To Grant or Not to Grant: Inventor Gender and Patent Examination Outcomes*

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Abstract

We explore the existence and causes of gender disparities in the patent examination process. We find that applications filed by female inventors are significantly less likely to receive a first-action approval or a final granting than those filed by male inventors. Consistent with the 'gender bias' hypothesis, the female disadvantage in patenting becomes smaller when inventors' gender is less likely known to examiners. Moreover, the economic value of patents granted to female inventors is significantly higher, suggesting that women must clear a higher hurdle to secure a patent compared to men. Additionally, we find that women are significantly more likely than men to abandon their applications after receiving a rejection in the first-action decision, lending support to our 'lack of persistence' hypothesis. Our findings shed light on the causes of gender differences in patent examination and offer implications for policies aimed at creating a level playing field in patenting.

JEL Classification: J16, O31, O38
Keywords: Gender Gap; Gender Bias; Patent Examination; Innovation; Statistical Discrimination

1. Introduction

Understanding women's role in the labor market is critical for society… If women do not have the same advantages and opportunities as men, or they participate on unequal terms, labor, skills, talent go wasted.

- Jakob Svensson (Chair, Economic Sciences Nobel Prize Committee 2023)

Gender disparities have received great attention from economists, sociologists, and policymakers in the past few decades. For example, a large body of literature has examined the causes and effects of female labor participation (Fernandez et al., 2004; Guzman and Kacperczyk, 2019), the gender pay gap (Bertrand, Goldin, and Katz, 2010; Blau and Kahn, 2017; Davis et al., 2022), glass ceilings faced by women (Adams and Funk, 2012). Recently, there have been increased studies in finance that examine gender diversity in C-suite and corporate board and its impact on corporate decision-making and firm performance (Duchin, Simutin, and Sosyura, 2021; Tate and Yang, 2015; Adams and Ferreira, 2009; Bernile, Bhagwat, and Yonker, 2018; Knyazeva, Knyazeva, and Naveen, 2021).

In this study, we focus on the gender gap in patenting, a topic that has received less attention in literature. Innovation activities are crucial drivers of economic growth (Romer 1986) and firms' long-term competitive advantage (Porter 1992). Patents, a common measure of innovation output, have been shown to contribute substantially to the financing, innovation, productivity, and profits of their holders (e.g., Farre-Mensa et al., 2020; Kogan et al., 2017). Despite the importance of patents on the economy and individuals, women are significantly underrepresented in patenting. According to the USPTO, the number of patents with at least one woman inventor increased from about 7% in the 1980s to 21.9% by 2019 (Toole et al., 2020), though women constitute over half of the college-educated workforce. Only a small proportion of this underrepresentation is explained by women's lower probability of holding a science or engineering degree (Hunt et al., 2013).

Despite the large attention inventor gender gap has received from the USPTO and the public, there is limited understanding regarding the main factors attributed to the gender disparity in patenting. Jensen et al. (2018) document that all women inventor teams are 7% less likely to receive a patent than all men teams, and this difference rises to 11% in the life sciences. Aneja et al. (2021) show that female inventors are 5.9–10.4% more likely to give up patent applications during the examination process due to a lack of legal expertise and supports. Koning, Samila, and Ferguson (2021) show that female inventors tend to develop female-focused inventions. Employing a randomized control trial at the USPTO that was designed to offer extra help to applicants who do not have legal representation, Pairolero et al. (2022) find that women applicants benefit from the trial to a greater extent than men applicants do, increasing their chances of obtaining a patent by an additional 11%.

Employing a large dataset of U.S. patent applications during 2001 through 2017, we investigate the presence and causes of gender disparities in the patenting process, focusing on the conversion of patent applications into granted patents. We propose a 'gender bias' hypothesis in which women's applications receive less favorable outcomes due to stereotype bias or statistical discrimination during the examination process. Due to imperfect information about patent quality, examiners might use statistical data on gender groups to infer individual inventor quality when examining female and male applications.

We find that applications with a higher proportion of female inventors are significantly less likely to receive a first-action allowance and have a lower chance of final approval. In terms of economic magnitudes, patent applications with a majority-female inventor team are 6.4% less likely to be granted than the applications that are filed by a majority-male inventor team. Majority-female-inventor applications are 14.5% less likely to receive first-action allowance than those with a majority-male team. Overall, the results indicate significant gender disparity in patent examination outcomes.

A potential explanation of the gender disparity in patenting is that it may reflect differences in the quality of patent applications, which are resulted from gender-based differences in abilities or preferences (e.g., risk-aversion, persistence in competing). Though we have controlled for application quality by including various application and inventor team characteristics as well as the triple $ArtUnit \times Subclass \times Year$ fixed effects, there may still be unobservable differences in the quality between female and male applications. To address this issue further, we compare findings between subsamples of applications with commonly used or rarely used inventor names. For rare names that only a few people ever used, examiners are less able to determine an inventor's gender based on the name alone. If our results are driven by gender bias or discrimination, we expect that the female inventor disadvantage would be weakened among rare-name applications. Conversely, if these documented disparities result from gender-based differences in factors like ability or preferences, which is unlikely to be correlated with name rarity, we expect the female inventor disadvantage to remain the same regardless of name commonality. We find evidence consistent with the 'gender bias' hypothesis. While solo-inventor applications authored by a woman are significantly less likely to receive first-action allowance and final approval in the subsample of applications filed by inventors with common first names, the female disadvantage becomes significantly smaller among applications whose solo-inventors have a rare name.

We next investigate whether the gender bias manifesting in patent examination outcomes arises from statistical discrimination—a phenomenon most pervasive when evaluators possess insufficient information for quality assessment. As inventors have a track record in patenting, examiners have less difficulty in evaluating the merit of the applications, hence are less likely to rely on statistical information of the gender group to infer individual patent quality (Arrow, 1974; Phelps, 1972), yielding a lesser gender gap. We also find that gender disparities in patenting is significantly attenuated among applications reviewed by examiners who have had greater prior experience with female patents, hence having a better ability to discern quality in the presence of imperfect information. The findings imply that the gender disparities in patenting are a result of statistical discrimination.

Furthermore, we find that granted patents held by women are associated with a significantly higher economic value. To the extent that patent value reflects the quality of inventions, this result demonstrates that women must overcome a higher hurdle than men in patenting, and consequently that average patent granted to a woman is of higher quality than the average patent granted to a man.

Finally, we delve into the 'lack of persistence' hypothesis, which is not mutually exclusive to the 'gender bias' hypothesis. The patenting process typically spans 2–3 years and requires several rounds of review and revision (referred to as 'amendment') or appeal. Consequently, the outcome of a patent examination is determined not only by the examiner's leniency but also by the inventor's tenacity in revising applications and filing amendments. We explore the potential gender difference in persistence throughout this examination process. Prior research demonstrates that women tend to display a heightened aversion to negative feedback, often causing them to recede from competition (Avilova and Goldin, 2018; Buser and Yuan, 2019). We examine the propensity for female and male inventors to file amendments following a non-final rejection during the first-action decision, using a Heckman selection model to correct for differences in the probability of female and male applications being sorted into the non-final rejection group. We find that, conditional on receiving a non-final rejection, female inventors are significantly less likely than their male counterparts to file an amendment. This discrepancy is mitigated among applications with greater resources and support — those that use a patent agent or are associated with a public traded company.

Our work is related to three strands of literature. First, it contributes to the literature on gender gaps in the labor market, such as labor participation of women (Fernandez et al., 2004), gender pay gap (Blau and Kahn, 2017; Davis et al., 2022). A nascent body of work delves into the gender gap among highly skilled professionals, particularly in the realm of patenting and innovation (Jensen et al., 2018; Pairolero et al., 2022; Aneja et al., 2021). Different from prior studies, our paper sheds new light on the causes of gender differences in the examination process through which patent applications are converted to granted patents. Our findings reveal that this gender gap emanates from two sources: 1) gender bias against female inventors, rooted in statistical discrimination in the examination process; and 2) a relative lack of persistence amongst female inventors with regard to amending their applications. By examining samples with rare versus common inventor names, we disentangle the effect of gender bias from the confounding effect arising from patent quality correlating with gender. Focusing on the likelihood of filing amendments in response to non-final rejections during initial evaluations allows us to dissect the "lack of persistence" hypothesis more closely.

Second, our paper speaks to the literature studying gender differences within organizations, as well as potential reasons for such disparities. For example, Guzman and Kacperczyk (2019) demonstrate that the gender gap in entrepreneurship is partly attributed to statistical discrimination. Lagaras et al. (2023) find that the gender pay gap in finance is predominantly explained by more skilled male employees sorting into finance. Cortés et al. (2023) study the divergences in job-seeking behaviors among genders and find that women tend to accept job offers much sooner than men, thus yielding an earnings gap. These gender differences can be explained by women's greater risk aversion and men's over-optimism. Our study unveils two explanations for the observed gender differences in patent examination outcomes— statistical discrimination and gender-based preferences. Discerning the causes of gender disparities allows policymakers (e.g., USPTO) to refine the patent examination process, consequently fostering enhanced outcomes for women in patenting.

Lastly, we add to the literature documenting gender differences resulted from psychological traits and preferences between the genders. For example, women tend to be more risk averse than men (e.g., Cortés et al., 2023), display greater modesty (e.g., Kuppuswamy and Mollick, 2016), fare less successfully in competitive environments (e.g., Gneezy et al. 2003), demonstrate a higher work quality (e.g., Hedge and Raj, 2023), and be more inclined to withdraw from competition following a loss (Avilova and Goldin, 2018; Wasserman, 2023). Our study shows that the differential responses by gender to the negative feedback in the early stage of the patent examination process contribute significantly in shaping the gender disparity within the realm of innovation.

The rest of the paper is organized as follows. In section 2, we describe the institutional background of patent examination at the USPTO and develop our research hypotheses. Section 3 describes the data and methodology. Section 4 presents the results, and section 5 concludes the paper.

2. Institutional Background of Patent Examination and Hypothesis Development

2.1 Patent Examination Process

We examine gender differences in the U.S. patent examination process through which patent applications are converted to granted patents. A patent application contains a group of claims outlining the legal rights that the inventor is aiming to obtain as well as disclosure of existing patents related to the patentability of the invention ("prior art"). After the applicant submits the application to the USPTO and pays the submission fees, the office will review it for completeness. Then, the application is given an initial technology classification and assigned randomly to one of the examiners who are responsible for that technology group (Art Unit).[1] The initial application fees generally entitle the applicant to two rounds of examination. During the first round, the assigned examiner will read and understand the application, and conduct a "prior art" search for earlier material related to the claimed invention. The examiner evaluates the viability of inventor's claims with respect to eligible subject matter (35 U.S.C. 101), novelty (35 U.S.C. 102) and non-obviousness (35 U.S.C. 103) and decides whether to accept the patent claims. The majority of applications (over 90%) are rejected in the first round of examination (first-action decision). The examiner issues an action document (first-action letter) mailed to the applicant, in

[1] Every art unit is led by a supervisory patent examiner, who verifies the technological classification of a patent application, and assigns it to an examiner in her/his art unit. Lemley and Sampat (2012) show that some art units assign applications using a "first-in-first-out" rule, whereas others use the last digit of the (randomly assigned) application serial number to assign patents. Though the assignment process varies from one art unit to another, the assignment methods used by the USPTO are consistent with that applications are assigned to examiners randomly in regard to the quality of the application or of the applicant. (e.g., Lemley and Sampat 2012; Sampat and Lemley 2010; Sampat and Williams 2019).

which she/he details the reasons for rejection (including restriction required[2], non-final rejection, or final rejection), or an allowance if the patent is granted. Applicants may respond to an initial or any subsequent rejection including final rejection by amending their claims or submitting appeals. Patent applications are not terminated until the inventor implicitly or explicitly abandons the application (Lemley and Sampat, 2008).

Figure 1 summarizes the patent evaluation process. Among the 1,893,325 applications in our sample, a mere 7.6% are granted after the first round of examination (first-action allowance), while the majority of 92.2% are confronted with a non-final rejection and a very small fraction (0.2%) receives a final rejection. Among those applications that are awarded a non-final rejection, 18.4% are ultimately abandoned; that is, the applicant fails to file an initial amendment in response to the examiners' comments. Among the remaining 81.6% applications in which the applicants file an initial amendment, nearly 70% are conferred patents within the second round of examination. The rest receives a 'final rejection,' whereby applicants retain the opportunity to continue addressing examiner comments by amending their claims and paying additional fees until they satisfy the examiner.

Figure 2 presents the same graph but separately portraying the applications from all-female and all-male inventor teams, which accounts for 86% of all applications in our sample. The applications authored by women exhibit a lower probability of obtaining first-action allowance than those authored by men (5.8% vs. 8.0%). Conditional on receiving a non-final rejection, female inventors are less likely to file an initial amendment (74.4%) than male inventors (81.8%). In essence, women are more inclined to abandon their applications following a non-final rejection

[2] This first-action decision refers to the cases in which the patent application's claims are focused on multiple independent inventions so the claims are required to be restricted to one patent, which can be considered as a special form of non-final rejection.

upon first-action decisions. Such a gender difference continues to manifest in subsequent round of patent examination, culminating a diminished patent grant rate for women (48.2%), as opposed to the 61.9% for men.

2.2 Hypothesis Development

We propose two non-mutually exclusive mechanisms contributing to gender disparities in patenting. The first one we consider is the 'gender bias' hypothesis. Theories of discrimination propose that gender disparities arise because of discrimination or negative stereotypes about gender (Ridgeway and Correll, 2006; Castilla, 2008). This mechanism might be particularly pervasive during the patent examination process for a couple of reasons. First, occupational schemas and stereotypes linked to patenting and invention evoke biases against females, as STEM activities and innovation are predominantly viewed as male-centric pursuits (Guiso et al. 2008; Carrell, Page, and West 2010). Goldin's (2015) pollution theory of discrimination argues that discrimination in labor market is a result of men's desire to maintain their occupational status and prestige. In essence, the low presence of women in patenting leads to the perception that they are less competent or less "normal" inventors, hence placing female inventors at a disadvantage. For example, Bordalo et al. (2019) find that both men and women underestimate the ability of women relative to their male counterparts within male-oriented activities. Secondly, sociological literature highlights individuals' predilection for homophily and similarity-attraction – an innate affinity for connecting with others who exhibit comparable demographic traits (e.g., McPherson et al., 2001). Whittington (2018) show that men (women) tend to include more men (women) in their collaborations in developing patents. Sherman and Tookes (2022) document that female faculty in finance tend to have *more* woman coauthors than their male colleagues. Considering the preponderance of male patent examiners, homophily and in-group biases (e.g., Tajfel and Turner, 1979) could lead to more (less) favorable patenting outcomes in male-led (female-led) applications. Therefore, we state our first hypothesis in the alternative form:

H1: Patent applications filed by female inventors receive less favorable patent examination outcomes.

Moreover, theories of statistical discrimination in particular indicate that stereotypes emerge in the presence of limited or ambiguous information, promoting economic agents rely on statistical information of the group to infer individual quality (Arrow, 1974; Phelps, 1972).[3] Specifically, prior research has demonstrated that the reliance on ascriptive characteristics decreases when more information about quality is available to evaluators (Simcoe and Waguespack, 2011; Bohren et al., 2019), or as evaluators are more experienced and have a higher ability to discern quality. For example, Botelho and Abraham (2017) find that evaluators become less inclined to base their judgments on gender when they possess a wealth of information about individual performance. Utilizing field experiments, Bohren et al. (2019) show that in dynamic environments where individuals repeatedly execute tasks, discriminatory tendencies towards women diminish as prior evaluations are available. Consequently, we expect the gender gap in patenting decreases as inventor teams present a credible signal of their abilities or when examiners acquire greater experience with female innovations. In light of these considerations, we put forth our second hypothesis in the alternative form:

H2: The gender disparities in patenting outcomes decline when inventors can better signal their ability or when examiners are more capable of evaluating patents.

[3] Statistical discrimination is belief-based, hence different from taste-based or preference-based discrimination that focuses on the role of prejudice (e.g., racism, sexism) to describe disparities in economic outcomes between demographic groups (Bohren et al, 2019).

The second catalyst for gender disparities in patenting emerges from the divergent tenacity exhibited by genders throughout the examination process – an attribute denoted as the "lack of persistence" hypothesis. Spanning approximately 2-3 years, the patenting journey encompasses many cycles of assessment and revision, known as amendments or appeals. Consequently, the final outcome for patenting hinges upon the diligence and steadfastness displayed by inventors in revising their applications and filing amendments.

Prior literature in experimental economics has explored difference in preferences and behaviors between women and men, thereby elucidating potential explanations for disparities observed in career selections and labor market outcomes (Bertrand, Goldin, and Katz, 2010; Lagaras et al., 2023). Stemming from laboratory experiments, Bordalo et al. (2019) show that women are less self-confident than men. Studies by Gneezy, Niederle, and Rustichini (2003) and Niederle and Vesterlund (2007) show a diminished willingness to engage in competition among females in comparison to their male counterparts. Drawing upon both lab experiments and field data from the Dutch Math Olympiad, Buser and Yuan (2019) document that girls are more likely than boys to quit competing after they lose in the earlier round. Wasserman (2023) highlights that female political candidates are 50% more likely to abandon election after initially suffering a defeat when compared with male candidates. The evidence suggests a heightened aversion amongst women toward receiving negative feedback (Avilova & Goldin, 2018). Therefore, we expect women inventors are more inclined to abandon the process of amending their patent applications as they encounter a rejection upon the first-action decision, compared to their male counterparts. This would contribute to the lower patent grant rate for women. Thus, we state our third hypothesis in the alternative form below:

H3: Conditional on receiving a non-final rejection upon the first-action decision, female inventors are less likely to file an amendment than male inventors.

3. Data and Methodology

3.1 Data and Variables

3.1.1 Our Sample

Our patent data are from two sources. The first is the Patent Examination Research Dataset (PatEx), which provides detailed information on U.S. patent applications and grants, along with their entire examination histories up to 2020. The second data source is the USPTO PatentView database, which covers assignee information, inventor name and location, technological classifications, and citations.[4] We focus on all utility patent applications filed at the USPTO between 2001 and 2017. We start our sample in 2001 because the PatEx dataset provides full coverage of all patent applications starting from that year (Jensen et al., 2018). We end the sample period in 2017 to mitigate data censoring issue since it typically takes 2-3 years for a patent to be granted after its application (Hall, Jaffe, and Trajtenberg, 2001). Following prior literature, we also exclude re-exam, re-issue, and provisional patent applications, as they may be handled differently in the examination process (Jensen et al., 2018; Graham et al., 2018).

3.1.2 Identify Inventor Gender

To identify inventor gender, we use name-gender dictionaries to infer gender based on inventors' first names, as done by Jensen et al. (2018) and Whittington (2018). Several data sources inform our gender inferences. Firstly, the U.S. Social Security application record provides

[4] Available at https://patentsview.org/.

applicant first name counts with corresponding genders. We employ a conservative method to avoid coding errors for unisex names, coding an inventor as female (male) only if their first name is used by a woman (man) more than 95% of the time. For example, if 65% of people named Jody are women, we do not assign a gender to inventors named Jody. If gender cannot be identified through this approach, we then use the second data source—genderize.io—an online service that gathers data from social media—to determine the gender distribution for each name while maintaining a 95% cutoff.

Using these filters, we are able to infer gender for about 90% of our sample inventors. To ensure the accuracy of calculating the percentage of female inventors in each team, we exclude patent applications where at least one inventor's gender cannot be identified. Consequently, our sample consists of 82% of the applications with clearly identifiable genders for all inventors, totaling 3,212,440 utility patent applications filed from 2001 to 2017.

3.1.3 Patenting Outcome Variables

We examine the effect of inventor gender on the patenting outcomes. Following Carley et al. (2015), we construct two measures of patent allowance: (1) a dummy variable, *First-Action Allowance*, which equals one if the application is approved (granted) upon the first-action decision, and zero otherwise; (2) a dummy variable, *Patent Granted*, which equals one if the patent is ultimately granted, and zero otherwise.

3.2 Empirical Setup

We estimate the inventor's gender effect on the patent application outcome using the following regression model:

$$Application\ Outcome_{i,j,k,t} = \beta_0 + \beta_1 Female\ Inventor_{i,t} + \lambda Application\ Characteristics_{i,t}$$
$$+ \phi Examiner\ Characteristics_{j,t} + ArtUnit \times Subclass \times Year_{k,t} + \epsilon_{i,t} \quad (1)$$

where *i* indexes application, *j* indexes examiner, *k* indexes the application's technology art unit subclass, and *t* is filing year. The dependent variables for patent application outcome are *First-Action Allowance* and *Patent Granted*. We estimate Probit models as both dependent variables are binary.

We use various measures of female inventor participation in a patent as independent variables: (1) the proportion of female inventors listed on a patent application (*Prop. Female Inventor*); (2) a dummy variable equal to one if at least 50% of the inventor team are females and zero otherwise (*Majority Female Inventor*); (3) a dummy variable equal to one if the entire inventor team consists only of females and zero otherwise (*All Female Inventor*); (4) a dummy variable equal to one for all-female inventor teams and zero for all-male inventor teams (*All Female Inventor-Non-Mixed Team*), focusing on non-mixed-gender teams; and (5) a dummy variable equal to one if there is a solo female inventor and zero if there is a solo male inventor (*Solo Female Inventor*), focusing on patent applications with only one inventor.

Following the prior literature, we include a wealth of control variables. We follow Hedge et al. (2022) and construct two measures of examiner characteristics: (1) *Examiner Scope Leniency*, calculated as the total number of independent claims of all patents that an examiner has granted in a specific art unit in the past, divided by the total number of all patents she has reviewed;[5] and (2) *Examiner Review Speed*, which is the average time lag in days per patent between application to

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[5]Specifically, $Examiner\ Scope\ Leniency_{i,j,a,\tau} = \frac{\#independent\ claims\ granted_{j,a,\tau}}{\#patents\ granted_{j,a,\tau}}$, where $\#independent\ claims\ granted_{j,a,\tau}$ is the number of independent claims of all granted patents examined by the examiner j before the first-action date τ of the focal patent application i, and $\#patents\ granted_{j,a,\tau}$ is the number of patents that the first-action has been made prior to τ.

first-action decision of all applications previously reviewed by the examiner.[6] Following Jensen et al. (2018), we also include a measure of examiner experience—*Ln(1+ Examiner Experience)*—defined as the natural logarithm of one plus the total number of patent applications reviewed by the examiner before the focal application. Our application-level controls include indicators for small entity (*Small Entity*), whether the application has foreign priority (*Foreign Priority*), foreign applicant (*Foreign Applicant*), whether it is filed as a continuation of a previously filed patent (*Continuation*). We also control for the number of inventors in the application (*Number of Inventors*), whether the application is filed by only one inventor (Solo Inventor), the number of initial claims on the application (*Initial Num. of Claims*), and the inventor's past patenting experience (*Inventor Experience*). Complete variable definitions can be found in Appendix A.

In addition to art units representing broad technology groups, patents are further categorized into smaller subclasses within the U.S. Patent Classification (USPC) system. Our sample consists of a total of 741 art units and includes 1 to 3,295 subclasses per unit, culminating in 104,578 unique subclasses. A primary concern is that female and male inventors may be sorted into different invention fields, resulting in varying patenting outcomes due to patent quality or field-specific attributes. There are substantial variations in patent grant rate across Art Unit. For example, 86.9% of patent applications were granted during 2001 to 2017 in the *Semiconductors/Memory* industry (Art unit of 2817), where only 6.3% of applications have at least one female inventor. On the other hand, the grant rate was only 49.5% in the *Immunology, Receptor/Ligands, Cytokines Recombinant Hormones, and Molecular* industry (Art unit of 1643)

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[6]Specifically, $Examiner\ Review\ Speed_{i,j,a,\tau} = \frac{t_{first-action\ time}{}_{j,a,\tau}}{\#patents\ reviewd_{j,a,\tau}}$, where $t_{first-action\ time}{}_{j,a,\tau}$ is the total first-action time taken by examiner j across all applications he/she reviewed before the first-action date τ of the focal patent application i, and $\#patents\ reviewd_{j,a,\tau}$ is the total number of patent applications review by examiner j prior to τ.

during the same period, where about 48.3% of applications have at least one woman inventor. To address potential discrepancies across distinct technology categories, we follow Hedge and Raj (2019) by incorporating ArtUnit×Subclass×Year fixed effects in all regressions with standard errors clustered at the ArtUnit×Subclass×Year level. Nonlinear models like Probit regression drop all observations within each $ArtUnit \times Subclass \times Year$ group in which the dependent variable is non-varying, e.g., *Patent Granted* is equal to one for all applications within a subclass in an art unit in a year. As a result, our final sample used in analyses is reduced to 1,893,325 patent applications filed during 2001 and 2017.

Table 1 presents the summary statistics of our final sample. Regarding inventor gender distribution, among the 1,893,325 applications, the average number of inventors per application is 2.37, with a median of 2 inventors. About 17% of our sample have at least one woman on the inventor team, with an average proportion of females in an inventor team being 7.9%. Patents applied by teams with a majority of female inventors (at least 50%) account for 3.8% of our sample, where 2.9% consists of all-female inventor teams. Among our sample, 720,370 (38%) of applications are filed by a solo inventor. As shown in Figure 1, upon the first-action decision, 7.6% of applications get approved after the initial round of examination, while the majority (92.2%) receive non-final rejection and a small group (0.2%) is awarded a final rejection. The latter two groups of applications can continue the examination process by filing amendments and appeals, respectively. Ultimately, about 61.1% of applications become granted patents.

4. Results

4.1 Inventor Gender Effect on Patent Application Outcomes

We start our analysis by examining the effect of inventor gender on patent application outcomes. Table 2 presents the Probit regression results of Equation (1), where the dependent variable is *First-Action Allowance* and *Patent Granted* in Panels A and B, respectively.[7] Starting with Panel A column (1), *Prop. Female Inventor* is significantly negatively related to the likelihood of receiving first-action allowance—meaning that female patent applications face lower chances of approval after the first round of examination. We use alternative measures of female participation in inventor teams in columns (2) and (3), finding that the coefficient estimates for *Majority Female Inventor* dummy and *All Female Inventor* dummy are both negative and statistically significant. In column (4), we examine the effect of *All Female Inventor* dummy by focusing on applications in which the inventor teams are either all females or all males—results remain qualitatively similar. Lastly, we focus on solo-inventor applications in column (5), which accounts for about 38% of the entire sample. Compared to the applications filed by solo-male inventors, solo-female applications are less likely to receive first-action allowance, though the result is statistically insignificant. In Panel B, we find that applications authored by inventor teams with more women are less likely to be granted after one or multiple rounds of examination. The results are statistically significant at the 1% level in all five models.

Regarding the economic magnitude, using column (2) of Panel A as an example, our calculations of marginal effects show that patent applications with a majority-female inventor team are 1.1% less likely to receive a first-action allowance compared to those filed by majority-male teams. This is a 14.5% decline relative to the 7.6% unconditional probability of an application

[7] The sample in Panel A is smaller than that in Panel B since the dependent variable is *First-Action Allowance* and *Patent Granted*, respectively. Probit models drop all observations within each $ArtUnit \times Subclass \times Year$ group in which the dependent variable is non-varying. Majority of the variable *First-Action Allowance* is equal to zero, thus more observations are dropped in Panel A.

being approved upon first-action decision. In Panel B, applications filed by majority-female inventor teams are 3.9% less likely to be granted, a 6.4% decline compared to the 61.1% unconditional patent grant rate, consistent with Jensen et al. (2018).

Among the control variables, *Examiner Scope Leniency* and *Examiner Experience* are positively related to the likelihood of receiving first-action allowance and grant rate, consistent with prior literature (e.g., Sampat and Williams, 2019; Aneja et al., 2021). *Examiner Review Speed* is negatively related to both patent examination outcome variables. As with Carley et al. (2015), foreign applications and those filed by small entities are significantly less likely for first-action approval or finally granting. Applications filed by inventors with greater patenting experience are more likely to receive first-action allowance or be finally granted. *Initial Num. of Claims* is positively associated with patent grant rate, in line with the finding in Farre-Mensa et al. (2020). Finally, to assess the goodness-of-fit in Probit models, we report the $\chi 2$ statistics at the bottom of Table 2. Across all models, the $\chi 2$ statistics are highly significant with p-values below 0.01, suggesting that the right-hand-side variables have significant power in explaining the outcome variables.

4.2 Rare vs. Common Names: A Falsification Test

The main challenge in our study is to disentangle whether the documented differences in female vs. male patenting outcomes stem from gender bias or differences in patent quality. Though we have included triple $ArtUnit \times Subclass \times Year$ fixed effects to control for patent quality, unobservable differences may exist between female and male patents' quality. To address this concern, we compare results between subsamples of applications whose inventors have commonly or rarely used first names. While inventors themselves, their employers, and patent agents or lawyers representing them are aware of inventors' gender, patent examiners and others may infer gender based on the inventors' first names listed on patent applications—either consciously or subconsciously. People can easily infer gender from common names, such as 'John' and 'Sarah.' However, for thousands of rare names used by only a few individuals, it is difficult to determine gender with confidence. For instance, 'Manijeh' is often a female name, and 'Irshad' is typically a male name, but many people may not recognize their gender associations due to their rarity. Consequently, examiners cannot identify the gender of inventors with rare names simply by their first names. If our results are driven by gender bias, we expect that the disadvantage for female inventors in first-action allowances and grant rates will diminish among applications with rare names. On the other hand, if patenting differences between female and male inventors stem from differences in patent quality, which is unlikely correlated with name rarity, we expect the female inventor disadvantage to remain consistent among applications with both rare and common names.

We utilize the Social Security Application database to categorize names as rare or common. Rare (common) first names are those with frequency counts in the bottom (top) 10 percentile or 1 percentile among all names in the database. We consider any inventor names not present in the database as rare. To avoid problems in aggregating across names with different frequency, we restrict the sample to solo-inventor applications in which we can clearly identify inventors as having a rare or a common name. We include an interaction term *Solo Female Inventor×Rare Name* in the regressions to capture the differential effect of name rarity on the inventor gender disparity, where *Rare Name* takes the value of one for a rare first name and zero for a common first name.

Probit regression results are reported in Table 3. We define rare (common) names using the bottom (top) 10 percentile in columns (1)-(2). The significant negative coefficients on *Solo Female Inventor* indicate that female inventors are associated with a lower likelihood of first-action allowance (column 1) and final granting (column 2) among applications with common inventor names. The coefficient estimates of *Solo Female Inventor×Rare Name* are positive and significant in both columns, suggesting that the female inventor effect on first-action allowance and patent grant rate is significantly weakened for applications with rare-named inventors whose gender is harder to identify. To ensure robust results, we use alternative cutoffs to define rare versus common names. A first name is defined as a rare (common) name if it falls in the bottom (top) 1 percentile in terms of frequency counts among all the names in the Social Security database, and the results reported in columns (3)-(4). Again, we find the female inventor disadvantage in first-action approval and final granting is attenuated among applications filed by inventors with rare names. These results lend support to our gender bias hypothesis H1.

Interestingly, the sum of the coefficients ($\beta 1+ \beta 2$) is statistically significant only in columns (2) and (4) in which the dependent variable is *Patent Granted*. This suggests that gender differences in the likelihood of receiving first-action allowance disappear among applications authored by inventors with rare names (a gender-blind sample). However, though the magnitude becomes much smaller, gender differences in the likelihood of patent granting persist among applications authored by inventors with rare names. While first-action allowance is entirely determined by examiners after patent applications are submitted, the probability of patent granting is influenced not only by examiner leniency but also by the diligence and persistence of inventors in revising their applications and filing amendments. The fact that a gender gap remains in patent grant rate among relatively gender-blind applications implies that other reasons than gender bias drive these disparities. We explore the potential gender difference in inventor persistence during the examination process in subsequent section 4.5, focusing on the 'lack of persistence' hypothesis.

4.3 Cross-Sectional Tests

Next, we investigate whether inventor gender disparities stem from statistical discrimination, in which gender bias arises due to limited or ambiguous information, causing economic agents to rely on statistical data for a group to infer individual quality (Arrow, 1974; Phelps, 1972). Consequently, we expect the gender gap in patenting to decrease when inventor teams can signal their abilities (e.g., through past patent applications) or when examiners have more experience with female patents and are better at discerning quality.

Prior literature indicates that entrepreneurial teams with prior founding experience are more likely to receive venture capital funding due to demonstrated skills and knowledge related to building startups (Hsu, 2007; Hallen, 2008). Bohren et al. (2019) find that individuals can signal their abilities through prior evaluations, thus reducing discrimination against women. Therefore, inventors' past experience in patenting can serve as a credible signal for their human capital and an appropriate proxy for patent quality. We construct a binary variable, *Experienced Inventor Team* that takes the value of one if at least one inventor listed on the patent application has previously filed for a patent and zero otherwise. Table 1 shows that about 72% of applications in our sample are filed by an experienced inventor team. We interact various measures of *Female Inventor* with *Experienced Inventor Team* using Probit regression, with results reported in Table 4.

In Panel A, where the dependent variable is *First-Action Allowance*, all five measures of female participation in patenting have significant negative relationships with the likelihood of first-action allowance. This indicates that female applications are less likely to be approved upon first-action decision when authored by inventor teams without prior patenting experience. However, the coefficient estimates for *Female Inventor*×*Experienced Inventor Team* are significantly positive in all five models, suggesting a smaller gender gap in approval likelihood for applications authored by experienced inventor teams with a track record of patent applications. Panel B, with *Patent Granted* as its dependent variable, shows similar results. Female-authored patent applications are less likely to be granted, but the gender gap is significantly reduced among those submitted by experienced inventor teams. Examiners have an easier time evaluating applications from inventors with a track record of patenting and are less likely to rely on gender-related statistical information to determine individual patent quality. Consequently, this results in smaller gender disparities.

To shed light on the moderating effect of examiners' ability to assess the quality of female patents, we used the number of female patents reviewed by an examiner over the past five years as a proxy for an examiner's experience with female patents. Female patents are defined as those with more than 50% women on the inventor team. We created a binary variable, *Examiner (More Female Experience),* which takes the value of one if the examiner's experience with female inventors is in the top tercile within their corresponding art unit in a year, and zero otherwise.

Table 1 indicates that approximately 49% of applications are reviewed by examiners with greater experience in female inventions. We interact various measures of female participation with *Examiner (More Female Experience)*; regression results are reported in Table 5. In Panel A, we find positive and significant coefficient estimates for the interaction term *Female Inventor×Examiner (More Female Experience)* across all five models, suggesting a reduced gender difference in the likelihood of receiving first-action allowance when examiners possess more prior experience with female inventors. Panel B reveals similar results, indicating a decreasing gender gap in patent grant rates, but only two out of the five models show statistical significance.

In summary, gender disparities in patenting are significantly smaller among applications authored by inventor teams with a patent application history or those reviewed by examiners with more familiarity with female inventors. This makes it easier for examiners to discern patent quality amid imperfect information. Our findings support hypothesis H2, implying that gender disparities in patenting stem from statistical discrimination.

4.4 Inventor Gender and Patent Quality

Next, we explore gender disparity among inventors regarding the quality of eventually granted patent applications. Our gender bias hypothesis proposes that women's applications are less likely to be granted upon first-action decisions due to stereotype bias or statistical discrimination during the examination process. If gender bias is present, women inventors must overcome higher barriers than men, resulting in the average patent granted to a woman inventor being of higher quality to that granted to a man. To investigate this, we consider two measures of patent quality: (1) forward citations, reflecting the scientific value of a patent; (2) economic value based on stock return related to the announcement of the patent grant.

4.4.1 Forward Citations

In Panel A of Table 6, we estimate Equation (1) using OLS regressions where the dependent variable is *Ln(Citation)*, which is the logarithm of one plus the total number of forward citations received by a patent. We include the same set of control variables and fixed effects as in Table 2. We find that there is a lower level of citation counts associated with female participation in inventor teams. While this may seem to imply that patents by female inventors are of lesser scientific quality, an alternative explanation could be that inventors are more likely to cite patents authored by their own gender (Hochberg et al., 2023). Considering the majority of patents are developed by men, this results in fewer citations for female-authored patents.

To examine this conjecture, we distinguish forward citations made by female patents from those by male patents. *Ln(Female Citation)* measures the logarithm of one plus the number of forward citations received from patents with at least one female in the inventor team, while *Ln(Male Citation)* measures the logarithm of one plus the number of forward citations received from patents with all male inventors. We rerun OLS regressions using *Ln(Female Citation)* and *Ln(Male Citation)* as dependent variables; results appear in Table 6 Panel B.[8] Columns (1), (3), (5), (7), and (9) demonstrate that female patents receive significantly more forward citations from other patents involving at least one female inventor. These results are consistent across all five measures of female patent participation. However, even numbered columns indicate that female patents receive significantly fewer forward citations from all-male patent teams.

The findings suggest that inventors are more likely to cite patents authored by the same gender authors and less likely to cite those authored by a different gender. Coefficient estimates in regressions with *Ln(Male Citation)* depicted larger magnitudes than those in models using *Ln(Female Citation)*. This indicates that additional citations from other female patents are not enough to offset the fewer citations from male-authored ones, and therefore yield a lower overall citation rate for female patents. Our study aligns with Hochberg et al. (2023), finding women's patents to be under-cited relative to their quality, especially by male inventors.

To determine if gender differences in forward citations are due to gender bias, we examine whether the results differ when the inventor's gender is difficult to discern from their first name. If gender bias drives these differences, we expect the female inventor disadvantage in citation to be lessened for patents with rare inventor names. In Table 6 Panel C, we focus on granted patents by solo inventors with either rare or common first names, which is defined as those whose frequency

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[8] We have fewer observations in Panel B than in Pane A since genders of some inventors of citing patents cannot be identified, and therefore they drop out of the sample.

counts in the Social Security application database fall in the bottom or top 10 percentile in column (1) and the bottom or top 1 percentile in column (2).

The coefficient estimates for *Solo Female Inventor* are significantly negative, indicating that female patents with easily identifiable gender names receive fewer citations than male patents. However, the interaction term *Solo Female Inventor×Rare Name* is positive and significant in both columns. The gender difference among inventors with rare first names is captured by the sum of the two coefficients on *Solo Female Inventor* and *Solo Female Inventor×Rare Name*. An F-test indicates that the sum is not significantly different from zero, implying that for patents developed by inventors with rare names (gender-blind), there is no difference in forward citation counts between female and male inventors, suggesting gender bias in patent citations.

4.4.2 Economic Value of Patents

While patent citations indicate scientific value, they offer limited insight into a patent's economic value. Kogan et al. (2017) calculate each patent's economic value based on stock market reactions to patent grant announcements, multiplying the firm's abnormal stock return around the announcement by its market capitalization one day prior. This method captures patent value using forward-looking asset prices and ex-ante information.

To explore inventor gender differences in patent economic value, we obtain related data from Noah Stoffman's website, limiting our sample to patents associated with publicly traded firms. We then regress patent value on inventor gender measures and include a set of firm characteristics as control variables, as previous literature suggests (e.g., Gu, Mao, and Tian 2017). The control variables include firm size (*LN_Asset*), return on assets (*ROA*), R&D expenditures (*R&D/Asset*), capital expenditures (*CAPEXTA*), leverage (*Leverage*), market-to-book ratio (*Market-to-book*), institutional holdings (*Institutional Holding%*), firm age (*Ln(Age)*), tangibility (*PPE/Asset*), industry competition (*HHI*) and squared *HHI*, and the Kaplan and Zingales (1997) index (*KZ-INDEX*). We also include firm and year fixed effects and cluster standard errors at the Firm×Year level.

Regression results are presented in Panel A of Table 7. We find that all five measures of female participation as inventors are associated with a higher economic value of the patent. Four out of five models display statistically significant results. Examining the economic magnitude, we observe that patents with predominantly female inventor teams, as illustrated in column (2), are associated with an additional $629,000 in value compared to those with primarily male inventor teams, representing an 8.5% increase from the median patent value in our sample. Consequently, this outcome suggests that female inventors face a higher hurdle than males in patenting, and patents granted to women are generally of higher quality than those awarded to men.

In Table 7 Panel B, we examine the gender differences in patent value among inventors with rare and common names. We find that patents authored by women with common names, which readily identify them as women, have a significantly higher value than those authored by men with common names, all else equal. However, the coefficient estimate for *Solo Female Inventor×Rare Name* is negatively significant across both columns. The F-test reveals that the sum of the coefficients on *Solo Female Inventor* and the interaction term ($\beta_1 + \beta_2$) is not statistically different from zero, indicating no significant gender difference in patent value among gender-blind inventors (with rare names). This result aligns with our findings in Table 3 regarding patent applications by females with rare names not facing disadvantages in first-action decisions when compared to males since their gender remains indiscernible through their first names.

4.5 Inventor Persistence

The average patenting process takes approximately 2-3 years and involves several rounds of review, revision (referred to as “amendment”), or appeal. Applicants may submit appeals even following a final rejection. Consequently, patent applications will not end until inventors implicitly or explicitly abandon their application (Lemley and Sampat 2008). As such, patenting outcomes depend on examiner leniency and inventor diligence and persistence when revising applications and submitting amendments. Our analysis in Table 3 shows that the gender gap in patent grant rate becomes smaller but remains significant for applications filed by inventors with rare names. This suggests that gender bias is not the sole reason for gender disparities in the patent examination process.

In this section, we examine the hypothesis of 'lack of persistence' by exploring potential gender differences in persistence during the patent examination process. Previous research indicates that women are often less willing to compete and more likely to stop competing after receiving negative feedback compared to men (Gneezy, Niederle, and Rustichini, 2003; Niederle and Vesterlund, 2007; Avilova and Goldin, 2018; Buser and Yuan, 2019; Wasserman, 2023). Here, we investigate whether female and male inventors respond differently to rejections upon the first-action decision.

4.5.1 Female Inventors and Filing Initial Amendments

Patent applications can be rejected for three reasons upon the first-action decision: non-final rejection, restriction required, and final rejection. However, inventors are allowed to revise their claims based on examiners’ feedback and can file an amendment to continue the examination process if they receive a non-final rejection or restriction required. Restriction required can be seen as a special type of non-final rejection where the examiner asks the applicant to limit the application's claims to one invention instead of multiple independent inventions. Therefore, we will refer to both groups as non-final rejection from now on. Figure 1 shows that, upon the initial decision, 92.2% of applications are given a non-final rejection (including restriction required) that allows applicants to submit an initial amendment. A very small percentage of applications (0.2%) receive a final rejection, which inventors can appeal. We want to analyze the effect of female presence in inventor teams on the probability of filing an initial amendment, which is not an option for the 0.2% of applications that receive a final rejection. Thus, we exclude them from the sample.

The results in Table 2 indicate a different rate of first-action allowance (i.e., a different non-final rejection rate) between applications by female and male inventors. Therefore, we employ a two-stage Heckman (1976) model to account for the potential non-random sorting of female applications into the rejection group. In the 1st stage, we estimate a Probit model of Equation (1) where the dependent variable is replaced with *Non-Final Rejection*.[9] We include the same control variables and fixed effects as in Table 2. In the 2nd stage, we estimate the effect of inventor gender on the likelihood of filing initial amendments by including the inverse Mills Ratio from the 1st stage to correct for selection bias. Table 8 reports summary statistics of the sample for the Heckman (1976) models. About 92.5% of applications are awarded a non-final rejection, of which 81.6% applications choose to file an initial amendment. In other words, about 18% of applications were abandoned by the applicants.

The first-stage Heckman model results, reported in Table 9 Panel A, reveal that female inventor applications are significantly more likely to receive non-final rejections (i.e., less likely to be approved) during first-action decisions compared to male inventor applications. These results align with those in previous tables. In Panel B, the second-stage results indicate that the coefficient estimates for the inverse Mills Ratio are significantly positive in all models, suggesting the need

[9] We exclude the 0.2% applications that receive final rejection upon the first action decision, since the appeal process might be different from filing an amendment.

to control for selection bias. Female applications are less likely to file an initial amendment after receiving a non-final rejection during the first-action decision, with statistically significant results in all five columns. Using column (2) of Panel B as an example, patent applications filed by a majority-female inventor team are 1.2% less likely to file an initial amendment after receiving a non-final rejection compared to applications authored by a majority-male inventor team. This finding supports hypothesis H3, implying that women inventors are more likely to abandon their patent applications after encountering a rejection.

4.5.2 The Role of Support

In response to the America Invents Act of 2011 and Presidential Executive Action Number Seven, the USPTO implemented the Pro Se Pilot Examination Unit (PSPEU) to better assist patent applicants without legal representation. Pairolero et al. (2023) show that women applicants benefit more from the PSPEU than male applicants, resulting in an additional 11% increase in patent grant rates. We next explore whether providing resources and support during the patent application process can reduce female inventors' reluctance to file amendments.

We use two proxies for patent application support: (1) Patent Agent involvement (*Have Patent Agent)*, a binary variable equaling one if the applicant employs a patent agent and zero otherwise; and (2) Public Assignee status (*Public Assignee)*, another binary variable equaling one if the patent right is assigned to a publicly traded firm and zero otherwise. As displayed in Table 8's summary statistics, approximately 72% of applications in our sample involve a patent agent, and 55% are assigned to a publicly traded firm.

Patent agents, professionally licensed by the USPTO, offer valuable advice and assistance during patent applications. They typically help inventors search for prior art, identify legally enforceable claims of ownership, complete and submit all paperwork, revise or amend applications upon rejection, and determine when to abandon an application. Upon a first-action rejection, a patent agent guides inventors in reviewing examiners' feedback, rewriting claims as per their suggestions, and consequently streamlining the revision and initial amendment filing process. This assistance is particularly beneficial for female inventors who may be more sensitive to negative feedback and less persistent throughout the lengthy patenting process (Avilova and Goldin, 2018; Buser and Yuan, 2019). Similarly, inventors working for public firms are expected to receive more support from designated departments handling patent applications. Thus, the gender gap in amendment filing propensity is expected to narrow as the applications are associated with patent agents or public assignees.

To test these conjectures, we incorporate interaction terms—*Female Inventor×Patent Agent* and *Female Inventor×Public Assignee*—in both 1st and 2nd stage regressions. We present the 2nd stage regression results in Table 10. In Panel A, the *Female Inventor* dummy remains negative and significant, implying that female inventors are less likely than men to file an initial amendment without a patent agent's assistance. However, the coefficient estimates on *Female Inventor×Patent Agent* are positive and statistically significant in four out of five models—suggesting that the inventor gender gap in amendment filing probability is reduced with a patent agent's involvement. The sum of coefficients ($\beta_1 + \beta_2$) is not statistically significant except for column (1), indicating that women are no different from men in filing an initial amendment upon non-final rejection at the first-action decision with a patent agent's help.

The results in Panel B show a similar qualitative trend. There exists a notable gender gap in filing amendments among applications linked to non-public assignees. The coefficient estimates for *Female Inventor×Public Assignee* are positive and significant across all five regressions, indicating that employment at publicly traded firms reduces female inventors' hesitance to file an initial amendment by providing increased resources and support. The combined coefficients ($\beta 1 + \beta 2$) are insignificant, except in column (5), suggesting minimal gender differences in the likelihood of filing initial amendments when working for public firms.

5. Conclusion

There are growing interests in Economics and Finance on the impact of gender disparities on economic activities and corporate decision-making, emphasizing female entrepreneurs, CEOs, and board directors. Yet, a dearth of research remains concerning gender gaps amongst inventors and their subsequent impact on patenting and innovative outcomes. In this paper, employing a large dataset of U.S. patent applications during 2001 to 2017, we examine the existence and causes of gender disparities in the patent examination outcomes. We find that applications authored by women are significantly less likely than those authored by men to receive a first-action approval or ultimate granting. Unveiling evidence supporting the 'gender bias' hypothesis, we first observe that the female disadvantage is attenuated when applications are filed by those with rare first names – thus obscuring their gender from examiners. Secondly, granted patents authored by women are associated with significantly higher economic value compared to their male-authored counterparts. To the extent that patent value reflects the quality of inventions, our findings indicate a higher hurdle that women must clear in the patent examination process. Further analysis reveals that the gender bias manifesting in patent examination outcomes arises from statistical discrimination—a phenomenon most pervasive when evaluators possess insufficient information for quality assessment. We find that the gender disparities in patenting are significantly smaller among applications in which examiners have more information concerning their quality or have more experience in discerning quality.

We emphasize that, while unfair treatment of women is one explanation for our findings, yet it does not stand alone. We find evidence supporting the ‘lack of persistence’ hypothesis. Upon receiving a non-final rejection at the first-action decision, female inventors are significantly less likely than male inventors to file an initial amendment, hence abandoning their applications with greater frequency. Additional analysis uncovers that providing resources and support to applicants can mitigate the gender gap in persistence.

Overall, our study documents inventor gender disparities in patent examination process, offering evidence of two primary causes contributing to this divide: 1) the manifestation of gender bias toward female inventors stemming from statistical discrimination within the examination process; 2) lack of persistence demonstrated by female inventors when amending their applications. Our findings shed light on the underlying causes of gender differences in the patent examination and offer policy implications to foster a more equitable landscape in intellectual property rights. Recognizing that a rigorous and unbiased patent grant system is essential for balancing the incentive effects of patents with their monopoly costs — thus catalyzing technological innovation — our study advocates for a 'gender blind' examination process while simultaneously emphasizing the importance of offering guidance and support throughout the filing and amendment processes. By embracing and implementing these transformative measures, we may significantly narrow the gender gap in patent examination outcomes.

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Figure 1. Examination Process of All Patent Applications

This figure reports the fractions of applications that proceed through each round of the patent examination process for all patent applications in our sample.

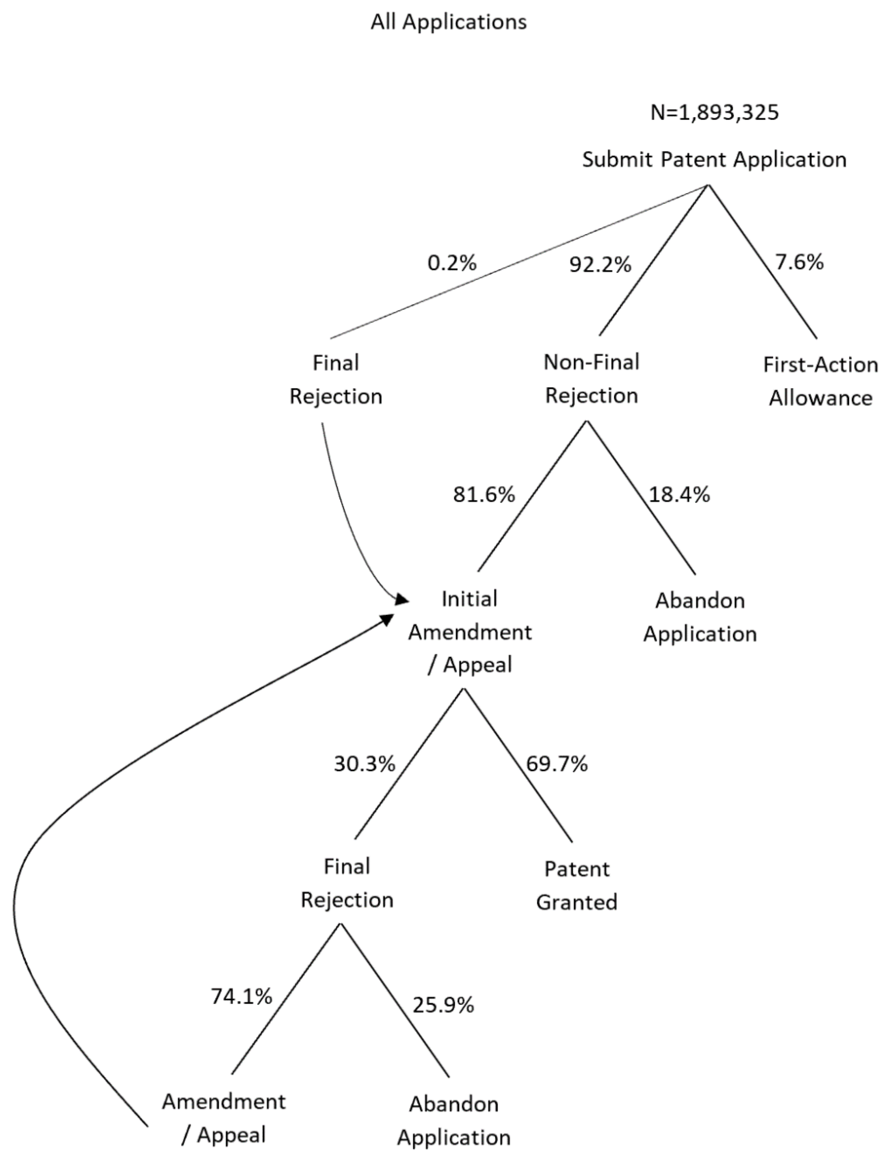

Figure 2. Examination Process of Patent Applications

This figure reports the fractions of applications that proceed through each round of the patent examination process for all-female and all-male inventor teams, which accounts for 86% of all applications in our sample.

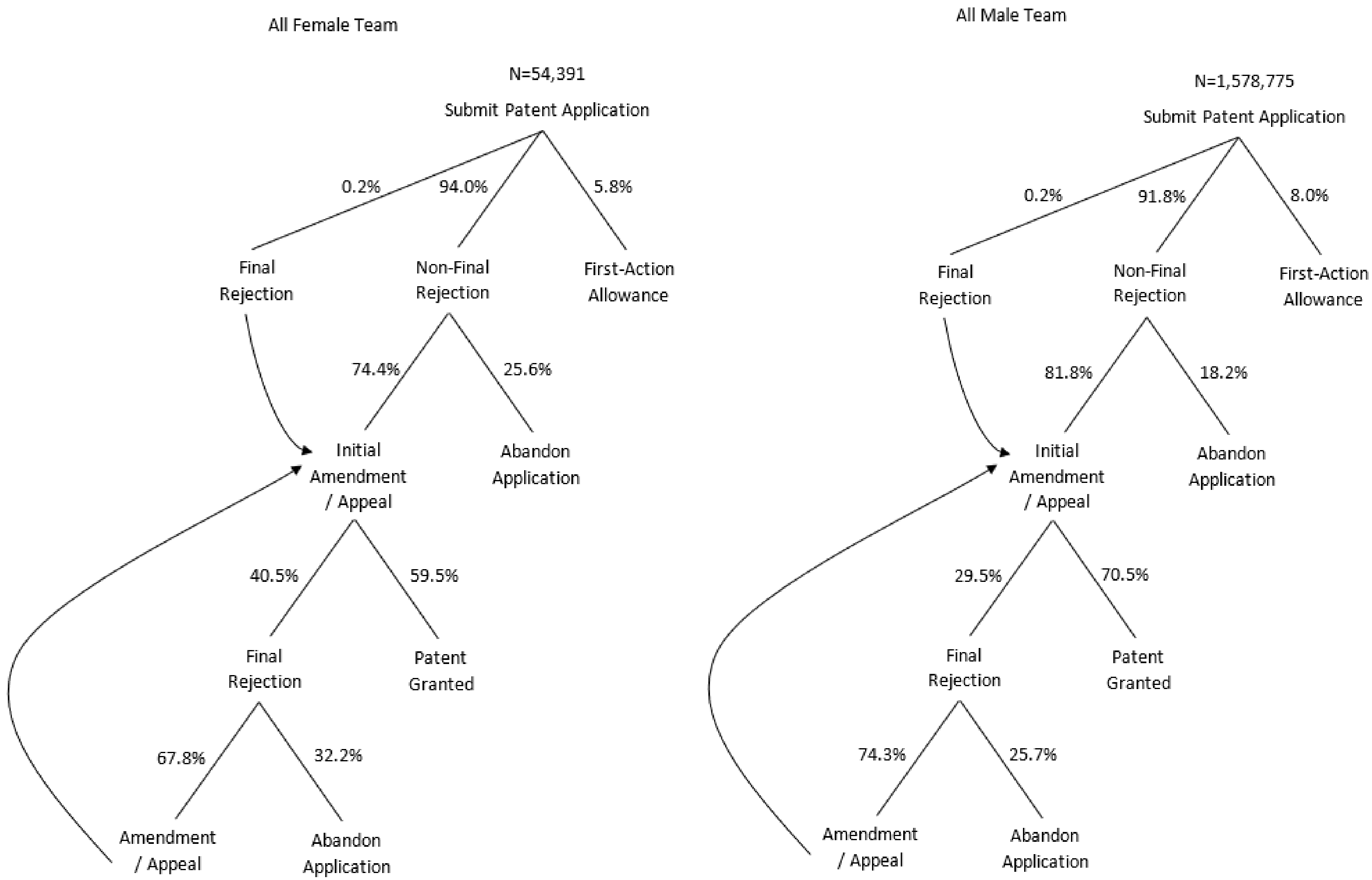

Table 1 Summary Statistics of Patent Application During 2001 to 2017

This table presents the summary statistics of utility patent applications filed from 2001 to 2017, for which we could identify the gender of all inventors of an application. Variable definitions are provided in Appendix A.

	N	Mean	Median	SD
First-Action Allowance	1,893,325	0.076	0	0.265
Patent Granted	1,893,325	0.611	1	0.488
Prop. of Female Inventor	1,893,325	0.079	0	0.209
Majority Female Inventor	1,893,325	0.038	0	0.191
All Female Inventor	1,893,325	0.029	0	0.167
All Female Inventor-Non-Mixed Team	1,633,166	0.033	0	0.179
Solo Female Inventor	720,370	0.064	0	0.245
Have at Least One Female Inventor	1,893,325	0.166	0	0.372
Examiner Review Speed	1,893,325	1.762	2	0.770
Examiner Scope Leniency	1,893,325	2.764	3	0.662
Examiner Experience	1,893,325	11.758	10	7.929
Small Entity	1,893,325	0.245	0	0.430
Foreign Priority	1,893,325	0.385	0	0.487
Continuation	1,893,325	0.590	1	0.492
Foreign Applicant	1,893,325	0.526	1	0.499
Number of Inventors	1,893,325	2.373	2	1.628
Solo Inventor	1,893,325	0.380	0	0.486
Initial Num. of Claims	1,893,325	3.357	3	4.327
Inventor Experience	1,893,325	26.207	5	136.959
Experienced Inventor Team	1,893,325	0.717	1	0.451
Examiner (More Female Experience)	1,893,325	0.487	0	0.500

Table 2. Female Inventors and Patent Examination Outcomes: Baseline

This table reports the results on the effect of inventor gender on patent examination outcomes. The sample consists of all utility patent applications filed from 2001 to 2017, for which we could identify the gender of all inventors in an application. In Panel A, the dependent variable *First-Action Allowance* is a binary variable that takes the value of one if the application is approved (granted) upon the first-action decision, and zero otherwise. In Panel B, the dependent variable *Patent Granted* is a binary variable that takes the value of one if the patent is eventually granted, and zero otherwise. In both panels, in column (1), the independent variable *Prop. Female Inventor* is the proportion of female inventors listed on a patent application. In column (2), the independent variable *Majority Female Inventor* is a binary variable that takes the value of one if at least 50% of the inventor team are females, and zero otherwise. In column (3), the independent variable *All Female Inventor* is a binary variable that takes the value of one if the entire inventor team consists of females, and zero otherwise. In column (4), the sample is limited to applications in which the inventor teams are either all females or all males, i.e., non-mixed inventor team. The independent variable *All Female Inventor-Non-Mixed Team* is a binary variable that takes the value of one if the entire inventor team consists of females and zero if the entire inventor team consists of males. In column (5), the sample only includes solo applications that are filed by a single inventor. The independent variable *Solo Female Inventor* is a binary variable that takes the value of one if the solo inventor is a female and zero if the solo inventor is a male. Definitions of other variables are in Appendix A. The unit of analysis is at application level. We include Art Unit×Subclass×Year fixed effects in all regressions. P-values based on robust standard errors clustered at the Art Unit×Subclass×Year are reported in parentheses under the corresponding estimated coefficients. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. *Wald* χ^2 is the χ^2-statistics for testing the null hypothesis that all slope coefficients are equal to zero, with the p-value reported in parentheses.

Panel A: Probit regressions where the dependent variable is *First-Action Allowance*

	(1)	(2)	(3)	(4)	(5)
	Dept. Var=First-Action Allowance				
Prop. Female Inventor	-0.044***				
	(0.000)				
Majority Female Inventor		-0.046***			
		(0.000)			
All Female Inventor			-0.034**		
			(0.007)		
All Female Inventor-Non-Mixed Team				-0.039**	
				(0.003)	
Solo Female Inventor					-0.023
					(0.174)
Examiner Review Speed	-0.082***	-0.082***	-0.082***	-0.073***	-0.074***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Examiner Scope Leniency	0.081***	0.081***	0.081***	0.080***	0.074***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ln(1+Examiner Experience)	0.451***	0.451***	0.451***	0.461***	0.512***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Small Entity	-0.098***	-0.098***	-0.098***	-0.097***	-0.121***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Foreign Priority	0.163***	0.164***	0.164***	0.170***	0.190***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Continuation	0.065***	0.065***	0.065***	0.059***	0.046***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Foreign Applicant	-0.047***	-0.047***	-0.047***	-0.042***	-0.035**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.006)
Number of Inventors	-0.008***	-0.008***	-0.008***	-0.008***	
	(0.000)	(0.000)	(0.000)	(0.000)	
Solo Inventor	0.008	0.010**	0.010*	0.008	
	(0.111)	(0.048)	(0.056)	(0.181)	
Initial Num. of Claims	-0.035***	-0.035***	-0.035***	-0.037***	-0.045***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Inventor Experience	0.000***	0.000***	0.000***	0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.858)
Model	Probit	Probit	Probit	Probit	Probit
Fixed Effects			Art Unit×Subclass×Year		
Log likelihood	-450247.3	-450248.5	-450253.9	-391374.2	-131616.9
Wald χ^2	29927.3***	29925.0***	29914.1***	26844.2***	10626.1***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	1,090,584	1,090,584	1,090,584	915,137	277,378

Panel B: Probit regressions where the dependent variable is *Patent Granted*

	(1)	(2)	(3)	(4)	(5)
			Dept. Var=Patent Granted		
Prop. Female Inventor	-0.148***				
	(0.000)				
Majority Female Inventor		-0.127***			
		(0.000)			
All Female Inventor			-0.144***		
			(0.000)		
All Female Inventor-Non-Mixed Team				-0.150***	
				(0.000)	
Solo Female Inventor					-0.137***
					(0.000)
Examiner Review Speed	-0.120***	-0.120***	-0.120***	-0.120***	-0.139***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Examiner Scope Leniency	0.179***	0.179***	0.179***	0.182***	0.195***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ln(1+Examiner Experience)	0.266***	0.266***	0.266***	0.272***	0.301***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Small Entity	-0.565***	-0.565***	-0.565***	-0.605***	-0.674***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Foreign Priority	0.265***	0.266***	0.266***	0.281***	0.377***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Continuation	0.009**	0.010***	0.010***	0.010**	0.070***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.000)
Foreign Applicant	-0.565***	-0.565***	-0.565***	-0.585***	-0.654***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of Inventors	0.016***	0.015***	0.015***	0.020***	
	(0.000)	(0.000)	(0.000)	(0.000)	
Solo Inventor	-0.101***	-0.094***	-0.093***	-0.091***	
	(0.000)	(0.000)	(0.000)	(0.000)	
Initial Num. of Claims	0.005***	0.005***	0.005***	0.006***	0.010***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Inventor Experience	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Model	Probit	Probit	Probit	Probit	Probit
Fixed Effects			Art Unit×Subclass×Year		
Log likelihood	-1028795.3	-1028927.1	-1028932.6	-853382.0	-303492.3
Wald χ^2	109298.8***	109035.3***	109024.2***	97852.5***	38888.7***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	1,893,325	1,893,325	1,893,325	1,575,666	542,480

Table 3. Female Inventors and Patent Examination Outcomes: Rare vs. Common Names

This table presents the effect of inventor gender on patent examination outcomes for applications led by inventors with rare names versus those with common names. The sample consists of solo utility patent applications filed from 2001 to 2017, for which we could identify the gender of the inventor. We further limit the sample to applications in which inventors have either a rare or a common name. An inventor's first name is considered rare (common) if it falls in the bottom (top) 10 percentile in columns (1)-(2) and in the bottom (top) 1 percentile in columns (3)-(4) in terms of frequency counts among all the names in the Social Security application database. *Rare Name* is a binary variable that takes the value of one if an inventor's first name is rare, and zero otherwise. The independent variable *Solo Female Inventor* is a binary variable that takes the value of one if the solo inventor is a female and zero if the solo inventor is a male. In column (1) and (3), the dependent variable *First-Action Allowance* is a binary variable that takes the value of one if the application is approved (granted) upon the first-action decision, and zero otherwise. In columns (2) and (4), the dependent variable *Patent Granted* is a binary variable that takes the value of one if the patent is eventually granted, and zero otherwise. We include the same set of control variables as that in Table 2, but do not tabulate them for brevity. Definitions of other variables are in Appendix A. The unit of analysis is at application level. We include Art Unit×Subclass×Year fixed effects in all regressions. P-values based on robust standard errors clustered at the Art Unit×Subclass×Year are reported in parentheses under the corresponding estimated coefficients. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. *Wald* χ^2 is the χ^2-statistics for testing the null hypothesis that all slope coefficients are equal to zero, with the p-value reported in parentheses.

	(1)	(2)	(3)	(4)
Dept. Var=	*First-Action Allowance*	*Patent Granted*	*First-Action Allowance*	*Patent Granted*
	Rare (Common) name in bottom (top) 10%		*Rare (Common) name in bottom (top) 1%*	
Solo Female Inventor (β_1)	-0.115***	-0.163***	-0.138***	-0.175***
	(0.000)	(0.000)	(0.000)	(0.000)
Solo Female Inventor×Rare Name	0.172***	0.049*	0.195***	0.050*
(β_2)	(0.000)	(0.085)	(0.000)	(0.094)
Rare Name (β_3)	0.160***	0.006	0.190***	0.042***
	(0.000)	(0.504)	(0.000)	(0.000)
Controls	Yes	Yes	Yes	Yes
Model	Probit	Probit	Probit	Probit
Fixed Effects		Art Unit×Subclass×Year		
Test: $\beta_1+\beta_2=0$	0.057	-0.114***	0.057	-0.125***
p-value	(0.114)	(0.000)	(0.129)	(0.000)
Log likelihood	-85960.8	-222518.1	-74642.0	-194941.6
Wald χ^2	101938.2***	200837.1***	124575.7***	255990.1****
	(0.000)	(0.000)	(0.000)	(0.000)
N	178,389	395,634	153,837	347,399

Table 4. Female Applications and Patent Examination Outcomes: Conditional on Experienced Inventor Team

This table presents the results of the effect of inventor gender on patent examination outcomes conditional on the inventor team's prior experience in patenting. The sample consists of all utility patent applications filed from 2001 to 2017, for which we could identify the gender of all inventors in an application. *Experienced Inventor Team* is a binary variable that takes the value of one if at least one of the inventors listed on the patent application has ever filed for a patent in the past, and zero otherwise. In Panel A, the dependent variable *First-Action Allowance* is a binary variable that takes the value of one if the application is approved (granted) upon the first-action decision, and zero otherwise. In Panel B, the dependent variable *Patent Granted* is a binary variable that takes the value of one if the patent is eventually granted, and zero otherwise. In column (1), the independent variable *Prop. Female Inventor* is the proportion of female inventors listed on a patent application. In column (2), the independent variable *Majority Female Inventor* is a binary variable that takes the value of one if at least 50% of the inventor team are females, and zero otherwise. In column (3), the independent variable *All Female Inventor* is a binary variable that takes the value of one if the entire inventor team consists of females, and zero otherwise. In column (4), the sample is limited to applications in which the inventor teams are either all females or all males. The independent variable *All Female Inventor-Non-Mixed Team* is a binary variable that takes the value of one if the entire inventor team consists of females and zero if the entire inventor team consists of males. In column (5), the sample only includes solo applications. The independent variable *Solo Female Inventor* is a binary variable that takes the value of one if the solo inventor is a female and zero if the solo inventor is a male. We include the same set of control variables as that in Table 2, but we do not tabulate them for brevity. Definitions of other variables are in Appendix A. We include Art Unit×Subclass×Year fixed effects in all regressions. P-values based on robust standard errors clustered at the Art Unit×Subclass×Year are reported in parentheses under the corresponding estimated coefficients. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. *Wald* χ^2 is the χ^2-statistics for testing the null hypothesis that all slope coefficients are equal to zero, with the p-value reported in parentheses.

Panel A: Probit regressions where the dependent variable is *First-Action Allowance*

	(1)	(2)	(3)	(4)	(5)
	Dept. Var=First-Action Allowance				
Prop. Female Inventor (β_1)	-0.069***				
	(0.000)				
Prop. Female Inventor× Experienced Inventor Team (β_2)	0.069***				
	(0.001)				
Majority Female Inventor (β_1)		-0.065***			
		(0.000)			
Majority Female Inventor× Experienced Inventor Team (β_2)		0.063**			
		(0.006)			
All Female Inventor (β_1)			-0.060***		
			(0.001)		
All Female Inventor×Experienced Inventor Team (β_2)			0.089***		
			(0.000)		
All Female Inventor-Non-Mixed Team (β_1)				-0.066***	
				(0.000)	
All Female Inventor-Non-Mixed Team ×Experienced Inventor Team (β_2)				0.093***	
				(0.000)	
Solo Female Inventor (β_1)					-0.044*
					(0.051)
Solo Female Inventor ×Experienced Inventor Team (β_2)					0.093**
					(0.007)
Experienced Inventor Team (β_3)	0.084***	0.086***	0.086***	0.084***	0.102***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls	Yes	Yes	Yes	Yes	Yes
Model	Probit	Probit	Probit	Probit	Probit
Fixed Effects	Art Unit×Subclass×Year				
Test: $\beta_1+\beta_2=0$	0.000	-0.002	0.029	0.027	0.049*
p-value	(0.999)	(0.907)	(0.121)	(0.173)	(0.062)
Log likelihood	-450027.6	-450031.5	-450030.2	-391184.6	-131499.9
Wald χ^2	30366.7***	30359.0***	30361.6***	27223.5***	10860.0***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	1,090,584	1,090,584	1,090,584	915,137	277,378

Panel B: Probit regressions where the dependent variable is *Patent Granted*

	(1)	(2)	(3)	(4)	(5)
			Dept. Var=Patent Granted		
Prop. Female Inventor (β_1)	-0.164***				
	(0.000)				
Prop. Female Inventor× Experienced Inventor Team (β_2)	0.076***				
	(0.000)				
Majority Female Inventor (β_1)		-0.163***			
		(0.000)			
Majority Female Inventor× Experienced Inventor Team (β_2)		0.123***			
		(0.000)			
All Female Inventor (β_1)			-0.177***		
			(0.000)		
All Female Inventor× Experienced Inventor Team (β_2)			0.153***		
			(0.000)		
All Female Inventor-Non-Mixed Team (β_1)				-0.182***	
				(0.000)	
All Female Inventor-Non-Mixed Team× Experienced Inventor Team (β_2)				0.152***	
				(0.000)	
Solo Female Inventor (β_1)					-0.159***
					(0.000)
Solo Female Inventor× Experienced Inventor Team (β_2)					0.158***
					(0.000)
Experienced Inventor Team (β_3)	0.102***	0.104***	0.105***	0.104***	0.138***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls	Yes	Yes	Yes	Yes	Yes
Model	Probit	Probit	Probit	Probit	Probit
Fixed Effects			Art Unit×Subclass×Year		
Test: $\beta_1 + \beta_2 = 0$	-0.088***	-0.040***	-0.024*	-0.030**	-0.001
p-value	(0.000)	(0.000)	(0.054)	(0.024)	(0.973)
Log likelihood	-1027967.9	-1028034.3	-1028034.2	-852636.9	-302946.2
Wald χ^2	110953.6***	110820.8***	110821.0***	99342.7***	39980.9***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	1,893,325	1,893,325	1,893,325	1,575,666	542,480

Table 5. Female Inventors and Patent Examination Outcomes: Conditional on Examiners' Experience

This table presents the results of the effect of inventor gender on patent examination outcomes conditional on whether the examiner is more or less experienced with female patent applications. The sample consists of all utility patent applications filed from 2001 to 2017, for which we could identify the gender of all inventors in an application. We proxy an examiner's experience with female patents using the number of female patents reviewed by an examiner over the past 5 years, where female patents are those with more than 50% of women on the inventor team. *Examiner (More Female Experience)* is a binary variable that takes the value of one if the examiner's experience with female patents is in the top tercile in the corresponding art unit of the year, and zero otherwise. In Panel A, the dependent variable *First-Action Allowance* is a binary variable that takes the value of one if the application is approved (granted) upon the first-action decision, and zero otherwise. In Panel B, the dependent variable *Patent Granted* is a binary variable that takes the value of one if the patent is eventually granted, and zero otherwise. In column (1), the independent variable *Prop. Female Inventor* is the proportion of female inventors listed on a patent application. In column (2), the independent variable *Majority Female Inventor* is a binary variable that takes the value of one if at least 50% of the inventor team are females, and zero otherwise. In column (3), the independent variable *All Female Inventor* is a binary variable that takes the value of one if the entire inventor team consists of females, and zero otherwise. In column (4), the sample is limited to applications in which the inventor teams are either all females or all males. The independent variable *All Female Inventor-Non-Mixed Team* is a binary variable that takes the value of one if the entire inventor team consists of females and zero if the entire inventor team consists of males. In column (5), the sample only includes solo applications. The independent variable *Solo Female Inventor* is a binary variable that takes the value of one if the solo inventor is a female and zero if the solo inventor is a male. We include the same set of control variables as that in Table 2, but we do not tabulate them for brevity. Definitions of other variables are in Appendix A. We include Art Unit×Subclass×Year fixed effects in all regressions. P-values based on robust standard errors clustered at the Art Unit×Subclass×Year are reported in parentheses under the corresponding estimated coefficients. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. *Wald* χ^2 is the χ^2-statistics for testing the null hypothesis that all slope coefficients are equal to zero, with the p-value reported in parentheses.

Panel A: Probit regressions where the dependent variable is *First-Action Allowance*

	(1)	(2)	(3)	(4)	(5)
			Dept. Var=First-Action Allowance		
Prop. Female Inventor (β_1)	-0.076***				
	(0.000)				
Prop. Female Inventor× Examiner (More Female Experience) (β_2)	0.036*				
	(0.083)				
Majority Female Inventor (β_1)		-0.093***			
		(0.000)			
Majority Female Inventor× Examiner (More Female Experience) (β_2)		0.051**			
		(0.038)			
All Female Inventor (β_1)			-0.084***		
			(0.000)		
All Female Inventor× Examiner (More Female Experience) (β_2)			0.055**		
			(0.041)		
All Female Inventor-Non-Mixed Team (β_1)				-0.090***	
				(0.000)	
All Female Inventor-Non-Mixed Team× Examiner (More Female Experience) (β_2)				0.057**	
				(0.042)	
Solo Female Inventor (β_1)					-0.090**
					(0.003)
Solo Female Inventor× Examiner (More Female Experience) (β_2)					0.080**
					(0.028)
Examiner (More Female Experience) (β_3)	0.129***	0.130***	0.130***	0.131***	0.140***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls	Yes	Yes	Yes	Yes	Yes
Model	Probit	Probit	Probit	Probit	Probit
Fixed Effects			Art Unit×Subclass×Year		
Test: $\beta_1+\beta_2=0$	-0.040**	-0.042**	-0.029*	-0.033**	-0.010
p-value	(0.002)	(0.002)	(0.065)	(0.041)	(0.618)
Log likelihood	-449679.8	-449679.6	-449687.4	-390877.4	-131436.4
Wald χ^2	31062.3***	31062.8***	31047.2***	27837.9***	10986.9***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	1,090,584	1,090,584	1,090,584	915,137	277,378

Panel B: Probit regressions where the dependent variable is *Patent Granted*

	(1)	(2)	(3)	(4)	(5)
			Dept. Var=Patent Granted		
Prop. Female Inventor (β_1)	-0.165***				
	(0.000)				
Prop. Female Inventor× Examiner (More Female Experience) (β_2)	0.012				
	(0.311)				
Majority Female Inventor (β_1)		-0.156***			
		(0.000)			
Majority Female Inventor× Examiner (More Female Experience) (β_2)		0.027**			
		(0.042)			
All Female Inventor (β_1)			-0.171***		
			(0.000)		
All Female Inventor× Examiner (More Female Experience) (β_2)			0.023		
			(0.127)		
All Female Inventor-Non-Mixed Team (β_1)				-0.180***	
				(0.000)	
All Female Inventor-Non-Mixed Team× Examiner (More Female Experience) (β_2)				0.027*	
				(0.095)	
Solo Female Inventor (β_1)					-0.171***
					(0.000)
Solo Female Inventor× Examiner (More Female Experience) (β_2)					0.032
					(0.124)
Examiner (More Female Experience) (β_3)	0.152***	0.152***	0.152***	0.155***	0.173***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls	Yes	Yes	Yes	Yes	Yes
Model	Probit	Probit	Probit	Probit	Probit
Fixed Effects			Art Unit×Subclass×Year		
Test: $\beta_1+\beta_2=0$	-0.153***	-0.129***	-0.148***	-0.153***	-0.139***
p-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log likelihood	-1027080.5	-1027213.0	-1027227.7	-851932.0	-302892.9
Wald χ^2	112728.4***	112463.4***	112434.0***	100752.4***	40087.6***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	1,893,325	1,893,325	1,893,325	1,575,666	542,480

Table 6. Female Inventors and Forward Citations

This table presents the results of the effect of inventor gender on the number of total forward citations, citation counts made by female inventors, and those made by male inventors. In Panel A, the dependent variable *Ln(Citation)* is the logarithm of one plus the total number of forward citations. In Panel B, the dependent variable *Ln(Female Citation)* is the logarithm of one plus the number of forward citations received from patents with at least one female in the inventor team. The dependent variable *Ln(Male Citation)* is the logarithm of one plus the number of forward citations received from patents with all male inventors. In Panel C, we interact the dummy variable *Solo Female Inventor* with the rare name measure. The sample in Panel C consists of solo utility patent applications filed from 2001 to 2017, for which we could identify the gender of the inventor. We further limit the sample to applications in which inventors have either a rare or a common name. An inventor's first name is considered rare (common) if it falls in the bottom (top) 10 percentile in column (1) and in the bottom (top) 1 percentile in column (2) in terms of frequency counts among all the names in the Social Security application database. *Rare Name* is a binary variable that takes the value of one if an inventor's first name is rare, and zero otherwise. We include the same set of control variables as that in Table 2, but do not tabulate them for brevity. Definitions of other variables are in Appendix A. We include Art Unit×Subclass×Year fixed effects in all regressions. P-values based on robust standard errors clustered at the Art Unit×Subclass×Year are reported in parentheses under the corresponding estimated coefficients. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Total citations

	(1)	(2)	(3)	(4)	(5)
			Dept. Var=Ln(Citation)		
Prop. Female Inventor	-0.084***				
	(0.000)				
Majority Female Inventor		-0.051***			
		(0.000)			
All Female Inventor			-0.044***		
			(0.000)		
All Female Inventor-Non-Mixed Team				-0.050***	
				(0.000)	
Solo Female Inventor					-0.046***
					(0.000)
Controls	Yes	Yes	Yes	Yes	Yes
Model	OLS	OLS	OLS	OLS	OLS
Fixed Effects			Art Unit×Subclass×Year		
N	1,578,808	1,578,808	1,578,808	1,349,809	450,414
adj. R-sq	0.291	0.291	0.291	0.295	0.299

Panel B: Citations by gender

Dept. Var=	(1) *Ln(Female Citation)*	(2) *Ln(Male Citation)*	(3) *Ln(Female Citation)*	(4) *Ln(Male Citation)*	(5) *Ln(Female Citation)*	(6) *Ln(Male Citation)*	(7) *Ln(Female Citation)*	(8) *Ln(Male Citation)*	(9) *Ln(Female Citation)*	(10) *Ln(Male Citation)*
Prop. Female Inventor	0.245***	-0.303***								
	(0.000)	(0.000)								
Majority Female Inventor			0.146***	-0.194***						
			(0.000)	(0.000)						
All Female Inventor					0.143***	-0.188***				
					(0.000)	(0.000)				
All Female Inventor-Non-							0.154***	-0.203***		
Mixed Team							(0.000)	(0.000)		
Solo Female Inventor									0.155***	-0.190***
									(0.000)	(0.000)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Model	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Fixed Effects	Art Unit×Subclass×Year									
N	1,015,709	1,015,709	1,015,709	1,015,709	1,015,709	1,015,709	874,864	874,864	278,833	278,833
adj. R-sq	0.219	0.264	0.215	0.262	0.214	0.262	0.208	0.260	0.209	0.264

Panel C: Total citations: Rare vs. common name

Dept. Var=	(1) *Ln(Citation)*	(2) *Ln(Citation)*
	Rare (Common) name in bottom (top) 10%	*Rare (Common) name in bottom (top) 1%*
Solo Female Inventor (β_1)	-0.072***	-0.083***
	(0.000)	(0.000)
Solo Female Inventor×Rare	0.057***	0.069***
Name (β_2)	(0.009)	(0.003)
Rare Name (β_3)	-0.052***	-0.061***
	(0.000)	(0.000)
Controls	Yes	Yes
Model	OLS	OLS
Fixed Effects	Art Unit×Subclass×Year	
Test: $\beta_1 + \beta_2 = 0$	-0.015	-0.014
p-value	(0.410)	(0.445)
N	319,027	279,550
adj. R-sq	0.384	0.389

Table 7. Female Inventors and Economic Value of Patents

The table presents the results of the effect of inventor gender on the economic value of patents, and how this relationship varies by the rarity of the inventor's name. The dependent variable *Patent Value* is the economic value of each patent based on the stock return of patent grant announcement (Kogan et al., 2017). Since this data is only available for granted patents of publicly traded firms, our sample is restricted to those patents only. In Panel A, we regress the patent value on the inventor gender measures. In Panel B, we interact the dummy variable *Solo Female Inventor* with the rare name measure. The sample in Panel B consists of solo utility patent applications filed from 2001 to 2017, for which we could identify the gender of the inventor. We further limit the sample to applications in which inventors have either a rare or a common name. An inventor's first name is considered rare (common) if it falls in the bottom (top) 10 percentile in column (1) and in the bottom (top) 1 percentile in column (2) in terms of frequency counts among all the names in the Social Security application database. *Rare Name* is a binary variable that takes the value of one if an inventor's first name is rare, and zero otherwise. Definitions of other variables are in Appendix A. We include firm and year fixed effects in all regressions. In Panel B, we include the same set of control variables as that in Panel A, but do not tabulate them for brevity. P-values based on robust standard errors clustered at the Firm×Year are reported in parentheses under the corresponding estimated coefficients. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Female inventors and patent value

	(1)	(2)	(3)	(4)	(5)
	Dept. Var=Patent Value				
Prop. Female Inventor	0.620***				
	(0.002)				
Majority Female Inventor		0.629***			
		(0.006)			
All Female Inventor			0.402*		
			(0.092)		
All Female Inventor-Non-Mixed Team				0.442*	
				(0.068)	
Solo Female Inventor					0.287
					(0.239)
LN_Asset	1.317	1.317	1.317	0.830	-0.234
	(0.125)	(0.125)	(0.125)	(0.333)	(0.796)
ROA	-5.751*	-5.748*	-5.747*	-6.976**	-10.463***
	(0.092)	(0.092)	(0.092)	(0.042)	(0.006)
R&D/Asset	-26.515***	-26.509***	-26.511***	-29.270***	-28.762***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CAPEXTA	19.820**	19.815**	19.811**	21.010**	12.494
	(0.023)	(0.023)	(0.023)	(0.014)	(0.119)
Leverage	7.307***	7.310***	7.312***	7.631***	6.204**
	(0.003)	(0.003)	(0.003)	(0.002)	(0.014)
Market-to-book	3.417***	3.417***	3.417***	3.430***	3.229***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Institutional Holding%	1.724	1.725	1.726	1.574	0.755
	(0.252)	(0.251)	(0.251)	(0.278)	(0.620)
Ln(Age)	4.314***	4.313***	4.308***	4.529***	3.217**
	(0.001)	(0.001)	(0.001)	(0.000)	(0.011)
PPE/Asset	-17.440***	-17.444***	-17.439***	-17.857***	-11.987***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)
HHI	-8.763	-8.750	-8.748	-10.392**	-6.132
	(0.105)	(0.105)	(0.105)	(0.043)	(0.190)
HHI^2	10.284**	10.275**	10.274**	11.217***	6.698*
	(0.017)	(0.017)	(0.017)	(0.007)	(0.083)
KZ-INDEX	0.000	0.000	0.000	0.000	0.000
	(0.733)	(0.734)	(0.731)	(0.186)	(0.109)
Constant	-11.159	-11.138	-11.113	-6.971	6.876
	(0.260)	(0.261)	(0.262)	(0.479)	(0.491)
Model	OLS	OLS	OLS	OLS	OLS
Fixed Effects	Firm and Year Fixed Effects				
N	712,894	712,894	712,894	612,613	209,986
adj. R-sq	0.657	0.657	0.657	0.654	0.657

Panel B: Rare vs. common name

	(1)	(2)
Dept. Var=	*Patent Value*	*Patent Value*
	Rare (Common) name in bottom (top) 10%	*Rare (Common) name in bottom (top) 1%*
Solo Female Inventor (β_1)	0.983**	0.960**
	(0.011)	(0.031)
Solo Female Inventor	-1.530***	-1.517**
×Rare Name (β_2)	(0.010)	(0.016)
Rare Name (β_3)	-0.349**	-0.441**
	(0.026)	(0.012)
Controls	Yes	Yes
Model	OLS	OLS
Fixed Effects	Firm and Year Fixed Effects	
Test: $\beta_1 + \beta_2 = 0$	-0.547	-0.557
p-value	(0.227)	(0.221)
N	160,057	146,556
adj. R-sq	0.644	0.643

Table 8. Summary Statistics of the Sample for Heckman Models

This table presents the summary statistics of utility patent applications filed from 2001 to 2017, for which we could identify the gender of all inventors in an application. Since we examine the decision of filing an initial amendment that is only available for applications that receive a non-final rejection, we exclude from the sample the applications that received a final rejection upon the first-action decision. *Initial Amendment* is a binary variable that takes the value of one if the applicant files an amendment after receiving a first-action non-final rejection, and zero otherwise. Definitions of other variables are provided in Appendix A.

	N	Mean	Median	SD
First-Action Non-final Rejection	1,880,304	0.925	1	0.264
First-Action Allowance	1,880,304	0.075	0	0.264
Initial Amendment	1,738,754	0.816	1	0.387
Prop. of Female Inventor	1,880,304	0.079	0	0.209
Majority Female Inventor	1,880,304	0.038	0	0.191
All Female Inventor	1,880,304	0.029	0	0.167
All Female Inventor-Non-Mixed Team	1,622,321	0.033	0	0.179
Solo Female Inventor	715,758	0.064	0	0.245
Examiner Review Speed	1,880,304	1.756	2	0.741
Examiner Scope Leniency	1,880,304	2.759	3	0.632
Examiner Experience	1,880,304	11.731	10	7.858
Small Entity	1,880,304	0.245	0	0.430
Foreign Priority	1,880,304	0.386	0	0.487
Continuation	1,880,304	0.590	1	0.492
Foreign Applicant	1,880,304	0.526	1	0.499
Number of Inventors	1,880,304	2.372	2	1.627
Solo Inventor	1,880,304	0.381	0	0.486
Initial Num. of Claims	1,880,304	3.353	3	4.318
Inventor Experience	1,880,304	20.448	5	41.055
Have Patent Agent	1,709,337	0.722	1	0.448
Public Assignee	1,880,304	0.545	1	0.498

Table 9. Female Inventors and the Likelihood of Filing an Initial Amendment

This table presents the results of Heckman selection models in which we investigate the likelihood of female inventors filing initial amendments in response to rejections at the first-action decision. Our sample consists of all utility patent applications filed from 2001 to 2017 for which we could identify the gender of all inventors in an application. We further exclude applications that received a final rejection upon the first-action decision. Panel A reports the results of the first stage regression of the Heckman selection model, where the dependent variable *Non-final Rejection* is a binary variable that takes the value of one if the application is rejected upon the first-action decision, and zero otherwise. Panel B reports the results of the second stage regression where the sample only includes applications that received a non-final rejection. The dependent variable *Initial Amendment* is a binary variable that takes the value of one if the applicant files an initial amendment, and zero otherwise. In column (1), the independent variable *Prop. Female Inventor* is the proportion of female inventors listed on a patent application. In column (2), the independent variable *Majority Female Inventor* is a binary variable that takes the value of one if at least 50% of the inventor team are females, and zero otherwise. In column (3), the independent variable *All Female Inventor* is a binary variable that takes the value of one if the entire inventor team consists of females, and zero otherwise. In column (4), the sample is limited to applications in which the inventor teams are either all females or all males. The independent variable *All Female Inventor-Non-Mixed Team* is a binary variable that takes the value of one if the entire inventor team consists of females and zero if the entire inventor team consists of males. In column (5), the sample only includes solo applications. The independent variable *Solo Female Inventor* is a binary variable that takes the value of one if the solo inventor is a female and zero if the solo inventor is a male. In Panel A, we include the same set of control variables as that in Table 2. In Panel B we include the same controls but dropping the examiner characteristics variables, since whether to file an amendment is a choice by the applicant. Definitions of other variables are in Appendix A. We include Art Unit×Subclass×Year fixed effects in all regressions. P-values based on robust standard errors clustered at the Art Unit×Subclass×Year are reported in parentheses under the corresponding estimated coefficients. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Heckman selection model: first stage

	(1)	(2)	(3)	(4)	(5)
			Dept Var=Non-Final Rejection		
Prop. Female Inventor	0.035***				
	(0.001)				
Majority Female Inventor		0.039***			
		(0.001)			
All Female Inventor			0.027**		
			(0.035)		
All Female Inventor-Non-Mixed Team				0.030**	
				(0.028)	
Solo Female Inventor					0.018
					(0.289)
Controls	Yes	Yes	Yes	Yes	Yes
Model	Probit	Probit	Probit	Probit	Probit
Fixed Effects			Art Unit×Subclass×Year		
Log likelihood	-443848.3	-443848.5	-443852.6	-385823.3	-129861.7
Wald χ^2	887696.7***	887697.0***	887705.3***	771646.6***	259723.4***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	1,076,121	1,076,121	1,076,121	903,296	273,573

Panel B: Heckman selection model: second stage

	(1)	(2)	(3)	(4)	(5)
			Dept. Var=Initial Amendment		
Prop. Female Inventor	-0.011***				
	(0.000)				
Majority Female Inventor		-0.012***			
		(0.000)			
All Female Inventor			-0.014***		
			(0.000)		
All Female Inventor-Non-Mixed Team				-0.013***	
				(0.000)	
Solo Female Inventor					-0.008*
					(0.074)
Inverse Mills Ratio	0.083***	0.083***	0.083***	0.074***	0.058*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.054)
Controls	Yes	Yes	Yes	Yes	Yes
Model	Heckman	Heckman	Heckman	Heckman	Heckman
Fixed Effects			Art Unit×Subclass×Year		
N	828,909	828,909	828,909	682,621	185,936
adj. R-sq	0.089	0.089	0.089	0.090	0.105

Table 10. The Effect of Patent Agent and Public Assignee on the Likelihood of Filing an Initial Amendment

This table presents the results of the second stage Heckman selection model where we investigate the effect of female inventor on the probability of filing an initial amendment, conditional on whether the applicants use a patent agent in Panel A or whether they work for a publicly traded firm (i.e., public assignee) in Panel B. The first stage regressions that predict the likelihood of being rejected upon the first-action decision are not tabulated for brevity. In Panel A, *Have Patent Agent* is a binary variable that takes the value of one if the applicant employed a patent agent, and zero otherwise. *Public Assignee* in Panel B is a binary variable that takes the value of one if the patent right is assigned to a publicly traded firm, and zero otherwise. The dependent variable *Initial Amendment* is a binary variable that takes the value of one if the applicant files an amendment after receiving a first-action non-final rejection, and zero otherwise. In column (1), the independent variable *Prop. Female Inventor* is the proportion of female inventors listed on a patent application. In column (2), the independent variable *Majority Female Inventor* is a binary variable that takes the value of one if at least 50% of the inventor team are females, and zero otherwise. In column (3), the independent variable *All Female Inventor* is a binary variable that takes the value of one if the entire inventor team consists of females, and zero otherwise. In column (4), the sample is limited to applications in which the inventor teams are either all females or all males. The independent variable *All Female Inventor-Non-Mixed Team* is a binary variable that takes the value of one if the entire inventor team consists of females and zero if the entire inventor team consists of males. In column (5), the sample only includes solo applications. The independent variable *Solo Female Inventor* is a binary variable that takes the value of one if the solo inventor is a female and zero if the solo inventor is a male. We include the same set of control variables as those in Table 6, but do not tabulate them for brevity. Definitions of other variables are in Appendix A. We include Art Unit×Subclass×Year fixed effects in all regressions. P-values based on robust standard errors clustered at the Art Unit×Subclass×Year are reported in parentheses under the corresponding estimated coefficients. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Conditional on having a patent agent

	(1)	(2)	(3)	(4)	(5)
	Dept. Var=Initial Amendment				
Prop. Female Inventor (β_1)	-0.018***				
	(0.001)				
Prop. Female Inventor×Have Patent Agent (β_2)	0.011*				
	(0.064)				
Majority Female Inventor (β_1)		-0.025***			
		(0.000)			
Majority Female Inventor×Have Patent Agent (β_2)		0.021***			
		(0.002)			
All Female Inventor (β_1)			-0.024***		
			(0.000)		
All Female Inventor×Have Patent Agent (β_2)			0.019**		
			(0.014)		
All Female Inventor-Non-Mixed Team (β_1)				-0.024***	
				(0.001)	
All Female Inventor-Non-Mixed Team×Have Patent Agent (β_2)				0.020**	
				(0.011)	
Solo Female Inventor (β_1)					-0.017*
					(0.083)
Solo Female Inventor×Have Patent Agent (β_2)					0.018
					(0.110)
Have Patent Agent (β_3)	0.016***	0.016***	0.017***	0.016***	0.023***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Inverse Mills Ratio	0.078***	0.078***	0.078***	0.074***	0.093***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)
Controls	Yes	Yes	Yes	Yes	Yes
Model	Heckman	Heckman	Heckman	Heckman	Heckman
Fixed Effects	Art Unit×Subclass×Year				
Test: $\beta_1+\beta_2=0$	-0.007**	-0.004	-0.005	-0.004	0.001
p-value	(0.015)	(0.273)	(0.159)	(0.331)	(0.927)
N	728,720	728,720	728,720	600,344	158,450
adj. R-sq	0.083	0.083	0.083	0.083	0.099

Panel B: Conditional on working for a public assignee

	(1)	(2)	(3)	(4)	(5)
			Dept. Var=Initial Amendment		
Prop. Female Inventor (β_1)	-0.023***				
	(0.000)				
Prop. Female Inventor×Public Assignee (β_2)	0.022***				
	(0.000)				
Majority Female Inventor (β_1)		-0.023***			
		(0.000)			
Majority Female Inventor× Public Assignee (β_2)		0.024***			
		(0.000)			
All Female Inventor (β_1)			-0.028***		
			(0.000)		
All Female Inventor× Public Assignee (β_2)			0.032***		
			(0.000)		
All Female Inventor-Non-Mixed Team (β_1)				-0.029***	
				(0.000)	
All Female Inventor-Non-Mixed Team×Public Assignee (β_2)				0.034***	
				(0.000)	
Solo Female Inventor (β_1)					-0.022***
					(0.001)
Solo Female Inventor×Public Assignee (β_2)					0.033***
					(0.000)
Public Assignee (β_3)	0.054***	0.055***	0.055***	0.053***	0.060***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Inverse Mills Ratio	0.087***	0.086***	0.086***	0.079***	0.064**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.033)
Controls	Yes	Yes	Yes	Yes	Yes
Model	Heckman	Heckman	Heckman	Heckman	Heckman
Fixed Effects			Art Unit×Subclass×Year		
Test: $\beta_1 + \beta_2 = 0$	-0.001	0.001	0.004	0.005	0.011**
p-value	(0.739)	(0.777)	(0.319)	(0.156)	(0.043)
N	828,909	828,909	828,909	682,621	185,936
adj. R-sq	0.093	0.093	0.093	0.093	0.109

Appendix A. Variable Definitions

Variable	Definition
<u>Patenting Outcome Variables</u>	
First-Action Allowance	An indicator that takes the value of one if the application is approved (granted) upon the first-action decision, and zero otherwise.
Patent Granted	An indicator that takes the value of one if the patent is eventually granted, and zero otherwise.
Non-Final Rejection	An indicator that takes the value of one if the application receives a restriction required or non-final rejection, and zero if the application is approved (granted) upon the first-action decision.
Initial Amendment	An indicator that takes the value of one if the applicant files an amendment after receiving a first-action non-final rejection, and zero otherwise.
<u>Measures of Female Inventor Participation</u>	
Prop. Female Inventor	The proportion of female inventors listed on the patent application.
Majority Female Inventor	An indicator that takes the value of one if at least 50% of inventor team are females, and zero otherwise.
All Female Inventor	An indicator that takes the value of one if the entire inventor team consists of females, and zero otherwise.
All Female Inventor-Non-Mixed Team	An indicator that takes the value of one if the entire inventor team consists of females and zero if the entire inventor team consists of males.
Solo Female Inventor	An indicator that takes the value of one if the solo inventor is a female and zero if the solo inventor is a male.
<u>Control Variables</u>	
Examiner Review Speed	The average time lag in years between application to first-action decision of all applications that the examiner has reviewed since she joined the USPTO database.
Examiner Scope Leniency	The average number of independent claims of the patents that an examiner has granted in a specific art unit since she joined the USPTO database.
Examiner Experience	The total number of patent applications the examiner reviewed since she joined the USPTO database.
Small Entity	An indicator that takes the value of one if the owner of the patent right being applied for is qualified for the USPTO's small-entity discounts on application fees, and zero otherwise.
Foreign Priority	An indicator that takes the value of one if the patent application is based on a patent or patent application previously submitted to a non-US patent office, and zero otherwise.

Continuation	An indicator that takes the value of one if the patent was filed as a continuation of previous patents, and zero otherwise.
Foreign Applicant	An indicator that takes the value of one if the primary inventor on the application was located abroad, and zero otherwise.
Number of Inventors	The total number of inventors listed on a patent application.
Solo Inventor	An indicator that takes the value of one if only one inventor is listed on a patent application, and zero otherwise.
Initial Num. of Claims	The total number of independent claims in the original patent application.
Inventor Experience	The maximum number of patents filed before the focal patent application by an inventor among the inventor team.
LN_Asset	The natural logarithm of total assets.
ROA	Operating cash flow scaled by total assets.
R&D/Asset	The ratio of R&D expenditures to total assets.
CAPEXTA	The ratio of capital expenditures to total assets.
Leverage	Book value of total debt scaled by total assets.
Market-to-book	The ratio of market value of assets to book value of assets.
Institutional Holding%	The average of the four quarterly institutional holdings divided by the number of outstanding shares, as reported by 13F.
Ln(Age)	The natural logarithm of the number of years since the firm first appears in Compustat.
PPE/Asset	The ratio of net property, plant and equipment to total assets.
HHI	Herfindahl Hirschman Index of firm's annual sales within 4-digit SIC industry.
KZ-INDEX	The financial constraint index as described in Kaplan and Zingales (1997).
<u>Other Patent Variables</u>	
Rare Name	An indicator that takes the value of one if the inventor has a rare first name, and zero if she/he has a common first name. An inventor's first name is considered rare (common) if it falls in the bottom (top) 10 percentile in columns (or in the bottom (top) 1 percentile) in terms of frequency counts among all the names in the Social Security application database.
Experienced Inventor Team	A binary variable that takes the value of one if at least one of the inventors listed on the patent application has ever filed for a patent in the past, and zero otherwise.

Examiner (More Female Experience)	A binary variable that takes the value of one if the examiner's experience with female inventors is in the top tercile in the corresponding art unit of the year, and zero otherwise.
Have Patent Agent	A binary variable that takes the value of one if the applicant employed a patent agent, and zero otherwise.
Public Assignee	A binary variable that takes the value of one if the patent right is assigned to a publicly traded firm, and zero otherwise.
Citation	The total number of forward citations.
Female Citation	The number of forward citations received from patents with at least one female in the inventor team.
Male Citation	The number of forward citations received from patents with all male inventors.
Patent Value	The economic value of each patent based on the stock return of patent grant announcement (Kogan et al., 2017).