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Gender inventorship equity in patent prosecution

W. Michael Schuster[1,3] & Jordana Goodman[2,3]✉

There are pervasive gender gaps throughout the patent process. Here, we add to the literature by providing an in-depth analysis of gendered outcomes across each stage of patent prosecution. We show that female inventors are more likely to face rejection, experience unsuccessful appeals, and exhibit lower responsiveness to rejections than male counterparts. Not only are women less likely to patent their invention, but each stage of examination individually contributes to a lower aggregate grant rate for female inventors. Our research finds that, unlike small and large entity industry equivalents, university-filed patent applications demonstrate increased gender parity in allowance rates and continued prosecution after rejection. Moreover, small entities—patent applicants with typically smaller budgets—are either more than or equally likely to exhibit gender parity when compared to larger firms. We anticipate this study to be a starting point for a more sophisticated discussion around closing gender gaps in patenting and STEM.

Female inventors patent less than men[1–4]. Whether due to credit differences[5,6], academic longevity[2,7], mentorship[8,9], funding[10,11], or external social and societal factors[12,13], women do not participate in the intellectual property system as much as their male peers.

Though education and employment barriers have long hindered equity in STEM careers, women are now graduating and working in these fields at higher rates than ever before[14,15]. The rate of female patenting, however, is improving at a disproportionately slow pace[16,17]. Many cite financial reasons and other resource constraints for this lack of improvement; women are not funded by venture capital at the same rate as their male counterparts, and women are not as wealthy as men[9,18–21].

We hypothesized that gender gaps exist across each stage of patent prosecution, but this effect will be mitigated for larger entities. All else equal, larger firms have access to greater stores of capital to fully prosecute applications from any inventor—male or female. Moreover, prior research finds elevated patent grant rates for large firms[21,22], which may indicate a willingness to invest the funds necessary to effectively prosecute any worthwhile application. Accordingly, we expected gender disparities to be at their lowest within larger firms. As discussed herein, evidence largely did not support our expectations regarding firm size.

The patent process begins with filing an application at the United States Patent and Trademark Office (USPTO). The USPTO assigns the application to an examiner with subject matter expertise. The examiner determines if relevant patentability standards are met. If so, a patent is immediately allowed (a "first action grant"). If not, the examiner issues a rejection (an "office action") listing the reasons for rejection. In response, the inventors can amend the application and argue for its patentability ("response filed"). Subsequently, the examiner may issue a final rejection—where the applicant must file a request for continued examination (RCE) or appeal the decision to the Patent Trial and Appeal Board (PTAB) to continue the patent process. At any stage, if an inventor does not respond, the application goes abandoned[23].

The pathway to securing a patent is accordingly a function of decisions and behaviors from two parties: the USPTO and the applicant. Examiners decide whether to grant or reject an application. In contrast, other decisions (e.g., whether to respond to a rejection) are made by the applicant. Thus, certain stages of prosecution are influenced by applicant choices, while others center around decisions from the USPTO.

Both industry and the USPTO have worked to close the gender gap. Many firms are increasing female representation, and others participate in childhood STEM education to provide opportunities to learn more about innovation and invention[24]. And while the USPTO cannot control the demographics of those who become inventors, it can provide education about the patent process. For example, a recent USPTO program for unrepresented inventors increased female applicants' grant rates by 16.8 percent[25]. In sum, the USPTO can provide guidance to inventors, while it is up to applicants to internalize and respond to that information. We propose that considering the complementary roles of the USPTO and applicants during patent prosecution is the best way to understand the causes underlying gendered outcomes in this field.

[1]University of Georgia, Terry College of Business, Athens, USA. [2]Massachusetts Institute of Technology; Illinois Institute of Technology, Chicago-Kent College of Law, Chicago, USA. [3]W. Michael Schuster and Jordana Goodman contributed equally to this work. ✉email: jgoodman3@kentlaw.iit.edu

Our analysis finds gender disparities at every stage of prosecution. Female inventors are less likely to respond to a rejection, appeal a final decision, and receive an allowance from the USPTO—collectively contributing to a lower overall patent grant rate for women. As further detailed in the methodology and results section, we control for several independent variables including application continuation status, examiner gender, inventor experience, inventor country of residence, subject matter, small entity status, and filing year.

Evidence did not, however, support our expectation that gender disparities would decrease at large firms. To the contrary, large entities exhibited the greatest gender gaps among the groups studied. One exception to this trend is notable; gendered outcomes did not vary by firm size for first action grants (i.e., patent grants without a previous rejection).

We also find that gender disparities for university applications are mitigated compared to their industry counterparts, and that small entities have lower gender disparities relative to their large entity counterparts. In response, we propose that further studies of the university patent system and its decision-making process may find successful keys to promoting gender parity.

Methodology

We analyzed 5,561,522 U.S. utility patent applications filed from 2001–17 and followed their trajectories until June 21, 2022. USPTO data was used to code for inventor location, grant data, priority claims, entity status, and prosecution history[26].

Demographic data

As the USPTO does not collect demographic data, we ascertained inventor gender by comparing first and middle names to a gender/name database in a manner consistent with prior literature[27]. Specifically, first and middle names were combined into a string, such as "William Michael." This information and the applicant's country were uploaded to the Gender API website—a database containing gender data for over six million names from 189 countries. This source has been previously used in the literature[28]and recognized as a top performing gender-identification service in a benchmark study[29]. Using this database, an inventor was coded as male or female if identified as being at least 70% likely to be that gender. We note that some individuals do not identify as "male" or "female." However, given the current inability to ascertain information outside of binary gender data, we employ this dichotomy[30].

Our approach associated gender information with approximately 92.5% of named inventors and approximately 90% of primary patent examiners. We coded applications for counts of male inventors, female inventors, and those inventors with non-gendered names. From this, we generated a Female Inventor Percentage metric, consisting of the number of female inventors divided by the sum of male and female inventors, to identify gender ratios within inventor groups. This accounts for entirely female teams, entirely male teams, and mixed-gender teams.

For robustness purposes, we employed a second method of ascertaining inventor gender—namely the USPTO's PatentsView Disambiguated Inventor dataset. In that data, the USPTO used an algorithm to incorporate country-specific name lists, inventor migration background, and disambiguation methods to estimate inventor gender[31]. Similar to the above, we used this data to calculate an alternate Female Inventor Percentage.

Subject matter collection

Given the differing grant rates and prosecution strategies in different fields, we coded applications for their technological area. Using USPTO-assigned examination groups, we sorted applications into eight technology categories ("coarse technical categories"), including Biotechnology, Chemical and Materials Engineering, Computer Networks, and Semiconductors. For robustness purposes, we additionally classified applications within 462 different United States Patent Classification (USPC) categories.

Applicant behaviors and funding

Applicant-side behaviors and attributes can drive disparities in patent outcomes. Filings may claim "priority" to earlier filings that disclose the same subject matter, which can affect patenting outcomes. We used a dummy priority variable (if the application made a priority claim to a non-provisional patent application) and coded applications for the earliest year of priority claim. Likewise, we coded applications as a "large entity" or "small entity"—the latter of which entitles applicants to a reduced fee structure and includes micro-entity filings. We note that our data on small entity status reflects the most recent data available as of publication of the dataset, as opposed to at grant or at application. We have no reason to believe this presents any non-random bias in our data. We tagged applications from public firms—companies whose stock is traded on a public exchange—to distinguish startup and established companies. To identify public firm applications, we extracted assignee names from a set of public firm-owned patents[32]and compared them to the first assignee for applications in USPTO data. We additionally identified applications filed by universities using publicly available data[33].

Ability and willingness to pay for legal fees beyond the initial filing may vary by entity and inventor gender. We therefore coded prosecution histories by event—including whether the application received a first action grant (i.e., a grant without the issuance of an office action) or whether the USPTO issued an office action. First action grant rates depend on attributes of the submitted application alone, without factoring in response choice and quality. We also coded applications for whether they responded to an office action, which indicates that the decision maker deemed the potential future patent worth the cost of continuing prosecution. Likewise, we identified applications with RCEs and PTAB appeals. In both instances, the applicant was willing to undertake the additional costs of prosecution after receiving a final office action.

We used USPTO data to identify individual inventors and count the number of patents they secured before filing the subject application. From this, each application was coded for an average inventor experience (i.e., average number of previously granted patents). Data on inventor country of residence and multi-national inventor teams was added. Lastly, we employed a proxy from the literature to control for invention value—namely, the number of countries in which patent protection for an invention was sought[34]. This data was identified by analyzing the filing trends for each family (i.e., series of related applications) in the Google Patents dataset.

Using the above controls, we ran logistic regressions with patent grant as the dependent variable and female inventorship (percent of inventors coded as female) as an independent variable. We identified odds ratios and associated confidence intervals for female inventorship at various stages of patent prosecution. Throughout, we used 95% confidence intervals.

Limitations

We recognize the limitations of our study. First, while several variables proxy for application novelty or value, we cannot directly quantify these attributes. Second, our data set does not include information about patent application funding—including whether inventors secured outside financing for patent prosecution. Because male inventors receive more grants than their female counterparts, this may disproportionately incentivize men to expend funds on continued prosecution in the face of a rejection[6]. Third, our data does not include the gender of the attorney who prosecuted the patent application. Because attorneys interact closely with the patent office—sometimes without significant input from the inventor—a patent application allowance or a rejection may correlate to attorney gender. Finally, our study uses algorithmic analysis to determine gender, which may not always accurately reflect gender identity, especially for non-binary individuals and for Asian first names.

Results

Our data is consistent with prior research findings that applications from female inventors are granted at a lower rate than their male counterparts. The odds ratios in Fig. 1 describe the likelihood of a female inventor team receiving a patent relative to other inventors, accounting for subject matter, entity status, continuation status, country of residence, examiner gender, and filing year, among other variables.

Beyond depicting gender disparities in patenting outcomes, Fig. 1 shows these trends improved during the early period of our study but have since tailed off. An odds ratio of 1 indicates gender parity in grant rate. Applications filed in 2008 were the closest to parity—with an all-female team having a 0.818 odds ratio relative to an all-male team. By 2017, this had dropped to a 0.757 odds ratio.

Figure 1 depicts the odds ratios for female inventor percentage by filing year from a logistic regression where patent grant was the dependent variable. Other independent variables included application continuation status, examiner gender, inventor country of residence, inventor experience, pro se status, national stage entry application, jurisdiction count, coarse technical subject matter controls, small entity status, and filing year. The same controls are used for Figs. 2 and 3 below.

We note two unreported models (using the same variables as Fig. 1) that included only single inventor and multi-inventor applications. Those regressions found that the Female Inventor Percentage odds ratios for single inventor applications (which are either 100% female or 0% female) were slightly higher than multi-inventor instances, where multi-gendered teams could exist. This difference was not, however, significant.

Testing our primary hypothesis, we identified gender gaps across each stage of prosecution. After submission, an application may receive a first substantive response from the USPTO examiner of allowance or an office action containing at least one rejection. Most applications (over 85%) received an office action, requiring inventors to invest additional resources to convince the USPTO to grant a patent. Failure to respond renders the application abandoned. Prior literature stated that female inventors or their advocates are less willing to engage in these negotiations[3]. We explore this proposition empirically.

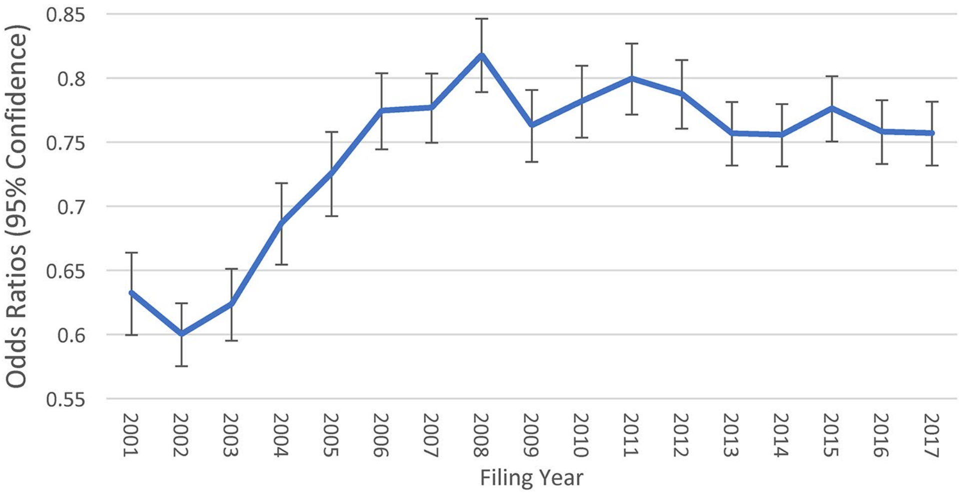

Fig. 1. Female inventor percent odds ratios by year (dependent variable: patent grant)

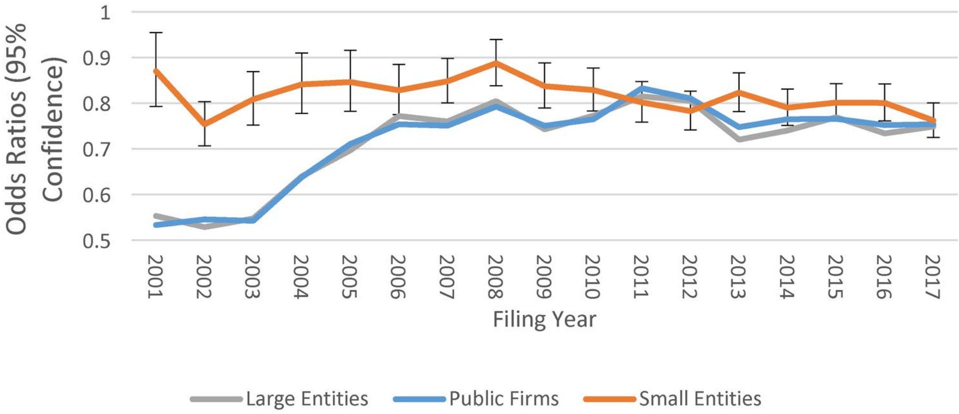

Fig. 2. Logistic odds ratios: female inventors (dependent variable: patent grant)

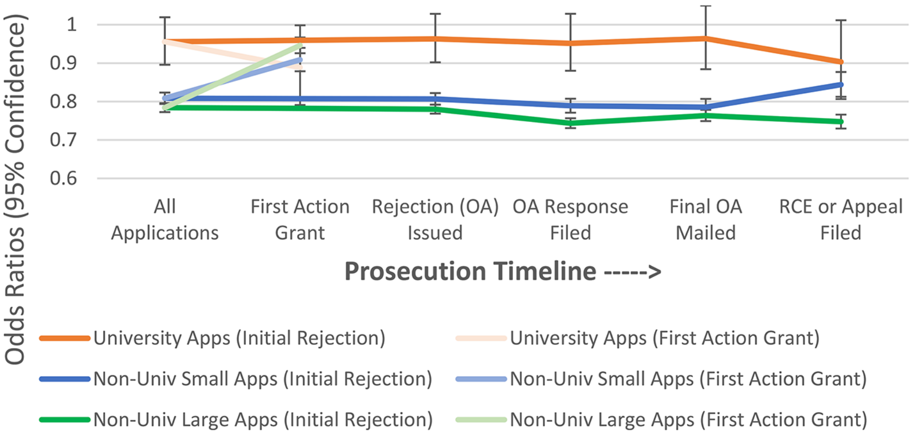

Fig. 3. Female inventor percent odds ratios during prosecution (dependent variable: patent grant)

Table 1 presents logistic regression results for two pathways: first action grants and office action rejection. If a first action grant is not issued and the applicant receives a rejection, then responding to the office action shows the applicant's willingness to negotiate with the USPTO. Applicants need not respond to a first action grant, other than paying an issue fee. Models 1, 2, 4, and 5 control for coarse technical categories, and for robustness purposes, Models 3 and 6 use all USPC classes. For the same reason, Models 2 and 4 use our alternative means of identifying inventor gender.

Table 1 (Models 4–6) shows evidence of gender disparities in first action grant rates (female inventors percentage odds ratios of 0.843, 0.903, and 0.954, respectively). Stated plainly, female inventors' applications receive fewer first action grants than their male counterparts.

Removing those immediately granted applications, regressions in Models 1–3 present evidence that female inventors are less likely to continue prosecution after receiving a rejection (odds ratios of 0.876, 0.863, and 0.904, respectively).

Combined, Models 1–6 show that both the choice to respond to a rejection and initial application attributes (i.e., first action grant) may be mechanisms driving gender differences in patent grant rate.

Unreported models regressing solely on Female Inventors % are similar, with an odds ratio of 0.725 for office action response and 0.636 for first action grant. Additional unreported versions of Model 1 and Model 4 used a log transformation of total inventors. Female Inventors % results were similar (0.869 odds ratio for office action response and 0.843 for first action grant).

We then investigated whether larger entities have reduced gender gaps. Small entities and micro-entities are individual inventors, small business concerns, and non-profits, and they typically have smaller intellectual property budgets than their larger counterparts. In 2023, the highest patenting small entities—the University of California and State University System of Florida—received 546 and 391 patents, respectively. This contrasts with Samsung Electronics and LG Corporation who received 9,036 and 4,170 patents[35].

We analyzed differences between public firms, small entities, and large entities. Smaller entities—including universities—likely have fewer resources dedicated to patent prosecution, which can lead to abandonment of disfavored applications[36]. If female inventors receive disproportionately negative treatment due to monetary concerns, we can expect lower odds ratios for women among small entities. In contrast, larger entities and public

(Logistic regressions)	Dependent variable: office action response			Dependent variable: first action grant		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Number of Observations	4,614,635	4,928,081	4,614,604	5,211,277	5,561,497	5,211,151
Pseudo R Squared	0.0714	0.0731	0.079	0.0378	0.0379	0.0639
Female Inventors %	0.876 (0.005) ***	0.863 (0.005) ***	0.904 (0.006) ***	0.843 (0.006) ***	0.903 (0.006) ***	0.954 (0.007) ***
Total Inventors	1.039 (0.001) ***	1.038 (0.001) ***	1.039 (0.001) ***	0.989 (0.001) ***	0.986 (0.001) ***	0.992 (0.001) ***
Continuation App	1.073 (0.004) ***	1.071 (0.004) ***	1.064 (0.004) ***	1.228 (0.004) ***	1.209 (0.004) ***	1.282 (0.005) ***
Female Examiner	0.970 (0.003) ***	0.970 (0.003) ***	0.988 (0.003) ***	0.755 (0.003) ***	0.751 (0.003) ***	0.821 (0.003) ***
Small Entity	0.406 (0.001) ***	0.406 (0.001) ***	0.423 (0.001) ***	0.898 (0.003) ***	0.906 (0.003) ***	0.956 (0.004) ***
Multi-Country App	1.009 (0.006)	1.022 (0.006) ***	1.008 (0.006)	0.940 (0.005) ***	0.945 (0.005) ***	0.95 (0.006) ***
Pro Se	0.469 (0.002) ***	0.472 (0.002) ***	0.473 (0.002) ***	0.956 (0.005) ***	0.950 (0.005) ***	0.947 (0.005) ***
University App	2.072 (0.022) ***	2.104 (0.022) ***	1.981 (0.021) ***	1.032 (0.013) *	1.031 (0.012) **	1.038 (0.013) **
Inventor Experience	1.001 (0.000) ***	1.000 (0.000) ***	1.000 (0.000) ***	1.000 (0.000) ***	1.000 (0.000)	1.0 (0.0) ***
Country Count	1.066 (0.001) ***	1.067 (0.001) ***	1.068 (0.001) ***	1.005 (0.000) ***	1.004 (0.000) ***	1.003 (0.0) ***
National Stage Entry	0.745 (0.003) ***	0.755 (0.003) ***	0.748 (0.003) ***	0.870 (0.004) ***	0.857 (0.004) ***	0.883 (0.004) ***
Coarse Tech Dummies	x	x		x	x	
USPC Tech Dummies			x			x
Priority Year Dummies	x	x	x	x	x	x
Alternate Gender ID		x			x	
IP5 Country Dummies	x	x	x	x	x	x
Constant	5.362 (0.069) ***	5.249 (0.068) ***	7.267 (0.179) ***	0.120 (0.001) ***	0.125 (0.001) ***	0.081 (0.003) ***

Table 1. Logistic regression of office action response and first action grants ***p < 0.001, **p < 0.01, *p < 0.05 (Standard errors in parentheses.).

firms would be less likely to abandon applications over monetary concerns. For example, the odds ratios are below 0.43 for small entities in Models 1–3 of Table 1 when regressing on whether an applicant responded to a first office action.

Analysis does not support the proposition that diminished access to prosecution funds (proxied through small entity status) hinders gender parity in patenting outcomes. As shown in Fig. 2, small entities fared better than large entities for gender parity. Large entities exhibited an overall female inventor odds ratio of 0.726 (±0.008, 95% confidence) and public firms had a ratio of 0.731 (±0.010). These are both significantly less than the 0.812 (±0.012) for small entities. Further, the significant difference remains even if we exclude university applications from the group of small entities, with small/non-university applications returning a female inventor odds ratio of 0.805 (±0.012). This is notable, as applications from universities exhibit a particularly high female inventor odds ratio of 0.913 (±0.050)—a trend that is further explored below.

We next calculated female inventor odds ratios for different entities after multiple points during prosecution—including application filing, issuance of a first office action, response to an office action, issuance of a final office action, and the filing of an RCE or appeal. This explores whether gendered outcomes pervade the entire patent prosecution process. We further expand this inquiry to analyze applications filed by universities, in addition to large and small entities (excluding university filings).

As shown above, the aggregate female inventor odds ratio for universities (0.926) is significantly higher than their industry counterparts (0.807 for small and 0.728 for large non-university entities), although all are less than 1 (parity). This is not, however, because universities have an overall higher grant rate. Indeed, within our sample, university applications were granted 69.6% of the time compared to 69.7% for industry (including 54.9% for small and 74.4% for large entities).

Moreover, Fig. 3 does not present evidence that university applications are better for gender parity at filing. Female inventor odds ratios are not significantly different between industry (large or small) and university applications when looking only to first action grants. This suggests that the initial attributes of university and industry applications are not differently gendered.

Data supports the contention that the differences by gender by applicant type arise from applicant choices made after filing. At all points after the USPTO issues an initial rejection, university applications exhibit greater gender parity. Further, small entities are more likely to continue prosecution of a female-inventor application relative to larger firms.

Figure 3 further presents evidence that—as the prosecution process continues—disparities between male and female inventors diminish. The decision to respond to a final office action and file an RCE or appeal both require significant additional monetary investments. In the complete set of 1,531,716 applications filing an RCE or appealing to the PTAB from our data, female inventors were less likely to receive a grant (odds ratio 0.763). This odds ratio, however, is significantly greater than the one for all applications that engaged in negotiations with the USPTO (i.e., filed a response to an office action). Indeed, considering all applications in our dataset, we see a significant increase in female inventor odds ratio from filing of an office action response (0.732 ± 0.008, 95% confidence) to the filing of an RCE or appeal (0.763 ± 0.013).

We note that applicants may occasionally file an RCE after receiving a Notice of Allowance (NOA). In such a case, the applicant is most likely to be seeking review of more prior art before the application issues. This arguably stands in contrast to an RCE that is filed to continue to argue that a patent should actually be granted, which can include substantial amendments to the patent claims. Accordingly, we ran the above models for RCE or Appeal Filed, both with and without any applications where an RCE was filed after a NOA was issued. The data did not change in a meaningful manner; the relationships of the different groups remained the same, as did the differences in odds ratios. Specifically, the odds ratio for university applications was 0.940 without post-NOA RCEs (from 0.926), non-university small applications was 0.875 (from 0.861), and non-university large applications was 0.733 (from 0.723).

Findings across each stage of the patent prosecution process and through multiple analytical perspectives support the proposition that female inventors are treated more equitably in applications that warrant the costs of extensive prosecution (e.g., filing a RCE or PTAB appeal). Indeed, for university applications, the odds ratios for percent female inventors begin to fall outside standard thresholds for statistical significance as prosecution continues. P-values for percent female inventors for university applications for rejection issued, office action response filed, final office action mailed, and RCE or appeal filed were 0.058, 0.077, 0.410, and 0.122, respectively. All other odds ratios were significant within standard thresholds.

Conclusion

This study highlights gender disparities throughout the patent prosecution process. Female inventors face higher rejection rates and are less likely to respond to rejections than their male counterparts. The initial rejection rate is equal across entities, in that there is no significant difference between the likelihood of initial patent grant for female inventors inventing for large entities, universities, or other small entities. The differences in gender parity among various entities during patent prosecution are statistically significant. Specifically, university entities show the highest level of gender parity after a patent rejection, while large entities exhibit the lowest level of gender parity. Non-university small entities display gender disparities that are greater than those of universities but less pronounced than those of large entities. Evidence supports the proposition that larger entity size does not correlate to increased gender parity.

This study also presents evidence that gender disparities may decrease as patent prosecution progresses—particularly in cases where inventors engage in extensive prosecution, such as filing a RCE or an appeal. Because gender disparities vary across different stages in patent prosecution and are substantially different in university prosecution than other similar entities, we recommend that future patent studies work to identify disparities within each stage of the patent prosecution process. We further recommend studies differentiate between stages within an applicant's control—like the decision to respond to a rejection—and stages within the USPTO's control, like the decision to reject an application. Finally, we recommend further study of university patent prosecution policies after receiving a rejection, as we identified this entity as more equitable in their patent prosecution than their industry counterparts.

Data availability

Data is provided within the manuscript or supplementary information files. All databases used in the paper, including PatEx, PatentsView, and GenderAPI, are publicly available resources and can be found at https://www.uspto.gov/ip-policy/economic-research/research-datasets/patent-examination-research-dataset-public-pair, https://www.uspto.gov/ip-policy/economic-research/patentsview, and https://www.genderapi.io/, respectively.

Publication funding was supplied by the MIT Libraries and the University of Georgia's Terry College of Business.

Received: 18 September 2024; Accepted: 21 November 2024
Published online: 15 January 2025

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Additional information

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-024-80796-2.

Correspondence and requests for materials should be addressed to J.G.