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GENDER DATA GAP: BASELINE OF U.S. ACADEMIC INSTITUTIONS

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Despite evidence of the positive impact of female participation in leadership roles of corporations, women remain consistently under-represented in business ventures, particularly in science, technology, engineering, and mathematics fields. For the U.S. economy to expand and produce jobs at an accelerated rate, women must account for a much higher percentage of entrepreneurial leaders throughout all phases of the innovation life cycle. Female academicians face disproportionately low engagement in the technology transfer process, both in the initial invention disclosure submission as well as in the patenting process (1-4). This investigation sought to both establish a baseline for measuring U.S. academic institutions' tracking of inventors by gender and gain insight about the barriers keeping technology transfer offices (TTOs) from tracking gender in commercialization-related areas. The researchers also conducted an initial analysis on the leading software tools currently being utilized to track gender in academic TTOs. Raising awareness of this issue on a national level will help institutional leaders create strategies and mechanisms to help address the issue of gender disparity and increase the inclusion of women in the innovation lifecycle, particularly at the university disclosure and patenting level.

Key words: Gender bias; Technology transfer; Patenting; Data collection; Women; Inventorship

INTRODUCTION

The Association of University Technology Managers (AUTM) Women Inventor's Committee (WIC) was conceived in 2011 and formally established in 2013 to help address the growing concern over how to address disparity of gender participation in technology transfer activities. AUTM WIC consists of 14 total individuals from nine universities and five non-university organizations (including government agencies, industry professionals, law firms, and investors) who volunteer their time to help increase the engagement of women in the technology commercialization process.

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AUTM is a nonprofit organization dedicated to bringing research to life by supporting and enhancing the global academic technology transfer profession through education, professional development, partnerships, and advocacy. AUTM's more than 3,200 members represent managers of intellectual property (IP) from more than 300 universities, research institutions, and teaching hospitals around the world as well as numerous businesses and government organizations.

The role of patenting at academic institutions has grown in significance since the passage of the Bayh-Dole Act in 1980, which transferred IP ownership based on federally funded research discoveries from government to universities. According to Sugimoto et al. (4), women's rate of total patenting has increased over the past several decades, from 2.7% in 1976 to 10.8% in 2013. During this period, the overall percentage of patents with women's names attached rose from an average of 2% to 3% across all areas to 10% in industry, 12% in individuals, and 18% in academia. The study also concluded that women in academia patent at higher rates compared to industry and government, a phenomenon attributed to the important role of technology transfer offices in setting policies that encourage women's innovation (4).

However, despite a narrowing of the gender gap in commercialization activities since the passage of Bayh-Doyle, significant disparities still exist. Multiple studies have articulated the disproportionately low engagement in the technology transfer process by female academicians. For example, a male faculty member is 43% more likely than a female faculty member to submit an invention disclosure (1-3) to his technology transfer office (TTO), which is the basic entry point of engaging the TTO. Patents in academia, government, and industry do not come close to reflecting the representation of women in science, technology, engineering, and mathematics (STEM), the fields most associated with patentable discoveries. The "impact score" assigned to patents with the names of women, calculated using the number of times these patents were cited in other patent filings, is much lower compared to patents with male names (4). The numbers reflect similar findings to earlier research on women and publishing, which found lower citation rates for women (5).

To focus on this phenomenon, the AUTM WIC formed three subcommittees: Barriers, Synergistic Organizations, and Metrics. The Barriers subcommittee was tasked with understanding in what ways the gender disparity in technology transfer activities existed and why. The Synergistic Organizations subcommittee was tasked with focusing on what organizations are doing to address the disparity and coalesce around best practices. Finally, the Metrics subcommittee (MSC) was formed to measure the impact of the overall WIC initiatives and assess whether AUTM WIC activities were having a measurable impact on increasing female participation in the commercialization process of AUTM-affiliated universities.

In order to gauge this impact, the WIC/MSC initially planned to survey existing AUTM members to gather baseline statistics by gender for relevant data (for example, invention disclosures and patent applications). Follow-up surveys could then be conducted to determine increases in identified areas and provide indication of the impact of the WIC efforts as an overall committee. AUTM conducts an annual survey for its university members to gather data around invention disclosure and patent information of individual TTOs; however, the gender variable had never been explored. Incorporating questions into this existing survey was considered an ideal approach for data collection.

The annual AUTM survey format has standardized questions as well as a "supplemental" section whereby committees can request to add questions. The WIC/MSC received approval to include two supplemental questions on the 2015 annual AUTM survey. The WIC/MSC began research into the best questions to serve the investigative purpose of WIC's overall mission and, during this due diligence, began to realize that few of the TTOs represented by WIC members were tracking gender. This discovery was surprising and led the subcommittee to question the timing of including the supplemental questions on the annual AUTM survey, as supplemental questions are only allowed for a period of two consecutive years. After the two-year period, if the questions are considered to be of continued value to the larger organizational community, they may be incorporated into the primary survey. However, if traction is not gained due

to low response rates, the questions are dropped, and further data gathering is not available in this format. Since it was anticipated that there would be an extremely low response rate due to the expectation that few university TTOs were tracking gender, the WIC/MSC decided instead to adopt an early-stage investigation and advocacy approach.

Alternatively, as an initial approach, the WIC/MSC decided to undertake an investigative study to uncover how TTOs were incorporating gender considerations into their metrics. This investigative study sought to determine which university TTOs were tracking inventors by gender and gain insight about the barriers keeping TTOs from tracking gender in commercialization-related areas. A secondary goal included increasing awareness about the importance of gender tracking for those who had not been considering gender impact in their routine activities. The final objective was to increase the number of university TTOs tracking gender in order to get maximum impact when the WIC/MSC decided to submit gender-specific questions to the AUTM annual survey.

LITERATURE REVIEW

This study has drawn upon previous literature and research on gender gaps and biases in innovation and invention, including literature on the history of the journey of women in innovation; trends in female participation in inventing and patenting; barriers to women's patenting activities, including implicit bias; variation in IP policies; the complexity of the patent process; gender socialization; issues of availability of data; and the role of institutions in providing resources. Our analysis contributes by reviewing current practices of academic institutions in tracking inventors by gender, with the intention of increasing awareness so that more focused resources can be developed and provided to support female inventors.

Participation of Women in Innovation and Commercialization

By failing to explore women's participation in innovation and commercialization, the U.S. is missing out on an enormous potential source of innovation. In 2016, a three-country study (U.S., Japan, and Europe) of patents related to life sciences, materials sciences, information technology (IT), and/or large tech companies found that women only represent 12% of U.S. inventors (6). Additionally, the average U.S. male is nine times more likely to contribute to an invention than the average U.S. female (6).

One important aspect of this issue begins in our research universities. As Stephan and El-Ganainy (7) reported, "Beginning with disclosure, a substantial gap exists between women and men in each stage of technology transfer and entrepreneurial activity." Reaching parity in patenting activities among the sexes at the current rate will take an extended amount of time. In 2010, the percentage of patents that included at least one female inventor had increased to 18.8% from 3.4% in 1970, and patents listing women as primary inventors were 7.7% of the total. While this is a start, at this rate, gender equity in patenting won't be reached until 2092 (8).

Gender Bias

In addition to educational, economic, and financial barriers, unflattering stereotypes and cultural norms prevent women from pursuing patent protection for their ideas. Indeed, as Kahler writes:

> History reveals that women have systematically been excluded from inventing, patenting, and other science and engineering-related endeavors, for a variety of legal, social, and economic reasons. Arguably, many of the more overt forms of discrimination toward women have diminished over time; however, informal barriers and subtle (albeit even unintentional and unconscious) bias persist. (9)

Draconian IP laws vested ownership with the woman's spouse and were not fully changed across the U.S. until the passage of the Married Women's Property Act. During the nineteenth century, starting in 1839, states began enacting common law principles affecting the property rights of married women. Married women's property acts differed in language, and their dates of passage span many years. It was not until 1900 that all of the states had enacted some version of the Married Women's Property Act (9).

Systematic gender biases in patenting and entrepreneurial activities in the sciences have been documented, ranging from the initial exclusion of female inventors from commercial opportunities to

the predominantly male-coded environment these women face. Murray and Graham (10) identified several barriers to female inventors, including a sense of exclusion, limited opportunities, the perception that male scientists and engineers were highly regarded, and a "boys' club" environment. These barriers were particularly evident when controls for other metrics (publications, industry collaborations, and patents) were included in the methodology. Gender socialization also affects the unequal distribution of home and caregiving responsibilities, which limits the amount of time women have to devote to patenting and other commercialization activities (10).

Implicit bias in the patent office, for example, can have an impact upon the likelihood of patent issuance. A 2011 study found that U.S. patent examiners expressed disdain for female-generated inventions and refused to provide support via feedback to female inventors, while, at the same time, they were willing to provide feedback to male inventors (9). Such biases can have severe implications for female participation in patenting and entrepreneurial activities. In another study of U.S. patent examiners, Garber (11) found the existence of implicit bias in granting patents to women inventors on the part of both male and female patent examiners, finding that, overall, patent examiners are less likely to grant patents to women inventors.

Implicit bias exists in the academic world as well. Ding et al. (12) conducted an analysis of patenting activities in academic life sciences fields and found that, while controlling for several variables (including productivity, networks, field, quality of research, and employer attributes), women's work is of equal or higher quality compared to men's; regardless, female life scientists are patenting at 40% of the rate of their male peers. Their analysis also reveals gendered patterns in attitudes toward patenting among faculty: Women see formidable challenges in balancing patenting with other career and life obligations and, differently from their male colleagues, have concerns that these tradeoffs could negatively affect their teaching roles and access to laboratories and other equipment or may be perceived as interfering with other academic duties (12).

Benefits

It has been established that "[b]oth pecuniary and non-pecuniary benefits accrue to inventors; women disproportionately are not inventors in most fields, and therefore fewer women than men experience these benefits" (9). These benefits can include preferential treatment in forms of better research opportunities, access to lab space and equipment, investment funding, personal earnings, access to networks, and enhanced reputation (9).

Access to networks and resources are important to moving new ideas forward. Men draw on broad-reaching networks, including industry contacts, for advice from multiple perspectives and for invitations to join high-level teams, whereas women tend to join smaller networks with strong relations and, potentially, have access to fewer influential ties in their networks (9,12).

Women are disadvantaged by a limited number of connections. Women receive fewer invitations to join teams and are typically invited to join comparable peers rather than high-level teams (12). The exclusion of female scientists early on leaves them with a smaller network and fewer market opportunities, resulting in female inventors being less prepared and less confident than their male counterparts (10).

Patenting often leads to investment, as venture capital investors frequently consider patents in their funding decisions. Women's access to this type of investment is constrained by low rates of patenting (8) and can be further inhibited by lack of access to professional networks (13). Thus, gender differences in patenting may be amplified in public versus private settings due to variations in (a) the differing network positions of men and women and (b) the varying importance of network position on productivity in industry and academia (13).

Environmental, Legal, and Policy Factors

The lack of economic means influences innovation, and the gender disparity issue is most serious in non-egalitarian environments, where domestic finances are frequently controlled by men, thus limiting women's autonomy and decision capacity. This can block innovation initiatives of entrepreneurial women (14). As Kahler notes:

> Among the pervasive barriers to early women inventors were laws that gave the legal rights to a wife's property and earnings to her husband. The law considered married women to be legal nonentities, subject to the control of their husbands, unable to enter into contracts on their own or engage in trade without permission from their husbands. With respect to intellectual property, a married woman could not sell her patent rights, mortgage real property to finance a business operation using a patent, or sue for patent infringement. (9)

Even once legal barriers were finally eliminated, women's opportunities have continued to be limited, as the cultural landscape takes time to evolve.

Three different constructs affect women's innovations in male-dominated technological industries: indicators of informal environment; the general economic, social, and family environment; and educational characteristics and general education at an institutional level. Specifically, "the discriminative position of women in society, denoted by the early marriages, the gender employment gap or the violence against women affect negatively to innovation led by women" (14). Gradual removal of local and state legal barriers to female ownership and control of their inventions and subsequent earnings provided a strong incentive for women to enter into the business world at the turn of the 19th century. After all "[i]nventing is inventing. Put an ingenious person in intimate contact with a problem and he or she will invent a solution-for everything from corralling the baby to damming a river to extracting gold from ore (all women's inventions)" (15).

Khan (16) found that the highest female per capita patenting rates in the U.S. were achieved in areas that featured more liberal laws towards women's economic rights. Much of the subsequent increase in female patenting activities has occurred in metropolitan centers where property rights were of greater concern. Their findings suggest the advent of women's property rights and sole trader laws encouraged higher patenting activities, as women were better able to secure the returns from their efforts, thus reducing transactions costs and increasing expected benefits. Legal reforms arguably stimulated women's investments in patenting and commercial activities. As such, "[t]he impact of nineteenth-century legal reforms thus deserves further attention, because it raises fundamental questions about the long-term consequences of arbitrarily excluding groups from participation in the market economy" (16).

Egalitarian workplaces provide support for female as well as male inventors. Workplaces with collaborative research teams, collective incentives, and horizontal distributions of positions and resources have much higher rates of female participation in patenting than more hierarchical settings (13,17). Hunt, Garant, Herman, and Munroe (18) suggest that growth in innovation and technological progress would be much higher if the entirety of the workforce (both men and women) were exploited. They conclude that increasing women's participation in patent-intensive fields of study would increase female patenting and suggest that early intervention is required (18).

These environmental factors are found within the academic environment as well. Frietsch et al. (19) note, "The higher the academic degree or position, the lower the share accounted for by women. These statistics reveal the well-known phenomenon of the 'leaky pipeline.' Figures for the U.S. likewise show the disappearance of women at each successive academic career stage." These studies have implications for academic and industry leaders in evaluating their organizational hierarchical structures. Specifically, "differences in the structure of collaborative relations in academia and industry have implications for the ways in which sector-level gender disparities in commercial activity arise" (13).

Industry Patenting Rates of Female Inventors

Silos exist for female patenting in industry. Patents with women as primary or sole inventor tend to fall into categories typically associated with female roles, including personal items, jewelry, and apparel. Patents with diverse mixed-sex teams of inventors span a greater variety, with top categories including chemistry and pharmaceuticals. It's interesting to note these diverse teams also had higher citation rates than single-sex teams in later patents (8). Moreover, as Kahler observes, "[t]he percentage of U.S.-origin patents that include a woman inventor increased from 2.6% in 1977 to 10.9% in 2002. Within the

utility patent category, we find a marked difference in women's participation across technologies, with more women inventors named on chemical patents than electrical or mechanical patents" (9). In their international analysis, Frietsch et al. note low shares of female patenting in the U.S. in the top two fields of pharmaceuticals and basic chemicals and found that, overall, the U.S. comes in below the international average in female patentees (19).

In IT fields, the overall level of female participation in IT patents remains low; however, recent trends are promising. While women held only 2% of all IT patents in 1980, the share increased to approximately 6% in 2005 and 8% in 2010. Women's patenting patterns differ widely from one organization to another. For example, several companies were shown to have 20% to 30% of their patents naming at least one female inventor, while some companies have less than 5% of their patents naming a woman inventor. This suggests that individual organizational environments do matter and can influence women's patenting patterns (20).

There is a strong gender gap in STEM entrepreneurship and patenting; across all STEM fields, women with doctorate degrees have lower rates of patenting and entrepreneurship than do men, with women STEM doctorates engaging in both activities at lower rates (5.4% versus 7%, respectively) (21). Influencing all of this is the ongoing issue with women entering and staying in STEM fields. Illustrating this point, "[i]n 2010, only 19.1% of engineering degrees, 20.9% of computer science, and 38.7% of degrees in the physical sciences were awarded to women, whereas 58.3% of degrees in the biological sciences were held by women" (8). Women in STEM are concentrated in the life sciences, which do not produce as many patentable inventions as do fields such as engineering and computer science. Hunt et al. (18) estimate that gender segregation across STEM fields accounts for 31% of the commercial patenting gap and that gender segregation in specific job tasks explains at least 13% of the commercialized patenting gap. This gender gap becomes more pronounced in positions where a great amount of experience is required (6). Women are also less likely than men to work in patent-intensive jobs, including research, development, and design. For example, 61% of men and just 46% of women holding STEM doctoral degrees work in research and development positions (22).

Frietsch et al. (19) find that, internationally, the relative contribution of women between 2003 and 2005—averaged across all technological fields—is highest in Spain (12.3%), followed by France (10.2%) and a group of countries with similar levels (of more than 8%) consisting of Denmark, Australia, the U.S., Belgium, and Sweden. At the lower end of the scale are Germany (4.7%) and Austria (3.2%). The general trend over time has been a strong increase in women's contributions to technology output in most countries, but it is still at a relatively low level. Female contributions are highest in pharmaceutical and basic chemicals, with the lowest contributions in engineering.

While all of these studies and prior work analyzed barriers to female patenting and entrepreneurship rates, many have also indicated a need for additional tools and resources to better understand and measure female participation in the innovation economy. Recommendations from prior work for increasing women's patenting activities include developing systems and data tools to better track gender (8). Our study is an initial analysis on such systems and tools.

METHODOLOGY

The following sections outline the specific aspects of the research methodology, including research questions, research design, sampling strategy, and data collection process as well as the data analysis strategy and validity and implications techniques that were undertaken.

Purpose of the Study

The purpose of this study was three-fold: to uncover how TTOs are incorporating gender considerations into their reporting activities, to increase awareness about the importance of gender tracking for those who have not considered gender impact, and finally to increase the number of university TTOs tracking gender. This investigative study was guided by the following questions:

1. What is the availability of data on participation rates at academic institution TTOs regarding

innovation based on gender?
2. What are the barriers that prevent collection of data by gender on participation rates in commercialization activity?
3. What are industry standard software programs available for monitoring technology transfer activities?

Research Design

Survey research was determined to be the best method suited to this type of inquiry. In order to develop a better understanding of how TTOs collect and utilize demographic information for their inventors, data and information was gathered from study participants using surveys (conducted either via email or telephone). Study participants included U.S. TTOs and TTO software application vendors.

Survey on Gender Tracking

An independent survey (WIC/MSC survey) was deployed to determine both baseline data regarding gender tracking in TTOs and to gain insight about potential barriers keeping TTOs from tracking gender in commercialization-related areas. The initial WIC/MSC survey consisted of five questions:

1. On behalf of which university or organization are you responding?
2. Does your university technology transfer office currently track gender for inventors?
3. If your university technology transfer office does not currently track gender, why not?
4. If your university is not currently tracking gender for inventors, would you be willing to speak with someone from our committee about implementing this?
5. If you answered yes to question #4 and would like us to contact you or someone in your department, please include contact information

Questions were designed to understand the current practices of university TTOs regarding gender tracking as well as obtain the referent information (university name and optional contact information for follow-up call). The survey also offered an opportunity for the respondents to have a follow-up conversation to learn more about gender monitoring and tracking in TTOs. The survey was kept intentionally short in the hopes of increasing participation and was introduced through an email providing the survey link and a brief introduction about the AUTM/WIC and the WIC/MSC and its mission. Survey Monkey® was used to collect and monitor data.

A master member list was obtained from the AUTM Metrics Committee, and the WIC/MSC survey was open from October 6 to October 16, 2015. The survey was sent to 189 university TTOs in the U.S. After this time, offices that had not responded to the survey were identified, and each WIC/MSC committee member received a number of TTOs with which to follow-up. Preference was placed on distributing university TTOs to WIC/MSC committee members who had a prior relationship with at least one person at the target TTO, and then non-responding TTOs were divided up randomly. Follow-up calls to non-responders were made between November 2015 and March 2016.

The WIC/MSC committee member making the follow-up call was instructed to engage in two tasks with these universities. The first task was to ask the original survey questions and enter the results into an Excel template. The second task had WIC/MSC committee members share several talking points to advocate and prompt additional discussions around implementing gender tracking at the target school. These advocacy talking points included:

1. How to start tracking gender if interested in starting to do so and sharing resources developed by WIC/MSC
2. Informing the TTO that gender-related questions will be included on the upcoming AUTM 2016 survey in order to encourage the TTO to begin tracking and possibly back entering data for the past year or two
3. Emphasize that tracking gender should not place additional burden on a department once implemented
4. Include any relevant anecdotal data for reference regarding barriers to implementing tracking
5. Ask which software the TTO office was using

Separate follow-up calls were also made to universities that responded to the initial survey and had

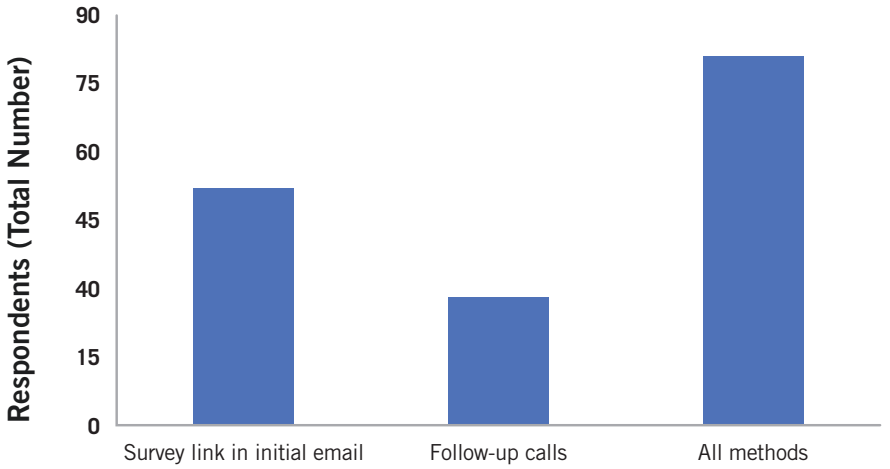

Figure 1. WIC metrics subcommittee response. The number of survey respondents and method of response.

indicated an interest in learning more about how to implement tracking at their universities. These calls were all made by the WIC/MSC chair, and the discussions included the advocacy talking points addressed in the committee follow-up calls to initial non-respondents outlined above.

Gender Tracking Technology

The WIC/MSC also reviewed the gender tracking capabilities of software utilized by TTOs to help determine what type of additional efforts would be required to track gender. Four primary companies were identified: InfoEd Global, Inteum, Tech Tracks/Knowledge Sharing System (KSS), and Wellspring. The WIC/MSC contacted all four companies regarding their capabilities and requested contact information to share with TTO offices for assistance if necessary. Initial contact was made via email explaining the mission of the WIC/MSC and requesting a follow-up call. Calls were completed with a senior executive of each of the software companies. This information was used to generate a software capability spreadsheet, which was posted on the WIC website. This spreadsheet was also utilized as a reference during follow-up calls with university TTOs.

RESULTS

Responses to the survey (Figure 1) included 52 TTOs responding directly to the emailed version of the WIC/MSC survey and 28 additional university TTOs using the follow-up call method. Total respondents to the survey were 81 universities out of 189, which gave an overall response rate of almost 43%.

Gender Tracking Survey Results

The data received by both outreach mechanisms showed that six TTOs were tracking gender at the time of the survey, which was 7% of overall respondents (Figure 2). The most cited reason for not tracking gender was attributed to the TTO having

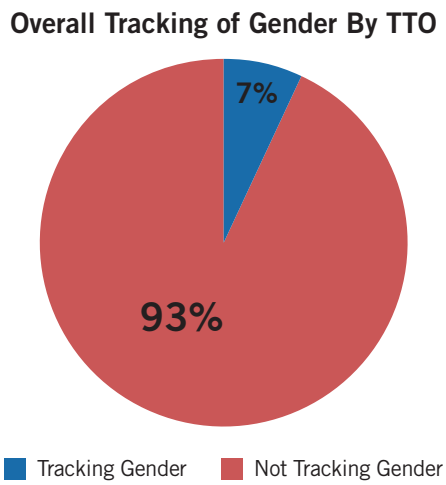

Figure 2. Overall tracking of gender by TTO. The percentage of survey respondents as to whether or not they track gender.

not considered gender tracking to be an important demographic to collect from those who submit invention disclosures, while 11% reported that they did not know why their offices did not track gender in their systems (Figure 3).

Additional details were provided by 21 of the total respondents as to why they did not currently track gender (Figure 4). These responses include:

- Concerns over liability of tracking gender and/or their internal human resource policies
- No perceived benefit to tracking gender
- A perception that tracking gender was or would be difficult to implement or concerns with the capability of their software to track gender
- A feeling that they could access the data through another campus resource if they needed or wanted
- No one has previously asked the TTO for this particular metric
- Resource constraints limiting the office from tracking
- A sense that the university is so small that the TTO staff was already familiar with the inventors, so formal tracking was unnecessary
- Consideration or actual planning was taking place in the office to begin tracking gender

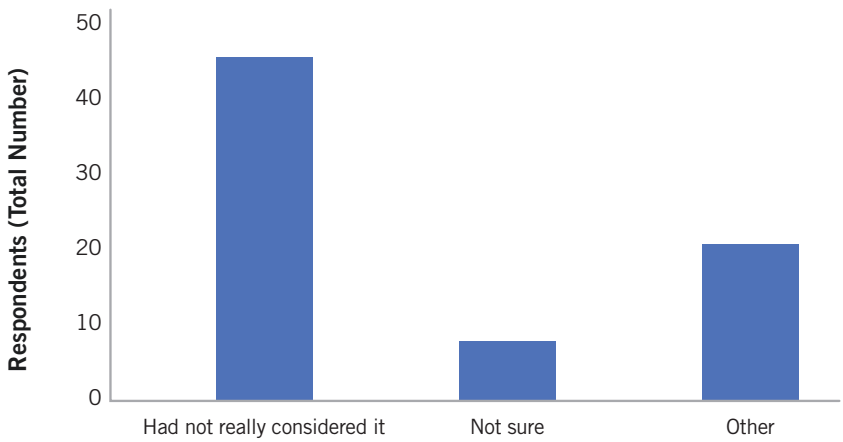

Figure 3. Rationale for not tracking gender. Reasoning provided by non-tracking universities as to why they have not been tracking gender.

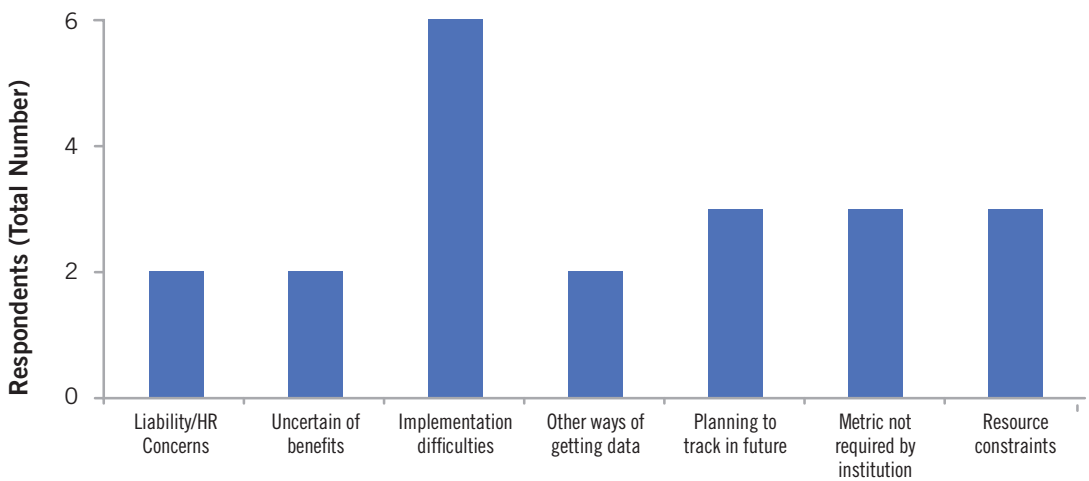

Figure 4. Additional reasons cited for not tracking gender.

In consideration of a TTO's willingness to understand gender tracking and possibly implement it, the survey asked whether an office not currently tracking was willing to take a future call for further conversation. Of the 52 schools who responded directly to the initial survey, 25 indicated they would like to have a future conversation, which was almost 50%, while 40% indicated they did not want to have a follow-up conversation. The WIC/MSC chair reached eight schools for advocacy conversations after the survey to discuss the implementation of gender tracking, while all 28 schools that received a phone call to gather initial survey data also received information on tracking gender.

Gender Tracking Technology Findings

Four predominant off-the-shelf software companies provide technology transfer databases: InfoEd Global, Inteum, KSS, and Wellspring. Of these four companies, two of them (KSS and InfoEd Global) already had built-in capability for tracking gender. After discussions with the WIC/MSC, Inteum updated their software to include gender-tracking capability in the fall of 2015. Prior to the initiation of this survey, Wellspring only offered gender tracking as an add-on available upon request. However, in the fall of 2016, Wellspring made it possible for users to add the gender field themselves.

CONCLUSION AND RECOMMENDATIONS

Research increasingly indicates that the disparity in gender regarding issues surrounding IP has negative impacts throughout the innovation lifecycle. Universities are at the forefront of much of the research being done, and a more comprehensive understanding of how university TTOs are addressing the issue of gender and innovation is a fruitful and important area for investigation.

This study directly addressed this issue by conducting the first known baseline study of TTO gender tracking at U.S. universities. The investigation sought to determine baseline data for gender tracking at university TTOs and gain insight about barriers keeping TTOs from tracking gender in commercialization-related areas. A secondary goal included increasing awareness about the importance of gender tracking for those who had not been considering gender impact in their routine activities. The final objective was to increase the number of university TTOs tracking gender in order to get maximal impact when the WIC/MSC decided to submit gender-specific questions to the AUTM annual survey.

Perhaps the most surprising result of the study was the low number of university TTOs that were tracking inventor gender. Of the 81 survey respondents, only six (7%) were tracking this metric. Furthermore, half of the leading software providers utilized by university TTOs did not have gender-tracking capability as a standard option at the start of this investigation. With the current emphasis on gender parity and increasing initiatives targeting women in STEM and innovation, the exclusion of this basic variable was unexpected. The results of respondents' reasoning behind not tracking gender provide important insights into why the gender variable has not previously been more widely incorporated. The majority of respondents reported that the reason their office was not tracking gender was that they "had not previously considered it."

There is an old axiom that says, "Identifying the problem is half the solution." The WIC/MSC research team found this to be an appropriate strategy in addressing the lack of gender tracking in TTOs and advocating for change during phone conversations between the WIC/MSC team and university TTO representatives. Almost 50% of original survey respondents indicated that they would like additional information about the issue and provided contact information. During these follow-up calls and the survey calls to initial non-respondents, the majority of respondents indicated high levels of interest in addressing the issue of gender tracking at their institutions and many shared that they wanted to act as advocates to help implement these changes. These responses indicated that the lack of gender tracking may simply have been historical oversight. Because of the historically lower level of involvement of females in higher academic research positions (i.e., the "leaky pipeline"), the majority of inventors have traditionally been male. As such, it can be hypothesized that gender tracking may not have been considered when TTOs were originally set up. Furthermore, the technology transfer profession is relatively young. The passage of the Bayh-Dole Act in 1980 precipitated a

dramatic increase in the academic technology transfer profession; the number of TTOs in the U.S grew from about 25 in 1980 to 200 in 1999 (23). It may be that systems are still being implemented, and this study highlights a need for re-evaluation in this area. This would appear to be the case for offices that do not have a high volume of commercialization activity. Several respondents reported that their offices were so small that they considered official tracking unnecessary, as the TTO representatives knew their inventor population and would be able to easily report metrics if asked.

One concern over tracking did arise however. Although only voiced by one respondent in the initial survey, concern was raised via the comment section that tracking gender metrics for innovators could reflect negatively on the university TTO if significant disparity was found. While this concern is understood from a public relations perspective, it is the contention of the authors that universities should actively encourage their TTOs to track gender metrics so that assessments can be made and programs and strategies implemented as appropriate.

At the time of the survey, only two of the four leading software companies utilized by TTOs had the capability to track gender embedded within their systems. This finding was significant because it highlights the lack of attention for a gender variable within TTOs. This finding aligns with the majority of technology transfer professionals' lack of awareness about the importance of this variable. It should be noted that Inteum and WellSpring did upgrade their systems to include a gender field after the survey was completed. It can be hypothesized that additional effort on the data entry side may result in lower tracking compliance for this metric. Furthermore, it should be noted that anecdotal feedback from university TTO personnel indicate that, as a result of the WIC/MSC survey, they were contacting WellSpring and Inteum to address the issue. This client advocacy likely had an impact on the companies' decisions to upgrade their systems.

Implications and Recommendations

Metrics are important. The data obtained by the AUTM Women Inventor's Committee can assist in developing and determining the effectiveness of replicable programs that encourage more women faculty, postdocs, and graduate students to submit new discoveries to their respective TTOs. It can also aid in 1) the development of greater awareness among TTO staff about inherent biases that may exist when they are working with women inventors; 2) the identification of and collaboration with organizations that promote women entrepreneurs to encourage more women-led start-ups; 3) the collaboration with organizations that have synergistic missions; and, 4) within AUTM's core competencies, the addition of value to what they are already doing (24).

The results of this study should serve as a call to action for the development of higher education, government, and industry policy in relation to both the tracking and encouragement of women's participation in the patenting and commercialization process. These policies must take into account the variety of social, cultural, economic, and political contexts in which students learn and in which work is performed. TTO leadership and commitment to commercialization is a significant influence on research and innovation, and, as such, they may expect to take a leadership role in implementing tracking of and developing metrics to analyze gender participation as well as encouraging the disclosure of new technologies by women inventors.

Future Research

There are a number of future research opportunities stemming from the results of this study. Several of these opportunities can be separated into three categories: analysis of the circumstances leading to the development of gender tracking; findings of gender participation by those institutions that have been tracking participation based on gender; and programs that might encourage increased participation by women in the innovation process.

Analysis of Gender Tracking Implementation

A better understanding of those institutions that are already tracking gender participation may provide insight into the types of environments that support gender tracking and help encourage other institutions to include gender as a part of their data collection. Areas for further research include:

a. For institutions that are collecting data, how

are they doing it, and what data are they collecting? Are they collecting this data by discipline?

b. What was the impetus for the pioneering institutions to collect data? Who are they? What specific characteristics do these institutions have in common?

Data Analysis to Identify Trends and/or Gender Bias

Further, substantive data gathered by those institutions should also be further analyzed to establish the degree of involvement in the patenting and commercialization process by women and to assess the variables that impact participation rates in innovation based on gender. Areas for further research include:

a. At participating institutions, what percent of total disclosures/patents included women? What does that percent look like across the institutions that participated in the survey?
b. Do institutions that track gender in relation to patenting and commercialization also track gender in relation to research funding? Is there a correlation in the percentage of women with research funding and the percentage of women involved in patenting and commercialization?
c. What is the entrepreneurial climate for institutions that are collecting data? What are indicators for promoting entrepreneurship in faculty? What incentive structures are there for faculty at these institutions?
d. Do institutional structures for technology transfer and commercialization affect women's participation in patenting and start-ups? What initiatives exist to intentionally raise awareness of and to engage women in the technology transfer process?

Promoting Women's Involvement in Patenting and Commercialization

As Milli et al. (8) suggested, there is a need for additional tools and resources to better understand and measure female participation in the innovation economy. This study is an initial analysis of such systems and tools, and it is hoped that — by raising awareness on a national level — more data will be made available for institutions to utilize and create strategies and mechanisms to help address the issue of gender disparity and increase the inclusion of women in the innovation lifecycle, particularly at the university disclosure and patenting level. If universities become more informed about their gender metrics in IP development, they can better address imbalances. Programs and outreach efforts can be targeted to help improve metrics, and culture changes can be explored/addressed and opportunities provided. The AUTM/WIC has ongoing initiatives to help address these challenges and continue to grow the knowledge base to provide strategies and resources. For example, the WIC/MSC has begun the second phase of the research outlined in this study: supplemental questions specifically related to commercialization tracking by gender added to the 2016 AUTM survey. This data will be addressed in future investigations as a follow-up to this research.

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