Who profits from patents?
Rent-sharing at innovative firms

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The opinions expressed in this presentation are those of the authors alone and do not necessarily reflect the views of the Internal Revenue Service or the U.S. Treasury Department.

Motivation

- Neoclassical model: Firms are price takers on input markets

$$wage = f\,(\text{skill})$$

- Growing evidence that firms *directly* influence wages [Abowd et al 2017; Helpman et al 2017; Goldschmidt and Schmeider 2017; Song et al 2016; Sorkin, 2018]

- This paper: Investigate how winning a patent affects firm performance and worker compensation

- Magnitude of responses relevant to many literatures:
  - Inequality: How important are skills vs employer conditions?
  - Innovation: Who profits from patents?
  - Tax policy: Patent boxes, fiscal externality of corporate & income taxes

This paper

- New linkage of USPTO administrative data to Treasury tax filings
  - Census of published USPTO patent applications
  - Business tax filings record firm outcomes such as revenue, value added
  - Link to worker-level W2 and 1099 filings
- Leverage variation in USPTO initial allowance decisions to infer the causal effects of patent allowances on firm and worker outcomes
  - Exploit methodology of Kogan et al (2017) to identify valuable patents
- New evidence on how winning a valuable patent impacts firms, workers, and inequality [Hall et al 2005; Balasubramanian and Sivadasan 2011; Toivanen and Väänänen 2012; Depalo and Di Addario 2013; Farre-Mensa et al 2016; Bell et al 2016; Kogan et al 2017; Aghion et al 2017]

Key findings

- Patent allowances persistently raise firm size / productivity
- Workers get \$0.30 of every \$1 of "surplus" (EBITD+wages)
- Gains concentrated among application cohort
  - Incumbent workers get \$0.50-0.60 of every \$1 of "surplus"
  - Largest impacts in upper half of earnings distribution
- No response of entry wages
  - Inconsistent w/ standard bargaining models [e.g., Pissarides 2000, 2009]
  - No evidence of impacts on growth rates [e.g., Postel-Vinay and Robin 2002]

Three generations of "rent sharing" elasticities

Group 1: Industry-level profit measure	
Christofides-Oswald (QJE 1992), Canadian manufacturing	0.140 (0.035)
Blanchflower-Oswald-Sanfey (QJE 1996), US manufacturing	0.060 (0.024)
Group 2: Firm-level profit measure, mean firm wage	
Abowd-Lemieux (QJE 1993), Canadian manufacturing	0.220 (0.081)
Van Reenen (QJE 1996), UK manufacturing	0.290 (0.089)
Barth-Bryson-Davis-Freeman (JOLE 2016), US	0.160 (0.002)
Group 3: Firm-level profit measure, individual-specific wage	
Guiso-Pistaferri-Schivardi (JPE 2005), Italy	0.069 (0.025)
Card-Devicienti-Maida (ReStud 2014), Italy	0.073 (0.031)
Card-Cardoso-Kline (QJE 2014), Portugal, between firm	0.156 (0.006)
Card-Cardoso-Kline (QJE 2014), Portugal, stayers	0.049 (0.007)
Bagger-Christensen-Mortensen (mimeo), Danish manufacturing	0.090 (0.020)

Source: Card, Cardoso, Heining, Kline (2018)

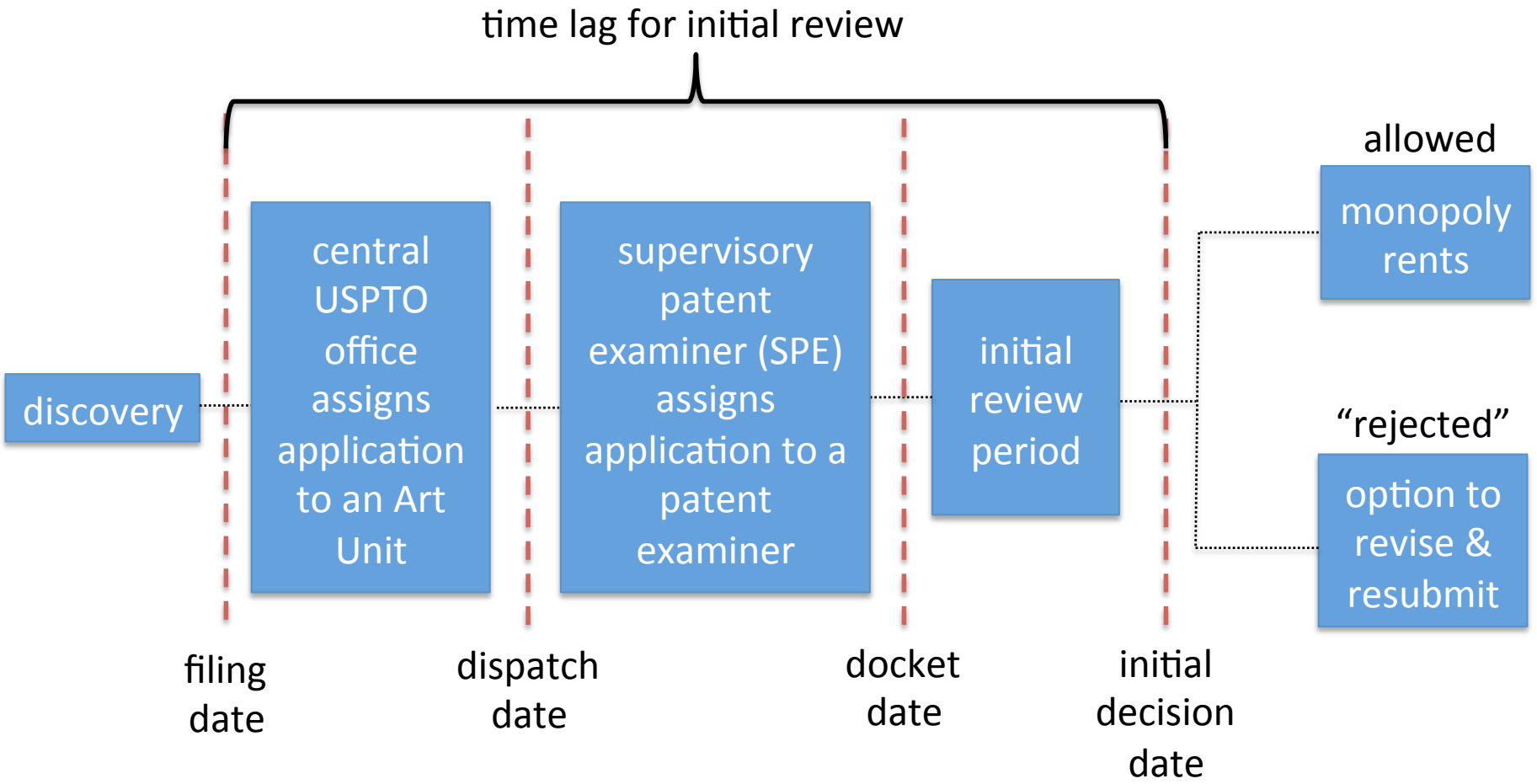
Patent grants

- Patent grants provide temporary monopoly power $\Rightarrow$ rents
- Should raise firm-specific marginal revenue products
- May alleviate credit constraints [Farre-Mensa et al 2016]
- Should matter most for first time patent applicants

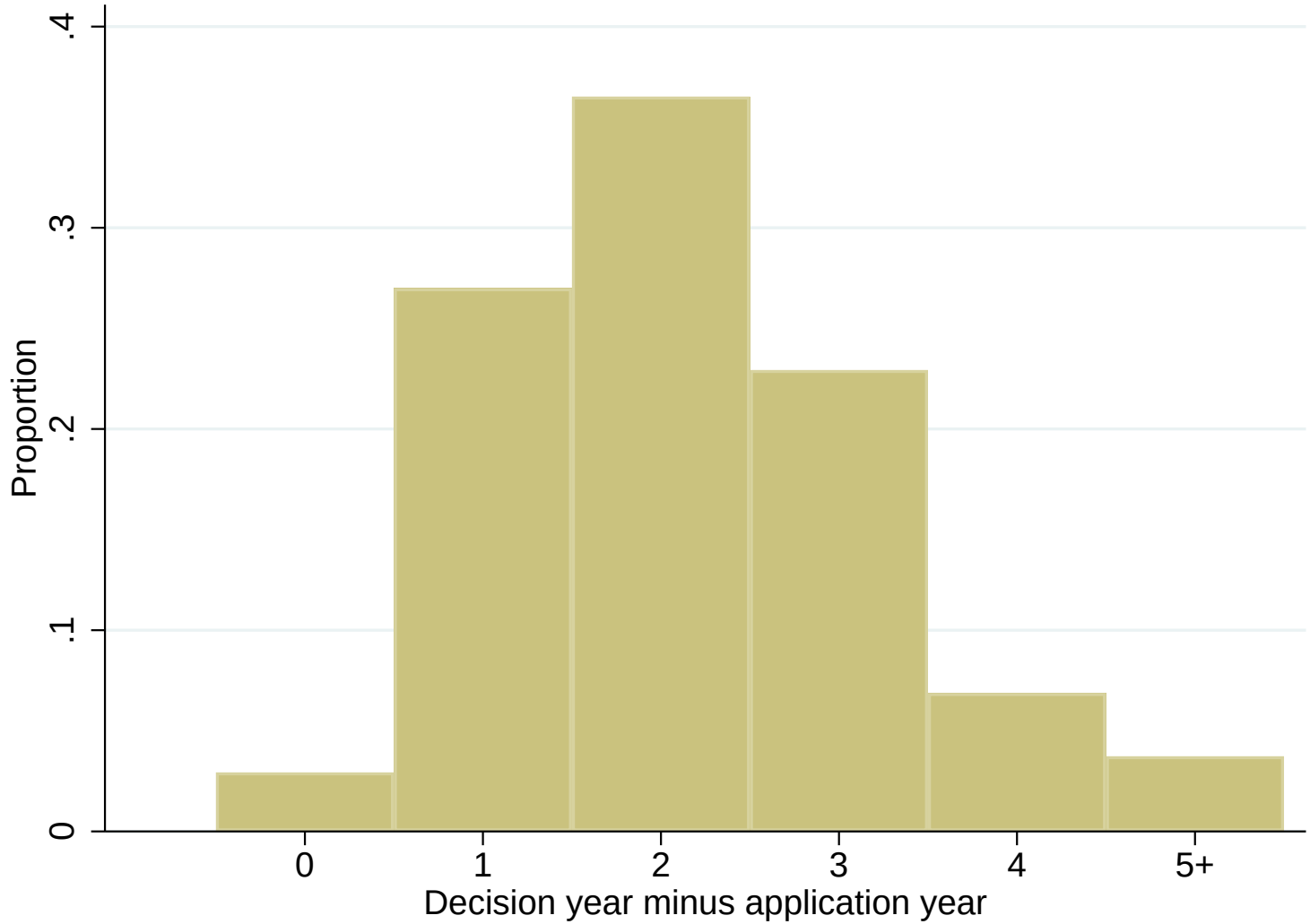
Obtaining a US patent (crash course)

- Discover a novel, non-obvious, useful idea
- Submit application to USPTO central office ("filing date")
  - Central office routes application to the supervisory patent examiner (SPE) of the appropriate art unit ("dispatch date")
  - SPE assigns application to a patent examiner ("docket date")
- Examiner issues an initial decision ("initial decision date")
  - Allowance (roughly 10% of initial decisions) or "rejection"
  - "Rejection" is a revise & resubmit
  - Applicant and examiner may engage in many rounds of revision

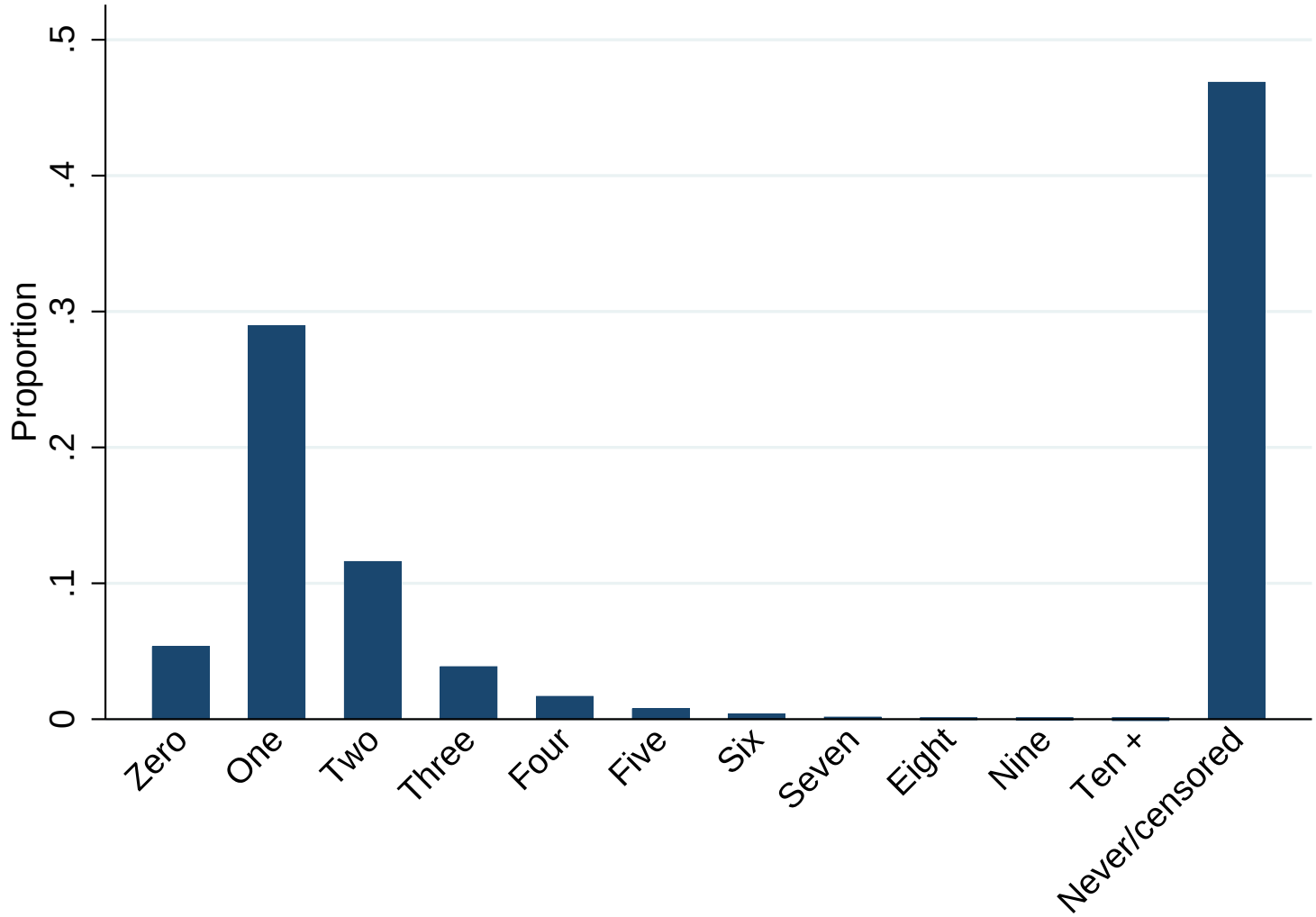
USPTO patent application process



Most initial decisions arrive within three calendar years



Nearly half of rejected applications are never accepted



Research design

- Two valuable patent applications submitted by two separate firms to the USPTO in the same year
- They are routed to the same art unit
- One is initially allowed and the other is not
- We assume parallel trends for initially allowed/rejected patents (DID)
  - Validate w/ event studies + balance tests + low-value patents

Model

- Extension of static wage posting model in Card, Cardoso, Heining, and Kline (2018) to allow separate recruiting and retention decisions
  - Competitive entry market but incumbent wage premia driven by training / recruitment costs [Becker 1964; Stevens 1994; Manning 2006]
  - Resulting incumbent wage rule analogous to older union bargaining models [de Menil 1971; Farber 1986; Brown and Ashenfelter 1986]
- Key predictions
  - Gap between entry and incumbent wages increasing in firm productivity
  - Pass-through of productivity shocks to worker wages governed by retention elasticity and product market power
- Analyze endogeneity biases

Timing

- Firm wakes up with I incumbent workers
- Hires N additional workers on entry market at competitive wage $w^m = w^m(A)$
- Produces output linear in # of retained workers then shuts down

Recruiting & Retention

- Hiring N workers incurs training / recruiting cost $c(N, I) = c(N/I)\, I$
- Incumbent workers receive outside offers from translated $\mathcal{B}(\eta, 1)$ distribution

$$G(\omega) = \left(\frac{\omega - w^m}{\bar{w} - w^m} \right)^{\eta} \qquad \omega \in [w^m, \bar{w}]$$

- Firm only knows $G(.)$, posts a wage w^I to retain $G\left(w^I\right) I$ incumbents

Output Price

- Constant product demand elasticity $\varepsilon > 1$:

$$P(Q) = P_0 Q^{-1/\varepsilon}$$

- Patent boosts P_0 (i.e., "TFPR" [Foster, Haltiwanger, Syverson 2008])

The Firm's Problem

$$\max_{\{w^I, N\}} \underbrace{P_0 \left[T\left(G\left(w^I\right) I + N\right)\right]^{1-1/\varepsilon}}_{\text{revenue}} - \underbrace{c\left(N/I\right) I}_{\text{training costs}} - \underbrace{w^m N - w^I G\left(w^I\right) I}_{\text{wage costs}}$$

- Marginal revenue product of a worker is fixed fraction of average product

$$MRP \equiv (1 - 1/\varepsilon) \underbrace{\frac{P\left(Q\right) Q}{L}}_{\text{average product}}$$

  where $L \equiv G\left(w^I\right) I + N$ is production workforce.

- Incumbent wage setting condition: MRP = marginal factor cost

$$MRP = w^I + \underbrace{\left(w^I - w^m\right)/\eta}_{\text{inframarginal wage costs}}$$

- Hire entry workers until $MRP = w^m$ + marginal training cost of new hire

$$MRP = w^m + c'\left(N/I\right)$$

Wage gap

Incumbent / entry wage gap is:

$$w^I - w^m = \underbrace{\frac{\eta}{1+\eta}}_{\text{exploitation}} \underbrace{c'(N/I)}_{\text{training}}$$

- When $c'(N/I) = 0$ incumbents are *replaceable*
- Parameter η governs monopsony power of firm [Robinson 1933]
  - When $\eta = 0$ incumbents are "trapped" and firm pays them w^m
  - As $\eta \to \infty$ incumbents capture full replacement cost
- Convex $c(.) \Rightarrow$ patent increases wage gap

Rent sharing

Wage rule for incumbents:

$$\begin{aligned} w^I &= \frac{1}{1+\eta} w^m + \frac{\eta}{1+\eta} MRP \\ &= (1-\theta)\, w^m + \theta MRP \end{aligned}$$

$\theta \in [0,1]$ parametrizes *rent-sharing*: how many cents of every extra dollar of MRP do incumbent workers get?

- $\theta = 0$: workers paid entry wage w^m (invariant to firm conditions)
- $\lim_{\theta \to 1}$: workers paid MRP (full pass through)
- $\theta = 1$: firms are price-takers (competitive model)

Analogous to Nash bargain over marginal surplus [Acemoglu and Hawkins 2014]

$$\theta = \frac{w^I - w^m}{MRP - w^m} = \frac{\text{worker rent}}{\text{gross match surplus}}$$

Endogeneity

Incumbent wage at firm is

$$w^I = (1-\theta)\, w^m + \underbrace{\theta\left(1-\frac{1}{\varepsilon}\right)}_{\equiv\pi} S$$

where:

- $S \equiv \frac{P(Q)Q}{L}$ is *average* labor productivity ("surplus per worker")
- π captures "pass-through" [Weyl and Fabinger 2013]

Omitted variables bias: don't see w^m (which could be correlated with S)

An Upward Bias (Correlated shocks)

- I am doing well: $S \uparrow$
- But all my competitors are doing well: $w^m \uparrow$
- $Cov\left(S, w^m\right) > 0 \Rightarrow$ upward biased π

A Downward Bias (The Cool Boss)

- The new boss is cool!
- Productivity is up!
- Reservation wages are down!
- $Cov\left(S, w^m\right) < 0 \Rightarrow$ downward biased π

Endogeneity

Incumbent wage at firm is

$$w^I = (1-\theta)\, w^m + \underbrace{\theta\left(1-\frac{1}{\varepsilon}\right)}_{\equiv\pi} S$$

IV strategy: Analyze *initial* patent decision

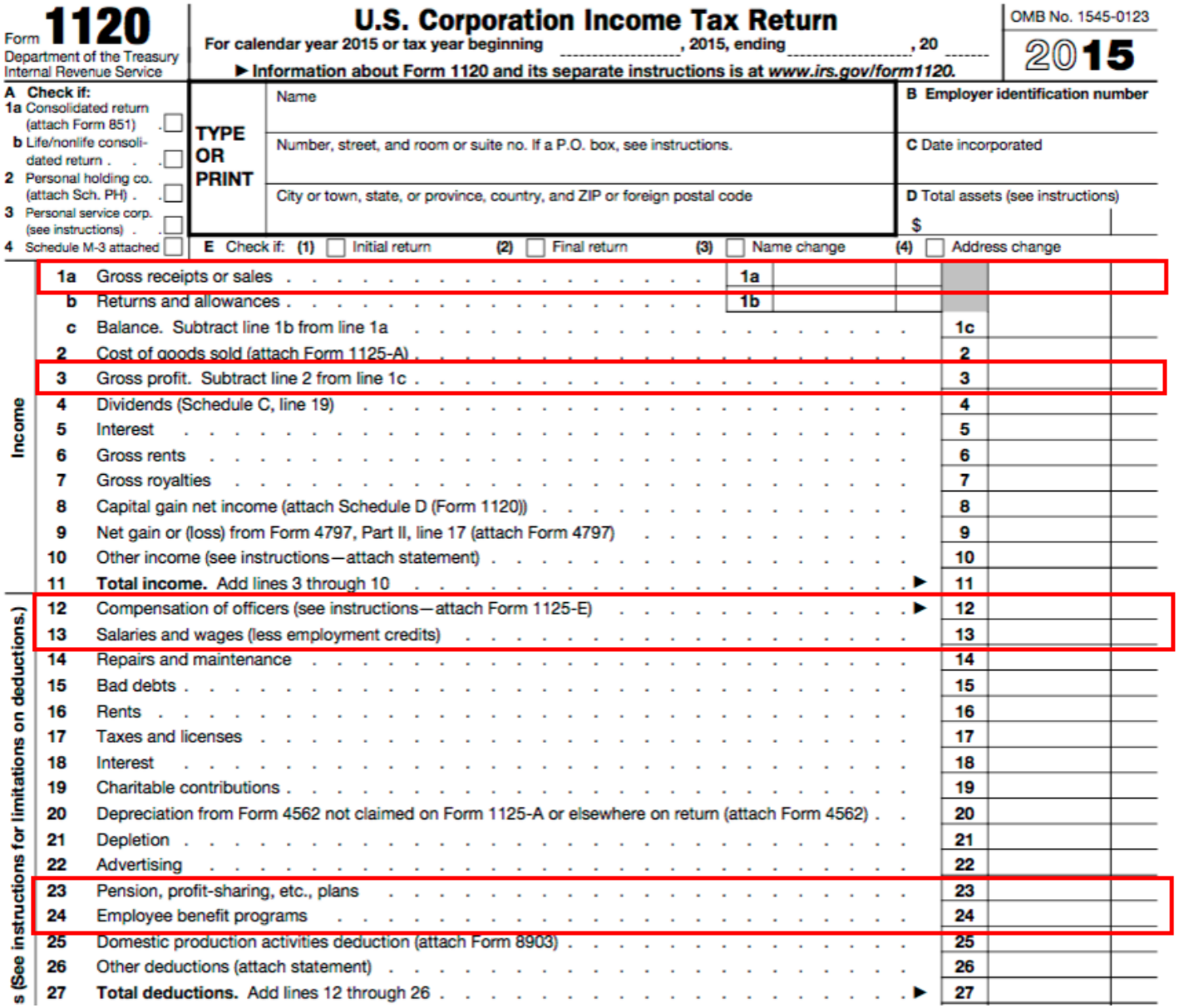
1. Patent decision affects S (**first stage**)
2. Patent decision does not affect w^m (**exclusion**)
3. Patent decision assigned independently of counterfactual trends (**exogeneity**)

US Treasury administrative tax data

We link business tax filings with worker-level filings

- Business filings record firm outcomes such as revenue, value added:
  - 1120: C corporations
  - 1120S: S corporations
  - 1065: Partnerships
- Linked to data constructed from worker-level W2 filings:
  - Number of employees
  - Various worker compensation measures
- Linked to data constructed from worker-level 1099 filings

Example: Form 1120 for C corporations



Form **1120**
Department of the Treasury
Internal Revenue Service

U.S. Corporation Income Tax Return

For calendar year 2015 or tax year beginning _____, 2015, ending _____, 20 _____

▶ Information about Form 1120 and its separate instructions is at *www.irs.gov/form1120*.

OMB No. 1545-0123

2015

A Check if:
1a Consolidated return (attach Form 851)
b Life/nonlife consolidated return
2 Personal holding co. (attach Sch. PH)
3 Personal service corp. (see instructions)
4 Schedule M-3 attached

TYPE OR PRINT

Name — **B Employer identification number**

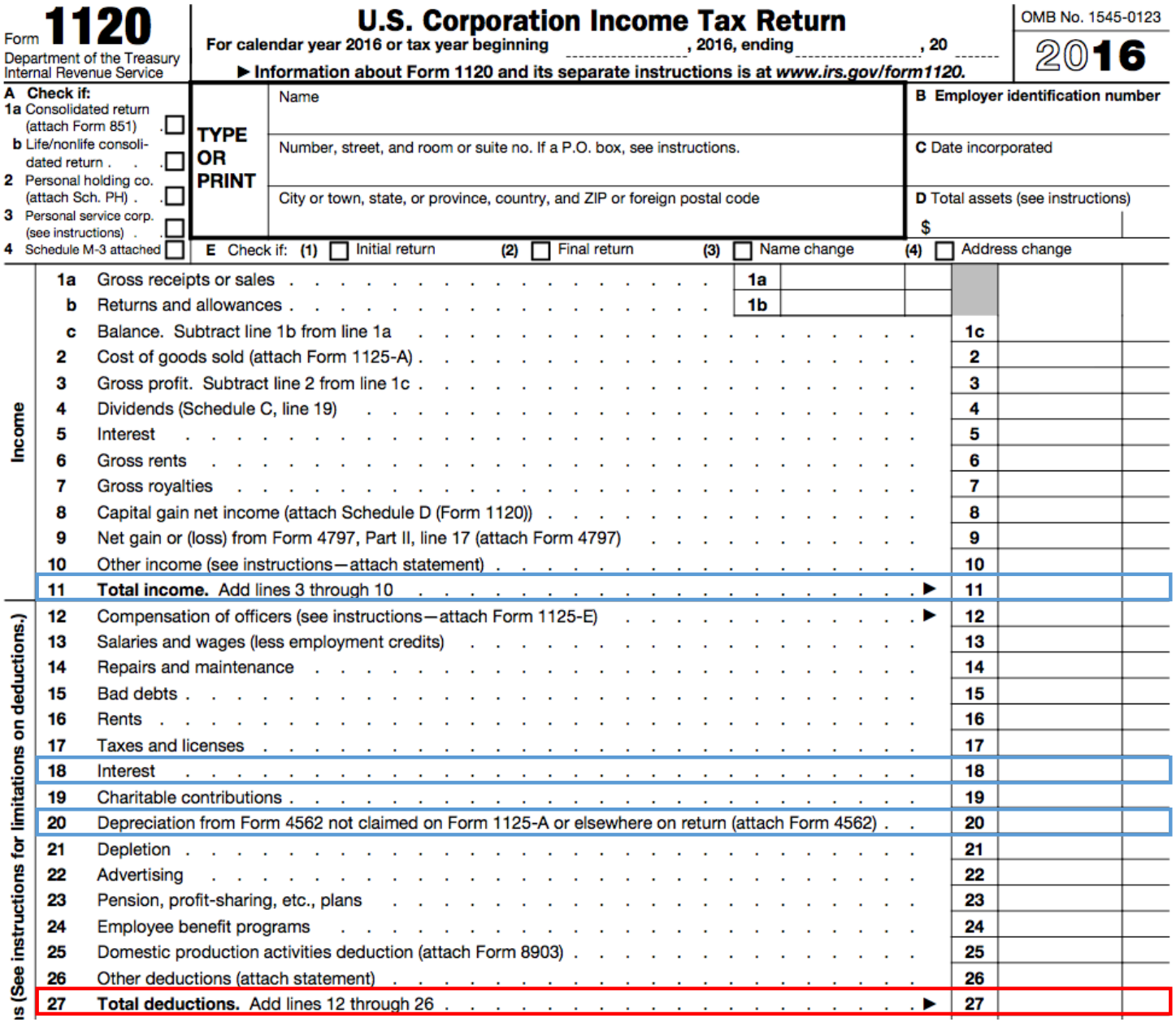
Number, street, and room or suite no. If a P.O. box, see instructions. — **C Date incorporated**

City or town, state, or province, country, and ZIP or foreign postal code — **D Total assets (see instructions)** $

E Check if: (1) Initial return (2) Final return (3) Name change (4) Address change

Income	1a	Gross receipts or sales	1a	
	b	Returns and allowances	1b	
	c	Balance. Subtract line 1b from line 1a		1c
	2	Cost of goods sold (attach Form 1125-A)		2
	3	Gross profit. Subtract line 2 from line 1c		3
	4	Dividends (Schedule C, line 19)		4
	5	Interest		5
	6	Gross rents		6
	7	Gross royalties		7
	8	Capital gain net income (attach Schedule D (Form 1120))		8
	9	Net gain or (loss) from Form 4797, Part II, line 17 (attach Form 4797)		9
	10	Other income (see instructions—attach statement)		10
	11	**Total income.** Add lines 3 through 10 ▶		11
(See instructions for limitations on deductions.)	12	Compensation of officers (see instructions—attach Form 1125-E) ▶		12
	13	Salaries and wages (less employment credits)		13
	14	Repairs and maintenance		14
	15	Bad debts		15
	16	Rents		16
	17	Taxes and licenses		17
	18	Interest		18
	19	Charitable contributions		19
	20	Depreciation from Form 4562 not claimed on Form 1125-A or elsewhere on return (attach Form 4562)		20
	21	Depletion		21
	22	Advertising		22
	23	Pension, profit-sharing, etc., plans		23
	24	Employee benefit programs		24
	25	Domestic production activities deduction (attach Form 8903)		25
	26	Other deductions (attach statement)		26
	27	**Total deductions.** Add lines 12 through 26 ▶		27

EBITD



Form **1120**
Department of the Treasury
Internal Revenue Service

U.S. Corporation Income Tax Return

For calendar year 2016 or tax year beginning _____, 2016, ending _____, 20 _____

▶ Information about Form 1120 and its separate instructions is at *www.irs.gov/form1120.*

OMB No. 1545-0123

2016

A Check if:
1a Consolidated return (attach Form 851) ☐
b Life/nonlife consolidated return ☐
2 Personal holding co. (attach Sch. PH) ☐
3 Personal service corp. (see instructions) ☐
4 Schedule M-3 attached ☐

TYPE OR PRINT

Name — **B Employer identification number**

Number, street, and room or suite no. If a P.O. box, see instructions. — **C Date incorporated**

City or town, state, or province, country, and ZIP or foreign postal code — **D Total assets (see instructions)** $

E Check if: (1) ☐ Initial return (2) ☐ Final return (3) ☐ Name change (4) ☐ Address change

Income	1a	Gross receipts or sales	1a		
	b	Returns and allowances	1b		
	c	Balance. Subtract line 1b from line 1a			1c
	2	Cost of goods sold (attach Form 1125-A)			2
	3	Gross profit. Subtract line 2 from line 1c			3
	4	Dividends (Schedule C, line 19)			4
	5	Interest			5
	6	Gross rents			6
	7	Gross royalties			7
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	9	Net gain or (loss) from Form 4797, Part II, line 17 (attach Form 4797)			9
	10	Other income (see instructions—attach statement)			10
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	15	Bad debts			15
	16	Rents			16
	17	Taxes and licenses			17
	18	Interest			18
	19	Charitable contributions			19
	20	Depreciation from Form 4562 not claimed on Form 1125-A or elsewhere on return (attach Form 4562)			20
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	23	Pension, profit-sharing, etc., plans			23
	24	Employee benefit programs			24
	25	Domestic production activities deduction (attach Form 8903)			25
	26	Other deductions (attach statement)			26
	27	**Total deductions.** Add lines 12 through 26 ▶			27

Example: USPTO patent application 14/776,586

US 20160143910A1

(19) **United States**

(12) **Patent Application Publication**

Arora et al.

(10) **Pub. No.: US 2016/0143910 A1**

(43) **Pub. Date: May 26, 2016**

(54) **METHODS OF TREATING CANCER AND PREVENTING CANCER DRUG RESISTANCE**

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(72) Inventors: **Shilpi Arora**, Cambridge, MA (US); **Michael Robert Costa**, South San Francisco, CA (US); **Ted Lau**, South San Francisco, CA (US); **Patrick Trojer**, Cambridge, MA (US); **Brian K. Albrecht**, Cambridge, MA (US); **Shane Buker**, Cambridge, MA (US); **Marie Classon**, South San Francisco, CA (US); **Victor S. Gehling**, Cambridge, MA (US); **Jean-Christophe Harmange**,

(73) Assignees: **CONSTELLATION PHARMACEUTICALS, INC.**, Cambridge, MA (US); **GENENTECH, INC.**, South San Francisco, CA (US)

(21) Appl. No.: **14/776,586**

(22) PCT Filed: **Mar. 14, 2014**

(86) PCT No.: **PCT/US14/29432**

§ 371 (c)(1),
(2) Date: **Sep. 14, 2015**

Related U.S. Application Data

(60) Provisional application No. 61/801,414, filed on Mar. 15, 2013, provisional application No. 61/804,083, filed on Mar. 21, 2013.

Publication Classification

(51) **Int. Cl.**

A61K 31/519	(2006.01)
A61K 31/437	(2006.01)
A61K 31/517	(2006.01)
A61K 45/06	(2006.01)

Firm-level assignee / business filing merge

1. Standardize IRS firm names and USPTO assignee organization names
   - Build on NBER Patent Data Project name standardization routine
   - e.g. Alcatel-Lucent U.S.A., INC. vs. Alcatel-Lucent USA INC
2. Match "similar" names
   - Use the SoftTFIDF algorithm to find the standardized IRS firm name that is "closest" to each standardized USPTO assignee name
3. Prune set of potential matches
   - Apply match quality thresholds based on a hand-match of 2,196 USPTO assignee names to Compustat
   - Yields Type I and II error rates of $\sim 5\%$
4. Validation based on worker-inventor match [Bell et al 2016]

Example: Analogous Compustat merge

USPTO Assignee Name	Compustat Firm Name (best match)	Match Score
angiotech pharmaceuticals corp	angiotech pharmaceuticals	.9982
assg brooks justin	brooks resources corp	.5857
hewlett packard development corp	hewlett packard corp	.8482
huawei device corp	huatue electronics corp	.0013
matsushita electric works corp	matson corp	.0012
olympus corp	olympus capital corp	.9109
safety crafted solutions corp	safety first corp	.3862
sc johnson home storage corp	sc holdings corp	.5144

Sample selection

1. Restrict to utility patent applications
2. Exclude if missing assignee organization name
3. Exclude if filing year is 2011 or later, to avoid censoring
4. Restrict to "first" patent applications
   - Focus on "first time" patent applicants, for whom the fate of a given patent application is likely to be the most consequential
   - Approximate using patents granted prior to our sample
   - Drop "child" applications

Sample construction

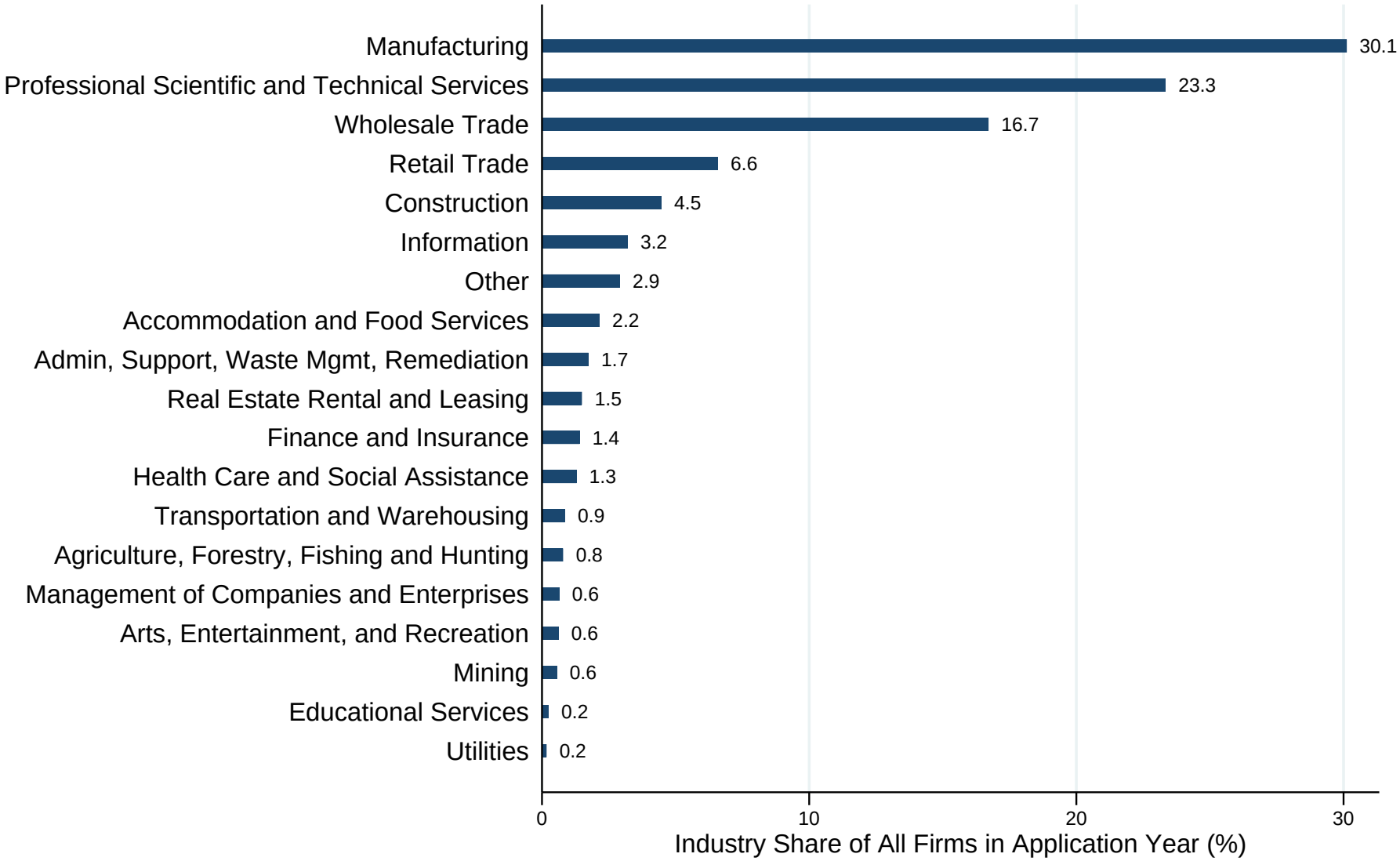
	App-Assg Pairs	Apps	Std Assgs	EINs
USPTO sample				
Full sample	3,737,351	3,601,913	317,370	—
Filed $\in$ [2000, 2010]	3,063,980	2,954,507	279,936	—
Non-missing assg	2,708,829	2,599,373	279,935	—
Non-child apps	1,341,843	1,295,649	130,619	—
Utility apps	1,339,146	1,293,054	130,113	—
First app by assg$*$	130,113	125,018	130,113	—
No prior grant to assg$**$	99,871	95,767	99,871	—
USPTO-tax merge	—	39,452	39,814	81,934
First app by EIN$***$	—	37,714	—	81,877
No prior grant to EIN$**$	—	35,643	—	78,291
Largest revenue EIN†	—	35,643	—	35,643
Drop inactive firms‡	—	9,732	—	9,732

With 49.6% US assgs (USPTO statistics) we have an implied 83% match rate from USPTO assignees to EINs.
*: Ties are broken by taking the smaller application number.
**: Prior grant refers to any grants from applications filed before 11/29/2000.
***: EINs with multiple first applications are dropped.
†: EIN with largest revenue in application year.
‡: Active firms have non-zero/missing total income or total deductions in the application year plus three years before, a positive number of employees in the application year, and revenue less than 100M in 2014 USD.

Under the hood

- Activity
  - Firm active if any income or deductions
  - Require activity in fours years leading up to application
  - Require at least one W2 in year of application
- Zeros
  - No W2 $\Rightarrow$ Emp=0
  - No income $\Rightarrow$ Rev=0
- Winsorize all variables at 5th and 95th percentiles based upon ratio relative to W2 employment

Industry composition



Summary statistics: Firm outcomes in application year

	Full sample			
	Mean	p10	p50	p90
Revenue	9,841	226.35	3,232	29,082
Value added	3,952	117.63	1,300	10,456
EBITD	104.05	-916.47	87.27	1,979
Employment	45.65	2	17.07	117.17
Value added / worker	116.39	15.66	84.72	287.36
EBITD / worker	0.82	-70.88	6.85	69.53
Predicted patent value	4,921	219	1,749	10,942
% Patents initially allowed	8.4	.	.	.

Notes: To protect taxpayer anonymity, p10, p50, and p90 refer to centile means. Dollar amounts reported are in thousands of 2014 USD. EBITD is earnings before interest, tax, and depreciation.

Summary statistics: Worker outcomes in application year

	Full sample			
	Mean	p10	p50	p90
Labor compensation	2,132	67.88	703.44	5,410
Wage bill	2,412	71.4	840.86	6,487
Labor compensation / worker	57.22	10.6	43.12	136.34
Wage bill / worker	54.98	17.94	47.94	109.33
% Female employment	30.2	0	25.6	66.1
% Contractors	18.4	0	10.5	53.0
% Entrants	28.8	0	24.6	62.9
% Inventors	11.4	0	2.5	36.4
Firm observations	9,732			

Notes: To protect taxpayer anonymity, p10, p50, and p95 refer to centile means. Dollar amounts reported are in thousands of 2014 USD.

Hard to predict initial allowances within art unit

	Initially allowed	
log(Employees)	-3.71	-2.06
	(1.85)	(2.18)
Revenue / worker	0.03	0.02
	(0.01)	(0.02)
Value added / worker	-0.14	-0.07
	(0.05)	(0.06)
Wage bill / worker	0.14	0.14
	(0.10)	(0.13)
EBITD / worker	0.11	0.06
	(0.05)	(0.07)
Observations	9,732	8,647
Art-Unit - App Yr FEs	NO	YES
p-value	0.005	0.494

Notes: Columns are linear probability models of initial allowance on listed covariates. Standard errors are clustered by art unit.

No geographic correlation

	Initially allowed							
	State		Zip		4-D NAICS		4-D NAICS × State	
(ρ)	0.000	0.000	0.068	0.058	0.000	0.000	0.000	0.000
p-value	1.000	1.000	0.297	0.465	1.000	1.000	1.000	1.000
Observations	9,732	8,647	9,732	8,647	9,732	8,647	9,732	8,647
Categories	51	51	4,501	4,231	355	347	3,376	3,185
AU-AY FEs	NO	YES	NO	YES	NO	YES	NO	YES

Notes: The above specifications are random effects models of the initial allowance variable – or its residualized variant that has taken out art unit by app year means – measuring the intra-state correlation and the intra-zip code correlation. ρ gives the correlation and the p-val is from a test of whether this correlation is significantly different from zero.

Power-up: KPSS

- Problem: Many patents worthless [Pakes 1986]

- Kogan, Papanikolaou, Seru, and Stoffman (QJE 2017; KPSS)
  - Estimate excess stock return responses to patent grant announcements
  - Empirical bayes posterior valuations ξ_j for each patent j

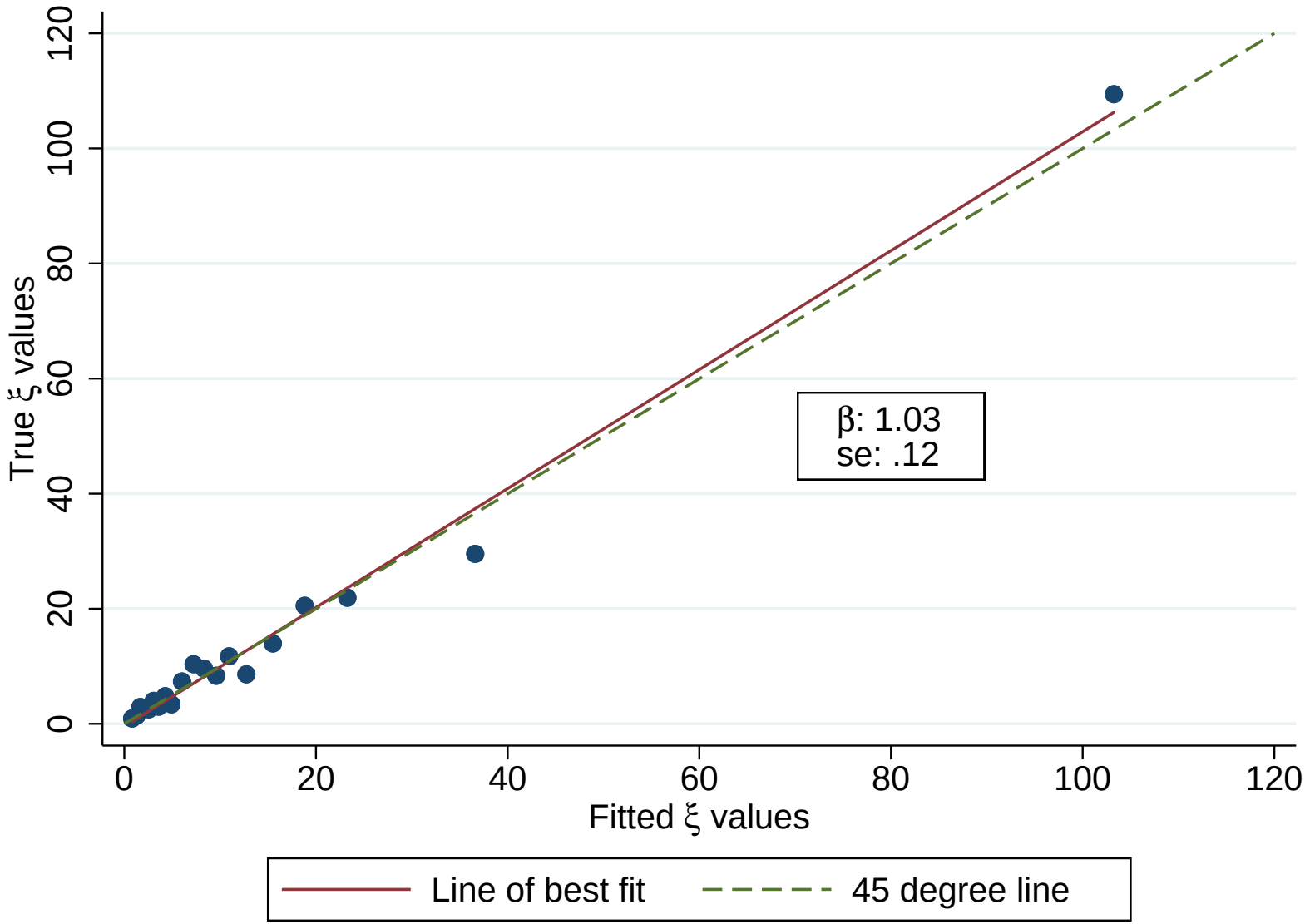
- Our idea: Use ξ_j to identify valuable patents in a broader sample
  - To extrapolate: Fit RE Poisson QML explaining ξ_j in terms of firm and application characteristics that are fixed at the time of application
    - ⋆ Extrapolate to non-public firms and to rejected applications
  - Very strong explanatory power ($R^2 = .69$)

Poisson model

	KPSS value (ξ)	
$\mathbf{1}$(patent family size $= 1$)	0.28	(0.06)
log(patent family size)	0.23	(0.04)
$\mathbf{1}$(number of claims $= 1$)	0.68	(0.19)
log(number of claims)	0.30	(0.03)
$\mathbf{1}$(revenue $= 0$)	1.42	(0.14)
log(revenue)	0.14	(0.02)
$\mathbf{1}$(employees $= 0$)	0.45	(0.07)
log(employees)	-0.01	(0.02)
application year	-0.03	(0.05)
(application year)^2	-0.01	(0.01)
decision year	0.30	(0.06)
(decision year)^2	-0.03	(0.01)
constant	-1.40	(0.21)
log(σ)	0.24	(0.05)
N 596	# groups	260

Notes: Random effects are by art unit. Standard errors are in parentheses.

Predicted vs. actual patent value



Notes: The fitted ξ values on the x-axis are obtained from a Poisson model of ξ on the DWPI count of unique countries where the application was filed, the number of claims in the application, the application year, the initial decision year, the revenue of the firm in the year of application, the number of employees in the application year, and art unit random effects.

Mean $\hat{\xi}$ by technology center

Top 5 tech centers			Bottom 5 tech centers		
Tech center	$\hat{\xi}$	N	Tech center	$\hat{\xi}$	N
Business Methods - Finance	15.079	152	Computer Networks	1.733	145
Electronic Commerce	10.237	365	Radio, Robots, & Nucl Sys	1.597	85
Databases & File Mgmt	9.726	261	Shoes & Apparel	1.444	470
Tires, Glass, & Plastics	8.035	134	Kinestherapy & Exercising	1.330	138
Computer Architecture	8.029	68	Fluid Handling	0.706	188

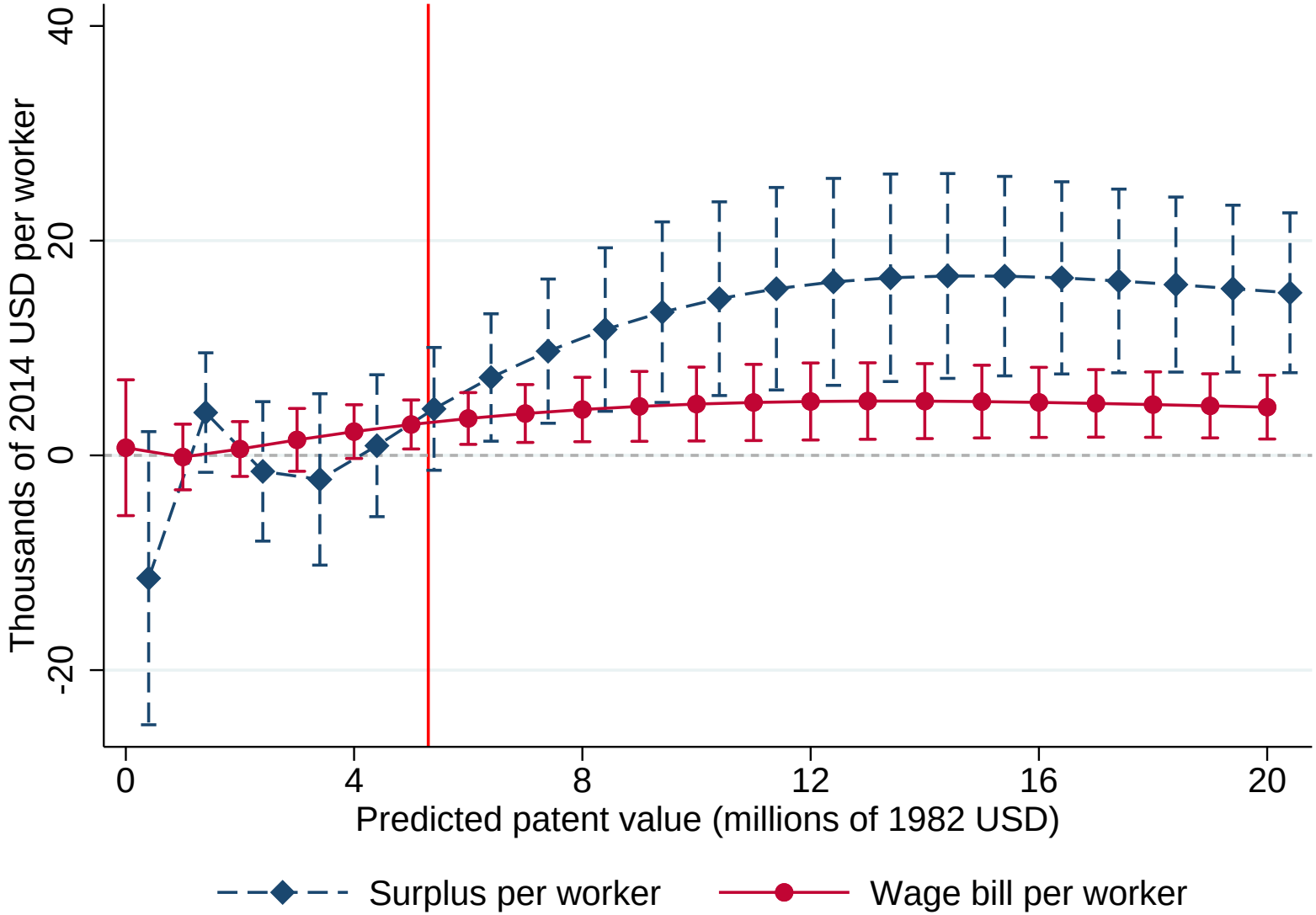
Notes: $\hat{\xi}$ is in millions of 1982 US dollars.

A "dosage" interacted DID

$$Y_{jt} = \alpha_j + \kappa_{t,k(j)} + Post_{jt} \cdot \left[\sum_{b=1}^{5} s_b\left(\hat{\xi}_j\right) \cdot \left(\tilde{\psi}_b + \tilde{\tau}_b \cdot IA_j\right) \right] + r_{jt}$$

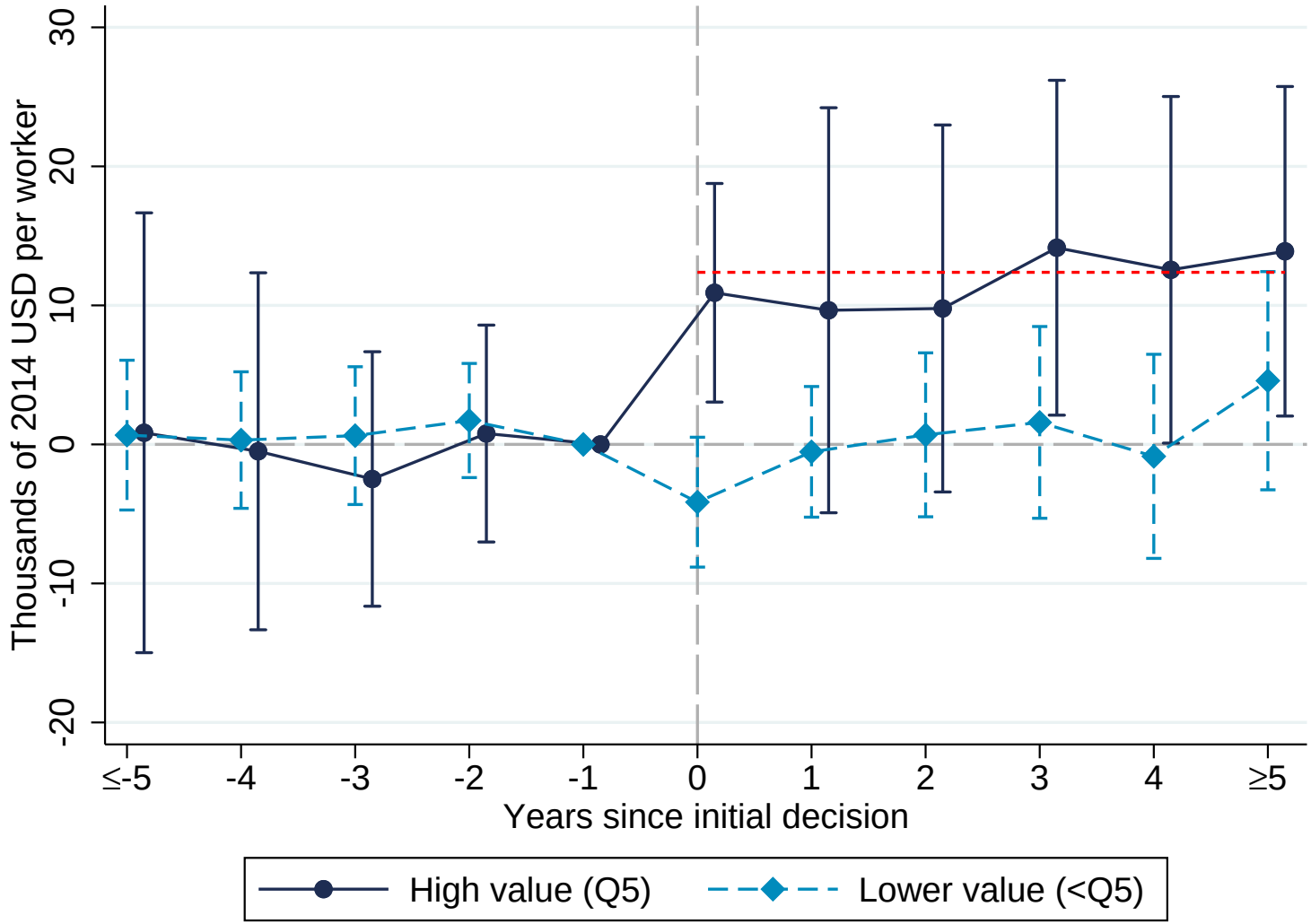
- Y_{jt}: outcome for firm j in calendar year t
- $k(j)$: art unit / application year cell
- $Post_{jt}$: indicator for time t after the decision year for firm j
- IA_j: indicator for the firm receiving an initial allowance
- $\{s_b(.)\}_{b=1}^{5}$: natural cubic spline basis (5 knots, linear endpoints)
- $\sum_{b=1}^{5} s_b(x)\,\tilde{\tau}_b$: impact of allowance for app w/ predicted value x

Impacts by predicted patent value: Surplus and wage bill



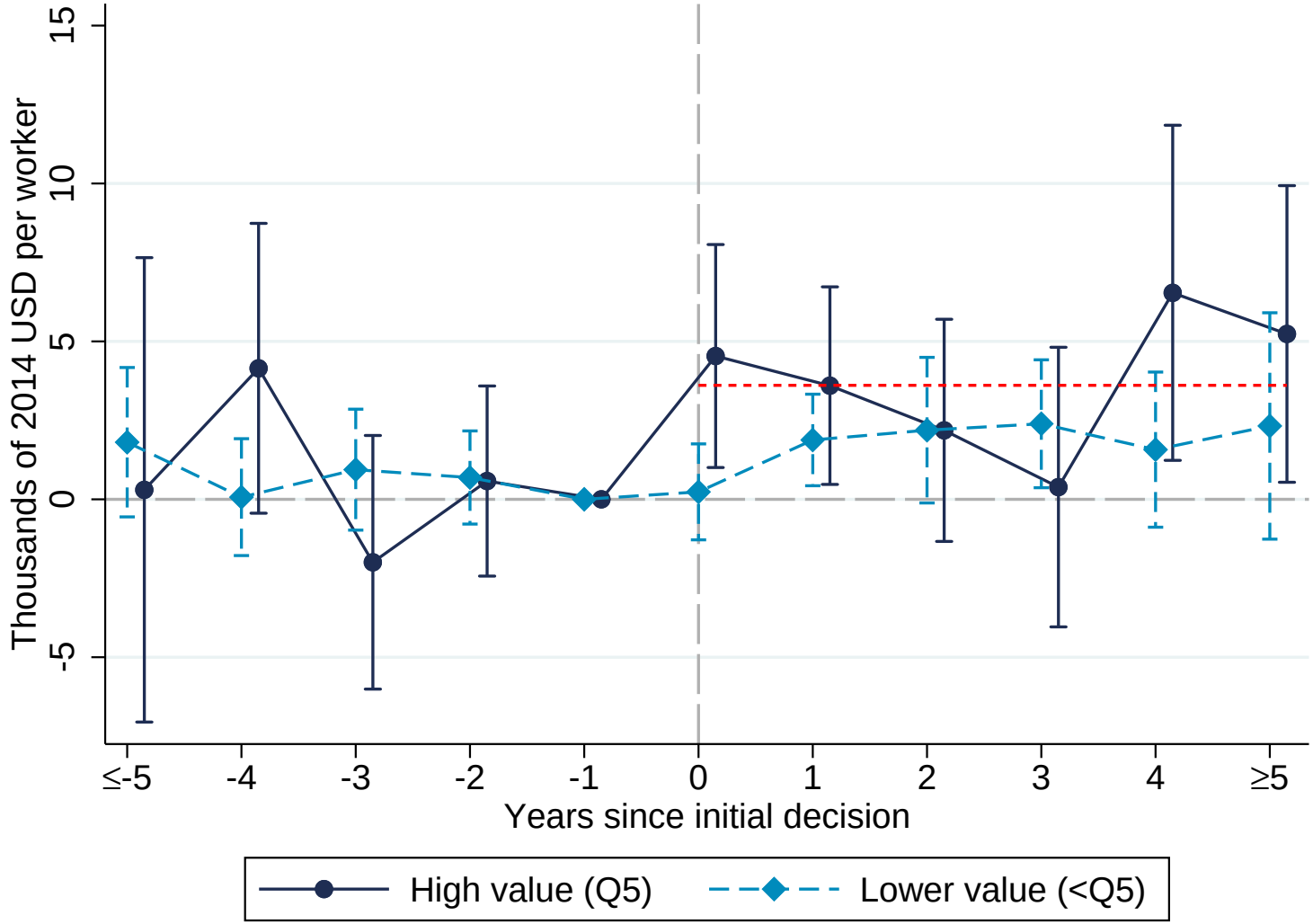
Notes: The vertical, red line is the cut-off value for the top quintile predicted patent value sample, and is equal to 5.3M 1982 USD. Values along the x-axis for the surplus series are offset from their integer value to improve readability. Surplus is EBITD (earnings before interest, tax, and depreciation) + W2 wage bill. 95% confidence intervals shown.

Event study: Surplus (EBITD + W2) per worker



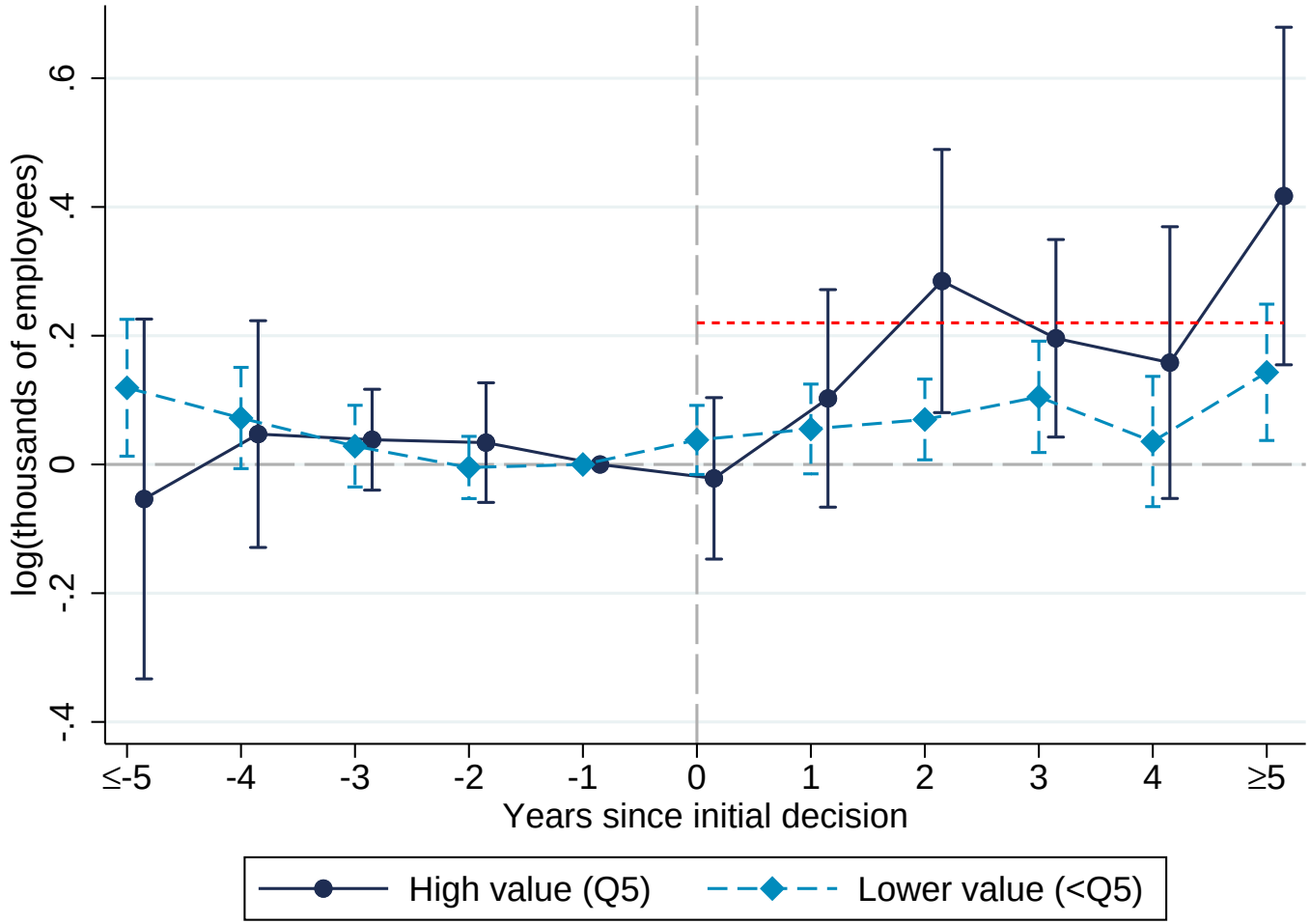
Notes: Two-way standard errors are clustered by (1) art unit, and (2) application year by decision year. Regressions include art unit by application year by calendar year fixed effects and firm fixed effects. Values along the x-axis for the $Q5$ series are offset from their integer value to improve readability. Surplus is EBITD (earnings before interest, tax, and depreciation) + W2 wage bill. $Q5$ is quintile 5 of predicted patent value. $< Q5$ are the remaining four quintiles. 95% confidence intervals shown. Dotted red line is pooled DID impact for a top quintile patent application receiving an initial allowance post-decision.

Event study: Wage bill per worker



Notes: Two-way standard errors are clustered by (1) art unit, and (2) application year by decision year. Regressions include art unit by application year by calendar year fixed effects and firm fixed effects. Values along the x-axis for the $Q5$ series are offset from their integer value to improve readability. $Q5$ is quintile 5 of predicted patent value. $< Q5$ are the remaining four quintiles. 95% confidence intervals shown. Dotted red line is pooled DID impact for a top quintile patent application receiving an initial allowance post-decision.

Event study: log(Firm size)



Notes: Two-way standard errors are clustered by (1) art unit, and (2) application year by decision year. Regressions include art unit by application year by calendar year fixed effects and firm fixed effects. Values along the x-axis for the the $Q5$ series are offset from their integer value to improve readability. $Q5$ is quintile 5 of predicted patent value. $< Q5$ are the remaining four quintiles. 95% confidence intervals shown. Dotted red line is pooled DID impact for a top quintile patent application receiving an initial allowance post-decision.

▸ Pr(Patent grant)

A simplified DID specification

$$\begin{aligned} Y_{jt} =& \alpha_j + \kappa_{t,k(j)} + Q5_j \cdot Post_{jt} \cdot (\psi_5 + \tau_5 \cdot IA_j) \\ &+ (1 - Q5_j) \cdot Post_{jt} \cdot (\psi_{<5} + \tau_{<5} \cdot IA_j) + r_{jt} \end{aligned}$$

- $Q5_j$: indicator for top quintile of predicted value
- τ_5: impact of initial allowance on top quintile firms
- $\tau_{<5}$: impact of initial allowance on firms in bottom four quintiles
- α_j: firm FE
- $\kappa_{t,k(j)}$: art unit / app year / calendar year FE

Basic impacts

	# Emp > 0	Log firm size	Val add / worker	EBITD / worker	Wage bill / worker	Surplus / worker
High value ($Q5$)	0.00	0.22	15.74	9.10	3.65	12.41
	(0.04)	(0.09)	(5.25)	(3.83)	(1.55)	(3.56)
Mean of outcome ($Q5$)	0.70	3.14	116.20	9.07	57.00	67.00
% Impact($Q5$)	-0.6		13.5	100.4	6.4	18.5
Lower value ($< Q5$)	0.00	0.03	0.84	-1.42	0.80	-0.26
	(0.01)	(0.04)	(3.82)	(1.77)	(0.90)	(2.05)
Observations	155,646	103,437	103,437	103,437	103,437	103,437

Notes: Two-way standard errors are clustered by (1) art unit, and (2) application year by decision year. Regressions include art unit by application year by calendar year fixed effects and firm fixed effects. EBITD is earnings before interest, tax, and depreciation. Surplus is EBITD + W2 wage bill. $Q5$ is quintile five of predicted patent value, $< Q5$ are the remaining four lower quintiles. % Impact reports the percent change in the outcome at the mean for winning an initial allowance. Sample size: observations vary if there are zero workers.

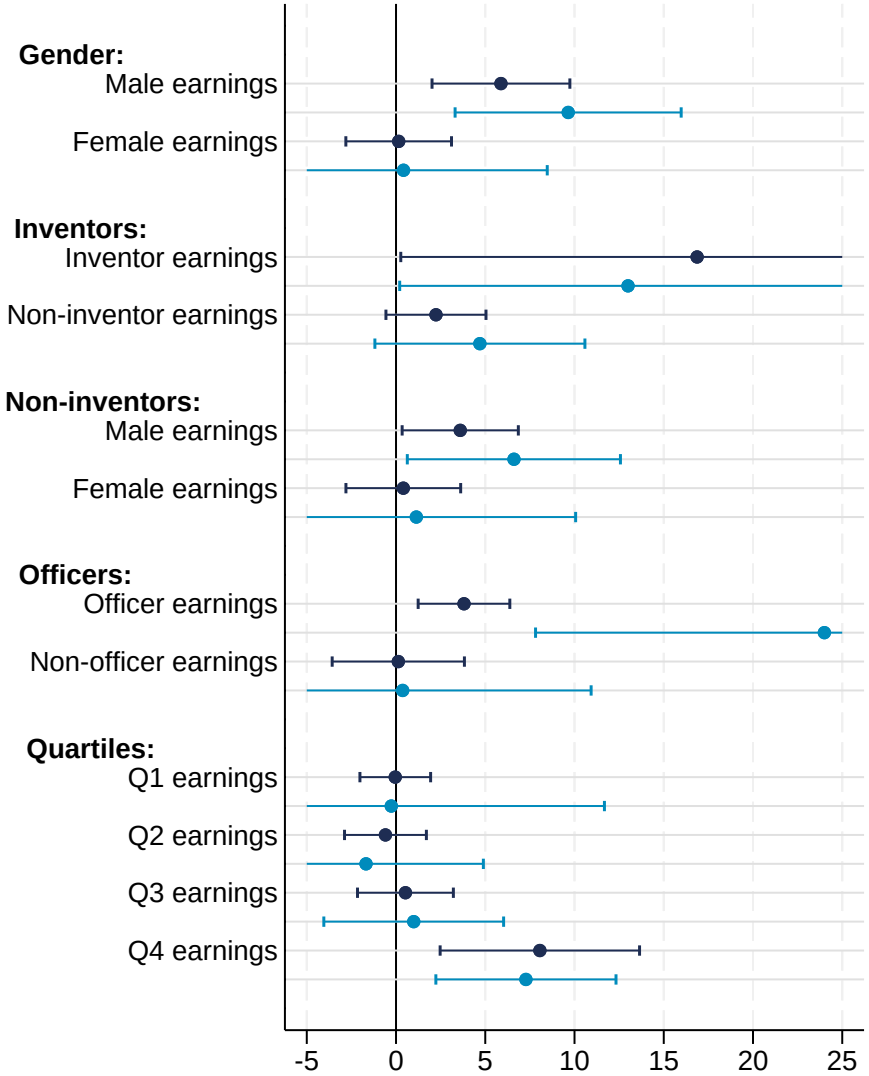
▸ Within firm inequality ▸ Closely-held firms ▸ Small firms ▸ Large firms

Workforce composition

	Share female	Share inventor	Avg entrant earnings (yr bef ent)	Avg separator earnings (yr bef sep)	Avg stayer earnings (in app yr)	Avg age	Log quality	Log quality (expanded)
High value ($Q5$)	-0.01	-0.01	-0.84	0.72	1.29	-1.10	-0.02	-0.01
	(0.01)	(0.01)	(2.05)	(1.11)	(1.58)	(0.56)	(0.03)	(0.03)
Mean of outcome	0.31	0.09	27.32	31.45	71.38	41.72	10.43	10.56
% Impact	-1.8	-13.1	-3.1	2.3	1.8	-2.6		
Lower value ($< Q5$)	-0.01	-0.01	0.49	0.00	1.01	0.08	0.00	-0.01
	(0.01)	(0.01)	(0.70)	(0.53)	(1.19)	(0.22)	(0.01)	(0.01)
Observations	103,437	103,437	70,079	75,524	99,558	103,434	103,437	97,786

Notes: Two-way standard errors are clustered by (1) art unit, and (2) application year by decision year. Regressions include art unit by application year by calendar year fixed effects and firm fixed effects. % Impact reports the percent change in the outcome at the mean for winning an initial allowance. Sample size: observations vary if there are zero workers. $Q5$ is quintile five of predicted patent value, $< Q5$ are the remaining four lower quintiles.

Within-firm heterogeneity

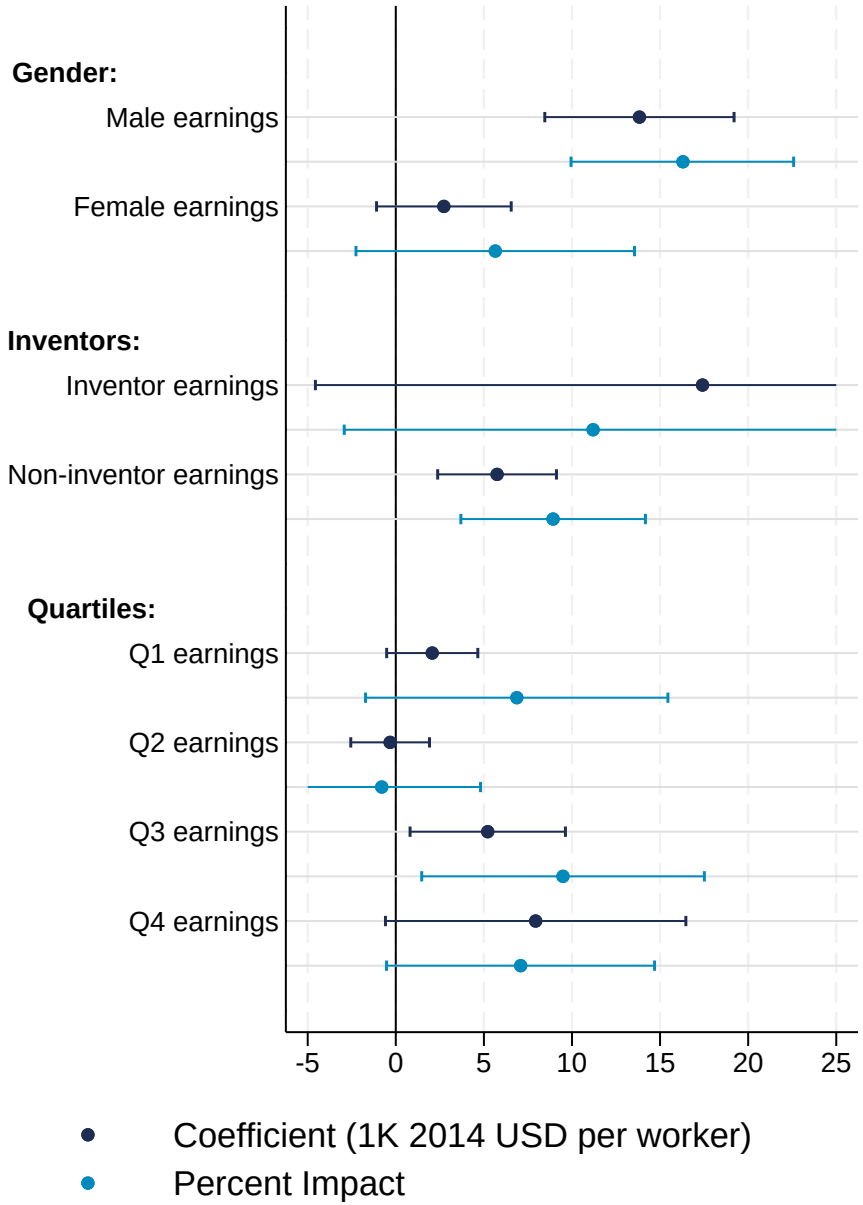


Earnings impacts on application cohort

					Δ since app year	
	Entrant earnings after entry	Separator earnings after sep	Recent entrant earnings	Post-app hire earnings	Entrant earnings	Separator earnings
High value ($Q5$)	3.96	7.78	-1.54	-2.71	6.50	2.77
	(2.29)	(2.93)	(1.94)	(1.81)	(3.10)	(5.65)
Mean of outcome	57.39	72.56	50.57	41.59	72.56	50.57
% Impact	6.9	10.7	-3.0	-6.5	9.0	5.5
Lower value ($< Q5$)	0.34	2.48	0.90	0.78	1.48	-3.87
	(1.18)	(1.59)	(1.39)	(1.01)	(1.63)	(2.40)
Observations	151,892	99,558	109,169	68,691	99,558	109,169

Notes: Two-way standard errors are clustered by (1) art unit, and (2) application year by decision year. Regressions include art unit by application year by calendar year fixed effects and firm fixed effects. $Q5$ is quintile five of predicted patent value, $< Q5$ are the remaining four lower quintiles. % Impact reports the percent change in the outcome at the mean for winning an initial allowance. Sample size: observations vary if there are zero workers. The "Δ since app year" columns are relative to the application year earning values.

Within-firm heterogeneity: Stayers



Pass-through: OLS & IV

	Wage bill per worker		Avg male earnings		Avg non-inv earnings	
	OLS	IV	OLS	IV	OLS	IV
Surplus / worker	0.16	0.29	0.18	0.53	0.13	0.19
	(0.01)	(0.12)	(0.01)	(0.18)	(0.00)	(0.11)
Elasticity	0.19	0.35	0.19	0.54	0.17	0.25
Observations	103,437	103,437	95,004	95,004	100,901	100,901
1^{st} stage F		12.12		10.60		9.34
Exogeneity		0.288		0.082		0.598
Anderson-Rubin 90% CI		(0.10,0.57)		(0.27,0.98)		(-0.01,0.43)

Notes: Two-way standard errors are clustered by (1) art unit, and (2) application year by decision year. Regressions include art unit by application year by calendar year fixed effects and firm fixed effects. Surplus: EBITD (earnings before interest, tax, and depreciation) + W2 wage bill. We instrument with a product of indicators: $Z_t = Post_{jt} \cdot Q5_j \cdot IA_j$, where $Post_{jt}$ signifies time t is after the initial decision for firm j, $Q5_j$ signifies firm j is in the top quintile of patent value, and IA_j signifies patent j received an allowance as a first decision. Elasticity reports the elasticity of the outcome with respect to surplus per worker at the mean of the outcome and the mean firm surplus per worker.

▸ 3-year average of surplus

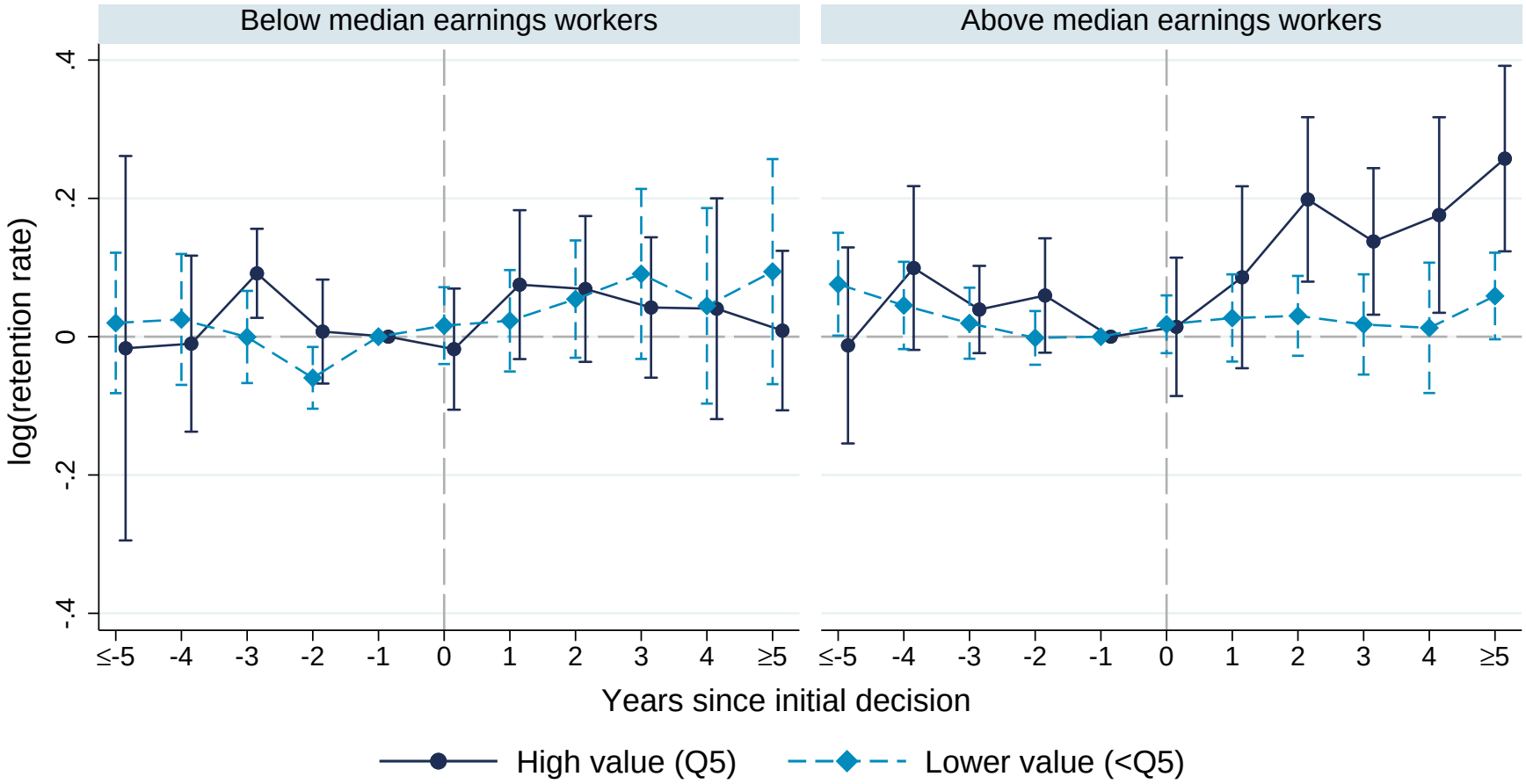
Pass-through: OLS & IV (continued)

	Avg stayer earnings		Avg differenced stayer earnings		Avg non-inv stayer earnings	
	OLS	IV	OLS	IV	OLS	IV
Surplus / worker	0.20	0.61	0.19	0.51	0.16	0.48
	(0.01)	(0.30)	(0.01)	(0.27)	(0.00)	(0.22)
Elasticity	0.19	0.56	0.18	0.47	0.17	0.50
Observations	99,558	99,558	99,558	99,558	94,909	94,909
1^{st} stage F		13.38		13.38		8.93
Exogeneity		0.137		0.217		0.078
Anderson-Rubin 90% CI		(0.21,1.36)		(0.11,1.14)		(0.21,1.18)

Notes: Two-way standard errors are clustered by (1) art unit, and (2) application year by decision year. Regressions include art unit by application year by calendar year fixed effects and firm fixed effects. Surplus: EBITD (earnings before interest, tax, and depreciation) + W2 wage bill. We instrument with a product of indicators: $Z_t = Post_{jt} \cdot Q5_j \cdot IA_j$, where $Post_{jt}$ signifies time t is after the initial decision for firm j, $Q5_j$ signifies firm j is in the top quintile of patent value, and IA_j signifies patent j received an allowance as a first decision. Elasticity reports the elasticity of the outcome with respect to surplus per worker at the mean of the outcome and the mean firm surplus per worker. Elasticity estimates evaluated at mean unadjusted earnings of firm stayers with high ex-ante value patents. For example, we take the passthrough coefficient of .51 and multiply it by .56/.61, which is the ratio of elasticity to impact estimate for average stayer earnings.

▸ 3-year average of surplus

Employee retention rate by application year earnings



Retention - wage elasticities

	ln(Ret rate)	ln(Top half ret rate)	ln(Male ret rate)	ln(Female ret rate)	ln(Non-inv ret rate)
ln (Avg stayer group earnings)	1.22	1.41	0.80	1.17	1.31
	(0.58)	(0.65)	(0.35)	(0.80)	(0.68)
Separation elasticity	-1.62	-2.76	-1.14	-1.73	-1.66
Observations	99,558	81,728	88,100	71,591	94,909
1^{st} stage F	7.81	5.80	31.13	3.61	6.74
Exogeneity	0.034	0.029	0.041	0.060	0.047
90% AR CI	(0.459, 3.080)	(0.597, 4.091)	(0.283, 1.524)	(0.233, 8.687)	(0.422, 3.655)

Notes: Two-way standard errors are clustered by (1) art unit, and (2) application year by decision year. Regressions include art unit by application year by calendar year fixed effects and firm fixed effects. We instrument with a product of indicators: $Z_t = Post_{jt} \cdot Q5_j \cdot IA_j$, where $Post_{jt}$ signifies time t is after the initial decision for firm j, $Q5_j$ signifies firm j is in the top quintile of patent value, and IA_j signifies patent j received an allowance as a first decision. "Separation Elasticity" is computed from the retention elasticity via a Taylor approximation. Specifically, the separation elasticity estimate is $-\frac{\bar{R}}{1-\bar{R}}\hat{e}$, where $\hat{e}$ is the IV estimate of the elasticity of retentions with respect to the wage and $\bar{R}$ is the mean retention rate among firms with high ex-ante value patents. 90% AR CI reports a 90% Anderson-Rubin confidence interval.

Interpretation

- We estimated $\frac{d \ln IG(w^I)}{d \ln w^I} \approx 1.2$.
  - In app year, $w^I/w^m \approx 1.8 \Rightarrow \eta = \frac{d \ln IG(w^I)}{d \ln w^I} \frac{w^I}{w^I - w^m} \approx 2.7$
  - Exploitation index: $\theta = \frac{\eta}{1+\eta} \approx .73$
  - Incumbents paid 73% of MRP

- Estimated pass through to incumbents of $\pi \in [0.5, 0.6]$
  - Closest to Rose (1987) study of trucking deregulation
  - Recall that $\pi = \theta \frac{\varepsilon - 1}{\varepsilon}$.
  - Implies $\varepsilon \in [3, 6] \Rightarrow$ approx 20-50% product markup

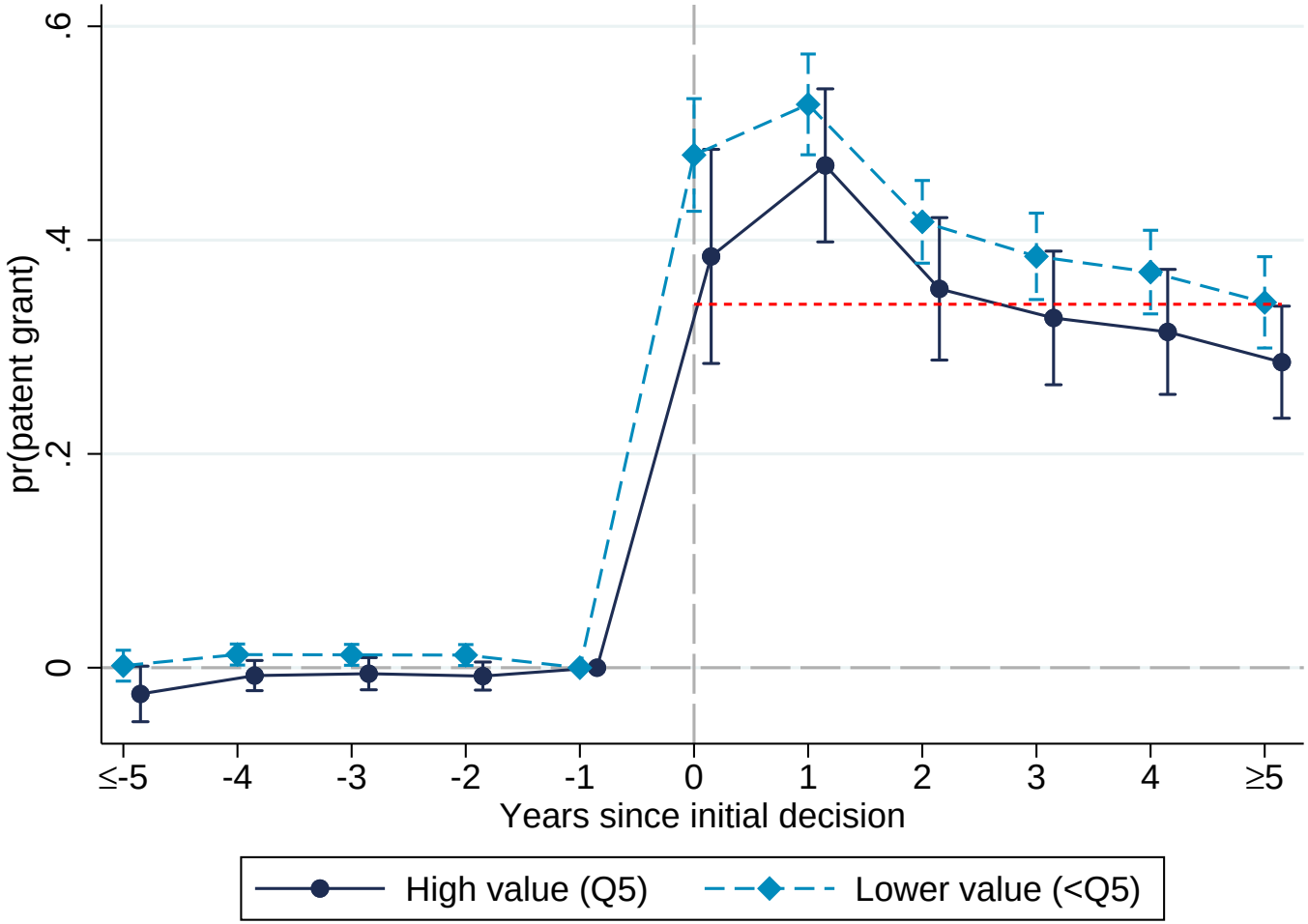
- Marginal replacement cost (in terms of annual earnings of new hire)
  - $\frac{c'(N/I)}{w^m} = \left[\frac{w^I}{w^m} - 1\right] / \theta = 0.8/.73 \approx 1.1$
  - Heterogeneity in wage responses explained by job type?

▸ Sensitivity analysis: Calibrated wage premium ▸ Sensitivity analysis: Calibrated ε

Conclusions

- Wages strongly dependent on "firm lottery"
  - Foster, Haltiwanger, Syverson (2008): std dev of annual *shocks* to TFPR $\approx$ 10% (in Census of Manufacturers)
  - We find: 10% increase in "surplus" yields $\approx$ 3-6% earnings increase
- Gains shared w/ incumbents: $\sim$\$0.50 of every \$1 of surplus captured by non-inventors
  - Revealed preference evidence that non-inventors costly to replace
  - Are they also key contributors to the innovation process?
- Muted response of entry wages
  - Inconsistent w/ standard DMP-variants [Pissarides 2000, 2009]
  - No evidence of impact on wage growth [e.g., Postel-Vinay and Robin 2002]
- Productivity shocks contribute to *within*- and *between*- firm inequality

Event study: Probability patent grant



Notes: Two-way standard errors are clustered by (1) art unit, and (2) application year by decision year. Regressions include art unit by application year by calendar year fixed effects and firm fixed effects. Values along the x-axis for the $Q5$ series are offset from their integer value to improve readability. $Q5$ is quintile 5 of predicted patent value. $< Q5$ are the remaining four quintiles. 95% confidence intervals shown. Dotted red line is pooled DID impact for a top quintile patent application receiving an initial allowance post-decision.

▸ Back

Basic impacts: Closely-held firms

	# Emp > 0	Log firm size	Val add / worker	EBITD / worker	Wage bill / worker	Surplus / worker
High value ($Q5$)	-0.04	0.33	32.72	21.84	8.49	31.11
	(0.08)	(0.14)	(8.24)	(6.08)	(3.42)	(7.44)
Mean of outcome ($Q5$)	0.71	3.00	119.30	20.11	49.40	70.60
% Impact($Q5$)	-5.2		11.0	27.4	108.6	17.2
Lower value ($< Q5$)	44.10	-0.02	0.02	-0.70	0.71	0.30
	(0.53)	(0.02)	(0.05)	(6.19)	(3.19)	(1.51)
Observations	4	75,132	49,943	49,943	49,943	49,943

Notes: The above table retains S-corporations and partnerships. Two-way standard errors are clustered by (1) art unit, and (2) application year by decision year. Regressions include art unit by application year by calendar year fixed effects and firm fixed effects. EBITD is earnings before interest, tax, and depreciation. Surplus is EBITD + W2 wage bill. $Q5$ is quintile five of predicted patent value, $< Q5$ are the remaining four lower quintiles. % Impact reports the percent change in the outcome at the mean for winning an initial allowance. Sample size: observations vary if there are zero workers.

▸ Back

Basic impacts: small firms

	# Emp > 0	Log firm size	Val add / worker	EBITD / worker	Wage bill / worker	Surplus / worker
High value ($Q5$)	-0.10	0.28	16.56	8.82	5.15	13.28
	(0.08)	(0.15)	(7.68)	(4.03)	(3.08)	(5.18)
Mean of outcome ($Q5$)	0.66	1.77	135.10	12.12	55.58	69.66
% Impact($Q5$)	-15.4		12.3	72.8	9.3	19.1
Lower value ($< Q5$)	-0.02	0.13	-3.57	-2.93	1.81	-0.89
	(0.02)	(0.06)	(5.57)	(1.95)	(1.26)	(2.36)
Observations	155,646	103,437	103,437	103,437	103,437	103,437

Notes: Two-way standard errors are clustered by (1) art unit, and (2) application year by decision year. Regressions include art unit by application year by calendar year fixed effects and firm fixed effects. EBITD is earnings before interest, tax, and depreciation. Surplus is EBITD + W2 wage bill. $Q5$ is quintile five of predicted patent value, $< Q5$ are the remaining four lower quintiles. % Impact reports the percent change in the outcome at the mean for winning an initial allowance. Sample size: observations vary if there are zero workers.

Back

Basic impacts: large firms

	# Emp > 0	Log firm size	Val add / worker	EBITD / worker	Wage bill / worker	Surplus / worker
High value ($Q5$)	0.05	0.20	14.04	8.89	2.16	10.67
	(0.03)	(0.07)	(6.95)	(5.38)	(2.73)	(6.26)
Mean of outcome ($Q5$)	0.72	4.02	103.90	7.10	57.91	65.28
% Impact($Q5$)	7.5		13.5	125.2	3.7	16.3
Lower value ($< Q5$)	0.01	-0.07	4.78	-0.03	-0.18	0.25
	(0.02)	(0.05)	(5.13)	(2.64)	(1.15)	(3.08)
Observations	155,646	103,437	103,437	103,437	103,437	103,437

Notes: Two-way standard errors are clustered by (1) art unit, and (2) application year by decision year. Regressions include art unit by application year by calendar year fixed effects and firm fixed effects. EBITD is earnings before interest, tax, and depreciation. Surplus is EBITD + W2 wage bill. $Q5$ is quintile five of predicted patent value, $< Q5$ are the remaining four lower quintiles. % Impact reports the percent change in the outcome at the mean for winning an initial allowance. Sample size: observations vary if there are zero workers.

Back

Within firm inequality

	Male earnings	Female earnings	Gender gap	Inventor earnings	Non-inv earnings	Inventor gap	Earn gap Q4-Q1
High value ($Q5$)	5.88	0.15	6.90	16.87	2.24	14.92	8.12
	(1.97)	(1.51)	(1.97)	(8.47)	(1.43)	(7.75)	(2.56)
Mean of outcome	66.43	39.53	27.68	139.00	51.72	85.98	102.30
% Impact	8.9	0.4	24.9	12.1	4.3	17.4	7.9
Lower value ($< Q5$)	0.35	-0.49	-0.06	-1.24	0.47	-1.72	2.77
	(1.16)	(0.51)	(1.06)	(4.60)	(0.81)	(4.70)	(2.34)
Observations	95,004	84,562	80,222	52,471	100,901	50,045	81,536

Notes: Two-way standard errors are clustered by (1) art unit, and (2) application year by decision year. Regressions include art unit by application year by calendar year fixed effects and firm fixed effects. $Q5$ is quintile five of predicted patent value, $< Q5$ are the remaining four lower quintiles. $Q_4 - Q_1$ refers to the difference in average earnings within quartile 4 and quartile 1 of a firm's wage distribution. % Impact reports the percent change in the outcome at the mean for winning an initial allowance. Sample size: observations vary if there are zero workers.

Back

Earnings impacts by stayer subgroups

	Male stayer earnings	Female stayer earnings	Stayer gender gap	Inventor stayer earnings	Non-inv stayer earnings	Stayer inventor gap
High value ($Q5$)	13.83	2.73	8.89	17.41	5.75	9.27
	(2.74)	(1.95)	(3.51)	(11.21)	(1.72)	(8.35)
Mean of outcome	85.03	48.35	37.77	156.00	64.37	91.85
% Impact	16.3	5.7	23.5	11.2	8.9	10.1
Lower value ($< Q5$)	2.17	0.70	-0.83	0.58	2.03	-2.78
	(1.96)	(0.83)	(1.80)	(6.31)	(1.26)	(6.91)
Observations	88,100	71,591	66,270	47,063	94,909	42,640

Notes: Two-way standard errors are clustered by (1) art unit, and (2) application year by decision year. Regressions include art unit by application year by calendar year fixed effects and firm fixed effects. $Q5$ is quintile five of predicted patent value, $< Q5$ are the remaining four lower quintiles. % Impact reports the percent change in the outcome at the mean for winning an initial allowance. Sample size: observations vary if there are zero workers.

Earnings of Officers / Owners

	All firms			Pass-through entities		
	Officer earnings per W2	Wages and salaries per W2	Non-officer comp per W2	Officer earnings per W2	Wages and salaries per W2	Non-officer comp per W2
High value ($Q5$)	3.81	0.13	-0.05	7.17	-1.43	-1.67
	(1.31)	(1.89)	(2.10)	(3.27)	(1.66)	(1.56)
Mean of outcome	15.89	35.07	38.91	14.86	27.85	31.25
% Impact	24.0	0.4	-0.1	48.3	-5.1	-5.4
Lower value ($< Q5$)	-0.83	1.46	1.97	-1.28	0.46	1.22
	(0.94)	(1.01)	(1.02)	(1.38)	(1.31)	(1.49)
Observations	103,437	103,437	103,437	49,943	49,943	49,943

Notes: This table reports difference-in-differences estimates of the effect of initial allowances on officer and non-officer earnings measures for all firms and pass-through entities. Estimates correspond to coefficients on interactions of the designated value category with a post-decision indicator and an indicator for the application initially allowed. Controls include main effect of value category interacted with a post-decision indicator, firm fixed effects, and art unit by application year by calendar year fixed effects. Standard errors (reported in parentheses) are two-way clustered by (1) art unit, and (2) application year by decision year. "% Impact" reports the percent change in the outcome at the mean for winning an initial allowance. Earnings are measured in thousands of 2014 USD.

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Pass-through: 3-Year Average of Surplus per Worker

	Wage bill per worker		Avg male earnings		Avg non-inv earnings	
	OLS	IV	OLS	IV	OLS	IV
Surplus / worker	0.20	0.35	0.23	0.70	0.16	0.31
	(0.01)	(0.15)	(0.01)	(0.25)	(0.01)	(0.14)
Elasticity	0.24	0.42	0.24	0.72	0.21	0.41
Observations	83,212	83,212	77,066	77,066	81,632	81,632
1^{st} stage F		8.00		6.21		6.38
Exogeneity		0.284		0.045		0.257

Notes: "Surp/emp" are three year average values for surplus per employee. Two-way standard errors are clustered by (1) art unit, and (2) application year by decision year. Regressions include art unit by application year by calendar year fixed effects and firm fixed effects. Surplus: EBITD (earnings before interest, tax, and depreciation) + W2 wage bill. We instrument with a product of indicators: $Z_t = Post_{jt} \cdot Q5_j \cdot IA_j$, where $Post_{jt}$ signifies time t is after the initial decision for firm j, $Q5_j$ signifies firm j is in the top quintile of patent value, and IA_j signifies patent j received an allowance as a first decision. Elasticity reports the elasticity of the outcome with respect to surplus per worker at the mean of the outcome and the mean firm surplus per worker.

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Pass-through: 3-Year Average of Surplus per Worker

	Avg stayer earnings		Avg differenced stayer earnings		Avg non-inv stayer earnings	
	OLS	IV	OLS	IV	OLS	IV
Surplus / worker	0.26	0.66	0.25	0.61	0.21	0.60
	(0.01)	(0.34)	(0.01)	(0.32)	(0.01)	(0.28)
Elasticity	0.25	0.63	0.24	0.58	0.22	0.63
Observations	81,075	81,075	81,075	81,075	77,939	77,939
1^{st} stage F		8.58		8.58		5.97
Exogeneity		0.179		0.216		0.072

Notes: "Surp/emp" are three year average values for surplus per employee. Two-way standard errors are clustered by (1) art unit, and (2) application year by decision year. Regressions include art unit by application year by calendar year fixed effects and firm fixed effects. Surplus: EBITD (earnings before interest, tax, and depreciation) + W2 wage bill. We instrument with a product of indicators: $Z_t = Post_{jt} \cdot Q5_j \cdot IA_j$, where $Post_{jt}$ signifies time t is after the initial decision for firm j, $Q5_j$ signifies firm j is in the top quintile of patent value, and IA_j signifies patent j received an allowance as a first decision. Elasticity reports the elasticity of the outcome with respect to surplus per worker at the mean of the outcome and the mean firm surplus per worker. Elasticity estimates evaluated at mean unadjusted earnings of firm stayers with high ex-ante value patents. For example, we take the passthrough coefficient of .61 and multiply it by .63/.66, which is the ratio of elasticity to impact estimate for average stayer earnings.

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Sensitivity analysis: Calibrated wage premium

	Baseline	Low incumbent premium	High retention elasticity	Low retention elasticity	High pass-through rate	Low pass-through rate
Calibrated inputs						
w_j^I / w_j^m	1.8	1.2	1.8	1.8	1.8	1.8
$d \ln G\left(w_j^I\right) / d \ln w_j^I$	1.2	1.2	1.8	0.6	1.2	1.2
π	0.61	0.61	0.61	0.61	0.91	0.31
Model-based outputs						
η	2.7	7.3	4.0	1.4	2.7	2.7
$c'(N_j / I_j) / w_j^m$	1.1	0.2	1.0	1.4	1.1	1.1
θ	0.73	0.88	0.80	0.59	0.73	0.73
ε	6.0	3.3	4.2	-	-	1.7

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Sensitivity analysis: Calibrated elasticity of product demand

	High retention elasticity	Low retention elasticity	High pass-through rate	Low pass-through rate
Calibrated inputs				
w_j^l / w_j^m	6.0	6.0	6.0	6.0
$d \ln G\left(w_j^l\right) / d \ln w_j^l$	1.8	0.6	1.2	1.2
π	0.61	0.61	0.91	0.31
Model-based outputs				
η	2.9	1.3	-	-
$c'(N_j / I_j) / w_j^m$	2.7	2.7	-	0.6
θ	2.6	0.4	-	-
ε	0.73	0.73	-	0.37

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