The Conceptualization of Technology in Scholarly Research and Public Policy Regarding University Technology Transfer [1]

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Abstract

This paper presents an alternative conceptualization and definition of technology in the context of university technology transfer. The ambiguity regarding the conceptualization of technology is apparent in the technology transfer literature. An expanded conceptualization of technology potentially opens new approaches to researching the topic of technology transfer. It may also cause policymakers to think more comprehensively about what it means to successfully transfer technologies derived from federally funded research to the private sector for use that benefits the public interest. This paper integrates constructs and ideas in the related literature to provide a new perspective of technology that can support future scholarly research and public policy formulation about technology transfer in general, and university technology transfer specifically. Although the paper focuses on university technology transfer to the private sector in the United States, the insights it presents are relevant to technology transfer more broadly and applicable in other geopolitical contexts.

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Introduction

Since the end of the Second World War, the federal government of the United States of America (U.S.) has implemented significant public policy regarding university technology transfer to the private sector and technology transfer in general. A significant body of scholarly research on the topic has been developed and continues to be developed, which informs public policy formulation. However, there is a danger that progress in the field will increasingly diminish without sufficient advancements that encourage and facilitate new analytical approaches.

Policy analysts cannot effectively identify, evaluate, and recommend solutions for policy problems, such as those related to university technology transfer, without first usefully formulating the problems (Dunn, 2016). Policy problems "have no existence apart from the individuals and groups who define them" (Dunn, p. 70); thus, there are no innate arrangements of social conditions that inherently constitute policy problems (Dunn). In the case of university technology transfer, such problem formulation includes consideration of various possible conceptions of the construct of technology.

Conceptualizing and defining constructs are forms of framing. How one frames an issue greatly influences the types of questions that researchers ask and the nature of the solutions that policymakers develop. Consequently, how researchers and policymakers conceptualize technology in the context of university technology transfer significantly effects the nature of the research and public policy they pursue, respectively.

The purpose of this paper is to present an alternative conceptualization and definition of technology in the context of university technology transfer. It integrates constructs and ideas in the related literature to provide a new perspective of technology that can support future scholarly research and public policy formulation about technology transfer in general, and university technology transfer specifically. Although the focus of the paper is university technology transfer to the private sector in the United States, the insights it presents are relevant to technology transfer more broadly and applicable in other geopolitical contexts.

Literature Review

There is no universally accepted definition of technology, either culturally or in the context of U.S. public policy. In fact, there is significant debate among scholars about the definition of the term. Moreover, the literature reveals that the concept of technology has

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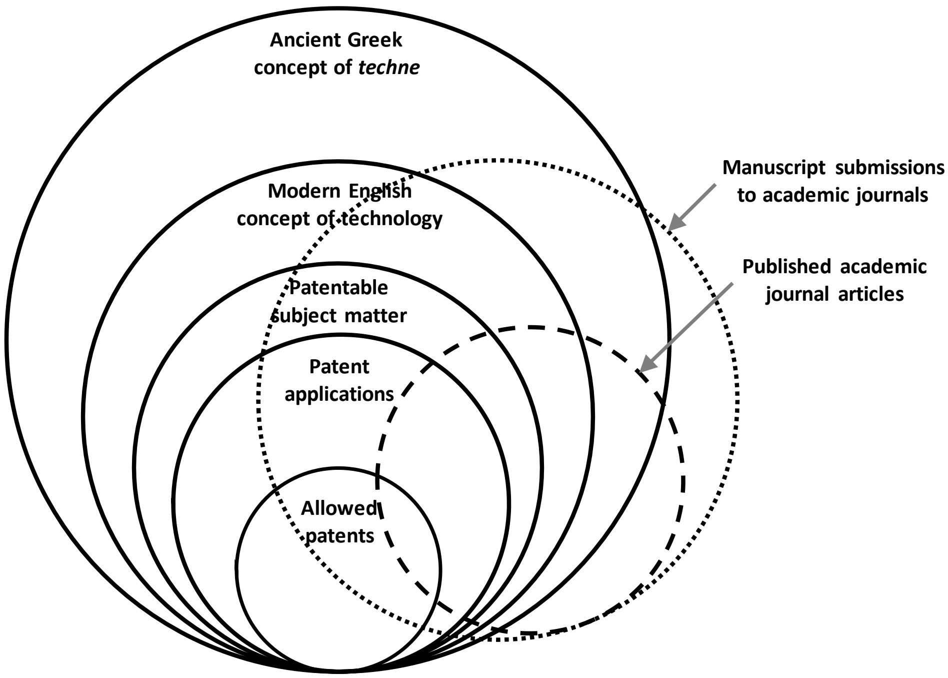
steadily narrowed over time (Figure 1). Defining technology and measuring the technology transfer phenomenon have posed significant challenges for researchers (Bozeman, 2000).



What is considered to be technology has narrowed considerably over time.

Note. Figure created by author.

Figure 1. The steadily narrowing conceptualization of technology

As a construct, it seems that the term *technology* is “a bastard child of uncertain parentage” (Schatzberg, 2018, p. 14). Throughout the course of history, the concept of technology has progressively narrowed from the meaning of the original Ancient Greek term *techne*, which is its oldest known cognate. As Schatzberg explained, *techne* referred to the science (i.e., principles and processes) of the useful arts (i.e., branch of learning or human activity). The German concept of *technik*, which was derived from the concept of *techne* in Ancient Greek, also had a broad meaning in its original use (Schatzberg). *Technik* was distinct from the German term *technologie*, both of which were associated with craft production

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(Schatzberg). *Technik* could take on a broad meaning referring to the rules, procedures, and skills for achieving an objective (i.e., art in the most general sense) or a narrower meaning referring to the physical aspects of commercial enterprise (Schatzberg).

Technik eventually shaped the modern concept of technology in the English language through an unfortunate mistranslation (Schatzberg, 2018). English language scholars mistranslated *technik*, whose meaning in the German language varied depending on context (Schatzberg). Mistranslation of t*echnik* contributed significantly to the current confusion in the meaning of technology in the English language (Mitchman & Schatzberg, 2009; Schatzberg 2018). It is this confusion that helps drive the current debate among English-speaking scholars about the definition of technology.

Debates surrounding ontological issues about technology and its relation to and influence on society eventually led to the establishment of philosophy of technology as a field of study, marked by the establishment of the Society for the Philosophy of Technology in 1976 (Dusek, 2006). Characterizations of technology generally fall into one of three categories – tools, rules, or systems (Dusek).

Currently there are two primary schools of thought among English-speaking scholars regarding the definition of technology (Mitchman & Schatzberg, 2009; Schatzberg, 2018). The instrumental school is the dominant view and conceptualizes technology as tools or implements that serve practical purposes (Schatzberg, 2018). Proponents of the idea that technology determines culture (i.e., technological determinism) generally espouse this view (Schatzberg). Alternatively, the cultural school views technology as the “creative expression of human culture” (Schatzberg, p. 3). Scholars in this camp point to the influence that human agency and culture have in shaping the form of technology over time (Schatzberg). Both these viewpoints seem to touch on fundamental truths about the nature of technology (Schatzberg) but neither serves as an adequate definition of technology in and of itself. Moreover, these viewpoints are not mutually exclusive. Rather, they are essentially two sides of the same coin.

In the early 1960s a definition of technology emerged in the English language that, although stable over the past several decades, is fairly muddled because it comprises three primary meanings (Schatzberg, 2018). The first meaning is the application of science (i.e., applied science) (Schatzberg). A second definition is an autonomous body of knowledge, practices, and artifacts (i.e., industrial arts) (Schatzberg). Finally, a third definition is technique (i.e., instrumental reason) (Schatzberg). According to Schatzberg, these meanings are incompatible with one another. One might also argue that these definitions are also somewhat arbitrary categorizations derived from the social machinations of various individuals who sought to manipulate the definition of technology to protect or increase the prestige and political clout of their respective disciplines.

Feibleman (1961) exemplified the quandary of conceptualizing technology. Feibleman attempted to distinguish between pure science, applied science, technology, and engineering. His approach essentially placed these constructs on a continuum with each one building on the previous one. Feibleman argued that pure science was systematic theoretical and experimental efforts to describe nature and discover laws with no concern for potential application while applied science was the application of pure science for improving human means and ends. Fiebleman defined technology as improvements of instruments used to extend applied science. This definition conforms to the instrumental reason conceptualization of technology. Fiebleman argued that engineering was technology applied to specific situations. Fiebleman did note, however, that scientific pursuits are not entirely pure science or entirely applied science.

Moreover, he observed that both applied science and technology often reveal previously unknown scientific principles and natural laws.

The ambiguity regarding the conceptualization of technology is apparent in the technology transfer literature. Typically, technology transfer studies have not bothered to define the term *technology*. However, they generally seem to conform to the instrumental definition when operationalizing the concept.

Scholarly research studies often operationalize technology, in the context of university technology transfer, as a disclosure of potentially patentable subject matter to a university or a patent right to a government recognized invention (see e.g., Anderson, Daim, & Lavoie, 2007; González-Pernía, Kuechle, & Peña-Legazkue, 2013; and Markman, Gianiodis & Phan, 2009). However, this approach is problematic. It fails to recognize that patentable subject matter is defined by law, which varies across geopolitical borders. What is patentable in one country may not be patentable in another country. Moreover, what is considered patentable subject matter may change over time and thus is not stable. As such, not all technology is patentable.

The ambiguity surrounding the meaning of technology is vexing for both public policy and society in general. For example, there are medications such as anti-depressants, anti-psychotics, and mood stabilizers that are used to treat various mental illnesses. Likewise, the L.E.A.P. (Listen, Empathize, Agree, Partner) method developed through scientific investigation helps mentally ill persons to accept treatment (Amador, 2012). The U.S. government and society in general tends to view the medications as technology but generally does NOT view advances like the L.E.A.P. method as technology. Moreover, application of the L.E.A.P. method by society does not show up in any technology transfer metric used to measure the transfer of research discoveries to the private sector. As such the L.E.A.P. method and other similar

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examples do not get factored into the policy debate about technology transfer in any significant way. However, if the L.E.A.P. method were patentable subject matter and patented accordingly, society and government metrics would likely recognize it as technology. This seems rather arbitrary and demonstrates a further narrowing of the meaning of technology from applied science and instrumental reason to patentable subject matter, which is evident in current U.S. public policy regarding technology transfer.

An Alternative Conceptualization and Definition of Technology

As an alternative, one can conceptualize technology in terms of information. Using this approach, technology can be defined as culturally influenced information that social actors use to pursue the objectives of their motivations, and which is embodied in such a manner to enable, hinder, or otherwise control its access and use. This definition is consistent with the observation of Lall (2001) that technology must be embodied in specific items as well as the notions of other scholars that have commented on the subject (see e.g., Herschbach, 1995; Leonard-Barton, 1990; Stoneman, 2002; Weber, 1922/1964; Williams & Gibson, 1990).

Conceptualizing technology in terms of information is not an entirely new idea in the discourse about technology transfer. Williams and Gibson (1990) offered a definition of technology as "information that is put to use" (p. 13). Leonard-Barton (1990) expanded on this by offering that technology was knowledge embodied in an artifact that facilitates the completion of some task. Leonard-Barton further stipulated that such knowledge is technology only when captured in a form that can be communicated. Herschbach (1995) acknowledged that technology embodies knowledge and argued that the knowledge embodied in technology only has meaning in the context of human activity. Stoneman (2002) also pointed out that technology has been

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defined as information or knowledge within the literature and doing so has certain analytical advantages.

The information sciences literature provides a foundation for conceptualizing technology in terms of information. The DIKW (data, information, knowledge, wisdom) hierarchy is the primary paradigm used in information science and knowledge management (Frické, 2019). Conceptualizing technology in terms of information as described in the DIKW hierarchy has at least one advantage. There is general agreement about the elements of the hierarchy, their definitions, and their ordering (Rowley, 2007).

Each category in the DIKW hierarchy includes the categories below it (Frické, 2019). According to Frické, data are symbols that represent the observable properties of objects, events, and environments (i.e., phenomena). By definition, intentionally false statements are not data (Frické). Data are assertions believed to accurately represent the nature of reality in the physical and social world. However, data can be inaccurate or incorrect even when they are intended to accurately represent reality.

Information, in turn, is data that has been processed to answer a query (Frické, 2019). The difference between data and information is more function than form (Frické). For example, the symbols in a table of federal obligations to universities for research and development represent data. They become information when one compiles them into the table to answer the question of whether federal funding for research and development is generally increasing or decreasing.

Knowledge in the DIKW hierarchy is information that has been transformed into instructions to enable control of a system – that is, know-that and know-how (Frické, 2019). In this respect, technology as defined above has a lot in common with knowledge as defined in the

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DIKW hierarchy. Whether technology and knowledge are synonymous, or one is a superset of the other remains to be debated and is beyond the scope of this paper.

It is important to note that the term *knowledge* is used differently in the DIKW framework than in western philosophy and everyday language. In western philosophy, knowledge is that which is known and the traditional definition of what it means to know is "justified true belief" (Ichikawa & Steup, 2018). To know means to justifiably believe an assertion is a true reflection of the physical and social world. However, since the 1960s epistemologists have posed and debated challenges to this definition of knowledge (Ichikawa & Steup). The way the term knowledge is used in everyday language is more appropriately called data and information in the DIKW hierarchy. For example, a political science professor might claim to have a significant amount of knowledge about the U.S. political system. Applying the DIKW framework, it is more appropriate to say that the professor has mentally retained a large amount of data and information about the U.S. political system. That data and information do not become knowledge until the professor applies them in some way to control a system, such as describing a new voting system that more closely resembles an ideal political mechanism.

Finally, in the context of the DIKW framework, wisdom is a more elusive construct. There has been limited discourse about wisdom in the information sciences and knowledge management literature (Rowley, 2007). Frické (2019) argued that wisdom is knowledge that is applied to achieve an end. Some scholars conceive of wisdom as accumulated knowledge from one domain applied to new situations or problems (Rowley, 2007, p. 174). However, an adequate definition of wisdom is not necessary to apply the DIKW hierarchy as a framework to underpin the proposed conceptualization of technology. Since technology is defined as a form of information, definitions for the first three components (data, information, and knowledge) will suffice.

Frické (2019) further argued that the DIKW hierarchy is an incomplete framework and should include document and sign as two additional concepts. This aligns with the notion expressed by Leonard-Barton (1990) that knowledge must be captured in communicable form to be considered technology. Frické also argued that documents are culturally specific tools for communicating knowledge, information, and data. This harkens to the cultural school of thought regarding the definition of technology. The proposed alternative conceptualization of technology captures these concepts through its requirements about embodiment.

Some technology transfer studies have broadened the idea of technology to include "academic knowledge" in the epistemological sense of the term knowledge (see e.g., González-Pernía, Kuechle, & Peña-Legazkue, 2013). By making a slight modification to the DIKW conceptualization of knowledge, one can harmonize it with the epistemological meaning of the term. Defining knowledge in the DIKW hierarchy as information that one can justifiably believe is a true reflection of the physical and social world that is used to explain, predict, or control phenomena better aligns the term with its use in epistemology while retaining its role in the DIKW hierarchy. Thus, if one conceptualizes technology as derived from information, it is apparent that technology is closely related to knowledge as conceptualized in both epistemology and the DIKW hierarchy. Moreover, technology and knowledge might well be synonymous. Within the framework of the DIKW, each category includes the categories below it (Frické, 2019). As such, knowledge consists of information. Likewise, technology as defined in the proposed alternative conceptualization is information that has been changed in some manner; but

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the information itself is conserved. As such, technology, like knowledge, consists of information.

Discussion

The aim of the discourse in the previous section was to integrate related literature into an alternative conceptualization of technology and convincingly demonstrate that the alternative conceptualization has merit. This section of the paper considers the implications of the proposed alternative conceptualization of technology for our efforts to understand and explain the phenomenon of university technology transfer and craft effective relevant public policy.

Advantages of the Proposed Conceptualization of Technology

A primary advantage of the proposed alternative conceptualization of technology is that it can be broadly applied. For example, a peer-reviewed journal article is simply information about a phenomenon that is embodied in a periodical format to facilitate its dissemination and accessibility for use. A patent (under U.S. patent law) is simply information about a manufacture, method, or improvement to a manufacture or method that is embodied in documentation that conforms to guidelines dictated by the government to facilitate its accessibility and use while enabling the patent holder to leverage the coercive powers of the state to prevent others from using the information for a specified period. A trade secret is simply information about something that has inherent economic value that is embodied in documentation, human memory, and protocols to control its accessibility and use while preventing unwanted parties from accessing and using the information. A Clovis point[2] is simply information about using pressure flaking to create a leaf shaped projectile point broader

[2] Clovis points are stone artifacts associated with a prehistoric Paleoamerican culture located in what is now the Americas that existed from around 11,050 BCE to 9,050 BCE (Clovis culture, 2021; Clovis point, 2021). They take their name from the city of Clovis, New Mexico, USA where the first artifacts were found in the 1920s (Clovis point).

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near its midsection and toward its base that is embodied in physical form to facilitate its use to achieve an end. A smartphone is information about using digital signals and electronic displays to communicate with others that is embodied in physical form to facilitate its use by the general public. All these examples represent embodiments of technology. It is possible, and quite likely, that the nature of the embodiment somehow affects the transfer of the technology from one party to another. This seems to play a role in issues surrounding how university technology transfer is measured and evaluated.

Implications for the Discourse about University Technology Transfer

The conceptualization and operationalization of university technology transfer seems to have been troublesome for scholarly research on the subject. How technology itself is conceptualized and defined has likely contributed to and exacerbated this difficulty.

Like the term *technology*, there is no universally accepted definition of the general concept of technology transfer. As with *technology*, most studies of technology transfer fail to explicitly define the term. The definition of technology transfer seems to vary depending on the context of the research. For example, an investigation of the effects of international technology transfer on welfare under the conditions of Bertrand and Cournot competition defined technology transfer as “the process of transferring a new technology from a firm in one country to a firm in another country” (Kuo, Lin, & Peng, 2016, p. 214). However, this definition is a bit circular. It also eliminates scenarios that one would generally consider to be cases of technology transfer, such as the transfer of technology between firms in the same country. Thus, it violates the general guidelines for constructing definitions (see e.g., Dusek, 2006, p. 30).

Another example is Kundu, Bhar, and Pandurangan (2015), which defined technology transfer as “the process by which technology, knowledge, and information developed in one

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organization for one purpose is applied and utilized by another area in another organization, for another purpose" (p. 70). They seem to have been striving for a definition that comprehensively captures the technology transfer phenomenon. However, this definition also violates generally accepted guidelines for crafting definitions because it is overly restrictive and excludes scenarios that should be included in the definition of technology transfer such as the use of technology, knowledge, and information by another organization for the same purpose for which the creating organization used it or intended its use.

Speser (2012) defined technology transfer as "the transfer of technology from one person to another across organizational lines" (p. xxiii). This definition does attempt to overcome the problem of reification of the organization construct, which is a relevant ontological issue that impacts how the phenomenon of university technology transfer is studied and understood. However, it is also circular and violates the generally accepted rules for formulating definitions. It fails to clarify what it means for a technology to be "transferred." Moreover, the definition of technology that Speser used is inconsistent. At one point, Speser defined technology as "a physical embodiment of an ideal that is helpful for accomplishing a task" (p. 16) but elsewhere argued that technologies are only those ideas that can be embodied in such a form that their creators can secure property rights (i.e., patentable subject matter) and rely on the coercive powers of the state to enforce those rights (p. 7-8). Again, this exemplifies the narrowing conception of technology as patentable subject matter.

The use of the term *commercialization* further exacerbates the issue of conceptualizing and defining university technology transfer. The term *commercialization* is often used as a synonym for technology transfer; however, it is generally used in the context of technology transfer endeavors driven by profit motives (see e.g., Fasi, 2022; Gulbrandsen & Rasmussen,

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2012; Mercelis, Galvez-Behar & Guagnini, 2017; Kirchberger, M. A., & Pohl, L., 2016). But this is not always the case. Moreover, technology transfer can occur in the absence of a profit motive.

In defining and operationalizing technology transfer, it is important to distinguish between it and the closely related phenomenon of technology diffusion. Technological diffusion is concerned with the dissemination of a technology throughout an industry, economy, or society after first incorporation whereas technology transfer has more to do with the introduction and first incorporation of a technology into a setting (Stoneman, 2002).

Generally, studies of technology transfer seem to conflate it with the mechanisms for achieving it. Moreover, most research studies of university technology transfer appear to select indicators and measures more for convenience rather than to maximize construct validity. This is possibly a direct function of how technology itself is conceptualized. Licensing and new venture formation are typically used as indicators of technology transfer. Research collaborations and faculty consulting agreements, although discussed in the literature, are used far less frequently. Executed patent licenses, established new business entities, and executed sponsored research agreements have also been used as proxies for technology transfer (see e.g., González-Pernía, Kuechle, & Peña-Legazkue, 2013; Hallam, Wurth & Mancha, 2014; Markman, Gianiodis & Phan, 2009; Tseng & Raudensky, 2014).

Each of the aforementioned approaches have their shortcomings. For example, if a private sector organization executes an exclusive license for a university-created technology but takes no further action because it wants to protect the market position of an existing product or service, should one consider this a case of university technology transfer? Or, if a new business entity is created explicitly to execute a license for a university-created technology but the venture

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fails to successfully introduce a market offering using the technology, should one consider this a case of university technology transfer? Such scenarios occur, show up in the metrics, and are often associated with significant financial transactions but neither really seems to produce incremental benefit for society. Moreover, the use of such operationalizations tends to reinforce the narrow conceptualization of technology as patentable subject matter.

Several scholars have commented on the limitations of typical conceptualizations of technology transfer. Approaches for measuring technology transfer success have transitioned from input metrics to output indicators to outcome and impact measures, the last of which technology transfer practitioners believe are more appropriate (Fraser, 2010). University technology transfer outcomes are only partially reflected in measures of income generation and new business venture formation (Carlsson & Fridh, 2002). Using licensing revenue as the primary measure of technology transfer success is limiting because it constitutes only a portion of the outcomes of technology transfer efforts (Herzog & Wasden, 2013). Other outcome and impact phenomena to which technology transfer contributes include the economic impact on the area in immediate proximity to the institution, number of lives saved, improvements in the lives of individuals, and increases in the competitiveness of commercial enterprises (Fraser). Conceptualizing technology more broadly can possibly cause scholars to think about university technology transfer more comprehensively and thus lead them to identify additional outcomes that are worthy of consideration in public policy discussions.

Conceptualizing technology as information may help bring some clarity to the definition of technology transfer, particularly university technology transfer. At the most basic level, one may think of technology transfer as simply the conveyance of technology (as defined above in terms of information) from the possession of one social actor to the possession of another social

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actor for the purpose of applying the technology in a setting in which it has not previously been applied. Since technology is defined in terms of information, technology transfer is simply the conveyance of information. This conveyance may occur in various contexts such as between affiliated or unaffiliated social actors and across geopolitical borders. It may occur in various manners such as formally or informally. It may occur through various mechanisms such as fee-based patent licenses, non-fee creative commons licenses, product sales, service delivery, or collaborative work arrangements. It may also occur through various methods such as sanctioned or illicit. Moreover, social actors may engage in technology transfer to achieve a variety of objectives such as generating financial gain, increasing the competitive advantage of a commercial enterprise, increasing the standard of living within a country, facilitating broader economic development within a geopolitical border, or simply developing culture and cultural structures.

Using the proposed alternative conceptualization of technology, one can go on to conceptualize university technology transfer as technology (again, as defined in terms of information) created by university researchers through systematic methods and practices of inquiry that is knowingly and willingly conveyed to other parties who intend to apply the technology in a setting in which it has not previously been applied to achieve an end. This end is often associated with a profit motive for the receiving party, but this need not be the case. Technology transfer can and has occurred in the context of humanitarian efforts in which the profit motive is minimal or even non-existent (see e.g., Association of University Technology Managers, 2021a).

This broader definition of technology expands the possibilities for various operationalizations of the construct in university technology transfer research. For example,

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rather relying on patents as the *de facto* operationalization, other embodiments of technology can be used such as patent applications, trade secrets, journal article manuscript submissions, project reports to funding agencies, or even blog posts. Such expansion is highly advantageous given the trends in university technology transfer in which greater emphasis is being placed on non-patented forms of intellectual property such as data, copyrights, know-how, and know-what. Thus, the broader conceptualization could lead to increased construct validity.

Additionally, an expanded conceptualization of technology potentially opens new approaches to research on the topic of technology transfer, particularly university technology transfer. A great deal of university technology transfer research relies on correlational analyses and various forms of multiple regression analysis. The data requirements of these methods constrain the types of research questions that can be examined and thus reinforces a narrow conceptualization of technology. By broadening the conceptualization of technology, it forces the researcher to think about university technology transfer more expansively and consider other types of operationalizations and data. Thus, researchers are challenged to contemplate and conceive new methodologies, methods, and techniques.

Consider for example, the true incidence of university technology transfer. How technology is conceptualized and operationalized greatly affects the resulting calculation of incidence rate. Consequently, the estimated true incidence of university technology transfer can vary widely. It is also apparent that the problem is further exacerbated when one considers that the definition of technology also influences the conceptualization and operationalization of university technology transfer, which contributes to additional variation in the possible calculations of the incidence rate.

Implications for Public Policy Regarding University Technology Transfer

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Finally, the broader conceptualization and definition of technology could and should cause policy analysts and policymakers to think more comprehensively about technology transfer and what it means to successfully transfer technologies derived from federally funded research to the private sector for use that benefits the public interest. Such reassessments are likely to lead to a larger array of better public policy innovations that generate greater benefits for society.

As of April 2022, there were at least 14 major federal laws and executive directives that form the core of public policy regarding university technology transfer (Table 1). These policies seem to focus predominantly on the problems of incomplete information and influencing the behavior of creators and suppliers of technology (i.e., supply-side actors). They also seem to imply a narrow conceptualization of technology as commercially valuable patentable subject matter. Take for example the Bayh-Dole Act of 1980 which allowed universities to take assignment of patents for inventions derived from federally funded research and development. The premise behind the law was that providing universities with property rights to inventions would create an economic incentive for universities to pursue the transfer of these technologies, primarily through licensing, to private sector commercial enterprises for use that benefits the

Table 1

Federal Legislation and Executive Action Relevant to University Technology Transfer

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Year	Policy	Relevant Provisions	Policy Target
1980	Pub.L. 96-517 Bayh-Dole Act	Permitted universities, nonprofit firms, and small businesses to take title to inventions derived from federally-funded research as a way incentive these organizations to facilitate the use of the inventions to benefit the public interest.	Supply-side
1980	Pub.L. 96-480 Stevenson-Wydler Technology Innovation Act	Mandated that federal laboratories establish an Office of Research and Technology Application (ORTA) to facilitate their active technical cooperation with the private sector.	Supply-side
1982	Pub.L. 97-219 Small Business Innovation Development Act	Mandated that federal agencies set aside a specific portion of their extramural research budgets to fund research and development projects within the scope of their agency missions to be performed by small businesses in the private sector.	Supply-side
1984	Pub.L. 98-462 National Cooperative Research Act	Enabled private sector businesses to enter into joint pre-competitive research and development ventures without violating federal antitrust laws. Eliminated treble damages in antitrust litigation arising from such ventures.	Demand-side
1986	Pub.L. 99-502 Federal Technology Transfer Act	Established the Federal Laboratory Consortium (FLC) for Technology Transfer and enabled government-owned, government-operated federal laboratories (GOGOs) to directly enter into cooperative research and development agreements (CRADAs) with private sector businesses.	Supply-side
1987	Executive Order 12591 Facilitating Access to Science and Technology	Further specified Pub.L. 99-502 for administrative purposes.	Supply-side
1987	Executive Order 12618 Uniform Treatment of Federally Funded Inventions	Further specified Pub.L. 99-502 for administrative purposes.	Supply-side
1988	Pub.L. 100-418 Ominbus Trade and Competitiveness Act	Established Manufacturing Technology Centers and designated the National Institute of Science and Technology (NIST) as the lead agency to administer them.	Supply-side

Table 1 (continued)

Federal Legislation and Executive Action Relevant to University Technology Transfer

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Year	Policy	Relevant Provisions	Policy Target
1989	Pub.L. 101-189 National Competitiveness Technology Transfer Act	Extended the ability to enter into CRADAs with private sector businesses to all government-owned contractor-operated federal laboratories (GOCOs).	Supply-side
1991	Pub.L. 102-245 American Technology Preeminence Act	Authorizes appropriations to be available for Regional Centers for the Transfer of Manufacturing Technology, State Technology Extension Program, Advanced Technology Program, and Satellite Manufacturing Centers.	Supply-side
1993	Pub.L. 103-160 Defense Authorization Act	Directed the Advanced Research Projects Agency (ARPA) to promote dual-use technology via technology reinvestment.	Supply-side
1995	Pub.L. 104-113 National Technology Transfer and Advancement Act	Enacted changes to ease the ability of private sector businesses to obtain exclusive license to inventions that result from cooperative research with the federal government.	Demand-side
2000	Pub.L. 106-129 Technology Transfer Commercialization Act	Requires license applicants for federally-owned inventions to commit to achieving practical application of the invention within a reasonable time.	Demand-side
2011	Pub.L. 112-29 Leahy-Smith America Invents Act	Reformed patent laws and instituted "first inventor to file" patent registration system.	Supply-side

Note. Table created by author.

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public interest. However, a consequence of this public policy approach is that technologies comprising non-patentable subject matter or patentable subject matter with low perceived profit-generating potential are unlikely to be pursued regardless of whether they could improve the well-being of citizens and residents.

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Since the at least the 1960s, it has been argued that the U.S. has a large unused store of technologies (Schrier, 1964). The problem may be much worse than we think considering the current narrow conceptualization of technology. Although the absolute number of technologies licensed to the private sector has increased over time, the situation regarding unused stores of technologies really has not changed. Given that the situation has not changed, it is prudent for researchers and policymakers to step back and re-evaluate how the issue is being approached and how public policy is being informed and crafted.

Evaluating rival problem formulations is among the most critical steps in policy formulation (Dunn, 2016). In addition to considering potential courses of action, productive policy debates also involve evaluating competing views of the nature of the problem itself. The proposed alternative conceptualization of technology may lead to alternative views of what it means to transfer university technology. This would in turn influence the policy objectives adopted and the types of policy solutions developed to achieve those objectives.

Conclusion

The aim of his paper was to present an alternative conceptualization of technology in the context of research and public policy regarding university technology transfer. It first demonstrated the challenges and limitations of current conceptualizations of technology. It then integrated ideas and constructs from the related literature to propose an alternative conceptualization and definition of technology as culturally influenced information that social actors use to pursue the objectives of their motivations, and which is embodied in such a manner to enable, hinder, or otherwise control its access and use. The paper then explored how this alternative conceptualization and definition of technology might influence scholarly research and public policy about university technology transfer. It is argued that the alternative conceptualization of technology would challenge researchers to innovate regarding the kinds of questions studied as well as the operationalizations of constructs and methods used to examine the phenomenon of university technology transfer. It would also likely lead researchers and policymakers to reimagine what it means to transfer university technologies to the private sector to benefit the public interest. There is the potential for these efforts to subsequently cause policymakers to consider different policy objectives regarding the transfer of technologies derived from federally funded research and help produce public policy innovations to achieve those policy objectives. Although the discussion focused on university technology transfer to the private sector in the United States, the observations and arguments presented in the paper are germane to technology transfer more broadly and pertinent to other geopolitical environments.

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