The Emergence Of University-Based Innovation And Organized Systems For Its Transfer And Utilization

By Ashley J. Stevens

This special issue focuses specifically on independent, third-party, multi-institutional tech transfer organizations (MiTTOs), because MiTTOs are frequently the first step in establishing tech transfer from university labs in an industrial ecosystem. This special issue has reviewed MiTTOs in 16 countries, including countries with major university research ecosystems such as Australia, Canada, France, Germany, Japan, Spain, the U.K. and the U.S. One of the questions that we answer in this special issue is: "When was the modern system of the formal, legal transfer of university-based innovation created?" And most importantly, how and with what purpose?

The study shows that there is no single global answer. It emerged at different times in different countries. It first emerged in the U.S. in the early years of the 20th Century, spread only slowly round the world and is still spreading into emerging economies.

Government—national or local—frequently, but not invariably, has driven the development of tech transfer, wanting to see the economic benefits of innovation. Tech transfer has generally been a not-for-profit activity, but there were three, ultimately unsuccessful, attempts to make it a for-profit activity. That said, at least two not-for-profit MiTTOs generated very large financial returns.

Equally, there was no single organizational driving mechanism. In several ecosystems—Canada, Chile, France, the U.K. and the U.S.—a national TTO serving the entire country launched systematic tech transfer. In others—Germany, South Africa—a multi-campus, national research organization was the first tech transfer practitioner, while in others—Australia—tech transfer was initiated by a far-sighted university that was a long way ahead of its time.

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1. What Do We Mean by Technology Transfer?

Throughout this special issue, we use the term "*tech transfer*" to mean the formal transfer of rights to intellectual property (IP) from a generating entity, normally a university or other not-for-profit performer of research, to a user of those rights, normally a company, through a formal legal agreement, normally a license agreement or assignment.

We therefore exclude informal, non-exclusive, transfers of technology through vehicles such as publications, lectures, hiring of graduate students, consulting, etc., although these transfers are significant, have a long history and considerably predate formal legal mechanisms. The pioneering discoveries of Wilhelm Röntgen in X-rays and Pierre and Marie Curie in radioactivity rapidly entered clinical application based on their publications alone and without IP protection. By contrast the electric arc (University of Oslo), insulin (University of Toronto) and vitamin D (University of Wisconsin) were commercialized through IP and formal legal transfer mechanisms.

Particularly in Europe, some of these informal transfer mechanisms are encompassed in broader measures of transfer, known as knowledge transfer, but in this discussion, we limit our discussion to formal, legal transfers.

One of the consequences of this definition is that it is important to have well-understood rules to determine who owns a particular piece of IP, because only the owner of that IP can transfer some or all of the rights to it to another entity that wishes to develop the IP.

As will become clear in this article, changes in the ownership paradigm have frequently been prerequi-

sites for, and have driven, the emergence of tech transfer ecosystems.

2. What Do We Mean by a Technology Transfer Office (TTO)?

A TTO is the office, either within an institution or, as with the organizations discussed in this special issue, outside the institution, that has the responsibility for transferring rights to that institution's IP. In most institutions, this responsibility finishes up being housed in a specialized office with a name that includes words like "licensing" or "technology transfer" or "technology development," etc., but at the outset the responsibility may be given to an individual who is housed in the office of sponsored programs, the office of general counsel, etc.

I use the abbreviation TTO for such organizations throughout this article.

3. How Do We Define When Tech Transfer Starts in a Country?

The commonly accepted definition of when an institution starts a formal program of tech transfer is when that institution assigns an individual to work on tech transfer matters for at least 50 percent of their time, *i.e.*, the institution is assigning 0.5 FTE to tech transfer. This is the definition that AUTM uses in its Annual Licensing Activity Survey in the U.S., and this definition has been used by other surveys.

However, there is no generally accepted definition as to when tech transfer starts in a country as opposed to at an individual institution within that country. Reading the historical accounts of different countries elsewhere in this special issue suggests the following two milestones as potential candidates for when tech transfer started in that country:

1. When the first successful transfer of an academic technology occurred in that country; and
2. When the first organization was established in that country whose mission it was to transfer academic technologies to industry.

In the three countries that pioneered formal tech transfer—in chronological order, the U.S., Canada and the U.K.—there were different relationships between the timing of these two milestones.

The oldest example of a formal, IP-based transfer of an academic technology in this special issue is documented by Taxt *et al*. in Norway, where Kristian Birkeland immediately patented his discovery of the electric arc in 1903 and used it to found Norsk Hydro. This was 10 years before Cotrell patented the electrostatic precipitator in the U.S. However, a tech transfer ecosystem did not develop in Norway for another 80 years.

- **Unites States**

The second country to formally transfer an academic technology through a legal agreement, as we have defined it above, was the U.S., where two events coincided in 1912:

- The development of an important technology, the University of California's (UC) electrostatic precipitator technology, which
- Created the need for someone to manage the transfer commercially.

This collision resulted in the creation of the Research Corporation (RC), which acted as an independent, third-party TTO for UC and managed the university's IP. It was the first TTO serving an individual institution though it was not formally affiliated with it in any way. RC was subsequently given additional IP to manage, and 25 years after its inception, it started managing technology transfer for other universities.

The second successful transfer, vitamin D by the University of Wisconsin in 1926, resulted in the creation of the Wisconsin Alumni Research Foundation (WARF), an independent foundation that was the first TTO closely affiliated with an individual university.

- **Canada**

In both Canada and the U.K., the first successful transfer of an academic technology preceded the establishment of the first TTO by a number of years.

Canada was the third country to successfully transfer an academic technology, with the successful transfer of the manufacture and use of insulin by the University of Toronto in 1923. Insulin was discovered by two medical doctors, Frederick Banting and J.J.R. Macleod and two research scientists, Charles Best and James Collip.[1]

The transfer was managed by an ad hoc committee, the Insulin Committee, which consisted of several of the discoverers, a number of high-level University of Toronto administrators and some senior individuals from industry who sat on the University of Toronto's Board.

The University of Toronto used the patents:

a. To control the quality of insulin produced by different companies; and

b. To make insulin available at low prices by licensing multiple companies non-exclusively.

The Insulin Committee managed the commercialization competently, with Eli Lilly having exclusive rights for a 12-month period in the U.S., Central and South America and paying a 5 percent royalty. Other U.S. companies subsequently received non-exclusive licenses at rates no more favorable than Lilly's. Canadian rights were retained by the university's wholly

1. See, for example, *The Discovery of Insulin*, Michael Bliss.

owned biologics company, Connaught Laboratories, which sold insulin in Canada (the University sold Connaught for $25 million in 1972). The University of Toronto assigned British and British Empire rights to the British Medical Research Council and authorized Nordisk Insulin Laboratory to be set up as a non-profit manufacturer and distributor in Copenhagen.

In the 1930s, the University of Toronto received $180,000 per year in royalties from insulin, a considerable sum at the time, and in total received $8 million between 1921 and 1967.

Perhaps inspired by the University of Toronto's success with insulin, the National Research Council of Canada (NRC) established patent management committees in all of its laboratories and by 1931 was receiving and evaluating up to 130 invention disclosures a year.

In 1947, Canadian Patents and Development Limited was established by NRC and eventually grew to manage tech transfer for all of Canada (national laboratories and a number of universities), including inheriting a major technology portfolio transferred from Germany as part of its WWII war reparations.

- **U.K.**

In the U.K., as discussed further below, the first successful transfer of an academic technology, Oxford's sugar beet drying technology, occurred in 1926, but the technology turned out to be fraudulent. This set back the emergence of tech transfer by individual institutions in the U.K. by decades.

The next successful transfer in the U.K., penicillin in 1944, was mismanaged by Oxford University and the MRC with significant negative economic consequences for both Oxford and the U.K., resulting in the demand for a commercially competent organization to manage such transfers in the future. In response, the National Research Development Corporation (NRDC) was set up in 1949 and served to transfer British academic and government laboratory technologies for 40 years, though its name was changed to the British Technology Group (BTG) after it was merged with the National Enterprise Board in 1981.

- **Germany**

As Stein describes elsewhere in this special issue, Germany was an early adopter of tech transfer, driven by the Fraunhofer organization's creation of its tech transfer office in 1955. Fraunhofer is a unique not-for-profit, multi-campus research organization dedicated to applied as opposed to basic research, so its early implementation of tech transfer is not surprising.

Another major research German organization, the Max Planck Society, started its TTO in 1970.

These developments took place while Germany operated under a Professor's Privilege paradigm. This was changed in 1999, and in 2000 the German government decided to auction UMTS-frequencies for 3G wireless networks to the highest bidder and received billions of Euros. A part of these profits was invested in pushing the boundaries of innovation. The government was convinced that it was losing traction in the international competition of innovation. One of the origins of this was based on the fact that, though German science was world class, translating those results into innovative products and services just did not seem to work that successfully. The solution was to provide Germany with a network of central technology transfer offices for every state, the Patentverwertungsagenturen (PVAs). So, by around 2000, 25 technology transfer companies were founded, of which 18 were MiTTOs with the mission of providing IP protection services, scouting and commercial exploitation to all German universities. Some of them did well, others did not. Their development depended very much on the individual structure, political/state support, and professional development capacity. Wijlands discusses the PVAs in detail.

- **Australia**

The fifth country to start to practice tech transfer was Australia in 1959.

Australia implemented tech transfer in a totally different way from the previous four countries. While the U.S., Canada, the U.K. and Germany were all utilizing national tech transfer offices (NTTOs) covering the entire country, the University of New South Wales set up a wholly owned non-profit company, Unisearch, in 1959. Unisearch's role was to engage with the private sector broadly and to generate revenues from consultancy and commercial training as well as tech transfer for that institution. The first two of these activities were low risk and immediately profitable, in stark contrast to formal tech transfer, which Unisearch soon found was much more costly, had an uncertain probability of success for any individual technology, and a long timeline to a financial return for those technologies that were successful.

UNSW was considerably ahead of its time, and other Australian universities did not follow UNSW's lead for 12 years.

Unisearch was a true pioneer in several respects:

- Being structured as a company wholly owned by and serving only UNSW;
- Its broad mandate—consulting, education and tech transfer—is not dissimilar to the current European concept of knowledge transfer; and
- It's noteworthy that the three fundamental challenges of tech transfer identified by Unisearch early in the development of the profession remain

fundamental issues wherever tech transfer is practiced to this day:

- o It has high upfront costs;
- o The probability of success for any individual technology is uncertain; and
- o It has a long timeline to a financial return;

• France

France was the next country to implement an entity to formally transfer academic technologies with the establishment of ANVAR in 1967 as an NTTO serving all of France. It had different iterations that were implemented later, being initially the result of overall SME development and later having a mandate of economic impact, a move that eventually led to the network of SATTs.

• The Worldwide Roll-Out

After France there was a hiatus in additional countries implementing tech transfer until the early 1980s, when Norway and Spain started to implement tech transfer. The next wave was around 2000, when a number of countries started practicing it. As I discuss below, the 2000 roll out was frequently driven by changes in the ownership paradigms of academic inventions, frequently requiring new laws to be passed to allow tech transfer to develop.

To put what happened in different ecosystems into perspective, I step back and look at the different IP ownership paradigms, their implications, and the changes in those paradigms that governments made over the years.

4. Who Owns Academic Inventions?

This simple question is critically important in any discussion of tech transfer systems, since only the owner of a piece of IP can transfer the rights to it. No company will invest large sums in developing a technology without assurance that the organization that purportedly transferred the rights to the technology to it in fact had the right to make that transfer.

I therefore next examine the different ownership models for academic IP. I show that most countries initially had either a formal or *de facto* individual ownership system, with the professors owning the IP they created. After WWII, in Canada, France, the U.K. and U.S. there was a transition to the national government owning or controlling the IP, frequently based on funding the research that led to the IP. Finally, starting around 1980, a transition to individual institutional ownership and control started and has emerged as the dominant system worldwide.

a. The Historic Approach

In most countries, the historic default position was that no one particularly cared about commercialization of university IP or even the commercialization of IP from government laboratories. Therefore, there were frequently no rules on ownership and certainly no institutional resources to support commercialization. By default, therefore, if anyone was going to take the IP out of the institution and into the marketplace, it was going to be the professors/scientists themselves.

For example, Boston University (BU) claimed no ownership in the telephone patents received by its Professor of Elocution and Vocal Physiology, Alexander Graham Bell, even though BU supported Bell's work on the telephone by giving him a one-year leave of absence and pre-paying his salary for the following year to allow him to support himself during his leave of absence while he perfected the telephone and prepared and filed his patent application.[2] Bell paid to file his patents himself and found backers to help him establish the first Bell Telephone Company to bring it to market.

In the biomedical field, the community even considered it unethical for physicians to get patents on potentially life-saving technologies. For example, as discussed by Bliss, in 1922, the University of Toronto's patent attorneys insisted that Frederick Banting, an MD, be named as an inventor on the patent application for insulin. Banting only agreed after the university agreed to indemnify and defend him if he was accused of violating his Hippocratic oath.

In 1943, the USDA's only rule on patenting was that government scientists couldn't take out U.S. patents on their government-funded work. The Medical Research Council in the U.K. had insisted that Oxford University not apply for patents on the penicillin work which it had funded. In retrospect, the patentability of Oxford's version of penicillin (penicillin F, produced by *P. rubens*) was probably questionable since the USDA had isolated a strain of *P. chrysogenum* that produced penicillin G, which is both structurally different from, and a superior drug to, penicillin F. However, there was outrage in the U.K. that USDA policy allowed USDA scientists to take out foreign patents in their own names based on their government-funded work, and that the U.K. finished up having to pay royalties on penicillin to Andrew Moyer, the USDA scientist who led the process development effort in Peoria, Illinois. As discussed by Hockaday elsewhere in this special issue, this experience was a major driver in the establishment of the NRDC in the U.K.

That said, in Australia and France, the universities, as institutions, have always owned the IP generated by their professors and employees, as is discussed elsewhere in this special issue.

The situation in Austria is typical of the situation

2. See, for example, *Bell: Alexander Graham Bell and the Conquest of Solitude,* Robert V. Bruce.

that generally held sway in Europe. Before 2004, the IP generated by professors at Austrian universities was owned by their employer, the Federation of Austria, which owned the universities. However, the Federation had no organization to decide what to do with a university's IP; so, in practice any IP that professors requested was almost always granted back to them. Very often professors did not make use of their IP because they had to pay all the costs themselves and there was no financial or administrative support for commercialization from their university. Austria passed a new national law in 2002, which was implemented in 2004, which gave ownership of the IP to the university and now Austria has a flourishing network of TTOs at many universities.

b. Potential Ownership Models

Conceptually, there are only five possible answers to the question of who owns an invention made at a university:

a) The professor and/or students who made the invention;

b) The national government, which frequently funded the research that led to the invention;

c) The institution itself;

d) The external, non-governmental organization that funded the research that led to the invention; or

e) Joint ownership through some combination of options a through d).

Next, I discuss these options and their implications.

i) Inventor Ownership

Inventor ownership, *i.e.*, ownership by the inventing professor, frequently referred to as the "Professor's Privilege" after the copyright exemption from employer ownership of academic writings, is, as discussed above, the first and oldest ownership system and was broadly used in Europe until relatively recently.

A. U.K.

Tech transfer got off on the wrong foot in the U.K. as a scandal at Oxford University in the 1920s had repercussions that lasted well into the 21st century, as discussed by Hockaday.[3]

Brynor Owens was a Ministry of Agriculture scientist who became head of an Institute of Agricultural Engineering that the Ministry funded at Oxford. Owens was a charlatan of heroic proportions and later served four years in prison for forgery and fraud on the International Harvester and Ford companies.

At Oxford, he obtained patents on a supposedly superior method of extracting sugar from sugar beets and sold the patents to a company called Sugar Beet & Crop Driers Ltd. When the company discovered that the patents were worthless, it and two other plaintiffs sued Oxford for £750,000, a colossal sum at the time. In 1939, the suit was settled for £75,000, and Oxford successfully persuaded the government to pay £50,000 of this, but the remaining £25,000 was still many times the government's total annual grant to Oxford at the time.

To prevent a repeat of this fiasco, both Oxford and Cambridge adopted policies in which they explicitly disavowed any interest in inventions made by their faculty and students, even if carried out in university facilities with university equipment, technicians and funds. In other words, Oxford and Cambridge created a *de facto* Professor's Privilege ownership model.

Oxford started to change this policy to claim ownership of its professors' inventions in 1986 when the Thatcher government abolished BTG's right of first refusal to academic IP, but the Professor's Privilege model lasted at Cambridge until well into the 2000s.

B. Overview of the Situation in Europe

Many European countries had formal policies giving ownership rights to the inventing professors, while in others it was the *de facto* system in the absence of any formal, legally prescribed system.

Spain was an early adopter of institutional ownership in 1986, and other European countries started changing to inventor ownership in the late 1990s to early 2000s as shown in Table 1:

Table 1: European Countries Moving From Professor's Privilege To Institutional Ownership

Country	Year
Spain	1986
Denmark	1998
Germany	2001
Austria	2002
Norway	2003
Finland	2007

Some of these changes prompted the creation of multi-institution TTOs.

C. Germany

As Wijland discusses elsewhere in this special issue, six Patentverwertungsagenturen (PVAs), which were MiTTOs, were established prior to the abolition of the Professor's Privilege in 2001. However, the pace of PVA creation accelerated after the abolition, with nine being created in 2001 and 2002 and an additional

3. "University Technology Transfer: What It Is and How to Do It," Tom Hockaday 2020.

three being created from 2004 to 2014.

D. Norway

A similar pattern was observed in Norway, with three MiTTOs being created prior to the abolition of the Professor's Privilege and five subsequently.

E. Italy

Italy went in the opposite direction and introduced Professor's Privilege in 2001 if the research was exclusively funded by the Italian government. If part of the funding was from other sources (*e.g.*, the E.U., local government, corporate, etc.) the university owned it.

F. Sweden

The last stronghold of the Professor's Privilege in Europe is Sweden, where Professor's Privilege remains the rule.

G. Canada

The invention ownership situation in Canada is unusual. There isn't a uniform national system based on a national law. Rather the ownership system is determined within the confines of each province by each individual university and encapsulated in its IP policy. The result is a mosaic, with a split between:

- Institutions with institutional ownership;
- Institutions with Professor's Privilege; and
- Institutions with joint institutional and professor ownership.

A 2021 survey by the Canadian Technology Transfer Professional Group (CTTP) found a fairly evenly balanced distribution of institutional ownership and inventor ownership policies across the country, with joint ownership less common as shown in Table 2:

Table 2: Invention Ownership Policies Of Canadian Institutions

Institutional	Inventor	Joint Institution and Inventor	Total
26	32	14	72

H. Japan

In Japan, the national universities were arms of government until they were corporatized in 2004, and, as such, at the time were unable to own patents. Prior to corporatization, ownership of Japanese academic IP, either by the government or the inventor, was determined on a case-by-case basis, resulting in professor ownership being the effective *de facto* ownership system, as Kato and Sumikura document elsewhere in this special issue.

I. Role of TTOs in Professor's Privilege Institutions

Having a Professor's Privilege ownership model does not eliminate a university's need for a TTO. Large research institutions operating under a Professor's Privilege paradigm generally have a TTO, but the inventors have to affirmatively choose to work with the TTO and have every right to choose to move forward by themselves independently of the university and the TTO. Some MiTTOs were established in Germany and Norway while they were operating under a Professor's Privilege paradigm. However, the TTO must offer particularly good customer service to persuade faculty to choose to work with them and royalty distribution policies at Professor's Privilege institutions are frequently more favorable to inventors than at institution-own institutions. For example, McGill University, which has joint ownership between itself and the professor, allocates 60 percent of income to the inventors if the university commercializes the IP and 70 percent if the inventors commercialize. By contrast, in the U.S., where all institutions operate under an institutional ownership model, inventor shares of income tend to be in the 25 to 40 percent range.

J. Advantages and Disadvantages of Professor's Privilege

The advantage of Professor's Privilege is that the inventor, who knows and understands the technology better than anyone, is maximally incentivized to ensure that it is commercialized, and frequently will doggedly pursue commercialization with considerable determination.

The negative is that the upfront costs of IP protection may deter faculty, particularly junior faculty, from commercializing their IP. Another negative is that each professor who makes an invention has to learn the basics of tech transfer from scratch, will make very common, basic mistakes and will probably have an inflated view of the value and potential of their invention. TTOs, by contrast, rapidly build up a body of expertise and experience in fairly valuing technologies, convincing prospective licensees of that value and commercializing them.

ii. Government Ownership

There are two ways governments can assert ownership or control over IP generated by universities:

- Government funded the research; and/or
- Government owns the university and has an IP Policy that retains ownership of IP to the institution.

Whether the government actually owned title to academic IP or merely gave a right of first refusal to an NTTO which determined which inventions to pursue, patent and license in practice have equivalent outcomes.

Government ownership of universities' IP has had a number of consequences.

- As Kato and Sumikura show elsewhere in this special issue, because Japanese universities were arms of government before they were corpora-

tized in 2004, they could not own patents and so ownership generally reverted to the professors, who would frequently partner with a company to pay for the costs of patenting.

- In other countries, such as Austria, where the government lacked any mechanism to utilize the patents, inventions were generally returned to inventors.
- In France, because universities were part of government, the government could establish ANVAR as a NTTO serving the entire country.
- This was also the case in East Germany pre-reunification, at a time when Professor's Privilege held sway in West Germany.

A. Canada

Canada established Canada Patents and Development, Ltd as an NTTO serving all of Canada in 1947. CPDL requested that all ownership interests be assigned to it in order to provide tech transfer services. It continued in this role until 1990. More recently provincial entities such as Axelys in Quebec have been given a similar mission even though ownership of the IP remains with the universities.

B. U.K.

As Hockaday discusses elsewhere in this special issue, the U.K. had government control of academic inventions from 1949, when the National Research Development Corporation was established and was granted a right of first refusal to all British academic and government lab inventions. This right of first refusal, which was owned by the British Technology Group after 1981, lasted until 1986 when the Thatcher government abolished this right of first refusal and ushered in institutional ownership and management.

C. United States

Government ownership was the primary U.S. system from around 1963 until the passage of the Bayh-Dole Act in 1980. Since U.S. universities are either private, non-profit corporations or are owned by a state government, rather than the federal government, the federal government's claim to ownership of patents came from the use of federal funding to perform the research that led to the invention. Since federal funding is the source of around 70 percent of research funding at U.S. universities, this meant that the majority of U.S. academic IP was owned by the U.S. government.

Efforts to establish a uniform patent policy for the federal government began in 1963 when President Kennedy issued a Presidential Memorandum and Statement of Government Patent Policy. That memorandum, revised in 1971, provided guidance to agencies for assigning title to inventions resulting from federally funded research and the U.S. federal government claimed ownership of all patents resulting from research that had been federally funded.

At that time, most U.S. funding agencies except for the defense agencies used the National Technical Information Service (NTIS) to license their technologies. NTIS had an Office of Federal Patent Licensing with six licensing specialists who negotiated royalty-bearing licenses for government-owned inventions.

The government's policy was to only grant non-exclusive licenses to prevent companies earning monopoly profits on inventions that had been taxpayer funded. Prior to granting an exclusive license, NTIS was required to show:

(1) Federal and public interests are best served by exclusive licensing;

(2) Expeditious practical application of the invention is unlikely to occur under a non-exclusive license;

(3) Exclusive licensing is a reasonable and necessary incentive to attract investment of risk capital;

(4) The proposed terms and scope of exclusivity are not greater than reasonably necessary; and

(5) Exclusive licensing will not tend substantially to lessen competition or result in undue market concentration.

This was burdensome and the delays often caused the prospective licensee to lose interest.

Additionally, NTIS could only grant an exclusive license to a government-owned patent if the intention to grant the license had been advertised in the Federal Register, together with the identity of the prospective licensee. Competitors had 60 days to object to the license grant, and frequently did.

NTIS was reactive, as opposed to proactive in its licensing efforts. Marketing was the responsibility of the owning agency, and as late as 1990, only three agencies listed their available inventions in any databases. NTIS waited for interested parties to learn about the patent, somehow, and request a license.

Another issue was that NTIS only controlled the patents and had no mechanism to give licensees access to the know-how, which resided at the university and in particular with the professor.

NTIS shared royalties with the funding agency, but not with the inventors, as the Office of Federal Personnel Management ruled in 1981 that there was no statutory authority for sharing royalties with inventors. This was remedied in the Federal Technology Transfer Act of 1986 which allowed Cooperative Research and Development Agreements (CRADA's) between federal labs and companies and also launched technology transfer by federal labs.

Because of these issues, in 1975, at the start of the

discussions leading up to the passage of the Bayh-Dole Act, a federal interagency committee on patent policy reported that, as of the end of fiscal year 1975, the government had an inventory of about 28,000 patented inventions but had licensed less than 5 percent of them to businesses.[4] This included both royalty-free licenses and where a professor had requested a license to their own invention to start a company.

A Government Accountability Office report in 1991 showed that the licensing rate had increased to about 10 percent of patent applications filed. By contrast, today TTOs license about half of the new patents they apply for each year.[5] The same GAO report found that in the early 1980s, fewer than half of the licenses issued were royalty-bearing. By 1990, over 95 percent of licenses were royalty-bearing.

D. France

France established the Agence Nationale de Valorisation de la Recherche (ANVAR) as an NTTO serving all of France. It continued in this role until 1979.

E. Advantages and Disadvantages of Government Ownership/Control

Governments have not proven to be effective technology managers, reflected in the fact that government ownership/control has largely been replaced by institutional ownership.

Government licensing organizations are necessarily bureaucratic and have obligations of transparency and equity that can be at odds with commercial realities. The U.S. government's policy of only licensing its inventions non-exclusively, intended to ensure that no individual company could get rich from taxpayer-financed research, was a noble and idealistic principle, but ignored the commercial reality that academic inventions are embryonic and early stage and frequently need substantial investments to get them to market readiness. No company would make that investment unless it was guaranteed a period of market exclusivity to ensure it generated a return before it was subject to market competition. The government's policy was the exact opposite of this—after the pioneering company had made the investment needed to show that the technology was viable, competitors could obtain licenses on the same terms without having to take the upfront risk of making the investment.

One of the most important elements of Bayh-Dole was that it allowed institutions the freedom to determine the appropriate commercialization pathway and the appropriate licensing terms for a specific technology. They could grant exclusivity for up to five years (probably modeled on the then policy of the American Cancer Society). Even this limitation was removed in the Stevenson-Wydler Act of 1984, which, as well as giving federal labs many of the opportunities that Bayh-Dole had given to universities, also corrected some of the deficiencies that had been identified in Bayh-Dole during its first few years of operation.

iii. Institutional Ownership

The prevalent model in most parts of the world today is institutional ownership by the inventing research organization. This model was pioneered in the U.S.

A. United States

1. Early TTOs in the United States

As Stevens shows elsewhere in this special issue, prior to 1980, most universities used Research Corporation to transfer their technologies. However, a few institutions established their own individual TTOs well before the passage of the Bayh-Dole Act as shown in Table 3:

Table 3: Early TTOs Established In The U.S

Organization	Year
Wisconsin Alumni Research Foundation	1926
Iowa State	1935
MIT	1940
Kansas State	1942
University of Minnesota	1957

Source: "University Technology Transfer in the U. S.: History, Status and Trends," Jon Sandelin, Presentation at the International Patent Licensing Seminar 2003. Tokyo: National Center for Industrial Property Information and Training (NCIPI), 2003.

One of the drivers for the creation of the Wisconsin Alumni Research Foundation (WARF) in 1926 was to keep the royalties from commercialization of the University of Wisconsin's vitamin D patents out of the hands of the state of Wisconsin. As an independent, not-for-profit entity, WARF had its own bank accounts over which the state of Wisconsin had no control.

2. Institutional Patent Agreements

As discussed above, from the Kennedy administration on, the U.S. government stipulated that any patents based on government-funded research were to be owned by the government.

Although the Bayh-Dole Act is widely credited with having changed this paradigm, it was in fact preceded by a system of Institutional Patent Agreements

4. "The Bayh-Dole Act and Revisionism Redux," Howard Bremer, Joseph Allen, and Norman J. Latker, *BNA's Patent, Trademark & Copyright Journal*, 78 PTCJ 483, 2-19 (2009)

5. See, for instance "Technology Transfer's Twenty Five Percent Rule", Ashley J. Stevens and Kosuke Kato, *les Nouvelles*, XLVIII #1, 44-51, March 2013;

(IPAs), a series of institution-by-institution agreements launched by the Department of Health Education and Welfare (DHEW) in 1963 and by the National Science Foundation (NSF) in 1973. If an institution requested and signed an IPA with one of these agencies, it was able to retain title to inventions funded by that agency if it agreed to staff a TTO to do something with the inventions. By 1976, 75 institutions had IPAs in place. For instance, the Cohen-Boyer patents, the foundational technology of genetic engineering, were invented at Stanford and the University of California using NIH funding and were filed in 1974, well before passage of Bayh-Dole. Stanford was able to solely own and manage the patents through the mechanisms of:

- Stanford's IPA with DHEW; and
- A Joint Invention Agreement between Stanford and UCSF.

3. The Bayh-Dole Act

The Bayh-Dole Act, in 1980, institutionalized IPAs and made their benefits available to all institutions and small businesses as of right. Indeed, part of the impetus for passage of Bayh-Dole was that the Carter administration had stopped issuing new IPAs.

Under Bayh-Dole, recipients of federal funding did not have to reach an agreement with a funding agency in order to own their federally funded inventions. Instead, they could automatically elect to claim title to their inventions and license them under terms they deemed appropriate. In other words, government ownership was replaced by institutional ownership.

One of the inspired aspects of Bayh-Dole was how unobtrusive it was. Of the major conditions it imposed on universities:

- Share proceeds with inventors;
- Require exclusive licensees to manufacture products to be sold in the U.S. in the United States;
- Give a preference to small businesses;
- Give a non-exclusive, royalty-free license to the U.S. government for its own use; and
- Retaining the right by the funding agency to grant a compulsory license in the public interest if the invention was not being practiced; only the last of these, the so-called "march-in" provision, has turned out to have a potentially significant impact.

Looking at the other major conditions:

- It made good sense to share proceeds with inventors so they were incentivized to do everything they could to help with the transfer and ensure the technology's success;
- Waivers are available if U.S. manufacture is not feasible;
- Small businesses turned out to be the natural partner of universities, as large companies frequently were uncomfortable dealing with the embryonic, untested nature of academic technologies; and
- In practice, the government use right turned out to be quite limited, since purchases of goods and services by the federal government are primarily in the defense sector.

The administrative requirements—disclosing federal funding and the government's rights in patent applications and reporting annually to the government on the utilization of technologies—are minor, so the government essentially got out of the way and left universities to develop their technologies.

The compulsory license or march-in provision is potentially more problematic by virtue of its potential to convert an exclusive license to a non-exclusive license at some point down the road after a company had made a major investment in developing the technology predicated on the expectation of exclusivity. This is a genie that, once let out of the bottle, cannot be put back in it and would forever undermine faith in the exclusivity of all academic licenses. Funding agencies, which must approve a march-in request, appear to understand the serious implications of approving one, and although march-ins have been requested seven or eight times, none has been granted to date.

Other countries have not been so hands-off as the U.S when implementing their versions of Bayh-Dole. An act proposed in one country could have required the professor to reimburse the government for part of the funds they had just spent if certain requirements were not met. That act has not been passed.

Another issue is that Bayh-Dole is an unfunded mandate. As it debated Bayh-Dole, the U.S. Senate did not discuss how this new activity would be paid for and provided no new funding to support the heavy upfront costs of technology transfer. It was assumed that the costs would be treated like other administrative mandates imposed on universities' research operations, such as grant administrators in offices of sponsored programs, animal health and safety, conflict of interest, etc., by allowing their costs to be included in an institution's indirect cost base and hence would be reimbursed through grants. However, most tech transfer costs are not allowed to be included in indirect costs and universities have had to pay the costs themselves. For most universities, costs have exceeded net and even gross licensing revenues.[6]

6. See, for example, "How U.S. Academic Licensing Offices are Tasked and Motivated—Is it all about the money?" Irene Abrams, Grace Leung and Ashley Stevens, *Research Management Review*, 17.1, Fall/Winter 2009;

B. U.K.

As Hockaday discusses elsewhere in this special issue, the U.K. was the second country to transition from government ownership/control to institutional ownership when the Thatcher government abolished the British Technology Group's right of first refusal to British universities' inventions in 1986 and allowed institutions to establish TTOs and manage the inventions themselves, ushering in institutional control in the U.K.

C. Europe

In France, the government has always been the owner of academic IP since researchers and professors are public servants. From 2010 onward new directives were issued to have universities become autonomous and thus responsible for commercializing their IP. Today universities have the responsibility to work with the researchers and decide in conjunction with their Société d'Accélération du Transfert de Technologies (SATT) whether IP created and disclosed by their faculty should be protected. Because the IP is funded by the government, the universities have become an arm of government, so any desire on the part of researchers to own and manage their own IP is avoided. Researchers receive shares in start-ups that are spun out of their inventions and a share of any royalty income their technology generates.

In East Germany, universities owned their faculties' IP, while in West Germany Professor's Privilege was the rule until 2001, when ownership of the IP was transferred to the university.

In Table 1, I show how major European countries started changing to an institutional ownership model starting around 2000, though Spain implemented institutional ownership in 1986.

D. Emerging Economies

Emerging economies started implementing institutional ownership in the late 1990s/early 2000s, as shown in Table 4:

Table 4: Emerging Country Implementation Of Institutional Ownership[7]

Country	Year
China	1996, 2002
Brazil	1996, 2004
Russia	2003
Mexico	2003, 2009
Malaysia	2009
Philippines	2009
South Africa	2010

E. India:

In most large institutions in India, the institution owns the IP, not the professors, though in some smaller institutions, the institution does not have a policy in place or mechanisms to administer patents. In these cases, the researchers have no choice but to do the filings themselves in their own names and at their own expense.

In India, many organizations borrowed policies either from the top Indian Institutes of Technology (IITs), *i.e.*, those in Bombay, Delhi, Kanpur, Chennai or the Council of Scientific & Industrial Research (CSIR, India's largest network of publicly funded labs). These IITs and CSIR established policies such that the ownership of IP was with the institution. This was based on the United States' experience, which many of their faculty who had trained in the U.S. had experienced and reinforced by alumni resident in the U.S. Some Indian funding agencies require the grantee to take responsibility for filing and maintaining the resultant IP, thus ensuring that the institution would take the lead. Much later the government announced a National IP Policy.

"The Protection and Utilization of Public Funded Intellectual Property Bill," the so-called Indian Bayh-Dole Act, was introduced into parliament in 2008, but was shot down and not passed into law. The bill would have mandated similar disclosure and election of title provisions as in the U.S. and mandated a more than 30 percent revenue share to the inventor, but the discloser had to specify in which countries they wished to retain title, which is hard to do at initial disclosure. The bill stated that its premise was to make an institution self-sufficient by incentivizing commercialization of IP, which flies in the face of U.S. and European experience. A particularly onerous requirement was that, if the inventor failed to fulfill their obligations under the bill, they could be fined up to 25 percent or 50 percent of the public funding and renounce their share in the royalties.

F. South Africa

Prior to 2010, the South African government did not claim ownership of state-sponsored research, and institutional IP policies were either non-existent or varied wildly: some institutions allowed inventors to own their own IP even if developed using public funds and some institutions claimed ownership but without having the capacity to exploit the IP. One of the biggest challenges was industry-sponsored research that was

7. Source: "The State of Patenting at Research Institutions in Developing Countries: Policy Approaches and Practices", Pluvia Zuniga, WIPO Economic Research Working Papers, Working Paper No. 4, December 2011.

heavily subsidized by state funds but with the industry partner then claiming full ownership of arising IP with no benefit back to the public purse. Most institutions did not have the capacity or power to assert ownership in this situation.

This situation was rectified by the "Intellectual Property Rights from Publicly Financed Research and Development Act" (IPR Act), which came into effect in 2010 and which gave IP ownership from publicly financed research to the institution.

G. Advantages and Disadvantages of Institutional Ownership

The institutional ownership model has many advantages:

- It results in the development of a consistent set of policies and body of expertise within the institution;
- The institution's researchers can pursue further research without the potential of being blocked by prior art under individual ownership;
- The institution can claim and promote a reputational return from successful technologies;
- There is a possibility of a potentially significant financial return to the institution from successful technologies; and
- The institution can manage the conflicts of interest that the possibility of personal wealth can exacerbate.

Another benefit is that with the multitude of external funding sources for any given researcher, a fair amount of work is required to ensure that IP rights have not been given away in prior grants/contracts. When, in the past, there was disagreement over ownership (usually with a private company), the institutional employer of the academic researcher would be drawn into the dispute. This was a compelling reason that argued for a migration to institutional ownership.

iv. Developer Ownership

Ultimately, of course, technologies need to be owned by (through assignment) or controlled by (through licensing) the organizations that are developing them. That is the objective of tech transfer, and the process, if successful, will generally result in a financial return to the originating institution to incentivize and pay for the tech transfer ecosystem needed to identify, assess, protect and prepare technologies for transfer. It will also give a return to society, which frequently paid for the research, through the availability of new products and services meeting unmet needs.

The author is not aware of any country with a system in which inventions are initially assigned to the organization that wishes to develop the technology, though some institutions (*e.g.*, the University of Manchester in the U.K.) routinely assign their IP to start-ups developing the technology. It's hard to imagine how funding could flow back to the university to support a TTO and pay for patent filings or how competing claims to a technology could be resolved under such a system.

In the U.S., even if a company pays for the research, it generally only receives a license or an option to negotiate a license to IP resulting from the research that will require future lump sum and running royalty payments. Canada and France also use this approach. Companies may protest having to pay extra for the IP after having already paid for the research, but universities generally only charge companies the cost of the research, and the university's only chance to make any financial return is from license payments for the IP resulting from the research. Companies even try to pay less than the full cost by protesting having to pay indirect costs, which they characterize as "overhead."

The Bayh-Dole Act does not allow universities to assign title to their patents without the permission of the funding agency, and the funding agencies simply will not give such permission, believing that an exclusive license gives the developer all the control over the IP they need for effective commercialization. TTOs in ecosystems which lack this legal protection, and institutions operating under a Professor's Privilege ownership model, report coming under pressure to assign their IP to start-up companies to facilitate fundraising. Compromises are generally reached to only assign the IP to the developer when a product is launched or when the company reaches an advanced stage of funding or files to go public, by which time the risk of failure and hence the need for the institution to reclaim the IP will have largely been eliminated.

A. The "Easy Access IP" Model

One model which is close to developer ownership in practice is the Easy Access IP system developed by the University of Glasgow starting in the late 2000s and adopted by Bristol and Kings College London in the U.K. and a small number of other institutions around the world. In this paradigm, some of the technologies owned by an institution are licensed, free of charge, to local start-up companies. The rationale for the system was that most academic inventions have a low value and frequently go unlicensed, and this would promote utilization of technologies while contributing to local economic development. Even though forgoing licensing revenues, the university benefits from providing sponsored research and consultancy services to the start-ups.

Although the financial impact of the Easy Access IP model is the same as if the company owned the technology, the technology is in fact still owned by the university.

B. Japan

In Japan, universities frequently grant co-ownership

of patents to companies because Japanese companies frequently collaborate on research projects with the universities. This reduces the university's leverage in subsequent licensing negotiations since the companies already have freedom-to-operate under the patents by virtue of their co-ownership and only need to license the university's interest to secure exclusivity.

C. South Africa

Elsewhere in this special issue, Barnett identifies how in South Africa there were elements of developer ownership prior to the passage of the 2010 IPR Act through companies claiming full ownership of IP arising from industry-sponsored research that had been heavily subsidized by state funds, with no benefit back to the public purse. Most institutions did not have the capacity or power to assert ownership in this situation. The IPR Act stopped this practice.

5. Today

It is broadly recognized around the world that the results of academic research can help rejuvenate local and even national economies by starting new growth industries, and many emerging economies are now attempting to implement formal tech transfer ecosystems. They are finding that institutional ownership is a pre-condition for an institution to create an organization to develop the skills to facilitate transfers to the private sector and are implementing this through laws that are frequently compared with the U.S.'s Bayh-Dole Act. However, as the examples of Canada and Sweden show, institutional TTOs can flourish under Professor's Privilege ownership paradigms as well.

6. A Final Caveat on Technology Ownership

As shown above, institutional ownership has emerged as the dominant system of academic IP ownership around the globe.

However, while certainty of ownership is a necessary condition for successful commercialization, it is not sufficient. Many countries implementing institutional ownership and expecting to see immediate benefits have yet to also implement some of the less visible elements that have contributed to the success of the U.S. and European tech transfer ecosystems:

- Faculty consulting policies that allow faculty to consult for outside entities for up to a day a week;
- Seed funding initiatives (institutionally funded or sponsored) to bring early-stage technologies further up the Technology Readiness Level (TRL) scale to a level of maturity to be able to initiate a transfer to a company;
- Small company research support programs such as the U.S.'s SBIR and STTR programs;
- Government support for the tech transfer function itself, such as the U.K.'s HEIF funding, France's SATT funding and the recently announced Australian government AUD1.2 billion funding for tech transfer; and
- The coupling of incubators and venture capital and angel funding with tech transfer activities in a vibrant innovating ecosystem. ■

Available at Social Science Research Network (SSRN): *https://ssrn.com/abstract=4255245*.

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