

# Technology Transfer and Academic Entrepreneurship: A Personal Journey, Lessons Learned From the Literature, and New Directions

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**Abstract:** In this essay, I describe the development of the field of technology transfer and academic entrepreneurship (henceforth, TT-AE) and my contribution to it, some lessons learned from these studies, and three new directions for research on this important topic. The new directions are more “micro”/OB/HRM research on TT-AE, more studies of TT-AE at government labs, as opposed to universities, and a greater focus on “pro-social” TT-AE. In addition to advancing knowledge, other useful outcomes of these new directions for research might be to increase the engagement of scientists in TT-AE and improve our understanding of how to “manage” the process to achieve maximum economic and social impact.

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## **1 Introduction**

Like Saint Augustine, I begin with a confession. My confession is that I am a member of a cult. The cult consists of a group of academics in economics, sociology, strategy, entrepreneurship, engineering, and public policy who have studied the managerial and public policy implications of technology transfer and academic entrepreneurship (henceforth, TT-AE). In this essay, I explain how I became a member of this cult and how I expanded the cult through my research and editorial activities. For cult members and those interested in joining the cult, I also present some key lessons learned from the literature on TT-AE and three new directions for research on this important topic. These new directions are more “micro”/OB/HRM research on TT-AE, more studies of TT-AE at government labs, as opposed to universities, and a greater focus on “pro-social” TT-AE. The lessons learned and new areas of research I identify are focused on one key goal: how to increase the engagement of scientists in TT-AE and help us to understand how to “manage” the process to achieve maximum economic and social impact.

## **2 From Innovation to TT-AE**

I was trained to be an academic economist at Columbia University, where I earned all three of my degrees. After receiving my Ph.D., I served as a Sloan Foundation post-doctoral fellow and Faculty Research Fellow at the National Bureau of Economic Research (NBER). At Columbia and NBER, I was schooled by three eminent scholars on the economics on innovation: Frank Lichtenberg, my dissertation advisor and co-author, the late Richard Nelson, my dissertation chairman, and the late Zvi Griliches at Harvard and NBER, who was my post-doc advisor, along with Ernie Berndt at MIT and NBER. My early research on innovation, which was heavily funded by NSF, the American Statistical Association, the W.E. Upjohn Institute for Employment Research, and the Sloan Foundation, focused on assessing the connection between innovation (broadly defined) and productivity, helping to develop more precise estimates of both the private and social returns to federally funded research, including basic research. These papers were published in the top journals in economics, such as the *American Economic Review* and the *Review of Economics and Statistics*.

In the next phase of my career, towards the end of the 1990s, I shifted my research on innovation to a greater focus on the managerial and public policy implications of TT-AE. At that point in time, we were witnessing a substantial rise in the commercialization of publicly-funded

research at research universities in the U.S. (Feldman et al., 2002) and Europe (Wright et al., 2007), via patenting, licensing, research joint ventures and sponsored research, and eventually, the formation of start-up companies. Examples of key technologies transferred from universities to firms include the famous Boyer-Cohen “gene-splicing” technique that launched the biotechnology industry, pharmacogenomics, diagnostic tests for breast cancer and osteoporosis, Internet search engines (e.g., Google), music synthesizers, artificial intelligence, computer-aided design (CAD), COVID-19/mRNA vaccines (e.g., Pfizer/Moderna, Oxford/Astra Zeneca) and treatments (e.g., Paxlovid), the Nicotine Patch, and green technologies. At the same time, there was a major increase in both public and private investment in incubators/accelerators, makerspaces, science and technology parks, and other property-based institutions that facilitate TT-AE.

My first foray into research on TT-AE occurred in 1998, when I secured a grant from the NBER/Sloan Foundation Project on Industrial Technology and Productivity with Al Link and David Waldman (an OB/HR professor, who was a colleague of mine at ASU). The mission of the NBER/Sloan project was to investigate the economic impacts of technological change, organizational innovations, and workplace practices. All grant recipients were required to conduct some qualitative research. As an economist, I had no idea how to conduct qualitative research, which is why I reached out to David.

Our project was motivated by a new phenomenon at American universities: the establishment of technology transfer offices (henceforth, TTOs) to commercialize the university’s intellectual property. We employed “mixed methods,” which means that we conducted both quantitative and qualitative research. On the quantitative side, we specified a production function for TT and pledged to conduct qualitative research on the “organizational practices” of TTOs. We were able to construct estimates of the relative productivity of 113 universities, with respect to licensing of technologies, using both parametric and nonparametric methods (Siegel et al., 2003).

In the key published paper in *Research Policy* (Siegel et al., 2003), which has now 3,074 citations, according to Google Scholar, we found that contrary to the maintained assumption of conventional economic models, variation in relative TTO performance across universities cannot be completely explained by environmental and institutional factors. The implication of this finding is that organizational practices are likely to be an important determinant of relative

performance. We supplemented our econometric analysis with qualitative evidence, derived from 55 structured, in-person interviews of 100 university technology transfer stakeholders at five research universities in Arizona and North Carolina. The field research allowed us to identify institutional policies and organizational practices that can potentially enhance technology transfer performance.

More specifically, the qualitative analysis identified three key impediments to effective university technology transfer. The first were informational and cultural barriers between universities and firms, especially for small firms. Another impediment was insufficient rewards for faculty involvement in university technology transfer. This includes both pecuniary and non-pecuniary rewards, such as credit towards tenure and promotion. Some respondents even suggested that involvement in technology transfer might be detrimental to their career. Finally, at the time, there were problems with staffing and compensation practices in the TTO, including a high rate of turnover among licensing officers, which is detrimental towards the establishment of long-term relationships with faculty, firms, and entrepreneurs. Other concerns were insufficient business and marketing experience in the TTO, and the possible need for incentive compensation. The bottom line was that organizational issues appeared to be important, in terms of explaining why some universities performed better in TT-AE.

### **3 Building the TT-AE Cult: Events and Special Issue of Journals**

The realization that organizational issues were salient in TT-AE led to a key event in development of the cult: a 2000 *Journal of Technology Transfer* (JTT) special issue conference at Purdue University on “Organizational Issues in University Technology Transfer.” I organized this event with two eminent economists at Purdue, the late Marie Thursby and Jerry Thursby, and Arvids Ziedonis, who at that time, was serving as an Assistant Professor of Management at the Wharton School. Marie and Jerry had also received a NBER/Sloan grant. Also, each of my fellow co-editors had written key papers on the topic (e.g., Jensen & Thursby, 2001; Mowery et al., 2001; Thursby et al., 2001). Marie and Jerry would soon leave Purdue for Georgia Tech and Emory, respectively, and then ultimately, the two would reunite in the business school at Georgia Tech.

The Purdue conference and the subsequent double issue of the JTT (see Siegel et al., 2001) constituted an all-star lineup of economists, sociologists, public policy scholars, and

management professors who were conducting leading edge research on TT-AE and would go on to shape the field. The lineup for the conference and the special issue included the late Richard Nelson (Columbia), Bronwyn Hall (UC-Berkeley), David Mowery (UC-Berkeley), Walter Powell (Stanford), Lynne Zucker (UCLA), Michael Darby (UCLA), John Scott (Dartmouth), Richard Jensen (Kentucky), Nicholas Vonortas (George Washington University), Tim Folta (Purdue), James Adams (University of Florida), Mike Santoro (Lehigh), Shanthi Gopalakrishnan (New Jersey Institute of Technology), Jason Owen-Smith (University of Arizona), Maryann Feldman (Johns Hopkins), Gilbert Omenn (University of Michigan), Janet Bercovitz (Duke), Irwin Feller (Penn State), Richard Burton (Duke), Paula Stephan (Georgia State University), Robert Morgan (Washington University), the late Proctor Reid (National Academy of Engineering), Denis Gray (North Carolina State University), Andy Lockett (University of Nottingham), and last, but certainly not least, my old friend, colleague, and collaborator, the late Mike Wright (University of Nottingham).

The papers in the JTT double special issue considered the following issues related to TT-AE, broadly defined: (a) the quality of relations between universities and firms, (b) strategy formulation and implementation by universities and firms, (c) antecedents and consequences of faculty involvement in TT-AE, and (d) assessing economic impact of TT-AE, and (e) evaluation of institutional performance in TT-AE. What was more important than the specific papers presented or published, was that we were building a community of scholars in multiple disciplines with a common interest in TT-AE. Not surprisingly, there were many heated discussions, since scholars had different paradigms and disciplinary orientations. Nonetheless, a cross fertilization of ideas and numerous additional research partnerships emerged. The presence of scholars in management at the Purdue event, and especially in the emerging fields (at that time) of strategy and entrepreneurship, also served to expand our scholarly community. Starting in the mid-to-late 2000s, it became quite common for there to be at least eight to ten sessions at the Academy of Management annual conference devoted to TT-AE.

Soon after the Purdue conference, I became an editor of the JTT and President of the Technology Transfer Society (henceforth, T2S). I served in both roles until Professor Maribel Guerrero assumed the Presidency in 2025 and I stepped down as editor as well. In addition to editing JTT, I also served as an editor of two management journals that have published numerous papers on TT-AE: the *Journal of Management Studies* and *Academy of Management*

*Perspectives*. I also co-edited 22 special issues on TT-AE in leading journals in economics, management, entrepreneurship, and innovation studies (e.g., *Research Policy* (6), *Journal of Management Studies*, *Academy of Management Perspectives* (2), *Industrial and Corporate Change* (2), *Journal of Business Venturing* (2), *IEEE-Transactions on Engineering Management*, *Strategic Entrepreneurship Journal* (2), *International Journal of Industrial Organization*, *Entrepreneurship Theory and Practice*, *Oxford Review of Economic Policy*, and *European Economic Review* (2)) on TT-AE. These activities helped to significantly expand publication opportunities in top-tier outlets in management and economics for the growing community of scholars of TT-AE.

I have also organized many special issue conferences and events on TT-AE, for numerous journals in economics and management (e.g., *Research Policy*, the *Journal of Business Venturing* and *European Economic Review*). While serving as President of T2S, we organized annual research conferences at such august institutions as Georgia Tech (twice), George Washington University (twice), George Mason University, Arizona State, RPI, UC-Riverside, the University at Albany, Johns Hopkins University, the University of Toronto, and the Kauffman Foundation. The T2S annual research conferences featured the following luminaries as keynote speakers: the late Tom Allen (MIT), Fiona Murray (MIT), the late William Baumol (NYU), Josh Lerner (Harvard), Howard Aldrich (UNC-Chapel Hill), and David Teece (UC-Berkeley).

Along with my colleague at RPI in those days, Professor Phil Phan, and the late Mike Wright, I organized a special issue conference in 2003 at RPI on “Science Parks and Incubators.” The RPI event was the first major academic conference on such property-based institutions and their role in TT-AE. We hosted this event with the support of the *Journal of Business Venturing*, thanks to the support of Sankaran Venkataraman (Venkat), who was Editor-in-Chief of JBV at the time. Key outcomes of the RPI conference were two well-cited special issues: one for the JTT and one for JBV.

## **4 Key Lessons Learned – Performance, Startups, Networks, Incentives and “Bypassing” the TTO**

### 4.1 Performance

In this section, I describe some lessons learned from the literature on TT-AE. Early studies addressed a fundamental issue: how do we measure and “explain” TT-AE “performance”? Numerous scholars have attempted to evaluate the productivity of TTOs, based on data measuring the “outputs” and “inputs” of university technology transfer (e.g., Siegel et al., 2003, and Thursby & Thursby, 2002). These authors typically employed a production or distance function framework (with multiple outputs), in which a “best practice” frontier is constructed (Chapple et al., 2005; Siegel et al., 2008). The distance from the frontier represents the level of “technical” inefficiency, or the inability of the organization to generate maximal output from a given set of inputs. In these studies, two methods were used to estimate these frontiers—data envelopment analysis (DEA) and stochastic frontier estimation (SFE).

I have already discussed our 2003 paper, which employed SFE. In contrast, Thursby and Kemp (2002) and Thursby & Thursby (2002) use data envelopment analysis (DEA) to assess whether the growth in licensing and patenting by universities can be attributed to an increase in the willingness of professors to patent, without a concomitant, fundamental change in the type of research they conduct. The alternative hypothesis is that the growth in technology commercialization at universities reflects a shift away from basic research towards more applied research. The authors find support for the former hypothesis. More specifically, they conclude that the rise in university technology transfer is the result of a greater willingness on the part of university researchers to patent their inventions, as well as an increase in outsourcing of R&D by firms via licensing. In general, production function models fit well and enable us to assess both absolute and relative performance.

### 4.2 University Startups, Incentives, and Human Capital

There are many interesting studies of university-based startups and the role of incentives and human capital (Lockett & Wright, 2005; Lockett et al., 2005; Colombo & Piva, 2012, see Siegel & Wright, 2015, for more). Lockett et al. (2003) find that equity ownership was more widely distributed among the members of the spin-off company in the case of the more successful

universities. Di Gregorio and Shane (2003) conclude that the ability of the university and inventor(s) to assume equity in a start-up, in lieu of licensing royalty fees, are significant determinants of the number of start-ups. They also find that a royalty distribution formula that is more favorable to faculty members reduces start-up formation, a finding that is confirmed by Markman et al. (2005). Di Gregorio & Shane (2003) attribute this result to the higher opportunity cost associated with launching a new firm, relative to licensing the technology to an existing firm.

Several authors have studied strategic issues related to TT-AE, focusing on startups. Franklin et al. (2001) analyzed UK university spinouts and concluded that universities seeking to launch successful technology transfer startups employ a combination of academic and surrogate (external to the university) entrepreneurship. Others have analyzed teams of academic startups. Grimaldi & Grandi (2003) study 40 Italian academic spin-offs and concluded that the frequency of founding teams' interactions with external contacts is influenced by the frequency of interaction of the underlying research groups and by their scientific and technological excellence. The frequency of contacts with external agents positively influences the market attractiveness of the business idea (Grandi & Grimaldi, 2005), as does the prior joint experience of the founders.

My late friend and co-author Mike Wright also wrote several interesting papers with Einar Rasmussen and Simon Mosey on how academic founders develop the necessary business competencies to commercialize research (e.g., Rasmussen et al., 2011, 2014). Based on extensive empirical analysis, the authors identified three core competencies academic founders must develop to build successful spin-offs: 1) *opportunity refinement*, which refers to evolving an initial scientific discovery into a commercially viable business model; 2) *leveraging*, which refers to strategically transforming academic networks and weak ties to secure resources, industry partners, and equity investors; and 3) *championing*, which they define as providing the ongoing energy and credibility needed to drive the venture through its early, high-risk stages.

#### 4.3 Social Networks

In the late 1990s and early 2000s, a group of prominent sociologists, most notably, Lynne Zucker, Woody Powell, and Jason Owen-Smith, explored the role of social networks in TT-AE. Several of these studies focused on “star scientists” in the life sciences and biotechnology. The authors hypothesized that networks are critical in such activities, given that the movement of

knowledge from universities to industry depends heavily on relationships, trust, and repeated interaction, not just patents or formal licensing agreements. Note that in addition to patents and licensing, TT-AE also includes startup creation, research collaborations, consulting, student mobility, and informal knowledge exchange.

Zucker et al. (1998) and Zucker & Darby (2001) assert that social networks shape how effectively these activities occur. This follows from a consideration of how social networks influence the ability of a university to connect researchers with industry. This study, along with several others, demonstrated that many innovations are transferred because university scientists have contacts in firms, government labs, venture capital, or entrepreneurial communities. The authors provide the following examples of network ties that can be useful in university technology transfer: former students working in industry, faculty consulting relationships, conference collaborations, alumni networks, professional associations, incubator and accelerator communities.

These relationships help firms identify promising technologies, locate experts, evaluate the credibility of research, and reduce uncertainty about new inventions. Without these networks, companies may never discover university innovations. Finally, network ties also help to build trust between universities and firms. That is, social networks create trust through repeated interactions and reputation effects.

#### 4.4 The Role of Incentives and “Bypassing” the TTO

The process of transferring technology from the lab to the marketplace begins with scientists disclosing their inventions to a university or federal lab. According to the Bayh-Dole Act, scientists at U.S. universities whose research is funded by a federal agency are required to disclose their inventions to their university’s TTO. Unfortunately, extensive interviews of academic scientists in the U.S. by Siegel et al. (2004) revealed that many faculty members were not disclosing their inventions to their university. Survey research by Thursby et al. (2001) confirms this finding. Markman et al. (2008) have documented that many technologies are indeed “going out the back door.”

The fact that many academics are not disclosing inventions highlights the problems for TTO officials in eliciting disclosures. Although the Bayh-Dole Act stipulates that scientists must file an invention disclosure, this rule is rarely enforced. Instead, the university needs to have

proper incentive schemes in place, specifying an adequate share for the inventors in royalties or equity. The importance of this share in securing researchers' cooperation in technology licensing has been analyzed by Macho-Stadler et al. (1996), Lach & Schankerman (2004), Link & Siegel (2005), and Jensen & Thursby (2001). Note that these studies focus on licensing, rather than commercialization through start-ups. Still, empirical studies of start-up formation by universities have demonstrated the importance of royalty regimes of the university, even on academic spin-off creation rates (e.g., Di Gregorio & Shane, 2003, and O'Shea et al., 2005).

It is also important to note that when a faculty member files an invention disclosure, the TTO (which, in most countries, owns the intellectual property) decides whether the invention should be patented, usually after consulting with a committee of faculty experts. In making this decision, the university assesses the commercial potential of the invention. Given the track record of many senior academics, firms or entrepreneurs may have already expressed sufficient interest in the new technology to warrant filing a patent. If firms or entrepreneurs have little interest in the technology, universities will be reluctant to file for a patent, given the high cost of filing and protecting patents. When a patent is filed and awarded, the university typically attempts to "market" the invention, by contacting firms that can potentially license the technology or entrepreneurs who are capable of launching a start-up firm based on the technology.

Scientists can also become directly involved in a licensing agreement as technical consultants or as entrepreneurs in a university spin-off. Jensen & Thursby (2001) show that faculty involvement in the commercialization of a licensed university-based technology increases the likelihood that such an effort will be successful. To provide sufficient incentives for faculty involvement, licensing agreements should entail either upfront royalties or royalties at a later date. For spin-offs, Macho-Stadler et al. (2008) demonstrate how the optimal contract between the university TTO, the researcher and the venture capitalist, entails the allocation to the researcher of an equity stake to secure her involvement in the venture. It may also require the researcher to be financially involved in the project as a way to give her incentives to provide effort. Spin-offs may generate higher financial returns to universities than licensing. Finally, although there have been several studies of the importance of pecuniary incentives for faculty members (e.g., royalty distribution formulas, see Lach & Schankerman, 2004; Link & Siegel,

2005), there has been no systematic analysis of the role of changes in promotion and tenure policies on the propensity of academics to engage in this activity.

## **5 New Directions – “Micro”/OB/HRM Perspectives on TT-AE**

It is important to note that most studies of TT-AE have focused on “macro” issues (economics, strategy, sociology) at *universities* and stressed the *financial gains* associated with such activities. In this section, I suggest that we shift away from this focus. The first new direction should be to consider several key OB/HRM issues that may be important determinants of both the propensity of scientists to engage in TT-AE and overall organizational performance (Balven et al., 2018). In my view, we need to apply more “micro” theories and concepts to TT-AE. I will focus on two micro/OB concepts that appear to be especially germane, in the context of TT-AE. The first is the concept of organizational justice.

### **5.1 Organizational Justice in TT-AE**

As noted in Balven et al. (2018), the academic literature on technology transfer has focused mainly on three formal mechanisms of technology transfer: patenting, licensing, and startup activity, where scientists follow standard procedures to commercialize their inventions through their university’s TTO. With rare exceptions (e.g., Link et al., 2007; Markman et al., 2008; Waldman et al., 2022), there has been little theory development or empirical research on what could be referred to as “deviant” technology transfer, or “bypassing” the TTO. Such activity could involve patenting outside a university or federal lab, commercializing research through consulting, or leaving to launch a startup company on the basis of technology that was conceived under the auspices of that university or federal lab.

An important reason why faculty and scientists at federal labs may “bypass” TTOs is a lack of “organizational justice.” In this context, organizational justice refers to perceptions of fairness on the part of university or federal lab scientists with respect to their organizations. The notion is that if a scientist perceives unfair treatment by the university or federal/national lab TTO or another academic administrator, such as a Department Chair or a Dean, the scientist may choose not to disclose the invention and instead, work to advance commercialization of the new technology outside the university or federal lab.

Traditional conceptualizations of organizational justice include distributive, procedural justice, and interactional justice (Colquitt, 2001; Rupp & Cropanzano, 2007; Colquitt & Rodell, 2011). We believe that these concepts may be useful in terms of predicting formal and informal technology transfer. Distributive justice refers to the extent to which an individual's outcomes (i.e., rewards, recognition, and so forth) are perceived to be in line with the effort, accomplishments, and other contributions of the individual to the organization. Procedural justice pertains to the extent to which the individual perceives consistency, lack of bias, and so forth, in the determination of his or her attained outcomes from the organization. Interactional justice involves both interpersonal and informational components in terms of whether individuals perceive that they are treated with dignity and respect, as well as whether procedures are explained in a candid, timely, and individualized or personalized manner.

In addition to these traditional ways of conceiving organizational justice, we also recognize that more recent, deontological perspectives may be relevant (Cropanzano et al., 2003). In contrast to the above justice dimensions that stress the individual's personal needs or interpersonal factors, deontic justice emphasizes the role that morality and the needs of others (e.g., society as a whole) can play in organizational justice perceptions (Cropanzano et al., 2003). Deontic justice may also be relevant, in terms of promoting "pro-social" TT-AE (more on that later). In sum, it would be useful for researchers to examine whether different types of justice perceptions can predict a propensity for scientists to engage specifically in informal technology transfer.

## 5.2 Lab Managers and Department Chairs as Champions of TT-AE

Next, we consider championing. Championing is also likely to play an important role in TT-AE. In the organizational behavior literature, championing has typically been studied in terms of a manager or leader's unbridled enthusiasm and support for a technological innovation, either a product or process innovation (Howell & Higgins, 1990). Howell & Shea (2001, p. 15) defined champions as "individuals who informally emerge in an organization and make a decisive contribution to the innovation by actively and enthusiastically promoting its progress through the critical [organizational] stages." Clarysse & Moray (2004) characterized championing as enthusiastically pushing an idea and then managing it all the way through development, which is similar to how Tushman & Nadler (1986) described championing. Through their communication

with the scientists themselves or others (e.g., TTO managers), champions within an organization increase the likelihood that a project will progress successfully throughout development (Howell & Shea, 2001). Champions are typically top-level managers/leaders who have the power and influence to promote such causes enthusiastically (Howell & Higgins, 1990).

Scholarly work also suggests that champions play a key role in university-based technology transfer. For example, Balven et al. (2018) considered the possible championing role of department chairs, specifically resulting in faculty engagement in technology transfer. Bercovitz & Feldman (2008) found that the propensity of faculty members to disclose inventions was positively related to the propensity of their department chairs to disclose. As such, their findings demonstrated that department chairs may serve as important champions or role models in technology transfer. Choi et al. (2022) reported qualitative evidence of championing of TT-AE at universities and federal labs, in relation to postdocs and their involvement in TT-AE.

## **6 New Directions – TT-AE at Federal/Government Labs**

While there are numerous studies of university technology transfer (Grimaldi et al., 2011; Link et al., 2015; Mowery et al., 2001; Perkmann et al., 2013), there are few recent studies of technology transfer at national/federal labs and (non-university) research institutes (e.g., Rahm et al., 1988; Bozeman & Crow, 1991; Crow & Bozeman, 1998; Jaffe & Lerner, 2001; Adams et al., 2003). The U.S. government defines a federal lab as “[a]ny federally-funded R&D center or any center that is owned, leased, or used by a federal agency and funded by the federal government, whether operated by the government or by a contractor.”

A key distinction among federal labs is between Government-Owned, Government-Operated (GOGO) vs. Government-Owned, Contractor-Operated (GOCO) labs (Westwick, 2003). Contractors can be universities (e.g., Berkeley, MIT, Chicago, Princeton, Cal Tech, Stanford, Stony Brook), firms (e.g., Honeywell, Bechtel), or nonprofits (Battelle). GOCO researchers are not Federal employees and have more freedom than GOGO scientists. They can assert copyrights, consult with industry, participate in start-ups, and can generate more income from royalty payments. Several major GOCO labs (e.g., Sandia) even have entrepreneurial leave programs for scientists. It is also important to note that both the NIH and the Department of Energy, the agency that manages the largest federal labs, known as the National Labs, have versions of NSF’s I-Corps program to train would-be academic entrepreneurs.

The lack of research on federal/government labs is unfortunate because these research organizations are an important component of national innovation systems. For example, the R&D expenditures of federal labs in California (which has 48 federal labs, including six major National Labs: Lawrence Berkeley National Lab, Lawrence Livermore National Lab, Sandia National Labs, Stanford Linear Accelerator Center, Ames Research Center, and the Jet Propulsion Laboratory) consistently exceed those for the entire University of California system (Windham, 2006). In 2023, U.S. universities received approximately \$58 billion from the federal government to conduct research, while federal or national labs received approximately \$62 billion (National Science Board, 2024). In France, the French National Centre for Scientific Research (CNRS), which has 10 research institutes, receives about 80% of all public funds for R&D. In Germany, Max Planck Institutes, Helmholtz Centers, and Fraunhofer Institutes also receive a substantial share of public funds for R&D. The Chinese Academy of Sciences oversees some 120 research institutes, including all of China's "big science" facilities. In 2018, China announced that its 200 national key laboratories will increase to around 700 by the end of 2020.

Like universities, labs and research institutes have a technology transfer mission. In 1980, (the same year the Bayh-Dole Act was enacted), the U.S. Congress adopted the Stevenson-Wydler Act, which sought to streamline technology transfer from federal laboratories to industry and mandated that labs establish technology transfer offices. In 1986, Congress passed the Federal Technology Transfer Act, which provided direct financial incentives for scientists at federal labs to patent, and it also established Cooperative Research and Development Agreements (CRADAs) between firms and federal labs (Mowery, 2003). In 2000, the Technology Transfer Commercialization Act was passed, which made it easier and more attractive for companies to patent and/or license a technology that was developed at a federal lab (e.g., commercialization resulting from a CRADA). Similar laws were enacted in other OECD nations that were designed to stimulate technology transfer at public sector, non-university research institutions. In 2015, China substantially revised its law on promotion of commercialization of S&T results, which gave substantial leeway to public research institutions and universities to manage and profit from the commercialization process.

Table 1 presents data on federal funding, invention disclosures, patents issued, new licenses executed, and licensing income for U.S. universities and federal labs in FY 2023. The numbers reveal that while federal labs receive more funding from the U.S. government and have

large “intramural” research programs, they lag far behind universities, in terms of tangible outcomes from TT-AE. We need more organizational research on TT-AE at federal labs to help explain what the bottlenecks are at the institutions.

**Table 1.**

Federal R&D Expenditures and Technology Transfer at Universities and Federal Labs (FY 2023 data)

<b>Variable</b>	<b>Universities</b>	<b>Federal Labs</b>
Federal R&D Expenditures	~58 Billion	~62 Billion
Invention Disclosures	27,112	5,149
Patents Issued	8,706	1,931
New Licenses Executed	10,050	377
Licensing Income (\$ mil)	2,820	95

## 7 New Directions – “Pro-Social” TT-AE

In a recent AMP article (Guerrero & Siegel, 2025), Professor Maribel Guerrero and I introduced the concept of “pro-social” TT-AE. This paper constitutes a fundamental shift in how we think about TTOs and TT-AE, more generally. At some universities, TTOs heavily stress maximizing licensing revenues, patents, and corporate spin-offs. That may be fine for some institutions.

However, for others with broader goals, we reframe how institutions deal with TT-AE by linking TT-AE to the economic definition of public goods. We also point out that TT-AE has led to the creation of common technological public goods or “public interest goods” (PIGs) which are designed to achieve an objective, based on the design of collaboration, institutions, and capabilities (Mazzucato, 2023), and “public interest technologies” (PITs), which are technologies developed and deployed to serve the public good and advance equity and other social goals (e.g., assessing the effects of using AI in our criminal justice system). To further document the huge economic and social impact of TT-AE, we also link it to the creation of general purpose technologies (GPTs), such as computers and the Internet, telecommunications, biotechnology, pharmacogenomics, and AI.

For those institutions interested in broader goals, we assert that they should leverage their innovation and entrepreneurial ecosystems to deliver broad-scale economic and social value, shifting the primary success metrics from financial profits to socio-economic impact. We also provide advice on how to implement a pro-social technology transfer model, focusing on three changes at three distinct levels. At the macro level, the focus should be on developing

institutional frameworks, intellectual property regimes, and addressing geopolitical realities in the home region or nation. At the meso level, the focus should be on modifying organizational strategies within universities and innovation ecosystems. This could involve restructuring university missions, re-aligning the objectives of TTOs, and creating collaborative networks that explicitly reward ethical, responsible, and sustainable innovation. Finally, at the micro level, there should be greater attention to “micro”/OB/HRM I mentioned earlier or the “human” side of TT-AE. At the ecosystem level, changes might include placing a heavier emphasis on that institution’s public mission, including adopting new dynamic capability metrics that capture how effectively their technologies mitigate global crises, climate change, health disparities, and economic inequalities.

Our analysis was strictly conceptual, we hope that others will critique, extend, and possibly implement our model, which lends itself both to quantitative and especially, qualitative research. We also think the emphasis on pro-social TT-AE provides a useful theoretical framework for those conducting research on entrepreneurial ecosystems. It also fits well with the strong pro-social motivations of the younger generation on campus, including those engaged in TT-AE.

## **8 Conclusions**

I began this essay with a confession, which is that I am a member of the TT-AE cult. I have tried to show how this cult evolved, outlined my contribution to its growth and development, and how I would like to see the cult evolve. I stressed the fact that, with rare exceptions, the literature on TT-AE has mainly focused on “macro” issues, given that most of the prominent scholars who helped define and develop the field were economists, sociologists, and strategy scholars. Most studies in this arena have also focused on universities, as opposed to federal/national labs and public research organizations. Finally, there has also been a strong emphasis on certain key outcomes that are readily reported and easy to measure, such as patents, licenses and licensing income, and the number of startups, stressing the financial gains associated with such activities. I also summarized some key lessons learned from the academic literature on TT-AE.

In the remainder of the essay, I argued that to further develop the cult and more importantly, to address some key managerial, organizational, and policy issues, we need more “micro”/OB/HRM research on TT-AE, more research (both micro and macro) on TT-AE at

federal/national labs and other public research organizations, and more research on “pro-social” TT-AE. I believe that these studies will address major gaps in the TT-AE literature. More importantly, they will also advance the interests of policymakers and practitioners, who are interested in increasing TT-AE. In addition to advancing knowledge, other useful outcomes of these new directions for research might be to increase the engagement of scientists in TT-AE and improve our understanding of how to “manage” the process to achieve maximum economic and social impact.

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