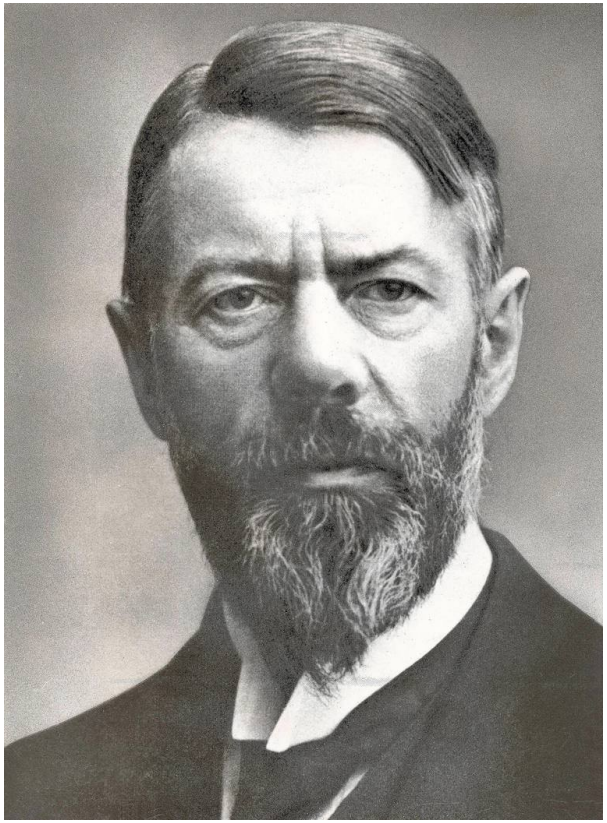
Does Gender Affect Work?

Evidence from U.S. Patent Examination

DEEPAK HEGDE

MANAV RAJ

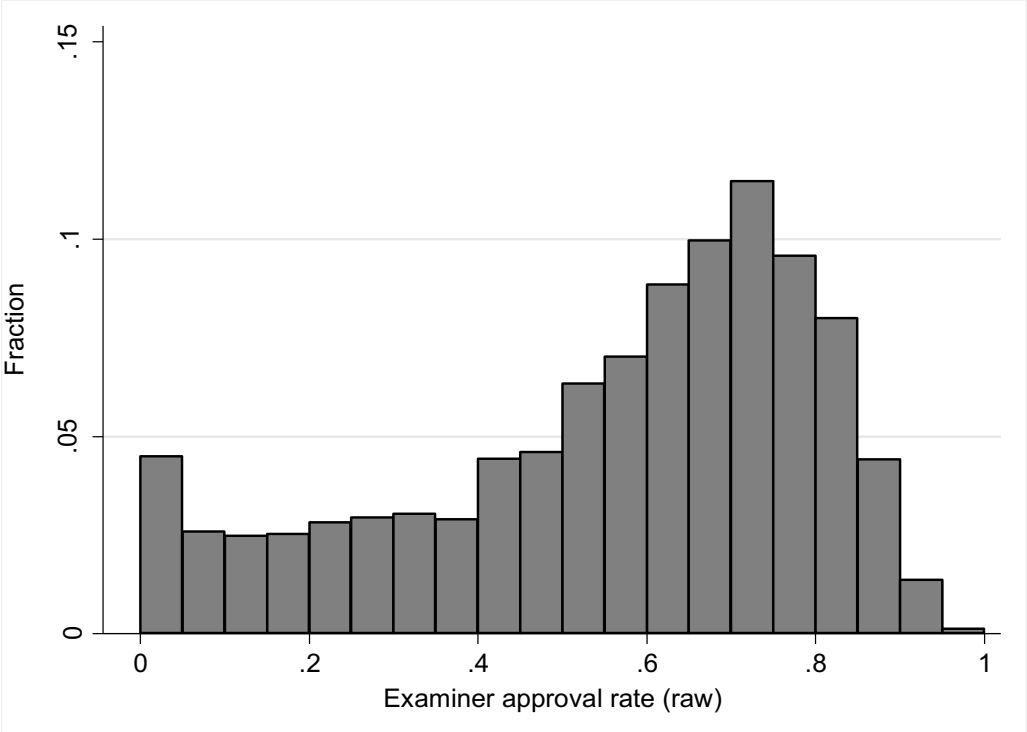


"Precision, unambiguity, knowledge of files, continuity, unity, strict subordination, reduction of friction and of material and personal costs – these are raised to the optimum point in the strictly bureaucratic administration."

— Max Weber, 1921/68 Economy and Society

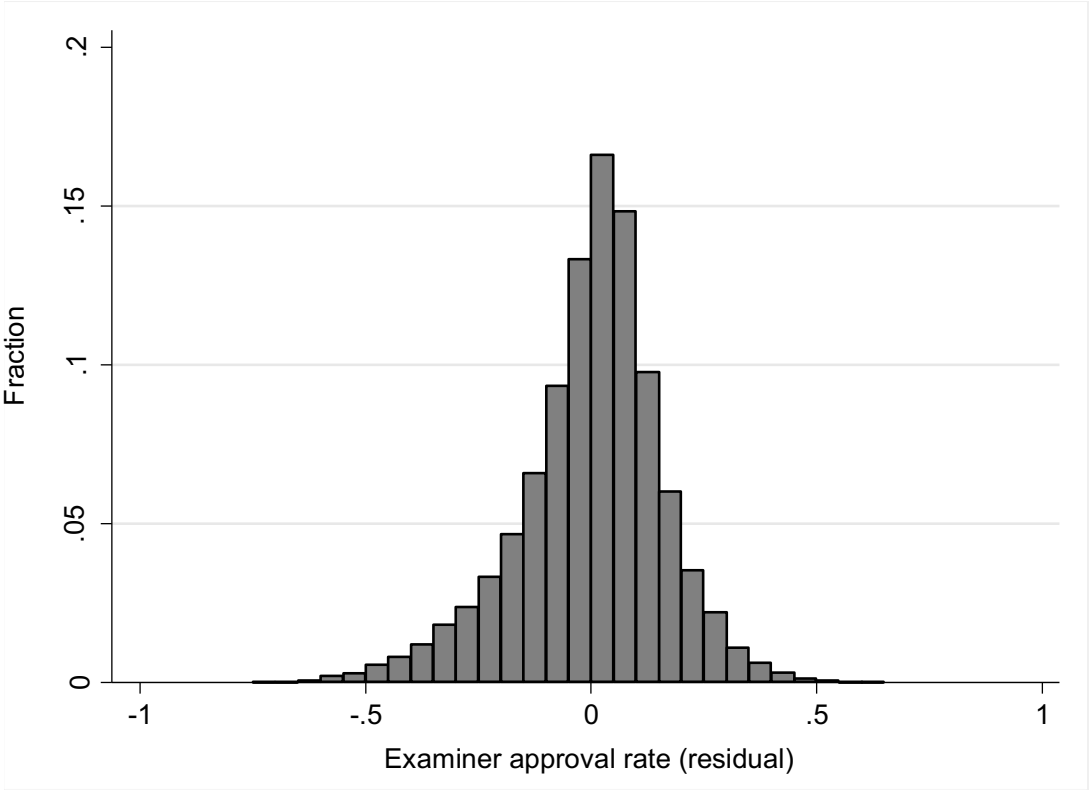
Data suggests large variance in examiner judgement

"there may be as many patent offices as examiners" (Cockburn, Kortum, & Stern, 2003)



Interquartile range (IQR) of examiner approval rate, based on all utility applications examined 2001-2015: **33%** (Farre-Mensa, Hegde and Ljungqvist 2019)

Data suggests large variance in examiner judgement



Interquartile range (IQR) of examiner approval rate after netting out art-unit X year effects: **17.7%** (Farre-Mensa, Hegde and Ljungqvist 2019)

Does examiner gender affect examination effort and outcomes?

THE USPTO PATENT EXAMINATION PROCESS

In theory, applications at the USPTO are evaluated on their "objective" merits (non-obviousness, novelty, utility)

Within narrowly defined technology areas (art units) applications are allocated randomly (with respect to merit of application) to examiners

The USPTO pays and promotes examiners on a count-based incentive system

- Target counts based on art unit (tech complexity) & examiner grade
- Several attempts to assess examiners on a broader set of indicators including quality
- But "USPTO's objectives may not be clear because it does not have a consistent definition of patent quality" (GAO 2016)

Previous research suggests large gender differences in some preferences and attributes

Men tend to prefer competitive, performance-based compensation schemes

- No gender differences in performance under fixed wage scheme, but men solve 40 percent more mazes under pay-for-performance scheme (Gneezy *et al* 2003)

Women's work is higher quality

- Women's writing is clearer and women take six months longer for *Econometrica* publications (Henge 2016)

Gender differences exist along several other attributes

- Women choose less risky gambles and lotteries than men (Migheli, 2015)
- Women exhibit pro-social preferences (Funk and Gathmann 2006)

Does examiner gender affect examination effort and outcomes?

THE DATA

All utility patent applications filed at the USPTO from 2001 to 2015.

- 3.8 million applications filed by 1.1 million primary inventors and examined by 12,851 unique examiners
- Applications assigned to 721 technology art-units and 15,534 subclasses

Using a 3rd-party contractor, we assign gender to each unique name

Data includes examiner characteristics (experience, grade, gender), inventor characteristics, application characteristics (claim count and word count) and examination characteristics .

Does examiner gender affect examination effort and outcomes?

EXAMINER EFFORT – SAMPLE STATISTICS

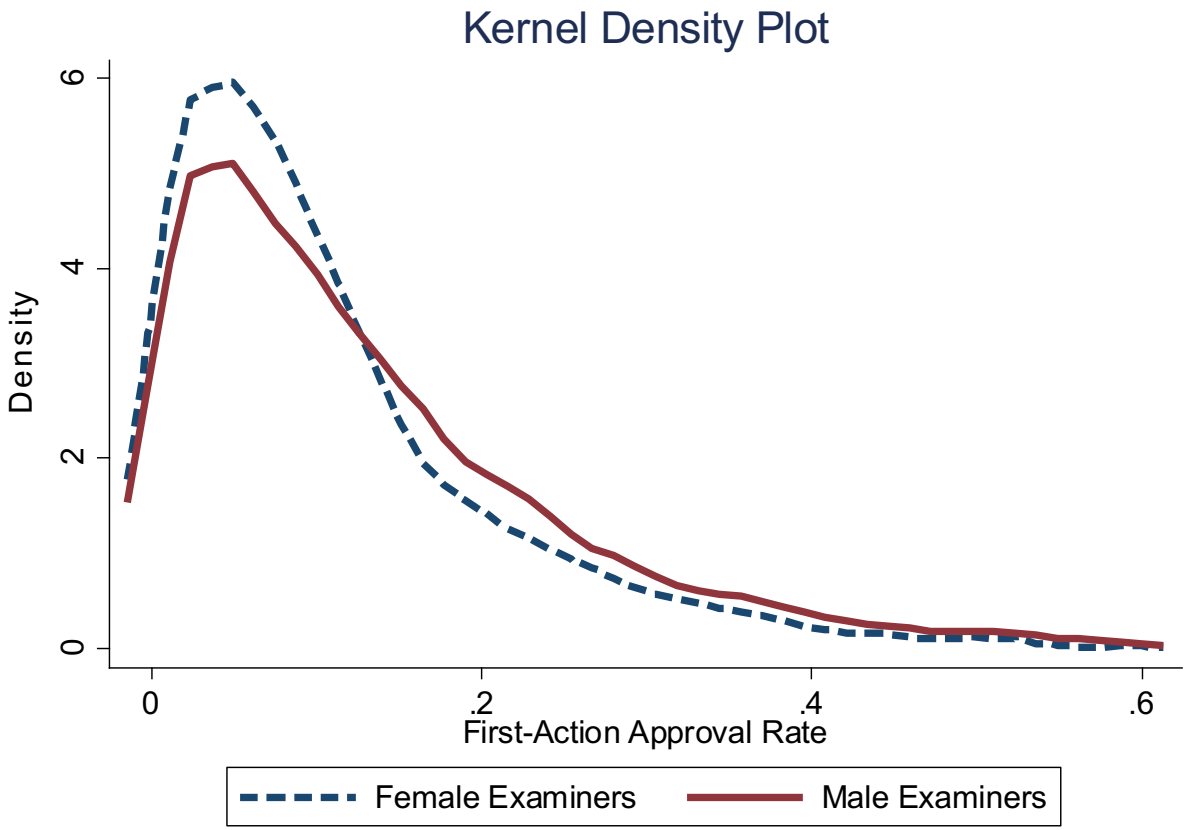
Variables	Female Examiner	Male Examiner
First-Action Approval Rate	15.3%	17.7%
	(36.0%)	(38.1%)
Rejection 101 Count (Eligibility)	0.15	0.16
	(0.46)	(0.46)
Rejection 102 Count (Novelty)	0.82	0.80
	(0.92)	(0.89)
Rejection 103 Count (Non-obviousness)	1.42	1.38
	(1.26)	(1.25)
Rejection 112 Count (Restriction)	0.66	0.59
	(0.85)	(0.80)
Percent Examiner-Inserted Citations	54.0%	57.1%
	(37.5%)	(36.9%)
Patent Independent Claim Count	2.65	2.74
	(2.02)	(2.04)

Does examiner gender affect examination effort and outcomes?

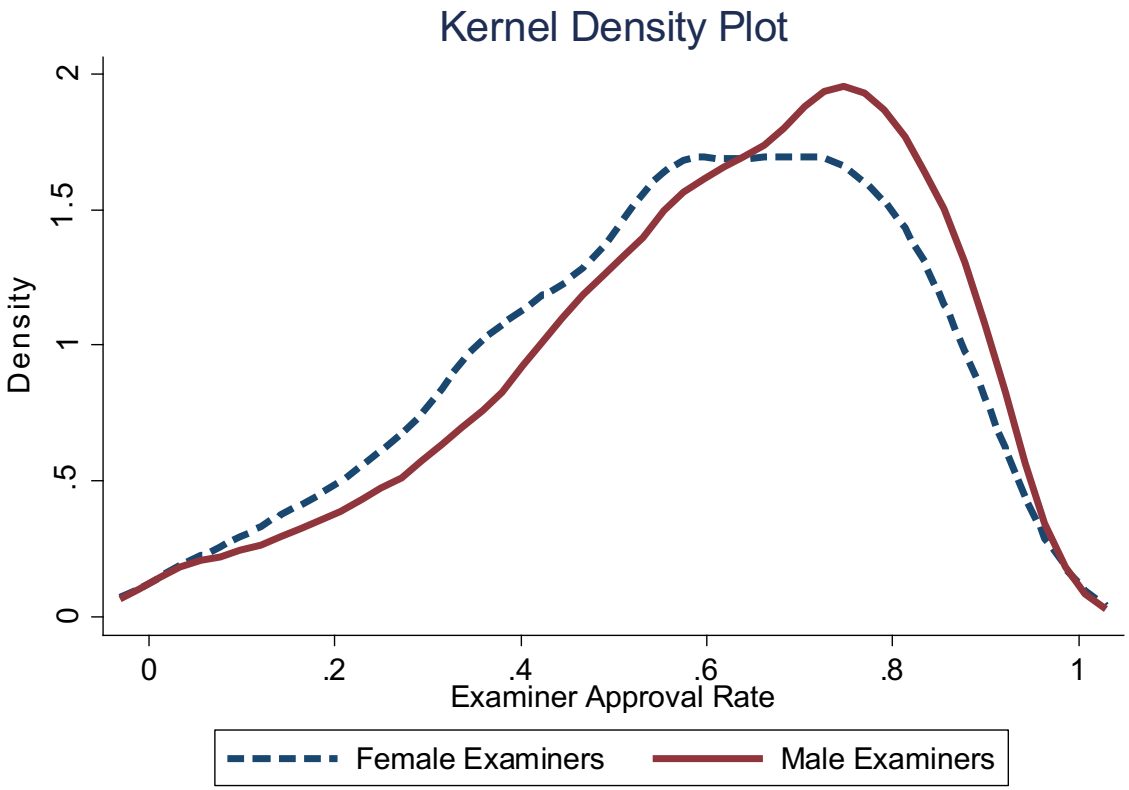
EXAMINATION OUTCOMES – SAMPLE STATISTICS

Variables	Female Examiner	Male Examiner
Approval Rate	64.4%	69.7%
	(47.9%)	(46.0%)
Process Time (Days)	857.2	836.2
	(541.6)	(525.1)
Four-Year Patent Renewal Rate	73.2%	73.4%
	(44.3%)	(44.2%)
Examination Decision Appeal Rate	6.2%	5.2%
	(24.1%)	(22.3%)
EPO Decision Match Rate	62.6%	61.9%
	(48.4%)	(48.6%)
Applications Processed Quarterly	9.9	10.2
	(8.5)	(8.9)
Quarterly Probability of Promotion	8.8%	9.8%
	(28.3%)	(29.8%)

Does examiner gender affect examination effort and outcomes?



Does examiner gender affect examination effort and outcomes?



Does examiner gender affect examination effort and outcomes?

THE EMPIRICAL MODEL

$$y_{iekt} = \alpha_1 G_e + \alpha_2 E_{et} + \alpha_3 TechnologyYearFE_{kt} + \epsilon_i$$

Dependent variables (y)

- **Examination effort**: (i) application approved without further scrutiny; (ii) frequency of various rejection codes; (iii) percent of examiner-inserted citations, (iv) reduction of independent claims
- **Examination outcomes**: (i) approval (ii) speed (iii) renewal (iv) appealed and (v) outcome matched EPO decision
- **Career growth**: Promotion (in a given quarter)

Independent variables

- **Examiner gender**
- Interaction between examiner gender and a) seniority and b) proportion of female examiners within technology art unit
- Control variables art-unit-subclassXyear effects, examiner seniority, grade
- Subclasses are narrowly defined: e.g., "Alkali metal and ammonium containing fertilizers," "Spellcheck software to process and program documents"

Application characteristics do not predict examiner gender

TEST FOR QUASI-RANDOM ASSIGNMENT

Dependent Variable	Examiner Female	Examiner Female	Examiner Female	Examiner Female
Average Word Count for Independent Claims at Pre-Grant Publication	-0.000			-0.000
	(0.000)			(0.000)
Claim Count at Pre-Grant Publication		0.000		0.000
		(0.000)		(0.000)
Word Count at Pre-Grant Publication			0.000	0.000
			(0.000)	(0.000)
Examiner Tenure Controls	Yes	Yes	Yes	Yes
Examiner Grade FEs	Yes	Yes	Yes	Yes
Art-Unit-by-Subclass-by-Year FEs	Yes	Yes	Yes	Yes
Observations	1,017,983	1,017,983	1,017,983	1,017,983
R-Squared	0.360	0.360	0.360	0.360

*** p<0.01, ** p<0.05, * p<0.1

Female examiners exert more examination effort

OLS ESTIMATES OF GENDER EFFECTS ON EXAMINER EFFORT

Dependent Variable	Approval on First-Action	Rejection 102 Count (novelty)	Rejection 103 Count (non-obviousness)	Percent Examiner-Inserted Citations	Independent Claim Count at Patent Grant
Examiner Female	**-0.012*****	**0.033*****	**0.013*****	**0.002****	**-0.014****
Independent Claim Count at Pre-Grant Publication					0.151***
Examiner Tenure Controls	Yes	Yes	Yes	Yes	Yes
Examiner Grade FEs	Yes	Yes	Yes	Yes	Yes
Art-Unit-by-Subclass-by-Year FEs	Yes	Yes	Yes	Yes	Yes
Observations	1,349,922	661,795	661,795	1,327,667	1,017,983
R-squared	0.219	0.182	0.292	0.272	0.279

*** p<0.01, ** p<0.05, * p<0.1

7.1% difference relative to sample unconditional probability

Female examiners are less likely to approve application, take slightly longer, and grant more valuable patents

OLS ESTIMATES OF GENDER EFFECTS ON EXAMINATION OUTCOMES

Dependent Variable	Approval	Process Time	Renewal	Decision Appealed	EPO Decision Match
Examiner Female	**-0.006*** **	**8.21*** **	**0.003** **	**0.003*** **	**0.003***
Examiner Tenure Controls	Yes				
Examiner Grade FEs	Yes				
Art-Unit-by-Subclass-by-Year FEs	Yes	Yes	Yes	Yes	Yes
Observations	2,032,159	2,029,915	782,906	2,032,159	657,166
R-squared	0.271	0.439	0.478	0.152	0.223

*** p<0.01, ** p<0.05, * p<0.1

1% difference relative to sample unconditional probability

Female examiners examine fewer applications and are less likely to be promoted

OLS ESTIMATES OF GENDER EFFECTS ON EXAMINATION VOLUME & PROMOTION

Dependent Variable	Quarterly Processed Applications	Quarterly Promotion Probability	Quarterly Promotion Probability
Examiner Female	**-0.597*****	**-0.004****	**-0.002***
Quarterly Processed App	**5.9% fewer applications per quarter**	**4.2% lower chances of promotion**	**2.1% lower chances of promotion**
Examiner Tenure Controls	Yes	Yes	Yes
Examiner Grade FEs	Yes	Yes	Yes
Art-Unit-by-Year FEs	Yes	Yes	Yes
Observations	248,621	248,629	248,629
R-squared	0.585	0.085	0.126

*** p<0.01, ** p<0.05, * p<0.1

Gender differences in examination effort increase among examiners with signatory authority (GS-14 and GS-15)

OLS ESTIMATES OF GENDER EFFECTS ON EXAMINER EFFORT

Dependent Variable	Approval on First-Action	Rejection 102 Count (novelty)	Rejection 103 Count (non-obviousness)	Percent Examiner-Inserted Citations	Independent Claim Count at Patent Grant
Examiner Female	-0.019***	0.030***	0.011	0.006***	-0.001
Independent Claim Count at Pre-Grant Publication					0.135***
Examiner Tenure Controls	Yes	Yes	Yes	Yes	Yes
Examiner Grade FEs	Yes	Yes	Yes	Yes	Yes
Art-Unit-by-Subclass-by-Year FEs	Yes	Yes	Yes	Yes	Yes
Observations	692,704	296,254	296,254	678,654	515,899
R-squared	0.266	0.264	0.327	0.319	0.325

*** p<0.01, ** p<0.05, * p<0.1

8.8% difference relative to sample unconditional probability

Gender differences in examination outcomes increase among examiners with signatory authority (GS-14 and GS-15)

OLS ESTIMATES OF GENDER EFFECTS ON EXAMINATION OUTCOMES

Dependent Variable	Approval	Process Time	Renewal	Decision Appealed	EPO Decision Match
Examiner Female	-0.013***	12.524***	0.001	0.002***	0.002
Examiner Tenure Controls	Yes				
Examiner Grade FEs	Yes				
Art-Unit-by-Subclass-by-Year FEs	Yes				
Observations	932,746	932,428	399,382	932,746	287,373
R-squared	0.308	0.481	0.511	0.233	0.291

*** p<0.01, ** p<0.05, * p<0.1

1.7% difference relative to sample unconditional probability

Fraction of female examiners decreases at highest examiner grade levels

Examiner Grade	Percent of All Applications Examined at Grade	Percent Female Examiners at Grade
GS-7	6.4%	29.6%
GS-9	8.6%	29.1%
GS-11	9.5%	29.9%
GS-12	11.2%	31.1%
GS-13	16.2%	31.6%
GS-14	46.0%	25.3%
GS-15	2.1%	19.5%
Total	100.0%	38.7%

Gender differences in examiner effort increase with examiner seniority

Dependent Variable	Approval on First-Action	Rejection 102 Count (novelty)	Rejection 103 Count (non-obviousness)	Percent Examiner-Inserted Citations	Independent Claim Count at Patent Grant
Examiner Female	0.007***	0.025**	0.027	-0.009***	0.004
Independent Claim Count at Pre-Grant Publication					0.151***
Examiner Grade 9 & Female	**-0.003**	**0.001**	**0.007**	**0.012*** **	**-0.005**
Examiner Grade 11 & Female	**-0.014*** **	**0.010**	**-0.044** **	**0.003**	**-0.026**
Examiner Grade 12 & Female	**-0.014*** **	**0.017**	**-0.053** **	**0.010** **	**-0.016**
Examiner Grade 13 & Female	**-0.018*** **	**0.002**	**-0.027**	**0.006***	**-0.032**
Examiner Grade 14 & Female	**-0.027*** **	**0.009**	**0.003**	**0.016*** **	**-0.016**
Examiner Grade 15 & Female	**-0.026** **	**0.027**	**0.012**	**0.004**	**-0.040**
Examiner Tenure Controls	Yes	Yes	Yes	Yes	Yes
Examiner Grade FEs	Yes	Yes	Yes	Yes	Yes
Art-Unit-by-Subclass-by-Year FEs	Yes	Yes	Yes	Yes	Yes
Observations	1,349,922	661,795	661,795	1,327,667	1,017,983
R-squared	0.219	0.182	0.292	0.272	0.279

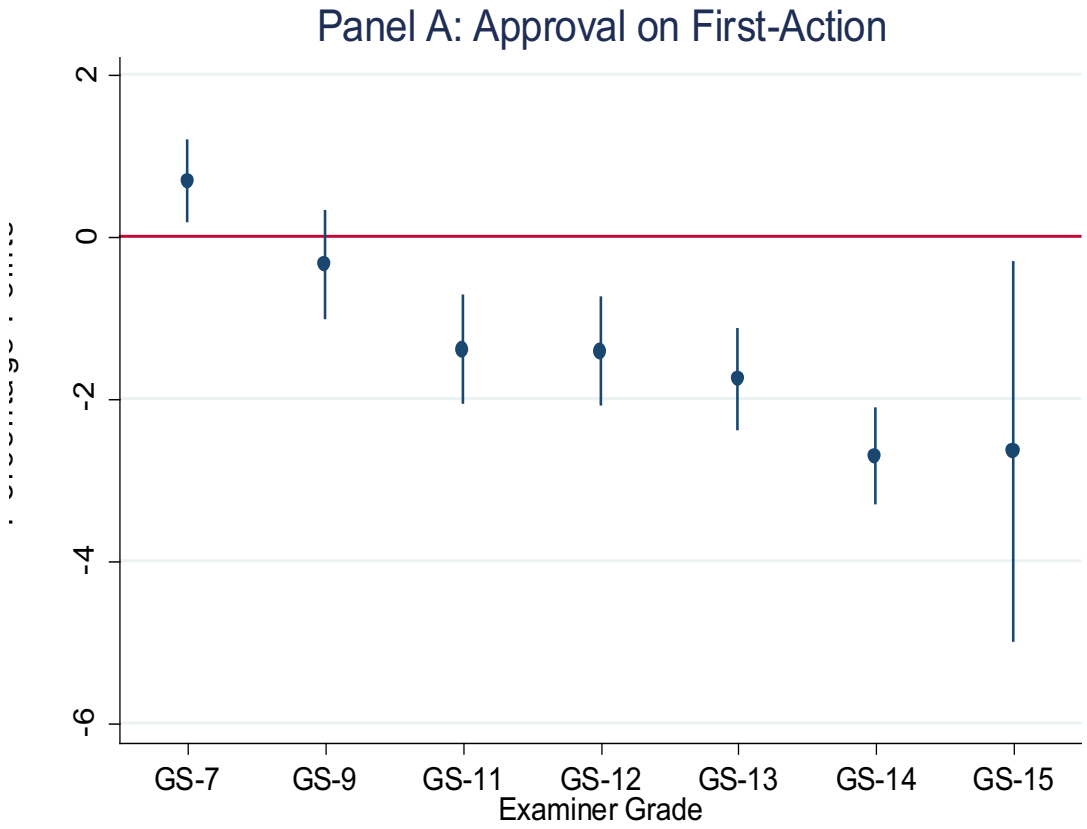
*** p<0.01, ** p<0.05, * p<0.1

Gender differences in examination outcomes increase with examiner seniority

Dependent Variable	Approval	Process Time	Renewal	Decision Appealed	EPO Decision Match
Examiner Female	0.017***	-6.511*	0.007*	-0.000	0.001
Examiner Grade 9 & Female	**-0.009****	**5.895**	**0.000**	**-0.001**	**-0.004**
Examiner Grade 11 & Female	**-0.021*****	**7.757***	**-0.002**	**0.002**	**0.001**
Examiner Grade 12 & Female	**-0.024*****	**7.859***	**-0.002**	**0.000**	**-0.001**
Examiner Grade 13 & Female	**-0.032*****	**7.554***	**-0.004**	**0.002**	**0.010**
Examiner Grade 14 & Female	**-0.025*****	**23.450*****	**-0.007**	**0.003**	**0.003**
Examiner Grade 15 & Female	**-0.074*****	**114.196*****	**-0.019**	**0.029*****	**-0.027****
Examiner Tenure Controls	Yes	Yes	Yes	Yes	Yes
Examiner Grade FEs	Yes	Yes	Yes	Yes	Yes
Art-Unit-by-Subclass-by-Year FEs	Yes	Yes	Yes	Yes	Yes
Observations	2,032,159	2,029,915	782,906	2,032,159	657,166
R-squared	0.271	0.439	0.478	0.152	0.223

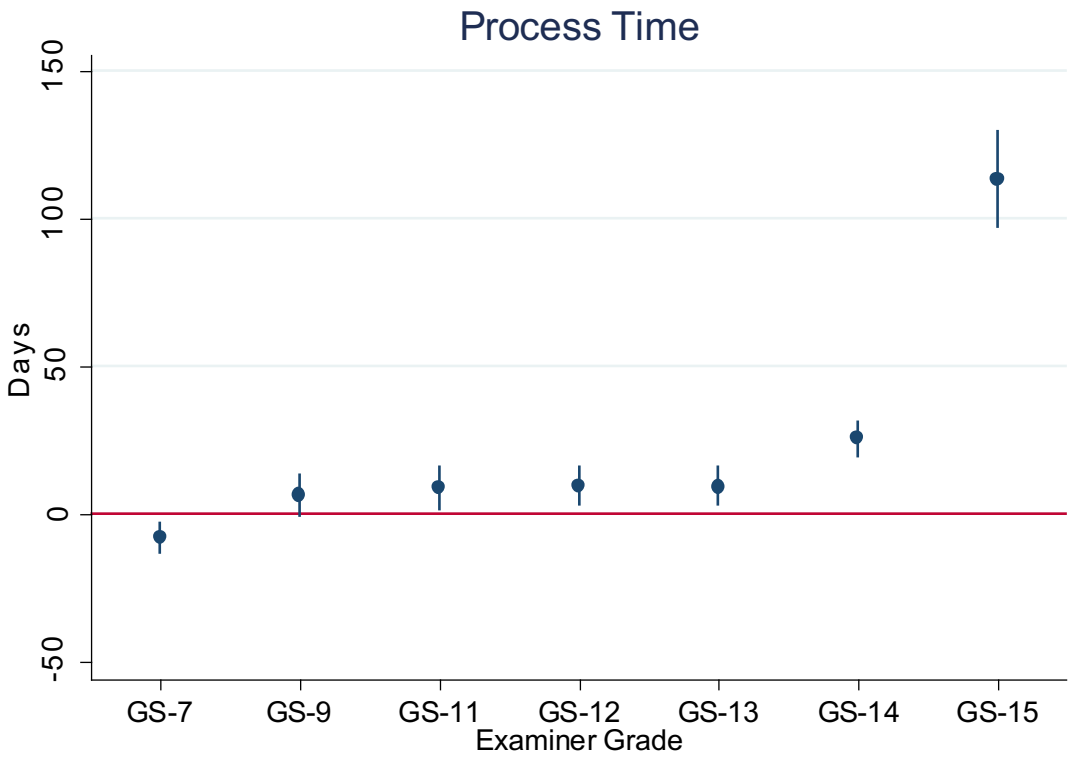
*** p<0.01, ** p<0.05, * p<0.1

Gender differences in examiner effort increase with examiner seniority

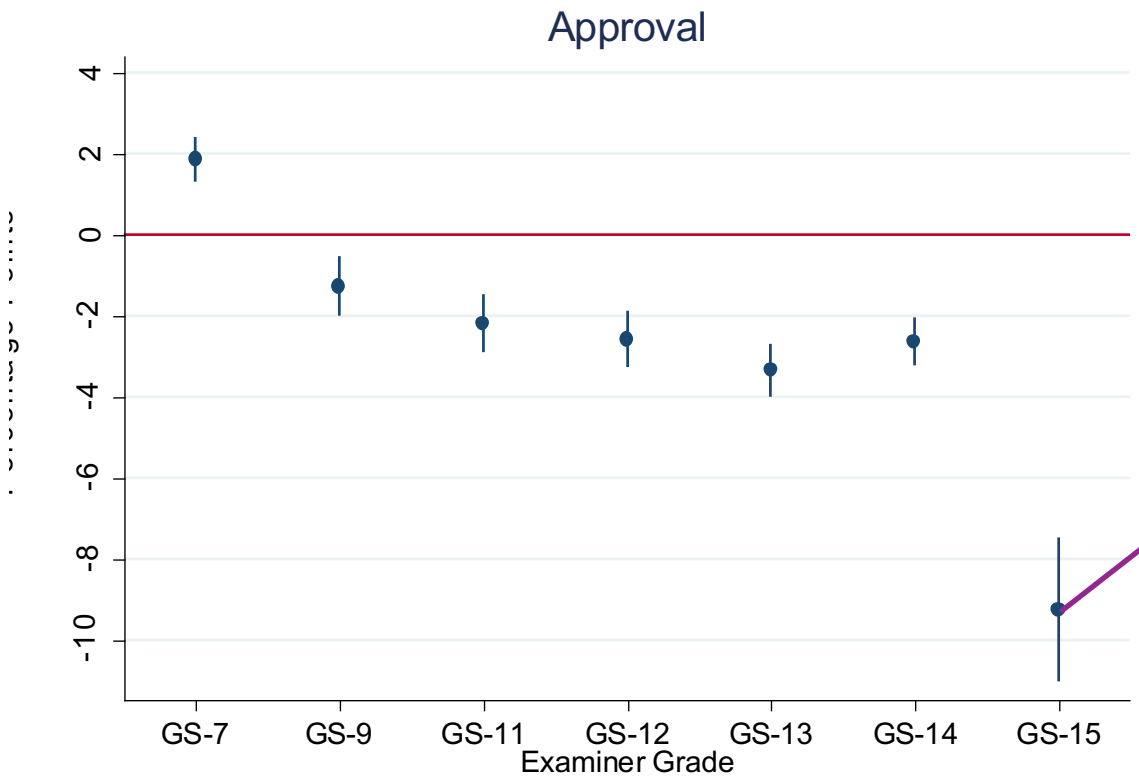


11.9% gender difference in first action approval rate at GS-15!

Gender differences in examination outcomes increase with examiner seniority



Gender differences in examination outcomes increase with examiner seniority



12.6% gender difference in approval rate at GS-15!

Gender differences in examiner effort are higher in technology units with higher fraction of women examiners

Dependent Variable	Approval on First-Action	Rejection 101 Count (usefulness)	Rejection 102 Count (novelty)	Rejection 103 Count (non-obviousness)	Rejection 112 Count (quality)	Percent Examiner-Inserted Citations	Independent Claim Count at Patent Grant
Examiner Female	-0.009***	-0.022***	0.023**	-0.042***	-0.064***	-0.003	0.010
Independent Claim Count at Pre-Grant Publication							0.160***
% Female Examiners in Tech Center X Examiner Female	**-0.012**	**0.098*****	**0.0224**	**0.206*****	**0.257*****	**0.017**	**-0.078**
Examiner Tenure Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Examiner Grade FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Art-Unit-by-Subclass-by-Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,840,115	934,394	934,394	934,394	934,394	1,806,212	1,334,726
R-squared	0.295	0.405	0.267	0.366	0.329	0.341	0.340

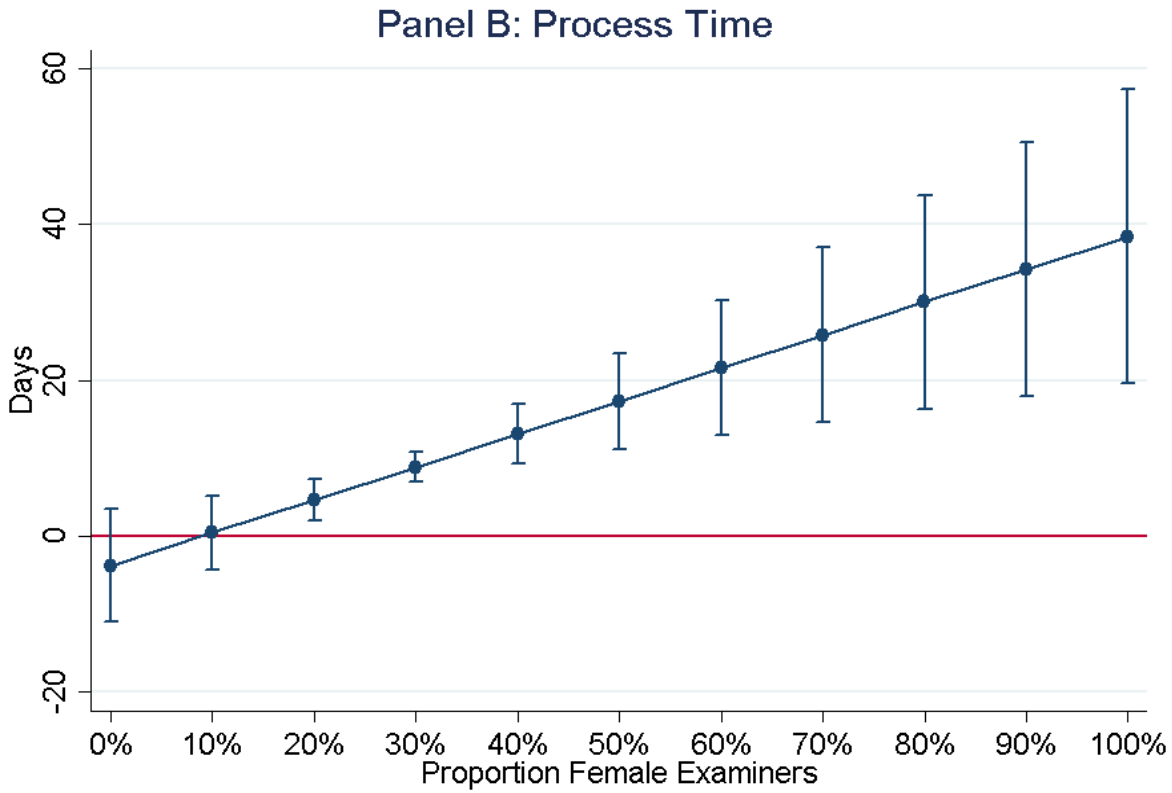
*** p<0.01, ** p<0.05, * p<0.1

Gender differences in examination outcomes higher in technology units with higher fraction of women examiners

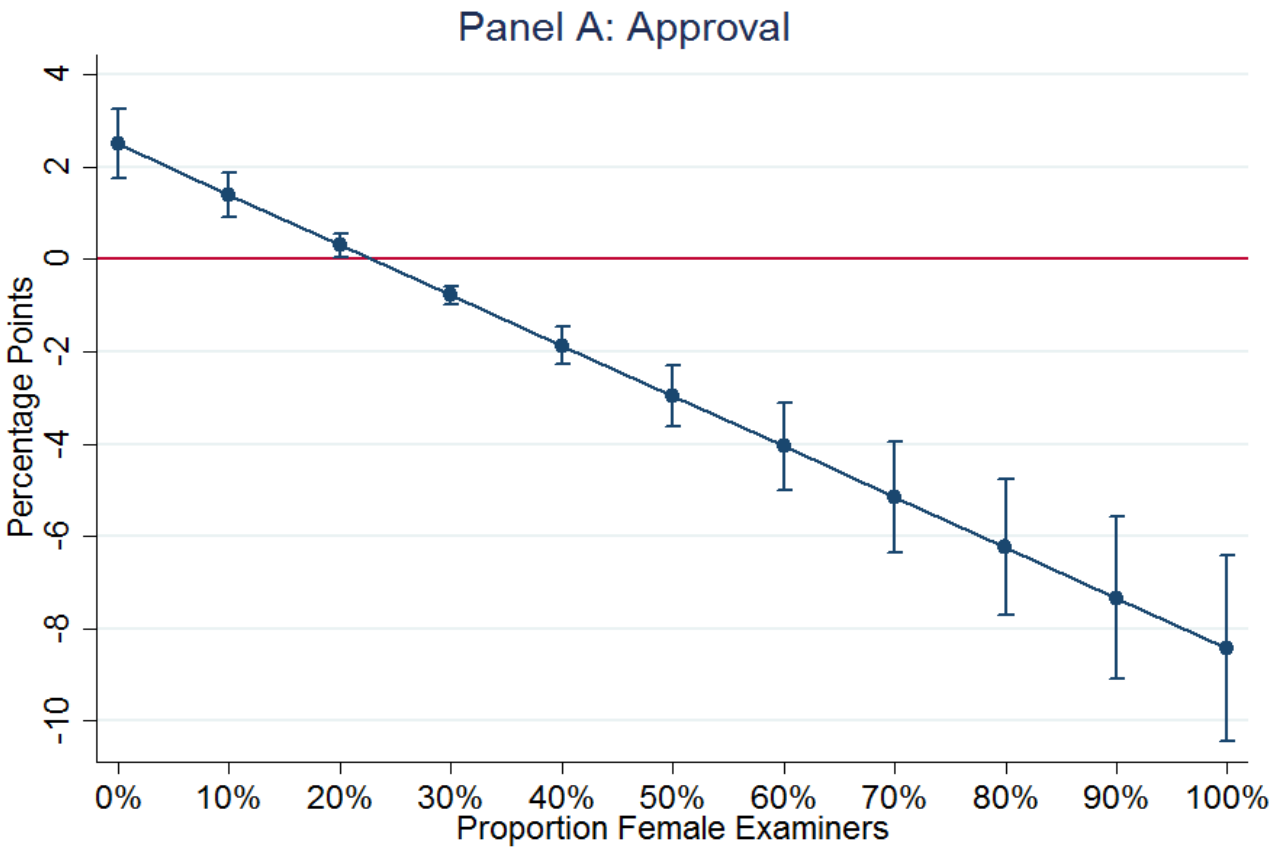
Dependent Variable	Approval	Process Time	Renewal	Decision Appealed	EPO Decision Match
Examiner Female	0.023***	-3.815	0.010**	-0.006***	0.002
% Female Examiners in Tech Center X Examiner Female	**-0.109*** **	**42.317*** **	**-0.026**	**0.027*** **	**0.004**
Examiner Tenure Controls	Yes	Yes	Yes	Yes	Yes
Examiner Grade FEs	Yes	Yes	Yes	Yes	Yes
Art-Unit-by-Subclass-by-Year FEs	Yes	Yes	Yes	Yes	Yes
Observations	2,866,951	2,864,199	1,021,455	2,866,951	842,522
R-squared	0.336	0.511	0.508	0.245	0.280

*** p<0.01, ** p<0.05, * p<0.1

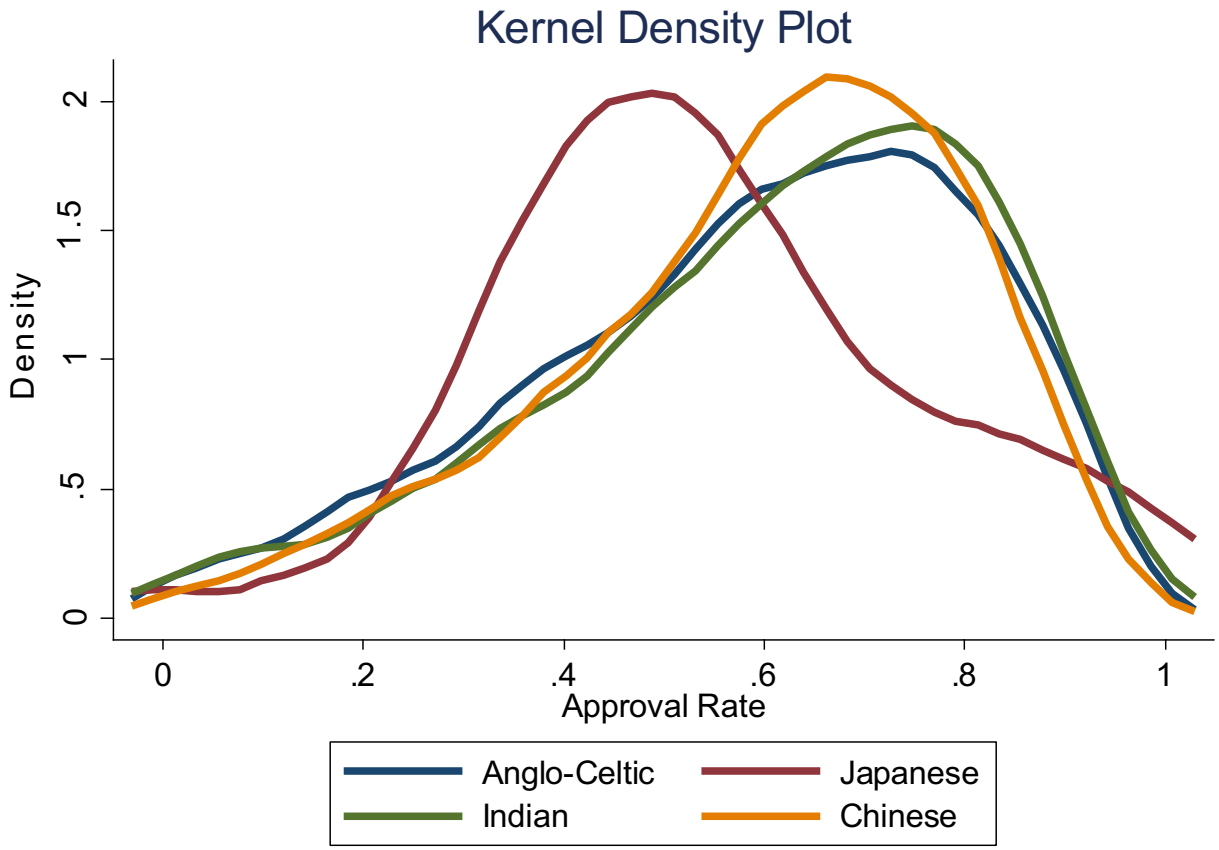
Gender differences in examination outcomes higher in technology units with higher fraction of women examiners



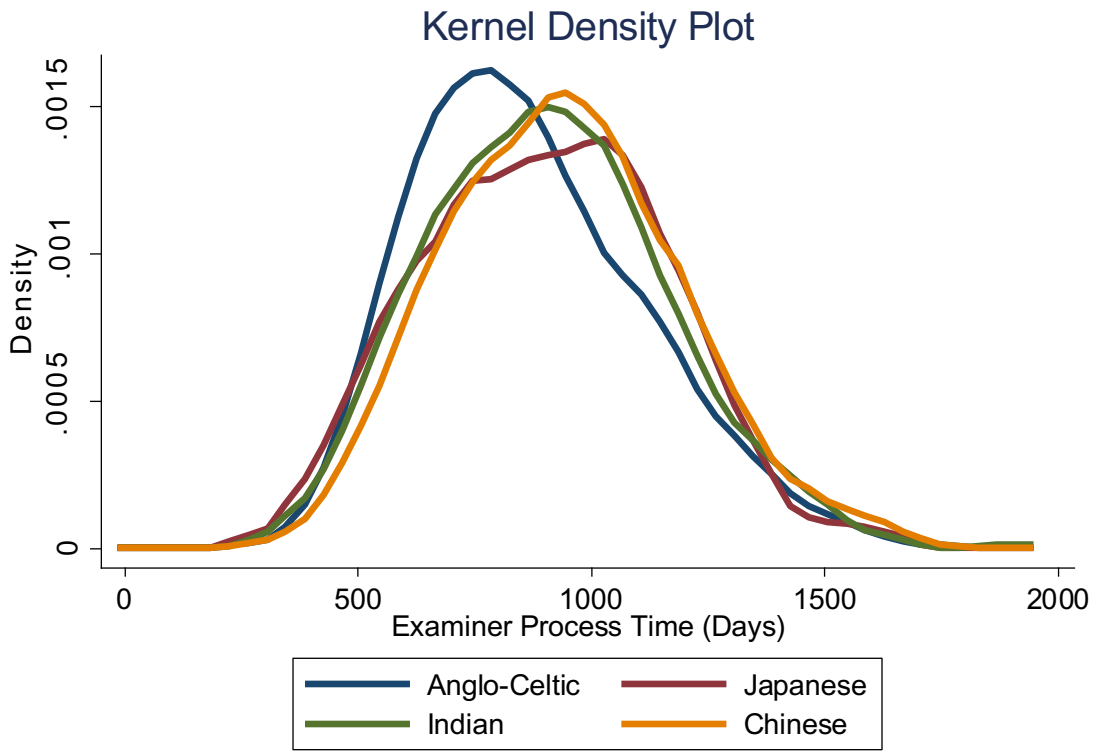
Gender differences in examination outcomes higher in technology units with higher fraction of women examiners



Approval Rate by Examiner Ethnic Origin



Average Process Time by Examiner Ethnic Descent



Policy Implications

Patent examination quality, speed and outcomes depend on examiner gender (examiner ethnicity & examiner grade)

- Systematic variance in USPTO's patent examination effort & judgement
- Follow-on innovation may depend on the applicant's "luck of the draw"

New explanation for gender gap

- Female examiners prioritize thoroughness over speed; quality over quantity
- Gender gap driven by prevalence of volume based (rather than quality based) incentives in the economy

Women's work resembles men's in male dominated technology centers

- Critical mass of minority group necessary to maintain the distinctive work characteristics of the group?

Thank you