Gender differences in obtaining and maintaining patent rights

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An examination of the prosecution and maintenance histories of approximately 2.7 million US patent applications indicates that women have less favorable outcomes than men.

Although women make up half of the population, they represent just 10% of US patent inventors and only 15% of inventors in the life sciences[1–4]. By tracking patent applications through the prosecution process, we found disparities between men and women inventors in the processes of obtaining and maintaining patent rights. Patent applications by women inventors were found to be more likely to be rejected than those of men, and those rejections were less likely to be appealed by the applicant team (inventor, assignee, and prosecuting attorney). Conditional on being granted, patent applications by women inventors had a smaller fraction of their claims allowed, on average, than did applications by men. Further, those claims allowed had more words added during prosecution, thus reducing their scope and value. The granted patents of women inventors also received fewer citations than those of men and were less likely to be maintained by their assignees. Surprisingly, many of these effects were larger in the life sciences than in other technology areas.

Methodology

Our study examined the individual prosecution histories of approximately 2.7 million US utility patent applications from the years spanning 2001 to 2014 (ref. 5). The US Patent and Trademark Office (USPTO) recently released these data in aggregate. In the past, researchers could access these data only one application at a time, through the USPTO's Patent Application Information Retrieval system (https://portal.uspto.gov/pair/PublicPair/), thus hindering the large-scale empirical study of patent-prosecution outcomes. We joined these prosecution histories with the maintenance-fee and full-text patent databases available from the USPTO. The joined data allowed us to inspect the communication between applicants and examiners, the manner in which application claims changed during prosecution, the dates of various communications, the payment of maintenance fees, the influx of forward citations, and other phenomena.

We determined the probable gender of each inventor by using forename gender distributions available from the US Social Security Administration (https://www.ssa.gov/oact/babynames/limits.html) and from two commercial databases (see **Supplementary Data**). In the covered population, 94.1% of forenames were associated at least 95% of the time with only one gender. If an inventor had a highly gendered forename, we accordingly classified that inventor as either a man or a woman. This approach allowed us to classify the probable genders of 89% of the inventors listed on the applications (detailed discussion and analysis of the classification process, including possible selection issues, in **Supplementary Data**). Because most applications listed multiple inventors, we calculated a 'proportion women' variable: the number of women inventors divided by the total number of inventors on each application. When we refer to effect sizes, the disparities between men and women represented a shift in this variable from 0% to 100%, from all men to all women inventors.

We used a series of linear regressions and Poisson count models to estimate the associations between gender and various patent-prosecution outcomes (**Fig. 1**). These models included controls for a variety of patent attributes, such as the number of claims, the number of inventors listed on the patent, and the size of the organizational assignee. Detailed descriptions of the models, as well as their robustness, are provided in the **Supplementary Data**. For example, we demonstrated the robustness of the results to using subsamples of patent applications—such as applications with only US inventors and only applications from large organizations—and to using alternative, nonlinear specifications of the inventor-team composition.

Results and discussion

In **Figure 1**, the dark-blue bars depict 'raw' gender differences, and the light-blue bars depict gender differences after introduction of a fixed effect for each application's primary technology class in the United States Patent Classification (USPC) system (https://www.uspto.gov/web/patents/classification/). (In the USPC, each application submitted to the USPTO is assigned to one or more of >400 different USPC classes, which reflect the subject matter of the application, in categories as diverse as 'apparel', 'music', 'surgery', and 'molecular biology and microbiology'. These classifications are used to assign the patent application to particular groups of patent examiners.) As the figure illustrates, men and women differed less in their outcomes after adjustment for the technology class. For example, the two topmost blue bars indicate that women inventors were 21% less likely than men inventors to have their application accepted, but that difference declined to 7% after technology-class fixed effects were included. This effect could be viewed as an example of 'Simpson's paradox'[6]; that is, two-thirds of the diminished probability of women's applications being accepted stemmed from women applying at higher rates than men to technology classes with lower acceptance rates. In those classes, it is

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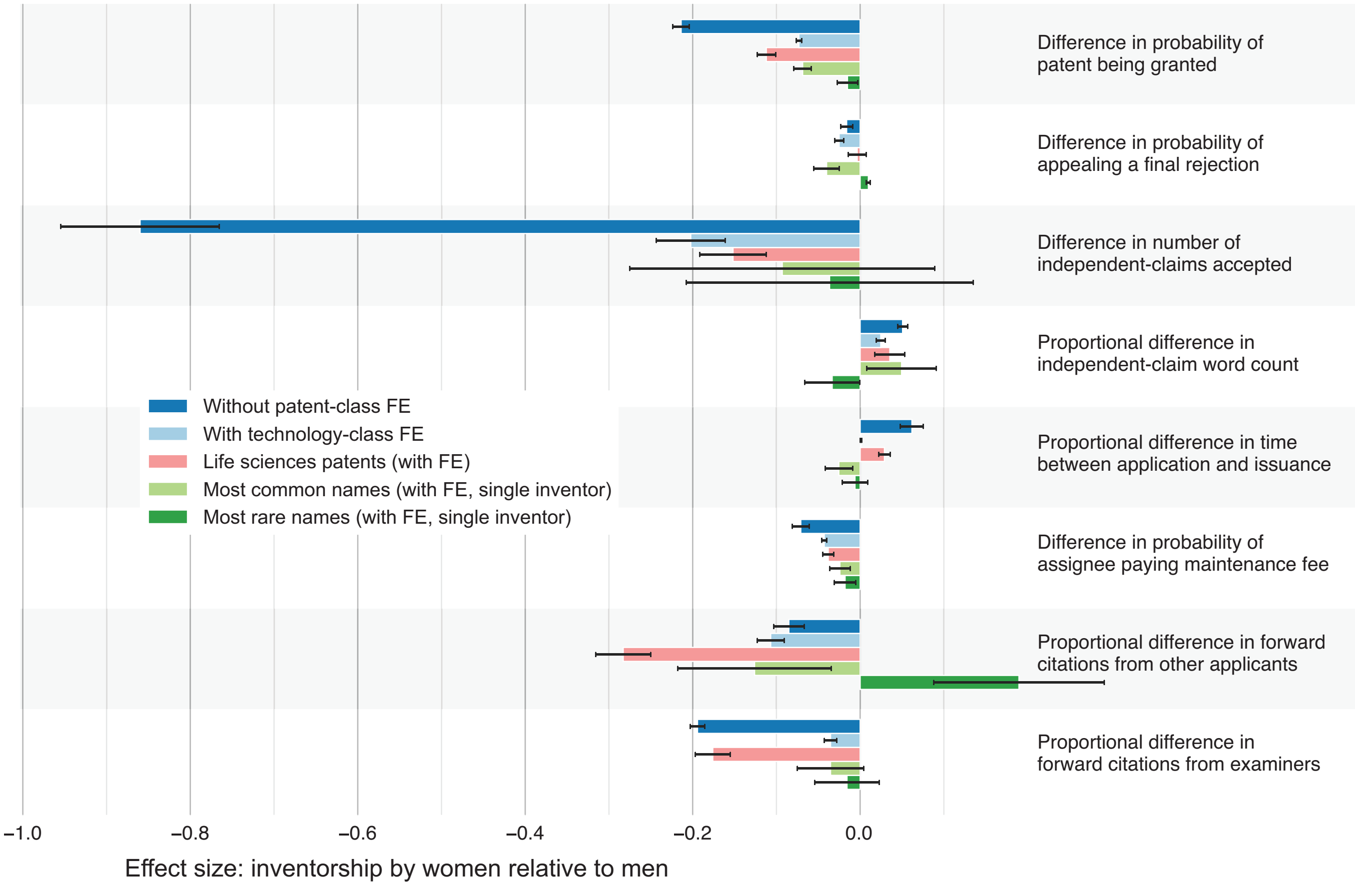

Figure 1 Estimated differences for teams of all women inventors relative to teams of all men, in the processes of obtaining and maintaining patent rights. Wide bars, point estimates; narrow bars, 95% confidence intervals (full model specifications in **Supplementary Data**). Teams with higher proportions of women had more negative outcomes during patent prosecution. For example, the topmost dark-blue bar indicates that patent applications by teams of all women inventors were 21% less likely to be granted than similar applications by teams of all men. The light-blue bar accounts for technology-class fixed effects (women are overrepresented in technology areas with lower acceptance rates); the topmost bar for example, indicates that even after accounting for technology-class fixed effects, all-women teams had a 7% lower probability of acceptance. The pink bars indicate the differences for patents in technology classes related to the life sciences. The final two bars (light and dark green) depict the estimated effects within two subsets of single-inventor patent applications. By examining the effects for inventors with common versus rare names, they provide an indication of the degree to which the gender differences stem from the applicant side—inventor, assignee, and attorney—versus the examiner side. The first two green bars, for example, suggest that approximately two-thirds of the lower probability of acceptance for applications with women inventors comes from the examiner side.

more challenging for anybody to get a patent approved, regardless of gender.

Even after adjustment for the differences across patent technology classes, however, women inventors still had less favorable experiences in nearly all outcomes. All else equal, relative to a team of all-men inventors, patent applications by teams of all women were 2.5% less likely to be appealed if rejected. Conditional on being granted, these applications, on average, had the number of independent claims reduced by one-fifth of a claim; had the number of words in their claims increased by 2.5%, thus narrowing the scope of these claims[7]; were 4.3% less likely to be maintained by their assignee; received 11% fewer citations from other patent applicants; and received 3.5% fewer citations from patent examiners. Forward citations trace the acknowledged contributions of prior art and are often used as measures of a patent's importance, scope, and value[8,9]. (These statistics all refer to the light-blue series in **Fig. 1**, which includes technology-class fixed effects, and appear in tabular form in the **Supplementary Data**.)

Although women might be expected to fare better in the life sciences, given their relatively higher representation in those fields, the data show no such pattern. The pink bars in **Figure 1** depict the gender differences within the subset of patents bearing life science classifications (description of how these are identified in **Supplementary Data**). For all outcomes that differed for the life sciences subset compared with the population of patents as a whole, the disparities in the life sciences appeared more disadvantageous to women. For example, in the life sciences, a team of all-women inventors was found to be 11% less likely than a team of all men to have its patent application accepted. Patents by women inventors in the life sciences also received 28% fewer forward citations from other inventors.

The data available did not allow us to isolate the mechanisms responsible for the gender differences in **Figure 1**—we were able to assess only the direction and magnitude of these differences. However, the natural variation in forename frequencies allowed us to gain some insight into the degree to which these differences arose from the applicant side—the inventor, assignee, and attorney—as compared with other parties. The inventors themselves are obviously aware of their own gender. Similarly, their employers and the attorneys representing them probably have firsthand knowledge of the inventors' genders. In contrast, the patent examiners and others must generally infer, either consciously or subconsciously, the gender of the inventors according to the forenames listed on patents and patent applications. (Examiners do sometimes meet with inventors in person and by telephone; robustness checks related to these scenarios are shown in the **Supplementary Data**.) For common names, such as 'Mary' and 'Robert,' outsiders can infer gender with a high level of confidence, but for thousands of rare names each held by only a few individuals, they cannot make such inferences. 'Jameire' and 'Kunnath,' for example, are also strongly associated with gender, with the first being male and the second being female, but because they are rare names, few people would be aware of these associations. The gender differences associated with common names therefore should capture both differences in behavior on the applicant side as well as differences in treatment of those inventors by others. Any gender differences associated with rare names, in contrast, should stem only from the behavior of the applicant side.

The two series of green bars in **Figure 1** show how the frequency of an inventor's forename moderates the effects of gender on various outcomes. Because these models also include a control for forename frequency, they account for any association between the rarity of a name and the underlying quality of the patent, for example, because those patents might disproportionately represent foreign applicants. To avoid complications in aggregating across names of varying frequency, these models include only single-inventor patents. Among those, two outcomes had large and statistically significant differences between inventors with common forenames and those with rare forenames. First, among inventors with common names, women had an 8.2% lower probability of having their application accepted than did men. In contrast, among inventors with rare names, women had only a 2.8% lower probability of acceptance than did men. This combination suggests that approximately two-thirds of the lower probability of acceptance for applications with women inventors stemmed from the examiner side. Second, future patent applicants cited the patents of women with common names 30% less frequently than those of men with common names. The patents authored by women with rare forenames, and who were therefore not easily identified as women, were cited approximately 20% more often than the average patent by a male inventor with a rare forename, all else equal. To the extent that citations reflect patent quality, this result suggests that women inventors must clear a higher hurdle than men and therefore that the average patent granted to a woman inventor is of higher quality than the average patent granted to a man.

Conclusions

These results should interest inventors, patent holders, and policymakers. In advanced economies, technical progress appears to be the primary driver of economic growth[10]. The patent system, moreover, is one of the principal public-policy mechanisms for promoting this progress: governments grant patent holders a limited monopoly in exchange for a thorough disclosure of their inventions, so that others may build upon those inventions[11]. That women inventors are underrepresented in this system and appear disadvantaged in the process of obtaining and maintaining patents suggests that changes to the patent system and its prosecution process would increase fairness and might even stimulate economic growth.

A thorough discussion of possible adjustments to the patent system is beyond the scope of this paper, but we can imagine many possibilities worth consideration. It may help, for example, to make the patent-prosecution process more 'blind' to the identity of participants. Patents and patent applications could list only the initials of the forenames of the inventors on patent applications and could require communication between examiners and applicants to occur on a platform that would maintain the anonymity of the applicants. Such blind processes have eliminated gender inequality in other settings: For instance, when orchestras introduced opaque screens to conceal the identities of those auditioning, they hired more women and placed more women in leadership positions[12]. The introduction of such practices at the patent office could help to ameliorate the gender differences in patenting both in the life sciences and in other technological areas.

Note: Any Supplementary Information and Source Data files are available in the online version of the paper.

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AUTHOR CONTRIBUTIONS
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COMPETING INTERESTS
The authors declare no competing interests.

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