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The Gender Gap in Academic Patenting

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The gender gap in academia has long been the focus of public discourse regarding the role of universities in promoting social values. In this study, we consider women's participation in transferring knowledge from the academy to industry. A prominent model for such transfer is reflected in patent registration for inventions developed through scholarly research. And while academic patenting is a significant component of the professional activities of many faculty members, the extent to which women's scientific discoveries are patented and commercialized has received relatively little attention.

The U.S. academy is a leader in science and a pioneer of technology transfer. This study analyzes the extent to which inventions by academic women are protected by university patents. Through analysis of inventors' names, we ascertain the expected gender of inventors listed on applications filed by U.S. academic institutions. From this data, we report the extent to which a gender gap exists in patent application, grant rates, fields of research, and forward citations.

Our study yielded several key findings. First, we found a significant increase in the number of patent applications originating from universities from 2000 to 2015. We identified a similar increase in applications by inventor teams made up of only women, though these applications were granted at a lower rate and were cited less frequently than patents obtained by teams including men. We found differences in team composition, with women being much more likely to work alone than men. We also noted an

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interesting disparity in subject matter, with drugs and chemistry (especially molecular biology) dominating the technological fields of university applications. The Article concludes that while women increasingly participate in academic patenting, a significant gender gap persists. Our findings may serve as a springboard for further research on the reasons for the failure to achieve gender equality, as women's representation in the academy continues to increase.

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INTRODUCTION

This study explores the intersection of two issues at the core of public discourse: the participation of women in scientific research and the transfer of knowledge from universities to industry. Identifying the extent to which a gender gap exists in these domains is necessary if we are to understand whether research universities are doing their share to promote equality in scientific inquiry and further the academy's role in encouraging innovation and knowledge dissemination.

Gender disparities in academia have long vexed institutions whose core responsibilities include promoting social values.[1] Integrating women into senior academic positions as faculty members is an essential aspect of promoting women's advancement in society, as these positions encourage the pursuit of higher education and command recognition of their contributions. The rising percentage of female professors is often touted as proof of academia's success in promoting gender equity.[2] Additional factors that might reflect more nuanced assessments of the gender gap may include women's rate of promotion within the academic ranks, their percentages at each rank, and their representation in leadership positions.

To learn more about how women succeed in the academy, this study examines the transfer of technology invented by women from universities to industry. The United States academic sector serves as an excellent case study for two reasons: first, the U.S. is a world leader in scientific research; and second, the U.S. has a pioneering technology transfer tradition that began in the early 1960s.

A prominent model for knowledge transfer is the registration and licensing of patents for inventions developed by academic researchers.[3]

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[1] *See, e.g.*, Jill M. Bystydzienski, *Gender and STEM in Higher Education in the United States*, *in* OXFORD ENCYCLOPEDIA OF GENDER AND SEXUALITY IN EDUCATION (Cris Mayo ed., 2022) (documenting that "a hostile academic climate, exclusionary practices, and subtle forms of discrimination in hiring and promotion, as well as lack of positive recognition of female scientists' work, account for relatively low numbers of women in fields such as engineering, physics, and computer science").

[2] *See, e.g.*, Bettina J. Casad, Jillian E. Franks, Christina E. Garasky, Melinda M. Kittleman, Alanna C. Roesler, Deidre Y. Hall & Zachary W. Petzel, *Gender Inequality in Academia: Problems and Solutions for Women Faculty in STEM*, 99 J. NEUROSCIENCE RSCH. 13, 16 (2020) (explaining how institutions such as the University of Michigan and the University of California, Davis have "developed interventions to increase the representation of women in STEM through recruitment, retention, and promotion, and cultivating a positive campus climate through dialogue, awareness, and fair policies").

[3] *See* HENRY ETZKOWITZ, THE TRIPLE HELIX: UNIVERSITY-INDUSTRY-GOVERNMENT INNOVATION IN ACTION 1-3 (2008); Arvids A. Ziedonis, *Empirical Analyses Related to University Patenting*, *in* RESEARCH HANDBOOK ON THE ECONOMICS OF INTELLECTUAL

Patent prosecution is often facilitated through University Technology Transfer Offices ("TTOs"), which assist in securing patents to promote the commercialization of patented technology.[4] To measure the extent to which women's scientific discoveries are supported through this process, we examined how frequently women are named as inventors in university patent applications. We used the inventor names listed in patent applications filed by universities to identify the likely gender of each inventor.[5] From this information, we counted the number of patent applications that named women inventors alone or as part of a group. We then determined the rates at which applications naming women as individuals or part of a group succeed. From this data, we evaluated additional characteristics such as technological fields and changes in patenting rates over the years.

Our findings reveal that women are named as inventors in university patent applications far less frequently than men. However, the percentage of women named as inventors in academic patents has increased over time. Even though academic women are being named more frequently as inventors, a significant gender gap persists. This disparity raises important questions about whether women's contributions are being credited in patent applications and if scientific discoveries are being made by women but not protected through patents — perhaps due to lack of adequate support from technology transfer offices.[6] The gender gap in academic patenting also raises significant

PROPERTY LAW 256, 256 (Ben Depoorter, Peter S. Menell & David L. Schwartz eds., 2019) (highlighting "empirical research on university patenting [over] twenty years"); Rebecca S. Eisenberg, *Public Research and Private Development: Patents and Technology Transfer in Government-Sponsored Research*, 82 VA. L. REV. 1663, 1679 (1996).

[4] David Orozco, *Assessing the Efficacy of the Bayh-Dole Act Through the Lens of University Technology Transfer Offices (TTOS)*, 21 N.C. J.L. & TECH. 115, 146 (2019). Scholars and policy makers have devoted substantial attention to the benefits and disadvantages of this model. *See, e.g.*, Patricia E. Campbell, *University Inventions Reconsidered: Debunking the Myth of University Ownership*, 11 WM. & MARY BUS. L. REV. 77 (2019) ("[E]valuati[ng] the technology transfer policies and practices of U.S. universities."); Peter Lee, *Patents and the University*, 63 DUKE L.J. 1 (2013) (evaluating the evolution of the relationship between patenting and the university); Christopher J. Ryan, Jr. & Brian L. Frye, *An Empirical Study of University Patent Activity*, 7 N.Y.U. J. INTELL. PROP. & ENT. L. 51 (2017) ("[I]nvestigat[ing] the relationship between universities and the patent system.").

[5] It should be noted that inventors in the academic sector include not only senior faculty members but also research students and post-doctoral researchers.

[6] *See* Waverly W. Ding, Fiona Murray & Toby E. Stuart, *Gender Differences in Patenting in the Academic Life Sciences*, 313 SCIENCE 665, 665-66 (2006); Francesco Lissoni, Fabio Montobbio & Lorenzo Zirulia, *Inventorship and Authorship as Attribution Rights: An Enquiry into the Economics of Scientific Credit*, 95 J. ECON. BEHAV. & ORG. 49, 49-69 (2013).

questions about whether women's entrepreneurial and innovative potential is being squandered, inhibiting scientific advancement.

Women's relatively low representation in academic patenting requires further investigation into possible obstacles that prevent their full integration into the academy. Barriers may originate from multiple angles. Co-inventors may not think to acknowledge the inventive contributions made by women, and legal counsel may not adequately follow up to determine that all who made inventive contributions are named. Women may be required or tasked with other departmental responsibilities and, as a consequence, may lack knowledge of or access to the benefits of seeking assistance from technology transfer and commercialization support services. Women might be relatively risk averse or hesitant to seek opportunities to promote and protect their inventions. Senior faculty may be less likely to value the inventive contributions of women and overlook the importance of encouraging women faculty members to commercialize knowledge. Tech transfer offices may be resistant to commercializing knowledge in fields where women represent a majority of faculty. In addition, women faculty often shoulder the bulk of home and childcare responsibilities and therefore may not have time to spare to consider and research the benefits of patenting their inventive contributions.

The Article proceeds in five parts. Following the introduction, Part I explains how sponsored research works and reviews the prior research on gender disparities in the academy and patent prosecution. In Section A, we tell the story of Gatorade's conception and how it upended perceptions of the economic potential in sponsored academic research. While the tale is well known, the significant contributions of two women have been largely ignored in the press and patent filings. The story illustrates why some female inventors may not be named in patent applications. Prior research supports this account, as well as the decision by many female inventors to not seek patent protection where their male colleagues might.[7] Section B reviews existing knowledge regarding the gender gap in patenting — both generally and within the academic sector. It then describes the challenges that women in the academy face when seeking to commercialize their inventions. We next consider women's representation in the American academy, with particular attention on STEM fields.

Parts II and III present our empirical methodology and primary findings. Our research illustrates that representation is not the only dimension on which gender parity could be achieved. When measured

[7] Ding et al., *supra* note 6, at 667.

through the metrics of named inventorship or patent citations, women are not credited as frequently as their male colleagues. Finally, Part IV discusses the implications of our findings and possible solutions. Our research highlights the necessity of focusing not just on the presence of women, but the extent to which their work is supported and credited by their colleagues. Part V offers concluding remarks.

I. BACKGROUND

In the United States, until 1980, intellectual property in publicly funded academic research belonged to the federal government. Because no mechanisms existed for incentivizing or commercially optimizing these rights, almost no patents were registered by the academic sector during this period. Technology transfer activity was also negligible, as public research institutions had no rights to transfer.[8] In 1980, Congress passed the Bayh-Dole Act, which established that intellectual property created through publicly funded research belonged to the research institution, not the United States government.[9] The Bayh-Dole Act led to a significant increase in the number of patent applications filed by academic institutions in the United States, and it is regarded as one of the most significant legislative initiatives of the twentieth century affecting the transfer of knowledge from the academy to industry. Legislation modeled on the Bayh-Dole Act has been enacted around the world.[10] The development of Gatorade at the University of Florida set the stage for this seismic change in technology transfer practices.

[8] *See* Eisenberg, *supra* note 3, at 1690.

[9] Patent and Trademark Amendments Act, 35 U.S.C. §§ 200-11 (1980).

[10] *See, e.g.*, DAVID C. MOWERY, RICHARD R. NELSON, BHAVEN N. SAMPAT & ARVIDS A. ZIEDONIS, IVORY TOWER AND INDUSTRIAL INNOVATION: UNIVERSITY-INDUSTRY TECHNOLOGY TRANSFER BEFORE AND AFTER THE BAYH-DOLE ACT 8 (2004) (suggesting that nations which emulate Bayh-Dole may be relying on a perception of its benefits that may not be supported by substantial evidence); David C. Mowery & Bhaven N. Sampat, *The Bayh-Dole Act of 1980 and University-Industry Technology Transfer: A Model for Other OECD Governments?*, 30 J. TECH. TRANSFER 115, 116, 125 (2004) (examining efforts to implement such incentives in OECD countries and concluding that "given the very different institutional landscape in the national higher education systems of much of Western Europe and Japan, it seems likely that the 'emulation' of Bayh-Dole that has been discussed or implemented in many of these economies is far from sufficient to trigger significant growth in academic patenting"). In recent years, there is significant public discourse on whether the Bayh-Dole Act achieved its purpose. *See, e.g.*, Ian Ayres & Lisa Larrimore Ouellette, *A Market Test for Bayh-Dole Patents*, 102 CORNELL L. REV. 271, 295 (2017) (questioning whether exclusivity is necessary in all instances where the goal is commercialization).

In presenting background information on the landscape that led to the underrepresentation of women in patenting and academia, we begin with the Gatorade story. It provides an excellent window into the positive synergies that can result when academic researchers collaborate with other members of the university and then proceed to patent and commercialize their innovations. Following this story, we provide additional background to situate our descriptive findings against the current landscape of women's representation in STEM research and patent prosecution pursued at U.S. universities.

A. *Lessons from Gatorade on Women's Inventive Contributions*

Gatorade's conception is an iconic model of what can happen when scientists and community members team up to solve practical challenges and commercialize their discoveries. The story is not, however, as well known for the contributions of two women.

In the 1960's, college football players were dying from heat-related illnesses.[11] University of Florida football coaches worried that their players were getting dangerously depleted from working in the heat.[12] In 1965, Florida Assistant Coach Dwayne Douglas sat down with his friend, the University of Florida kidney disease specialist Robert Cade, over coffee.[13] Douglas was worried. He confided that twenty-five football players had been admitted to the hospital over the past weekend with heat exhaustion and dehydration.[14] As a former NFL player, Douglas knew how depleted a player can feel, especially towards the end of a game.[15] Replacing the obvious elements of sweat was not working. Players that drank water got stomach aches, and those that took salt tablets suffered from leg cramps.[16] No one had yet determined what else was being lost. Because water proved to be an imperfect hydration solution, some football coaches prohibited their players from drinking fluids during games.[17]

Cade was intrigued by the possibility of learning whether it was more than just salt and water that was lost in the heat, and if so, whether he

[11] DARREN ROVELL, FIRST IN THIRST: HOW GATORADE TURNED THE SCIENCE OF SWEAT INTO A CULTURAL PHENOMENON 10 (2006).

[12] *Id.*

[13] E. LYNNE WRIGHT, IT HAPPENED IN FLORIDA 71 (2003).

[14] ROVELL, *supra* note 11, at 10. He did not understand how players could lose over 15 pounds on the field while urinating so little. *See id.* at 10-11.

[15] *Id.*

[16] *Id.* at 10.

[17] *See id.*; *The Sweat Solution*, SEC (Feb. 25, 2015), https://www.secsports.com/article/12212716/sweat-solution [https://perma.cc/E43R-C385] [hereinafter *Sweat Solution*].

could discover how to replenish those nutrients.[18] He also loved to play mixologist by concocting beverages in the lab at the end of the week. To this end, Cade gathered a team of University of Florida scientists to work with the football team to learn how the players' chemical composition was changing in the heat.[19] They discovered that the athletes were losing sugar, salt, potassium, and blood volume during practice. The scientists worked towards a drink that would reintroduce electrolytes and other nutrients in a way that would not interfere with performance.[20]

Their first efforts failed. When they tried adding glucose to their solution, it became as hard as rock instead of dissolving.[21] Once they solved that problem, the mixture tasted so foul that Robert Cade vomited up his first sips.[22] Mary Cade (Robert Cade's wife) suggested adding fresh lemon juice to make the concoction drinkable.[23] Her idea worked, and this contribution is often credited as the moment Gatorade was born.[24] Nonetheless, Mary Cade was not named as an inventor.

Once the drink became palatable, the University coaches permitted the scientists to test Gatorade on their freshman team.[25] In an experimental game, the freshman were clobbered by the senior team in the first quarter.[26] However, once the older players became depleted from the heat, the Gatorade-drinking freshmen came back to beat the

[18] *Sweat Solution*, *supra* note 17; *see also* Kyle Welch, *Born in the Lab, Proven in the Market: Gatorade's Impact on U.S. IP Policy & Research Innovation*, 20 WAKE FOREST J. BUS. INTELL. PROP. L. 277, 280 (2020).

[19] Welch, *supra* note 18, at 286.

[20] *Id.* at 286-87.

[21] Gilbert Rogin, *The Bottle and the Babe*, SPORTS ILLUSTRATED (July 1, 1968), https://vault.si.com/vault/1968/07/01/the-bottle-and-the-babe [https://perma.cc/MKV9-5354]; *see also* Joseph Kays, *Innovation Turns 50: Gatorade Changed UF Forever*, EXPLORE (June 29, 2015), https://explore.research.ufl.edu/innovation-turns-50.html [https://perma.cc/CFB8-T22D].

[22] Sarah Laskow, *The First Batch of Gatorade Tasted Terrible*, ATLANTIC (Nov. 28, 2014), https://www.theatlantic.com/technology/archive/2014/11/the-first-batch-of-gatorade-tasted-terrible/383214/ [https://perma.cc/N2S3-VL7F]. Other team members reported it tasted like turpentine or piss and was "so awful it could choke a maggot." ROVELL, *supra* note 11, at 23.

[23] *Obituary, Mary Strasburger Cade*, GAINESVILLE SUN (Sept. 3, 2021), https://www.gainesville.com/obituaries/pgai0059187 [https://perma.cc/JKB9-5BRZ].

[24] Welch, *supra* note 18, at 287 n.82; Kays, *supra* note 21; Rogin, *supra* note 21; *Sweat Solutions*, *supra* note 17.

[25] Welch, *supra* note 18, at 288.

[26] *Id.*

upperclassmen.[27] After that, the entire team began using Gatorade.[28] A clear advantage over their competitors soon became apparent on the field. After establishing the drink's benefits, the team scaled up production so others could benefit from its rehydrating properties.[29]

The development team initially offered the invention to the University of Florida for $10,000, and the University administration declined.[30] They would later find a buyer through a chance social interaction that led to Stokely-Van Camp, Inc. ("Stokely") agreeing to pay the team $25,000 up front, a $5,000 bonus, and a five-cent royalty on every gallon.[31] The company filed patent applications claiming the formulation in both the United States and abroad.[32] But after Gatorade looked like it would be a long-term commercial success, the University of Florida sued the inventors and Stokely.[33] Although the University declined the inventors' offer to purchase the rights to the technology and Cade never assigned his rights to the school, it claimed that it had an ownership interest in the intellectual property because the development team used University property and personnel during testing.[34]

The federal government also intervened in the legal battle. At that time, the fruits of federally sponsored research were the property of the United States. Accordingly, the government claimed that it owned all patent rights because members of the research team were funded by government grants.[35] Ultimately, all the parties settled. The University obtained a percentage of the profits, and the United States government agreed to settle if Stokely abandoned its U.S. patent applications and published the formula.[36]

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[27] Joe Kays & Arline Phillips-Han, *Gatorade: The Idea that Launched an Industry*, EXPLORE MAG. (2003), https://www.research.ufl.edu/publications/explore/v08n1/gatorade.html [https://perma.cc/Z76L-AYR6] ("Cade says Graves witnessed the turnaround and was impressed enough to ask him if he could make up a supply for the varsity to use the next day in its game against heavily favored Louisiana State.").

[28] *Id.* ("Soon, [they were] selling hundreds of thousands of gallons of Gatorade annually and interest in ownership rights grew.").

[29] *See* Welch, *supra* note 18, at 291-93.

[30] Darren Rovell, *Royalties for Gatorade Trust Surpass $1 Billion: 'Can't Let It Spoil Us*,' ESPN (Oct. 1, 2015), https://www.espn.com/college-football/story/_/id/13789009/royalties-gatorade-inventors-surpass-1-billion [https://perma.cc/B2Y4-4ZAG].

[31] *Id.*

[32] Welch, *supra* note 18, at 292-93.

[33] *Id.* at 299.

[34] *Id.* at 300.

[35] *Id.* at 296-98 (citing *Gatorade and Patent Policy*, 100 SCI. NEWS 143, 143 (1971)).

[36] Welch, *supra* note 18, at 300.

The result made sense from one perspective. The salaries of the inventors, the tools they used, and the setting they worked in were all funded by federal and state tax money. It was then the policy that those who paid for the research should own it.[37] However, the Gatorade story revealed that this ownership structure thwarted the incentive policy underlying patent law. It became clear that without the opportunity to commercialize their discoveries, the Gatorade inventors may not have offered the beverage beyond the University of Florida, and Stokely may not have invested in the product's future success.[38] Following the lessons learned from the litigation, Congress passed the Bayh-Dole Act, making it possible for universities and private persons to own the intellectual property ("IP") rights in government sponsored research. [39]

This story illustrates that innovative solutions are not always the inspiration of one solitary inventor who has a eureka moment.[40] Often, great contributions are socially constructed. In the case of Gatorade, the product was perfected only after years of collaboration between scientists, coaches, athletes, and two women — a chemist for a private company and a dedicated spouse who each contributed key elements to Gatorade. Their contributions lead to an underreported aspect of the story: the role of women in the product's development and the extent to which their involvement is recognized.

Although Mary Cade's suggestion made the drink palatable, it was still not terribly appealing until after June Davis, a chemist at Stokely, set to work on the challenge of improving the flavor. Davis experimented until she discovered a method for making the drink taste sweet without adding performance-inhibiting sugars.[41] Even in lengthy treatments of the Gatorade story, her contributions are largely ignored. Media reports identify Robert Cade and three other male doctors as the lab team that made the original invention.[42] Mary Cade's contribution is sometimes noted in the media, and in Robert Cade's book-length treatment, Davis's inventive contributions are reported.[43] However, these critical improvements to the product's commercial viability are often noted as an afterthought.

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[37] *Id.* at 303.

[38] *Id.* at 306-07.

[39] Bayh-Dole Act, 35 U.S.C. §§ 200-12 (1980).

[40] *See* JESSICA SILBEY, THE EUREKA MYTH: CREATORS, INNOVATORS, AND EVERYDAY INTELLECTUAL PROPERTY 2-3 (2014).

[41] ROVELL, *supra* note 11, at 46-47.

[42] Rovell, *supra* note 30; *see* Laskow, *supra* note 22.

[43] Kays, *supra* note 21; *Obituary*, *supra* note 23; Rogin, *supra* note 21; *Sweat Solution*, *supra* note 17.

The publicly available patent applications do not mention Mary Cade or Davis's contributions. While no Gatorade patents filed before 1991 appear in the public record, subsequent patent applications do not list Davis and Mary Cade as inventors despite their significant contributions.[44] The 1991 patent applications name Melvin J. Fregly, Malcolm R. Privette, and Robert Cade.[45] Although at least two women made critical contributions to the drink, none of the inventors named in U.S. Gatorade patents are women.

One explanation would posit that they were not named in the 1991 applications because their contributions occurred earlier in the development process. There is, however, strong evidence they were not acknowledged in the original patent filings either. Applications contemporaneously filed in Great Britain named five men — Kent P. Bradley, James Robert Cade, Dana L. Shires, Alejandro Marcelo De Quesada, and James Free Harry — as inventors.[46] Neither Mary Cade nor June Davis were credited as making an inventive contribution in these or any other subsequently filed patent in the United States or Great Britain. Although one may wonder whether a flavor addition can be a sufficiently novel or nonobvious, U.S. patent records indicate many instances where flavor additives or improvements have been credited as inventive contributions.[47]

Given the extraordinary impact of the Gatorade story on federal legislation and the practices of sponsored research, this omission merits further consideration and provides important insights for our research. It illustrates the importance of looking at women's contributions in the public patent records with the understanding that these records may reveal not just whether women contribute inventive ideas, but whether the contributions they make are credited at all.

As more and more women join STEM faculties, it is time to see whether their scientific discoveries are being acknowledged, protected through patent law, and commercially optimized. With this in mind, our goal is to examine trends in women's inventorship on patents that

[44] *See* U.S. Patent Nos. 4,918,687, 5,089,477, 5,147,650, 5,236,712, and 5,238,684.

[45] *See* '712, '684 patents.

[46] G.B. Patent No. 1,252,781.

[47] *See, e.g.*, U.S. Patent No. 8,877,280 (issued for "[a] composition for improving the *flavor* and juiciness of marinated meats and inhibiting growth of pathogenic and spoilage microorganisms and a process for making the composition are described. *Lemon* juice and vinegar are neutralized, concentrated and blended with non-neutralized *lemon* juice and non-neutralized vinegar in appropriate proportions to achieve the desired water binding and antimicrobial effects" (emphasis added)).

originate in the academy. But first, we evaluate the literature on gender and patenting.

B. The Gender Gap in Patenting

A growing interest in women's ownership of intellectual property rights has led to various studies on gender disparity in intellectual property, including patents. Many studies show a sizable gender gap in both patent applications and issued patents.[48] In the most comprehensive research to date, the World Intellectual Property Organization surveyed international patent applications in 182 countries and found that only 29% of applications listed female inventors.[49] Although this percentage has increased over time, it is still low relative to the population and differs substantially across countries, technologies, and sectors.[50] The British Intellectual Property Office conducted a major study of the European Patent Office Worldwide Patent Statistics and PatBase databases.[51] The study found that women represented less than 2% of inventors for most of the twentieth century. Over the past two decades, that percentage has risen steadily to over 10%. The nations with the highest percentage of women inventors are France (11.7%) and Russia (15.7%), a stark contrast from the lower end reflected in data from Japan (3.7%), Korea (4.4%), and Germany (5.5%).[52] Data from Britain (7.3%) and the U.S. (8.7%) hover around the current average of 7.2%.[53] This international variation is consistent with that found in other studies[54] but does not appear to correlate with

[48] *See* Allie Porter, *Where Are the Women? The Gender Gap Within Intellectual Property*, 28 TEX. INTELL. PROP. L.J. 511, 512-16 (2020).

[49] Gema Lax Martinez, Julio Raffo & Kaori Saito, *Identifying the Gender of PCT Inventors* 8 (World Intell. Prop. Org. Econ. Rsch., Working Paper No. 33, 2016), https://www.wipo.int/edocs/pubdocs/en/wipo_pub_econstat_wp_33.pdf [https://perma.cc/34AW-Y7TD].

[50] *Id.* at 9-19; *see also* INTELL. PROP. OFF., GENDER PROFILES IN WORLDWIDE PATENTING: AN ANALYSIS OF FEMALE INVENTORSHIP 30 (2016), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/567518/Gender-profiles-in-worldwide-patenting.pdf [https://perma.cc/76UK-WD9Y] [hereinafter GENDER PROFILES].

[51] INTELL. PROP. OFF., GENDER PROFILES, *supra* note 50, at 3.

[52] *Id.* at 30.

[53] *Id.*

[54] INTELL. PROP. OFF., GENDER PROFILES IN UK PATENTING: AN ANALYSIS OF FEMALE INVENTORSHIP 7 (2016), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/514320/Gender-profiles-in-UK-patenting-An-analysis-of-female-inventorship.pdf [https://perma.cc/KF2A-6VLD]; INTELL. PROP. OFF., GENDER PROFILES IN WORLDWIDE PATENTING: AN ANALYSIS OF FEMALE INVENTORSHIP 10 (2019), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/846363/Gender-profiles-in-worldwide-patenting-2019.pdf

socioeconomic indicators, such as GDP or the number of women in the labor market.

Studies indicate women are being named in patents more frequently,[55] even in countries where scientific publications by women have stagnated.[56] In fact, the number of patents listing women inventors increased more than fivefold between 1975 and 2015, though aggregate growth has been slow.[57] As of 2014, 73% of patent applications worldwide still listed only male inventors.[58]

Studies on the gender gap in U.S. patenting have uncovered troubling findings. Between 1977 and 2010, only 7.7% of U.S. patents named a woman as the lead inventor.[59] In 1977, only 3.4% of patents had at least one woman inventor, while in 2010, 18.8% of all patents had at least one woman inventor.[60] By 2019, 21.9% of patents had at least one woman inventor, showing noticeable growth, but not by much.[61] In 1980, just 28% of women patented again within five years of the first

[https://perma.cc/UH8D-C9D5] [hereinafter GENDER PROFILES IN WORLDWIDE PATENTING]; Fulvio Naldi, Daniela Luzi, Adriana Valente & Ilaria Vannini Parenti, *Scientific and Technological Performance by Gender*, *in* HANDBOOK OF QUANTITATIVE SCIENCE AND TECHNOLOGY RESEARCH 299, 307 (Henk F. Moed, Wolfgang Glänzel & Ulrich Schmoch eds., 2004); Rainer Frietsch, Inna Haller, Melanie Funken-Vrohlings & Hariolf Grupp, *Gender-Specific Patterns in Patenting and Publishing*, 38 RSCH. POL'Y 590, 592-95 (2009).

55 Ding et al., *supra* note 6, at 665; Taehyun Jung & Olof Ejermo, *Demographic Patterns and Trends in Patenting: Gender, Age, and Education of Inventors*, 86 TECH. FORECASTING & SOC. CHANGE 110, 110 (2014).

56 *See* Frietsch et al., *supra* note 54, at 595.

57 INTELL. PROP. OFF., GENDER PROFILES, *supra* note 50, at 14.

58 *Id.* at 30.

59 JESSICA MILLI, BARBARA GAULT, EMMA WILLIAMS-BARON, JENNY XIA & MEIKA BERLAN, THE GENDER PATENTING GAP 2 (Inst. for Women's Pol'y Rsch. 2016), https://iwpr.org/wp-content/uploads/2020/12/C441_Gender-Patenting-Gap_BP-1.pdf [https://perma.cc/77NH-D63Z] [hereinafter THE GENDER PATENTING GAP]. A report from the same author group clarifies that "[a] primary inventor is typically defined as the first inventor listed on a patent. While it is the usual practice in academic research to list authors in order of relative contribution, it is sometimes the case in patent applications to simply list inventors in alphabetical order. As a result, this method of defining the intensity of women's involvement in patenting is an imperfect one." JESSICA MILLI, EMMA WILLIAMS-BARON, MEIKA BERLAN, JENNY XIA & BARBARA GAULT, EQUITY IN INNOVATION: WOMEN INVENTORS AND PATENTS 8 n.2 (Inst. for Women's Pol'y Rsch. 2016), https://iwpr.org/wp-content/uploads/2020/12/C448-Equity-in-Innovation.pdf [https://perma.cc/D3ZQ-7LS7] [hereinafter EQUITY IN INNOVATION].

60 MILLI ET AL., EQUITY IN INNOVATION, *supra* note 59, at 7.

61 U.S. PAT. & TRADEMARK OFF. [USPTO], PROGRESS AND POTENTIAL: 2020 UPDATE ON U.S. WOMEN INVENTOR-PATENTEES 3 (2020), https://www.uspto.gov/sites/default/files/documents/OCE-DH-Progress-Potential-2020.pdf [https://perma.cc/4FMU-2TRV] [hereinafter PROGRESS AND POTENTIAL].

patent, while in 2014, that number rose to 46%.[62] In 1977, only 1,500 U.S. patents named at least one woman as an inventor, and by 2010 this number increased to 23,000.[63] Notwithstanding this growth, women are still underrepresented as inventors named in patents. Some of this disparity may be explained by an underrepresentation of women in STEM fields generally and in patent-intensive STEM fields specifically.[64]

Despite notable growth in the women named in patents, women are still rarely included as inventors in patent applications. Men filed more than three times as many patent applications as women between 2000 and 2016.[65] Women held about two million science and engineering jobs in 2017, but only 27,000 women were named as inventors in patents.[66] From 2009 to 2014, the number of new women patentees grew around 10.8% each year, but from 2014 to 2019 this number dropped to just 4% per year.[67] Among college graduates, women are less likely to apply for a patent,[68] and not surprisingly, women hold a disproportionately low number of positions in patent-intensive areas, such as development and design.[69] The Institute for Women's Policy Research found that even if the current rate of progress holds, the U.S. will not reach gender parity in patenting until around 2092.[70]

The small percentage of patents that list women as the primary inventors usually fall under the category of technologies associated with

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62 *Id.* at 5.

63 MILLI ET AL., EQUITY IN INNOVATION, *supra* note 59, at 3.

64 *See* DAVID BEEDE, TIFFANY JULIAN, DAVID LANGDON, GEORGE MCKITTRICK, BEETHIKA KHAN & MARK DOMS, U.S. DEP'T OF COM., WOMEN IN STEM: A GENDER GAP TO INNOVATION 2-3 (2011), https://files.eric.ed.gov/fulltext/ED523766.pdf [https://perma.cc/Y3V3-WBSS]; Lisa D. Cook & Chaleampong Kongcharoen, *The Idea Gap in Pink and Black* 2 (Nat'l Bureau of Econ. Rsch., Working Paper No. 16331, 2010), https://www.nber.org/system/files/working_papers/w16331/w16331.pdf [https://perma.cc/4U95-LWZY].

65 MILLI ET AL., EQUITY IN INNOVATION, *supra* note 59, at 11.

66 USPTO, PROGRESS AND POTENTIAL, *supra* note 61, at 3.

67 *Id.* at 4.

68 MILLI ET AL., EQUITY IN INNOVATION, *supra* note 59, at 5.

69 Jennifer Hunt, Jean-Phillippe Garant, Hannah Herman & David J. Munroe, *Why Don't Women Patent?* 2 (Nat'l Bureau of Econ. Rsch., Working Paper No. 17888, 2012), https://www.nber.org/system/files/working_papers/w17888/w17888.pdf [https://perma.cc/VK7V-NFPZ]; *see also* LORI TURK-BICAKCI & ANDREA BERGER, AM. INSTS. FOR RSCH., LEAVING STEM: STEM PH.D. HOLDERS IN NON-STEM CAREERS 2 (2014), https://files.eric.ed.gov/fulltext/ED545309.pdf [https://perma.cc/3UHC-NQSK].

70 MILLI ET AL., THE GENDER PATENTING GAP, *supra* note 59, at 5.

gender roles, such as jewelry and apparel.[71] In 2010, only five patent classes had more than 20% of patents with a woman as the primary inventor: "travel goods and personal belongings," "jewelry, symbolic insignia, and ornaments," "apparel," "apparel and haberdashery," and "chemistry: natural resins or derivatives."[72] Several of these categories are for design patents — not utility patents — which are the subject of the current study. In general, women are more involved in life sciences, which has a relatively low patenting rate, while men are more involved in engineering fields, which are more patent-intensive.[73] Research has shown that gender diverse teams are usually more successful than single-sex teams, yet women are still less likely to be invited to join development teams.[74]

Men also succeed more frequently in prosecuting their applications before the U.S. Patent and Trademark Office ("USPTO"). From 2000 to 2016, 67.2% of all applications filed by women succeeded in obtaining a patent, while 73% of applications filed by men succeeded.[75] One possible explanation for this disparity is that women inventors are heavily concentrated in medical and chemistry fields, which have lower acceptance rates, while men are more commonly involved in mechanical and electronic fields, which have higher grant rates.[76]

Research by Jensen et al. provides another explanation. They found that — even accounting for the application's field of technology — women applicants were 7% to 21% less likely to secure a patent than their male counterparts.[77] Their team found that this gender gap narrowed when the woman inventor had a rare name, so that her gender

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[71] *Id.* at 3. See MILLI ET AL., EQUITY IN INNOVATION, *supra* note 59, at 8 n.2, for a discussion about a "primary" inventor being the first listed and why this may, or may not, be important.

[72] MILLI ET AL., EQUITY IN INNOVATION, *supra* note 59, at 10.

[73] *Id.* at 20.

[74] Fiona Murray & Leigh Graham, *Buying Science and Selling Science: Gender Differences in the Market for Commercial Science*, 16 INDUS. & CORP. CHANGE 657, 669 (2007).

[75] MILLI ET AL., EQUITY IN INNOVATION, *supra* note 59, at 12.

[76] Michael Carley, Deepak Hegde & Alan Marco, *What Is the Probability of Receiving a US Patent?* 23-24 (USPTO Econ. Working Paper No. 2013-2, 2016), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2849631# [https://perma.cc/3BDX-96HS].

[77] Kyle Jensen, Balázs Kovács & Olav Sorenson, *Gender Differences in Obtaining and Maintaining Patent Rights*, 36 NATURE BIOTECH. 307, 307 (2018); *see also* W. Michael Schuster, R. Evan Davis, Kourtenay Schley & Julie Ravenscraft, *An Empirical Study of Patent Grant Rates as a Function of Race and Gender*, 57 AM. BUS. L.J. 281, 306 (2020) [hereinafter *An Empirical Study of Patent Grant Rates*] (reporting similar findings).

could not be readily ascertained.[78] Even when women succeeded in securing patents, the USPTO allowed fewer of their inventive claims and narrowed the claims they did allow to a greater degree than their male counterparts (thereby rendering women's claims more narrow and potentially less valuable).[79] Finally, patents granted to women are cited less frequently and their assignees are less likely to pay maintenance fees to maximize the patent term.[80]

Beyond issues in prosecution, prior work has found that women professors are less likely to seek and obtain patents than their male counterparts, even in areas approaching gender parity among faculties, such as the biological sciences.[81] A 2006 study by Ding, Murray, and Stuart found that women faculty members in the American academy patent at about 40% of the rate of men (5.65% are female inventors and 13% male inventors).[82] In a consistent vein, Frietsch et al. found that women scholars patent their research less frequently than they publish it.[83]

Social scientists have studied the possible causes for the gender gap in patent rates, explaining insights that warrant further research to determine how remediation may be most effective. To approach the issue informed by an interdisciplinary foundation, the remainder of this section summarizes research from various fields in an attempt to understand the gender gap and search for solutions.

Complexity and expense of the patenting process. The patenting process can be complex, time-consuming, and expensive. The cost of applying for and maintaining a patent can be tens of thousands of dollars.[84] Patent applications are also risky — costly to obtain but not certain to issue, and if issued, not certain to be economically valuable enough to recoup the prosecution investment. Since women generally earn less than their male colleagues, women may lack the funding necessary to

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78 Jensen et al., *supra* note 77, at 309; *see also* Schuster et al., *An Empirical Study of Patent Grant Rates*, *supra* note 77, at 282.

79 Jensen et al., *supra* note 77, at 307.

80 *Id.*

81 *See* Annette I. Kahler, *Examining Exclusion in Woman-Inventor Patenting: A Comparison of Educational Trends and Patent Data in the Era of Computer Engineer Barbie*, 19 AM. U. J. GENDER, SOC. POL'Y & L. 773, 787-91 (2011).

82 Ding et al., *supra* note 6, at 665.

83 Frietsch et al., *supra* note 54, at 595. On a positive note, other studies indicate that women are named as inventors more frequently in patents owned by universities than by companies. *See* INTELL. PROP. OFF., GENDER PROFILES IN WORLDWIDE PATENTING, *supra* note 54, at 24.

84 *See USPTO Fee Schedule*, USPTO, https://www.uspto.gov/learning-and-resources/fees-and-payment/uspto-fee-schedule#Patent%20Fees (last updated Mar. 1, 2020) [https://perma.cc/UER6-93YA].

secure their intellectual property rights with the USPTO. Because patents and pending applications are attractive to venture capitalists, women entrepreneurs may be less likely to obtain start-up financing if they are less likely to have the intellectual property rights these investors value.[85] Given the lack of access to funding, women may also have a more difficult time affording patent prosecution counsel to assist them in the complex, long, and expensive process of patent prosecution.[86]

The concentration of women in less patent-intensive fields and jobs. Another possible explanation for the gender gap in patenting is the gender gap in STEM fields overall. Women are underrepresented in STEM fields globally,[87] with obvious implications for the gender gap in patenting.[88] Nonetheless, research shows that while increasing the number of women in STEM can increase the number of women who own patents, eliminating IP-specific obstacles for women already in STEM would increase their share of commercialized patents even more. Within science and engineering, the percentage of women varies by field: women tend to work in less patent-intensive life sciences, while men tend to concentrate in the more patent-intensive engineering fields.[89] The number of women with advanced engineering degrees positively correlates with patenting and commercialization among women. Negative stereotypes, workplace biases, hostile environments, and ineffective messaging, however, deter women from STEM fields.[90] Furthermore, fewer women hold positions in development and design, which are the most patent-intensive.[91] For all of these reasons, increasing the number of women in engineering, design, and development positions and providing them with support could increase their patenting rates.

Limited networking among women. Studies find that informal social networks within industries enhance product innovation and resource

85 MILLI ET AL., EQUITY IN INNOVATION, *supra* note 59, at 15-16.

86 DELIXUS, NAT'L WOMEN'S BUS. COUNCIL, INTELLECTUAL PROPERTY AND WOMEN ENTREPRENEURS 15-16 (2012).

87 *See* BEEDE ET AL., *supra* note 64, at 2-3.

88 *See* Hunt et al., *supra* note 69, at 1 (explaining how the magnitude of the gender gap in patenting reflects gender inequity and the inefficient use of female innovative capacity).

89 *See* Kahler, *supra* note 81, at 787.

90 *See* NAT'L ACAD. OF ENG'G, CHANGING THE CONVERSATION: MESSAGES FOR IMPROVING PUBLIC UNDERSTANDING OF ENGINEERING 52-54 (2008) (describing the perceptions of engineers and how it affects diversity in the field).

91 TURK-BICAKCI & BERGER, *supra* note 69, at 7; *see also* Hunt et al., *supra* note 69, at 13.

exchange,[92] influence the choice of a research area, and give key inventors access to information affecting both research quality and patenting rates.[93] Networks can also provide expert advice on patentability and a source of potential co-inventors.[94] Exclusion from STEM fields, on the other hand, limits women scientists' access to important networks. And the networks to which women do have access tend to be less experienced and more female in composition, further limiting access to potentially critical resources,[95] and, in turn, the patent system. Male academics also hold more central positions within their networks, giving them an advantage in terms of potential joint inventors.[96] Most of the female scholars in Ding et al.'s study[97] also reported fewer contacts to industry, which affected access to resources for assessing patentability and commercial value. Navigating the patenting process may be more challenging for women who lack a network of advisors or experienced peers to guide them.[98] Studies also show that early-career exclusion from commercial networks and opportunities may leave female academics with less help in developing the skills to sell their research and fewer opportunities to develop patentable technologies.[99] Workplace organization matters as well: organizations structured like networks exhibit higher patenting rates among women than do hierarchically structured organizations.[100]

Socialization and biases against women in commercializing science. Murray and Graham found that historically, those who commercialized academic science were predominantly men, creating a stereotype of academics who commercialize their research.[101] Academic women who

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[92] Wenpin Tsai & Sumantra Ghoshal, *Social Capital and Value Creation: The Role of Intrafirm Networks*, 41 ACAD. MGMT. J. 464, 464 (1998).

[93] Atul Nerkar & Srikanth Paruchuri, *Evolution of R&D Capabilities: The Role of Knowledge Networks Within a Firm*, 51 MGMT. SCI. 771, 771-72 (2005).

[94] *See* Lien-An Hsu, Kun-Hong Lee & Chien-Chiang Lin, *A Comparison of Individual and Team Research Performance: A Study of Patents in III*, *in* 2010 PICMET TECHNOLOGY MANAGEMENT FOR GLOBAL ECONOMIC GROWTH 1-6.

[95] Murray & Graham, *supra* note 74, at 679.

[96] Kjersten Bunker Whittington, *Patterns of Male and Female Scientific Dissemination in Public and Private Science*, *in* SCIENCE AND ENGINEERING CAREERS IN THE UNITED STATES: AN ANALYSIS OF MARKETS AND EMPLOYMENT 195, 224 (Richard B. Freeman & Daniel Goroff eds., 2009).

[97] Ding et al., *supra* note 6, at 666.

[98] DELIXUS, *supra* note 86, at 14-15.

[99] Murray & Graham, *supra* note 74, at 660.

[100] Kjersten Bunker Whittington & Laurel Smith-Doerr, *Women Inventors in Context: Disparities in Patenting Across Academia and Industry*, 22 GENDER & SOC'Y 194, 198 (2008).

[101] Murray & Graham, *supra* note 74, at 660-61.

commercialized their research often described themselves as less competent and believed that patenting and commercialization took time away from students, teaching, and university obligations, while men thought that patenting improved the quality of their teaching.[102]

Murray and Graham[103] emphasize three traits typical of women scientists: (1) their mentors are primarily women; (2) cultural stereotypes about women and money reinforce their ambivalence about commercializing their work; and (3) they have more caregiving responsibilities than their male peers. Poor communication between male and female scientists and between patent examiners and inventors may also play a role[104] and affect whether women perceive their own work as patentable and whether others perceive that work as important. Women also face sexism from peers, industry contacts, and customers.[105]

Lack of uniform cross-organizational support structures. Given their limited access to resources and informal networks, institutionalized support is significant for women in patenting. Women who lack personal networks often turn to university TTOs or patenting services for help. Women use TTOs for a range of resources, including contacts, advice, and encouragement, while men rely more on their networks[106] and use TTOs only for legal support. Women who are not affiliated with a university or company have very few resources available to them.[107] Institutional support is vital in bankrolling the patent application process. Inventors often turn to venture capitalists to fund their patenting, but evidence indicates that men are four times more likely than women to receive outside funding,[108] perhaps due to biases among venture capitalists.[109]

Beyond social issues, prior work on the intersection of intellectual property law and gender has examined whether systemic *legal* issues may impede would-be women patentees. While patent doctrine may

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102 *Id.* at 677.

103 *Id.* at 679-80.

104 *See id.* at 671-74; DELIXUS, *supra* note 86, at 29.

105 *See* DELIXUS, *supra* note 86, at 27-28.

106 Ding et al., *supra* note 6, at 667.

107 *See* DELIXUS, *supra* note 86, at 32-33.

108 *See* ALICIA ROBB, SMALL BUS. ADMIN., ACCESS TO CAPITAL AMONG YOUNG FIRMS, MINORITY-OWNED FIRMS, WOMEN-OWNED FIRMS, AND HIGH-TECH FIRMS 17 tbl.4 (2013), https://www.sba.gov/sites/default/files/files/rs403tot(2).pdf [https://perma.cc/LDQ7-C3MT] (noting outside equity for women-owned businesses in 2009 to be $1,690, compared to $7,270 for male-owned businesses the same year).

109 Paula E. Stephan & Asmaa El-Ganainy, *The Entrepreneurial Puzzle: Explaining the Gender Gap*, 32 J. TECH. TRANSFER 475, 481 (2007).

appear gender neutral, biases are apparent in practice.[110] For example, the notoriously nebulous "PHOSITA" ("Person Having Ordinary Skill in the Art") standard for the utility and non-obviousness requirements for patentability is subject to cultural biases and assumptions about who has ordinary skill in a given art.[111] Likewise, what qualifies as "patentable subject matter" is based on inherently androcentric definitions of "invention," "technology," and "industrial application" in ways that may exclude inventive work in fields dominated by women.[112]

The gender gap in patenting may have generated negative externalities for society as a whole: most importantly, the loss of tremendous entrepreneurial and innovative potential. Given the value of patents to technological entrepreneurialism, this gap is also an obstacle for women in commercializing their innovations. Innovation is expensive, so inventors and entrepreneurs need patents to protect against free-riding on investments in their inventions[113] and their investments in commercializing those inventions.[114] Patents also help signal an enterprise's technological expertise and the innovative legitimacy of its products and services to potential investors and licensing partners.[115] Patent owners can also use their patents to ward

[110] Kara W. Swanson, *Intellectual Property and Gender: Reflections on Accomplishments and Methodology*, 24 AM. U. J. GENDER SOC. POL'Y & L. 175, 185, 191 (2015).

[111] Dan L. Burk, *Diversity Levers*, 23 DUKE J. GENDER L. & POL'Y 25, 37-38 (2015); Dan L. Burk, *Do Patents Have Gender?*, 19 AM. U. J. GENDER SOC. POL'Y & L. 881, 883-84, 907-09 (2011).

[112] *See* Shlomit Yanisky-Ravid, *Eligible Patent Matter — Gender Analysis of Patent Law: International and Comparative Perspectives*, 19 AM. U. J. GENDER SOC. POL'Y & L. 851, 852-54, 875-77 (2011).

[113] *See generally* WILLIAM M. LANDES & RICHARD A. POSNER, THE ECONOMIC STRUCTURE OF INTELLECTUAL PROPERTY LAW 294-95 (2003) (comparing patents with copyrights and discussing how patents allow inventors to recoup the costs of research and development for their inventions while protecting against any duplicates of the patented invention).

[114] *See* Michael Abramowicz & John F. Duffy, *Intellectual Property for Market Experimentation*, 83 N.Y.U. L. REV. 337, 340 (2008) (arguing that intellectual property protection should be extended to market experimentation for early inventors by comparing market advantages between early experimenters and late-entering competitors). *But see* Ted Sichelman, *Commercializing Patents*, 62 STAN. L. REV. 341, 343-44 (2010) (questioning whether the current patent system provides adequate protection for commercialization investments).

[115] *See generally* Stuart J.H. Graham, Robert P. Merges, Pam Samuelson & Ted Sichelman, *High Technology Entrepreneurs and the Patent System: Results of the 2008 Berkeley Patent Survey*, 24 BERKELEY TECH. L.J. 1255, 1287-90 (2009) (discussing survey results that demonstrate that patenting confers a significant competitive advantage for technology startup companies, but that this finding is context-specific).

off infringement suits by threatening to countersue for infringement.[116] Finally, patent applications and patents also increase the probability of obtaining necessary investment funding from various sources.[117] However, despite the economic importance of patents, research repeatedly shows that women have less access to patent protections than their male colleagues.

C. Technology Transfer from Academy to Industry

In the past several decades, industrialized countries have established complex processes to leverage the knowledge created in the academic sector for industrial and economic development. This "transfer of knowledge" — also known as "technology transfer" — from academic institutions to the private sector occurs in various ways.[118] In fact, the term "knowledge transfer" refers not only to the dissemination of knowledge that originated in academic research to private businesses and other sectors, but also to the processes of applying and implementing this knowledge in those sectors.[119] One of the most prominent mechanisms for transferring academic knowledge is by patenting inventions developed in the academic sector and commercializing these technologies through licensing arrangements with entities in the private sector.[120] In this way, academic institutions

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116 Ted Sichelman & Stuart J.H. Graham, *Patenting by Entrepreneurs: An Empirical Study*, 17 MICH. TELECOMM. & TECH. L. REV. 111, 113 (2010) (and sources cited therein).

117 EMMA WILLIAMS-BARON, JESSICA MILLI & BARBARA GAULT, INNOVATION AND INTELLECTUAL PROPERTY AMONG WOMEN ENTREPRENEURS 1 (2018), https://iwpr.org/wp-content/uploads/2018/07/C472_Report-Innovation-and-Entrepreneurship-7.24.18.pdf [https://perma.cc/M475-ZF4Q].

118 MOWERY ET AL., *supra* note 10, at 34; *see also* NIVA ELKIN-KOREN, THE TRANSFER OF KNOWLEDGE THROUGH COMMERCIALIZATION OF INTELLECTUAL PROPERTY RIGHTS 16 (Samuel Neeman Inst. for Pol'y Rsch. in Isr. & Technion Inst. of Tech. for Isr. 2007).

119 ELKIN-KOREN, *supra* note 118, at 16 (emphasizing that technology transfer is a narrow concept relating to the development of technological applications of academic knowledge, while knowledge transfer is encompassing a broader range of activities designed to spread the research and implement it in various sectors).

120 This is the same with traditional mechanisms of knowledge distribution, including: Publishing research results in academic journals, granting academic training, invited research, scientific parks, and research institutions. *See id.* at 17. This is also the mechanism for transferring knowledge created by government research institutions. *See* Sharon Bar-Ziv, *The Implications of Transferring Knowledge from the Government Sector Through the Intellectual Property Rights Commercialization*, *in* AN INTERDISCIPLINARY PERSPECTIVE OF INTELLECTUAL PROPERTY 659 (Miriam Marcowitz-Bitton & Lior Zemer eds., 2015).

are ideally positioned to encourage growth in the pursuit of knowledge and optimize its use for commercial advantage.[121]

D. The Gender Gap in the U.S. Academy

Although the STEM gender gap has improved considerably in recent years, it is still large, and the U.S. is a long way away from gender equity in STEM fields. According to statistics from the United States Census Bureau, in 1970 women made up 38% of all U.S. workers, yet only 8% worked in STEM fields.[122] By 2019 both numbers rose tremendously, with women comprising 48% of U.S. workers and 27% of those working in STEM.[123] While the percentages have increased in all STEM fields, the most notable increase was in social science jobs, where the presence of women rose from 19% in 1970 to 64% in 2019.[124] In 2019, women worked in 47% of jobs in math, and 45% in life and physical sciences.[125] Despite these significant improvements, the gender gap persists overall because little progress has been made in the most populated STEM fields. Approximately 80% of STEM jobs outside the military are in computer science and engineering, and in 2019, women accounted for only 25% of computer scientists and 15% of engineers.[126]

In addition to the STEM gender gap, women also face a significant pay gap. In 2020, women across all industries earned just 84% of what men earned on average.[127] A similar gap persists within STEM fields,[128] and it often expands as women become more senior in their professions.[129] In 2018, the Pew Research Center estimated that women

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[121] ELKIN-KOREN, *supra* note 118, at 17.

[122] Anthony Martinez & Cheridan Christnacht, *Women Making Gains in STEM Occupations but Still Underrepresented*, CENSUS.GOV (Jan. 26, 2021), https://www.census.gov/library/stories/2021/01/women-making-gains-in-stem-occupations-but-still-underrepresented.html [https://perma.cc/Q58Z-PSN4] (noting that "women are nearly half of U.S. workforce but only 27% of [STEM] workers").

[123] *Id.*

[124] *Id.*

[125] *Id.*

[126] *Id.*

[127] Amanda Barroso & Anna Brown, *Gender Pay Gap in U.S. Held Steady in 2020*, PEW RSCH. CTR. (May 25, 2021), https://www.pewresearch.org/fact-tank/2021/05/25/gender-pay-gap-facts/ [https://perma.cc/Y4VN-93JE].

[128] *See, e.g.*, *Gender Pay Gap Among STEM Graduates*, 117 PNAS 29993 (2020) (reporting survey results indicating that "women in entry-level engineering and computer science jobs, on average, are paid less than their male counterparts" and suggesting that self-efficacy may be contributing to this disparity).

[129] Claire R. Rollor, *Narrowing the Gender Pay Gap by Providing Equal Opportunities: The Need for Tenured Female Professors in Higher STEM Institutions in an Effort to Recast*

working in STEM fields earn 40% less than men, and more than half of these women report experiencing discrimination or harassment at work.[130] This wage gap is so prevalent that universities have grown to accept it, even displaying the data on their websites, with full knowledge of how unlikely it is that they will be forced to pay their women equitably.[131]

1. Gender Disparities at American Universities

The gender disparity among STEM professors and academics named in patents is not a function of women having a lack of interest in STEM fields, at least not initially. In the spring of 2021, 59.5% of college students in the U.S. were women, yet they were vastly underrepresented in many STEM college programs.[132] Indeed, these aggregate trends unsurprisingly lead to similar outcomes after graduation. Although women comprise half of all employed college graduates ages twenty-five and up in the U.S., they only represented 25% of employees with a STEM degree.[133] Furthermore, the women that do pursue STEM degrees are less likely to pursue a career in STEM. In 2009, around 40% of men with STEM degrees worked in STEM fields, but only 26% of women with STEM degrees worked in STEM positions.[134] When these women within STEM fields, they were disproportionately likely to work in

Gender Norms, 21 UCLA WOMEN'S L.J. 143, 171-72 (2014) (describing that women are at a disadvantage to men in acquiring tenure positions due to "the research factor"); *see also* Andresse St. Rose, *STEM Major Choice and the Gender Pay Gap*, ON CAMPUS WITH WOMEN (2010), https://go.gale.com/ps/i.do?id=GALE%7CA238751293&sid=googleScholar&v=2.1&it=r&linkaccess=abs&issn=07340141&p=AONE&sw=w&userGroupName=anon%7E59fcea7b [https://perma.cc/VW78-DYRC].

130 *There Are Racial Earnings Gaps in the STEM Workforce for Both Men and Women*, PEW RSCH. CTR. (Jan. 8, 2018), https://www.pewresearch.org/social-trends/2018/01/09/women-and-men-in-stem-often-at-odds-over-workplace-equity/ps_2018-01-09_stem_a-09/ [https://perma.cc/556A-3MC2].

131 *See, e.g.*, ELIZABETH DICKINSON, BRENT WISSICK & NOAH EISENKRAFT, COMMITTEE ON THE STATUS OF WOMEN REPORT: UNC GENDER SALARY EQUITY STUDY (2019), https://facultygov.unc.edu/wp-content/uploads/sites/261/2019/04/COSOW-2019-Gender-Pay-Equity-Pres-April-2019-FEC.pdf [https://perma.cc/A67S-Z4HD] (demonstrating an overall gender pay gap of 28% with medical and dental faculties exceeding that average with 39% and 33%).

132 *Women Outnumber Men in US Colleges — Nearly 60% of Students in 2020/21 Were Women*, ERUDERA COLL. NEWS (Sept. 10, 2021), https://collegenews.org/women-outnumber-men-in-us-colleges-nearly-60-of-students-in-2020-21-were-women/ [https://perma.cc/TQ6P-V3H2].

133 BEEDE ET AL., *supra* note 64, at 5.

134 *Id.* at 6.

education or healthcare.[135] Looking at gender-specific data from 2009, women with STEM degrees represented 11.6% of all college-educated employees (versus 30% for men).[136]

Gender disparities differ between STEM fields. In 2009, 57% of female STEM students majored in physical and life sciences (31% of male STEM majors) and 10% of women majored in math (6% of male STEM majors).[137] But 48% of male STEM majors studied engineering, while only 18% of women entered the field.[138] In 2014, women earned only 20% of all physics bachelor's degrees and 18% of all physics doctoral degrees.[139] In engineering, women earned only 19.8% of bachelor's degrees and accounted for only 22% of Ph.D. recipients.[140] At the undergraduate level, for every woman earning a bachelor's degree in computer science, more than four men earn one, and in 2014, only 20% of doctorates in the field were women.[141] The gender gap in computer science appears to have grown. In the mid-1980s, women earned 35% of computer science bachelor's degrees, but this percentage dropped to 28% in the 1990s and fell even further to approximately 18% by 2014.[142]

2. Gender Disparities in University Faculties

Although women comprise slightly more than 50% of the U.S. population, university STEM faculties do not reflect what one might expect based on population alone. Women are highly underrepresented in U.S. STEM faculties, and their presence and pay rates wane as they become more senior. Presently, women make up just 38% of the overall faculty in U.S. universities and four-year colleges, comprising only 26% of physical and related scientists, 14% of engineering faculty, and just

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135 One in five college educated women work in healthcare, while only one in ten men work in healthcare. Nat'l Ctr. for Educ. Stat., *Digest of Education Statistics: 2016*, NCES (Feb. 2018), https://nces.ed.gov/programs/digest/d16/tables_3.asp [https://perma.cc/H2NP-6ALG]. Around 14% of women with STEM degrees go into education, as opposed to only 6% of men. *Id.*

136 *See* BEEDE ET AL., *supra* note 64, at 6 (using the statistics in the cited paper to calculate the data).

137 *Id.*

138 *Id.*

139 AM. PHYSICAL SOC'Y, WOMEN IN PHYSICS (2015), https://www.aps.org/programs/education/statistics/upload/women-physics-2020.pdf [https://perma.cc/4JL5-MQU3].

140 *See* Jaquelina Falkenheim, Amy Burke, Peter Muhlberger & Katherine Hale, *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017*, NAT'L SCI. FOUND. (2017), http://www.nsf.gov/statistics/2017/nsf17310/ [https://perma.cc/HNM9-HWAS].

141 Nat'l Ctr. for Educ. Stat., *supra* note 135.

142 *Id.*

10% of computer science faculty.[143] Women on STEM faculties tend to be ranked lower than their male colleagues. Only 14% of full professor positions in the physical sciences and engineering faculties at U.S. institutions are filled by women, and most of them are assistant professors.[144] The lower the rank, the higher the percentage of women. Women make up 23% of assistant professors and fill 45% of non-tenure track positions as lecturers or instructors in STEM faculties.[145] In 2010, only 14% of physics faculty were women.[146] In non-STEM disciplines, women constitute a far greater percentage of faculty members. Across all disciplines, 32.5% of full professors were women, 45% of associate professors were women, and 50% of assistant professors were women.[147]

While women fill relatively few STEM professorships, they are significantly represented in other high-ranking university positions. Women hold many high-ranking administrative positions at American universities. For example, 30% of university presidents in the U.S. are women.[148] Women have served as presidents of the nation's most elite universities, including the University of Pennsylvania, Cornell University, Brown University, and the University of California, Berkeley. However, in high-ranking positions on STEM faculties, women remain underrepresented. In 2015, women were serving in only 10% of leadership positions, such as deans, department heads, or chairs, in physical sciences and engineering programs in U.S. universities and four-year colleges.[149] As academic rank increases, the number of women

143 Falkenheim et al., *supra* note 140.

144 Bystydzienski, *supra* note 1 ("Only 14% of full professor ranks in the physical sciences and engineering at U.S. four-year institutions are filled by women."); Audrey Leath, *Report Advocates Changing the Culture of Science and Math Education*, AM. INST. OF PHYSICS (May 14, 2003), https://www.aip.org/fyi/2003/report-advocates-changing-culture-science-and-math-education [https://perma.cc/CNX8-ZD8H].

145 Bystydzienski, *supra* note 1; Cynthia Helba, Anne Marie Porter, Starr Nicholson & Rachel Ivie, *Women Among Physics and Astronomy Faculty*, AM. INST. PHYSICS (Dec. 2019), https://files.eric.ed.gov/fulltext/ED602756.pdf [https://perma.cc/8MC3-ZXPX].

146 RACHEL IVIE, SUSAN WHITE, ARNELL GARRETT & GARRETT ANDERSON, WOMEN AMONG PHYSICS AND ASTRONOMY FACULTY: RESULTS FROM THE 2010 SURVEY OF PHYSICS DEGREE-GRANTING DEPARTMENTS 1 (2013), https://www.aip.org/sites/default/files/statistics/faculty/womenfac-pa-10.pdf [https://perma.cc/A78T-GHHJ].

147 Ronnie Hays, *New Data on Full-Time Women Faculty and Faculty of Color*, AM. ASS'N OF UNIV. PROFESSORS (Dec. 9, 2020), https://fhsu-aaup.org/2020/12/09/new-data-on-full-time-women-faculty-and-faculty-of-color/ [https://perma.cc/5JJA-AHWV].

148 *Fast Facts: Women Working in Academia*, AM. ASS'N OF UNIV. WOMEN (Mar. 27, 2020), https://www.aauw.org/resources/article/fast-facts-academia/ [https://perma.cc/T32M-86KF].

149 *Survey of Doctorate Recipients Survey Year 2015*, NAT'L SCI. FOUND. (Mar. 2018), https://ncsesdata.nsf.gov/doctoratework/2015/ [https://perma.cc/GWR9-22NH].

decreases. In 2019 at Yale, 38.3% of STEM faculty were women, but only 17.6% of tenured faculty, 10% of directors of undergraduate studies in STEM, and 11% of STEM department chairs were women.[150]

The STEM gender gap is also pervasive in university tenure processes. In 2017, only 35% of tenured and tenured-track faculty in science, engineering, and health disciplines were women.[151] Women make up just 15% of tenure-track engineering faculty and 14% of computer science tenure-track faculty.[152] Research has shown that women are not awarded tenure as often as their male peers.[153] Women may be given less guidance and mentoring than their male peers. A 2020 study found that when comparing men in non-STEM fields to women in STEM and non-STEM fields, women were more likely to perceive tenure expectations as unclear.[154] Women in STEM are less likely to agree that tenure decisions are based on performance criteria and more likely to be unsatisfied with the department chair's fairness when evaluating their work.[155]

In addition, women in STEM are less likely to be satisfied with the amount of personal interaction with tenured faculty.[156] Moreover, because so few tenure positions in STEM are filled by women, women in junior faculty positions have few women mentors to guide them. Another suggested reason for the lack of women in STEM tenure positions is that the process of getting a doctorate, postdoctoral position, and then a tenure-track job usually happens at the time when

150 *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2019*, NAT'L SCI. FOUND. (2019), https://ncses.nsf.gov/pubs/nsf19304/data [https://perma.cc/L9NW-83B8].

151 *Survey of Doctorate Recipients Survey Year 2017*, NAT'L SCI. FOUND. (Feb. 2019), https://ncsesdata.nsf.gov/doctoratework/2017/ [https://perma.cc/9YLR-MH86].

152 *Fast Facts: Women Working in Academia*, *supra* note 148.

153 Scott Jaschik, *Productivity or Sexism?*, INSIDE HIGHER ED (Aug. 18, 2014), https://www.insidehighered.com/news/2014/08/18/study-raises-questions-about-why-women-are-less-likely-men-earn-tenure-research [https://perma.cc/8PRY-3L8F] (noting that "[n]ot only are men more likely than women to earn tenure, but in computer science and sociology, they are significantly more likely to earn tenure than are women who have the same research productivity").

154 Rodica Lisnic, Anna Zajicek & Brinck Kerr, *Women Faculty in STEM Disciplines: Experiences with the Tenure Process and Departmental Practices*, 46 HUMAN. & SOC'Y 52, 53 (2020), https://journals.sagepub.com/doi/10.1177/0160597620978773 [https://perma.cc/ZMH8-4GMV].

155 *Id.* at 65.

156 *Id.*

women are most likely to have young children.[157] Women who choose to have children may opt out of the process altogether. Only 44% of tenured women professors have children, while 70% of tenured men have children.[158] In a survey of scientists across STEM fields in nine research universities, 63.9% of women reported that family obligations greatly or somewhat interfered with their work, while only 45.2% of men agreed with that notion.[159]

With the backdrop of the gender gap in patenting generally and a parallel gender gap in STEM professorships, Part II turns to our exploration of these two intersecting gaps.

II. DATA REFLECTING ACADEMIC PATENT APPLICATIONS

Our data analysis begins by describing the methodology we used to identify patent applications filed by university researchers,[160] the gender of named inventors, and other relevant data reflected in our patent applications dataset. Next, we sorted the data by gender, grant rate, technology classification, forward citations, and filing years. This Section also describes the challenges in identifying university applications, sets forth other limitations of our approach, and explains why we do not believe these limitations introduce bias into the data. After explaining our methodology, the following Subsections illustrate our findings.

A. Methodology

1. Analysis of Patent Applications

Patent applications reveal a trove of information about new inventions. To meet the specification requirements for issuance, a patent application must instruct a person having ordinary skill in the relevant field how to recreate and use the disclosed technology.[161] This requirement fulfills one of the core missions of patent law — to promote

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[157] *See* REMOVING BARRIERS: WOMEN IN ACADEMIC SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS 6 (Jill M. Bystydzienski & Sharon R. Bird eds., 2006) [hereinafter REMOVING BARRIERS].

[158] *Fast Facts: Women Working in Academia*, *supra* note 148.

[159] Mary Frank Fox, Carolyn Fonseca & Jinghui Bao, *Work and Family Conflict in Academic Science: Patterns and Predictors Among Women and Men in Research Universities*, 41 SOC. STUD. SCI. 715, 723-25 (2011).

[160] University researchers include academic staff as well as students who are researchers.

[161] 35 U.S.C. § 112(a) (2018).

the progress of science by contributing new inventions to human knowledge through public dissemination.[162] Beyond disclosure of the new knowledge, an application includes the names of the inventors and may also identify who acquired their rights by assignment.[163]

This information's availability facilitates quantitative analysis of inventor collaboration, demographic information, and technology transfer.[164] From large datasets containing this information, we devised means for locating patent applications filed by research universities and analyzed this data to identify trends in inventor team composition, fields of innovation, and inventor demographics. To understand the scope of our contribution, it is important to note the limitations of findings based on patent prosecution data.

While patent applications identify inventors and describe their inventions, they provide only a limited snapshot of the broad and varied landscape of innovative activity. Some inventors and their assignees choose to maintain their discoveries as trade secrets or forgo filing a patent application for other reasons. A cost-benefit analysis may favor the choice to forego patent prosecution, and in such cases, data about the innovation will not be reflected in patent datasets.[165] Relatedly, the propensity to file a patent application has changed over time due to an evolving legal environment and changing incentives. Therefore, information derived from patent applications reflects these strategic choices.[166] Lastly, patent documents may not reflect all the innovative discoveries behind the invention. Another consideration is that not all patents incorporate an equal quantity of inventive contributions. A

162 *See* U.S. CONST. art. I, § 8, cl. 8; Bonito Boats, Inc. v. Thunder Craft Boats, Inc., 489 U.S. 141, 150-51 (1989).

163 Andrew W. Torrance & Jevin D. West, *Patent Analytics: Information from Innovation*, *in* LEGAL INFORMATICS 257, 258 (Daniel Martin Katz, Ron Dolin & Michael J. Bommarito eds., 2021).

164 *See*, *e.g.*, Richard Gruner, *The Golden West: Influential Innovation from the San Francisco Region Revealed in Patent Records*, 20 TUL. J. TECH. & INTELL. PROP. 43, 66 (2017) ("The patents in this sample, along with related information on quick citations (up through June 2015), inventor locations, and patent assignments, were used to characterize San Francisco innovation and to compare it to innovation elsewhere."); Sari Pekkala Kerr & William R. Kerr, *Global Collaborative Patents*, 128 ECON. J. F235, F235 (2018) (studying international collaborations leading to patents); Schuster et al., *An Empirical Study of Patent Grant Rates*, *supra* note 77, at 281 (studying patent grant rates as a function of race and gender).

165 ORG. FOR ECON. COOP. & DEV., OECD PATENT STATISTICS MANUAL 27-28 (2009).

166 Sharon Bar-Ziv, Orit Fischman-Afori & Miriam Marcowitz-Bitton, *Where the Gender Gap Meets Academic Patenting: An Empirical Study*, 18 OHIO ST. TECH L.J. 239, 273 (2022); William S. Comanor & F.M. Scherer, *Patent Statistics as a Measure of Technical Change*, 77 J. POL. ECON. 392, 392-93 (1969).

single patent can embody both a radical innovation and an incremental improvement on earlier technology.

While recognizing the limitations of patent application analysis, these concerns do not preclude meaningful study. Rather, we focus on ascertaining information about how universities and academic inventors utilized the patent system. From this data, important information about university innovation and trends in patenting behaviors can be explored.

2. Data Collection

Our primary source of data was the USPTO's Office of the Chief Economist ("OCE") Patent Assignment Dataset.[167] The version analyzed contained data on utility patents through 2016 and was updated with patent grant data through 2019.[168] This dataset comprises self-reported patent ownership information including assignment, security interests, name changes, and firm mergers. Each filing includes ownership information on one or more patents, including the name of the party obtaining the interest in the patent.[169]

We initially associated these filings with their corresponding patent application(s). Next, we identified whether each filing was an assignment or a recording of some other property interest (e.g., a security interest or patentee name change). Data unrelated to assignments was discarded, because it is irrelevant to application ownership.[170] To focus our analysis on academics dedicated to research and a digestible number of universities, we limited our dataset to the 250 top universities[171] by Research and Development expenditure for

[167] *Patent Assignment Dataset*, USPTO, https://www.uspto.gov/ip-policy/economic-research/research-datasets/patent-assignment-dataset (last updated June 13, 2022, 10:58 AM EDT) [https://perma.cc/4Q8A-EYCA]; *see also* Alan C. Marco, Amanda F. Myers, Stuart Graham, Paul D'Agostino & Kirsten Apple, *The USPTO Patent Assignment Dataset: Descriptions and Analysis* 2-4 (USPTO Econ. Working Paper No. 2015-2, 2015), http://ssrn.com/abstract=2636461 [https://perma.cc/W6BS-5XEE] (describing the available data).

[168] The patent grant data was through August of 2019 and came from the USPTO's PatentsView dataset. We omitted plant patents, design patents and reissued patents from the data.

[169] After submission, the filing is assigned a unique reel/frame number that is associated with the patents and applications related to the filing.

[170] The OCE Patent Assignment Dataset identifies each filing as an "Assignment" or one of several other types of filings.

[171] The 250-university threshold was adopted from prior USPTO research. *See General Description of the Report* in *U.S. Colleges and Universities — Utility Patent Grants 1969-2012*, USPTO, https://www.uspto.gov/web/offices/ac/ido/oeip/taf/univ/doc/doc_

the financial year 2019.[172] Consistent with past USPTO research on university patenting, we then matched university names (or their known patent-holding entity names) with assignee names in the database. This analysis proceeded as follows.

Identifying universities within the assignment data was a multi-step process. We initially ran a search identifying assignments including specific terms that were indicative of a university, such as "university," "college," or "academy." This data was then culled to only include assignees that shared a relevant term with a university included in the study (e.g., assignee names including the word "Oregon" were included because of "Oregon State University" and "University of Oregon"). Then, we hand-reviewed the remaining list and excluded any non-university assignees.[173]

This approach is consistent with the methodology previously adopted to this end.[174] However, as recognized by the USPTO, a "lack of consistency in the format of assignee names" poses a problem in complete identification of *every* relevant application.[175] For example, in the public data, many patents and applications have been assigned to Johns Hopkins University. However, one would only see a fraction of them if they searched only for the University's official name. In the USPTO data, ninety-eight different variations of Johns Hopkins University's name are reflected in the assignment filings.[176] Likewise,

info_2012.htm (last visited Feb. 12, 2022) [https://perma.cc/W339-D36Q] ("Other statistical tables display the patent activity for each U.S. college and university institution ranked in the top 250 by total research and development (R&D) expenditures in fiscal year (FY) 2011.").

172 *See Higher Education Research and Development: Fiscal Year 2019*, NAT'L SCI. FOUND. (Jan. 29, 2021), https://ncses.nsf.gov/pubs/nsf21314#data-tables [https://perma.cc/8JLY-MZZ] (Table 5, Higher education R&D expenditures at higher education institutions in both survey populations, ranked by all R&D expenditures, by source of funds: FY 2019).

173 After the initial hand review by a research assistant, one of the authors conducted a secondhand review for any assignee listed on at least five assignments. This review canvassed over 93% of all assignments. Each distinct assignee name was associated with an arbitrary number corresponding with a relevant university. This was accomplished first by associating assignee names and locations with university names and locations. Second, hand identification of relevant universities was conducted.

174 *See General Description of the Report* in *U.S. Colleges and Universities — Utility Patent Grants 1969-2012*, *supra* note 171.

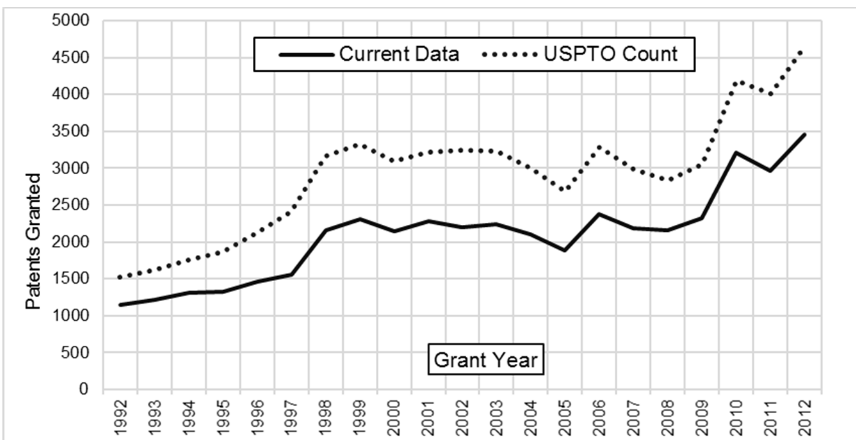
175 *Id.*

176 Examples include: "JOHNS HOPKINS UNIVERSITY, THE, A NOT-FOR-PROFIT CORP. OF MD.," "THE JOHNS HOPKINS UNIVERSITY," "JOHNS HOPKINS UNIVERSITY, THE," "JOHNS HOPKINS UNIVERSITY,THE, A CORP. OF MD.," "JOHNS HOPKINS UNIVERSITY," and "JOHNS HOPKINS UNIVERSITY, A CORP. OF MD."

Stanford University is listed in our dataset under 315 different variations. While this variation poses some difficulty in identifying *all* university applications, it is not a critical drawback. The current study is interested in *trends* in university patenting over time, as opposed to simply reporting the number of applications filed. Therefore, while we may not identify *every* relevant application, we can still achieve our goal of recognizing trends and patterns within the data.

Further, as a robustness check, we compared our data to the USPTO's report entitled, "*U.S. Colleges and Universities Utility Patent Grants, Calendar Years 1969-2012*." We did not expect our data to match their findings perfectly.[177] Our algorithms and hand-coding of universities is almost certainly different from theirs, and the sets of analyzed universities vary because the USPTO used the top 250 research universities in 2011 and we look at the list from 2019. Nonetheless, the findings are very similar. Figure 1 illustrates that the trend lines (in patents granted per grant year) are nearly identical.

Figure 1: USPTO Patent Count Data v. Current Data



The dotted ribbon in Figure 1 represents the USPTO data for patents granted each year to universities, and the solid ribbon represents the data used in our study. As illustrated in Figure 1, while our study identified fewer university patents,[178] the ratio of the patents we

[177] While our study looks at applications filed by university researchers, here we counted the number of patents that arose from those applications.

[178] As discussed in *supra* notes 168–170 and associated text, we intentionally excluded a set of patent applications in the interest of identifying applications naming university researchers as inventors. This may explain some of the variation in aggregate patent count.

identified to those identified by the USPTO is consistent. Indeed, the correlation between the two datasets was .99.[179] This close correlation supports the goal of analyzing trends in university patent activity, as opposed to simply reporting the number of patent applications filed overall or by any one university.

After identifying the full scope of applications assigned to universities, we attempted to cull this dataset to exclude applications that did not name university researchers as inventors. For example, patents that were assigned to a university by some entity outside the institution are not representative of academic patenting and were therefore excluded from our data. We also employed the OCE dataset's "employer assignment" code to identify employee-to-employer assignments.[180] Using this variable presented both opportunities and drawbacks. We were able to identify inventor-assignors that are university researchers, and we assumed that these university employees are largely professors and graduate students (although they could include other university researchers).

Using the OCE database's "employer assignment" code does have drawbacks. Of the applications in our dataset, approximately 102,000 were transferred to a university through an "employer assignment" — as coded in the OCE database compared to approximately 124,000 applications that were assigned to relevant universities through employer assignments or otherwise. Analysis of the full 124,000 plus

[179] The correlation coefficient was calculated via the equation described at *CORREL Function*, MICROSOFT, https://support.microsoft.com/en-us/office/correl-function-995dcef7-0c0a-4bed-a3fb-239d7b68ca92 (last visited Feb. 12, 2022) [https://perma.cc/PNT7-H3UF]. In their written summary of the project, the USPTO also identified the six universities as receiving the most patents in 2012. *See Summary* in *U.S. Colleges and Universities – Utility Patent Grants 1969-2012*, *supra* note 171. They were, in descending order: University of California, Massachusetts Institute of Technology, Stanford University, University of Wisconsin, University of Texas, and California Institute of Technology. *Id.* Our data identified the same six universities as receiving the most patents in 2012, although our data had Wisconsin at number six, with Texas and California Institute of Technology up one spot each.

[180] The USPTO designated particular assignments as "employer assignments" (employee-inventor to employer assignments) based on two criteria. Initially, it ran a keyword search within the assignment for phrases such as "employment agreement," which indicate an employer assignment. Marco et al., *supra* note 167, at 11. In a larger portion of assignments, no such language was used and the USPTO and assignments were coded via algorithm. Specifically, an employer assignment was identified where each of the following was found: (1) it was the first executed assignment on record for the application, (2) the assignment only dealt with one application, (3) the assignment was executed before the application was granted or abandoned, and (4) the text contained the word "assignment." *Id.* Of course, as recognized by the USPTO, such an algorithmic coding will be imperfect. *Id.*

applications would be over-inclusive because *all* applications assigned to a university would be included — *regardless of whether a university researcher was listed as an inventor*. Given our interest in applications filed by university researchers, we eliminated any application that was not filed by a university employee. Unfortunately, hand-review found that some applications that were not identified as being assigned by a university employee listed professors and other university researchers as inventors.[181]

This finding posed a quandary. We could choose to be over-inclusive by analyzing *all* patent applications assigned to a university. This approach would include some applications that did not list university researchers as inventors.[182] Alternatively, we could choose to include only assignments indicating that the inventors were university researchers. This decision would focus our dataset on applications listing university researchers as inventors and exclude some applications that listed professor inventors but were not coded as "employer assignments."[183]

We chose to analyze only applications assigned through an "employer assignment." As stated earlier, our goal was not simply to count the number of patent applications owned by universities. Instead, we chose to focus on trends in women's representation as inventors in academic patent application rates. Because no systemic bias would be introduced by excluding non-employer assigned applications and because our sample size was so large, we removed those files. This strategy facilitated the collection of data focused on the subject of our inquiry — university inventors (inventors who are college and university professors and other academic researchers, such as graduate students).

Next, we created two distinct datasets. The first set identified all university applications and the inventors who signed "employer assignments." This data revealed the university researchers listed on an

[181] For example, under the USPTO's algorithm to identify employee assignments described in *supra* note 170, if an inventor team consisted of a university professor and three employees at a private company, their patent application would not be identified as being assigned to a university by an employee if one of the employees of the private company executed an assignment to the private company, *even if the university professor assigned his or her interest to the university shortly thereafter*.

[182] For example, U.S. Patent No. 7241612 was assigned via a non-employer coded assignment to the University of Georgia. An internet search showed this to be correctly coded for our purposes, as the individual was not a professor (but rather a "Non-compensated Affiliate" as per the UGA website).

[183] For example, in U.S. Patent No. 7,326,568, two University of Georgia professors assigned their patent right to UGA, but the assignment was not coded as an employer assignment by the USPTO algorithm.

application to the exclusion of non-university inventors (who may have signed later assignments to other entities). We call this the "University Researcher Only Dataset," as it excluded non-university employee inventors. Using this dataset, we were able to identify trends in the attributes of university inventors and their patenting activities.

Due to its exclusion of inventors from outside the academy, the University Researcher Only Dataset did not allow us to study inventor team attributes comprising both university and non-university inventors. Because we were interested in learning about the presence of women on inventor teams, we created a second dataset (the "All Inventor Dataset") that includes *all* inventors named on applications assigned to a university.

After the two datasets were created, we began the work of estimating the gender of each inventor. The USPTO does not collect gender data from patent applicants, and due to the large size of the data, hand coding (e.g., looking up the profile of each individual) was not feasible. Accordingly, we adopted a method common in the literature: identifying gender or other demographic information from an individual's name.[184] Prior work has employed this estimation through two distinct methods.

One approach identifies the likelihood that an individual with a particular name has a particular attribute from a data source and codes that individual with a percent chance of having that attribute.[185] For example, Social Security Administration data shows that 86.8% of babies named "Micah" are boys.[186] Applying this methodology, any individual with the first name "Micah" would be coded as 86.8% likely to be male and 13.2% likely to be female. This approach may add more nuance to gender identification (e.g., including information on gender-

[184] *See, e.g.*, Jensen et al., *supra* note 77, at 307 (explaining that they "determined the probable gender of each inventor by using forename gender distributions available from the U.S. Social Security Administration"); Schuster et al., *An Empirical Study of Patent Grant Rates*, *supra* note 77, at 295-98 (noting that the inventors' gender had to be extrinsically ascertained using data identifying the probability of particular first or middle names being given to a boy or girl); William Michael Schuster, Miriam Marcowitz-Bitton & Deborah R. Gerhardt, *An Empirical Study of Gender and Race in Trademark Prosecution*, 94 S. CAL. L. REV. 1407, 1433-34 (2021) [hereinafter *An Empirical Study of Gender and Race*] (discussing methods using first names to determine one's gender or country of residence).

[185] *See, e.g.*, Schuster et al., *An Empirical Study of Gender and Race*, *supra* note 184, at 1452 (coding gender attributes on a 0-1 continuous scale).

[186] Schuster et al., *An Empirical Study of Patent Grant Rates*, *supra* note 77, at 296-97 (compiling data from *Get Ready for Baby*, SOC. SEC. ADMIN., https://www.ssa.gov/oact/babynames/index.html (last visited Feb. 12, 2022) [https://perma.cc/2UY6-UG8S]).

ambiguous names), but it does not allow for identifying "all male" or "all female" inventor groups because few inventors are coded as 100% male or female. Given the goals of this paper, we looked for an alternative method.

A second approach codes individuals with a binary variable indicating whether they have a demographic attribute or not. This can be accomplished in several ways. Initially, a binary database can be used that associates a given name (and possibly a home country) with a specific gender.[187] Alternatively, a name can be associated with a likelihood of having an attribute (e.g., "Micah" is 86.8% likely to be male), and then the individual is coded with a binary gender if that likelihood exceeds a particular threshold. For example, if our threshold is anywhere below 86.8%, then all "Micahs" will be coded with a 1 for being male.

Given our interest in coding the gender of as many inventors as possible, we adopted this later approach with a 50% threshold.[188] Data was compiled from the Gender API website, which contains gender data for over six million names from 189 countries.[189] We uploaded the first name and country of residence for each inventor[190] and Gender API

187 *See, e.g.*, Martinez et al., *supra* note 49, at 6 (attributing gender to patent inventors by cross-referencing patent information with a world gender-name dictionary).

188 There will be miscoding in some instances but given the size of the dataset and the non-systemic nature of the miscoding, it is safe to assume that these miscodings will largely cancel out.

189 GENDER API, https://gender-api.com/ (last visited Feb. 12, 2022) [https://perma.cc/XN5D-VM3D]; *see also* Anne X. Nguyen, Xuan-Vi Trinh, Jerry Kurian & Albert Y. Wu, *Impact of COVID-19 on Longitudinal Ophthalmology Authorship Gender Trends*, 259 GRAEFE'S ARCHIVE CLINICAL & EXPERIMENTAL OPHTHALMOLOGY 733, 735 (2021) ("The application program interface Gender-API (https://gender-api.com/) was used to determine a person's gender based on their first name and country of affiliated institution."); LUCÍA SANTAMARÍA & HELENA MIHALJEVI , COMPARISON AND BENCHMARK OF NAME-TO-GENDER INFERENCE SERVICES 2 (2018), https://doi.org/10.7717/peerj-cs.156 [https://perma.cc/MN9Q-8NTQ] (comparing five gender identification services within a set of benchmarks and finding "Gender API is in general the best performer in our benchmarks").

190 This information either came from the OCE Assignments database or the oce_pair.application_data database (for the "Professor Only Dataset" or the "All Inventor Dataset," respectively). The Application database contains entries for inventors' first and middle names. Thus, if no gender data was available for the first name, we attempted to collect gender data from the middle name. For the OCE Assignments database, a single entry contains name data for the inventor-assignee. Thus, a regexp code was used to extract the first name, which was then corresponded with gender information. *See String Functions*, GOOGLE CLOUD, https://cloud.google.com/bigquery/docs/reference/standard-sql/string_functions#regexp_extract (last visited Feb. 10, 2022) [https://perma.cc/XFY3-6ZUU] (describing regexp functions).

associated over 96% of inventors with a gender.[191] We then coded each patent application for which the gender of all inventors was available as including only female inventors (Women Only), only male inventors (Men Only), or both male and female inventors (Mixed).

As a robustness check for the use of Gender API, we took a sample of 100 patents[192] assigned to research universities and randomly pulled one inventor's name for each patent. We then conducted a Google search to identify the apparent gender of the inventor through an online photo or gendered pronoun. We also ran those 100 first names and the inventor's location through Gender API, which returned a gender for ninety-seven of the names. Of those ninety-seven, the perceived gender of ninety-four was identified via Google search. Of those ninety-four, Gender API coded ninety-one of them correctly (96.8%).[193] This robustness check supports the validity of our approach.

Because our dataset is derived from inventor information reflected in patent applications, it includes information on inventions by university researchers that chose to protect their discoveries with the USPTO. Our data does not reflect discoveries if the university or inventor did not choose to seek patent protection. Moreover, no information is available for analysis regarding inventions described only in a provisional application,[194] as the USPTO does not release information associated

[191] In their new paper, Rembrand Koning, Sampsa Samila, and John-Paul Ferguson used the Gender API subject to this limitation: "We kept the gender information only for names for which there were at least 20 samples in the database and that were assigned to one gender at least 95% of the time." REMBRAND KONING, SAMPSA SAMILA & JOHN-PAUL FERGUSON, SUPPLEMENTARY MATERIAL FOR *WHO DO WE INVENT FOR? PATENTS BY WOMEN FOCUS MORE ON WOMEN'S HEALTH, BUT FEW WOMEN GET TO INVENT* 23 (2021), https://www.science.org/doi/suppl/10.1126/science.aba6990 [https://perma.cc/ZYX5-2W7N] (under "Supplementary Material," choose "Download" and see Table S-4 explanation on page 23). Using this approach, we could only associate gender data with 73.1% of inventors and our percentage of aggregate male inventors fell at a rate of 2.66%. While this difference is not nominal, we are willing to accept it to increase the scope of our coverage.

[192] The patents ranged between numbers 10,384,024 and 10,390,406.

[193] Of the three individuals that we could not identify via Google search, each name was heavily gender-specific (Barbara, Carl, and Toshio). If we include these names as correctly coded by Gender API (which is very likely), the correct identification of gender within our dataset is 96.9%.

[194] "A provisional patent application provides the means to establish an early effective filing date for a later . . . non-provisional patent application." Shashank Upadhye, *To Use or Not to Use: Reforming Patent Infringement, the Public Use Bar, and the Experimental Use Doctrine as Applied to Clinical Testing of Pharmaceutical and Medical Device Invention*, 4 MINN. INTELL. PROP. REV. 1, 56 (2002). "Provisional applications will not be examined for patentability, never mature into patents, and automatically become abandoned twelve months after their filing date." William N. Hulsey III, Anthony E.

with provisional applications if the inventor does not later file a non-provisional patent application.[195]

B. Findings

Our initial findings reflected a dramatic increase in patent applications filed by university researchers since 2000. Between 2001 and 2015, the number of employer-assigned applications increased over 70% (and over 87% between 2001 and 2014). Figure 2 illustrates the distribution of patent applications filed by the top 250 U.S. research universities (by research and development ("R&D") expenditures) from 2001 to 2015.[196] While the number of all applications assigned to a university exceeds the number of applications assigned through an "employer assignment"[197] by approximately 20% each year, the general trends are the same. In fact, the correlation between the two datasets is .991.[198]

Peterman & Steven Sprinkle, *Recent Developments in Patent Law*, 4 TEX. INTELL. PROP. L.J. 99, 125 (1995) (citing 35 U.S.C. § 111(b) (2018)).

195 35 U.S.C. § 122(b)(2)(A) (2018) ("An application shall not be published if that application is . . . (iii) a provisional application."); *see* Colt Int'l Clothing Inc. v. Quasar Sci., LLC, 304 F. Supp. 3d 891, 894 n.1 (C.D. Cal. 2018) ("Provisional patent applications generally do not become public until well after they are filed, if at all." (citing 35 U.S.C. § 122(b))).

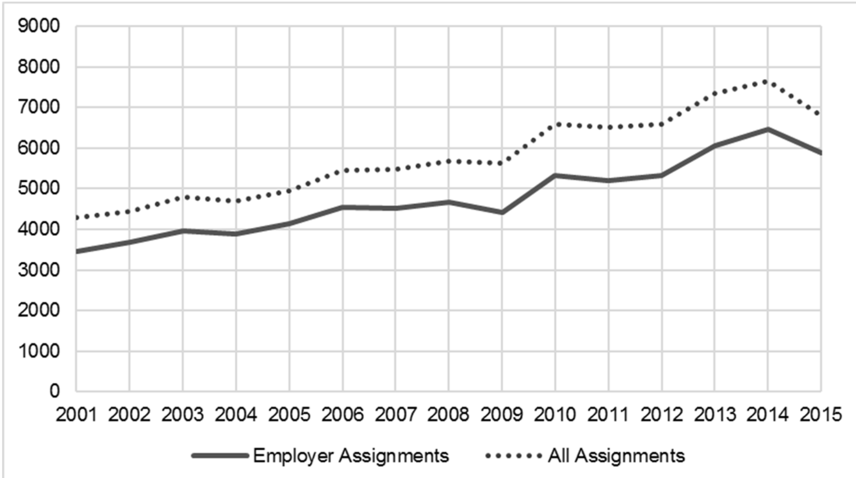
196 The filing year was the actual filing year of each application (not the effective filing year).

Applications filed on or after November 29, 2000, are, with certain limitations, available for inspection eighteen months after filing. 35 U.S.C. § 122(b)(1)(A) (2018); Tewari De-Ox Sys., Inc. v. Mountain States/Rosen, LLC, 637 F.3d 604, 611 (5th Cir. 2011). Accordingly, we start our analysis in 2001.

197 See *supra* note 184 and accompanying text.

198 Correlation calculated via the equation described in *CORREL Function*, *supra* note 179.

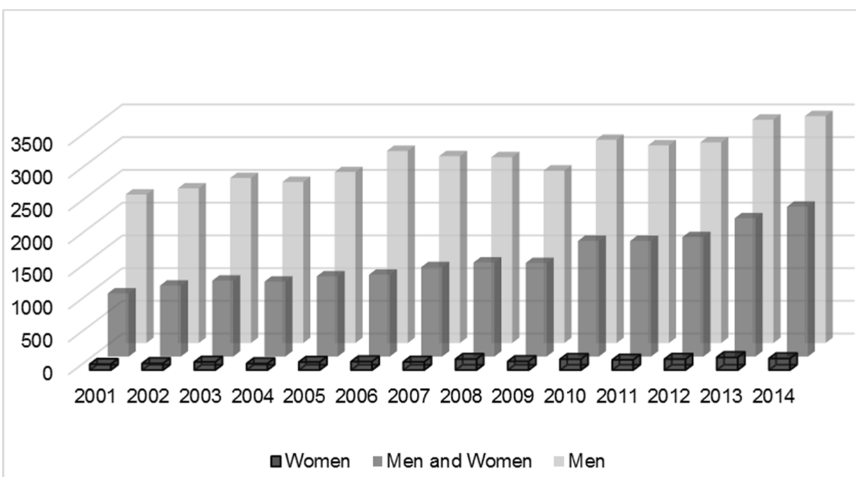
Figure 2: University Patent Applications by Year



Given the near identicality of this trend data, the following analysis will reflect only employer assigned patent applications unless otherwise noted.

Figure 3 depicts the gender profiles of inventor teams by year. This analysis draws from the "All Inventor" dataset, as we are interested in the breakdown of the entire inventor group, not just the inventors employed by the university. The graphs show the number of applications filed annually between 2001 and 2014.

Figure 3: Gender Profiles of Inventor Teams, 2001–14

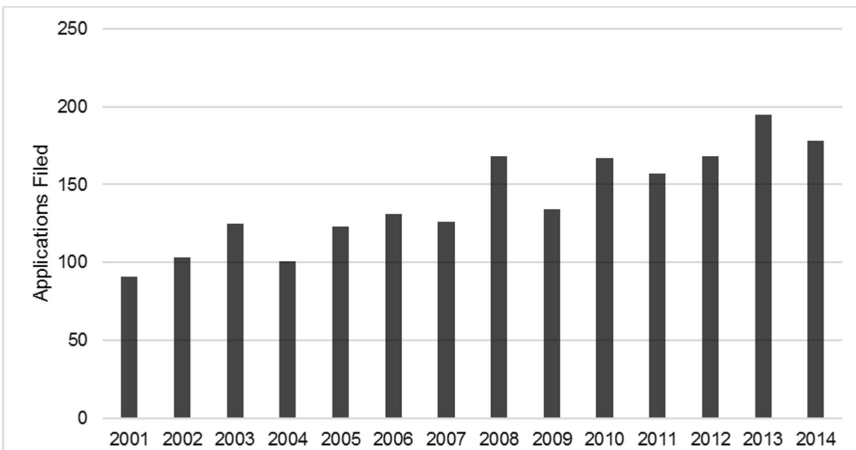


Each application that lists only women as inventors is depicted in charcoal gray. The medium gray bars represent teams with at least one woman and one man, and the lightest gray bars depict applications with teams of all men. Overall, the number of applications steadily increases over the fourteen-year period.

As illustrated in Figure 3, teams of all men still constitute the greatest percentage of academic patent applications filed each year. However, teams with women are gaining ground. The number of applications filed by all women and mixed gender teams doubled over this fifteen-year period. The number of applications filed by all men also increased, but not nearly as substantially. Because teams of all women still constitute a slim minority of all inventor teams, the next chart zooms into the data reflecting their applications.

Figure 4 depicts the number of university patent applications listing only women inventors by filing year.[199]

Figure 4: Applications of All Women Inventor Teams



The number of patent applications filed by women increased substantially over the fourteen years we examined. Submitting a patent application is not easy, and therefore, just putting an invention forward for a patent marks significant progress. However, the economic value of the innovation is generally increased if a patent is granted by the USPTO. Therefore, we next looked at the extent to which academic women have succeeded in prosecuting patents to issuance.

199 Again, the figure depicts applications filed by year.

The following table compares the grant rate for patent applications filed by university inventors by team gender breakdown between 2001 and 2015.[200]

Table 1: Comparison of Patent Applications to Granted Patents, 2001-15 Application Year

Group	Patent Applications	Granted Patents	Grant Rate
Women Only	2,105	1,244	59.10%
Men Only	41,980	28,622	68.18%
Men and Women	22,394	14,340	64.04%
Total	66,519	44,238	66.50%

The results show that men working with other men (or alone) have the highest grant rate. While 68.18% of patent applications filed by teams of only men were granted, the mixed gender teams had a 64.04% rate and teams of only women had a 59.1% grant rate. This disparity is an important topic for further research to determine whether this difference may be explained by subject matter or other less objective variables.

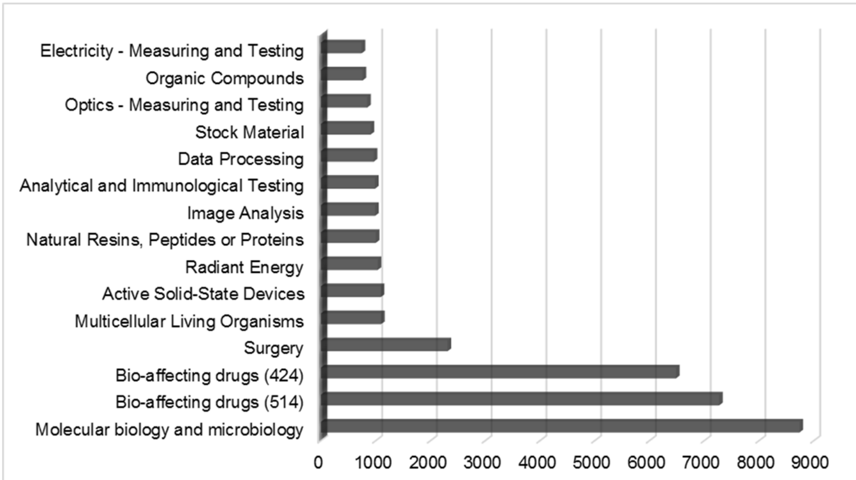
Figure 5 shows the university inventor applications by United States Patent Class ("USPC") for the top fifteen most popular technological classes out of 370 represented in the data.[201] The substantial skew towards the bottom of the figure is notable, with the largest three classes (USPC classes 435, 514, and 424) accounting for 36.0% of all filings. Further, the second and third classes (USPC Classes 514 and 424, both "Drug, bio-affecting and body treating compositions") are largely interchangeable, with 514 being "considered to be an integral part of

[200] This is by actual year filed, not priority date.

[201] USPC data collected from the OCE's application_data_2015 dataset. The full names of the classes and their USPC numbers are (from most common to 15th most common): (435) Chemistry: molecular biology and microbiology, (514) Drug, bio-affecting and body treating compositions, (424) Drug, bio-affecting and body treating compositions, (600) Surgery, (800) Multicellular living organisms and unmodified parts thereof and related processes, (257) Active solid-state devices (e.g., transistors, solid-state diodes), (250) Radiant energy, (530) Chemistry: natural resins or derivatives; peptides or proteins; lignins or reaction products thereof, (382) Image analysis, (436) Chemistry: analytical and immunological testing, (702) Data processing: measuring, calibrating, or testing, (428) Stock material or miscellaneous articles, (356) Optics: measuring and testing, (536) Organic compounds — part of the class 532-570 series, and (324) Electricity: measuring and testing.

Class 424" by the USPTO.[202] The skew towards a few classes continues throughout the data with 74.1% of all applications falling in 10% of the classes represented and 86.7% being represented in 20% of the classes.

Figure 5: Applications Filed by USPC Class, 2001–2014



The findings depicted in Figure 5 are notable in comparison to patents issued to the general public. The three dominant classes in university applications (435, 514, and 424) shown above — were the sixth, fourth, and ninth most common classes among patents issued over overall 2001 to 2014.[203]

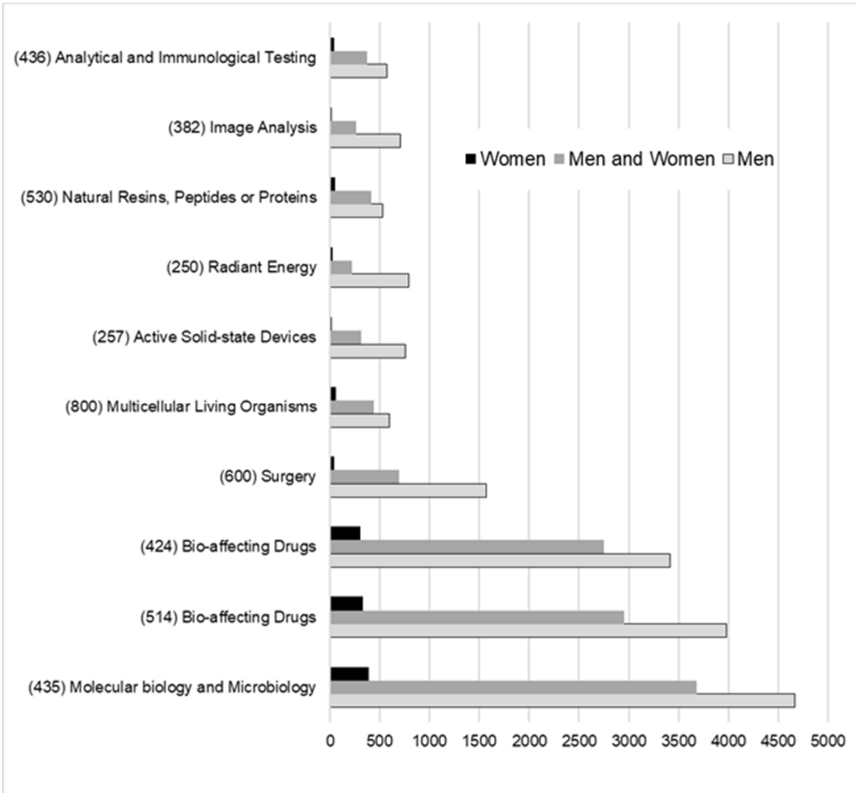
Figure 6 displays the number of patent applications filed by teams of only men, only women, and mixed men and women inventor groups from 2001 to 2014 in the ten most common USPC classes.[204]

[202] *Class 514 Drug, Bio-Affecting and Body Treating Compositions*, USPTO, https://www.uspto.gov/web/patents/classification/uspc514/sched514.htm (last visited Feb. 13, 2022) [https://perma.cc/H2TF-TJP8].

[203] *Patent Counts by Class by Year January 1977 – December 2015*, USPTO, https://www.uspto.gov/web/offices/ac/ido/oeip/taf/cbcby.htm (last visited Feb. 13, 2022) [https://perma.cc/B9B2-NXY6].

[204] See *supra* note 201 for list of full class numbers and names.

Figure 6: Gender Composition of Inventor Teams in Top Ten Patent Application Fields

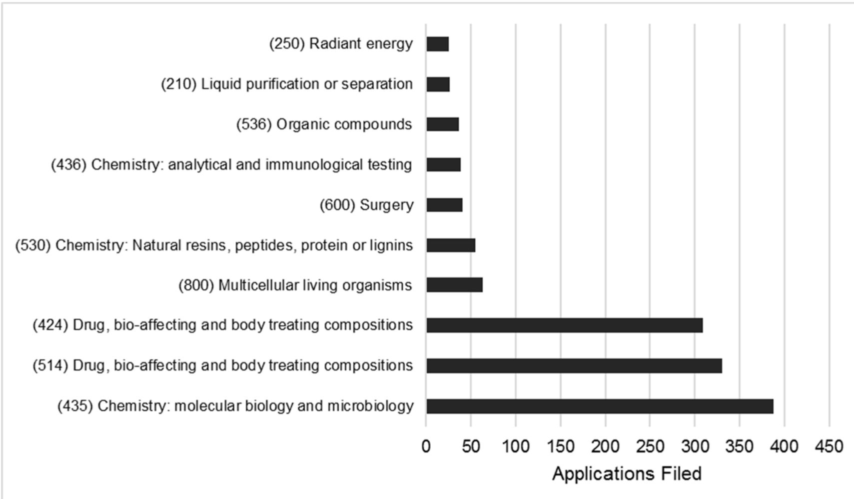


As this figure illustrates, chemistry (molecular biology and microbiology) and drug classes have been the dominant fields of innovation for teams of men only, women only, and mixed gender.

Teams of only women accounted for 4.10% of the applications across these top ten USPC classes, compared with 3.15% in the aggregate. Classes 800 (Multicellular living organisms and unmodified parts thereof…) and 530 (Chemistry: natural resins or derivatives…) had the highest rates of women inventor teams, 5.74% and 5.49%, respectively. Classes 600 (Surgery), 257 (Active solid-state devices — e.g., transistors, solid-state diodes), and 382 (Image analysis) reflected the lowest representation of women inventor teams. In these fields, teams of women filed less than 1.80% of patent applications.

Figure 7 below shows the top ten USPC classes for application filings by women inventor teams from research universities from 2001 to 2014.[205]

Figure 7: Top Ten Fields Naming Only Women as Inventors in Patent Applications



Consistent with Figure 5[206] (detailing all university applications by USPC class), chemistry (molecular biology and microbiology, USPC class 435) and pharmaceuticals (bio-affecting and body treating compositions, USPC classes 514 and 424) dominate applications by women inventor teams.

Table 2 breaks down citation patterns for granted patents arising from applications filed from 2001 to 2015 (as of August 2019[207]) for the different inventor gender categories. Forward citations serve as a measure of patent quality in the literature, and therefore, it is important to explore this measure in our dataset.[208]

[205] See *supra* note 201 for list of full class numbers and names.

[206] *See supra* Figure 5.

[207] Citation data derived from the USPTO's PatentsView dataset (uspatentcitation_201908).

[208] W. Michael Schuster & Kristen Green Valentine, *An Empirical Analysis of Patent Citation Relevance and Applicant Strategy*, 59 AM. BUS. L.J. 231 (2022) (discussing forward citations as predictive of value).

Table 2: Distribution of Forward Citations

Cites	Men	Women	Mixed
0 to 10	82.69%	89.32%	86.60%
11 to 20	7.85%	6.10%	6.62%
21 to 30	3.43%	2.09%	2.68%
31 to 40	1.92%	0.96%	1.35%
41 to 50	1.11%	0.64%	0.67%
51 to 60	0.66%	0.32%	0.52%
61 to 70	0.45%	0.08%	0.36%
71 to 80	0.37%	0.08%	0.22%
81 to 90	0.32%	0.24%	0.20%
91 to 100	0.17%	0.00%	0.13%
over 100	1.02%	0.16%	0.67%

Table 2 shows that 89.32% of patents filed by teams of women have been cited ten or fewer times, compared to 86.60% for mixed gender teams and 82.69% for teams of men. We see a general trend of patents with male inventors being cited more often than those with female inventors.[209] Within our data, teams of men were cited more often than those of women and mixed genders in every category (except for ten or fewer citations). Likewise, mixed gender patents were cited more often than those prosecuted by women in all categories except eighty-one to ninety citations and ten or fewer citations.

One possible source of error is notable. Within our data, a larger percentage of patents with all male inventors issued earlier (as male-only grants have been increasing at a slower rate than the others). Therefore, a greater number of male-only patents had a longer period to amass citations. To check whether longevity may account for this difference, we ran the same data for patents granted in 2010 and 2015, so all relevant patents would have had the same amount of time to garner citations. Our findings were largely consistent. For the 2010 group, ignoring the ten or fewer citation group, the group of women inventors had the largest percent of patents with thirty-one to forty and forty-one to fifty citations, and the mixed group had the largest percent of patents with seventy-one to eighty citations and over 100 citations. For the 2015 group, ignoring the ten or fewer citation group, the all-

[209] *Cf.* Jensen et al., *supra* note 77, at 309 (among patents filed by the general public, "future patent applicants cited the patents of women with common names 30% less frequently than those of men with common names").

male group was equal to or greater than the other groups in every category except eleven to twenty citations, where the mixed group was less than .02% ahead of the male only group. Therefore, even accounting for the possibility that older patents will attract more citations, inventor groups that included men had citation rates that far exceed those of women inventor groups.

Additionally, we analyzed the breakdown of inventor groups by gender and team size. For this analysis, we evaluated all university applications in the All Inventor dataset between 2001 and 2014 for which gender data was available for all inventors. Unsurprisingly, the percent with some missing gender information continues to climb as the number of inventors goes up. Thus, we acted in accordance with past research and only analyzed teams with four or fewer inventors, because using larger inventor groups would have required eliminating more than 10% of applications due to missing inventor gender data.[210] Our data included 43,715 applications naming two to four inventors with the distributions shown in Table 3:[211]

Table 3: Distribution of Applications With Two to Four Inventors by Group

Group	No. of Applications	Percentage
Men Only	27,472	62.84%
Women Only	705	1.61%
Mixed Groups	15,538	35.54%
Total	43,715	100.00%

Consistent with the analysis up to this point, we analyzed only "employer assignments" for this part.[212] However, for robustness purposes, we also ran an analysis including all assignments to universities. Our results had nominal variation, with 62.99% of 50,904 applications filed by male only teams, 1.58% by female only teams, and 35.43% by mixed gender teams.

Next, we analyzed inventor-team breakdown by size for groups of men (including single inventor teams, which were not included in Table 3). Table 4 shows this distribution:

[210] *See* Bar-Ziv et al., *supra* note 166, at 290.

[211] As an alternative, if we analyze teams of one to four inventors, we find 54,050 applications. Among these, 67.55% are all male, 3.63% are all female, and 28.75% are mixed gender teams.

[212] *See supra* note 180 and accompanying text.

Table 4: Distribution of No. of Inventors (Men Only)

Number of Inventors	Number of Applications	Percentage of All Applications
4	4,352	11.92%
3	8,561	23.45%
2	14,559	39.87%
1	9,041	24.76%
4 or less	36,513	1

Again, a robustness check for employer assignments versus all assignments found little variation.[213] These results show that joint inventor teams outnumber solo inventors by more than three to one.

Applying the same inventor team size analysis to teams of women yielded very different results, as illustrated in Table 5:

Table 5: Distribution of No. of Inventors (Women Only)

No. of Inventors	No. of Applications	Percentage
4	23	1.17%
3	110	5.61%
2	572	29.17%
1	1,256	64.05%
4 or less	1,961	1

Surprisingly, this analysis revealed a significant deviation in the prevalence of solo invention by gender.[214] Over 60% of patent applications filed by women are prosecuted by solo inventors, compared with less than 25% of patent applications filed by men.[215] Our last analysis in this vein looked at the breakdown of mixed gender inventor

[213] Looking at all assignments to universities by male only teams, 12.55% were filed by groups of four inventors, 24.13% by groups of three inventors, 39.44% by groups of two inventors, and 23.88% by solo inventors.

[214] Similar findings have been made regarding non-professor patenting. *See* Bridget Diakun, *Data Reveals Strong Growth in the Number of Female Inventors, but There Is Still a Long Way to Go*, IAM (Oct. 11, 2019), https://www.iam-media.com/patents/data-reveals-strong-growth-number-female-inventors-there-still-long-way-go [https://perma.cc/7BWV-NSGE] ("In most patents where a female inventor is listed, they are either working alone or as part of a mixed gender team.").

[215] Again, the robustness check looking at all assignments to universities (not just employer assignments) was consistent. The breakdown was: four-member team (1.19%), three-member team (6.02%), two-member team (29.78%), and solo inventor (63.01%).

teams. Again, we limited our consideration to groups for which gender data on all named inventors could be identified.

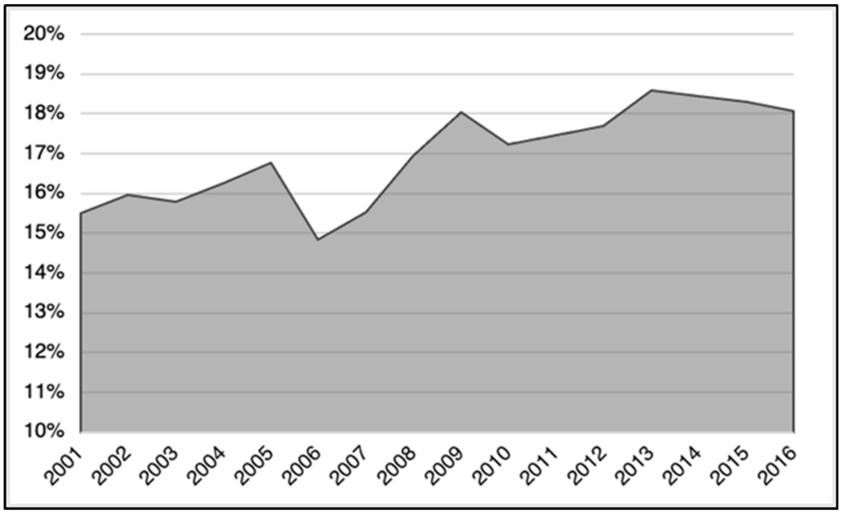
Table 6: Distribution of Inventors in Mixed Groups

No. of Inventors	Group Composition	No. of Applications	% of Total Applications
2 Inventors	Man and Woman	5,311	34.18%
3 Inventors	1 Man and 2 Women	1,243	8.00%
	2 Men and 1 Woman	4,690	30.18%
3 Inventor Total		5,933	38.18%
4 Inventors	2 Men and 2 Women	1,087	7.00%
	1 Man and 3 Women	220	1.42%
	1 Woman and 3 Men	2,987	19.22%
4 Inventor Total		4,294	27.64%
Total		15,538	100%

We see that group size tends to be well distributed among mixed gender teams, with two, three, and four member teams accounting for 34.18%, 38.18%, and 27.64%, respectively. Consistent with the general underrepresentation of women in our data, it was not surprising to see that male majority teams are significantly more common than female majority teams. Among mixed-gender teams with three inventors, groups with two men (and one woman) occur more than three times as often as groups of two women (and one man). Looking at four-member teams, teams of three men (and one woman) are more than ten times as common as teams of three women (and one man).

Our analysis so far has focused on the All Inventor Dataset, which gives us information about all inventors named on applications assigned to research universities. However, we now turn to the University Researcher Only Dataset, which only includes data on individuals that signed an employer assignment to a research university and thus can be assumed to be a professor or a researcher. Figure 8 depicts the percentage of named inventors[216] who are women from 2001 to 2015 by application year.

Figure 8: Percentage of Women Inventors Named in Patent Applications, 2001–16



As a check on the above, we compare our findings to contemporaneous research conducted by Jordana R. Goodman.[217] Her research analyzed 719 patents granted to universities between the fall of 2000 and the spring of 2015 (2,294 inventors listed out of 1,836 unique inventors from between twenty-five to thirty schools).[218] She identified gender data on the individual inventors through website and direct email searches supplemented with information from name/gender probability datasets.[219] Despite the differences in her methodology versus ours (i.e., she used direct identification of gender of inventors from a smaller group of patents/universities, while we used indirect identification of gender for a large group of inventors/applications/universities), the results are largely similar.

[216] Figure 8 depicts the percentage of named inventors whose gender could be identified by their name.

[217] Jordana R. Goodman, *Sy-STEM-ic Bias: An Exploration of Gender and Race Representation on University Patents*, 87 BROOK. L. REV. 853, 882-84 (2022). Goodman additionally explored the race of these university inventors, though that is not relevant to the current paper for comparison purposes.

[218] *Id.* at 870-71.

[219] *Id.* at 871.

Goodman reported the percentage of female inventors on patents granted to schools in four groups. The groups and percentage of female named inventors from 2000 to 2015 were: Ivy League Colleges (14.4%), Highly Ranked Schools outside of the Historically Black Colleges and Universities ("HBCU") system with the most tenured Black faculty (17.5%), HBCUs (20.1%), and Research Institutions (12.3%).[220] Our annual data from 2001 to 2016 was largely consistent, finding that, annually, 14-19% of named inventors from universities were women.

Analyzing the data further, Figure 8 notably shows an increase in the percentage of named inventors that are women over the period studied. However, data shows that the number of university researchers (e.g., professors) who are women increased over the same period.[221] To compare the relative output of university researchers and professors by gender, data on women's representation within the university as a whole must be ascertained. Ideally, annual data would be available on women's representation in science and engineering faculty at research universities, mimicking our dataset. Unfortunately, this ideal data was not available.[222]

[220] *Id.* at 885.

[221] *See, e.g.*, BRIAN L. YODER, AM. SOC'Y FOR ENG'G EDUC., ENGINEERING BY THE NUMBERS 32, https://aseecmsduq.blob.core.windows.net/aseecmsdev/asee/media/content/papers%20and%20publications/pdfs/16profile-front-section.pdf (last visited Feb. 13, 2022) [https://perma.cc/VMS6-MYTR] (showing an increase in the percentage of female engineering professors from 2007 to 2016). National Science Foundation data is similar. A 2017 survey of "U.S. residing employed doctoral scientists and engineers" that were employed at a "[four]-year educational institutions" found 37.8% to be women. *See Survey of Doctorate Recipients Survey Year 2017*, *supra* note 151 (percentage calculated from Table 17 data). This was a slight increase from the 2013 finding of 36.4% from the same survey. *See Survey of Doctorate Recipients Survey Year 2013*, NAT'L SCI. FOUND. (Sept. 2014), https://ncsesdata.nsf.gov/doctoratework/2013/ [https://perma.cc/8AJT-TF8Z] (percentage calculated from Table 17 data). Similar findings from 2010 found 35.0% of these individuals to be female. *See Survey of Doctorate Recipients Survey Year 2010*, NAT'L SCI. FOUND. (Apr. 2014), https://ncsesdata.nsf.gov/doctoratework/2010/ [https://perma.cc/HQC9-ZB5G] (percentage calculated from Table 17 data).

[222] Annual gender data was available for engineering professors. *See* YODER, *supra* note 221. However, prior research has found that the gender gap is highest within engineering. Ann M. Beutel & Donna J. Nelson, *The Gender and Race-Ethnicity of Faculty in Top Science and Engineering Research Departments*, 11 J. WOMEN & MINORITIES SCI. & ENG'G 389, 391 (2005) ("Gender gaps in faculty composition at top S&E research departments are greatest in engineering and physical sciences, where 8.5% and 8.4% of faculty, respectively, are female."). Thus, if we compared our data to that dataset, we would expect to see a significant relative overrepresentation of female patentees because we were drawing from a sample with a larger percent of women. Indeed, unreported data found just this.

Similarly, annual gender data was available for all "doctoral scientists and engineers" that were employed at "[four]-year educational institutions." *See* National Science

However, one study provided a snapshot of the gender breakdown of science and engineering professors at top research universities for the year 2002.[223] The study found that "14.8% of the faculty members in top S&E research departments are female."[224] This data is similar to our finding that women represented 15.96% of named researchers from universities in 2002 (and 15.78% in 2003 and 16.25% in 2004).[225] This data suggests an equal use of the patent system by university researchers regardless of gender. In contrast, recent research by Goodman analyzed a subset of 719 university patents compared to the percentage of women on the respective schools' faculty and reported a disparity in patenting rates by gender between 2000 and 2015.[226] Specifically, she found a significant overrepresentation of male professors among named inventors. These disparate preliminary findings indicate that this topic warrants further research.

Foundation sources cited *supra* note 221 and accompanying text. This data would be significantly over-inclusive, as it includes scientists and engineers employed at non-research (or research-light) universities. *See, e.g.*, *Table 105.50* in *List of 2017 Digest Tables*, NAT'L CTR. FOR EDUC. STAT., https://nces.ed.gov/programs/digest/d17/tables/dt17_105.50.asp (last visited Feb. 13, 2022) [https://perma.cc/FW84-M8HG] (listing 3,004 four-year colleges in the U.S. in 2015-16, compared to the 250 top research universities studied here); *146 Results for Basic = "Doctoral Universities: Very High Research Activity,"* CARNEGIE CLASSIFICATION OF INSTS. OF HIGHER EDUC., https://carnegieclassifications.iu.edu/lookup/srp.php?clq=%7B%22basic2005_ids%22%3A%2215%22%7D (last visited Feb. 13, 2022) [https://perma.cc/4N9E-B46P] (listing 146 "Very High Research Activity" universities); Michael T. Nietzel, *Movin' on Up: Nine Universities Climb to Highest Carnegie Classification in 2021*, FORBES (Dec. 21, 2021), https://www.forbes.com/sites/michaeltnietzel/2021/12/21/movin-on-up-nine-universities-climb-to-highest-carnegie-classification/?sh=646f6d774d8b [https://perma.cc/734B-62P3] (discussing ranking criteria for research universities). Professors at research universities are more likely to be male than at non-research universities. MARTIN J. FINKELSTEIN, VALERIE MARTIN CONLEY & JACK H. SCHUSTER, TIAA INST., TAKING THE MEASURE OF FACULTY DIVERSITY 5 (Apr. 2016), https://www.tiaainstitute.org/sites/default/files/presentations/2017-02/taking_the_measure_of_faculty_diversity.pdf [https://perma.cc/W599-L6RS] ("While that gender gap has shrunk by nearly half over the ensuing twenty years, it nonetheless remains fairly substantial (2.3 men to 1 woman) among tenured appointments at the research universities, especially the private research universities (2.5:1)."). Thus, we would expect to see a larger female representation in the National Science Foundation data. Indeed, in unreported data, we find a significantly larger portion of female doctorate professors at "all 4-year universities" than within our patentee data.

[223] *See* Beutel & Nelson, *supra* note 222, at 389-91 (reviewing "biological sciences, engineering, physical sciences, psychology, and social sciences" at the "top 50 [departments] for research and development expenditures in a given discipline according to the National Science Foundation").

[224] *Id.* at 391.

[225] *See supra* Figure 8.

[226] Goodman, *supra* note 217, at 886-87.

III. PRIMARY CONCLUSIONS

Our primary findings are as follows. *First*, academic patenting is on the rise. Patent applications originating from universities increased significantly between 2000 and 2015. *Second*, inventor teams that included women had patents granted at a lower rate than teams of only men. Teams of all women had the lowest grant rate, mixed teams fared better, and teams of all men had the highest grant rate. The differences between male-only and women-only teams requires further research to understand the reason for their differences and their robustness.

Third, we found that three USPC classes — consisting of drugs and chemistry (molecular biology) — dominate the technological classes of all types of inventors groups. *Fourth*, the study also uncovered that patents from men-only inventors teams tend to be cited more often than those from women-only and mixed-gender teams. *Fifth*, we also found that there are many more men-only teams than women-only teams, with mixed-gender inventor teams in the middle. This finding is consistent with work showing that researchers tend to work with people of the same gender,[227] as well as literature showing a majority of university STEM professors are men.[228] Moreover, men-only teams were most likely to work in pairs (about 40%), but groups of one and three inventors were also common (about 24%). In contrast, almost two thirds of women who sought patents filed as solo inventors. Mixed-gender groups teams tended to be two or three people, though groups of four were not uncommon.

Sixth, the percentage of named female university researchers and inventors has increased over time. However, due to lack of historical and current data on the representation of female academic staff and researchers who engage in research and development in STEM in the U.S. academy, we are unable to normalize the data and understand whether their representation amongst patentees correlates with their representation amongst faculty and researchers in the U.S. academy. More research and data in this field is required.

It is interesting to note that women's participation in academic patenting in the U.S. is greater than their average participation in patenting in the U.S. generally and worldwide.[229] Indeed, our study

227 *See* Luke Holman & Claire Morandin, *Researchers Collaborate with Same-Gendered Colleagues More Often than Expected Across the Life Sciences*, 14 PLOS ONE 1, 9 (Apr. 26, 2019), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6485756/ [https://perma.cc/L2UR-QERV].

228 Negin Sattari & Rebecca L. Sandefur, *Gender in Academic STEM: A Focus on Men Faculty*, 26 GENDER, WORK & ORG. 158, 158 & n.1 (2019).

229 *See supra* Part I.

reveals that women were named as an inventor in 36.5% of applications filed by U.S. universities from 2001 to 2014, which is greater than the worldwide 29% total representation reported in prior literature.[230] The percentage of American women's academic patenting is also much higher than the average representation of women in patenting worldwide generally, which is 7.2%, and is also higher than the 8.7% U.S. average representation of women in patenting.[231] Further, our study reveals that women in the U.S. academy participate in patenting at much higher rates than American women generally, who are named as inventors in less than 22% of applications as of 2019.[232]

IV. PROPOSALS

Based on our findings, we recommend the following proposals for further research to better understand the gender gap in patenting and how it may be remediated. Preliminarily, more research on global trends should be conducted. While much empirical research focuses on the U.S. market, not many studies delve into these trends internationally over time, making it difficult to discern which countries are progressing on closing the gender gap and why.

There are many possible remedies and actions that can facilitate closing the gender gap in patenting generally, while some proposals are specifically tailored to addressing the gender gap in academic patenting. These include:

Changes to patent law and policy — Potential changes include addressing subject matter eligibility criteria, the patent prosecution process (e.g., blind review of patent applications with inventors' names redacted, reduced fees for small businesses, and government guidance through the process), and introduction of an unregistered patent system to provide more egalitarian protection which may reduce the patenting gender gap.[233]

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[230] However, one should take into account that Martinez, Raffo, and Saito study examined only PCT applications. *See* Martinez et al., *supra* note 49, at 9. Also, comparing academic patenting to patenting in other sectors might be misleading because the academic sector is unique in its character and goals, which influence its intellectual property rights management. *See* Eric Johnson, *Myriad Problems: An Analysis of the Challenges to Gene Patents and the Policy Questions Raised*, 43 U. TOL. L. REV. 695, 713-14 (2012).

[231] GENDER PROFILES, *supra* note 50, at 30.

[232] USPTO, PROGRESS AND POTENTIAL, *supra* note 61, at 3.

[233] *See* Miriam Marcowitz-Bitton & Emily Michiko Morris, *The Distributive Effects of IP Registration*, 23 STAN. TECH. L. REV. 306, 362-63 (2020); Miriam Marcowitz-Bitton,

Introducing data tools to track women's patenting activity — The lack of available data on the gender of inventors makes research on this subject far more challenging than it would be if the USPTO collected demographic information on inventors. Compounding the absence of inventor data, there is no systematic collection of data on women in STEM in the U.S. academy. To better understand women's patenting activity and make decisions about potential policy solutions, it is crucial to collect data systematically on women in STEM fields in the U.S. academy and to establish methods for studying diversity, such as voluntary surveys and other methods.

Developing networks of support services for inventors — While different resources are available to women in the U.S., a comprehensive database of resources could help women and men inventors in all sectors secure assistance in the patenting process.

Fostering networks for women entrepreneurs and inventors — Women often lack mentors and networking opportunities, making it more difficult for them to navigate advance professionally.[234] A 2016 study found that having industry contacts is the most important factor for getting women more involved in patenting.[235] Mentorship and networking programs could be implemented to support research conducted by women. Networks are extremely helpful for inventors and provide industry contacts, access to funding sources, technical assistance with research and development, and opportunities to collaborate on projects. Promoting awareness and familiarity with different networks can promote women's engagement with these groups lead to increased access to resources and opportunities for collaboration.

Supporting efforts to increase women's interest in STEM fields — Women are still underrepresented among STEM degree holders globally, and women are substantially underrepresented in particular fields in the U.S., such as engineering. Therefore, another solution is to encourage girls in middle school and high school to be involved in STEM to prepare them for studying STEM subjects in college. When both boys and girls were asked to draw a scientist, girls were twice as

Yotam Kaplan & Emily Michiko Morris, *Unregistered Patents & Gender Equality*, 43 HARV. J.L. & GENDER 47, 73 (2020).

234 Andie Kramer, *Women Need Mentors Now More than Ever*, FORBES (July 14, 2021, 9:38 AM EDT), https://www.forbes.com/sites/andiekramer/2021/07/14/women-need-mentors-now-more-than-ever/?sh=370c9c32bbdc [https://perma.cc/2ZTL-JJHL].

235 *See* Yu Meng, *Collaboration Patterns and Patenting: Exploring Gender Distinctions*, 45 RSCH. POL'Y 56, 64 (2015).

likely to draw a man scientist than a woman.[236] Seventy percent of six-year-old girls drew a female scientist, but only 25% of sixteen-year-old girls did so.[237] As girls get older, they often lose the courage to enter the STEM world, so it is vital to start supporting girls who want to enter STEM at a young age and keep that support in place during middle and high school. Interpersonal interventions (such as mentorship, outreach, and campaigns against stereotypes) and systematic changes (such as enforcing policies against discrimination and harassment in hiring and promotion and tenure decisions) should also be employed to address the gap.[238]

Supporting family responsibilities — Research in the U.S. and elsewhere shows that one of the most significant challenges women academic scientists face is balancing work and family obligations.[239] STEM faculties in universities often emphasize the importance of keeping up with academic standards and having total devotion to the field.[240] This mentality makes it very difficult for women to set aside time to raise children at early stages in their careers. Therefore, institutions need to find ways to support women who would like to work in STEM and have a family. Family-oriented policies, such as pausing the tenure clock for maternity leaves, are important changes that can help recruit and retain more women in science. Women outside of academia face similar issues. In recognizing the importance of family-oriented workplace policies in attracting and retaining talented female (and male) employees, employers should consider offering paid maternity and paternity leave

Creating a variety of institutional incentives to file for patents — Ding et al.[241] show that gender differences in attitudes towards patenting exist. Women academic scientists tend to view patenting activity as coming at the cost of less time with students, teaching, and university

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[236] Carly Berwick, *Keeping Girls in STEM: 3 Barriers, 3 Solutions*, EDUTOPIA (Mar. 12, 2019), https://www.edutopia.org/article/keeping-girls-stem-3-barriers-3-solutions [https://perma.cc/JBZ3-5GAZ].

[237] Youki Terada, *50 Years of Children Drawing Scientists*, EDUTOPIA (May 22, 2019), https://www.edutopia.org/article/50-years-children-drawing-scientists [https://perma.cc/48T7-3LQP].

[238] *See* Vicky J. Rosser, *Faculty Members' Intentions to Leave: A National Study on Their Worklife and Satisfaction*, 45 RSCH. HIGHER EDUC. 285, 302-06 (2004); Alanna Petroff, *The Exact Age When Girls Lose Interest in Science and Math*, CNN (Feb. 28, 2017), https://money.cnn.com/2017/02/28/technology/girls-math-science-engineering/index.html [https://perma.cc/ZD6J-GR35].

[239] *See* Rosser, *supra* note 238, at 289-90.

[240] *See* REMOVING BARRIERS, *supra* note 157, at 6.

[241] Ding et al., *supra* note 6, at 665-66.

obligations. Men, by contrast, are more likely to state that commercial activity complements their teaching. Murray & Graham[242] found that many women scientists were ambivalent about commercial science and expressed reservations about the practice. Institutional rules indicating a university's support for commercialization and metrics for how such activities factor into the promotion and tenure process could help assuage women's reservations and provide guidance on how the university views patenting activity. For example, in 2006, Texas A&M University approved a measure to include inventions in its tenure and promotion decisions.[243] Since then, many universities have followed suit. The ever-increasing market value for patenting supports making it a measure of success for in STEM fields.[244] Additionally, behavioral changes, such as requiring inventors to report on whether their inventions are patentable, could encourage more reflection on the possibility of patent prosecution.

Funding opportunities for women — One reason for the gender gap in patenting is related to venture capital funding. Around 76% of venture capital investors consider patents when determining which companies to fund.[245] Although around 36.3% of all businesses in the U.S. are owned by women, only 3% of venture capital funding went to businesses with a woman CEO between 2011 and 2013.[246] Men who own businesses are significantly more likely than women to receive outsider equity to fund their businesses.[247] Outside funding is extremely important for businesses going through the patenting process because it can be lengthy and expensive. A patent that lasts twelve or more years can have maintenance fees ranging from $3,000 to over $12,000, and thousands of dollars in attorney's fees.[248] The lack of funding makes it difficult for women-owned businesses to meet the high costs of patent prosecution.

Implementing initiatives to enhance gender equality generally — Women in STEM often report feeling ignored, discriminated against,

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242 Murray & Graham, *supra* note 74, at 682.

243 Ashley J. Stevens, Ginger A. Johnson & Paul R. Sanberg, *The Role of Patents and Commercialization in the Tenure and Promotion Process*, 13 TECH. & INNOVATION 241, 241 (2011).

244 MILLI ET AL., EQUITY IN INNOVATION, *supra* note 59, at 17.

245 MILLI ET AL., THE GENDER PATENTING GAP, *supra* note 59, at 7.

246 *Id.*

247 *See* ROBB, *supra* note 108, at 17 tbl.4.

248 *See* Gene Quinn, *The Cost of Obtaining a Patent in the US*, IP WATCHDOG (Apr. 4, 2015, 3:05 AM), http://www.ipwatchdog.com/2015/04/04/the-cost-of-obtaining-a-patent-in-the-us/id=56485/ [https://perma.cc/F9SM-XYCW].

and sexually harassed in the workplace.[249] These fields need to change their value systems and behaviors to create a more welcoming environment for women. Educational and social initiatives to support gender equality generally, and women inventors specifically, can help narrow the patent gender gap.

Finally, in October 2021, President Joe Biden nominated Kathi Vidal to be the next Director of the USPTO.[250] On April 5, 2022, the Senate confirmed this nomination,[251] making Vidal the second female director of USPTO in U.S. history, which may encourage more women to see themselves as potential leaders in intellectual property intensive fields.

V. CONCLUDING REMARKS

This study explored a dimension of the gender gap in academia that is often overlooked. Although past studies have examined the disparity in men's and women's representation among faculty in various contexts, our study looked empirically at differences in men's and women's participation in technology transfer from academia to industry. Specifically, we examined the gender of inventors named in U.S. patent applications and found that a substantial gender gap exists both in the number of patent applications and how often women's inventions are cited by others.

These findings call for further research to examine the reasons these gaps exist and to formulate solutions for optimizing academic women's inventive work. Faculty inventors are entitled to royalties stemming from the commercialization of their patents. Accordingly, women's low rate of participation in patenting activity has tangible financial consequences: as a group, female faculty members benefit less than their male counterparts from the financial rewards that STEM faculty often receive. This observation is consistent with the overall data on the gender pay gap in the general workforce. Moreover, the low integration of women into knowledge transfer activities and patent

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[249] Emmeline de Pillis & Lisette de Pillis, *Are Engineering Schools Masculine and Authoritarian? The Mission Statements Say Yes*, 1 J. DIVERSITY HIGHER EDUC. 33, 34 (2008).

[250] Matthew Johnson & Michael Lavine, *Kathi Vidal Nominated for USPTO Director*, JD SUPRA (Nov. 9, 2021), https://www.jdsupra.com/legalnews/kathi-vidal-nominated-for-uspto-director-2398826/ [https://perma.cc/NU5A-K88X].

[251] Michael Burke, *Kathi Vidal Confirmed as the Next USPTO Director*, JD SUPRA (Apr. 6, 2022), https://www.jdsupra.com/legalnews/kathi-vidal-confirmed-as-the-next-uspto-1876505/https://news.bloomberglaw.com/ip-law/senate-approves-biden-pick-vidal-for-patent-and-trademark-office [https://perma.cc/FAG2-8E7Q].

commercialization may reduce their exposure to the private market, which can, in turn, diminish their professional opportunities.

Our findings can serve as a springboard for further in-depth research on the different aspects of women's integration in academia, and to identify failures in achieving gender equality that may be masked by women's increasing representation on academic faculties. The results of our study make clear that equality in academia is not merely a question of how many women are present. It is also a question of whether women faculty can and do participate in their institution's patenting and other important research activities at similar rates as their male colleagues.