meanwhile, licensing and commercialization of inventions consume 28 % of staff time on average, while interacting with faculty typically accounts for a mere 10 % of personnel hours. However, the same study found that the amount of time that TTO officers spend intermingling with faculty is increasing at many U.S. universities, and further linked these interactions to potential TTO success. Notably, it is important that TTO staff have sufficiently diverse technical backgrounds to relate to faculty across a range of disciplines.

The TTOs examined in the present study employ different human resource models to attain the multifaceted expertise necessary for successful technology transfer. Technology managers at Stanford and UC Davis have interdisciplinary training, with backgrounds comprising at least two of the three preferred general skill sets (i.e., scientific/technical, legal, or business). On the other hand, most technology transfer officers at CONICET, U Católica, and U Concepción have expertise in one particular area. However, in recent years the three Latin American institutions have increasingly demonstrated a preference for hiring personnel with at least two of the preferred general skill sets.

At Stanford, officers with technical skills comprise more than two thirds of total staff (67 %). Business skills are preferred secondarily (28 % of staff). The Stanford Office of Technology Licensing (OTL) has an open policy of not hiring lawyers to handle technology transfer (5 % of staff have legal backgrounds), as the licensing practice of OTL is to take risks, which may not be congruent with the training that attorneys receive (Page 2007). As a result, Stanford's license agreements are not negotiated or drafted by lawyers.

In contrast to Stanford's policies, at the UC Davis TTO—known as *InnovationAccess*—legal skills are valued above business skills: 26 % of staff have legal backgrounds, while 15 % have business training. As a public institution, the University of California prefers to take fewer risks than Stanford, and lawyers are considered essential. Communication skills, although not required, are also considered important. Notably, more than half (52 %) of *InnovationAccess* personnel have technical backgrounds.

CONICET, the Argentinian institution, does not prescribe a specific skill set for its personnel. CONICET prefers to pair lawyers with staff trained in business to negotiate and

execute technology transfer agreements, while employees with technical skills and intellectual property training manage IP issues and elaborate the technology portfolio. Staff members with business training are in charge of conducting market analysis and marketing technologies, and communication skills are valued for all TTO personnel. Overall, CONICET employs a balanced approach, with 37 % of staff having legal backgrounds; 37 % technical; 13 % business; and 13 % other forms of training.

At U. Católica in Chile, business (50 %) and technical (38 %) skills are preferred over legal skills (6 %). While officers with technical backgrounds or expertise in IP-related issues conduct IP assessment and management, staff with business and technical backgrounds coordinates extramural funding and knowledge transfer efforts. At the time of writing, only one officer with both legal and business training formed part of the U. Católica technology transfer team.

Finally, in U. Concepción's Technology Transfer Unit (TTU), technical skills (57 %) are strongly favored over legal (15 %) and business (14 %) skills. Similar to Stanford's OTL, U. Concepción's TTU does not involve lawyers in technology transfer agreements. A lawyer is, however, in charge of the Intellectual Property Unit (UPI), which oversees the TTU at an administrative level (Fig. 1).

2.3 Institutional structure

The position of the technology transfer office within the institution's administrative structure can have a substantial impact on the ability of the TTO to fulfill its technology transfer objectives (Bercovitz et al. 2001). The situation of the TTO within the institutional "hierarchy" reflects the importance that the institution intends to place on technology transfer activities, and can determine the degree of autonomy that the TTO enjoys. In some

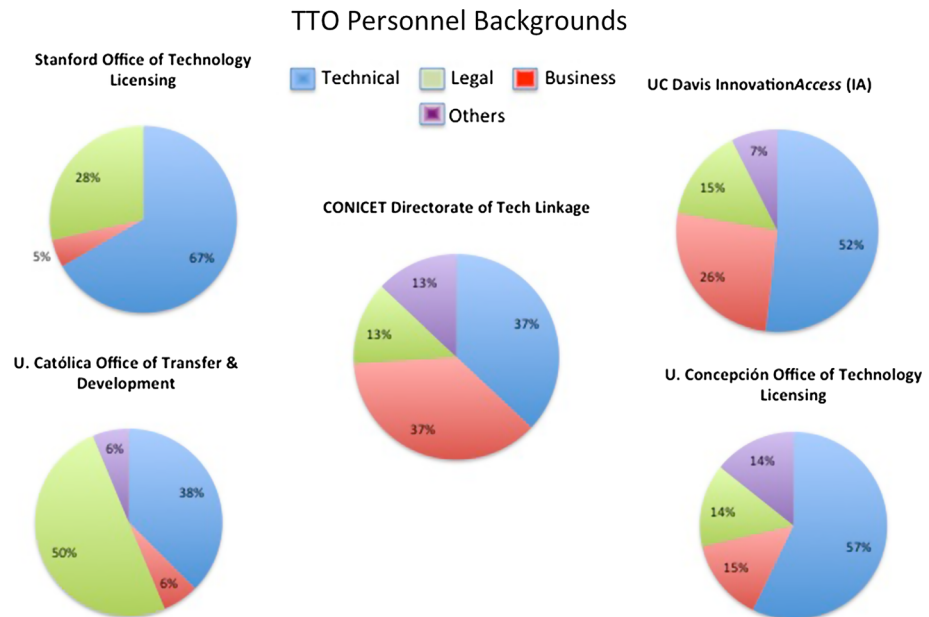


Fig. 1 TTO personnel backgrounds at the 5 institutions studied

cases, the level of financial support that the institution provides to the TTO can also be affected as a result of the program's position in the organizational structure. There is no one formula for how to configure a research institution and its various administrative units, but in all cases the TTO should be structurally endowed with sufficient access to human and financial resources.

Four of the five TTOs studied are organized under their institution's Office of Research. This is consistent with the position of most university TTOs in the United States (Abrams et al. 2009). The exception is CONICET, whose technology transfer office reports directly to the Vice President for Technology. CONICET recently reorganized its internal operations to connect the TTO more directly with the overall institutional management structure. The motivation behind the reorganization was to provide the TTO with greater institutional support, while simultaneously fostering linkages between the program's technology managers and CONICET's researchers.

The situation of the TTO within the institution's Office of Research establishes a clear and direct linkage between the basic and applied science developed therein, and the transmission of research results into commercializable products. Furthermore, given that an institution's research programs comprise the first step in all technology transfer activities, we recommend that TTO offices be located physically proximate to research facilities and personnel. Proximity enables a more fluid relationship between TTO officers and the academic scientific community (Phan and Siegel 2006). Thus, the TTO may gain visibility, and program personnel can "walk the halls" and converse informally with researchers. These interactions may result in personal relationships, which according to several of the personnel we interviewed form a fundamental part of the academic culture in all three countries studied. New TTOs, as well as established offices, should consider that even the best initiatives might fail if researchers do not feel included or believe that the administration does not understand their needs. The academic research community is the "heart" of a technology transfer office, and without its allegiance even the best program may be unlikely to succeed.

3 Institutional policies for intellectual property management and technology transfer

3.1 Intellectual property policies

Institutional intellectual property (IP) policies delimit the parameters for how technology transfer will be realized, while ideally minimizing associated delays and costs. These policies should be consistent with relevant national legal frameworks, international treaties, and the institution's own priorities and mission. Several key issues are frequently addressed in institutional IP policies, including the types of rights covered; ownership of rights; individuals subject to the policy; obligations of the institution and its staff; and management of conflicts of interest and commitment (Kowalski 2007).

All five institutions studied have approved and implemented IP policies and regulations, which include the key issues summarized above. Among these institutions, Stanford and UC Davis have the most elaborate policies and regulations related to IP management and conflicts of interest and commitment. Nevertheless, all institutions clearly identify the categories of IP rights covered in their policies and the different criteria used for managing the various categories of rights. The Latin American institutions tend to employ a single,

comprehensive policy to manage all forms of IP that could result from scholarly and research activities (e.g., copyrights, patents, trademarks, etc.). In contrast, Stanford and UC Davis maintain separate policies for patents, copyrights, and trademarks.

Various individuals may be subject to an institution's IP policy, based on their position at the institution or the source of funding for their research. Faculty, staff, students, doctoral and post-doctoral fellows, visiting faculty, employees, and persons acting under contract are all possible subjects of the institution's IP policy. Alternatively, individuals with obligations under an IP policy may be defined based on participation in research projects affiliated with the institution or use of institutional funding and/or facilities, rather than based on employment. Often, individuals subject to institutional IP policies fall into both categories. Among the institutions studied, Stanford, UC Davis, CONICET, and U. Católica combine both criteria to identify the individuals subject to their IP policies. U. Concepción alludes only to employment situation.

The ownership of the IP rights associated with inventions generated within an institution may be granted to various persons and/or entities. Ownership could be vested in the inventor as an individual, or with the research institution providing resources and facilities to the inventor, or the company or government agency providing research funding. A further option is that inventions are not protected at all, but rather are released directly into the public domain. Thus, institutional IP policies should explicitly identify the owner(s) of the invention and how IP generated within the institution will be managed (Fig. 2).

The World Intellectual Property Organization (WIPO) recommends that research institutions, regardless of their funding sources, own inventions and related IP rights in order to facilitate the management thereof (WIPO 2015). The IP policies of Stanford, UC Davis, U. Católica, and U. Concepción are consistent with the WIPO recommendation, stating that the institution owns all inventions and related IP rights. CONICET's IP policy, on the other hand, specifies CONICET as the owner of only the results of research performed with CONICET funding. However, according to TTO staff, at the time of writing CONICET had claimed ownership over all inventions created by its researchers, regardless of funding source.

All five institutions studied include in their policies the obligation of inventors to disclose all potentially patentable inventions. Furthermore, all five institutions specify that researchers must assign all rights, title and interest over their inventions to the institution, and sign all documents necessary to implement the assignment. However, it is notable that the language of Stanford's assignment agreements affords researchers more flexibility in placing new inventions into the public domain than the other four institutions studied. Stanford researchers are granted the latitude to make their inventions publicly available so long as doing so does not compromise Stanford's interests or those of any relevant third parties.

None of the five institutions studied obligates individuals subject to its IP policy to actively collaborate with the technology transfer office. However, according to TTO personnel interviewed, all institutions prefer that inventors play an active role in all phases of the technology transfer process. Furthermore, all five institutions specifically enumerate



Fig. 2 Initial stages of the technology transfer process

other obligations in their IP policies, which include the responsibilities that the institution has towards its researchers, and vice versa.

For instance, the TTOs at all five institutions are responsible for the protection of inventions and effective IP management, and these responsibilities are conveyed in their respective IP policies. However, each institution employs different criteria for deciding whether or not to pursue IP protection of disclosed inventions. At Stanford, the inventor has the choice whether to disclose the invention. Once disclosed, Stanford decides whether IP protection should be sought. By contrast, at CONICET, U. Católica, and U. Concepción, the institution decides whether or not to protect the invention and makes all decisions related to IP management. UC Davis officially abides by an analogous policy, but—according to interviews with TTO staff—in practice the inventor's preference is decisive in determining whether to pursue IP protection.

Of particular interest to researchers is the share of revenue they may receive as inventors of patented and commercialized products. A commonly cited principle is that 100% of royalty revenue should inure to the institution until all out-of-pocket expenses associated with protection and exploitation of the invention have been reimbursed (Friedman and Silberman 2003). Subsequently, the inventor's share can vary widely from institution to institution, but in U.S. universities this amount is typically between 25 and 50 % of net revenue after expenses (Siegel et al. 2004). Finally, remaining income is shared between the organization and any other stakeholders that it may identify.

Stanford and UC Davis have similar formulas for calculating shares of revenues, with one third of net benefits distributed to the inventors at both institutions. At the Latin American institutions, a substantially larger share of benefits is shared with researchers. Specifically, CONICET, U. Católica, and U. Concepción all distribute 50% of royalty revenues to inventors, either before or after costs are subtracted. This practice may be indicative of a general tendency in more recently established TTOs to initially share a relatively larger proportion of benefits with inventors, in order to motivate them to participate in the technology transfer process. Indeed, generous benefit sharing provisions have been shown to induce greater involvement in invention disclosure and technology transfer activities (Weckowska 2015). Once such participation is achieved, the share of benefits may be reduced, though doing so could obviously result in tension between an institution and its researchers.

In some cases, an institution will decide not to protect an invention and, provided there are no third party rights involved, it might offer inventors the opportunity to protect and own their inventions privately. In such situations, the institution may still reserve certain rights over the invention and resulting IP for research, humanitarian, or other purposes. The IP policies at Stanford, UC Davis, CONICET, and U. Concepción all mention the possibility of assigning rights associated with an invention to the inventors upon university refusal to proceed with IP protection. UC Davis and CONICET go on to specify that their institutions will retain a royalty-free, non-exclusive license to the invention and any related IP rights in the event that the invention is assigned to its inventors.

3.2 Conflict policies

A conflict of interest (COI) is any situation in which there tension exists between an individual's private interests and his or her professional obligations, such that an independent observer might reasonably question whether the individual's professional actions or decisions are affected by his or her private interest (Chin and Kulakowski 2006). Meanwhile, a conflict of commitment (COC) takes place when there is a potential for a

conflict between the institution's primary educational and research mission, and its interest in supporting technology transfer and economic development (Callaert et al. 2015). The existence of a conflict only indicates the potential for making biased decisions, not any likelihood of doing so or *a priori* misconduct (Bennett 2007).

At the time of writing, only three of the five institutions studied had implemented policies covering the identification and management of conflicts of interest and commitment. These institutions are Stanford, UC Davis, and U. Católica. Each addresses conflicts differently. While Stanford has implemented a single policy for COIs and COCs, the University of California addresses each type of conflict separately, and has additionally issued specific policies for managing conflicts associated with the licensing of technologies. Similar to Stanford, U. Católica has recently issued a single policy for conflicts of interest and commitment. Finally, it is notable that CONICET has a policy for the creation of start-ups that includes provisions for the declaration and management of COIs/COCs, but the policy only applies to this limited context. At the time of writing, both U. Concepción and CONICET were in the process of elaborating comprehensive conflict of interest and commitment policies.

Regardless of the form that they take, conflict policies should be consistent with relevant legal and regulatory frameworks. For instance, as public officials, University of California employees are subject to the California Political Reform Act of 1974. This means that they should perform their duties without bias attributable to personal financial interests, and should disqualify themselves from participating in decisions when they have conflicts of interest. The presence of a personal financial interest in the outcome of a decision could constitute a conflict of interest with criminal penalties. The institutional policy at UC Davis specifies that investigators must complete financial interest disclosures whenever a sponsored project is proposed, including consulting income from the sponsoring entity. Furthermore, other financial interests such as equity, other income, and gifts from research sponsors must be divulged and reviewed by a university Conflict of Interest Committee. As a public institution, UC Davis' policies are strict.

CONICET employees are also considered public officials and are therefore are subject to Argentinean laws on management of ethics in public institutions, specifically the Code of Ethics for the Public Sector (Decree 41/99). This legal framework establishes prohibitions against certain actions, as well as the duty of public officers to disclose conflicts. In the event that a conflict of interest is found, the public officer must recuse him or herself from the situation giving rise to the conflict. Failure to comply with these provisions may result in criminal liability.

Employees of Chilean public institutions are also subject to strict regulations on public service ethics. However, U. Católica and U. Concepción are private entities, so their researchers are not subject to those laws. Thus, the policies of the Chilean universities studied are relatively lenient. Similarly, although Stanford is based in California, USA, as a private institution its employees are not subject to the laws of that state governing conflicts of interest for public officials. In the context of conflict policies, leniency may be understood as institutional guidelines whose language is less specific and instead more reliant on the principle of reasonableness. For instance, Stanford requires disclosure of personal financial relationships or activities with outside entities that would reasonably appear to be related to a faculty member's institutional responsibilities. Such potential conflicts are evaluated by the university based on a common sense understanding of whether an independent observer might reasonably question whether the individual's professional actions or decisions would be determined by considerations of personal financial gain. Another significant difference between conflicts of interest that may arise in public versus

private institutions located in jurisdictions such as the State of California is that in the former context, impropriety may be punished by criminal sanctions imposed by the government, whereas in the latter violations of conflict policies would only be subject to institutional administrative penalties.

As a final consideration, conflict of interest and commitment policies should also be consistent with any requirements and restrictions imposed by the government agencies that fund research within the institution. For example, in the United States, researchers participating in projects involving human subjects research sponsored by the Public Health Service (PHS) or the National Institute of Health (NIH) are required to complete an online training on conflicts of interest before any funds can be released for expenditures, as well as to file a Statement of Economic Interests. At the time of writing, Argentinean and Chilean funding agencies did not impose similar requirements.

4 Ip management and technology licensing

Given resource limitations, technology transfer offices typically only choose to invest in IP protections for inventions that appear to have both commercial value and substantial social impact. The procedures and internal criteria used for the evaluation of inventions vary from one institution to another depending on the priorities, mission, policies, and structure of each institution's TTO. However, consensus generally exists surrounding certain common steps, which include (in chronological order): invention disclosure; invention evaluation; definition of IP strategy; and filing for IP protections.

4.1 Invention disclosure and evaluation

All five institutions use standardized invention disclosure forms as the initial step to learn about new inventions. In addition to these forms, some of the TTOs studied utilize other mechanisms to identify inventions. Additional means to identify new inventions include review and revision of applied science project portfolios, visits to laboratories, and personal interviews with researchers. CONICET, U. Católica, and U. Concepción utilize these types of complementary mechanisms in order to strengthen the link between the TTO and the academic-scientific community, as well as to identify possible inventions early in the inventive process. For example, the U. Católica TTO regularly conducts screenings in its research departments in collaboration with faculty, to identify research projects with commercial potential (Table 3).

The evaluation process for a potentially commercializable invention usually involves conducting analyses to determine: (1) whether the invention meets the requirements necessary for IP protection (often referred to as “patentability”); and (2) whether the invention has commercial potential (“marketability”) (Wu et al. 2015). All five institutions conduct these analyses of patentability and marketability during the process of invention evaluation. However, there are some differences in the ways these analyses are performed, and also in the timing of when each analysis occurs.

For instance, the two U.S. institutions studied consider both patentability and marketability as key elements for in-depth analysis. Thus, assessment of patentability, inventorship, obligations to research sponsors, and commercial licensing potential, including distribution channels for a disclosed invention, are all evaluated. In contrast, the three Latin American institutions have traditionally based their analyses primarily on

Table 3 Institutional invention disclosure procedures

Institution	What must be disclosed?	Who must disclose?	To whom to disclose?	When is disclosure required?
Stanford	All potentially patentable inventions first reduced to practice in whole or in part in the course of University responsibilities or with more than incidental use of University resources	Inventors who are members of the faculty or staff, including student employees.	The University (Office of Technology Licensing)	“On a timely basis” following the conception or reduction to practice of any potentially patentable invention
UC Davis	All potentially patentable inventions conceived or developed while employed by the University or while using any University research facilities or gift, grant, or contract funds	University employees, persons not employed by the University but who use its research facilities or gift, grant, or contract funds	InnovationAccess (the UC Davis TTO)	“Promptly” following the creation of a potentially patentable invention. Ideally, before it has been published or publicly presented
U Católica	Any creation, discovery, or invention, with the potential to be patentable or protectable through intellectual or industrial property	Members of the University community or persons who participate in activities or projects in any of the University’s departments	The Projects and Innovation Director within the Vice-presidency of Research and Doctorate Studies, and the Dean of the corresponding Faculty	As soon as possible, prior to any publication or diffusion of the relevant work
U Concepción	Any technology susceptible to intellectual or industrial property protection developed by faculty or staff on their own, or as part of their academic or research work	All faculty or staff of the University, including contractors, who develop a technology susceptible to intellectual or industrial property protection on their own, or as part of their academic or research work	The Intellectual Property Committee (organized under the Presidency of the University, and containing 5 members)	Not specified

Table 3 continued

Institution	What must be disclosed?	Who must disclose?	To whom to disclose?	When is disclosure required?
CONICET	The results of research and development including patentable inventions, creations protectable as utility models, drawings or designs protectable as industrial designs, computer programs, cultivars protectable with plant breeders' rights, multimedia works, databases, and web pages, know how, created or modified biological material with commercial value, and any other creation not protectable with IP but with commercial value	Researchers, contractors, support staff, scholars, or technical-administrative personnel who generate or participate in the production of the results of research and technological development	The Directorate of Technological Linkage	Within a period of no more than 60 days upon receiving knowledge of technically or scientifically novel results

patentability considerations, including assessment of inventorship, obligations to research sponsors, and prior art search. In these institutions, marketability studies are most frequently postponed until deciding whether to file a foreign application or a PCT application, and depending on available funds. Interestingly, U. Católica has recently implemented an invention evaluation worksheet, which is used to determine commercial potential of inventions, typically after filing the first (national) patent application.

4.2 IP protection strategy

Depending on the results of the patentability evaluation, TTOs decide whether to proceed with the protection of the invention and, if so, to what extent and in which territories. The two U.S. universities employ comprehensive strategies for filing patent applications, and expressly include funding for patent filings in their annual TTO budget allocations. In the United States, initial filings frequently take the form of U.S. provisional applications, which have lower associated costs and fewer requirements than utility patent applications, but still secure the earliest priority date possible. Provisional applications are then converted into non-provisional U.S. patent applications only if an outside organization has expressed interest in licensing the invention.

In certain circumstances, the North American institutions might file full U.S. utility patent applications in the absence of a defined licensee, such as when there is a strong market opportunity, or based on an expert's advice that the invention is commercially viable. In such cases, the IP officer involved in patent prosecution would reevaluate the commercial potential of the technology when an office action from the patent office is

mailed. In most cases, international/foreign applications are not filed unless there is an actual licensee to cover the costs of prosecution. In the rare case that an international application via the Patent Cooperation Treaty (PCT) is filed without initially identifying a prospective licensee and no licensee is later identified, the application will most likely not enter into downstream national-phase filings.

The three Latin American institutions employ similar strategies as their North American counterparts. As a general rule, these institutions first file a national patent application in their respective countries given the relatively low cost associated with this filing, followed by a PCT application. Notably, Chile is a member of the PCT, while Argentina is not. As a result, CONICET is unable to utilize the administrative efficiencies of the PCT system, though the institution could nevertheless file separate applications in the national territories it would deem relevant as part of an international patent prosecution strategy. Interestingly, Argentinian research institutions, including CONICET, often collaborate with international research partners who are members of the PCT to jointly file a PCT patent application for technologies whose target markets are international.¹ Regardless of the approach that institutions might take, it is common in all three of the countries studied for expenses associated with patent protection to be covered either by government subsidies or by the institution itself, unless the invention is a result of a sponsored research contract.

Once the IP protection strategy has been defined, at all five institutions TTO staff oversee the drafting, review and revision, and submission of the patent application to the appropriate patent office. TTO officers also supervise all subsequent patent prosecution until either the patent is awarded or the application abandoned. However, the inventors, outside patent attorneys, and other external actors may also actively participate in this process.

Each of the five institutions defines these participants' roles differently. For instance, at Stanford and UC Davis an outside attorney drafts the initial patent application, which is then reviewed and revised by a TTO officer—or in some instances the inventor herself—and subsequently filed by an outside attorney. Similarly, at CONICET and U. Católica, an outside attorney most frequently drafts the initial application, though in some cases a CONICET TTO officer will be responsible for generating this document. Subsequently, the practices of these two institutions diverge, in that the final application is filed by a TTO officer in the case of CONICET, and by an outside attorney for U. Católica. Finally, at U. Concepción a TTO officer drafts the initial application, which is reviewed by the inventor and then filed by the same TTO officer. These varying strategies are the result, in part, of the different realities in each institution, surrounding for instance the volume of invention disclosures, the diversity of research conducted by the institution, the maturity of the TTO, and the amount of funding allocated to the technology transfer program.

4.3 Marketing of inventions and technology licensing

The goals of the marketing phase of the technology transfer process are to bring motivated parties to a license negotiation (Keiller 2007) and also to mitigate potential conflicts of interest. To this end, academic TTOs will commonly attempt to identify potential fields of application, users, and possible partners for their technology portfolio. This is fundamentally a self-interested analysis, as one of the primary objectives of the technology transfer process is to receive the maximum benefit—for both the institution and the

¹ In order to file a PCT application, at least one of the applicants must be member of the Patent Cooperation Treaty.

inventor—in exchange for the value conveyed. An additional and fundamental consideration is the generation of societal impact that the transferred technology could beget in a variety of contexts. However, this latter consideration may be difficult to gauge *ex ante*, given that such impact will only manifest when and if the technology reaches the market.

Technology transfer offices seeking to market inventions in their portfolios will frequently conduct market analyses, by collecting information about the technology of interest, its associated market(s), and potential candidates interested in developing the invention into a commercially viable technology. It is also important to understand the technical aspects of the invention, its advantages in comparison to alternative technologies, and any products and services that could represent potential competitors. To begin gathering information pertinent to marketing an invention, some institutions require that inventors complete a marketing information sheet in addition to the invention disclosure form (MacWright and Ritter 2007). Conducting a market analysis provides insights about the market's size, characteristics, and requirements, which will guide TTO officers on how to advertise and disseminate their institution's technologies.

All five institutions conduct in-house market analyses for most of their inventions. Generally, information is first obtained through an invention disclosure form. Further details may be garnered by interviewing inventors and by conducting online searches to determine the type, size, and characteristics of the specific market for a given technology, as well as to identify potential stakeholders and any competitor technologies within that particular space. The institutions' most common sources of information are open-access search engines and public databases—with the exception of CONICET and UC Davis, which have access to proprietary databases—and publications available online. The market analysis will be conducted by external collaborators only where funding has been specifically allocated for that purpose, or when an invention's commercial potential justifies a more exhaustive analysis than can be conducted in-house.

Once market information has been gathered, a non-enabling, non-confidential abstract describing the invention will typically be drafted and used to “enter” the invention into the commercial sector. This document is characteristically addressed to a non-specialist audience, and therefore will usually contain very limited technical data (MacWright and Ritter 2007). All five institutions include non-confidential abstracts in their technology portfolios, and use them to advertise their inventions among commercial entities.

Generally, TTOs attempt to market and advertise their technology portfolios as openly and broadly as possible during their searches for potential licensees, in order to avoid favoring certain parties over others. For instance, Stanford and UC Davis have policies to market all technologies broadly (combining direct and indirect marketing strategies) before they grant an exclusive license. The three Latin American institutions recently added indirect marketing as a complementary tool to their existing direct marketing approach, though they do not adhere to the same policy as Stanford and UC Davis surrounding the grant of exclusive licenses. This may be due to the fact that the Latin American institutions do not typically experience the same magnitude of demand for their technologies as the U.S. institutions.

All of the institutions employ similar direct marketing strategies. These consist of sending e-mails, making phone calls, and organizing showcase meetings with the primary market stakeholders—including potential technology licensees, university start-ups, and alumni investors, among others. Stanford, for example, identifies approximately ten companies and extends a direct offer to each, while simultaneously conducting mass marketing of the same technology.

Indirect marketing strategies vary among the institutions studied. Stanford utilizes the Techfinder search engine and participates in technology scouting events. UC Davis leverages social networks and search engines such as the iBridge.Network (www.ibridgenetwork.org). In addition to participating in events, CONICET convenes “missions” to advertise their technologies to potential licensees. Finally, U. Católica advertises new inventions in newsletters and journals, while U. Concepción relies primarily on its TTO’s website, as well as social networks to promote the technologies generated within the institution.

4.4 Potential licensee selection

Evaluating companies as potential licensees involves at least four key questions: (Keiller 2007)

1. Does the technology fit the company’s needs?
2. What is the company’s timeline for developing the product?
3. Does the company have the budget to develop the product?
4. Would the technology compete with other priorities in the company’s development plan?

In order to address these questions, institutions typically request development and commercialization information related to the technology for which a license is being requested.

UC Davis provides a “Commercialization Information Request Letter” to interested parties, which clearly explains that UC Davis’ main goal is to select a company that may effectively and promptly transfer the technology to the marketplace. Interested companies are evaluated based on financial stability, ability to commercialize the technology, the university’s technology transfer objectives, and interest on the part of other companies in licensing the technology. This letter is accompanied by a “Commercialization Information Worksheet,” in which the university requests that the prospective licensees provide answers to specific questions regarding the company’s intentions and abilities to bring the technology to market.

Stanford has a guide called the “New Company Outline Prospectus” which outlines the invention and its advantages, and then requests information about the company, its technology development and marketing strategy, its business development plan, and a risk analysis. This guide is used when analyzing potential exclusive licensees. For well-established companies, a development plan and projected sales numbers are required. In this case, the institution compares the requests received, selecting the company or companies that are most committed to and capable of bringing the technology to market. According to interviews with TTO staff at the institution, Stanford does not look for the best company per se, but rather the best “home” for the technology.

The three Latin American institutions recently adopted commercialization information request protocols, which interested companies should complete. Nevertheless, the commercialization strategies for each individual technology are still evaluated on a case-by-case basis. The TTO officers whom we interviewed attributed the need for case-by-case evaluation to the general reluctance of companies in Latin America to provide commercialization information. On some occasions, the Latin American institutions negotiate licensing agreements absent information related to invention development and/or commercialization. However, CONICET recently began to require that companies provide an appropriate development and business plan, including a schedule of activities and

milestones, as well as guarantees that the company has the capacity to achieve the set milestones on its own or by partnering with third parties.

4.5 Closing the transaction

Once the parties have decided to proceed with a license agreement, each side will likely appoint members to its respective negotiation team. Negotiators may include persons with legal, financial, or other areas of expertise, and at least one attorney will typically be present on each team (Giorando-Coltart and Calkins 2007). However, an unusual case is that of Stanford: since no lawyers are involved in the licensing process, the assigned licensing associate conducts all negotiations and finalizes the transaction without any legal assistance.

Before entering into the license agreement, a “termsheet” may be employed to enumerate the major issues that are expected to arise in the negotiations. This document represents a straightforward way to discuss key areas of concern without needing to wade through paragraphs of boilerplate language. By stating both parties’ primary objectives at the outset, it may be easier for each to consider the needs of the other throughout the negotiation process (Mahoney 2007).

Rather than offering a universal termsheet for all technology fields, Stanford has drafted a Standard Operating Procedure (SOP) for license agreements. This protocol specifies that its OTL must internally define the desired financial terms, the best alternative to non-agreement, and the walk-away conditions for each type of license agreement (i.e., non-exclusive, field exclusive, or exclusive), prior to commencing negotiation with the selected potential licensees. The licensing associate considers these steps when drafting the termsheet. Stanford also offers “Ready-to-Sign Agreements,” which are template contracts with standard terms and conditions, tailored specifically to particular technology sectors. Interestingly, these Ready-to-Sign Agreements are based on actual licenses granted by Stanford’s OTL to external licensees (Table 4).

Like Stanford, UC Davis also offers form license agreements for particular technology fields, known as “Express Licenses.” However, unlike Stanford’s practice these express licenses are not expressly based on real technology transfer cases undertaken at the University of California. Meanwhile, UC Davis requires agreement on essential issues prior to drafting the license agreement, which may often be negotiated by the parties in a termsheet. Key terms include the type of license to be granted, the ability to sublicense, the type and amount of compensation, the rights retained by UC Davis, and compliance

Table 4 Institutions’ use of template documents to facilitate negotiations

Institution	Termsheets	Ready-to-sign agreements	First license meeting agenda	Guiding principles document	Sample agreements
Stanford		X	X	X	X
UC Davis	X	X			X
U Católica	X				
U Concepción	X				
CONICET	X				

milestones. Once the termsheet has been agreed upon, UC Davis licensing officers include its provisions in a Standard License Agreement, which might require further negotiation surrounding other clauses.

Stanford's OTL has also created two additional template documents, including an outline of the main points to address during the first licensing meeting, and the so-called "Streamlining Negotiations with OTL," which explains the current fundamental considerations of the Stanford technology transfer office, for the purpose of facilitating negotiations.

Template agreements were not yet considered standard practice among Latin American institutions at the time of writing. Nevertheless, over the past several years CONICET, U. Católica, and U. Concepción have all begun to employ termsheets as a means to accelerate the negotiation process with licensees in the private sector.

5 Creating start-ups and fostering entrepreneurship

In many cases, well-established companies may be the best licensees for technologies invented in universities and academic research institutions. Well-established companies frequently have suitable facilities for scaling-up and manufacturing, appropriate channels to market, experienced management, sufficient knowledge of the relevant industry, and networks of contacts (e.g., Stanford OTL 2012). Established businesses are also typically familiar with the key actors and processes associated with obtaining regulatory approval, if this is required for the product in question. Yet if significant time and financial investment would be required by a prospective licensee—and especially where technological risks or high market penetration exist—well-established companies may not find the technology sufficiently attractive to invest in it. This is most likely to occur in cases involving early stage or cutting edge technologies.

In such cases, the creation of a start-up company may serve as an effective alternative means of commercialization. Start-up companies take many forms and in many cases are entirely unaffiliated with academic or research institutions. Yet in the context of institutional technology transfer, start-ups may be understood as businesses created by members of the research community as a consequence of, and with the aim to commercialize, technologies developed within the research organization (Brown and Soderstrom 2007). While a well-established company might have several technologies in its portfolio and with them multiple priorities, a start-up will most likely initiate its activities with only one or a handful of technologies. As a result, the inventors themselves will often have a vested interest in the success of the licensed technologies. Given this close relationship with the inventors, the new venture will likely enjoy broad access to associated *know-how* and to detailed knowledge of the technology. Access to the inventor's *know-how* or "latent knowledge" may be quite valuable to ensure successful commercialization (Agrawal 2006).

In some of the institutions studied, the inventors' opinions about the technology are decisive for the determination of the transfer strategy. For instance and as discussed in Section II above, Stanford carefully weighs the inventor's perspective when designing the commercialization plan for a particular technology. Therefore, founding a start-up company may represent the optimal strategy in various situations, for instance where ongoing consultation with the inventors is desirable; where the inventors manifest a clear intention to engage in entrepreneurship; or where the inventors had previously created a start-up

based on a prior technology, and they now wish that the new technology be licensed to their company.

Notwithstanding the potential advantages of involving the inventors of a technology in the commercialization thereof, it is not necessarily the case that institutions will favor their faculty when granting licenses. For instance, Stanford and UC Davis both have a clear mandate as part of their institutional IP policies to market the technologies developed in their respective institutions as broadly as possible in order to choose the most suitable candidate for licensing. In other words, the North American institutions have a formal policy to not favor in-house start-ups in technology licensing, although in practice both Stanford and UC Davis strongly promote licensing to start-ups created by inventors whom they employ. In contrast, the three Latin American institutions tend to favor the independence of the researcher-entrepreneur, preferring to license to the new ventures that these researchers create. Thus, CONICET, U. Católica, and U. Concepción appear to grant licenses to start-up companies under more liberal conditions in comparison to licenses granted to well-established companies. This situation may be the result of the lack of a robust regional or national innovation ecosystem. Such an environment would include a critical mass of established private companies in a given industrial sector, which would collectively embrace a culture of public-private partnership creation by means of licensing agreements, in order to exploit new university-developed technologies.

5.1 TTO involvement in fostering entrepreneurship

Once the institutional strategy has been defined, the technology transfer office will typically determine the role that it will play in creating start-up companies. The TTO's engagement can be either active or passive.

Where the technology transfer office is actively involved in the creation of new ventures, it may engage in activities such as writing or helping to write the business plan; assisting with the incorporation of the company; locating the initial seed funding; or recruiting the management team (O'Shea et al. 2005). In contrast, where the TTO is not actively involved in the process of creating or incorporating the new company, interactions between the company and the TTO will be limited to arms-length negotiation and the eventual granting of a license for the use of one or more technologies developed within the institution. Researchers who contact the passively-involved TTO in search of support for their entrepreneurial activities will usually be directed to a business incubator, entrepreneurial centers, courses and programs, etc., which may or may not be housed within the institution itself.

The TTOs at Stanford, UC Davis, U. Concepción, and U. Católica are all passively involved in the creation of new ventures. All institutions limit their participation to: (1) providing information to entrepreneurs (e.g., Stanford Start-Up Guide, UC Davis Faculty Roadmap for Starting a Company); and (2) linking entrepreneurs to the entities or authorities within the institution responsible for entrepreneurial activities (e.g., incubator manager or person in charge of entrepreneurial programs and courses).

Unlike the other institutions studied, CONICET's TTO is in the process of becoming more actively engaged. It recently developed a policy to regulate the involvement of researchers in the creation of start-ups. According to this policy, researchers' equity participation will be supervised by the TTO and must be approved by CONICET's Board of Directors on a case-by-case basis. Approval involves filing the business plan with the TTO and disclosing information related to any other business associates (e.g., shareholders, funders). This policy also foresees the ability of CONICET to acquire a minority equity

stake in the new company, if CONICET's Board approves.² Finally, professionals from CONICET's TTO may provide guidance and assistance to researcher-entrepreneurs throughout the process of start-up creation.

5.2 Building professional networks and capacities

In accordance with their differing policies for supporting entrepreneurship, all five institutions link entrepreneurs within their communities to formal or informal professional networks. Furthermore, some of these institutions have created organizations, centers, and/or programs dedicated expressly to fostering an entrepreneurial culture.

Stanford offers advisory sessions with professional entrepreneurs to its academic community. However, a more important factor for this institution might be its geographical location in Silicon Valley. The physical environment in which an institution is located has been found to significantly influence the TTO's ability to commercialize that institution's inventions (Warren et al. 2008). Stanford's local Silicon Valley ecosystem includes an external entrepreneurship network and several entrepreneurship-oriented clubs. Additionally, the university makes a wide number of other organizations and resources available to entrepreneurs, many of which are not sponsored by Stanford itself but rather are supported by private actors who are related to Stanford in some way (e.g., alumni).

While not located physically in Silicon Valley, UC Davis offers a variety of resources to its community, such as advisory sessions with an entrepreneurship network, a Sustainable AgTech Innovation Center, an undergraduate entrepreneurship organization, and an Engineering Student Startup Center. Additional resources are provided through mechanisms at the Graduate School of Management's Child Family Institute for Innovation and Entrepreneurship.

At U. Católica, support for and strengthening of the local entrepreneurial community is catalyzed through the institution's innovation and entrepreneurship network (REDIE), the innovation and entrepreneurship program at the university's School of Administration, the entrepreneurship and social innovation laboratory, the "Emprende UC" initiative, and the UC Anacleto Angelini Center for Innovation.

5.3 Entrepreneurship-related courses and programs

Of the five institutions studied, Stanford, UC Davis, U. Católica, and U. Concepción all offer a range of courses and programs related to entrepreneurship. Although their focuses are disparate, the overarching objective of these initiatives is to educate students surrounding the abilities associated with entrepreneurship and innovation. As with other strategies for fostering entrepreneurship, the courses and programs offered by the five institutions frequently endeavor to link participants with networks of professional entrepreneurs and investors.

Stanford convenes a wide variety of classes on entrepreneurship, housed throughout university department, as well as in its professional schools. Other course offerings include

² In some instances, a research institution may elect to acquire an equity stake—usually in the form of shares of stock—in a start-up venture. Such active participation in the creation of new businesses can significantly enhance both financial and non-financial benefits to the institution. However, equity acquisition also increases the institution's exposure to various financial, legal, and ethical risks, including possible impact on tax-exempt status; creation of taxable, unrelated business income; exposure to legal liability; and creation of conflicts of interest and commitment (Brown and Soderstrom 2007).

a class entitled “Entrepreneurial Design for Extreme Affordability,” in addition to the “Lean Launchpad,” and the Stanford Technology Venture Program.

UC Davis also provides multiple programs, courses, and specific activities related to entrepreneurship. These include the UC Entrepreneurship Academy, the Business Development Certificate Program, the Ignite Conference, the Biomedical and Engineering Entrepreneurship Academy, and the Ag Innovation Entrepreneurship Academy.

Similarly, U. Católica offers the possibility to obtain academic formation in the areas of entrepreneurship and innovation. These activities occur both within individual departments (i.e., engineering, administration, business, etc.), and as channeled through specific initiatives. For instance, the program “Do Future” provides support in the form of events, talks by experts, and access to a professional network.

Finally, U. Concepción houses a Program for Support and Development of Entrepreneurship, known as the “Programa Emprendo.” This initiative is structured as an academic course whose objective is the development and strengthening of entrepreneurial capacities. Thus, capacity-building activities related to conducting research, applying to graduate programs, obtaining continuing education, and locating technical assistance and consulting are all conducted under the auspices of the “Programa.”

5.4 Business incubators and accelerators

Business incubators and accelerators have become increasingly common in the past two decades as tools for stimulating local economic development. These entities provide a new company with a number of services, frequently including business planning and legal, accounting, and marketing support (Zablocki 2007). Such resources can enable the start-up’s managers to focus on running their core business, rather than spending time resolving logistical or administrative issues. None of the institutions studied runs an incubator directly through its TTO. Nevertheless, all of them host their own business incubators on-site.

At Stanford, the StartX incubator conceives of itself as an educational non-profit organization whose mission is to accelerate the development of the university’s top entrepreneurs through experiential education and “collective intelligence.” StartX provides start-ups with seed funding, free office space and legal services, and education through customized programming and on-demand experts. Stanford also runs Innovation Farm Teams (iFarms), among other entrepreneurship-related initiatives.

UC Davis houses the Engineering Translational Technology Center (ETTC), a technology incubator that primarily focuses on supporting tenure-track professors during critical stages of idea development. However, the ETTC also seeks to provide learning experiences surrounding applied technology research to students, and to encourage partnerships and collaborations with other groups on campus, like the UC Davis Center for Entrepreneurship. The ETTC further endeavors to guide researchers to legal resources provided by the university to ensure that IP rights over the inventions implicated in start-up activities are clearly defined. Additionally, in 2015 a new business incubator was launched at UC Davis in collaboration with the company HM.CLAUSE, known as the Life Science Innovation Center (LINC). This center is located off campus, and includes biochemistry, molecular biology, and chemistry lab space owned by HM.CLAUSE.

The business incubator at U. Católica, “Incuba UC,” seeks to facilitate the development of start-up businesses and to support the subsequent scaling-up of such enterprises, via access to diverse professional networks, public subsidies, and private investors. Incuba UC

also provides access to public funds and private financing, assessment, and mentoring, and access to national and international networks.

“IdeaIncuba” is an incubator for high technology businesses at U. Concepción. This program supports the development of technologies that originate both within the university, and by independent professionals and businesses external to the institution. *IdeaIncuba* backs entrepreneurial initiatives from an early stage, such as immediately after a project with commercial potential has been identified in the laboratory. Thus, the incubator provides strategic assessment surrounding business modeling, support for IP protection, access to public and private financing mechanisms, project sponsorship services, infrastructure services, and diffusion of information via the incubator’s communication platforms.

CONICET’s Business Incubator (*Incubadora de Empresas*, or IE) provides physical space to entrepreneurs, which includes wet labs, computers, and network access. Additionally, the IE offers shared facilities to its clients, to reduce the fixed costs associated with managing a business. Finally, entrepreneurs have access to legal, accounting, and financial services through the IE.

5.5 Business plan contests

All five institutions except for CONICET host contests and programs designed to develop and/or test business plans.

Stanford’s Business Association of Stanford Entrepreneurial Students (BASES) Challenge is a contest whose mission is to inspire, develop, and fund Stanford-affiliated startups by enabling teams to present their ventures to industry leaders for a share of \$100,000 in prize money in addition to mentorship opportunities. Additionally, BASES hosts other entrepreneurship-oriented competitions, such as the Frosh Battalion program for Stanford freshmen.

The UC Davis Child Family Institute for Innovation and Entrepreneurship also offers a large-scale entrepreneurial competition, the “Big Bang!” Business Competition, which awards prizes of \$10,000 and \$5,000 as well as mentorship opportunities. This contest provides a forum for the UC Davis community to collaborate, develop, and test business visions and plans. The Big Bang! further offers mentorship, team building, education, financing, and networking services to aspiring entrepreneurs.

U. Católica, through its business incubator (“Incuba UC”), offers two large entrepreneurial competitions to members of its academic community. The first is “Geek Camp,” whose mission is to identify talented information technology entrepreneurs and connect them to companies in Silicon Valley to accelerate economic development in Chile. The second *Incuba UC* competition is the High Tech Program for identifying entrepreneurs with “disruptive” projects derived from applied research.

Finally, U. Concepción also offers an entrepreneurship competition through its business incubator, known as the “Desafío High Tech.” The objective of this contest is to motivate innovative projects with high potential for growth, oriented towards the creation of new technology-based businesses.

5.6 Providing funding for new ventures

Ready access to venture capital investments is vital to the success of start-up companies, especially in capital-intensive high-technology sectors (Wyse 2007). All five institutions endeavor to link entrepreneurs with opportunities to access venture capital. Furthermore,

some of the institutions directly provide seed funding to new ventures, but these sources of financial support vary widely. This diversity is understandable, given that the institutions themselves are very different from one another in terms of their funding models, and their own access to financial capital. For instance, Stanford is a private institution with a substantial endowment. Its economic capacity coupled with a location in Silicon Valley proximate to other sources of venture capital enable Stanford to leverage substantial funds with which to support start-up businesses.

In contrast, other institutions are situated in the public sector and are more limited in their ability to access liquid funds with which to support new ventures. For example, CONICET functions as a governmental research entity organized under the auspices of Argentina's Ministry of Science, Technology, and Productive Innovation. Located between these two examples is UC Davis, which like CONICET is a public sector research institution, but like Stanford has a sizeable endowment. Given the fundamental differences in the structures and finances of the institutions studied, it is logical that each would differ in its ability to provide monetary support for new ventures.

Stanford has created mechanisms through which new ventures can pursue investment capital. For instance, the President's Venture Fund invests in early stage companies that have licensed Stanford technologies. Meanwhile, the Center for Entrepreneurial Studies at Stanford's Graduate School of Business hosts multiple student organizations through which aspiring entrepreneurs can network with mentors and venture capitalists outside of the university. One example, the Private Equity Club, fosters awareness of and interest in the private investment industry, while the Venture Capital Club links students with experienced entrepreneurs and venture capitalists by hosting small group dinners, speaking events, and workshops. Finally, Stanford Angels & Entrepreneurs (SA&E) is a membership organization that seeks to strengthen Stanford's start-up community by fostering relationships among entrepreneurs and alumni investors. Membership in SA&E is open to all Stanford alumni and affiliates.

Meanwhile, the University of California recently announced the creation of UC Ventures, a dedicated independent fund with \$250M in initial funding, whose purpose will be to support enterprises born out of research at the University of California (2014). UC Ventures is designed to invest in commercial opportunities arising out of the UC system as a whole, without using any monies derived from tuition or state funding. Instead, the fund will be seeded with money from the UC endowment (University of California 2014). Additionally, various specialized resources exist at the UC Davis campus to assist entrepreneurs in obtaining financing for start-up businesses. For instance, Venture Catalyst—a service unit at the UC Davis Office of Research—facilitates the translation of UC research by supporting the development of new ventures. Venture Catalyst administers the Science Translational & Innovative Research (STAIR) Grant, whose mission is to help move UC Davis technologies towards commercialization by supporting translational research for which other funding sources do not exist. Additionally, Venture Catalyst engages with the business, governmental, and economic development community in the Sacramento, California region to highlight the development of technologies and ventures emerging from UC Davis.

Generally, the Latin American institutions studied do not provide venture capital to start-up businesses directly. Nevertheless, these institutions frequently attempt to link entrepreneurs to funders, primarily through their business incubators. For instance, U. Católica's *Incuba UC* and U. Concepción's *IdeaIncuba* give their clients access to public financing to bring ideas to market, with subsidies from the Chilean Economic Development Agency (CORFO) and private funds. Finally, the business incubator at CONICET offers

financial evaluation services to participating entrepreneurs, and assists entrepreneurs in connecting with venture capitalists and angel investors external to the institution.

Although the institutions studied vary considerably in the infrastructure and resources that they are able to provide to support new ventures, all are manifestly interested in such activities. Each of the institutions has publicly announced its intention to foster a culture of entrepreneurship, and all have undertaken concrete steps to promote a more business-minded climate in their localities. In the future, we expect that the research institutions studied—among many others in North and Latin America—will continue to develop activities designed to link academic investigation with the commercialization of new technologies.

6 Conclusion

The study presented in the present article compared the structure and operation of technology transfer offices, and the mechanisms through which to foster entrepreneurship, in five large research institutions across the Americas. Included in the analysis were two U.S. universities, two Chilean universities, and one Argentinean public research center. Our research revealed common goals and core activities, shared and implemented in similar ways among all five institutions. However, the analysis also highlighted some divergent areas within the structure and operation of the technology transfer and entrepreneurial support programs, which represented significant differences between the five institutions.

Perhaps unsurprisingly, we generally observed that the two U.S. universities were more similar to each other than to the three Latin American institutions, and vice versa. Meanwhile, among the Latin American institutions, the two Chilean institutions were more similar to each other than to the Argentinean entity studied. However, all three Latin American institutions appeared to be in the midst of implementing practices to render them increasingly akin to their North American counterparts.

It would be difficult to explain with certainty why TTOs located in the same countries and regions tend to resemble each other more than those in institutions abroad, beyond venturing obvious justifications. One speculation is that TTOs located within institutions in the same country share a common legal framework. For instance, in the United States both Stanford's OTL and UC Davis' *InnovationAccess* were either directly or indirectly born as a consequence of the Bayh-Dole Act (1980), whose goal was to promote the commercialization of university science by allowing research institutions to own inventions—and therefore also any associated intellectual property—created under the auspices of federal funding. The existence of this legal framework in the United States for more than 35 years, coupled with attendant economic and social factors, could help to explain why the U.S. institutions resemble each other more than their Latin American analogues.

Likewise, some scholars have discussed the role of the university in an “entrepreneurial society.” In such a setting, many if not most aspects of the university contribute to the generation of entrepreneurship capital, whether explicitly through the commercialization of research results or implicitly through the promotion and celebration of freedom of inquiry, both within the institution and beyond its walls (Audretsch 2014). Therefore, perhaps broader, cultural factors could be at play to explain the differences between North American and Latin American university technology transfer practices. For instance, some studies have reported cultural, social, and economic factors that have negatively influenced

the existence of entrepreneurial activity in Latin America as compared with other regions (Kantis et al. 2004).

Yet there is evidence that the entrepreneurial ecosystem is evolving in many Latin American countries, as governments implement policies designed to foster innovative activity. For instance, Chile has launched programs designed to support the growth of angel investor networks and business incubators, while in parallel creating a national seed capital fund and platforms to finance institutional strategies that promote the development of entrepreneurial skills (Kantis and Federico 2012). Argentina has similarly implemented initiatives designed to support the creation of business incubators, as well as to provide financial support for the commercialization of research results emerging from public R&D centers and universities through the foundation of new technology-based firms. Although such policy initiatives have become common across the Latin American region, the earliest examples date principally from the early 2000s. This fact could help to explain why the Latin American institutions examined in the present study are increasingly implementing technology commercialization activities that resemble those of their North American counterparts.

While the rationale underlying the similarities and differences between the institutions is interesting to consider, the main objective of this study was to outline and compare several technology transfer models and their associated strategies for implementation. Our methodology focused on assessing the common practices of the five institutions observationally and qualitatively, rather than attempting to quantify the performance of their TTOs. Some of these models could provide a reference for other research institutions planning to establish their first TTO or to implement revised strategies for IP management or technology transfer. Institutions could therefore utilize the practices described as sources of inspiration to inform their own local initiatives.

However, it is important to note that the purpose of this study was not to provide a recipe for successful IP management and technology transfer. Instead, the creation of an efficacious technology transfer office depends on many distinct, case-specific factors. Accordingly, adaptation to the general and specific realities that an institution faces will be required for any of the activities described in this analysis. A non-exhaustive list of influential factors includes: geographical region, cultural idiosyncrasy, particularities of the institutional mission, existence of all the required actors on site, tools available for the implementation, worldview of scientists and decision makers in the institution, available budget, degree of managerial level institutional support, level of academic community involvement, among others. Ultimately, the success of a research institution's technology transfer office depends, most fundamentally, on the people involved.

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