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WHERE THE GENDER GAP MEETS ACADEMIC PATENTING: AN EMPIRICAL STUDY

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The gender gap in academia has long been the focus of public discourse regarding the role of academic institutes in promoting social values. Integrating women into senior academic positions, especially in the STEM (Science, Technology, Engineering and Mathematics) fields, is an essential aspect of promoting women's advancement in society in general, and it also has significant implications on female entrepreneurial and innovative potential.
In this study, we seek to assess the gender gap in the Israeli academy by examining the nature and extent of women's participation in transferring knowledge from the academy to the industry. One of the most prominent models for such transfer of knowledge is based on the registration of patents for inventions developed by academic institutes in the course of their activities. Academic patenting is thus a significant component of the professional activities of faculty members worldwide. Yet, female academic patenting has received little attention thus far.

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The Israeli academy serves as an important case study for examining female academic patenting because Israel is not only a world leader in scientific research, but it also has an ongoing technology transfer tradition that began in the early 1960's; and because Israel is a small country, it is possible to conduct a comprehensive study, examining all patent applications filed by academic institutes since the State's establishment in 1948. In this study, we examine the extent to which women participate in patent filing activity in Israeli academic institutes as compared to men. Our comparative examination is anchored in a quantitative analysis of inventors' names indicated in patent applications filed by academic institutes in Israel. The study then examines the gender of the named inventors when controlling for various other characteristics of patent applications, such as rates of acceptance for registration, fields of research, forward citations, and more.

Our study yielded several key findings. We found that women file patent applications far less than men. Our database included 6825 patent families, out of which 320 applications were filed by women inventors only, 3607 applications were filed by men only, and 2898 applications were filed by mixed inventor groups comprising both male and female inventors. These data alone demonstrate a gender disparity in patenting activity in the Israeli academy. A thorough examination of the gender composition of mixed-group patent applications shows further that women are outnumbered by men in joint applications naming inventors of both genders. The study also found that women's involvement in patenting activity in the academic sector is significantly lower than men's, considering women's representation in STEM faculties in Israel. We found that while the share of patent applications filed by men was higher than their representation in academic positions, the share of patent applications filed by women was much lower than their representation in academic positions. For instance, the study found that in the years 2017-2018, women patented at about 35% of the rate at which men patented. Nevertheless, our analysis reveals that applications naming male, female, and mixed-group inventors have comparable acceptance rates, and that there is no meaningful gender-based distinction when it comes to the scientific filed of the invention or forward citations.

The importance of this study is that it reveals that even when it appears that women are successfully engaged in academic activity—i.e., they have been appointed to the senior faculty in STEM fields—there remains a significant gap in terms of the activities that women and men pursue. Moreover, our results suggest that women have not achieved their full potential for invention and knowledge transfer in the STEM fields, resulting in potential economic and social losses to society.

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

CONTENTS

I. Introduction

This study explores the intersection of two issues at the core of public discourse around the world: the participation of women in the academic sector, and the transfer of knowledge and technology from the academic sector to the industry. These issues are central to the academy's goal of closing the gender gap in academia and promoting equality in society generally, as well as to its role in encouraging innovation and knowledge utilization.

Gender disparity in academia has long vexed the institutions whose core responsibilities include promoting social values.[2] Integrating women into senior academic positions as faculty members is an essential aspect of promoting women's advancement in society in general, as such positions encourage women to pursue higher education, to reach their full potential, and to command higher salaries, among other benefits.[3] A commonly-used standard to assess the extent of women's integration into the academy is to measure their numerical representation among faculty members.[4] These statistics are then used as the basis for examining the academic sector's success in promoting gender equity.[5] Additional factors considered in 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 at various academic management positions.[6]

In this study, we seek to assess the integration of women in the Israeli academy by examining the nature and extent of women's participation in the transfer of knowledge from the academy to the industry. The Israeli academic sector serves as an important case study for three main reasons: *first*, Israel is a world leader in scientific research; *second*, Israel has a technology transfer tradition that began in the early 1960s; and *third*, Israel is a small country, allowing for a comprehensive review of all patent applications filed

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[2] *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. 2021).
[3] *Id.*
[4] *Id.*
[5] *Id.*
[6] *Id.*

by academic institutes since the establishment of the State in 1948, rather than a random sample.

A prominent model for transferring knowledge is based on the registration and licensing of patents for inventions developed by academic institutes in the course of their activities.[7] Patent registration is often made through Technology Transfer Companies (TTC) owned by the institutes, which also promote the commercialization of the registered patents through licensing and other means.[8] Accordingly, we examined how many women participate in patent filing activity in the academic sector and compared women's rate of participation in this central academic activity to men's. We carried out this comparative examination through quantitative analysis of the inventors' names indicated in patent applications filed by academic institutes in Israel.[9] The study examined various characteristics of patent applications, including their scientific categories. We quantified the number of patent applications involving women as inventors (alone or as part of a group), the number of patent applications involving men only as inventors (alone or as part of a group), and the number of patent applications that include both women and men as inventors. We then examined the rates at which these three groups of applications have been accepted for registration or denied, as well as other important patenting-related issues, including research fields and changes in patenting rates over the years, among others. The results of our study indicate how many women in academic institutes take part in one of today's most significant areas of activity in the academic sector.

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[7] Rebecca S. Eisenberg, *Public Research and Private Development: Patents and Technology Transfer in Government-Sponsored Research*, 82 VIRG. L. REV. 1663, 1693-95 (1996); HENRY ETZKOWITZ, THE TRIPLE HELIX: UNIVERSITY-INDUSTRY-GOVERNMENT INNOVATION IN ACTION (2008); Arvids A. Ziedonis, *Empirical Analyses Related to University Patenting*, *in* RESEARCH HANDBOOK ON THE ECONOMICS OF INTELLECTUAL PROPERTY LAW (B. Depoorter, P. Menell, & D. Schwartz eds. 2019).

[8] 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, 117-122 (2019); *see* Hagit Messer-Yaron, *Capitalism and the Ivory Tower: The Gordian Knot Between Money and Science*, 57 ISR. J. ECOLOGY & EVOLUTION 331 (2010). Scholars and policy makers have devoted substantial attention to the benefits and disadvantages of this model. *See, e.g.*, Peter Lee, *Patents and the University*, 63 DUKE L.J. 1 (2013); 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); Patricia E. Campbell, *University Inventions Reconsidered: Debunking the Myth of University Ownership*, 11 WM. & MARY BUS. L. REV. 77 (2019).

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

Our findings reveal that women participate in filing patent applications far less than men. The rate at which women file patent applications is also low compared to their level of representation among the faculty members at Israeli academic institutes. Moreover, the research findings show that women's participation as inventors is much greater when they collaborate with male researchers than when they collaborate with other women.

The importance of this study is that it reveals that even when it appears, based on standard measures, that women are successfully engaged in academic activity and have achieved gender equality in the scientific academy—i.e., they have been appointed to the senior faculty in science fields—there remains a significant gap in terms of the activities that women and men pursue. This gap at the top of the academic-professional pyramid reveals that efforts to integrate women into the ranks of the senior faculty and to advance their participation in the academic realm have been insufficient. Moreover, the gender gap in academic patenting has significant implications on female entrepreneurial and innovative potential, which, in turn, has major implication on society as a whole.

Accordingly, policymakers should focus on establishing policies that will encourage the full integration of female faculty members in the transfer of technology from the academy to industry—an activity that is perceived as a significant component in the academic activity in many institutes.

Women's relatively low participation in patent filing at the Israeli academy requires further in-depth investigation into the possible obstacles that prevent their full integration into the academy. Barriers may include, for example, lack of knowledge or understanding of the activities of academic technology transfer and commercialization; lack of encouragement directed toward women faculty members to commercialize knowledge; or lack of encouragement to commercialize knowledge in the fields where women represent a higher proportion of academic faculty.[10] Such barriers may even originate with women's perception that

[10] Miriam Marcowitz-Bitton et al., *Unregistered Patents & Gender Equality*, 43 HARV. J.L. & GENDER 47, 49-52 (2020).

technology transfer activity is inappropriate for their academic and social role as researchers, or perhaps from general social perceptions that cause women to choose activities that are unrelated to technology transfer and commercialization of knowledge.[11]

This article proceeds as follows: Part B reviews the existing knowledge regarding the gender gap in patenting in general and in the academic sector in particular and describes the challenges that women in the academy are known to face when seeking to commercialize their inventions. This part also discusses practices concerning the commercialization of knowledge by the academic sector in general and by the Israeli academy in particular. We also discuss the extent of women's integration in the Israeli academy, particularly in the scientific fields, and describe the existing knowledge regarding the representation of women as faculty members at academic institutes in Israel. Part C presents the empirical research, explaining its methodology and describing the project's major findings. Finally, part D discusses the implications of our findings, Part E presents possible solutions, and Part F includes concluding remarks.

II. Background

a. The Gender Gap in Patenting

A growing interest in women's access to intellectual property rights (IPRs) has led to various studies on gender disparity in intellectual property (IP), including patents. Below is a review of the major existing literature on patenting trends among women. Study after study, has shown a sizeable gender gap in applications for and grants and ownership of patents.[12] In the most comprehensive study to date, WIPO surveyed international patent applications in 182 different countries and found that merely 29% of applications listed female inventors, and although this share has increased over time, it is still low and differs substantially across countries, technologies, and

[11] *Id.*

[12] *See* Jonathan M. Barnett, *The Anti-Commons Revisited*, 29 HARV. J.L. & TECH. 127 (2015); *See also* Bystydzienski, *supra* note 1.

sectors.[13] The British Intellectual Property Office's major study of the European Patent Office (EPO), Worldwide Patent Statistics (PATSTAT) and PatBase databases found that women represented less than 2% of inventors for most of the 20th century but steadily rose to over 10%–doubling in the past twenty years.[14] Female inventors are most common in France (11.7%) and Russia (15.7%) but least common in Japan (3.7%), Korea (4.4%) and Germany (5.5%).[15] The worldwide average now is 7.2%, near that in Britain (7.3%) and the U.S. (8.7%).[16] This inter-country variation is consistent with that found in other studies[17] but does not appear to correlate with socioeconomic indicators, such as GDP or the number of women in the labor market.

The number of patents listing female inventors increased more than fivefold between 1975 and 2015, but growth has been slow.[18] Studies indicate increased patenting by women,[19] even in countries where scientific publications by women have stagnated,[20] but 73% of patent applications worldwide still listed only male inventors in 2014.[21]

Little information exists on patenting by Israeli women. One report shows that from 1995 to 1999, Israeli women filed only 11.6% of all international patent applications, which increased only to 12.8% among Israeli nationals and 13.5% among Israeli residents between

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[13] Gema L. Martinez et al., *Identifying the Gender of PCT Inventors* 1, 8 (33 WIPO Econ. & Stat. Series, Working Paper NO. 33, 2016); *see also* INTELL. PROP. OFF., GENDER PROFILES IN WORLDWIDE PATENTING: AN ANALYSIS OF FEMALE INVENTORSHIP 30 (2016) [hereinafter WORLDWIDE PATENTING 2016].
[14] *Id*. at 14.
[15] *Id.* at 15.
[16] *Id.* at 17.
[17] Rainer Frietsch et al., *Gender-Specific Patterns in Patenting and Publishing*, 38 RES. POL'Y 590, 592-95 (2009); Fulvio Naldi et al., *Scientific and Technological Performance by Gender*, *in* HANDBOOK OF QUANTITATIVE SCIENCE AND TECHNOLOGY RESEARCH 299, 307 (H.F. Moed, W. Glänzel & U. Schmoch eds., 2004); U.K. INTELL. PROP. OFF. INFORMATICS TEAM, GENDER PROFILES IN UK PATENTING: AN ANALYSIS OF FEMALE INVENTORSHIP, (Mar. ed., 2016); WORLDWIDE PATENTING 2019, *supra* note 13, at 4.
[18] *Id*. at 10.
[19] Waverly W. Ding et al., *Gender Differences in Patenting in the Academic Life Sciences*, 313 SCIENCE 665, 666 (2006); Taehyun Jung & Olof Ejermo, *Demographic Patterns and Trends in Patenting: Gender, Age, and Education of Inventors*, 86 TECH. FORECASTING & SOC. CHANGE 110, 110 (2014).
[20] Frietsch et al., *supra* note 17, at 595.
[21] WORLDWIDE PATENTING 2019, *supra* note 13, at 10.

2011 and 2015.[22] Between 2012 and 2015, approximately 11% of patent applications by Israeli inventors in the five leading patent offices (IP5) involved women, as compared to those for the U.S. (10%) and the EU (7%), even though women were involved in 40% of all Israeli biotechnology inventions.[23] Israeli scholars have also examined U.S. patent applications by Israelis between 1963 and 1999 and found that, judging by first names, only 3% of the applicants were almost certainly female, with a maximum of only 7% when looking also at gender-neutral names.[24]

Academic patenting reveals very similar trends, even in areas approaching gender parity (such as bioscience),[25] and women continue to patent less often than they publish.[26] A 2006 study by Ding, Murray, and Stuart study 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).[27] This trend may be partly because even now, less than 13% of all inventors worldwide are women, although this percentage is slowly growing.[28] Women are also well known to be underrepresented in the STEM fields generally, and in patent-intensive STEM fields specifically.[29]

However, the mere disparity in the number of women in STEM fields cannot alone account for the gender gap in patenting. Studies of the intersection of IP law and gender have identified several ways in which the law and other factors also contribute to gender disparities in IPRs, including patents.[30] These factors fall into three basic categories: the way IP doctrines apply to subject matter involving gender and sexuality; the gendered nature of the various

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[22] Martinez et al., *supra* note 13.
[23] OECD, THE PURSUIT OF GENDER EQUALITY: AN UPHILL BATTLE (2017).
[24] Annette I. Kahler, *Examining Exclusion in Woman-Inventor Patenting: Comparison of Educational Trends and Patent Data in the Era of Computer Engineer Barbie*, 19 AM. U. J. GENDER SOC. POL'Y & L. 773, 776-77 (2011).
[25] *Id*.
[26] Frietsch et al., *supra* note 17, at 592.
[27] Ding et al., *supra* note 19, at 665-66.
[28] WORLDWIDE PATENTING 2019, *supra* note 13, at 4; Ding et al., *supra* note 19, at 667; Frietsch et al., *supra* note 17, at 597; Jung & Ejermo, *supra* note 19, at 117.
[29] DAVID BEEDE ET AL., U.S. DEP'T OF COM., ISSUE BRIEF NO. 04-11, WOMEN IN STEM: A GENDER GAP TO INNOVATION 2-3 (2011); Lisa D. Cook & Chaleampong Kongcharoen, *The Idea Gap in Pink and Black* 2 (Nat'l Bureau of Econ. Rsch., Working Paper No. 16331, 2010).
[30] Kara W. Swanson, *Intellectual Property and Gender: Reflections on Accomplishments and Methodology*, 24 AM. U. J. GENDER SOC. POL'Y & L. 175, 176 (2015).

IP doctrines themselves; and the above-mentioned gender disparities in ownership of IP rights.[31]

For example, although patents by women in fields such as biotechnology are thought to be equal to or better in quality and impact than those by men,[32] other research shows patent applications by women are more likely to be rejected and that those rejections are less likely to be appealed.[33] Indeed, patent applications filed by women inventors are 21% more likely to be rejected by the patent office than applications filed by men.[34] Examiners also tend to allow fewer claims in women's applications and tend to narrow the claims they do allow in scope and value more than those in men's applications.[35] Finally, patents granted to women are less often cited and less likely to be maintained by their assignees.[36]

This is because many patent doctrines that appear to be neutral on their face instead assume a certain level of masculinity in practice.[37] 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.[38] Likewise, what qualifies as "patentable subject matter" is based on inherently androcentric definitions of "invention," "technology," and "industrial application" in ways that may be detrimental to female inventors.[39] Empirical findings also suggest that the patent

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[31] *Id.* at 182-83.
[32] Steven G. McMillan, *Gender Differences in Patenting Activity: An Examination of the US Biotechnology Industry*, 80 SCIENTOMETRICS 683, 683 (2009); Kjersten B. Whittington & Laurel Smith-Doerr, *Gender and Commercial Science: Women's Patenting in the Life Sciences*, 30 J. TECH. TRANSFER 355 (2005) (measuring patent quality based on its impact and usefulness for follow-up innovation, measured by forward and backward patent citations).
[33] Kyle Jensen et al., *Gender Differences in Obtaining and Maintaining Patent Rights*, 36 NATURE BIOTECHNOLOGY 307, 307 (2018).
[34] *Id.*; Michael Schuster et al., *An Empirical Study of Patent Grant Rates as a Function of Race and Gender*, 57 AM. BUS. L.J. 281, 281 (2020).
[35] Jensen et al., *supra* note 33, at 307.
[36] *Id.*
[37] Swanson, *supra* note 30, at 185, 191.
[38] 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).
[39] 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).

gender gap stems in part from gender biases among patent examiners.[40] Gender gaps in patent approval rates are more pronounced when applicants have names easily recognizable as feminine.[41]

Even before they file applications with the patent office, however, female inventors face other hurdles that prevent them even from accessing the patent system. The patenting process is complicated and often requires a substantial investment of time and money, often tens of thousands of dollars per patent.[42] Women tend to have fewer financial resources, including access to venture capital and other funding.[43] Women also have less access to the kinds of networks of experienced professionals and other support structures that can aid in entering into and navigating the patenting process.[44] Blatant sexism from peers, industry contacts, customers, and even patent examiners also plays a role in whether women perceive their own work as patentable and whether others perceive that work as important.[45]

For all of the insights that previous studies have revealed, however, one seldom recognized consideration is what several of these factors—the gendered application of patentability doctrines; bias among patent examiners; and the handicaps women face in simply accessing the patent system—have in common: the patent registration and examination system.

Social science studies, limited mostly to the patent gender gap in the U.S., offer a range of possible explanations for the gender gap in patenting, as surveyed below.

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[40] Schuster et al., *supra* note 34, at 282.
[41] *Id.*; Jensen et al., *supra* note 33, at 309.
[42] *See USPTO Fee Schedule*, U.S. PAT. & TRADEMARK OFF. (Jan. 2, 2021), https://www.uspto.gov/learning-and-resources/fees-and-payment/uspto-fee-schedule [https://perma.cc/X73D-32S5].
[43] ALICIA ROBB, ACCESS TO CAPITAL AMONG YOUNG FIRMS, MINORITY-OWNED FIRMS, WOMEN-OWNED FIRMS, AND HIGH-TECH FIRMS 31 (2013); Paula E. Stephan & Asmaa El-Ganainy, *The Entrepreneurial Puzzle: Explaining the Gender Gap*, 32 J. TECH. TRANSFER 475, 481 (2007).
[44] Ding et al., *supra* note 19, at 666.
[45] DELIXUS, INC. & NAT'L WOMEN'S BUS. COUNCIL, INTELLECTUAL PROPERTY AND WOMEN ENTREPRENEURS - PART II: QUALITATIVE 15-16 (2012); Fiona Murray & Leigh Graham, *Buying Science and Selling Science: Gender Differences in the Market for Commercial Science*, 16 INDUS. & CORP. CHANGE 657, 668 (2007); Christine Wenneras & Agnes Wold, *Nepotism and Sexism in Peer-Review*, 387 NATURE 341, 341 (1997).

Complexity and expense of the patenting process. The patenting process can be complex, time-consuming, and expensive.[46] The cost of applying for and maintaining a patent can be tens of thousands of dollars in the U.S.[47] or more in the European Patent system.[48] Patent applications are also risky – costly to obtain but potentially valuable in commercializing innovation.[49] Women tend to have fewer financial resources, however, preventing them from filing applications.[50] Because patents and applications can help seek funding, female entrepreneurs are also less likely to obtain start-up financing.[51] Women often perceive the patenting process as too complex, long, and expensive, further discouraging them from pursuing patent protection.[52]

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,[53] with obvious implications for the gender gap in patenting.[54] 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.[55] And even within science and engineering, the proportion of men to women varies by field: women tend to concentrate in the less patent-intensive life sciences, whereas men tend to concentrate in the more patent-intensive engineering fields.[56] The number of women with advanced engineering degrees thus positively correlates with patenting and commercialization

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[46] David Hsu & Rosemarie H. Ziedonis, *Patents as Quality Signals for Entrepreneurial Ventures*, 2008 ACAD. MGMT. PROC. 1, 1-6 (2008).
[47] *USPTO Fee Schedule*, *supra* note 42.
[48] *See Schedule of Fees*, EUR. PAT. OFF. (Apr. 1, 2020), https://my.epoline.org/epoline-portal/classic/epoline.Scheduleoffees?language=en [https://perma.cc/PQK4-42ZG].
[49] ROBERT LITAN & HAL SINGER, UNLOCKING PATENTS: COSTS OF FAILURE BENEFITS OF SUCCESS 1 (2014).
[50] Stephan & El-Ganainy, *supra* note 43, at 479-86.
[51] JESSICA MILLI ET AL., EQUITY IN INNOVATION: WOMEN INVENTORS AND PATENTS 5, 19 (2016), https://iwpr.org/wp-content/uploads/2020/12/C448-Equity-in-Innovation.pdf.
[52] DELIXUS, INC. & NAT'L WOMEN'S BUS. COUNCIL, *supra* note 45, at 3.
[53] BEEDE ET AL., *supra* note 29, at 3.
[54] Jennifer Hunt et al., *Why Don't Women Patent?* (NBER, Working Paper No. 17888, 2012).
[55] *Id.* at 13.
[56] *Id.* at 6-7.

among women.[57] Negative stereotypes, workplace biases, hostile environments, and ineffective messaging, however, deter women from STEM fields.[58] Furthermore, fewer women hold positions in development and design, which are the most patent-intensive.[59] Thus, increasing the number of women in engineering and design and development positions and providing them with support systems could increase their patenting rates.

Limited networking among women. Studies find that informal social networks within industries enhance product innovation and resource exchange,[60] influence the choice of a research area, and give key inventors access to information affecting both research quality and patenting rates.[61] Networks can also provide expert advice on patentability and a source of potential co-inventors.[62] Exclusion from STEM fields, on the other hand, limits women scientists' access to important networks.[63] 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,[64] and, in turn, to the patent system.[65] Male academics also hold more central positions within their networks, giving them an advantage in terms of collaborative co-patenting networks.[66] Most of the female scholars in Ding et al.'s study also reported fewer contacts to industry, which affected access to resources for assessing

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[57] COOK & KONGCHAROEN, *supra* note 29, at 21-22.
[58] NAT'L ACAD. ENG'G, CHANGING THE CONVERSATION: MESSAGES FOR IMPROVING PUBLIC UNDERSTANDING OF ENGINEERING 10 (2008).
[59] LORI TURK-BICAKCI & ANDREA BERGER, LEAVING STEM: STEM PH.D. HOLDERS IN NON-STEM CAREERS 2 (2014); Hunt et al., *supra* note 54, at 2.
[60] Wenpin Tsai & Sumantra Ghoshal, *Social Capital and Value Creation: The Role of Intrafirm Networks*, 41 ACAD. MGMT. ANN. 464, 472 (1998).
[61] *See* Atul Nerkar & Srikanth Paruchuri, *Evolution of R&D Capabilities: The Role of Knowledge Networks Within a Firm*, 51 SCI. 679 (2005).
[62] Lien-An Hsu, Kun-Hong Lee & Chien-Chiang Lin, *A Comparison of Individual and Team Research Performance: A Study of Patents*, *in* PICMET TECHNOLOGY MANAGEMENT FOR GLOBAL ECONOMIC GROWTH 2169 (2010).
[63] NAT'L ACAD. SCI., ENG'G, & MED., PROMISING PRACTICES FOR ADDRESSING THE UNDERREPRESENTATION OF WOMEN IN SCIENCE, ENGINEERING, AND MEDICINE: OPENING DOORS 50 (2020).
[64] Murray & Graham, *supra* note 45, at 679.
[65] *Id.* at 659.
[66] 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 24 (Richard B. Freeman & Daniel Goroff eds., 2009).

patentability and commercial value.[67] Even navigating the patenting process is more confusing for women who lack a network of advisors or experienced peers to guide them.[68] Studies have also shown 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.[69] Workplace organization matters as well: organizations structured like networks exhibit higher patenting rates among women than do hierarchically structured organizations.[70]

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.[71] Academic women who commercialized their research often considered themselves 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.[72] Women also feel more ethically opposed to commercialization and have more difficulty reconciling it with research.[73]

Murray and Graham 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.[74] Poor communication between male and female scientists and between patent examiners and inventors may also play a role[75] and affect whether women perceive their own work as patentable and whether

[67] Ding et al., *supra* note 19, at 666.
[68] DELIXUS, INC. & NAT'L WOMEN'S BUS. COUNCIL, *supra* note 45, at 3.
[69] Murray & Graham, *supra* note 45, at 657.
[70] Kjersten Bunker Whittington & Laurel Smith-Doerr, *Women Inventors in Context: Disparities in Patenting Across Academia and Industry*, 22 GEND. SOC. 194 (2008).
[71] Murray & Graham, *supra* note 45, at 659.
[72] *Id.* at 677.
[73] *Id.* at 674.
[74] *Id.* at 679-80.
[75] *Id.* at 678.

others perceive that work as important.[76] Women also face sexism from peers, industry contacts, and customers.[77]

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 technology transfer offices (TTOs) or their companies' patenting services for help.[78] Women use TTOs for a range of supports, including contacts, advice, and encouragement, while men rely more on their networks[79] and use TTOs only for legal support.[80] Women not affiliated with a university or company, moreover, have very few resources.[81] Institutional support is vital in bankrolling the patent application process.[82] 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,[83] perhaps due to biases among venture capitalists.[84]

This gender gap in patenting likely has very real consequences for women and 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[85] and their investments in commercializing those inventions.[86] Patents also help signal an enterprise's technological expertise and the innovative legitimacy of its products and services to potential

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[76] *Id.* at 665.
[77] Schuster et al., *supra* note 34.
[78] Ding et al., *supra* note 19, at 666.
[79] *Id.* at 667.
[80] *Id.*
[81] Schuster et al., *supra* note 34, at 317.
[82] Lisa Ouellette & Andrew Tutt, *How Do Patent Incentives Affect University Researchers?*, 61 INT'L REV. L. & ECON. 1, 1 (2019).
[83] ROBB, *supra* note 43, at 15.
[84] Stephan & El-Ganainy, *supra* note 43, at 478.
[85] WILLIAM M. LANDES & RICHARD A. POSNER, THE ECONOMIC STRUCTURE OF INTELLECTUAL PROPERTY LAW 294-95 (2003).
[86] Michael Abramowicz & John F. Duffy, *Intellectual Property for Market Experimentation*, 83 N.Y.U. L. REV. 337 (2008); *but see* Ted Sichelman, *Commercializing Patents*, 62 STAN. L. REV. 341 (2010) (questioning whether the current patent system provides adequate protection for commercialization investments).

investors and potential cross-licensing partners.[87] Patent owners can even use their patents to ward off infringement lawsuits by meaningfully threatening to countersue for infringement.[88] Last but perhaps most important, patent applications and patents also increase the probability of obtaining necessary investment funding from various sources.[89] However, despite the economic importance of patents, research has repeatedly shown that women have lesser access to patent protections than their male counterparts.[90]

b. 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.[91] This "transfer of knowledge" - also known as "technology transfer" - from the academic sector to the private-business sector may be carried out in various ways.[92] 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.[93] One of the most prominent mechanisms for transferring academic knowledge is through the process of patenting inventions developed in the academic sector and commercializing the patents through licensing arrangements with entities in the

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[87] Stuart J.H. Graham et al., *High Technology Entrepreneurs and the Patent System: Results of the 2008 Berkeley Patent Survey*, 24 BERKELEY TECH. L.J. 1255, 1287-1309 (2009).
[88] 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).
[89] EMMA WILLIAMS-BARRON ET AL., INNOVATION AND INTELLECTUAL PROPERTY AMONG WOMEN ENTREPRENEURS 1 (2018).
[90] *Id*.
[91] *See* DAVID C. MOWERY ET AL., IVORY TOWER AND INDUSTRIAL INNOVATION: UNIVERSITY-INDUSTRY TECHNOLOGY TRANSFER BEFORE AND AFTER THE BAYH-DOLE ACT IN THE UNITED STATES 65 (Stan. Univ. Press, 2004).
[92] *See id.* In Israel, *see* NIVA ELKIN-KOREN**,** THE TRANSFER OF KNOWLEDGE THROUGH COMMERCIALIZATION OF INTELLECTUAL PROPERTY RIGHTS 16 (Samuel Neeman Inst. for Pol'y Rsch. Isr. & Technion Inst. Tech. for Isr., 2007).
[93] Messer-Yaron, *supra* note 8; ELKIN-KOREN, *supra* note 92, at 16 (Elkin-Koren emphasizes 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).

private sector.[94] This mechanism is premised on the view that the role of the academic sector is, among other things, to serve overall growth.[95]

In the United States, until 1980, IPRs in the products of publicly funded academic research belonged to the United States government.[96] Because no mechanisms existed for handling and exploiting these IPRs, almost no patents were registered by the academic sector during this period.[97] Thus, technology transfer activity was correspondingly negligible, as public research institutions had no rights to transfer.[98] In 1980, however, Congress passed the Bayh-Dole Act, which established that the IPRs in the products of publicly funded research belonged to the research institution, not the United States government.[99] 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 20th century affecting the transfer of knowledge from the academy to the industry.[100] Legislation modeled on the Bayh-Dole Act has been enacted around the world.[101]

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[94] 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 ELKIN-KOREN, *supra* note 91, at 17. This is also the mechanism for transferring knowledge created by government research institutions, see Sharon Bar-Ziv, מסחור זכויות קניין רוחני במגזר המחקר והפיתוח הממשלתי: האם משרת את יעדי מגזר זה [*The Implications of Transferring Knowledge from the Government Sector Through the Intellectual Property Rights Commercialization*]**,** *in* קניין רוחני: עיונים בינתחומיים [AN INTERDISCIPLINARY PERSPECTIVE OF INTELLECTUAL PROPERTY] 659 (Miriam Markovitz Bitton and Lior Zemer eds., 2015).

[95] ELKIN-KOREN, *supra* note 92, at 17; Messer-Yaron, *supra* note 8, at 340.

[96] *Id*.

[97] *Id*.

[98] Messer-Yaron, *supra* note 8, at 331-32. *See also* Eisenberg, *supra* note 7.

[99] Patent and Trademark Amendments Act, 35 U.S.C. §§ 200-211 (1980).

[100] *See* CONG. RSCH. SERV., THE BAYH-DOLE ACT: SELECTED ISSUES IN PATENT POLICY AND THE COMMERCIALIZATION OF TECHNOLOGY 1 (2012).

[101] *See, e.g.*, 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, 123 (2005); Mowery et al., *supra* note 90. In recent years, there is a significant public discourse on whether the Bayh-Dole Act achieved its purpose. *See, e.g.*, Orozco, *supra* note 8; Ian Ayres & Lisa Larrimore Ouellette, *A Market Test for Bayh-Dole Patents*, 102 CORNELL L. REV. 271, 273 (2017).

In Israel, technology transfer from the academy to the industry through patenting began in the 1960s.[102] In recent years, this activity has proliferated in Israel as it has worldwide,[103] with Technology Transfer Companies ("TTCs") owned by the academic institutes serving as intermediaries for commercial transactions between the institutes and businesses in the private sector.[104] The TTCs file the patent applications on behalf of the academic institutes and manage collaborations with business entities through various means, including licensing.[105] Additionally, the TTCs manage and oversee activities such as research commissioned by the private-business sector and carried out in the academic institutes, and academy-industry partnerships in which faculty members take an active role.[106]

The legal framework that governs academic patenting in Israel is based on the rule that intellectual property rights in inventions developed by faculty members belong to the academic institutes, as their employers.[107] Like many other countries' laws, Israeli patent law generally grants initial ownership of an invention to its inventor. However, when the invention was commissioned or developed as part of the inventor's employment, the invention's owner will be the employer.[108] According to the Israeli Patent Act, an invention developed by an employee in the course of her employment becomes the employer's property absent a contrary agreement, or unless the employer relinquishes its rights to the invention within six months after being notified of its development.[109] Accordingly, the

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[102] GILI S. DRORI ET AL., THE HELIX MODEL OF INNOVATION IN ISRAEL: THE INSTITUTIONAL AND RELATIONAL LANDSCAPE OF ISRAEL'S INNOVATION ECONOMY E-1, E-75 (Gili S. Drori ed., 2013).

[103] In Israel *see* HANOCH GUTFREUND, COMMITTEE ON ACADEMY-INDUSTRY INTERRELATIONS REPORT (2005); THE STATE COMPTROLLER, INSTITUTIONS OF HIGHER EDUCATION, דוח שנתי ביקורת 63א [ANNUAL AUDIT REPORT 63A] הרוחני הקניין בניהול היבטים באוניברסיטאות [ASPECTS OF INTELLECTUAL PROPERTY MANAGEMENT IN ISRAELI UNIVERSITIES] (2012) [hereinafter THE STATE COMPTROLLER REPORT], https://www.mevaker.gov.il/he/Reports/Report_115/5e04094c-1f79-462f-8760-bc80333e0cc0/7775.pdf; Eisenberg, *supra* note 6.

[104] Orozco, *supra* note 8, at 121; *see also* Eisenberg, *supra* note 7, at 1693.

[105] Gail A. Van Norman & Roï Eisenkot, *Technology Transfer: From the Research Bench to Commercialization: Part 2: The Commercialization Process*, 2 JACC BASIC TO TRANSLATIONAL SCI. 197, 198 (2017).

[106] Messer-Yaron, *supra* note 8; *see* Eisenberg, *supra* note 7, at 1663.

[107] Messer-Yaron, *supra* note 8.

[108] For an extensive discussion on academic results *see id.*; ELKIN-KOREN, *supra* note 92.

[109] WIPO, PATENTS LAW 5727-1967 (consolidated ver. 2014, WIPO trans.), https://www.wipo.int/edocs/lexdocs/laws/en/il/il040en.pdf.

inventions of faculty members in Israel are usually owned by the academic institutes that employ them.[110] Furthermore, most academic institutes in Israel impose individual contractual provisions on faculty members that regulate many aspects of IPRs.[111] These provisions generally relate to the question of ownership of the IPRs in products developed within the scope of faculty activities, including ownership of inventions, as well as related issues such as reporting duties and conflicts of interest faculty members may have vis-à-vis the private-business sector.[112] Under standard contractual provisions governing academic IPRs, faculty members in Israel are obligated to conduct their technology transfer activities, including filing patent applications, only through the TTCs.[113] Standard provisions also govern the issue of royalties stemming from the IPRs developed by faculty members.[114] Typically, the faculty member is entitled to a certain percentage of royalties, thus providing a significant incentive for faculty members to engage in inventive activity and to patent and commercialize its outcomes.[115]

The transfer of technology from the academy to industry is the subject of significant debate in the public discourse in Israel.[116] On the one hand, commentators point to increased funding for research, enhanced interest in developing technological applications, and incentives for excellence as among the benefits of knowledge transfer activities.[117] On the other hand, commercialization of the fruits of academic research through patent licensing raises profound

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[110] *Id.*

[111] Adi Sapir & Amalya Oliver, *Loose Coupling, Conflict, and Resistance: The Case of IPR Policy Conflict in an Israeli University*, 73 HIGHER EDUC.: INT'L J. HIGHER EDUC. RSCH. 709, 709 (2017).

[112] *Id.*

[113] ELKIN-KOREN, *supra* note 92; *see* WIPO, *supra* note 109; *see also* THE STATE COMPTROLLER REPORT, *supra* note 103.

[114] THE STATE COMPTROLLER REPORT, *supra* note 103, at 200.

[115] *See id.* (explaining the royalties that the faculty member inventor is entitled to varies; however, a usual share is 40-50% out of the overall royalties that the institution is entitled to, and occasionally the faculty member's lab is entitled to additional 20% of the royalties).

[116] THE STATE COMPTROLLER REPORT, *supra* note 103, at 211; ROY GOLDSCHMIDT, INTELLECTUAL PROPERTY IN ISRAEL RESEARCH AND DEVELOPMENT INSTITUTIONS (Info. & Rsch Center, Knesset eds., 2012); ARNON BENTUR ET AL., אפיון פעילות יישום ידע של מסחור והעברת טכנולוגיה בהתבסס על מדדים של אוניברסיטאות בישראל [CHARACTERIZATION OF KNOWLEDGE TRANSFER OF ISRAELI UNIVERSITIES BASED ON INDICES OF COMMERCIALIZATION AND TECHNOLOGY TRANSFER] 1, 3 (2019).

[117] ELKIN-KOREN, *supra* note 92, at 58.

concerns that research agendas will be driven toward applied research and away from research driven by mere curiosity, as well as the fear of creating an obstacle to widespread use of the fruits of academic research.[118] Despite these concerns, the transfer of knowledge through the commercialization of patents is currently carried out widely in Israeli academic institutes and is regarded as an integral component of academic activity.[119] Indeed, because the commercialization of patents stemming from academic research is seen as a reflection of success in the performance of the academy's role, faculty members are encouraged to participate in technology transfer activity.[120]

c. The Gender Gap in the Israeli Academy

The public discourse on women's integration into the Israeli academy emerged primarily over the past two decades, when systematic data collection began.[121] In 2000, the Israeli National Council for the Advancement of Women in Science and Technology (operating in the Ministry of Science, Technology, and Space) was established.[122] The Council published its first report in 2003, which pointed out significant gaps and barriers to women's advancement in research.[123] In 2011, the Israeli Council of Higher Education Committee for Planning and Budgeting appointed a team (headed

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[118] *Id.*

[119] *See e.g.*, DAVID PINES & MIRAV KATZ, 2018-2017 בישראל ידע למסחור חברות סקר [SURVEY OF TECHNOLOGY TRANSFER COMPANIES FOR COMMERCIALIZATION OF ACADEMIC KNOWLEDGE IN ISRAEL 2017-2018] (2019), https://www.cbs.gov.il/he/mediarelease/DocLib/2019/391/12_19_391b.pdf. According to this survey, in 2018 university researchers and various academic institutes filed 1048 reports of developed inventions to the TTCs. The Israeli TTCs filed 644 patent applications in 2018. TTCs were involved in the establishment of fifty-six start-up companies in 2018. It was further reported that in 2018 there was an increase in the number of professional employees hired by the Israeli TTCs and that the expenses of TTCs had grown as well. According to this survey, a 2016 international comparison determined that Israel stands at a relatively high place in the revenues of TTCs as a percentage of the total R&D expenditure of a country.

[120] *See, e.g.*, THE STATE COMPTROLLER REPORT, *supra* note 103, at 215; *see also* GUTFREUND, *supra* note 103, at 22.

[121] *See, e.g.*, Devorah Eden, *Women's Participation in Academic Conferences in Israel*, 38 J. HIGHER EDUC. POL'Y. & MGMT. 406 (2016).

[122] *Council for the Advancement of Women in Science and Technology*, MINISTRY SCI. & TECH. (Jan.1, 2001), https://www.gov.il/en/departments/units/most_women_council.

[123] Hagit Messer-Yaron et al., בישראל האקדמי ובסגל במדע הנשים קידום [*Promoting Women Science and Academic Staff in Israel*], *in* בישראל ייצוג והבטחת מתקנת העדפה [AFFIRMATIVE ACTION AND ENSURING REPRESENTATION IN ISRAEL] 331 (Anat Maor ed., 2004).

by Prof. Rebecca Karmi) to examine the status of women in the faculties of academic institutions.[124] In May of 2011, this team submitted a report of its conclusions, which made various recommendations for improving women's representation among senior faculty positions in the Israeli academy (Karmi Report).[125] The Karmi Report's main recommendations included the establishment of a new position of Presidential Advisor within academic institutions to promote the status of women; the formulation of a policy that encourages the integration of women into the faculties; and the development of policies regarding promotion and integration of women into the central management committees in academic institutions.[126]

In 2015, a report was issued by the Committee for the Advancement and Representation of Women in Institutions of Higher Education, which was established in cooperation with the Council for Higher Education and the Council for the Advancement of Women in Science and Technology (headed by Prof. Ruth Arnon - the Arnon Report).[127] The Arnon Report concluded that in 2015, the rate of women faculty members at Israeli universities was 29%.[128] In public colleges, the rate was 39%.[129] The report found that women's representation varied across academic disciplines, and that across all fields, the percentage of women faculty members decreased as the academic ranks got higher.[130] The report found that in the exact sciences, women were particularly underrepresented, while in the humanities, social sciences, and education, their representation was greater.[131]

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[124] Natan Aridan, *Rivka Carmi*, JEWISH WOMEN'S ARCHIVE: SHALVI/HYMAN ENCYCLOPEDIA JEWISH WOMEN (June 23, 2021), https://jwa.org/encyclopedia/article/carmi-rivka [https://perma.cc/8BDH-A2Z4].

[125] RIVKA CARMI ET AL., גבוהה להשכלה במוסדות האקדמי בסגל נשים של מצבן לבחינת צוות [A TEAM TO EXAMINE THE SITUATION OF WOMEN IN THE ACADEMIC STAFF OF INSTITUTIONS] דו"ח והמלצות [REPORT AND RECOMMENDATIONS] 3-4 (2011).

[126] *Id.* at 5.

[127] RUTH ARNON ET AL., קידום וייצוג נשים במוסדות להשכלה גבוהה [PROMOTION AND REPRESENTATION OF WOMEN IN INSTITUTIONS OF HIGHER LEARNING] (2015).

[128] *Id.* at 5.

[129] *Id.* at 7.

[130] *Id.*

[131] *Id.*

These reports reflect that the percentage of women in the faculties at academic institutes in Israel has grown gradually over the years.[132] As shown in Table 1, women's integration into STEM faculties has grown slowly. For example, in 2010, the representation of women in academic positions in Israel was as follows: in the field of medicine (not including medical support such as nursing), women represented 33.5% of faculty members; in the exact sciences, 11.2%; in life sciences, 27%; in agriculture, 26%, and in engineering, 13.8%.[133] Later data collected in 2013 show a slight increase in women's representation.[134] In life sciences, women represented 30% of faculty members; in agriculture, 31%; in medicine, 35%; in mathematics and computer science, 11%; and in engineering, including architecture, 14%.[135]

Table *1*: Women's Representation in the STEM fields in 2010[136] and 2013[137]

Year/ Field	**Medicine, Medical Support & Nursing**	**Exact Sciences**	**Life Sciences**	**Agriculture**	**Engineering**	**Medicine**	**Medical Support & Nursing**	**Mathematics and Computer Science**	**Engineering and Architecture**
2010	42%	17% **11.2%**	24% **27%**	26%	12.5% **13.8%**	**33.5%**	**63.4%**	10%	-
2013	-	13%	30%	31%	-	35%	62%	11%	14%

Other data show the percentage of women among the senior faculty members in faculties in the various science fields by academic rank.[138] Data for the year 2010, shown in Table2 , clearly show that as the academic rank advances, the percentage of women faculty

[132] *See* CARMI ET AL., *supra* note 125; ARNON ET AL., *supra* note 127.
[133] ARNON ET AL., *supra* note 127, at 46.
[134] *Id.* at 45.
[135] Interestingly, according to data provided by the Council of Higher Education, in the public colleges, including the engineering colleges, women's presence in academic faculty is higher than that of the universities. *See* ARNON ET AL., *supra* note 127, at 7.
[136] SCI. & TECH. COMM. IN KNESSET, REPRESENTATION OF WOMEN IN THE FACULTY OF UNIVERSITIES IN ISRAEL FOR 2010 (2012); NAAMA TESHNER, תמונת מצב עדכנית - נשים במדע [WOMEN IN SCIENCE, AN UP-TO-DATE SNAPSHOT] (2014). There is a discrepancy in the data reported in the two sources above. The highlighted data are from the 2014 report.
[137] ARNON ET AL., *supra* note 127, at 45.
[138] *Id.* at 27.

members decreases. Thus, in mathematics and computer science, while in 2010, the overall rate of women among the faculty members was 10%, women made up 27.8% of all lecturers (entry-level), while their representation among full professors was only 6.7%.[139] These figures reflect all Israeli universities without distinction among the various academic institutes.

Table*2* : Proportion of women among senior academic staff in universities by field and by rank, 2011

Field/Rank	Entry Level	Assistant Professor	Associate Professor	Full Professor	Total
Medicine	55.5%	39.3%	36.2%	19.4%	33.5%
Medical Support & Nursing	80.5%	68.7%	53.9%	35.4%	63.4%
Mathematics & Computer Sciences	27.8%	12.5%	10.5%	6.7%	10%
Physics	42.1%	18.5%	15%	4.7%	11.2%
Life Sciences	71.9%	30.8%	21.3%	19.9%	27%
Engineering	22.9%	19.8%	14.4%	8.1%	13.8%

The data regarding the percentage of women faculty members in the various sciences according to their academic rank remained unchanged three years later, in the year 2013, as seen from **Error! Reference source not found.**:[140]

[139] *Id.* at 49.

[140] E-mail from Michal Perry, Pub. Inquiries Coordinator, Council for Higher Educ., Response to the Knesset Rsch. and Info. Ctr. (Jan. 13, 2014) (on file with author).

Table 3: The Rate of Women Faculty Members in Universities by Academic Department and Rank - 2013

	Entry Level	**Assistant Professor**	**Associate Professor**	**Full Professor**	**Total Positions**	**Total Rate of Women**
Total	49%	36%	27%	16%	4602	29%
Humanities	46%	45%	35%	24%	896	38%
Education	62%	53%	55%	44%	213	53%
Social Sciences	47%	45%	38%	20%	668	37%
Business & Management	39%	34%	22%	6%	134	27%
Law	49%	22%	18%	26%	112	27%
Medicine	61%	37%	37%	25%	301	35%
Medical Support & Nursing	78%	69%	55%	36%	133	62%
Mathematics & Computer Sciences	29%	16%	12%	6%	389	11%
Physics	64%	21%	14%	5%	486	13%
Life Sciences	73%	39%	21%	21%	402	30%
Agriculture	74%	36%	25%	13%	69	31%
Engineering & Architecture	20%	17%	16%	9%	606	14%
Other	45%	25%	12%	11%	189	24%

The Arnon report of 2013 included a detailed list, by academic institution, of the percentage of women in senior academic positions, as shown in Table 4. In the fields of STEM, there were significant variations among institutions.[141] For example, in mathematics and computer science, while the cumulative percentage of women at all universities stood at 11%, the percentage was very different across institutions.[142] At Tel-Aviv University, women comprised only 5% of faculty members in this field,[143] while at the Weizmann Institute of Science (Weizmann Institute), women accounted for 22% of the faculty.[144] It is difficult to compare these figures, however, given differences in the nature of the institutions as specialized, scientific institutions or general research universities, as well as size differences in the relevant faculties.

[141] ARNON ET AL., *supra* note 127, at 45.
[142] *Id.* at 43.
[143] *Id.*
[144] *Id.*

Table 4: The Rate of Women Faculty Members in Universities by Academic Field and Institution – 2013

Field/ Institution	Total	Hebrew U.	Technion	Tel Aviv U.	Bar-Ilan U.	Haifa U.	Ben-Gurion U.	Weizmann Institute
Total	29%	27%	17%	29%	33%	41%	26%	31%
Humanities	38%	40%	64%	38%	35%	35%	40%	-
Education	53%	39%	66%	53%	55%	67%	35%	58%
Social Sciences	37%	32%	25%	37%	46%	39%	33%	-
Business & Management	27%	28%	-	23%	18%	17%	35%	-
Law	27%	22%	-	27%	25%	34%	-	-
Medicine	35%	27%	21%	47%	-	-	39%	
Medical Support & Nursing	62%	27%	-	66	-	74%	76%	-
Mathematics & Computer Sciences	11%	8%	7%	5%	7%	21%	8%	22%
Physics	13%	7%	11%	8%	8%	-	15%	21%
Life Sciences	30%	17%	39%	23%	32%	26%	22%	39%
Agriculture	31%	31%	-	-	-	-	-	-
Engineering & Architecture	14%	10%	16%	14%	21%	-	11%	-
Other	24%	38%	17%	71%	18%	50%	19%	-

Some academic institutions have occasionally published data on the percentage of women in the faculties by academic ranks. For example, Table 5 shows the total percentage of women faculty members at the Israeli Institute of Technology (Technion) from 2003 to 2013, broken down by academic rank but not by faculty.[145] A review of this table reveals a slight but consistent increase in the percentage of women in the faculties at this institution over the reported decade: in 2003, the total rate was 12%, and in 2013 it was 16%.[146] Modest growth is also observed when classification by academic rank is taken into account. For example, in 2003, the rate of women as full professors at the Technion stood at 4%, and by 2013, it was at 8%.[147]

[145] MIRIAM EREZ, WOMEN AND MEN AT THE TECHNION STUDENTS AND FACULTY: ANNUAL REPORT 24 (2013) https://www.gov.il/BlobFolder/generalpage/most_women_council_reports/he/Annual%20Report%20Women%20and%20Men%20at%20the%20Technion%20Students%20and%20Faculty%202013.pdf.

[146] *Id.*

[147] *Id.*

Table 5: Number and Rate of Women Faculty Member at the Technion by Academic Rank 2003-2013

Year/Rank	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total	12% (71)	13% (72)	13% (74)	14% (77)	15% (78)	16% (84)	15% (80)	15% (78)	15% (77)	16% (82)	16% (87)
Entry Level	30% (3)	40% (2)	40% (2)	40% (2)	25% (1)	75% (3)	33% (2)	38% (3)	29% (2)	44% (4)	46% (6)
Assistant Professor	25% (37)	27% (38)	27% (40)	29% (42)	28% (38)	30% (36)	27% (29)	23% (24)	21% (22)	27% (28)	25% 29)
Associate Professor	12% (23)	12% (23)	12% (23)	12% (22)	15% (28)	16% (31)	18% (35)	20% (37)	21% (38)	19% (34)	19% (34)
Full Professor	4% (8)	3% (7)	4% (9)	5% (11)	5% (11)	6% (14)	6% (14)	7% (15)	6% (15)	7% (16)	8% (18)

Following a request by the Freedom of Information Act, we received detailed information from the Council of Higher Education concerning the number of positions held by women versus men in the various faculties between 2017 and 2020, classified according to institution and rank in the STEM fields, as shown in Table 6. This data indicates that the slow rise in the number and percentage of female faculty members in STEM fields has continued in recent years, yet in most academic institutions, the percentage of women is still very low. This is particularly prominent at the Technion, where the rate of female faculty members had not yet exceeded 20%.

Table 6: Number and Rate of Women Faculty Members (in all academic ranks from entry-level to full professor) in the STEM Fields by Academic Institutions 2017-2020

Year/Institute	Ben-Gurion U.	Hebrew U.	Tel Aviv U.	Haifa	Bar-Ilan U.	Technion	Weizmann Institute	Open U.	Ariel U.
2017	224.9 28%) (	268.8 29.1) (%	283.6 29.1) (%	253.2 43.6 %)(	222.1 34.1) (%	95.5 (17.5 %)	161 (35.4%)	44.5 (46.5 %)	122.3 (34.4 %)
2018	218.6 (27.5 %)	270.3 (29.2 %)	286.7 (29.6 %)	253 (43.5 %)	228.1 (35.3 %)	104 (18.9 %)	164 (35.7%)	44 (47.3 %)	140.3 (35.8 %)
2019	222.4 (27.8 %)	279.4 (29.8 %)	291.1 (29.5 %)	256.3 (43.7 %)	238.8 (35.5 %)	106 (19.5 %)	167 (35.9%)	45.4 (46.8 %)	143.1 (35.2 %)
2020	229 (28.2 %)	296.3 (30.4 %)	319.9 (31.3 %)	259.6 (43.7 %)	241.8 (35.7 %)	108.5 (19.8 %)	172 (36.2%)	48.4 (44.8 %)	155.4 (35.9 %)

As shown below in Table 7, data provided by the Council of Higher Education indicates that between the years 2017-2020, there was a

slow but sustained rise in the percentage of women faculty members in STEM fields across all universities. In 2017 the rate stood at 31.2%, while four years later it reached 32.54%. In other words, fewer than one-third of the senior academic positions in STEM fields in Israeli institutions are held by women.

Table 7: Number and Rate of Academic Positions in the STEM fields in all Israeli Academic Institutes, 2017-2020

Year/Gender	Men	Women	Total
2017	3698.6 (68.8%)	1676.2 (31.2%)	5374.8
2018	3695 (68.38%)	1709.7 (31.62%)	5404.4
2019	3736.5 (68.11%)	1749 (31.89%)	5485.5
2020	3796.3 (67.46%)	1830.7 (32.54%)	5627

As a leading institution that specializes in the STEM fields and conducts significant patent registration activity, the Weizmann Institute is central to this research,[148] and the data from that institution may be used as a unique case study. Information about the gender of faculty members at the Weizmann Institute began to be collected in 2001.[149] Data provided to us pursuant to a Freedom of Information request reveals that between 2001 and 2021, the number of women in the academic faculties has consistently been significantly below that of men:

[148] E-mail from Michal Perry, *supra* note 140.
[149] *Id.*

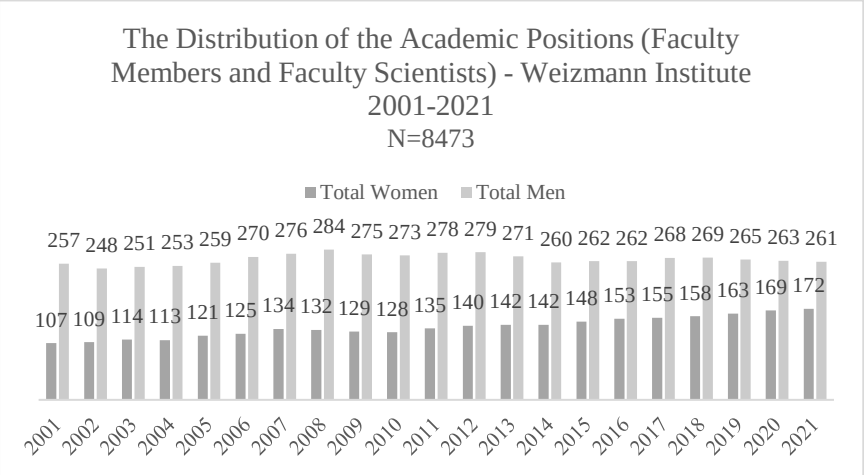

Figure 1: Weizmann Institute - Gender Distribution of Academic Positions (Faculty Members and Faculty Scientists), 2001-2021

The extent of the gender gap differs across faculties. Thus, while the average rate of female faculty members at the Weizmann Institute between 2001 and 2021 stood at 34% (Figure 2), in the Faculty of Mathematics and Computer Science, the average rate of female faculty members was only 23% (Figure 3). At the Physics faculty, the average rate of female faculty members stood at only 8% (Figure 4), while in the Faculty of Science Teaching, 61% of faculty members were women (Figure 5).

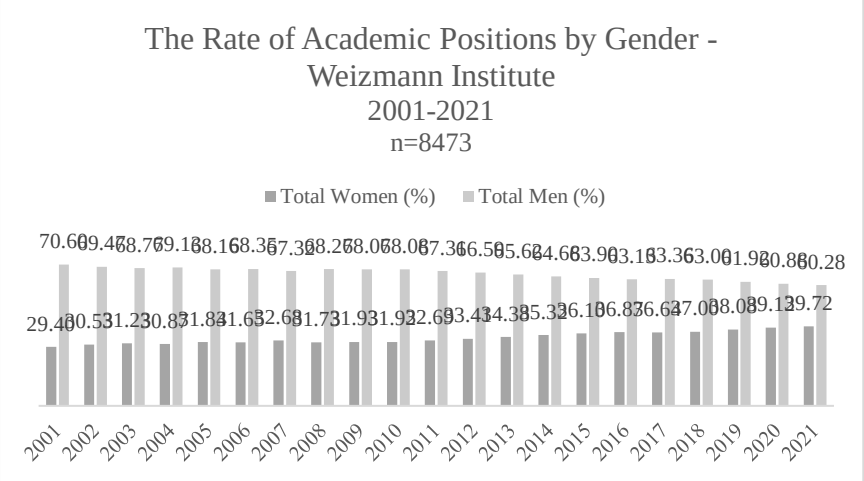

Figure 2: The Rate of Academic Positions by Gender – Weizmann Institute, 2001-2021

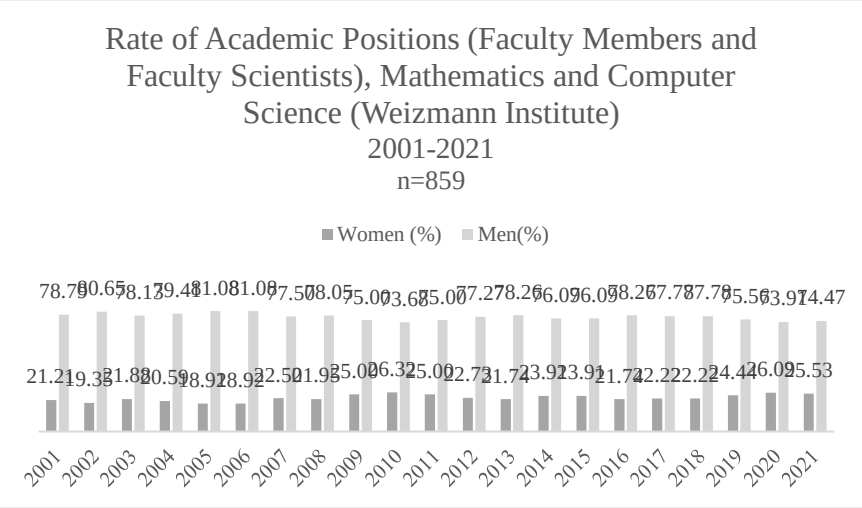

Figure 3: Rate of Academic Positions – Mathematics & Computer Science (Weizmann Institute), 2001-2021

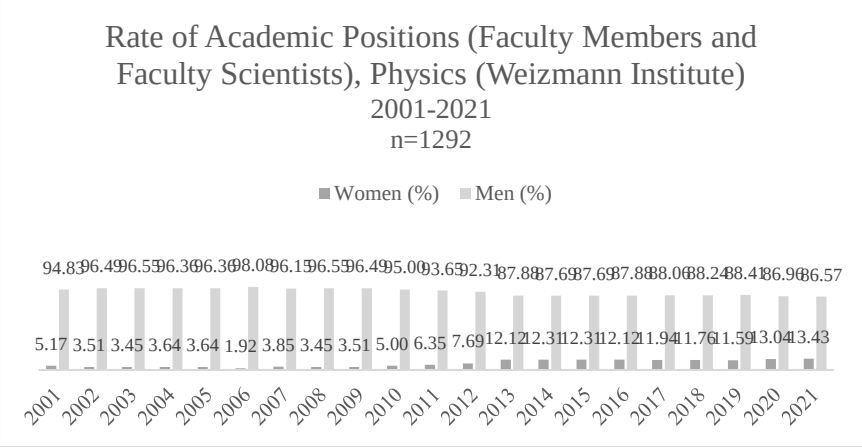

Figure 4: Rate of Academic Positions – Physics (Weizmann Institute), 2001-2021

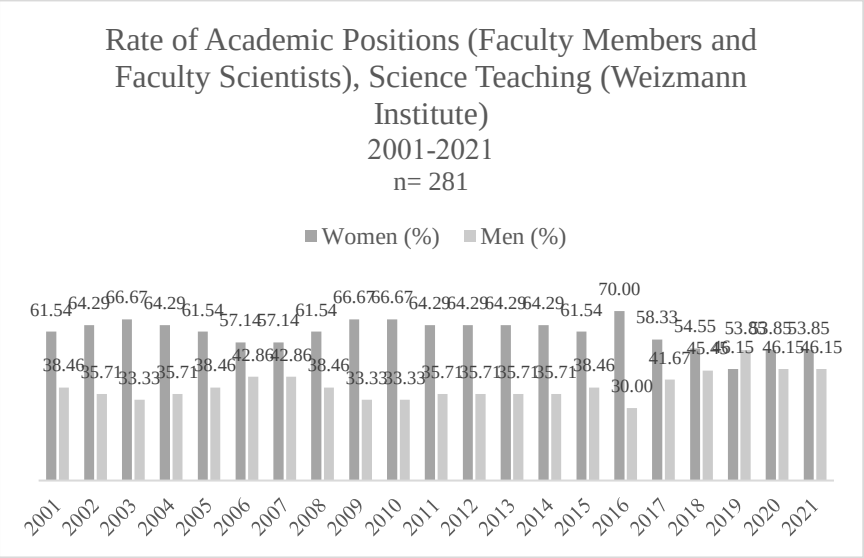

Figure 5: Rate of Academic Positions – Science Teaching (Weizmann Institute), 2001-2021

The Weizmann Institute classifies its academic faculty into two groups: "senior scientific faculty members" and "faculty scientists."[150] Gender gaps are also conspicuous in these two groups. While 76% of all male faculty between 2001 and 2021 were classified as senior scientific faculty members, only 27% of female faculty were classified senior scientific faculty members. In the Biochemistry, Chemistry, and Biology faculties at the Weizmann Institute, whose faculty members may register patents in the pharmaceutical industry—a substantial field of patent registry by the academic sector—the data suggests that except in the Faculty of Chemistry, the gender gap between senior scientific faculty member and faculty scientists increased between 2001 and 2021.

The Technion also had significant gaps in male and female faculty members. On average, the total percentage of female faculty members between the years 2014 and 2021 was only about 16%:

[150] *Id.*

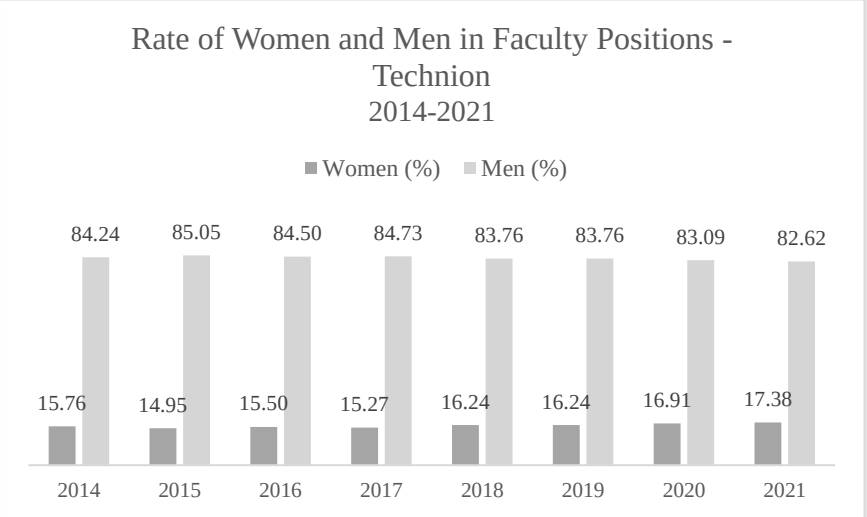

Figure*6* : Rate of Women and Men in Faculty Positions – Technion, 2014-2021

In addition to data regarding the number of women in senior faculty positions at academic institutions, there is much more data regarding the number of female students in the relevant areas, which can shed light on the gender gap in academic institutions in all levels. As shown below, women are represented at higher rates than men in some areas of science, both at undergraduate and graduate levels. Women are represented at increasing rates as students in all fields including the STEM fields. In 2016, 56% of all medical students were female. Female students also represented 83% of all undergraduate pre-medical students and 66% of all undergraduate students in life sciences.

However, at the graduate level, women's representation decreased, and in some fields women continued to be a minority. For example, only 36% of graduate students in the exact sciences were women. The same was true in mathematics, including statistics and computer science (31%). The lowest student rate of women is recorded in the engineering and architecture professions (29%). Overall, women constituted 62% of all graduate students in science. At the Ph.D. level, data show that in 2016, 78% of students in medical support professions were female. In mathematics, statistics, and computer science, the rate was 26%, and in exact sciences, 39%.

In 2018, a slight increase in women’s representation at the undergraduate level was reported: medicine – 60.1%; medical

support – 82.2%; life sciences – 68.7%; exact sciences – 38.5%; mathematics, statistics, and computer science – 33%; engineering, and architecture – 30.3%; and agriculture – 51%. At the graduate level, the representation of women was as follows: medicine – 54.1%; medical support – 87%; and life sciences – 66.6%. In other STEM professions, there was a low representation of women in graduate studies: exact sciences – 35.2%; mathematics, statistics, and computer science – 26.7%; engineering, and architecture – 26.2%. In Ph.D. studies, women's representation was high in some areas and low in others: in life sciences and medical support professions, there was a high rate of representation (60% and 81.7%, respectively), while in exact sciences the rate was only 37.4%; engineering, and architecture – 31.3%; and mathematics, including statistics and computer science – only 24.2%.

Table 8 below shows the percentage of male and female students pursuing undergraduate degrees in various fields between 1999-2000 and 2017-2018. These data show a general growth trend in women's representation in the STEM fields.

Table 8: Percentage of Female Undergraduate Students in the Various Academic Fields in Israel in 2000 and 2018

Year/ Field	**Medical Support & Nursing**	**Education & Teaching**	**Social Sciences**	**Humanities**	**Medicine**	**Business & Management**	**Law**	**Natural Sciences & Mathematics**	**Engineering & Architecture**
2018	82%	80%	69%	63%	60%	60%	53 %	41%	30%
2000	81%	85%	67%	68%	50%	43%	49 %	39%	25%

This phenomenon—a high percentage of female students at the undergraduate level followed by a precipitous decline at the graduate level—is known in academia as the "scissors curve."[151]
In conclusion, the gender gap in the academy remains significant. Although there has been a gradual, modest improvement in the rate of women in the STEM fields in academic institutions over the years, there is still a meaningful gap, and its pace of reduction has been slow.

[151] *Paving the Way for the Future of Women Scientists: Interview with Prof. Idit Shachar*, WEIZMANN INST. SCI. (Apr. 19, 2021), https://heb.wis-wander.weizmann.ac.il/node/11301 [https://perma.cc/3BYP-N3H3].

III. An Empirical Examination of Academic Patent Filing – Israel as a Case Study

a. Background

This study examines how women in the Israeli academic sector participate in technology transfer from academia to the industry through the filing of patents and compares their participation to that of their male colleagues. Our analysis is based on a quantitative study of patent applications filed by Israeli academic institutes.
This part describes our methodology, including its advantages and limitations. We then turn to describe the process of creating a patent dataset of all applications filed by Israeli academic institutes and its analysis by years, classifications, jurisdictions, grant rates, and forward citations. The findings of these analyses are discussed thereafter.

b. Methodology

1. A Quantitative Analysis of Patent Applications

A patent application is a legal document that defines the scope of the proprietary rights in a protected invention.[152] As part of the broad disclosure requirements designed to enrich human knowledge, patent applications describe innovative inventions.[153] Accordingly, they include a tremendous amount of information about the covered inventions, including their technological innovation, their inventors, assignees, one or more modes of practice, and more.[154] In recent years, sophisticated computerized tools have been used to analyze the rich data contained in patent applications.[155]

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[152] Sharon Bar-Ziv et al., פטנט לרישום בקשות של אמפירי ניתוח ?ופיתוח מחקר על המשפט משפיע כיצד [*How Does Law Affect Research and Development? An Empirical Analysis of Patent Applications*], 44 HEBREW U. L. REV. 973, 1003 (2015).
[153] Andrew W. Torrance & Jevin D. West, *Patent Analytics: Information from Innovation*, *in* LEGAL INFORMATICS 257 (Daniel Martin Katz et al. eds., 2021).
[154] *Id*. at 258. A detailed description of the patent structure can be found in the OECD Patent Statistics Manual. ORG. FOR ECON. COOP. & DEV., OECD PATENT STATISTICS MANUAL 24 (2009) [hereinafter OECD].
[155] DAPHNE GETZ ET AL., בהשוואה ישראלים פטנטים: 1990-2008 בישראל ופיתוח מחקר תפוקות בינלאומית [RESEARCH AND DEVELOPMENT OUTPUTS IN ISRAEL 1990-2008: ISRAELI PATENTS

Along with detailed information about the invention,[156] patent applications also contain significant data concerning the identity of the inventors and assignees, including names and addresses[157] and the patent nationality.[158] Therefore, patent applications are a popular tool for conducting quantitative studies and serve as an indicator for studying economic and technological performance, the dynamics of the process of innovation (including collaboration and knowledge transfer between various academic institutes), R&D activities, and technological and scientific innovation across countries, regions, and commercial entities.[159]

Despite the great benefits of patent applications analysis as documents reflecting R&D outputs or participation in such processes, this methodology has certain limitations. *First*, a patent is a strategic legal tool, and not all inventions are patented due to cost-benefit considerations, depending on the invention's characteristics.[160] Therefore, patent filing is not a complete indicator of innovation.[161] *Second*, the tendency to file for a patent has changed over the years due to legal changes in patent requirements, antitrust regulation, the nature of the industrial activity, the scope of R&D activity, the utilization of public funds, and the procedures of

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IN INTERNATIONAL COMPARISON] 1 (May, 2011) https://www.neaman.org.il/EN/Files/RD_Outputs_Patents_June_21_FINAL.PDF; Sharon Bar-Ziv et al., *supra* note 152.

[156] These data include, inter alia, title and abstract of the invention, the patent claims, the classification of the technological fields in which the invention deals and the prior art. There is also a lot of data that includes different dates and numbers, including: Priority Data, filing date, publication date, grant number and date and the list of selected countries. Sharon Bar-Ziv et al., *supra* note 152.

[157] There are difficulties in analyzing inventions by address, partly due to the lack of uniformity between the patent offices in various countries. *See* OECD, *supra* note 154, at 94.

[158] The U.S. Patent Office determines the "nationality" of the patent according to the address of the first inventor. In the European Patent Office, the patent is associated with the nationality of each of the inventors. Sharon Bar-Ziv et al., *supra* note 152, at 1003. A detailed description of the patent structure can be found in the OECD Patent Statistics Manual. OCED, *supra* note 154, at 24.

[159] *Id*. at 26; ZVI GRILICHES, R&D AND PRODUCTIVITY: THE ECONOMETRIC EVIDENCE (1998); *see* Igami Mitsuru & Jai Subrahmanyam, *Patent Statistics as an Innovation Indicator? Evidence from the Hard Disk Drive Industry*, 70 JAPANESE ECON. REV. 308 (2019); *see also* Ekaterina Khramova et al., *Statistical Patent Analysis Indicators as a Means of Determining Country Technological Specialisation* (Nat'l Rsch. Univ. Higher Sch. Econ., Working Paper No. WP BRP 09/STI/2013, 2013).

[160] Sharon Bar-Ziv et al., *supra* note 152, at 1004.

[161] OECD, *supra* note 154, at 27; *see also* Sharon Bar-Ziv et al., *supra* note 152, at 1005.

patent registration offices.[162] *Third*, the tendency to file for patents varies depending on corporate culture.[163] Thus, while in the past, researchers at research institutions have spent most of their time publishing in professional journals, in recent years, these researchers and research institutions are also involved in the filing and commercialization of patents.[164] *Fourth*, the tendency to file for a patent does not necessarily reflect their innovative level, as patents do not necessarily reflect the overall effort invested in research work,[165] and the patent application does not necessarily reflect the innovation level.[166] Therefore, patent applications do not necessarily reflect all R&D activity and do not generally serve as a single indicator for evaluating innovation. *Last*, a significant part of the registered patents is not implemented in production.[167] The patent assignees may have concluded that their inventions have low economic value or that it is better to use more advanced technology.[168]

However, today, patent applications are still considered an important indicator for innovation and are useful for measuring female innovation in all sectors, including the academy. Therefore, we employ this methodology to explore the gender gap in academic patenting.

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[162] William S. Comanor & Frederic M. Scherer, *Patent Statistics as a Measure of Technical Change*, 77 J. POL. ECON. 392, 392 (1969); *see also* Sharon Bar-Ziv et al., *supra* note 152, at 1004.

[163] Sharon Bar-Ziv et al., *supra* note 152, at 1004.

[164] NIVA ELKIN-KOREN & ELI M. SALZBERGER, THE LAW AND ECONOMICS OF INTELLECTUAL PROPERTY IN THE DIGITAL AGE: THE LIMITS OF ANALYSIS (2013).

[165] Sharon Bar-Ziv et al., *supra* note 152, at 1004.

[166] "It is important to emphasize that this claim is not different from the claim made against statistics that use the numbers of researchers, engineers, research and development expenditures as a measure of innovative activity, despite being accepted indicators as well." *Id.*

[167] *Id.* at 1005.

[168] A 2005 survey shows that 40% of granted patents are not used for production for strategic reasons or because the patent owner does not have the means to support their production. It found that 18% of patents are used only to block competitors and 17% of patents are considered "dormant patents." OECD, *supra* note 154, at 26.

2. Data Collection: Patent Applications Filed by Israeli Academic Institutes

The data analyzed in this study was drawn from the PatBase database,[169] which includes over 140 million patent families filed in more than 100 patent offices worldwide.[170] We began by creating a database of patent applications filed by Israeli research institutions using the following steps: first, we collected the names of all Israeli research institutions,[171] including all universities, private and public colleges, and education colleges as well as the names of all TTCs owned by the Israeli academic institutes. We then entered the entities on this list into the PatBase as assignees, which yielded a database containing 8219 patent families, which includes both registered patents and patent applications.

Of these, 1394 did not include the inventors' names and had apparently been abandoned before examination. These results were removed from the database. Thereafter, the database contained 6825 patent families filed by Israeli academic institutes between 1948 (when the State of Israel was established) and December of 2020.[172] After the final database was assembled, we determined the inventor's gender for each patent family. We relied on various sources, such as the researchers' homepages, LinkedIn pages, open Google searches, assistance from the technology transfer companies, and other sources that indicated the inventors' gender. We then divided the patent families into three groups: patent families that included only female inventors (Women Only), patent families that included only male inventors (Men Only), and patent families that included both male and female inventors (Mixed).
In the next step, we performed a separate analysis for each academic institution, looking at total patent applications as well as applications

[169] PATBASE, https://www.patbase.com/login.asp [https://perma.cc/TG7V-ZBAT].
[170] Patent families are an array of patents (or applications) in several countries that share identical priority data that are related to each other. In other words, in the case of a patent application that has been filed in several countries – all the applications that have been filed in the different countries will be merged into one family, with identical priority data. *See* OECD, *supra* note 154, at 110.
[171] The institutes' names were collected from the Israeli Council for Higher Education. COUNCIL FOR HIGHER EDUC., https://che.org.il/en [https://web.archive.org/web/20220405083906/https://che.org.il/en/].
[172] Since it can take up to eighteen months for a patent application to be published and during this period the data on the number of applications may be partial, the analysis presented in the article refers to the period until the end of 2018.

by group, by classification,[173] by year, by jurisdiction, and by citations for each of the three inventor groups (i.e., Women Only, Men Only, and Mixed).

It is important to mention that the data examined in this study includes only patent applications actually filed in patent offices and does not include inventions that the TTCs elected not to patent, as information about such inventions is not publicly available. Similarly, the study's database does not include provisional patent applications. as patent offices do not report such applications, and this data is not publicly available from the TTCs.

c. Findings

The study's findings are described below.

Figure 7 illustrates the distribution of patent applications filed by Israeli academic institutes, from 1957, when the first patent application was filed, until 2018.[174]

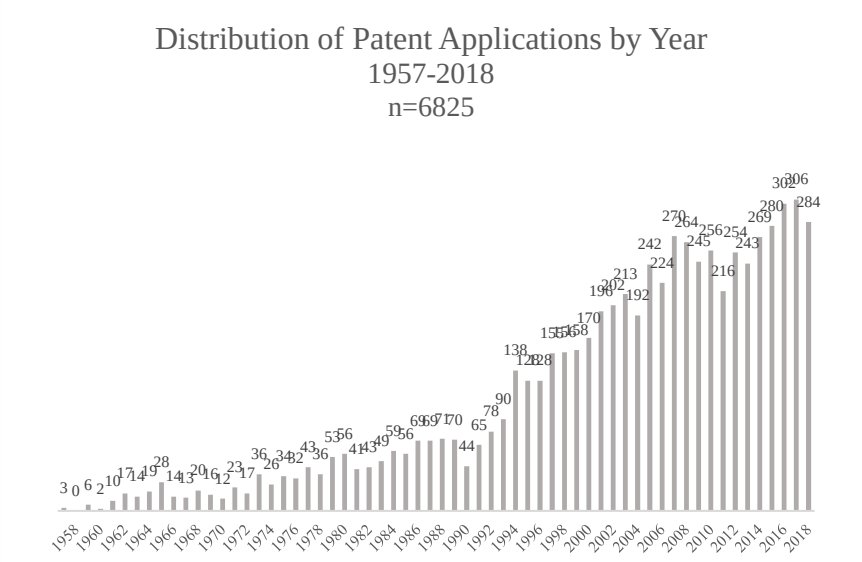

Figure 7: Distribution of Patent Applications by Year

[173] This analysis was based on the classification system of the World Intellectual Property Organization (WIPO) – the International Patent Classification (IPC). *IPC Publication*, WIPO IP PORTAL, https://ipcpub.wipo.int/ (last visited Apr. 21, 2022).

[174] The filing year analysis was based on the earliest priority date of each patent family. OECD, *supra* note 154, at 72.

Since 1993, there has been a sharp increase in patent applications as compared with earlier years.

Until 1992, an average of 34.5 patent applications were filed each year, while an average of 214.6 applications were filed each year between 1993 and 2018 (a six-fold increase).

Figure 8 illustrates the distribution of patent applications with female inventors only filed by Israeli academic institutes:

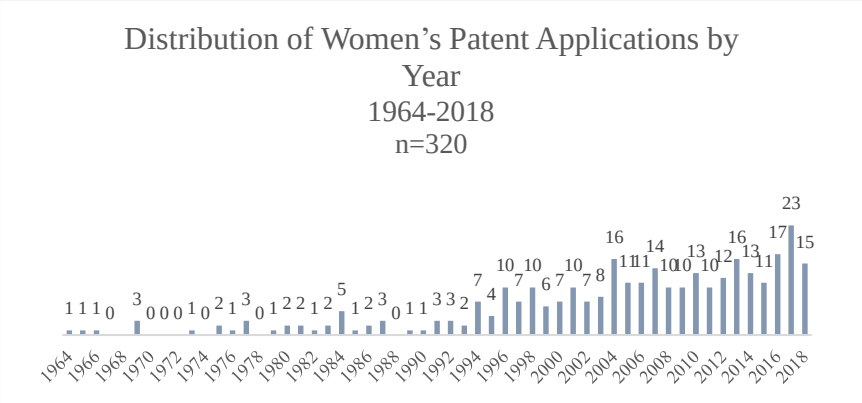

Figure 8: Distribution of Women's Patent Applications by Year, 1964-2018

A sharp increase is observed in the number of patent applications filed by female inventors from 1993 onwards. Nevertheless, the number of patent applications with only women as inventors is extremely low.

Figure 9 illustrates the distribution of the patent applications with male inventors only filed by Israeli academic institutes:

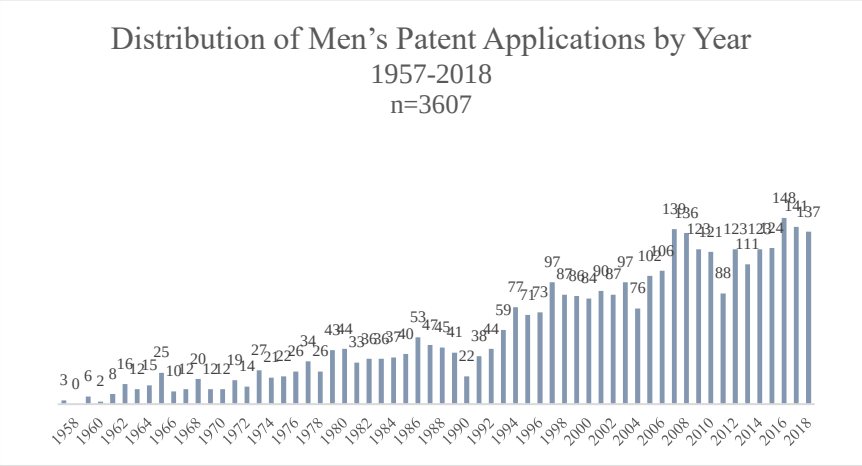

Figure 9: Distribution of Men's Patent Applications by Year, 1957-2018

A sharp increase is observed in the number of patent applications filed by male inventors from 1993 onwards.

Figure 10 below shows the distribution of patent applications with mixed inventor groups filed by Israeli academic institutes.

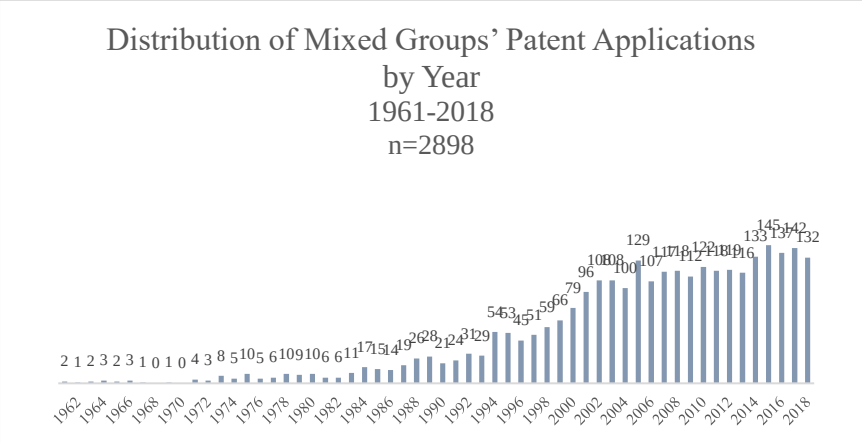

Figure 10: Distribution of Mixed Groups' Patent Applications by Year, 1961-2018

Again, a sharp increase is observed in the number of patent applications with mixed-gender inventor groups from 1993 onwards.

Table 9 shows the average number of patent applications filed by Israeli academic institutes from the establishment of the State of Israel until 1992, and between 1993-2018:

Table 9: Comparison of Patent Applications of Academic Institutes between Women, Men and Mixed groups, 1957-2018

Group	1948-1992		1993-2018		Ratio
	Total Applications	Yearly Avg.	Total Applications	Yearly Avg.	Yearly Avg.
Women Only	40	1.1	280	10.8	9.8 times more
Men Only	901	25.1	2706	104.1	4.2 times more
Mixed	303	8.4	2595	99.8	11.9 times more
Total	1244	34.6	5581	214.7	6.2 times more

The data in Table 9 reveal a 6.2-fold increase in the average number of patent applications per year between 1993-2018 as compared with 1948-1992. The average number of applications filed per year filed with women only inventors multiplied by 9.8 when comparing the same time periods. This observation reveals the growing involvement of women in the activities of filing patent applications. However, it should be noted that the number of applications filed by women is still significantly lower than that of men. Women's increasing involvement is also evident in the mixed-gender groups, where the numbers have multiplied by 11.9 – a rate of increase that is almost twice the average increase in the total number of applications.

Table 10 below shows the total number of patent applications filed by Israeli academic institutes from 1948 to 1992 and from 1993 to 2018, by institute:

Table 10: Patent Applications Filing in Israeli Academic Institutes:

Institute	1948-1992		1993-2018		Ratio
	Total Applications	Yearly Avg.	Total Applications	Yearly Avg.	
Weizmann Institute	**489**	**10.86**	**1219**	**46.9**	**4.31 times more**
Hebrew University	**253**	**5.62**	**1325**	**51**	**9.1 times more**
Technion	**246**	**5.46**	**1088**	**41.85**	**7.66 times more**
Tel Aviv University	**130**	**2.8**	**1042**	**40.1**	**14.32 times more**
Ben Gurion University	89	1.98	663	25.5	12.87 times more
Bar-Ilan University	36	0.8	294	11.3	14.12 times more
Haifa University	0	0	56	2.15	
Ariel University	0	0	69	2.65	
Colleges	20	0.44	75	2.88	6.55 times more
Total	1263		5831		

Over the years, the Weizmann Institute, the Hebrew University, the Technion, and Tel Aviv University were the leading academic institutes in terms of patent applications filing. These institutes increased the average number of applications filed annually after 1993 by 4.31 times (Weizmann Institute), 9.1 times (Hebrew University), 7.66 times (Technion) and 14.32 times (Tel Aviv University). It bears noting that the information reported is not sensitive to the number of researchers in the STEM fields in the various institutions. There is no doubt that the greater the number of researchers in the STEM fields, the greater the patent filing activity. Naturally, the larger and more established institutions with a greater number of STEM researchers file more patent applications. Later in the study, we standardize the data to account for variations in the overall number of faculty members in the STEM fields of the respective institutes to portray more accurately the gap between women's and men's representation in patenting activity.

The following Table 11 shows a comparison between the number of patent applications filed by Israeli academic institutes and the number of patents granted between 2000-2018.[175] This examination

[175] A patent family is classified as a Granted Application if it has at least one granted application. It is important to note that in Israel there is no official publication of granted applications, but only "publication after examination and before opposition." An

was performed only for the years 2002-2019 because the U.S. Patent Office had begun to publish patent applications only in March of 2001.[176]

Table 11: Comparison of Patent Applications to Granted Patents, 2000-2018:

Group	Patent Applications	Granted Patents	%
Women Only	227	107	47%
Men Only	2072	1105	53%
Mixed Groups	2159	1103	51%
Total	4458	2315	52%

There is no statistically significant difference in the patent grant rate among women only, men only, and mixed inventor groups. Overall, the grant rate was 52%. In the women's group, the grant rate was only 47%, but this may be due to the sample size.

Figure 11 below shows the ten leading jurisdictions in which Israeli academic institutes filed patent applications:[177]

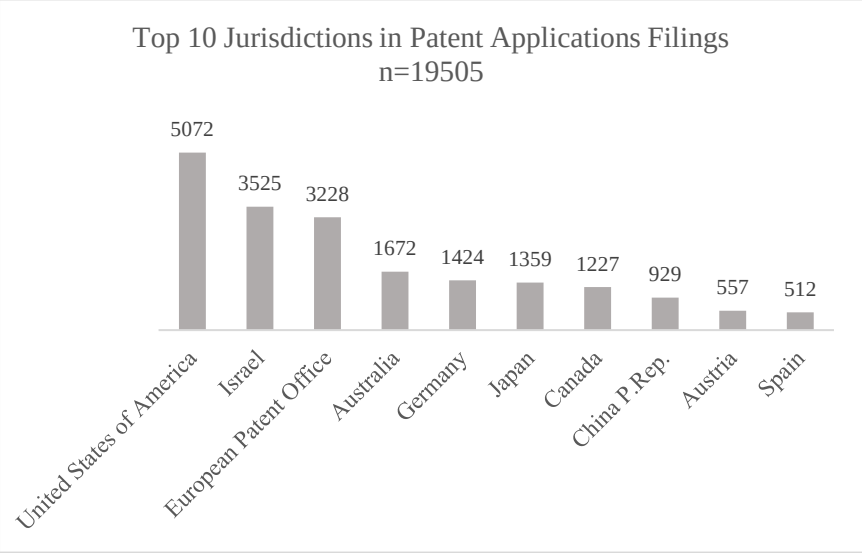

Figure 11: Top 10 Jurisdictions in Patent Applications Filings

examination of the rate of objections filed annually between the years 2002-2019 shows that the average rate of objections in this period is only 0.79% of the total number of applications filed in that year. In light of the fact that the rate of objections seems marginal, we assumed that at very high rates applications that have been filed in Israel and are in the status of "publication after examination and before objection" can be referred to as "granted." Orit Fischman Afori et al., *Uncovering Patent Prosecution: An Obvious(ness) Negotiation*, 40 CARDOZO ARTS & ENT. L.J. (forthcoming 2022).

[176] *Patent Full-Text Databases*, U.S. PAT. & TRADEMARK OFF., https://patft.uspto.gov/ [https://perma.cc/5Q4L-GVYC].

[177] The jurisdiction analysis examined the number of patent family filings in each jurisdiction, by each institution in general, and by each of the three gender groups.

As this figure illustrates, most applications were filed in the U.S. Patent Office, Israel, and the European Patent Office. Twenty-six percent of all patent applications were filed in the U.S. Patent Office, 18% were filed in Israel, and 16% were filed in the European Patent Office.

Figure 12 below shows the leading classifications of the patent applications filed by Israeli academic institutes.[178] It is interesting to see that 70% of all applications filed fall within 30% of all classifications, which are the top ten classifications. Pharma, biotechnology, and organic chemistry are the three classifications having the greatest number of applications over the years, followed by medical technologies, computers, biological materials analysis, and measuring tools.

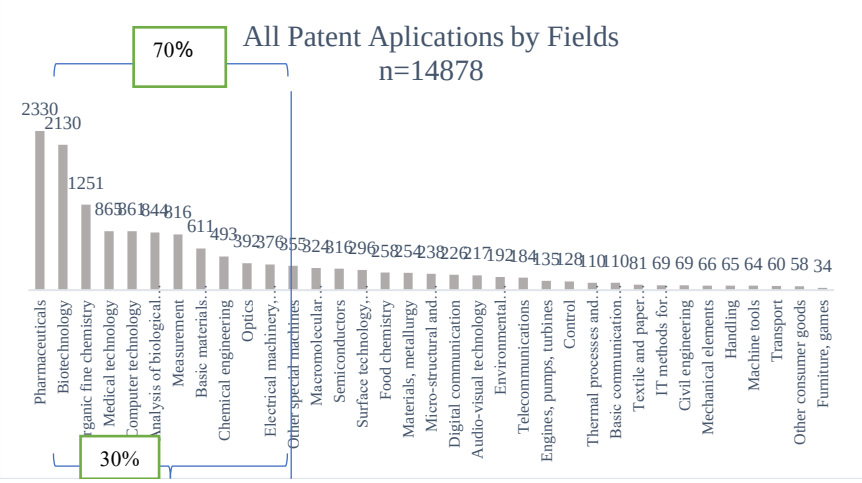

Figure 12: All Patent Applications by Field

Figure 13 below illustrates the different rates of women only, men only, and mixed inventor groups involved in filing patent applications in the top classifications in Israeli academic institutes.

[178] The classification analysis was based on the classification system of the World Intellectual Property Organization (WIPO) - the International Patent Classification (IPC). *See International Patent Classification (IPC)*, WIPO, https://www.wipo.int/classifications/ipc/en /[https://perma.cc/584D-QU8W].

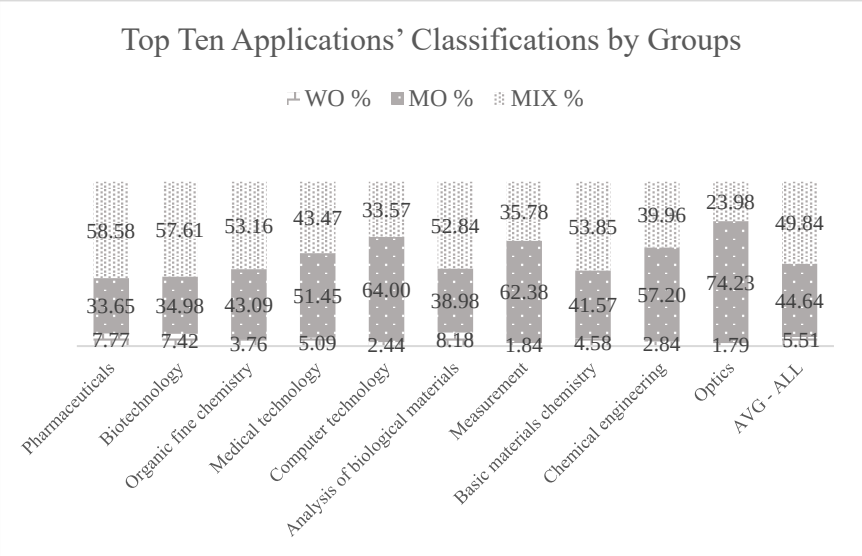

Figure 13: Top Ten Applications' Classifications by Groups

The average rate of women in each field is 5.51% of all patent applications in the top ten fields. In pharmaceuticals, biotechnology, and analysis of biological materials, the rate is significantly higher than this average. The rate of men in all areas is 44.64%, with their proportion in medical technology, computing technologies, measuring tools, optics, and chemical engineering exceeding the overall average. The average rate of mixed-gender groups involved in all fields is 49.84%. In pharma, biotechnology, organic chemistry, analysis of biological materials, and basic material chemistry, the numbers are significantly higher than this average.

Figure 14 below shows the top ten fields for patent filing by women only at Israeli academic institutes.

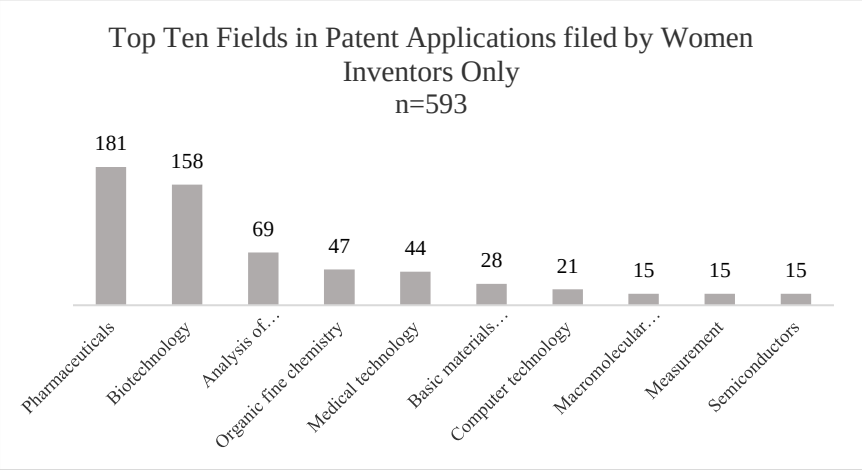

Figure 14: Top Ten Fields in Patent Applications filed by Women Inventors Only

As this figure illustrates, pharmaceuticals and biotechnology are leading fields for women, together comprising more than half (57%) of all patent applications filed by this group.
Figure 15 below shows the top ten fields for patent filing by men only at academic institutes in Israel.

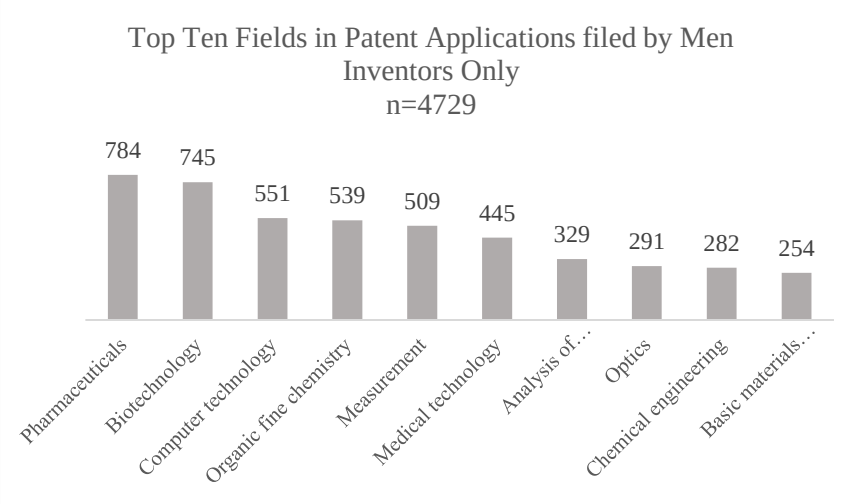

Figure 15: Top Ten Fields in Patent Applications filed by Men Inventors Only

As this figure illustrates, pharmaceuticals and biotechnology are also leading fields for this group, although together they comprise only about a third (32%) of all patent applications filed by this group.
Figure 16 below shows the top ten fields for patent filing by mixed-gender groups in Israeli academic institutes.

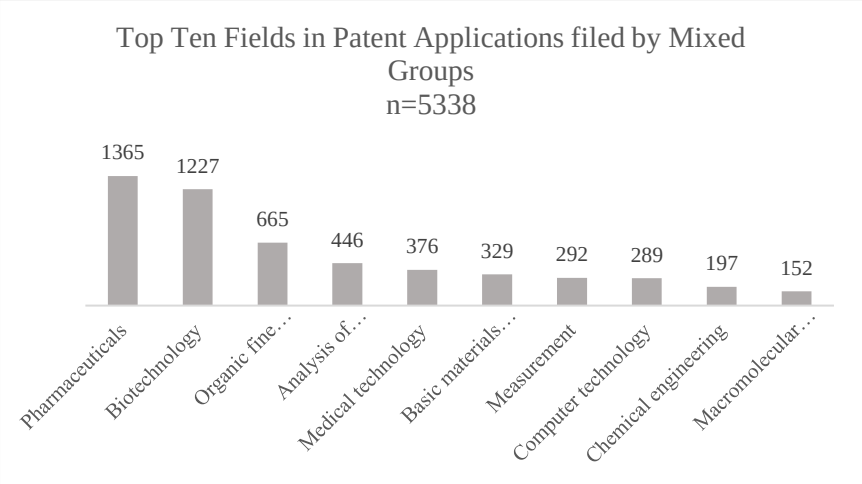

Figure 16: Top Ten Fields in Patent Applications filed by Mixed Groups Inventors Only

As this figure illustrates, pharmaceuticals and biotechnology are also leading fields for this group, comprising almost half (48%) of all patent applications filed by this group.

Figure 17 below shows the relative parts of each group – women, men, and mixed groups, within each category of forwarding citations, out of all applications cited from each group.

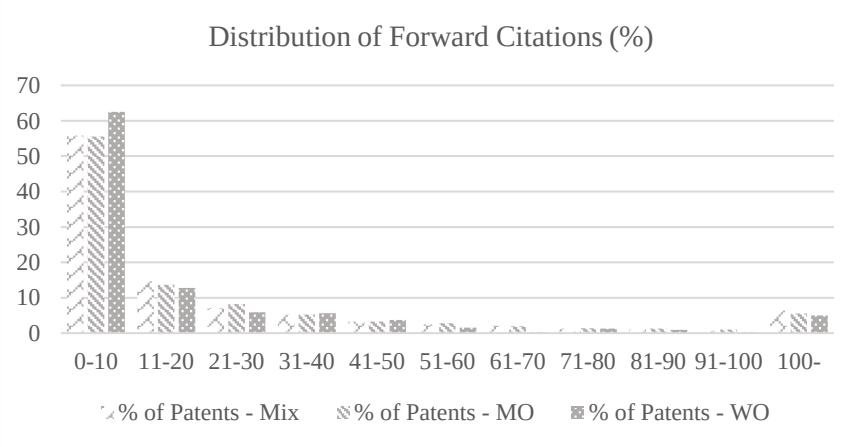

Figure 17: Distribution of forwarding Citations

This figure illustrates that 62.5% of the applications that were filed by women only have been cited up to ten times, while 55.6% of men-only applications, and 55.8% of mixed-group applications have been

cited up to ten times. Meanwhile, of the 3608 applications filed by men only, 201 were cited 100 or more times (about 6%), while 16 out of a total of 320 applications filed by women only (about 5%), and 183 out of a total of 2897 mixed-group applications (6%) were cited a hundred or more times. In other words, no gender disparity is observed in the number of citations.

Table 12 below shows the number of applications filed by the leading academic institutes in Israel[179] from the establishment of the State in 1948 to 1992, and from 1993 to 2018, followed by the increase in the ratio for each group:

Table 12: Comparison number of patent applications filed by each group, in the Leading Israeli Academic Institutes

Institute	Group	1948-1992	1993-2018	Increase
The Hebrew University	Women	6	50	8.3 times more
	Men	172	602	3.5 times more
	Mixed Groups	75	673	9 times more
	Total	253	1325	5.2 times more
Weizmann Institute	Women	13	63	4.8 times more
	Men	321	517	1.6 times more
	Mixed Groups		638	4.1 times more
	Total	489	1218	2.5 times more
Technion	Women	7	31	4.4 times more
	Men	221	608	2.75 times more
	Mixed Groups	19	449	23.6 times more
	Total	247	1088	4.42 times more
Tel Aviv University	Women	9	67	7.4 times more
	Men	81	489	6 times more
	Mixed Groups	40	486	12.1 times more
	Total	130	1042	8 times more

As this table illustrates, all of the academic institutes saw a significant increase in patenting activity in the period 1993-2018 as compared with the period 1948-1992, with the most significant increase in the mixed group, followed by the women only group.
Table 13 compares the percentage of senior faculty positions held by women at the various academic institutes within the STEM fields, with the percentage of patent applications filed by the institutes that had women only inventors.[180] It should be noted, however, that the

[179] Institutes who filed more than 1000 applications.
[180] The data concerning academic positions is based on Table 7 above. It is important to note that the data in Table 7 concern the number of positions held by women, and not necessarily the number of women per capita. Therefore, for instance, part-time employment is taken into account in Table 7. Nevertheless, the comparison between the low percentage of women in the STEM faculties and their even lower percentage among inventors named

data reflecting patent applications by women inventors may involve the participation of not only female senior faculty members, but also female research students and female post-doctoral and graduate students.

Table 13: Comparison of the Relative Part of Women in the Senior Academic Positions to their Relative Part in Filing Patent Applications, 2017-2018

Year/Institute	Ben Gurion University	Hebrew University	Tel Aviv University	Haifa University	Bar-Ilan University	Technion	Weizmann University	Ariel University
2017 – Percentage in Academic Positions	28%	29.1%	29.1%	43.6%	34.1%	17.5%	35.4%	34.4%
2017 – Percentage in Patent Application Filings	15%	5.7%	5.88%	0%	5.55%	5.06%	8.6%	0%
2018 – Percentage in Academic Positions	27.5%	29.2%	29.6%	43.5%	35.3%	18.9%	35.7%	35.8%
2018 – Part in Patent Application Filings	2.94%	12%	2.19%	0%	9%	4.7%	2.56%	0%

Table 14 below compares the distribution of women and men among faculty members in the STEM fields with the distribution of women and men among inventors in all patent applications filed by each institution. As noted above, inventors named in patent applications filed in the academic sector often include research students, post-doctoral students, and others of both genders as well as senior faculty members, making it difficult to draw decisive inferences from our data concerning the rate at which female senior faculty at Israeli institutions participate in the patenting activity of those institutions. Accordingly, we also compared the distribution of men

in the institutions' patent applications sheds light on the depth of the gender gap. It should also be noted that the data also include patent applications filed by mixed groups of men and women, in groups of up to four inventors (inclusive). Mixed applications were divided according to the relative proportion of women and men among the named inventors.

and women among senior faculty members with the distribution of men and women in patent applications with a single inventor, as we assume that in most cases, the inventor named in such applications is a senior faculty member. This focused comparison, while based on a small group of single inventors, can serve as an indicator supporting the comparison between the two datasets: the distribution of men and women among on the senior faculty, and the participation by faculty members of each gender in filing patent applications.

Table 14: Comparison of the Distribution of Women and Men among Senior Academic Staff and the Distribution of Women and Men in Patent Application Filing, 2017-2018

Year/Gender	Men	Women
2017 – Representation in Academic Positions	68.8%	31.2%
2017 – Representation in Patent Application Filings	76%	24%
2017 – Patent Applications filed by single inventor	75%	25%
2018 – Representation in Academic Position	68.38%	31.62%
2018 – Representation in Patent Application Filings	79%	21%
2018 – Patent Applications filed by a single inventor	74%	26%

This table illustrates that the rate of patent applications filed by women, whether women-only or as part of a mixed group, was less than that of women's representation as senior faculty members between 2017–2018. A similar pattern is observed when comparing the distribution of men and women in patent applications with single inventors. That is, when the data used for comparison is limited to patent applications in which the inventors are assumed to be senior faculty members, the results support the conclusion that female faculty participate in patenting activity at lower rates than their rate of representation among the senior faculty in the relevant fields.
Figure 18 compares the rate of male and female faculty members at Weizmann Institute and the rate of patent applications filed by men only and women only.

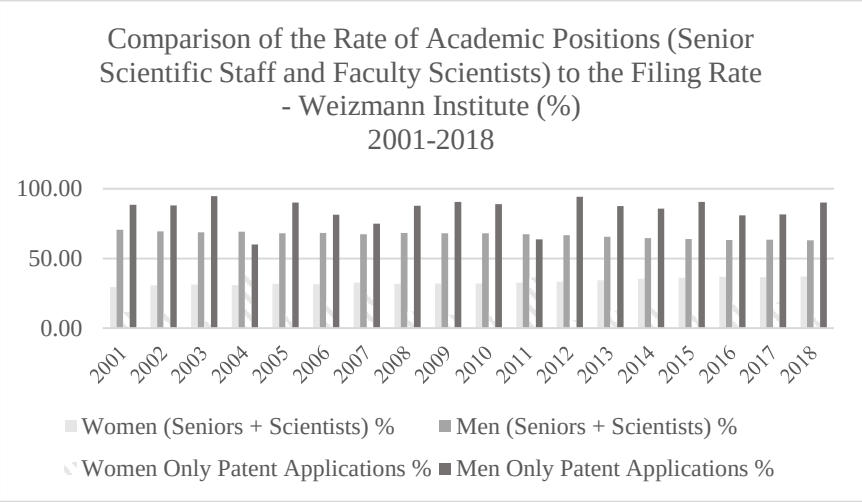

Figure 18: Comparison of the Rate of Academic Positions to the Filing Rate - Weizmann Institute (%), 2001-2018

It is evident that the percentage of patent applications filed by men only is significantly higher (about 84% on average) than their relative part in the faculty membership (about 67% on average), while the percentage of patent applications by women only (about 16% on average), is lower than their relative part of the faculty membership (about 33% on average).

The scenario is similar in the Technion. Figure 19 shows that the percentage of patent applications filed by men is higher than men's representation on the faculty, while the percentage of patent applications filed by women is lower than women's representation on the faculty. While the rate of male faculty members was 84% from 2014- 2018, their representation as inventors on patent applications filed during that period is 92% on average. Meanwhile, women represented 16% of faculty members on average between

2018–2014, while their representation as inventors on patent applications was only 8%.

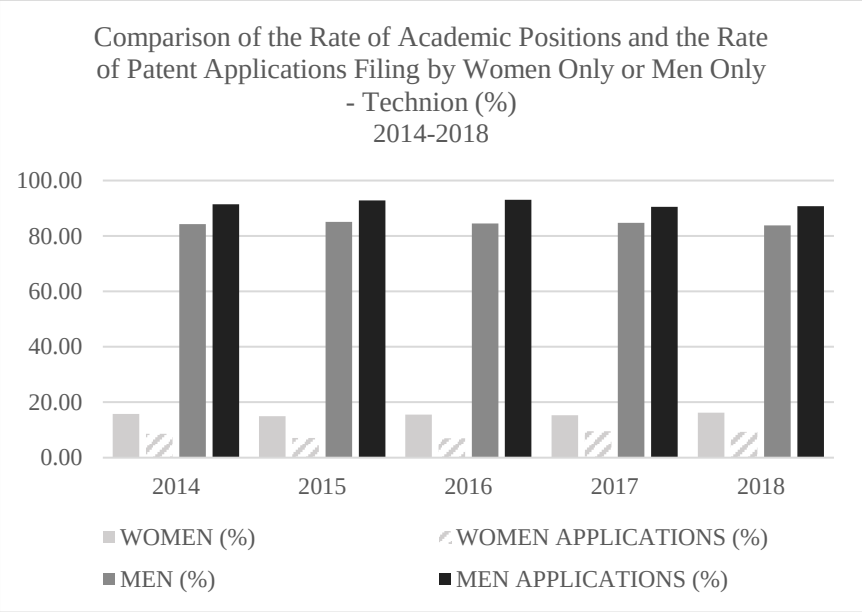

Figure 19: Comparison of the Rate of Academic Positions and the Rate of Patent Applications Filing by Women Only or Men Only - Technion (%), 2014-2018

Later, we examined the gender breakdown in the groups of inventors who filed joint (i.e., non-single inventor) patent applications at Israeli academic institutes. To do this, we classified the names of the inventors according to gender based on their names and other available sources of identifying information such as their home pages and other sources. When we were uncertain about how to classify a researcher's name based on gender - we removed that patent applications from the dataset. We then sampled all patent applications filed by researchers at Israeli academic institutes in groups of up to four inventors.[181] Of the 6825 patent applications filed from 1948-2018, 4900 applications (72%) had up to four named inventors in the distribution shown in Table 15 below:

[181] In groups of five inventors or more, we experienced difficulties in identifying the gender of many inventors. Moreover, particularly large groups of inventors raised concerns about double and incorrect registration of inventors' names, and therefore we could not ascertain the absolute size of each group of inventors in relation to the applications filed.

Table 15: Distribution of Applications with up to 4 inventors by group:

Group	No. of Applications	%
Men Only	2999	61%
Women Only	302	6%
Mixed Groups	1599	33%
Total	4900	100%

To examine the group of men only, a second sample was performed, and applications with inventor groups of up to four inventors were positively identified as men.

Table 16 below shows the distribution of groups comprising men only:

Table 16: Distribution of No. of Inventors (Men Only)

No. of Inventors	No. of Applications	%
1 Inventor	621	21%
2 Inventors	1159	38%
3 Inventors	712	24%
4 Inventors	507	17%
Total	2999	100%

This table illustrates that most men, 79%, filed joint patent applications.

To examine the group of women only, a third sample was performed, and applications with inventor groups of up to four inventors were positively identified as female. Table 17 below shows the distribution of groups comprising women only:

Table 17: Distribution of No. of Inventors (Women Only)

No. of Inventors	No. of Applications	%
1 Inventor	120	40%
2 Inventors	121	40%
3 Inventors	36	12%
4 Inventors	25	8%
Total	302	100%

This table illustrates that 60% of women filed patent applications with at least one another inventor.

To examine the composition of the mixed-gender groups of inventors, we looked at the distribution of these groups, as shown below in Table 18. As mentioned above, there were 1599 mixed groups of up to four inventors: 443 groups of two inventors - man and woman; 576 groups of three inventors and 580 groups of four inventors. It is important to note that to show the distribution of men

and women in the mixed groups, gender identification of all of the named inventors is required. This was possible in only 1188 of the 1599 mixed-group applications (74%): 443 groups of two inventors – man and woman; 397 groups of three inventors, and 348 groups of four inventors, as shown below:

Table 18: Distribution of Inventors in Mixed Groups

No. of Inventors	Group Composition	No. of Applications	% of Total Applications
2 Inventors	Man and Woman	443	37%
3 Inventors	1 Man and 2 Women	96	8%
	2 Men and 1 Woman	301	26%
Total 3 Inventors		397	34%
4 Inventors	2 Men and 2 Women	121	10%
	1 Man and 3 Women	34	3%
	1 Woman and 3 Men	193	16%
Total 4 Inventors		348	29%
Total		1188	100%

Groups of two inventors (male and female) comprise a significant part of the mixed-gender groups – 37%, while groups of three inventors – two men and a woman – comprise 26%, and groups of four inventors – a woman and three men – comprise 16%. In 42% of all applications filed by mixed-gender groups, women were outnumbered. In 37% of groups, there were two inventors, and therefore, gender equality.

IV. Discussion

The main findings of this study draw a clear picture revealing women's low rate of participation in the patenting activity of Israeli academic institutes, both as compared with men's participation in patenting activity and with the representation of women on the STEM faculties of these institutes. That is, the gender gap in the academic sector in Israel is expressed not only in the gender disparity among faculty at each of the institutes, but also in the (even more pronounced) gender disparity in the patenting activity of these institutes—an activity that is perceived as central in the STEM fields, which aim to transfer knowledge from the academy to the industry.[182] This uncovers a dimension of the gender gap that has

[182] *Patents*, WIPO, https://www.wipo.int/patents/en/ [https://perma.cc/6UAS-53FE] ("One of the main functions of the patent system is to foster technological innovation by providing an incentive for research and development. The patent system also works to disseminate technical information and promote technology transfer.").

poorly explored, and that reflects a significant disparity in women's integration in an important academic activity.

As outlined above, Israeli academic institutes filed a total of 6825 patent applications between 1948 and 2018. Of these, 320 applications were filed by women inventors only, 3607 applications were filed by men only, and 2898 applications were filed by mixed inventor groups. This data alone demonstrates a gender disparity in patenting activity in the Israeli academic sector. Even if the mixed groups of inventors were equally divided between the genders (50% men and 50% women), it would be clear that female inventors are involved in patenting activity at significantly lower rates than male inventors. As our study reveals, the discrepancy is even more prominent than it appears at first blush. A thorough examination of the gender composition of mixed-group patent applications (N=2898) shows not only that women are underrepresented as inventors named in patents emerging from the academic sector, but also that women are outnumbered by men in joint applications filed in this sector with inventors of both genders. In the mixed groups (most of which include two to four inventors), women's representation was significantly below 50%. Thus, for example, out of a total of 397 applications with three inventors, 301 were filed by a group consisting of two male inventors and one female inventor. Out of 348 applications with four inventors, 193 applications were filed by a group consisting of three male inventors and one female inventor. This data reinforces the overall finding that women's participation in the patenting activity of the academic sector in Israel is significantly lower than that of men. Furthermore, examining the number of patent applications filed by women alone and men alone in leading institutes such as the Weizmann Institute and the Technion shows that the percentage of applications filed by women alone is significantly lower than their (already low) representation on the faculty of these institutions.

Indeed, it can be argued that fewer women apply for patents in the academic sector than men due to their lower representation among the faculty in the STEM fields. Except for the data shown above regarding the Weizmann Institute and the Technion, there is no reliable, historical data showing the number of women on the STEM faculties of Israeli academic institutes. However, in response to a Freedom of Information request, we received data from the Council

of Higher Education for the years 2017-2020. The Arnon report also provided data for the year 2013.[183] These data allow for a comparison in these years between women's rate of participation in patenting activity and their rate of representation on the faculties of all Israeli academic institutes, although, as noted above, the comparison is inexact, because some of the inventors named on patent applications probably were not faculty members.

The comparison reveals broadly that women are underrepresented in the patenting activity of Israeli academic institutes, even when compared to their representation on the STEM faculties of those institutes. Thus, for example, in 2017, 306 patent applications were filed by Israeli academic institutes, of which 141 were by men only, 23 were by women only, and 142 applications were by mixed groups. In the same year, there were 1676.2 female faculty members and 3698.6 male faculty members in the STEM fields of the Israeli academic institutes (a rate of 31.2% women faculty members). In 2018, 284 patent applications were filed by academic institutes in Israel, of which 137 were by men only, 15 were by women only, and 132 were by mixed groups. In that year, there were 1708.7 female faculty members and 3695.7 male faculty members in the STEM fields of the Israeli academic institutes (a rate of 31.62% women faculty members). This finding suggests that among the faculty members in the STEM fields, fewer women engage in patent activity than their male colleagues.

It is interesting to note, however, that women's participation in academic patenting in Israel is greater than their average participation in patenting generally and worldwide, according to other studies.[184] Indeed, our study reveals that women in the Israeli academy are named in 47.1% of the applications examined in both the women only (320 patent families) and mixed inventors groups (2898 patent families), totaling 3218 patent families, which is greater than the worldwide 29% total representation reported in the WIPO study.[185] The percentage of Israeli women's academic

[183] *See generally* ARNON ET AL., *supra* note 127.
[184] *See supra* Section II.
[185] *See* Martinez et al., *supra* note 13. However, one should take into account the WIPO study examined only PCT applications. 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 IPR management.

patenting is also much higher than the average representation of women in patenting generally worldwide which is 7.2% and is also higher than the U.S. average representation of women in patenting, which is 8.7%.[186] Further, our study reveals that women in the Israeli academy participate in patenting at much higher rates than Israeli women generally, who are named as inventors in 11.6% to 13.5% of patents overall, according to selected patenting activity reports.[187] These findings call for further comparative and in-depth research focusing on the reasons for this gap.

Our results can also be compared with those of other comparative studies,[188] such as the 2006 study of Ding *et al*., which found that women faculty members in the United States patent at about 40% of the rate of male faculty members.[189] Our study shows that female faculty in Israel patent at about 35% of the rate of male faculty (in 2017-2018, about 25% of patentees were female and about 75% were male). Notwithstanding differences between Israeli academy and the American academy as well as differences in the methodology and focus of the studies themselves,[190] a comparison of the studies' results reveals the significance of the gender gap in academic patenting that has persisted around the world over the years.

Interestingly, our analysis reveals no gender bias with respect to the acceptance rate of patents for registration or patent citation. We also observed no difference between gender groups with respect to the countries in which patents were registered (which likely reflects a policy determined by the TTCs). As for the fields of technology, our findings indicate that the pharmaceutical and biotechnology fields are the leading areas of patent registration across all institutes and all gender groups. However, for women, patent applications in pharmaceuticals and biotechnology comprise more than half (57%) of all patent applications, while for men, patent applications in the

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[186] Martinez et al., *supra* note 13.
[187] *Id.*
[188] *See supra* Section B.
[189] Ding et al., *supra* note 19.
[190] Ding's study was based on a sample focusing on life sciences, while our analysis pertains to all academic patents in Israel in all fields; but this data was compared to the percentage of women in the STEM faculties only in years 2017-2018. The database included a random sample of 4227 life scientist, comprised of 903 women scientists and 3324 men scientists, and tracked their patenting activity within a period of 30 years. *See id.*

fields of pharmaceuticals and biotechnology comprise only about a third (32%) of all patent applications. This finding can be explained by the non-uniform distribution of female faculty members at various faculties within the STEM fields, with a relatively higher proportion of women in fields relevant to pharmaceuticals and biotechnology (e.g., life sciences), than in fields such as computer science or engineering, in which women are represented at a lower rate.

To conclude, understanding the gender gap in Israeli academic institutes requires more than a comparison of each gender's representation in senior faculty positions. Indeed, a more complete (thought certainly not exhaustive) picture of women's incomplete integration into some of these institutes' central activities emerge from the close look we have taken at how male and female inventors participate in the transfer of knowledge from academia to the industry through patenting. Our findings highlight the need for follow-up studies to examine the reasons women take part in patenting activities at lower rates than men and the barriers to women's optimal integration into the academic sector. For example, it is necessary to explore whether women in the academic sector lack access to technology transfer activities. The policies and practices of TTCs should be examined to determine whether these companies are optimizing access by female faculty members. Additionally, practices within STEM research groups should be examined to investigate whether there exists gender bias in determining who will be named as inventors in patent applications.

The gender gap in academic patenting may also have implications concerning financial incentives for women faculty members. As mentioned above, academic inventors may be entitled to royalties. Accordingly, women's comparatively low representation in academic patenting may produce a significant earning gap. As a result, women faculty who have succeeded professionally and have integrated into the academic sector within the STEM fields may still suffer from earning inferiority. The gender gap in academic patenting may also affect women's reduced exposure to the business sector, which can, in turn, reduce their professional opportunities.
Finally, the lack of optimal integration of women in transferring knowledge from the academy to the industry may hinder the accomplishment of academic goals in promoting innovation, as the

potential of women researchers in the STEM fields is not fully achieved.

V. Proposals

Different proposals have been made to narrow the gender gap in patenting in different countries, but these proposals have been tailored to the findings of specific studies.[191] Most studies and proposals relate to the U.S. market and are thus limited to that market.

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. Including 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;[192]

Introducing data tools to track women's patenting activity. The lack of available data on female inventors hampers research on this subject. The Israeli patent office does not collect demographic information on inventors. As our study has clearly uncovered, there is no systematic collection of data on women in STEM in the Israeli academy, and obtaining such data has been a very challenging task. To better follow 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 Israeli academy and to establish methods for studying diversity, such as voluntary surveys and other methods;

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[191] Muireann Bolger, *Senators Unveil Bill to Close 'Patent Gap' Faced by Women*, WORLD INTELL. PROP. REV. (Dec. 3, 2022), https://www.worldipreview.com/news/senators-unveil-bill-to-close-patent-gap-faced-by-women-21136 [https://perma.cc/AWL6-LQ5J].

[192] Miriam Marcowitz-Bitton et al., *supra* note 10; Miriam Marcowitz-Bitton & Emily Michiko Morris, *The Distributive Effects of IP Registration*, 23 STAN. TECH. L. REV. 306 (2020).

Developing networks of support services for inventors. While different resources are available to women in Israel, 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. Networks are extremely helpful for inventors and provide industry contacts, access to various funding sources, technical assistance with research and development, and opportunities to collaborate on projects.[193] Promoting awareness and familiarity with different networks can promote the involvement of and active engagement with women in these groups and lead to greater 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 such as engineering in Israel. Efforts to get more women and girls interested in these fields may be an effective tool in addressing the gender gap. 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;[194]

Supporting family responsibilities. Research in the U.S. and elsewhere shows that the most significant challenge female academic scientists face is balancing work and family obligations.[195] Family-oriented policies, such as stopping the tenure clock around the birth of a child, providing on-site childcare, and making it easier for academic institutes to hire academic spouses, are important changes that can help recruit and retain more women in science.[196]

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[193] *See generally* Jennifer Streeter, *Networking in Academia*, 15 EMBO REP. 1109 (2014).
[194] Vicky J. Rosser, *Faculty Members' Intentions to Leave: A National Study on Their Worklife and Satisfaction*, 45 RSCH. HIGHER EDUC. 285 (2004).
[195] *Id.*
[196] *See* JEAN WALTMAN & LOUISE AUGUST, TENURE CLOCK, MODIFIED DUTIES, AND SICK LEAVE POLICIES: CREATING "A NETWORK OF SUPPORT AND UNDERSTANDING" FOR UNIVERSITY OF MICHIGAN FACULTY WOMEN DURING PREGNANCY AND CHILDBIRTH 1, 3-7 (2004), http://www.cew.umich.edu/PDFs/tcmdrept.pdf.

Women outside of academia face similar issues.[197] 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. Such means should also be adopted to help self-employed women entrepreneurs and inventors;

Creating a variety of institutional incentives to file for patents. Ding et al. show that gender differences in attitudes towards patenting exist.[198] Women academic scientists tend to view the patenting activity as coming at the cost of less time with students, teaching, and university obligations.[199] Men, by contrast, are more likely to feel that commercial activity complements their teaching.[200] Murray & Graham found that many women scientists were ambivalent about commercial science and expressed reservations about the practice.[201] 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. Additionally, behavioral changes, such as requiring inventors to report on their inventions' (un)patentability could encourage patent filing;

Implementing initiatives to enhance gender equality generally. Educational and social initiatives to support gender equality generally and women inventors specifically can help narrow the patent gender gap.

VI. Concluding Remarks

This study has 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 activity

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[197] *See* Tuvia Melamed, *Career Success: The Moderating Effect of Gender*, 47 J. VOCATIONAL BEHAV. 35, 51-55 (1995).
[198] Ding et al., *supra* note 19, at 666.
[199] *Id.*
[200] *Id.*
[201] *See* Murray & Graham, *supra* note 45, at 658-661.

from academia to the industry, using Israeli academia as a case study. Specifically, we examined the filing rates of patent applications by male and female inventors and revealed a gender gap that is more prominent than it appears based on a comparison of faculty representation in the STEM fields of the Israeli academy alone.

This finding calls for further studies to examine the causes of this phenomenon and to formulate solutions for optimizing women's integration in the academic sector, and, in particular, in the technology transfer and commercialization activities of academic institutes. As noted above, 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 commercialization may reduce their exposure to the private market, which can, in turn, affect their professional opportunities.

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