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# Patent Examiners and the Citation Bias in Innovation

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**Abstract**

Patent citations are a key indicator for judging the diffusion of knowledge and the technological impact of underlying inventions. Patent examiners, in their function as gatekeepers, hold a decisive position in deciding which prior art becomes significant and which forgotten. This study investigates whether the gender of examiners affect their citing decisions by making use of the entire universe of over a million granted patents in the U.S. between 2001 and 2014. The first set of results indicates that disparity exists in how examiners treat a patent, according to the gender of its originator. The second set of findings demonstrate that male and female examiners diverged in their citation patterns. Because of the vast underrepresentation of female inventions, small differences in citation patterns lead to large inconsistencies. This paper explores the presence of gender bias in the assessment of technical knowledge and its impact on innovation dissemination, and highlights the importance of gender neutrality in governmental structures such as the United States Patent and Trademark Office. If prior inventions are disregarded because of the gender of their originator, technological progress will be hindered overall.

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# 1 Introduction

Gender differences impact the entire lifecycle of innovation. At equal abilities in childhood, women are less likely to become inventors in first place (Bell et al. (2018)). Institutional challenges, such as less favorable prosecution outcomes when filing for patents further hinder female inventorship (Jensen et al. (2018)). And should a female patent be granted, it is less likely to be cited by future inventions compared to patents by males (Jensen et al. (2018)). Gender discrepancies impact a woman's ability to become scientist or engineer, obtain a patent and to disseminate her knowledge. Such gender differences in patenting impose a societal cost, as gender inequality in education and employment reduces economic growth (Lagerlöf (1999); Dollar and Gatti (1999); Klasen and Lamanna (2009): Kabeer (2016)). Social biases against female scientists have been demonstrated by a range of studies. Female scholars receive fewer and smaller grants (Wennerås and Wold (1997); Bornmann et al. (2007)), fewer and less prestigious awards (Lincoln et al. (2012); Yifang et al. (2019)), and are less likely to be promoted and receive leadership positions in academia (McDowell et al. (2001); Jagsi et al. (2011)). This 'Mathilda' effect, named after feminist critic Matilda Gage, posits that contributions by women in Science, Technology, Engineering and Mathematics (STEM) are systematically under-recognized and achievements by female scientists are attributed to their male colleagues (Rossiter (1993)).

This paper explores the presence of biases in the assessment of technical knowledge by studying the behavior of patent examiners. Patent examiners deployed by patent offices serve as gatekeepers to ensure that only novel and non-obvious inventions are granted patent protection (Lemley and Sampat (2012)). To that end, when assessing patent application submitted by inventors, they screen and determine the state of the art that prevails at the time of the filing. This study is the first to undertake an examination of whether the characteristics of patent examiners, in particular their gender, impact their citation behavior. With recent advances in scholarship demonstrating differences in the assessment of male and female inventions, this paper subjects the role of the gender of the examiner to inquiry. Undercitation, if established, would imply that the scientific and engineering expertise and knowledge constituting the state of the art is not being reflected accurately, disregarding contributions made by female scientists. Further, the number of citations a patent receives is the first indicator for its perceived technological impact and economic value in social sciences. Gender differences in the reference to prior art influenced by the gender of examiners lead to a lack of diffusion and recognition of female-developed knowledge, and to differences in the perceived quality and value of female patents.

Psychological experimental studies underline the fact that, frequently, social biases affect both male and female in their decision-making. Subjects of both gender are more likely to hire a male scientist (Steinpreis et al. (1999)) and find female applicants less competent and worthy of a lower starting salary (Moss-Racusin et al. (2012)). However, in some decision-making processes, the biases appear to be gender-specific. In their academic citations, in particular, authors are more likely to cite research by scholars sharing their gender (Ferber (1988); Mitchell et al. (2013); Dion et al. (2018)). This paper contributes to this strand of the literature by seeking to determine whether male and female patent examiners cite male and female patents in identical or different fashion. The paper further contributes to the burgeoning literature that examines the effects of gender, religion or political preferences on legal case outcomes and decision. Decision-making biases have been identified for judges, whose function is to rationally and neutrally apply abstract legal concepts to concrete facts (Choi and Gulati (2008)). For innovation, where patent examiners hold a central function, individual characteristics of examiners have been found to be associated with their leniency (Kuhn and Thompson (2017), Frakes and Wasserman (2017)) . Lastly, the paper contributes to the literature on gender differences in patenting, that highlights that women face higher hurdles in innovative processes (Jensen et al. (2018)).

This paper fills a gap in literature by examining whether male examiners are more likely to cite male patents using the entire universe of individual-level patent data granted in the U.S. between 2001 and 2014 . Firstly, it finds that male patents in the field of Drugs & Medical and in the field of Computers and Communication are cited more by examiners by 10 percentage points. Second, it finds that in male examiners are more likely to cite patents by male innovators by 1 percentage and the difference is statistically significant at the 5 percent level – but only for Drugs & Medical patents. These findings imply that examiners over-cite male patents in certain fields, and that the gender of the examiner may well affect their citation behavior. These results are in line with past scholarship finding that female inventors are particularly disadvantaged in the field of life sciences (Jensen et al. (2018)).

## 2 Patent Application and the Role of Patent Examiners

The first Section streamlines the patent application process for inventions before the US Patent and Trademark Office, discusses the role of patent citations as prior art disclosure and reviews past scholarly evidence suggesting that individual characteristics of the examiner matter for his or her decision-making.

### 2.1 Application Process and Assignment

When entering examination, a patent application is assigned a to an Art Unit based on the subject-matter of the invention[1]. The latter is an administrative set of eight to fifteen patent examiners that specialize in a particular technology, responsible for the examination. The Supervisory Patent Examiner of the Art Unit then assigns the application to one examiner. This assignation is made largely on a random basis (Frakes and Wasserman (2017)), although there is some concern of sorting based on the examiner's familiarity with the technology and docket flow management (Lemley and Sampat (2012); Sampat and Williams (2019); Righi and Simcoe (2019)). Strong informational and historical barriers bar the patent office from sorting: the tradition of 'all patents are created equal' reflects the egalitarian custom of the patent system (Merges (1999)). When assigned to a less experienced patent examiner, i.e., an assistant patent examiner, the examination is subject to review from more senior examiners, i.e., by primary patent examiners (Alcácer and Gittelman (2006)).

### 2.2 Patent Citations as Prior Art Disclosure

When filing for a patent, all applicants, their attorneys and agents have a duty to disclose all information known to be material to patentability, other patents in particular (Title 37 of the Code of Federal Regulations, §1.56(a); Collins and Wyatt (1988)). Failure to comply bears drastic consequences: a patent may be declared unenforceable for its term (Erstling (2011)). Despite the duty of disclosure, there is no affirmative requirement for applicants to lead prior art searches, and incentives for applicants to conduct the search vary across industry (Lemley and Sampat (2012)). The examination therefore begins with the patent examiner conducting his own prior art search. Examiners are presumed to be more objective in their knowledge of the relevant prior art. Generally

[1]Classes and subclasses examined by the art unites are retrieved under `uspto.gov/patents-application-process/patent-search/understanding-patent-classifications/patent-classification`.

speaking, the examiner can add citation differing in nature from the applicant citations ('gap-filing') or that are similar ('tracking') (Alcácer and Gittelman (2006)). The examiner will search for earlier patents or non-patent documents such as scientific articles, newsletters and dissertations that have the same or similar feature than the invention at stake, but also more broadly that define the state of the art . Based on the set of prior art references, the examiner will determine the patentability of the claimed invention under the standpoint of novelty (35 U.S.C. 102) and nonobviousness (35 U.S.C. 103). Examiners rely almost exclusively on the prior art they identified to narrow patent claims, rather on prior art submitted by applicants (Cotropia et al. (2013)). A feature of policy concern is that the time allotted for examiners to review patent applications has tightened and is insufficient to conduct extensive reviews (Lemley (2001); Jaffe and Lerner (2004); Frakes and Wasserman (2017)).

### 2.3 Examiner Characteristics Matter

The process of how patent rights are created has become under increasing scrutinity over the last years. Despite uniform patentability criteria, the patent examiner in charge of the examination matters. Examiners differ in their experience level and technological specialization, and the latter have been found to be associated with trial outcomes (Cockburn et al. (2003)), grant rates (Frakes and Wasserman (2017); Righi and Simcoe (2019)) and citation patterns (Lemley and Sampat (2012)). Some examiners are systematically more lenient or tougher when determining the patent's scope (Kuhn and Thompson (2017)). The gender of patent examiners, however, has been subject to little inquiry. The only study in that regard notes that the gender of examiners does not correlate with the probability an application is granted (Lemley and Sampat (2009)).

# 3 Data and Methodology

## 3.1 Data

### 3.1.1 Patent Data Construction

We extracted patent data from PatentsView, a database sourced from US Patent and Trademark Office provided text and data[2]. We restricted our analysis to applications for granted patents from 2001 to 2014. Following a change in procedure in 2001, patent applications indicate whether a prior art reference was added by an examiner or the applicant . In accordance with past scholarship in innovation science, we only retained utility patents, deleting applications for design patents. We excluded foreign patents as foreign applicants may differ in their prior art submission practices (Alcácer and Gittelman (2006)). We merged the patent data with citations made to US granted patents. Two patent technology classifications were utilized. The first records the USPTO technology classes at patent issue date, and classifies patents in about 400 main 3-digit classes (hereafter the technology "class" level) and over 120,000 patent subclasses (hereafter the technology "subclass" level) . This system was designed with the purpose of identifying the function of the patent to facilitate prior art searches (Allison et al. (2004)) and is updated continuously to reflect technological changes (Hall et al. (2001)). The second, the National Bureau of Economic Research (NBER) technology categories, distinguishes patents in six broad technological fields: (1) Computers and Communications, (2) Drugs and Medical, (3) Electrical and Electronics, (4) Chemical, (5) Mechanical and (6) Others (Hall et al. (2001)). In total, our sample represents 1,011,080 granted utility patents by U.S. assignees from the period 2001 to 2014. Of those, we can identify the gender of the examiner and the gender of the inventors of at least one cited patent for 885,253 patents; unless specified otherwise, this is the data subject to inquiry.

### 3.1.2 Gender Coding Construction

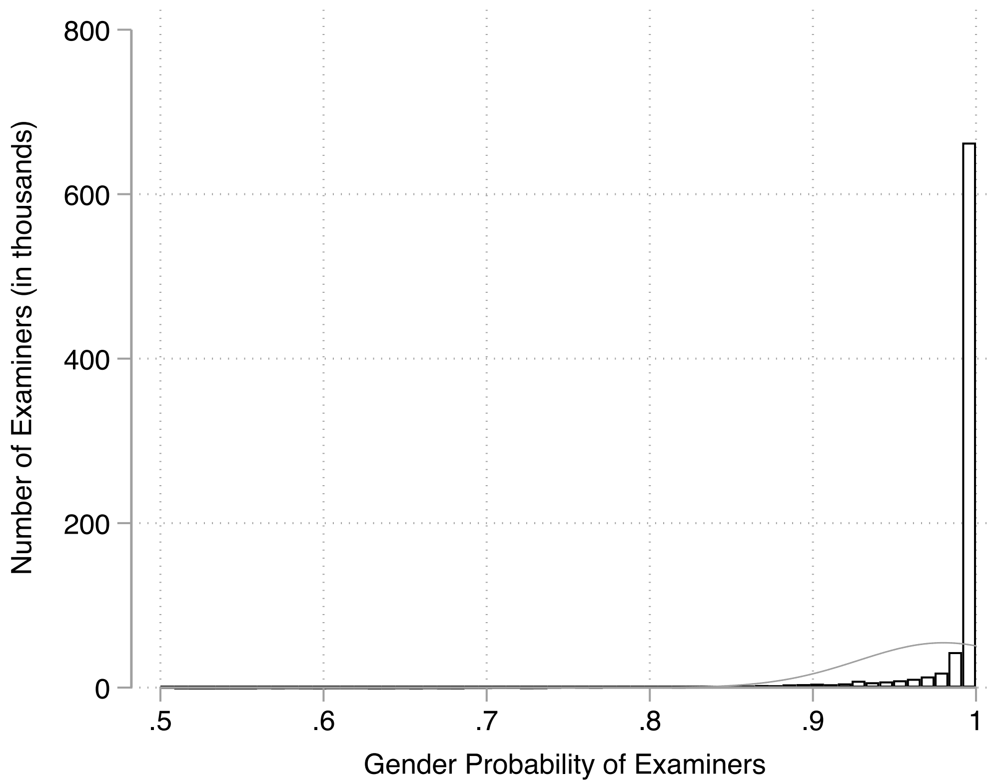
We inferred the probable gender of inventors and patent examiners by using U.S. Social Security Administration records at the national, state and territory level[3]. The disambiguation of gender is conducted by an assessment of the distribution of first names and the gender they were attributed to at birth. The database lists a total of 97,205 unique first names associated with over 50.01% to either the male or the female gender. Most names are associated with a gender with a high

[2] http://www.patentsview.org/download.

[3] https://www.ssa.gov/oact/babynames/limits.html.

likelihood (see Figure 1 for the patent examiners). The lack of ability to identify gender is a major limitation for this paper. The interpretation of the paper is conditional on the limited ability of administrative datasets to identify the gender of names, in particular for Asian names.

Figure 1: Gender Probability Distribution




Footnotes: Figure 1 presents the distribution of the likelihood of examiners to be associated to either gender.

### 3.2 Variables

A male patent is defined as a continuous variable that measures the percentage of male inventors at the patent level. The number of citation counts is defined as the number of times the patent is cited by examiners. Male citations is defined as a continuous variable that measures the percentage of citations that are made to patents that have male inventors only. Illustratively, should a patent cite two patents as prior art, one developed by a male inventor, the other by a team including both male and female inventors, Y(i) would be 0.5. Should the patent cite two patents, both developed by all-male inventors, male patent is assigned 1. Alternatively, we only use a dummy variable that equals one if all citations are male, and zero if any of the citations is not male.

The definition of the gender of the examiner is straightforward when the patent is examined by only one person. Should the examiner be a male, it will be 1; should the examiner be a women, it will be 0. However, in some instances, the patent was recorded to be examined by both a primary examiner and an assistant examiner. In this case, the gender of the primary examiner was used as the gender of the examiner. For robustness tests, we also adopted the assistant examiner's gender as the gender of the examiner.

### 3.3 Methods and Regression Setup

In a first step, we examine whether examiners are overall more likely to cite male patents. In a second step, we investigate the differences of citation outcomes by the gender of the examiner. For both of these research questions, we use two different levels of technological controls: year-specific (i) technology class fixed effects and (ii) technology subclass fixed effects. We exploit variation within technology class or subclass. The assumption of the method is that there is no endogenous sorting of examiner by gender and citation gender at the subclass level. In other words, one may be concerned that there is a concentration of women examiner in the field of women innovators. If this is the case, we would find that female examiners are more likely to cite female innovators, not because of citation preference, but because of the specialization of the field. Thus, we first examine the possibility of this threat directly in the appendix by looking at whether males examiners are correlated with male patents.

We use linear regression models with robust standard errors to account for heteroskedasticity. For dichotomous outcomes, such as whether the cited patents are all male, linear regression models provide unbiased estimates of the conditional mean probability of an outcome and avoid incidental parameter bias even when it includes a large number of intercepts. Specifically, to answer the first question on whether male patents are being cited more often, we estimate the model below:

$$CitationCounts(i) = \beta 0 + \beta 1 * MalePatent(i) + \delta + k + \epsilon(i) \tag{1}$$

Where $\beta 1$ measures the relationship between being a male patent and the number of citations received by the examiners. $\delta$ represents a vector of year-specific-USPC class indicator variables; in other words, it uses year-specific-USPC class fixed effects. In the alternative regression set up, $\delta$ represents a vector of year-specific-USPC subclass indicator variables. $k$ represents a set of vectors that represent the fixed effects for the number of citations the patent has received, the fixed effects for the number of citations that the patent has made, the fixed effects for the number of inventors, the fixed effects for the number of claims that the patent can make, the number of patents the examiner has approved, and a dummy for whether the patent has cited any of its own authors or cited patents that has the same assignee.

To answer the second question, we estimate the model below:

$$Y(i) = \beta 0 + \beta 1 * ExaminerGender(i) + \delta + k + \epsilon(i) \tag{2}$$

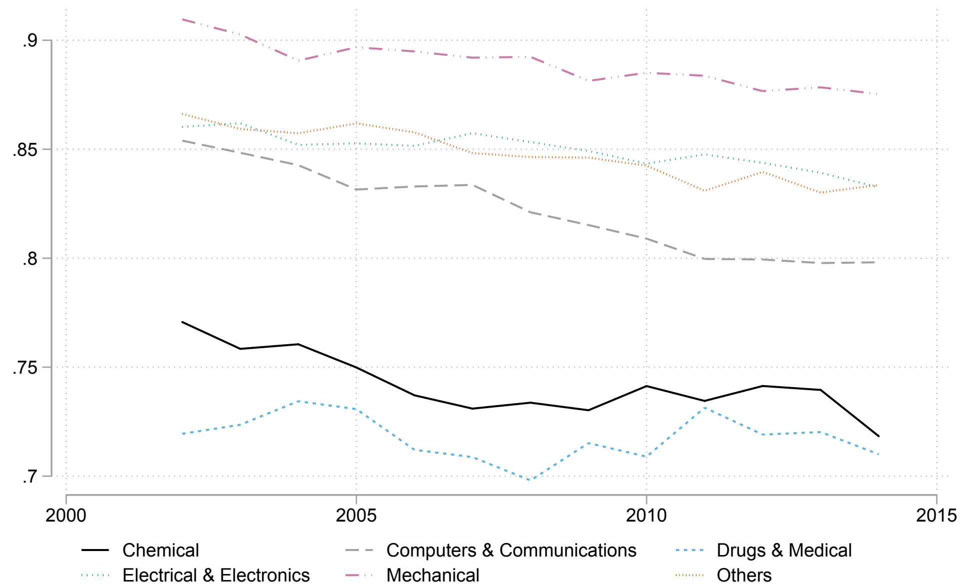
Where $\beta 1$ represents the coefficient of interest, which measures the examiner gender and partial correlation of the proportion of citations that have all male innovators.

# 4 Results

## 4.1 Descriptive Results

A male inventor (or a team of all-male inventors) developed 82 percent of all patents, a gender gender-mixed team 15 percent of all patents, and a female (or a team of all-female inventors) 2.7 percent of all patents. Across technological field, the representation of male and female inventors varied. As indicated by Figure 2, the Mechanical field had the highest level of male inventions. Women have traditionally been vastly underrepresented in latter field, receiving less than 20 percent of engineering degrees, compared to close to 60 percent in biomedical sciences (Milli et al. (2016)). Accordingly, the Drugs & Medical field had the highest share of female or gender-mixed (teams of) inventor(s). Female inventorship rised from 16% in 2002 to 20% in 2014. This reflects the fact that the gender gap in Science, Technology, Engineering, Mathematics, and Medicine is closing, if slowly (Holman et al. (2018)).

Figure 2: Representation of Male Inventors by Technology




Footnotes: Figure 2 presents the share of male inventors by year and technological field as defined by the NBER classification.

Descriptive statistics are presented in Table 1. About twenty percent of all examiners were female. The USPTO is seeking to narrow the gender gap and reported that in 2018, its patent examiner corpus comprised 27% of women (Hosler (2018)). Female examiners were, on average, less experienced than male examiners, having granted 331 versus 490 inventions. Male examiners examined inventions patented by male-only inventors in 83 percent of all cases, and cited all-male patents in 85 percent of the cases. Female examiners examined inventions patented by all-male inventors in 79 percent of all cases, and cited all-male patents in 83 percent of the cases.

Table 1: Summary Statistics

| | (All) | | (Male Examiners) | | (Female Examiners) | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| A. Examiner Characteristics | | | | | | |
| Gender (Primary Examiner) | 0.8 | 0.4 | - | | - | |
| Number of Patents Reviewed | 458.2 | 511.4 | 490.9 | 542 | 331.2 | 350.2 |
| B. Inventor Characteristics | | | | | | |
| Share of Male in Teams | 0.918 | 0.21 | 0.921 | 0.2 | 0.9 | 0.22 |
| All-Male Team | 0.82 | 0.38 | 0.827 | 0.38 | 0.79 | 0.41 |
| C. Patent Characteristics | | | | | | |
| Number of Inventors | 2.7 | 1.8 | 2.7 | 1.8 | 2.8 | 1.9 |
| Number of Claims | 19.9 | 13.9 | 19.8 | 13.9 | 19.6 | 13.7 |
| Number of Citations by Examiner | 5.8 | 6.3 | 5.9 | 6.37 | 5.5 | 5.7 |
| Number of Subsequent Citations | 13.4 | 34.4 | 13.6 | 34.7 | 11.9 | 31.4 |
| Self Citation (Cited Inventor) | 0.172 | 0.38 | 0.17 | 0.38 | 0.18 | 0.38 |
| Self Citation (Cited Assignee) | 0.413 | 0.49 | 0.408 | 0.49 | 0.42 | 0.49 |
| D. Citation | | | | | | |
| To All-Male Patents | 0.849 | 0.24 | 0.855 | 0.24 | 82.6 | 0.27 |
| To Only-All Male Patents | 0.586 | 0.49 | 0.591 | 0.49 | 56.6 | 0.49 |
| E. Observations | | | | | | |
| Number of Observations | 885253 | | 708283 | | 176970 | |

Footnotes: 'Share of Males in Team' is computed as a continuous variable and 'All-Male Teams' as a discrete binary variable. 'Number of Citations by Examiner' indicates the number of citations made by examiner and 'Number of Subsequent Citations' the total number of citations the patent subsequently receives. Self-Citation represents the tendency of examiners to cite patents including at least one inventor listed on the examined patent ('Cited Inventor') or if the assignee is identical ('Cited Assignee'). Citations to 'All-Male Patents' represent the share of citations made to all-male patents and 'Only All-Male Patents' the citations made to all-male patents only, that is if a patent cites one all-male and one gender-mixed patents, their count is 0.5 and 0, respectively.

Other characteristics of the patent, such as the number of inventors listed, and at the citation level, such as the rate of self-citation, were similar for both male and female examiners. Male examiners cited on average 5.9 patents, female examiners 5.5 patents. Patents examined by men were on average more likely to be cited by subsequent inventions, with 13.6 versus 11.9 future citations. The evolution of gender citation patterns over time are further presented in Figure A.1. Overall, citations made to female patents increased from 14.6% to 16.7%. The representation of female prior art in Computer & Communications grew the most, with a jump of five percentage points. Other fields, such as Drugs & Medical or Electrical & Electronics were not subject to any apparent high-level change.

## 4.2 Examiners Overcite Male Patents

Table 2 explores whether examiners cite more male than female patents as prior art. Linear regression estimations find that a male patent was associated with higher citation rates, but the results are driven by certain technologies only. Drugs & Medical patents, illustratively, were associated with 24 percentage points of citations by examiners using year-specific technology class fixed effects. The coefficients becomes smaller at 10 percentage points with year-specific technology subclass fixed effects. Using this more refined method, the number of citations associated with patent gender in the field of Drugs & Medical or the field of Computers and Communication remained statistically significant.

Table 2: Male Patent and Citations by Examiners

| | Number of Citations | | | | | | |
|---|---|---|---|---|---|---|---|
| | All | Chemical | CmpCmm | DrugsMed | Elec | Mech | others |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | Panel A. No Controls | | | | | | |
| Male Patent | 59.838*** | 53.217*** | 30.054*** | 102.542*** | 36.828*** | 33.722*** | 53.217*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Observations | 959709 | 88774 | 358229 | 99071 | 189180 | 111468 | 88774 |
| | Panel B. With Main Class Fixed Effects | | | | | | |
| Male Patent | 5.739*** | 3.300 | 2.097 | 24.087*** | 3.024 | -0.374 | 7.221 |
| | (0.009) | (0.358) | (0.646) | (0.000) | (0.482) | (0.947) | (0.195) |
| Observations | 959709 | 88774 | 358229 | 99071 | 189180 | 111468 | 112982 |
| | Panel C. With Main Subclass Fixed Effects | | | | | | |
| Male Patent | 8.794*** | 4.460 | 10.991** | 10.713*** | -0.892 | 15.006 | 7.795 |
| | (0.004) | (0.486) | (0.034) | (0.008) | (0.879) | (0.119) | (0.405) |
| Observations | 959709 | 88774 | 358229 | 99071 | 189180 | 111468 | 112982 |
| | Panel D. With Main Subclass Fixed Effects and Additional Controls | | | | | | |
| Male Patent | 15.242*** | 9.183 | 19.272*** | 17.485*** | 5.483 | 15.906 | 13.090 |
| | (0.000) | (0.159) | (0.000) | (0.000) | (0.345) | (0.099) | (0.162) |
| Observations | 959707 | 88773 | 358228 | 99071 | 189180 | 111468 | 112982 |

*p*-values in parentheses | ** $p < 0.05$, *** $p < 0.01$

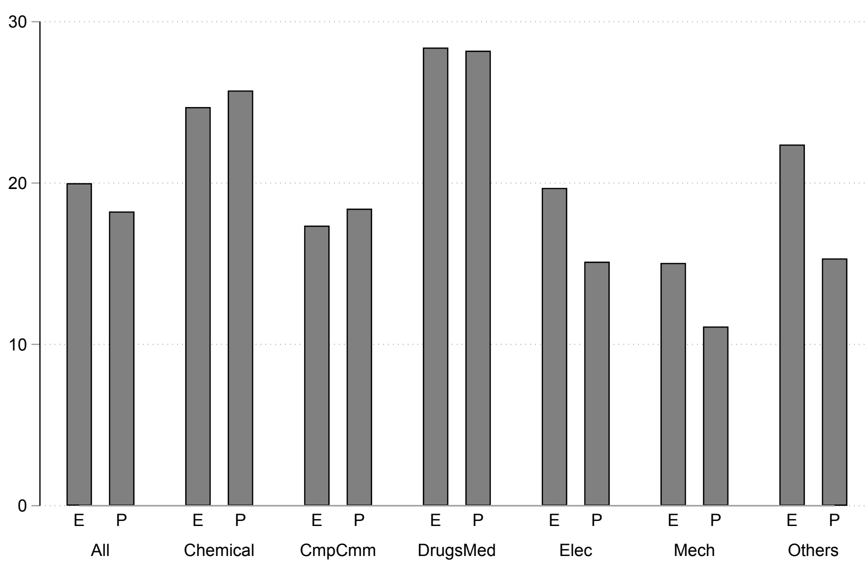
Footnotes: The outcome is defined as the number of total citations by patent examiners. Male patent is defined as a continuous variable that measures the percentage of male innovators in the team. Panel A examines the correlation of the number of citations and patent gender. Panel B examines the correlation of the number of citations and patent gender controlling for year-specific technology class fixed effects. Panel C examines the relationship of the number of citations and patent gender controlling for year-specific technology subclass fixed effects. Panel D examines the correlation of the number of citations and patent gender controlling for year-specific technology subclass fixed effects as well as other fixed effects that are indicators of patent qualities and examiner characteristics, which includes the fixed effects for the number of citations the patent has received, for the number of citations that the patent has made, for the number of inventors, for the number of claims of the patent, for the number of patents the examiner has approved, and a dummy for whether the patent has cited any of its own authors or cited patents that has the same assignee.

When including additional controls at the patent, citation, and examiner level, the results hold (see Table 2 Panel D). To control for the potential explanation that our results are distorted by the presence of a small number of male superstars – such as Nobel Prize winners – who skew the distribution of citations, the additional specifications control for the number of total citations a patent receives (Rosen (1981); Hengel (2019)). In the same vein, we include the number of claims of a patent, a proxy for its expected economic value (Lanjouw and Schankerman (2199); Squicciarini et al. (2013)), and the number of inventors, an indicator for the resources invested in solving an innovation problem (Fleming and Sorenson (2199)). To account for higher rate of self-citations by men (King et al. (2199)), we control for latter variable. Male patent examiners were, on average, more experienced than their female peers. We control for this by including the number of granted invention at the examiner level (Cockburn et al. (2003)).

### 4.3 Male Examiners Overcite Male Patents

The representation of female inventors and female examiner appears to be roughly proportional by technological field. As illustrated by Figure 3, Drugs & Medical and Chemical patents had both the highest share of female inventors and examiners. On the other hand, the share of female examiner and inventors was lowest in the Mechanical technology.

Figure 3: Representation of Female Patents and Examiners by Field




Footnotes: Figure 3 presents the share of female examiners ('E') and of female patents ('P'), defined as patents of all-female or gender-mixed inventor teams, by technological field as defined by the NBER classification.

In Table A.1, using technology fixed effects, we find that while being a male examiner was correlated with patent gender in the year-specific technology class fixed effects in several fields (Panel A), it was not correlated with patent gender in the year-specic technology subclass fixed effects in any field (Panel B). This lessens the concern that our findings are driven by the concentration of female examiners and female innovators in technological silos.

Descriptively, Figure 4 shows that male examiners appear to cite male patents to a greater extent than female examiners. Over time, male examiners were increasingly incorporating female knowledge in their patents, but since female examiners did so too, the difference seems to persist over the years.

Figure 4: Citations to Male Inventions by Examiner Gender


Footnotes: Figure 4 presents the share of citations to male patents by male and female examiners over time.

Table 3 examines the relationship between the examiner gender and percentage of male patents in citations at the patent level. In Panel A, without any controls, we find that having a male examiner was associated with 2.8 percentage points increase of male patents citation, a coefficient statistically significant at the 1% level. However, when we use year-specific technology class fixed effects, the coefficient was reduced and not significant.

Table 3: Male Examiners and Male Citations

| | % of Male Patents in Citations | | | | | | |
|---|---|---|---|---|---|---|---|
| | All | Chemical | CmpCmm | DrugsMed | Elec | Mech | others |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | Panel A. No Controls | | | | | | |
| Male Examiner | 2.836*** | 3.951*** | 1.088*** | 5.562*** | 0.477*** | 0.715*** | 3.680*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.001) | (0.000) | (0.000) |
| Observations | 885253 | 80888 | 324187 | 92601 | 174448 | 105526 | 107600 |
| | Panel B. With Main Class Fixed Effects | | | | | | |
| Male Examiner | 0.545*** | 0.635** | 0.001 | 2.414*** | 0.169 | -0.183 | 1.125*** |
| | (0.000) | (0.023) | (0.993) | (0.000) | (0.255) | (0.322) | (0.000) |
| Observations | 885253 | 80888 | 324187 | 92601 | 174448 | 105526 | 107600 |
| | Panel C. With Main Subclass Fixed Effects | | | | | | |
| Male Examiner | 0.154 | -0.438 | -0.000 | 0.765** | 0.161 | 0.139 | 0.244 |
| | (0.129) | (0.448) | (1.000) | (0.020) | (0.449) | (0.667) | (0.449) |
| Observations | 885253 | 80888 | 324187 | 92601 | 174448 | 105526 | 107600 |
| | Panel D. With Main Subclass Fixed Effects and Additional Controls | | | | | | |
| Examiner Gender | 0.216 | -0.445 | 0.019 | 1.060** | 0.410 | -0.116 | 0.144 |
| | (0.066) | (0.563) | (0.910) | (0.033) | (0.240) | (0.825) | (0.772) |
| Observations | 885251 | 80887 | 324186 | 92601 | 174448 | 105526 | 107600 |

*p*-values in parentheses

** $p < 0.05$, *** $p < 0.01$

Footnotes: The outcome variable is defined as the share of citations that are cited patents by all male innovators at the patent level. Male examiner is defined as 1 if the primary examiner is a male and zero if the primary examiner is a female. Panel A examines the correlation of the number of citations and patent gender. Panel B examines the correlation of the number of citations and patent gender controlling for year-specific technology class fixed effects. Panel C examines the relationship of the number of citations and patent gender controlling for year-specific technology subclass fixed effects. Panel D examines the correlation of the number of citations and patent gender controlling for year-specific technology subclass fixed effects as well as other fixed effects that are indicators of patent qualities and examiner characteristics, which includes the fixed effects for the number of citations the patent has received, for the number of citations that the patent has made, for the number of inventors, for the number of claims that the patent can make, for the number of patents the examiner has approved, and a dummy for whether the patent has cited any of its own authors or cited patents that has the same assignee.

When we break down the results by technological fields, while the coefficients were all statistically significant when we examine the relationship without any controls, only the coefficient associated with the field of Chemical, Drugs & Medical, and Others were statistically significant when we use year-specific technology class fixed effects. After we use year-specific technology subclass fixed effects, only the coefficient associated with the field of Drugs & Medical was statistically significant (with a 1 percentage points increase of male patents citation).

We conduct additional sensitivity tests in Table A.2. In Panel A, we restrict patents to all those that have gender identified in the citation. In Panel B, we restrict patents to all those that have names. In Panel C and D, we adopt the primary examiner's gender when the patents are examined by one person, and adopt the assistant examiner's gender when the patents are examined by two people team. In Panel E and F, we restrict the sample to patents where the gender of the primary and assistant examiner is identical. The results hold in most robustness tests. However, when we include the assistant gender (the gender of the assistant and the primary assistant differed in about 10 percent of the patents), the results are only significant when using year-specific technology class fixed effects, not year-specific technology subclass fixed effects.In Table A.3, we further modify the outcome variable by relying on a dummy variable that equals one if all citations are male, and zero otherwise. These sensitivity tests yield similar results; but, additionally, the results are significant using year-specific technology subclass fixed effects when we restrict the sample to patents with primary and assistant examiner of the same gender.

## 5 Discussion, Policy Implication, and Conclusion

Our analyses shed light on disparities existing in how examiners treat patents. We find that patent examiners are more likely to cite male than female inventions as prior art. This effect was mostly driven by two fields, Computer and Communications and Drugs & Medical, where female patents were underrepresented by ten to twenty percentage points. Even when including controls for patent quality, citation patterns, and examiner characteristics, the magnitude of this finding remained surprisingly large. The diffusion of female inventions appears to be lower – independently of the scientific and technological merits of the underlying patented invention – due to the gender of the inventors. On a positive note, our findings indicate that patents developed by female or gender-mixed teams of inventors in other disciplines, such as Chemical, Mechanical, and Electrical and Electronics are not less likely to be cited than those by their male peers.

Compared to female patent examiners, male examiners were more likely to refer to male inventions; but the effect is concentrated in life sciences only. While on average male examiners referred to male inventions at a greater rate of 3 percentage points than female examiners, linear regression models indicate that the difference was closer to 1 to 2 percentage points. The magnitude of this difference can be illustrated using rough average estimations. When male examiners cite male inventions in 87% of all cases and female examiners in 84% (as it was the case in 2002), a male examiner processing 100 patent applications would end up citing 75 female or gender-mixed inventions, while a female examiner would have cited 92 female or gender-mixed inventions (assuming 5.8 inventions as average number of citations)[4]. With a difference of 1.5 percentage point, male examiners undercite female or gender-mixed inventors by approximately 10%[5]. Because of the vast underrepresentation of female inventions, even small differences in citation patters lead, when accumulated, to large inconsistencies.

The concentration of gender differences in life sciences raises a number of questions. Our study is not the first to note such disparities, and mirrors results by Jensen et al. (2018). In their study examining prosecution outcome before the patent office, the authors find that the effects of gender difference is particularly large for life sciences compared to other technologies. Despite their higher representation, women appear to be treated less favorably in life sciences than in other fields. This result is particularly worrisome: it suggests that the field with the highest female

[4]Out of the 580 cited inventions, a male examiner would cite 504.6 male inventions and 75.4 female or gender-mixed inventions; a female examiner would cite 487.2 male inventions and 92.8 female or gender-mixed inventions

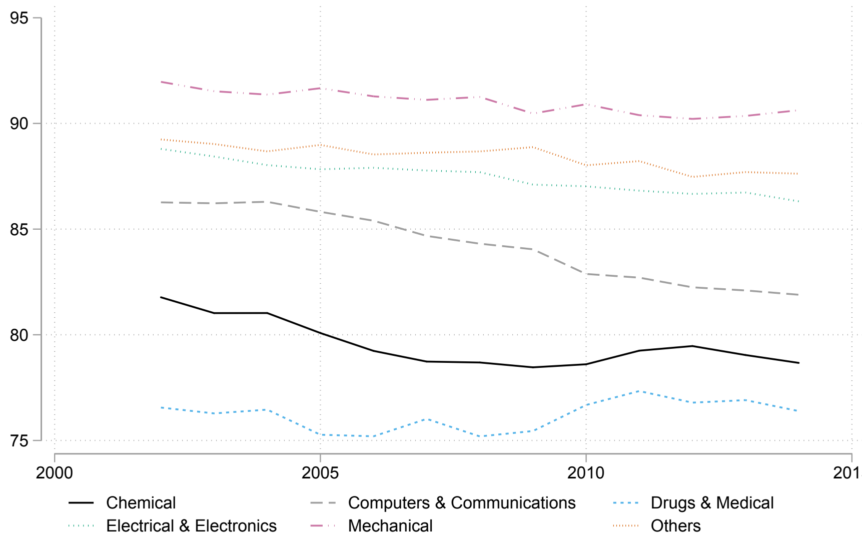
[5]Female examiners citing 80 versus 88 female or gender-mixed patents for male examiners, taking 86.25% and 84.75%.

representation is in fact the one where female inventors face the highest hurdles in disseminating their knowledge. Gender bias falls in line with role congruity theories, which prescribe that gender roles encompass both beliefs about the attributes and qualities of men and women. Men are associated to agentic characteristics (self-confidence, leadership and objectivity) while female are linked to communal characteristics (sympatethy and helpfulness) (Knobloch-Westerwick et al. (2013)). When women engage in scientific activity, the perceived inconsistency between the communal qualities associated with women and the agentic qualities applying to scientists prejudices women. It might be the case that this perceived inconsistency is particularly strong in life sciences.

It is well established that women obtain less patents than men, and that they are underrepresented in the corpus of patent examiners, registered patents agents and patent attorneys (Vishnubhakat (2014); Hosler (2018)). Our analysis highlights how, without blatant open discrimination, gender differences at the examiner level may contribute to calibrate the patent system to disadvantage female inventors (Burk (2010)). We highlight how the role of gender can impact the assessment of engineering and scientific knowledge. The diffusion of female-developed inventions is hindered, or at least lower, if men (and women) do not refer to them to the extent they are due. Should our findings be generalizable, they would imply that women face significant hurdles in the recognition of their technical knowledge, as their contributions are discounted no matter their underlying scientific merit. Developing further understanding of the behavioral reasons underlying the gender differences at work is key. A simple yet effective counter to such imbalance is for patent applications to be filed and published without complete first names details. Listing the first letter only of inventors on patent documents is a change patent offices can easily implement and with immense potential for the diffusion of female knowledge.

# Appendix

Figure A.1: Representation of Male Citations by Technology




Footnotes: Figure A.1 presents the share of citations to male patents by year and technological field (NBER classification)

Table A.1: Appendix: Male Examiners and Male Patents

| | Male Patent | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | All | Chemical | CmpCmm | DrugsMed | Elec | Mech | others |
| | Panel A. with Technology Class Fixed Effects | | | | | | |
| Male Examiner | 0.003*** | 0.005** | -0.001 | 0.017*** | 0.002 | -0.004** | 0.008*** |
| | (0.000) | (0.028) | (0.203) | (0.000) | (0.148) | (0.033) | (0.000) |
| Observations | 861042 | 80467 | 309794 | 91818 | 167187 | 104434 | 107339 |
| | Panel B. with Technology Subclass Fixed Effects | | | | | | |
| Male Examiner | 0.001 | 0.004 | -0.001 | 0.005 | 0.000 | -0.003 | 0.000 |
| | (0.477) | (0.353) | (0.614) | (0.055) | (0.975) | (0.272) | (0.883) |
| Observations | 861042 | 80467 | 309794 | 91818 | 167187 | 104434 | 107339 |

*p*-values in parentheses | ** $p < 0.05$, *** $p < 0.01$

Footnotes: Table A.1 Panel A examines the correlation of male examiners and male patents controlling for year-specific technology class fixed effects. Panel B examines the correlation of male examiners and male patents controlling for year-specific technology subclass fixed effects.

Table A.2: Appendix: Male Examiners and Male Citations Robustness Tests I

| | % of Male Patents in Citations | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | All | Chemical | CmpCmm | DrugsMed | Elec | Mech | Others |
| | Panel A. Limitation Samples to No Missing Innovator Names (Technology Class FE) | | | | | | |
| Male Examiner | 0.496*** | 0.683** | -0.023 | 2.308*** | 0.195 | -0.345 | 1.154*** |
| | (0.000) | (0.036) | (0.845) | (0.000) | (0.240) | (0.176) | (0.000) |
| Observations | 720677 | 60855 | 311254 | 81823 | 149243 | 63521 | 53979 |
| | Panel B. Limitation Samples to No Missing Innovator Names (Technology Subclass FE) | | | | | | |
| Male Examiner | 0.175 | -0.124 | -0.022 | 0.850** | 0.212 | 0.045 | 0.404 |
| | (0.117) | (0.858) | (0.872) | (0.017) | (0.372) | (0.921) | (0.452) |
| Observations | 720677 | 60855 | 311254 | 81823 | 149243 | 63521 | 53979 |
| | Panel C. Adopt Examiner Assistant Gender (Technology Class FE) | | | | | | |
| Male Examiner (assistant) | 0.320*** | 0.761*** | -0.126 | 0.767*** | 0.356*** | -0.061 | 0.981*** |
| | (0.000) | (0.003) | (0.239) | (0.001) | (0.008) | (0.715) | (0.000) |
| Observations | 867699 | 79039 | 317030 | 91310 | 171011 | 103385 | 105921 |
| | Panel D. Adopt Examiner Assistant Gender (Technology Subclass FE) | | | | | | |
| Male Examiner (assistant) | 0.022 | -0.082 | -0.135 | 0.130 | 0.142 | -0.072 | 0.146 |
| | (0.808) | (0.878) | (0.276) | (0.632) | (0.453) | (0.809) | (0.616) |
| Observations | 867699 | 79039 | 317030 | 91310 | 171011 | 103385 | 105921 |
| | Panel E. Limit to Primary and Assistant Examiner Same Gender (Technology Class FE) | | | | | | |
| Male Examiner | 0.604*** | 0.724 | -0.041 | 2.316*** | 0.278 | -0.176 | 1.491*** |
| | (0.000) | (0.016) | (0.757) | (0.000) | (0.094) | (0.417) | ( 0.000) |
| Observations | 775409 | 72183 | 287749 | 74709 | 153142 | 93858 | 93766 |
| | Panel F. Limit to Primary and Assistant Examiner Same Gender (Technology Subclass FE) | | | | | | |
| Male Examiner (assistant) | .166 | -.287 | -.016 | .646 | .216 | .106 | .365 |
| | (0.159) | (0.662) | (0.917) | ( 0.090) | (0.373) | (0.789 ) | (0.349 ) |
| Observations | 775,409 | 72,183 | 287,749 | 74,709 | 153,142 | 93,858 | 93,766 |

*p*-values in parentheses | ** $p < 0.05$, *** $p < 0.01$

Footnotes: The outcome variable is defined as the share of citations that are cited patents by all male innovators at the patent level. Male examiner is defined as 1 if the primary examiner is a male and zero if the primary examiner is a female. Panel A and C examines the relationship of citations and the gender of the patent examiner controlling for year-specific technology subclass fixed effects. Panel B and D examines the relationship of citations and the gender of the patent examiner controlling for year-specific technology subclass fixed effects. Panel A and B limit the samples to patents with citations that can all find a match of innovators names. Panel C and D adopt primary examiner's gender when the patents are examined by 1 person, and adopt examiner assistant gender when the patents are examined by 2 people team. Panel E and F limit the sample to patents where the gender of the primary and assistant examiner is identical.

Table A.3: Appendix: Male Examiners and Male Citations Robustness Tests II

| | Male Patents in Citations | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | All | Chemical | CmpCmm | DrugsMed | Elec | Mech | Others |
| | Panel A. Dependent Variable Variation (Technology Class FE) | | | | | | |
| Male Examiner | .003** | .0198*** | -.0067*** | .0221*** | .001 | -.016*** | .014*** |
| | (0.031) | (0.000) | (0.004) | ( 0.000) | (0.820) | (0.001 ) | (0.000 ) |
| Observations | 885,253 | 80,888 | 324,187 | 92,601 | 174,448 | 105,526 | 107,600 |
| | Panel B. Dependent Variable Variation (Technology Subclass FE) | | | | | | |
| Male Examiner | -.0012 | .004 | -.005 | .0018 | .005 | -.008 | .002 |
| | (0.524) | (0.694) | (0.033) | (0.698) | (0.225) | (0.287 ) | (0.779) |
| Observations | 885,253 | 80,888 | 324,187 | 92,601 | 174,448 | 105,526 | 107,600 |
| | Panel C. Dependent Variable & Assistant Examiner Variation (Technology Class FE)) | | | | | | |
| Male Examiner | .000 | .020*** | -.014*** | .0168*** | -.001 | -.021*** | .019*** |
| | ( 0.991) | ( 0.000 ) | ( 0.000) | ( 0.000 ) | ( 0.738 ) | ( 0.000 ) | ( 0.000 ) |
| Observations | 775,409 | 72,183 | 287,749 | 74,709 | 153,142 | 93,858 | 93,766 |
| | Panel D. Dependent Variable & Assistant Examiner Variation(Technology Subclass FE)) | | | | | | |
| Male Examiner | .004** | .006 | -.011*** | -.0018 | .005 | -.018** | .006 |
| | ( 0.045) | (0.536) | ( 0.000) | (0.740) | ( 0.346 ) | ( 0.049 ) | (0.467) |
| Observations | 775,409 | 72,183 | 287,749 | 74,709 | 153,142 | 93,858 | 93,766 |

*p*-values in parentheses | ** $p < 0.05$, *** $p < 0.01$

Footnotes: The outcome variable is defined as a dummy variable that equals one if all citations are male, and zero if any of the citations is not male. Panel A and C examines the relationship of citations and the gender of the patent examiner controlling for year-specific technology subclass fixed effects. Panel B and D examines the relationship of citations and the gender of the patent examiner controlling for year-specific technology subclass fixed effects. Panel C and D limit the sample to patents where the gender of the primary and assistant examiner is identical.

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