Worker Composition and Heterogeneous Firms: Employment Protection, Population Aging and Productivity

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Heterogeneous Firms, Worker Composition and Aggregate Productivity

- "Human side" of (heterogeneous) firms:
  - A burgeoning literature on *interactions* between firms and workers: Engbom et al. (2019), Gregory (2020), Bagga (2022), Bilal et al. (2022), Engbom et al. (2023) and Kim (2023) etc.
- Population aging is found to have substantial impact on firms and macro-economy via changing growth rate of working-age population: Karahan et al. (2019), Peters and Walsh (2021), Hopenhayn et al. (2022) and Bianchi and Paradisi (2024) etc.
- Aging also changes the composition of workers by age/experience
- **This paper:** understand how changes in the *composition of labor supply across demographic groups* affect firm-level and aggregate outcomes
- Understanding optimal allocation of workers to firms $\Rightarrow$ helps inform policies, including immigration, education, retirement etc.

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- Study how heterogeneous (e.g., age) workers are matched with heterogeneous firms (establishments) and how age structure of workers affects market concentration and aggregate productivity using data from Japan:
  1. Develop *static* framework to understand "optimal" allocation of heterogeneous (e.g., age) workers to heterogeneous firms $\Rightarrow$ Use firm-worker-bin level data to back out firm-worker-bin level productivity
  2. Document new facts on relationship between firm size and worker age and tenure + propose *dynamic* model with firing cost to account for these facts
  3. Work-in-Progress: study how *age structure of workers/employment protection* affect (1) worker composition of firm, (2) firm performance (e.g., profitability and concentration), (3) aggregate productivity

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Data

Data: Source

- Basic survey of wage structure (BSWS) from Japanese government: establishment-employee matched data
  1. 1998-2017 at annual frequency (roughly $55,000$ establishments and 1.25 million workers per year) + manuf. and service establishments
  2. Employment cutoff: five (ten) workers for private (public) establishments
  3. Representative rotating sample of both establishments and workers
  4. Can construct short panel of establishments ($\exists$ establishment ID)
- Caveat: can't link workers over time (no time-invariant worker ID)

Data: Information

- Information at establishment level:
  1. Employment, industry, location
  2. Employment by work type (temporary, regular, and non-regular)
- Information at worker level:
  1. Worker's **age**, education and **tenure**
  2. We infer **experience** = age - (6+length of education)
  3. Working hours (incl. overtime hours), wages, and bonus pay
  4. Other characteristics: job type (manuf./mana./admin./R&D etc.)
  5. After 2005: work type is added (fixed-term or temporary vs. regular; full-time vs. part-time)
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Data: Summary Statistics at establishment Level

Table 1: Summary Statistics

	mean	count	sd	p10	p25	p50	p75	p90
emp	101.1	1094653	321.3	8	13	28	71	193
$tenure_{mean}$	10.24	1094653	6.052	3	5.455	9.417	14.11	18.57
age_{mean}	41.65	1094653	7.649	32.09	36.83	41.50	46.35	51.43
edu_{mean}	2.605	1073209	0.660	1.889	2.056	2.500	3.077	3.600

Time period: 1998-2017. For $tenure_{mean}$, age_{mean}, edu_{mean}, we calculate plant-level averages of workers being surveyed first and then report the summary statistics across plants and over the years. edu_{mean} takes four possible values: 1 (middle school), 2 (high school), 3 (2-year/community college), 4 (university/graduate school).

▸ Correlation

Allocation of Workers across Firms: Static Model

Static Model

- Economy with a continuum of firms (unit mass) with productivity $z \sim \Phi(z)$
- Firms produce homogeneous good using labor from different *types* of workers
- Worker belongs to group $g \in \mathcal{G}$ where $\mathcal{P}$ is partition of $\mathcal{G}$:
  - skills and experience (or age): observable
  - L_g denotes supply of type g workers and $L \equiv \sum_g L_g$ is total labor supply
- Firm-level profit equals (taking wages w_g as given)

$$\max_{l_g \geq 0} F\left(\{l_g\}; z\right) - \sum_g w_g l_g \tag{1}$$

  where $\{l_g\} = (l_1, ..., l_G)$ denote set of labor allocations.
- Total output:

$$\int F\left(\{l_g\}; z\right) \phi(z) dz$$

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Static Model: cont.

- Labor market clearing conditions for group g:

$$\int l_g^*(z)\ d\Phi(z) = L_g \quad \forall g \tag{2}$$

- **Competitive Equilibrium:** A competitive equilibrium is characterized by a set of labor allocations $l_g(z)$ for each firm z and type of worker g, and a set of wages w_g such that firm optimize (1) and markets clear (2)
- **Social Planner:**

$$\max_{l_g(z)\geq 0} \int F\left(\{l_g\}; z\right)\phi(z)dz \quad s.t \quad \int \left(\sum_{g\in P_s} l_g(z)\right)\phi(z)dz = L_s,$$

each $P_s \in \mathcal{P}$ is set of groups g that planner can adjust

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Static Model: Example

- General production function (CES):

$$\left(\sum_g A_g(z)^{\frac{1}{\sigma}} l_g^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\alpha\sigma}{\sigma-1}}$$

  - $\sigma \in (0, \infty)$ is E.S. and $\alpha \in (0, 1)$ measures DRS
  - $A_g(z)$ **is firm-worker-specific productivity**
- Key assumptions on firm-worker productivity:
  1. DRS for production function
  2. Imperfect substitution between workers of different types (evidence: Card and Lemieux (2001), Borjas (2003), Ottaviano and Peri (2012))
- We consider case where $\frac{\alpha\sigma}{\sigma-1} = 1 \Rightarrow \max_{l_g} \sum_g A_g(z)^{\frac{1}{\sigma}} l_g^{\frac{\sigma-1}{\sigma}} - \sum_g w_g l_g$

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Optimal Allocation

- Denote $\bar{A}_g := \int A_g(z) d\Phi(z)$ and $\bar{A} := \sum_g \bar{A}_g$
- Optimal allocation of workers:

$$L_g^* = L \frac{\bar{A}_g}{\bar{A}}$$

  - $A_g(z)$: sufficient statistics that can be estimated but require firm-level information (no explicit solution in general)
  - This is true only when there is no reallocation friction (e.g., firing cost)

Static Model: Identification

- Goal: Backing out $A_g(z)$:
  - Assume skill is unobservable but experience is observable
  - Worker-establishment bins: worker skill-experience-establishment size bins $(I * J * K)$ where we set $I = 2$, $J = 9$ and $K = 2$.
  - Data moments: $J * K$ wage and $J * K$ employment for $J * K$ worker experience-establishment size bins
  - Share of high-skill workers within experience group:
    1. Increasing first and then decreasing (main specification):

$$\xi_j = [0.3, 0.3, 0.4, 0.4, 0.5, 0.5, 0.3, 0.3, 0.3]$$

    2. $\xi_j = \xi = 0.5 \ \forall j$
  - $\sigma = 2.5$ and $\alpha = 0.6$
  - Impose monotonicity of wage schedule along skill dimension

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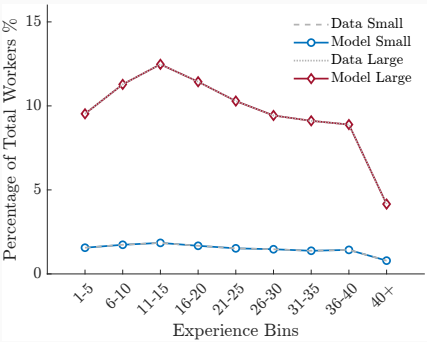
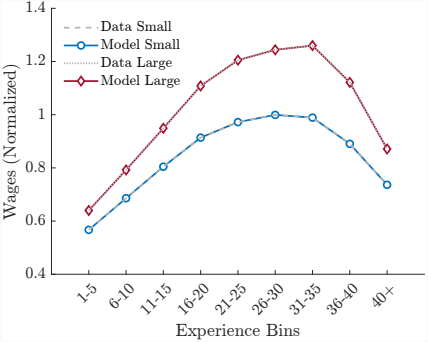
Results: Moments

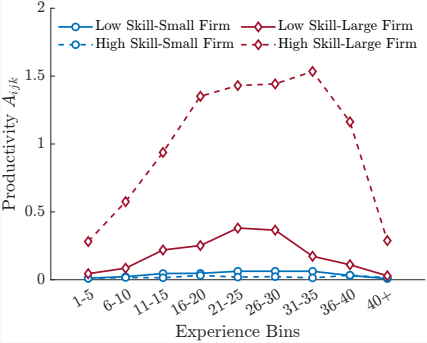


(a) Labor by Experience, ξ_j Variable

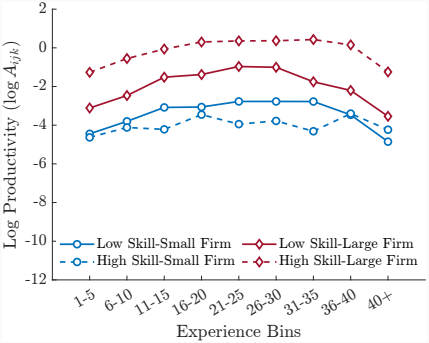


(b) Wages by Experience, ξ_j Variable

Calibrated Productivity



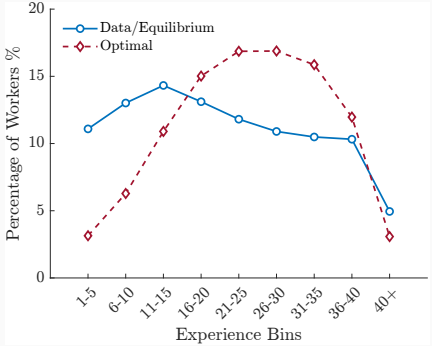
(a) Worker-Firm Productivity, ξ_j Variable



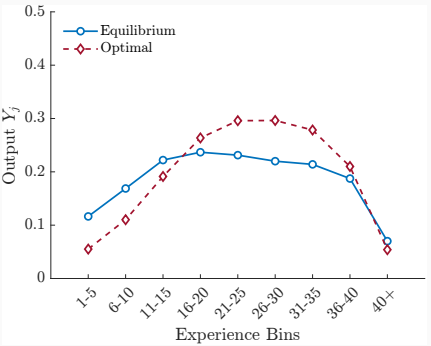
(b) Worker-Firm Productivity, ξ_j Variable

Optimal Allocation: Output Gains by $\Delta\%Y = 5.3\%$

Figure 3: Optimal Labor and Output



(a) Labor Supply, ξ_j Variable



(b) Output, ξ_j Variable

Static Model: Results

- Robustness: Equal share of high-skill workers ($\xi_j = \xi = 0.5 \ \forall j$) ▸ results
- Robustness: CES production function ▸ results
- Key lessons:
  - Log supermodularity between establishment size (productivity) and worker skill
  - High wage for workers with experience $\in [21, 35] \Rightarrow$ high establishment-specific productivity $\Rightarrow$ more workers should allocated to these bins $\Rightarrow$ population aging *does not* necessarily reduce output

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Worker Composition of Firms: Establishment-level Findings

Larger Establishments have Younger Workers with Longer Tenure on average

workers≤60 years old | within-establishment tenure distribution | within-establishment experience distribution

Table 2: Worker Characteristics and Plant Size (1998-2003): full Sample

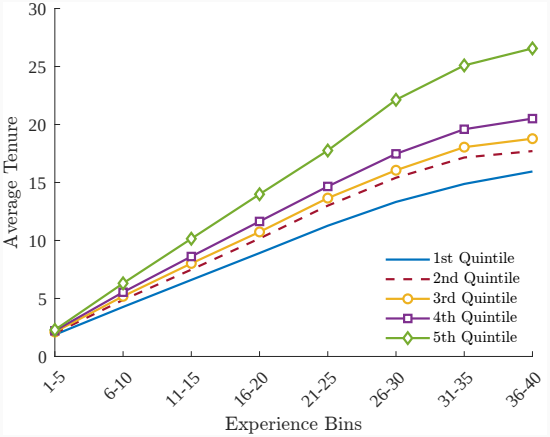
Size Bin	emp_{mean}	age_{mean}	exp_{mean}	$tenure_{mean}$	$wage_{mean}$	edu_{mean}
1	8.49	42.13	23.83	10.54	32078.94	12.30
2	16.83	40.56	21.91	10.95	35749.17	12.65
3	32.11	40.24	21.51	11.47	36916.25	12.73
4	72.46	39.96	21.11	12.24	38314.43	12.85
5	677.31	39.02	19.72	14.52	44639.36	13.30

Time period: 1998-2003. *exp*: experience (years of working). Unit of *wage*: one hundred yen (or one USD). edu_{mean}: years of schooling. We divide plants to five size bins with equal number of plants in each bin. Size bin 1: emp ≤ 11; Size bin 2: emp $\in [12, 22]$; Size bin 3: emp $\in [23, 44]$; Size bin 4: emp $\in [45, 115]$; Size bin 1: emp ≥ 116.

Channel: Experience-tenure Profile

tenure-wage age-tenure

Figure 4: Experience-tenure profile (pooled cross-section: 1998-2003)



Note: Experience = age - (length of education + 6). Size bin 1: emp ≤ 11; Size bin 2: emp $\in [12, 22]$; Size bin 3: emp $\in [23, 44]$; Size bin 4: emp $\in [45, 115]$; Size bin 1: emp ≥ 116.

Establishment Age

- Establishment age is an important confounding factor:
  - Smaller establishments tend to be younger establishments → their workers must have shorter tenure (mechanical correlation)
  - Smaller establishments tend to be younger establishments → younger establishments tend to have younger labor force (see Ouimet and Zarutskie (2014))
- Robustness: ▸ controlling for establishment age

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Mechanism

- **High-productivity establishments**:
  - **Hire** more young workers who are more talented on average
  - **Fire** middle-aged and old workers who didn't upgrade their human capital enough
- **Low-productivity establishments**:
  - **Hire** fewer young workers who are less talented on average
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Dynamic Model

Setup: Worker and Establishments

- Life-cycle model of workers with two-dimensional heterogeneity:
  1. Workers at age (i.e., experience) a_j and with human capital h_i
     - Assumption: Deterministic accumulation of experience and *stochastic* accumulation of human capital
     - Learning/forgetting shocks + exiting from labor market randomly (over life-cycle)
- Comparative advantage of productive establishments:
  1. Assumption: More productive establishments benefit more by using workers with more human capital

$$y(\varphi, h_i, a_j, l_{ij}) = \int_{h_i \in H, a_j \in A} \left[l_{ij}^{\frac{\sigma-1}{\sigma}} \left(\varphi h_i + \varphi^{\nu} a_j \right) \right] dh_i da_j, \tag{3}$$

     where $y(\varphi, h_i, a_j, l_{ij})$ is output of homogeneous good and $\nu \in [0, 1)$
  2. Worker type-specific output is *log super-modular* (*log sub-modular*) w.r.t. $(\varphi,\ h_i)$ (w.r.t. $\varphi,\ a_j$)

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Firing Cost

- Employment protection: establishments have to pay τ fraction of worker's wage if fired:

$$FC_{ijt} = \tau w_{ij} \max\{0, (L_{ijt} - l_{ijt})\},$$

  for worker group (h_i, a_j). l_{ijt}: empl. choice; L_{ijt}: inherited empl. stock
- Employment decision is dynamic: employment stock and expected firing prob
- Workers are also separated from establishments (without being fired) with prob. η every period

▸ Equilibrium ▸ Solution Algorithm

Calibration: Work-in-Progress

Calibration

- Estimation:
  - Two types of establishments
  - τ: fixed
- Targeting (different weights):
  - Tenure-experience profile (x2)
  - Employment-experience distribution (x2)
  - Employment-tenure distribution
  - Wage-experience profile (normalized)
  - Average tenure by firm
  - Average experience by firm
  - Average wage by firm (normalized)
  - Firing rate (x2)

Calibration

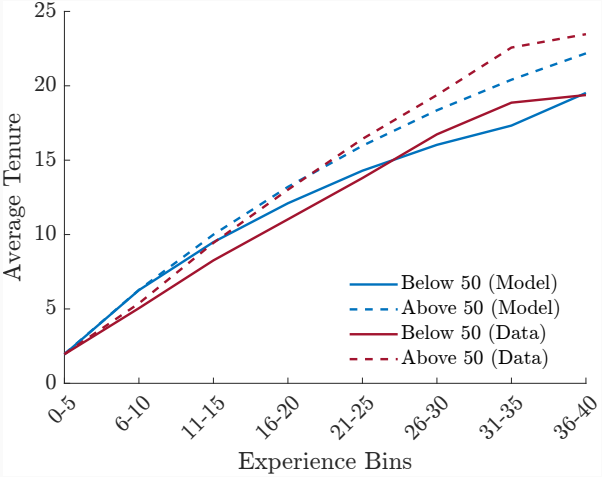
- Estimation:
  - Two types of establishments
  - τ: fixed
- Targeting (different weights):
  - Tenure-experience profile (x2)
  - Employment-experience distribution (x2)
  - Employment-tenure distribution
  - Wage-experience profile (normalized)
  - Average tenure by firm
  - Average experience by firm
  - Average wage by firm (normalized)
  - Firing rate (x2)

Parameter Values

▸ moments: data v.s. model ▸ policy functions

Parameter	Description	Value
Externally Calibrated		
β	Discount rate (4 years)	0.815
σ	Elasticity of Substitution Inputs	3
g_0	Initial Distribution of Human Capital	[0.17 0.17 0.17 0.17 0.17 0.17]
τ	Firing Costs	0.2 (fixed)
Simulated Method of Moments		
ν	Elasticity of Output Relative to Experience	0.006
δ	Survival Rate of Cohort	0.938
η	No Exogenous Separation	0.862
ϕ	Firm Productivity	[8.293 22.926]
h	Levels of Human Capital	[1 2.62 4.24 5.86 7.48 9.1]

Experience-tenure profile: Model v.s. Data



Counterfactual: Work-in-Progress

Firing Cost and Distributional Effects

- Increasing τ from zero to 0.2 or 0.3
- Distributional effects on workers:
  1. Aggregate labor demand in submarket: driven by demand from large firms.
  2. $\tau \Uparrow \rightarrow$ productive firms reduce demand for young workers and fire fewer old workers $\rightarrow$ young workers lose and old workers gain ▸ Figures
- Distributional effects on establishments:
  1. $\tau \Uparrow \Rightarrow$ productive (unproductive) establishments hire fewer (more) young workers + employment/output share of productive establishments $\Downarrow$
  2. Productive establishments' productivity and profitability can increase relative to unproductive ones (equilibrium effect):
     - Young (old) workers' wages drop (increase) + productive establishments hire more young workers $\Rightarrow$ productive establishments lose less ▸ tables and figures
- Higher (product) market concentration (i.e., lower firing cost) can lead to increase in worker movement and reduce wage inequality

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Population Aging and Market Concentration

- Change age structure of workers with fixed L (surviving rate of worker $\delta \Uparrow \Rightarrow$ average age/experience $\Uparrow$) $\Rightarrow$ Concentration of productive establishments $\Downarrow$
- Drag of pop. aging on agg. productivity: making productive establishments shrink

Table 3: Outcomes Changing δ (surviving rate): fixing L

$\tau = 0$	$\delta = 0.8$	$\delta = 0.938$	$\delta = 1$
Output ϕ^h (%)	91.1 %	90.5 %	90.3 %
Employment ϕ^h (%)	90.2 %	89.1 %	88.7 %
$\tau = 0.2$	$\delta = 0.8$	$\delta = 0.938$	$\delta = 1$
Output ϕ^h (%)	91%	90.3 %	90 %
Employment ϕ^h (%)	89.5 %	88.5 %	88.1 %
$\tau = 0.5$	$\delta = 0.8$	$\delta = 0.938$	$\delta = 1$
Output ϕ^h (%)	86.9 %	85.5 %	84.8 %
Employment ϕ^h (%)	81.9 %	79.6 %	78.6 %

Evidence: growth of work. age pop.⇓ ⇒ top establishments' emp. share⇓

	pref.-year level		ind.-pref.-year level	
	(1)	(2)	(3)	(4)
	$empl\ share^{top\ 5\%}_{pref,y}$	$empl\ share^{top\ 10\%}_{pref,y}$	$empl\ share^{top\ 5\%}_{ind,pref,y}$	$empl\ share^{top\ 10\%}_{ind,pref,y}$
working $gr_{p,y}$	1.458***	1.211***	0.464***	0.391***
	(0.427)	(0.372)	(0.108)	(0.102)
Prefecture FE	Yes	Yes	No	No
Industry-prefecture FE	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	1598	1598	19913	19913
R^2	0.899	0.907	0.744	0.747
adj. R^2	0.894	0.902	0.730	0.733

Notes: Census of manufacturing plants (1985-2018) is used. The estimate of the constant is suppressed. Standard errors are clustered at prefecture-year level. For columns 3-4, ind.-pref.-year obs. with at least 100 plants are included. * 0.10 ** 0.05 *** 0.01.

- Growth of working-age pop. (*working* $gr_{p,y}$): -0.52% (mean) and 0.86% (s.d.)
- Endogenous migration across prefectures ⇒ using lagged birth rate

IV: using (20-year) lagged birth rate (corr. coeff.: 0.867)

	pref.-year level		ind.-pref.-year level	
	(1)	(2)	(3)	(4)
	$empl\ share^{top\ 5\%}_{pref,y}$	$empl\ share^{top\ 10\%}_{pref,y}$	$empl\ share^{top\ 5\%}_{ind,pref,y}$	$empl\ share^{top\ 10\%}_{ind,pref,y}$
$birth\ rate_{p,y-20}$	0.620***	0.536***	0.200***	0.205***
	(0.178)	(0.142)	(0.0321)	(0.0298)
Prefecture FE	Yes	Yes	No	No
Industry-prefecture FE	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	1588	1588	19873	19873
R^2	0.901	0.909	0.744	0.747
adj. R^2	0.896	0.904	0.729	0.733

Notes: Census of manufacturing plants (1985-2018) is used. The estimate of the constant is suppressed. Standard errors are clustered at prefecture-year level. For columns 3-4, ind.-pref.-year obs. with at least 100 plants are included. * 0.10 ** 0.05 *** 0.01.

- Lagged birth rate ($birth\ rate_{p,y-20}$): 1.34% (mean) and 0.34% (s.d.)

Robustness: using average age of prefecture-level population

	pref.-year level		ind.-pref.-year level	
	(1)	(2)	(3)	(4)
	$empl\ share^{top\ 5\%}_{pref,y}$	$empl\ share^{top\ 10\%}_{pref,y}$	$empl\ share^{top\ 5\%}_{ind,pref,y}$	$empl\ share^{top\ 10\%}_{ind,pref,y}$
$average\ age_{p,y}$	-0.00000277	-0.00148	-0.00484***	-0.00511***
	(0.00688)	(0.00568)	(0.00140)	(0.00131)
Prefecture FE	Yes	Yes	No	No
Industry-prefecture FE	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	1598	1598	19913	19913
R^2	0.894	0.903	0.744	0.747
adj. R^2	0.899	0.898	0.733	0.733

Notes: Census of manufacturing plants (1985-2018) is used. The estimate of the constant is suppressed. Standard errors are clustered at prefecture-year level. For columns 3-4, ind.-pref.-year obs. with at least 100 plants are included. * 0.10 ** 0.05 *** 0.01.

- Average age ($average\ age_{p,y}$): 42.6 (mean) and 3.87 (s.d.)

Final Comments

Conclusions

- We propose simple static model and use Japanese data to back out firm-worker specific productivity and to study optimal allocation of workers
- We study worker-composition of heterogeneous firms $\Rightarrow$ **comparative advantage of using worker skill for productive firms**
  1. Large, more productive firms have **up-or-out** dynamics
  2. Small, less productive firms hire **gradually**
- **Distributional effects of firing cost on firms:** Productive firms may gain relatively despite that they fire workers and shrink
- Higher (product) market concentration **does not necessarily** reduce worker movement and increase wage inequality
- Pop. aging leads to **less concentrated** market/drags down agg. productivity

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Appendix Slides

Data: Simple Correlation

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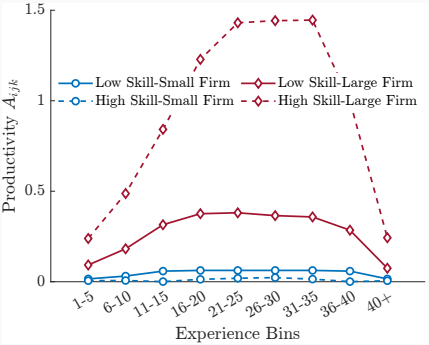
Table 4: Correlations of Variables

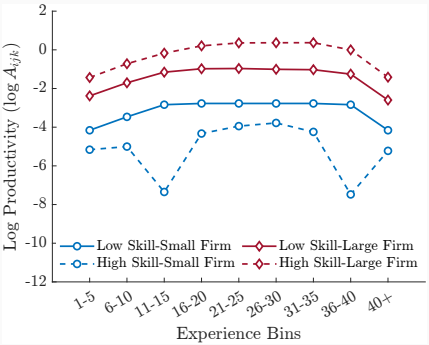
	$log(emp)$	edu_{mean}	age_{mean}	$tenure_{mean}$	$lwage_{mean}$
$log(emp)$	1				
edu_{mean}	0.171***	1			
age_{mean}	-0.0784***	-0.299***	1		
$tenure_{mean}$	0.179***	-0.0489***	0.341***	1	
$lwage_{mean}$	0.277***	0.197***	0.0311***	0.547***	1

Time period: 1998-2017. *edu* takes four possible values: 1 (middle school), 2 (high school), 3 (2-year/community college), 4 (university/graduate school). *emp*: plant employment. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results: Calibrated Productivity with $\xi = 0.5$



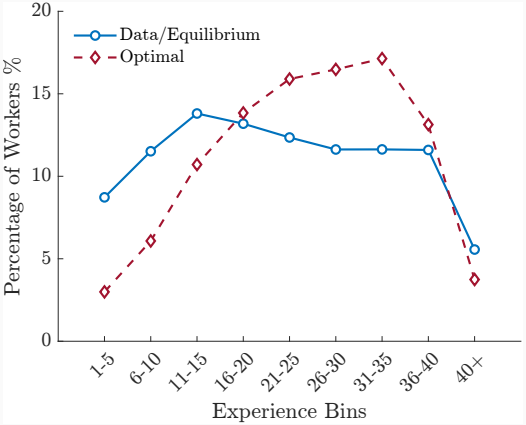
(a) Worker-Firm Labor Productivity, $\xi = 0.5$



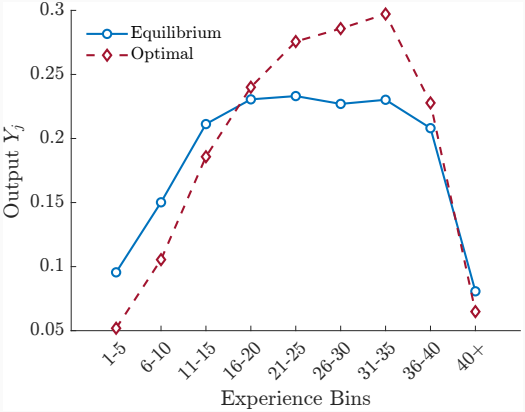
(b) Log Labor Productivity, $\xi = 0.5$

Results: Optimal Allocation with $\xi = 0.5$: Output gains $\Delta\%Y = 4.06\%$ Go back

Figure 6: Optimal Labor Supply and Output

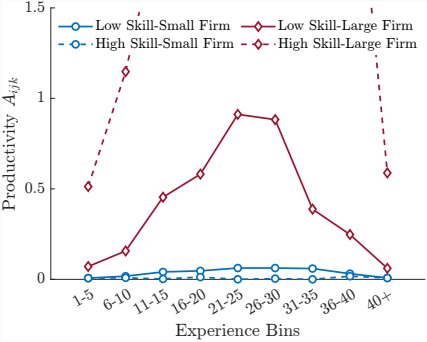


(a) Labor Supply by Experience L_j

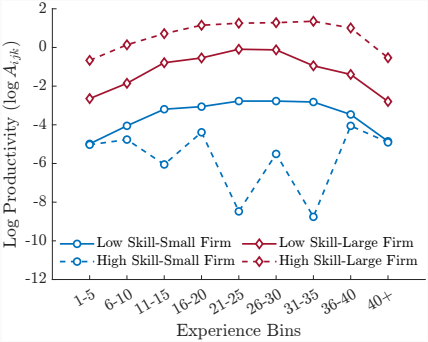


(b) Output by Experience

Results: Calibrated Productivity under CES with $\sigma = 3$

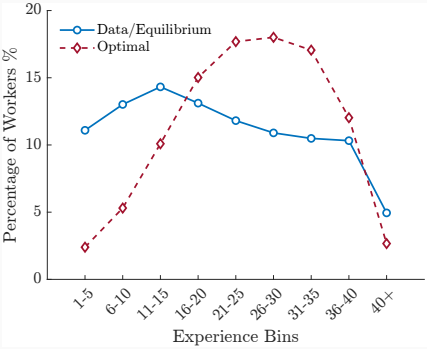


(a) Productivity A_{ijk}

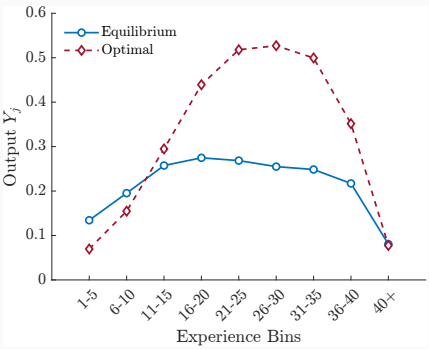


(b) Log Productivity log A_{ijk}

Results: Optimal Allocation under CES with $\sigma = 3$ Go back



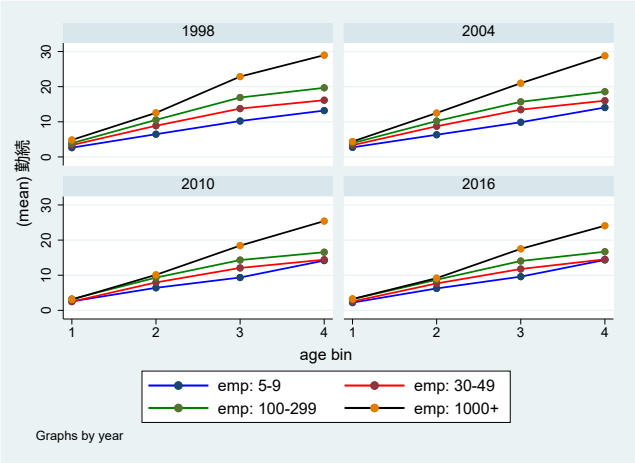
(a) $\sigma = 3$: Labor Supply L_j



(b) $\sigma = 3$: Output

Channel: Age-tenure Profile (various years)

Go back

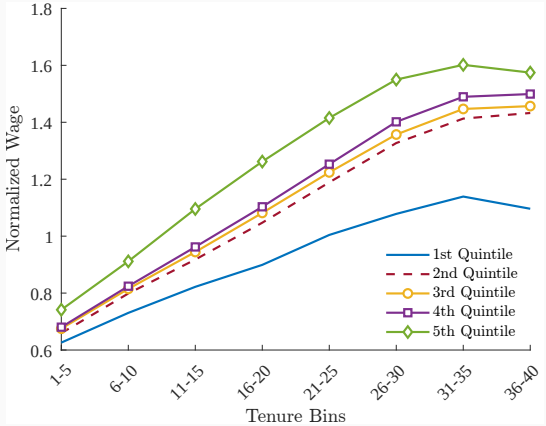


Note: This figure plots how tenure varies with the age bin and establishment size. Age bin: 1 (age$\leq$30), 2 (age$\in [31, 40]$), 3 (age$\in [41, 50]$) 4 (age$\geq$51).

Channel: Tenure-wage Profile

Go back

Figure 9: Tenure-wage profile (pooled cross-section: 1998-2003)



Note: Average wage is normalized to one. Size bin 1: emp ≤ 11; Size bin 2: emp $\in [12, 22]$; Size bin 3: emp $\in [23, 44]$; Size bin 4: emp $\in [45, 115]$; Size bin 1: emp ≥ 116.

Regression results: 1998-2007

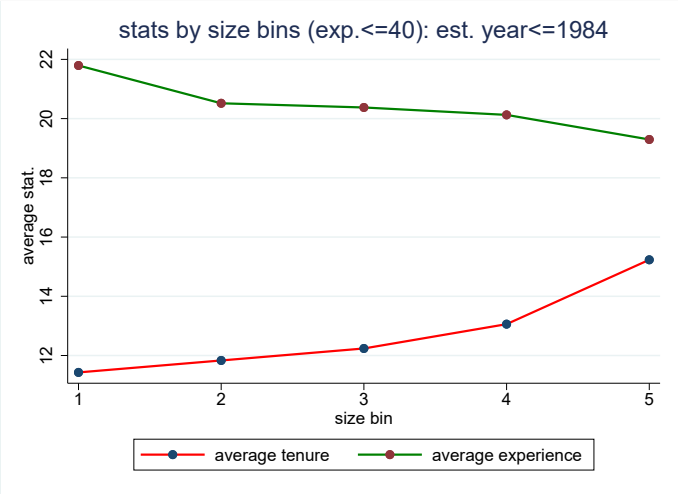
▸ 2004-2011

Table 5: Cross-sectional regression of experience, age and tenure: 1998-2007

Dep.Var:	(1) ave. experience	(2) ave. age	(3) ave. tenure
plant age	0.101***	0.093***	0.121***
	(0.001)	(0.001)	(0.001)
log(empl.)	-1.487***	-1.263***	0.335***
	(0.017)	(0.016)	(0.013)
constant	24.720***	43.380***	5.570***
	(0.066)	(0.060)	(0.046)
City FE	Yes	Yes	Yes
Industry-year FE	Yes	Yes	Yes
Prefecture-year FE	Yes	Yes	Yes
N	298970	303625	303625
R^2	0.342	0.348	0.357

* 0.10 ** 0.05 *** 0.01. Standard errors are clustered at the firm level.

Average tenure and experience (excluding young establishments): 1998-2001



▸ average tenure by establishment age bin ▸ average exp. by establishment age bin ▸ 2008-2011

Experience-tenure profile conditioning on est. age: 1998-2001

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4: est. age 18-27; 5: est. age 28-37; 6: est. age 38-47; 7: est. age 48+

2008-2011

Larger establishments are more likely to hire entrants than experienced workers

Table 6: Cross-sectional regression of hiring new v.s. hiring old

	(1)	(2)	(3)	(4)
Dep.Var:	*hiring new* >0 - *hiring old* >0			
log(empl.)	0.125***	0.124***	0.124***	0.124***
	(0.002)	(0.002)	(0.002)	(0.002)
plant age		0.003***		0.002***
		(0.000)		(0.000)
constant	-0.506***	-0.569***	-0.503***	-0.566***
	(0.006)	(0.007)	(0.006)	(0.008)
Year FE	Yes	Yes	No	No
City FE	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	No	No
Industry FE	Yes	Yes	No	No
Industry-year FE	No	No	Yes	Yes
Prefecture-year FE	No	No	Yes	Yes
N	135918	108371	135716	108247
R^2	0.099	0.103	0.130	0.133

* 0.10 ** 0.05 *** 0.01. Standard errors are clustered at the firm level. *hiring new* >0 (*hiring old* >0) is an indicator of (net) hiring of job-market entrants (incumbents).

Larger establishments hire disproportionately more entrants

Go back

Table 7: Cross-sectional regression of hiring shares

Dep.Var:	(1) $log(hired\ fresh)$	(2) $\frac{hired\ fresh}{empl.}$	(3) $\frac{hired\ fresh}{net\ hire}$
log(empl.)	0.539***	0.005***	0.135***
	(0.004)	(0.000)	(0.002)
plant age	-0.002***	-0.000***	0.002***
	(0.000)	(0.000)	(0.000)
constant	-1.248***	-0.002***	-0.173***
	(0.016)	(0.000)	(0.008)
City FE	Yes	Yes	Yes
Industry-year FE	Yes	Yes	Yes
Prefecture-year FE	Yes	Yes	Yes
N	70587	303625	54285
R^2	0.462	0.129	0.260

* 0.10 ** 0.05 *** 0.01. Standard errors are clustered at the firm level. *hired fresh* denotes the number of hired job market entrants, while *net hire* is the change in employment over two consecutive years (i.e., net hiring or firing). $\frac{hired\ fresh}{net\ hire}$ is one (or missing), if the net hiring of job-market incumbents is negative (or the hiring of job-market entrants is zero and the net hiring of job-market incumbents is non-positive).

Regression results: 2004-2011

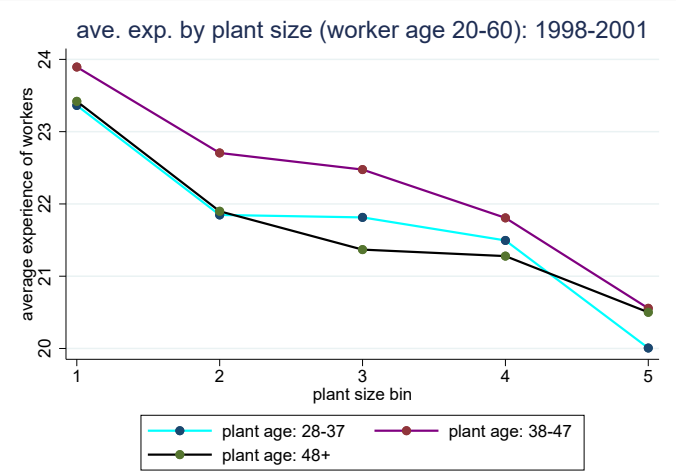
Go Back

Table 8: Cross-sectional regression of experience, age and tenure: 2004-2011

Dep.Var:	(1) ave. experience	(2) ave. age	(3) ave. tenure
plant age	0.092***	0.091***	0.112***
	(0.001)	(0.001)	(0.001)
log(empl.)	-1.377***	-1.185***	0.150***
	(0.018)	(0.017)	(0.013)
constant	24.788***	43.642***	6.067***
	(0.065)	(0.061)	(0.045)
City FE	Yes	Yes	Yes
Industry-year FE	Yes	Yes	Yes
Prefecture-year FE	Yes	Yes	Yes
N	309312	317156	317156
R^2	0.319	0.355	0.383

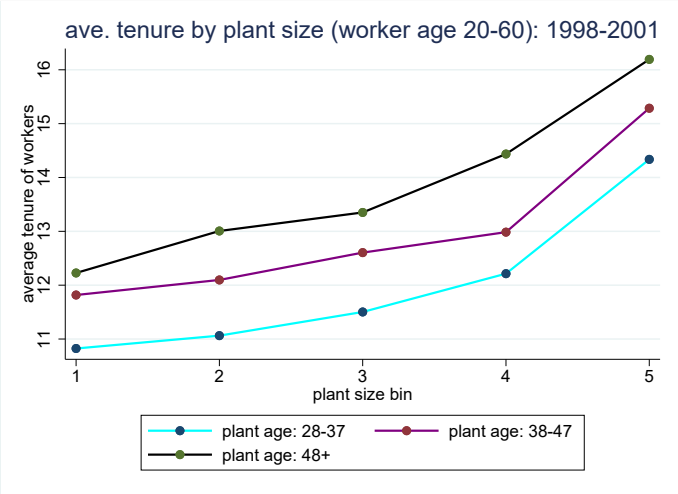
* 0.10 ** 0.05 *** 0.01. Standard errors are clustered at the firm level.

Average experience by establishment age and size: 1998-2001



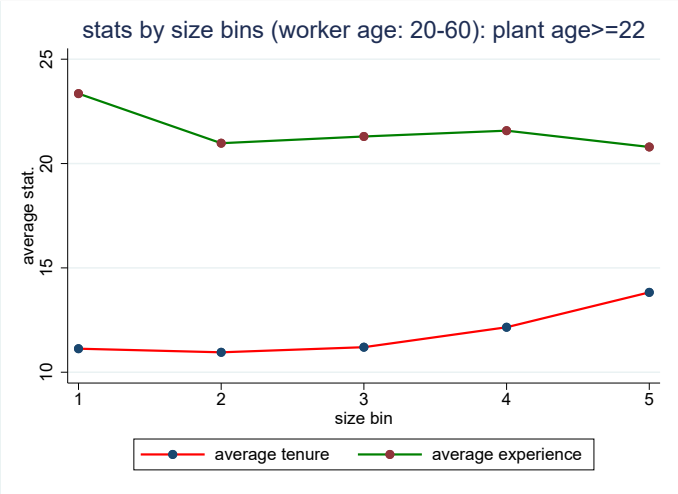
Go back

Average tenure by establishment age and size: 1998-2001



Go back

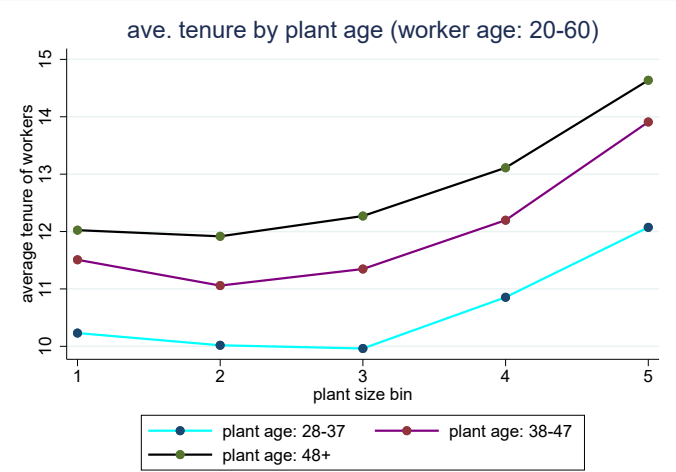
Average tenure and experience (throwing away young establishments): 2008-2011



Average experience by establishment age and size: 2008-2011

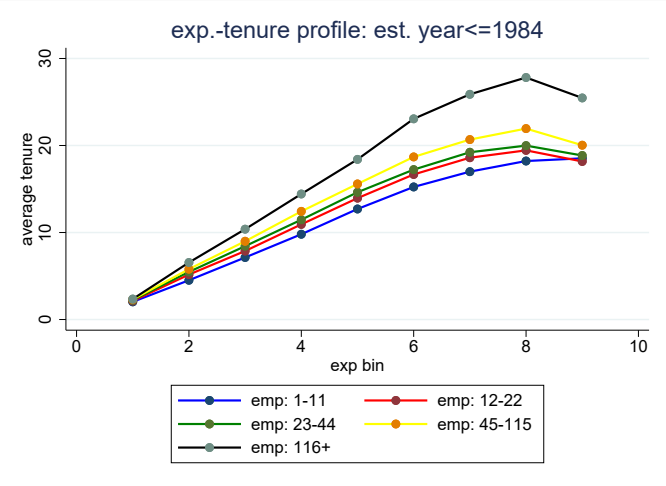
Go back

Average tenure by establishment age and size: 2008-2011



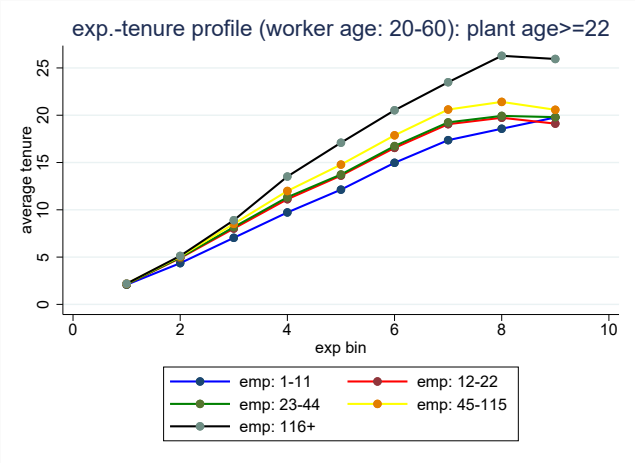
Go back

Experience-tenure profile (excluding young establishments): 1998-2001



▸ 2008-2011 ▸ Go back

Experience-tenure profile (throwing away young establishments): 2008-2011



▸ Go back

Experience-tenure profile conditioning on establishment age: 2008-2011

4: est. age 18-27; 5: est. age 28-37; 6: set. age 38-47; 7: set. age 48+ Go back

Larger establishments hire disproportionately more entrants

Go back

Table 9: Panel regression of hiring shares

Dep.Var:	(1) $log(hired\ fresh)$	(2) $\frac{hired\ fresh}{empl.}$	(3) $\frac{hired\ fresh}{net\ hire}$
log(empl.)	0.555***	0.001**	-0.361***
	(0.017)	(0.000)	(0.017)
constant	-1.336***	0.010***	2.261***
	(0.081)	(0.001)	(0.081)
Industry-year FE	Yes	Yes	Yes
Prefecture-year FE	Yes	Yes	Yes
Plant FE	Yes	Yes	Yes
N	52311	279587	25402
R^2	0.775	0.627	0.672

* 0.10 ** 0.05 *** 0.01. Standard errors are clustered at the firm level. $\frac{hired\ fresh}{net\ hire}$ is one (or missing), if the net hiring of job-market incumbents is negative (or the hiring of job-market entrants is zero and the net hiring of job-market incumbents is non-positive).

Solution Method

Go Back

- Procedure
  1. Given expected firing probs. and wage schedule, solve empl choice of workers at age a_1 (youngest workers)
  2. Solve emp. choice of workers age a_j given expected firing probs. for age a_{j+1} and empl. stock inherited from employed workers of age a_{j-1} last period
  3. Find wage schedule w_{ij} that clears each labor submarket based on establishments' emp. choices and expected firing probs.
  4. Calculate *actual* firing probs. based on establishments' choices and update expected firing probs. until they converge

Solution Method: Ideas

Go back

- Key challenge: vf iteration does not work due to curse of dimensionality
- Key is to derive FOCs of empl. analytically
  - Firm's inaction region of hiring/firing workers at age a_j depends on expected firing probs. for workers at age a_{j+1}
  - Firm's empl. choice of workers at age a_j depends on its inaction region and empl. stock (i.e., empl. choice of age a_{j-1} last period).

Solution Method: Ideas

Go back

- Key challenge: vf iteration does not work due to curse of dimensionality
- Key is to derive FOCs of empl. analytically
  - Firm's inaction region of hiring/firing workers at age a_j depends on expected firing probs. for workers at age a_{j+1}
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Facts: Larger Establishments have Younger Workers who have Longer

Table 10: Worker Characteristics and Plant Size: workers who are at most 60 years old

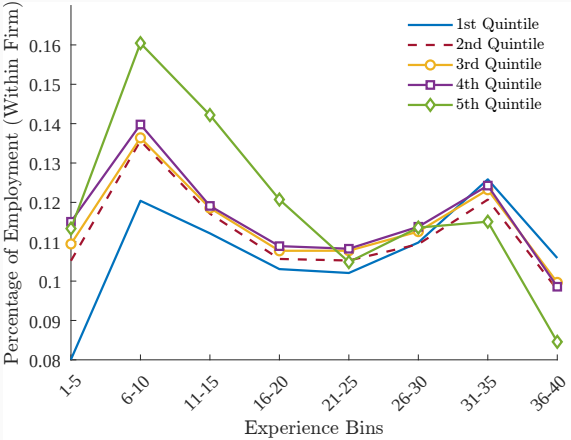
Size Bin	emp_{mean}	age_{mean}	exp_{mean}	$tenure_{mean}$	$wage_{mean}$	edu_{mean}
1	8.53	38.88	20.33	9.56	32547.41	12.54
2	16.84	38.15	19.29	10.40	36176.99	12.86
3	32.16	38.31	19.40	11.03	37249.1	12.92
4	72.53	38.33	19.31	11.90	38577.94	13.02
5	683.28	38.00	18.58	14.19	44775.83	13.42

Time period: 1998-2003. *exp*: experience (years of working). Unit of *wage*: one hundred yen (or one USD). edu_{mean}: years of schooling. We divide plants to five size bins with equal number of plants in each bin. Size bin 1: emp ≤ 11; Size bin 2: emp $\in [12, 22]$; Size bin 3: emp $\in [23, 44]$; Size bin 4: emp $\in [45, 115]$; Size bin 1: emp ≥ 116.

Go back

Within-firm Employment Distribution: Experience

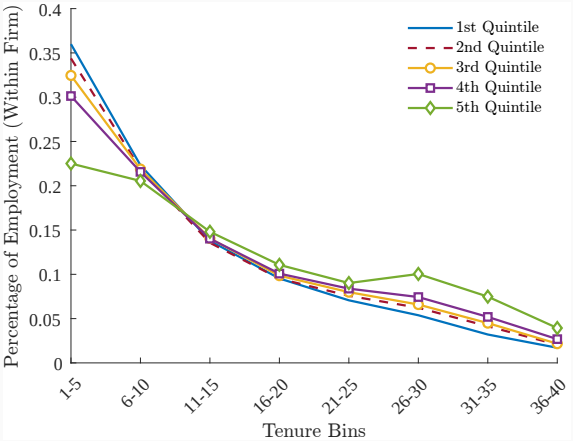
Figure 10: Distribution of Workers across Experience Bins (pooled cross section: 1998-2003)



Note: Size bin 1: emp ≤ 11; Size bin 2: emp $\in [12, 22]$; Size bin 3: emp $\in [23, 44]$; Size bin 4: emp $\in [45, 115]$; Size bin 1: emp ≥ 116. Go back

Within-firm Employment Distribution: Tenure

Figure 11: Distribution of Workers across Tenure Bins (pooled cross section: 1998-2003)



Note: Size bin 1: emp ≤ 11; Size bin 2: emp $\in [12, 22]$; Size bin 3: emp $\in [23, 44]$; Size bin 4: emp $\in [45, 115]$; Size bin 1: emp ≥ 116. Go back

Equilibrium Conditions

- Establishments maximize profit and demand labor in each labor submarket (h_i, a_j)
- Workers choose highest-paying establishment to work
- Every labor submarket clears
- Product market clears (product price is numeraire)

Go back

Equilibrium Conditions

- Establishments maximize profit and demand labor in each labor submarket (h_i, a_j)
- Workers choose highest-paying establishment to work
- Every labor submarket clears
- Product market clears (product price is numeraire)

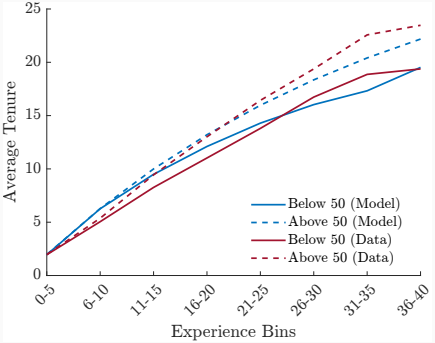
Go back

Moments

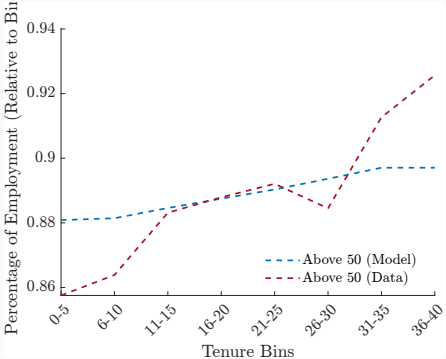
Table 11: Moments

Moment	Data	Model
Firing Rate	0.44%	0.44%
Average Tenure	[11.1 13]	[12;12.5]
Average Experience	[21.3 20.9]	[22.2 20.7]
Average Wages (Normalized)	[0.872 1.018]	[0.861;1.018]

Moments: cont.



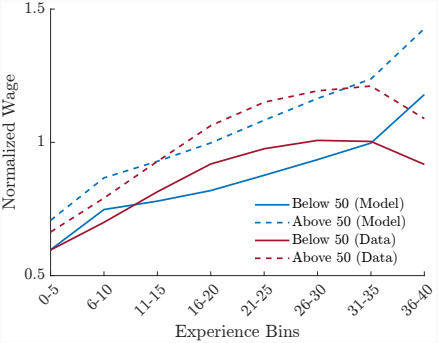
(a) Tenure-experience profile



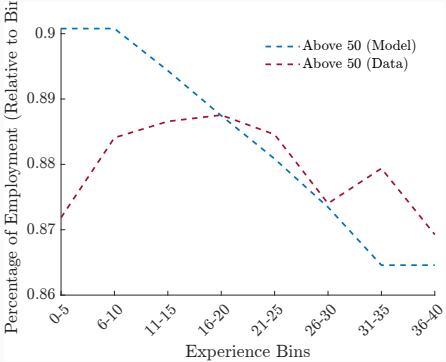
(b) Employment share of large firm by tenure bin

Moments: cont.

Go back



(a) Experience-wage profile

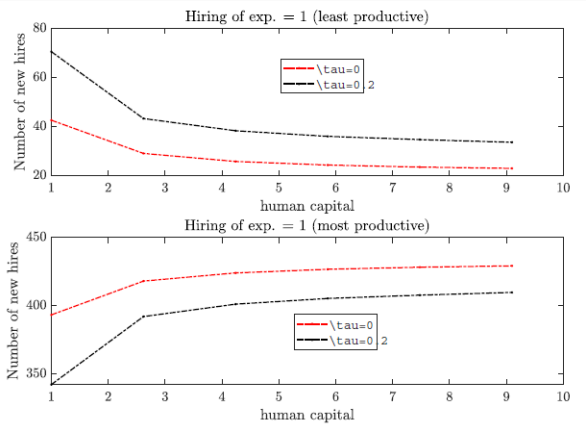


(b) Employment share of large firm by experience bin

Firing and Hiring

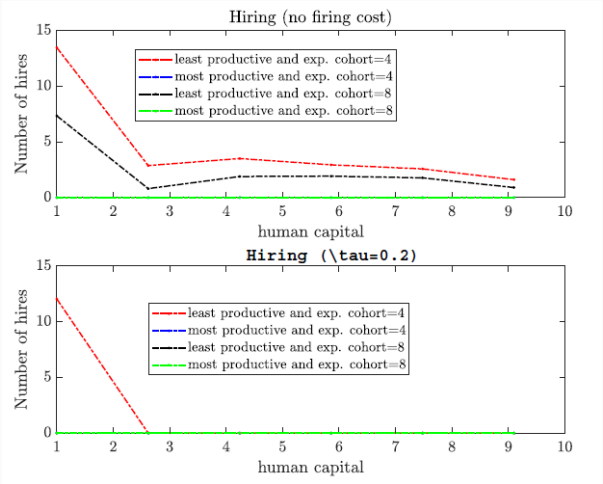
- Different hiring (job-market incumbents vs. job-market entrants) and firing strategies across firms ▸ employment choice

Hiring of Job-market Entrants: Productive Firms Hire Disproportionately More



This figure plots the hiring decision of job-market entrants.

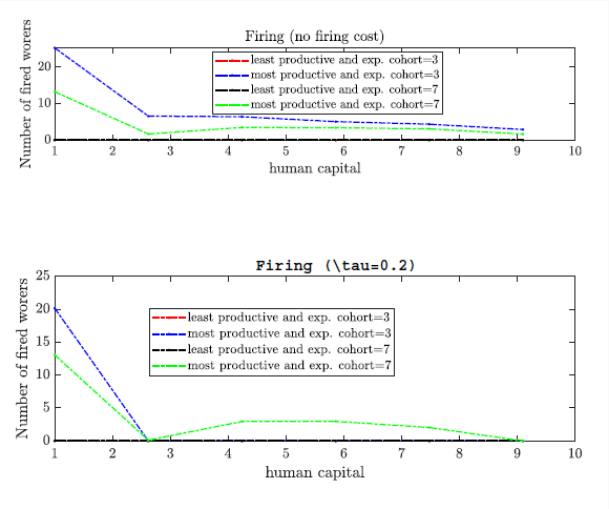
Net Hiring of Job-market Incumbents: Only Unproductive Firms Hire



This figure plots the hiring decision of job-market incumbents.

Firing Strategies: No Firing by Unproductive Firms

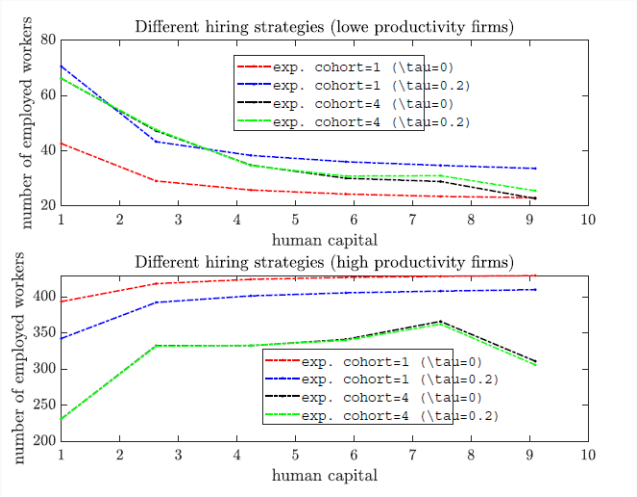
Go back



This figure plots the firing decision of job-market incumbents.

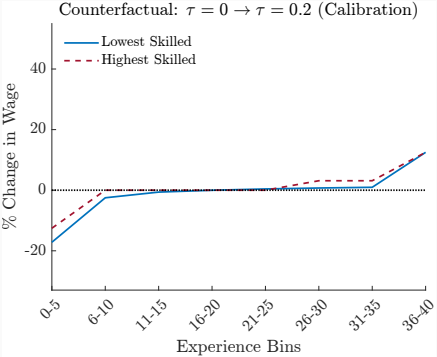
Employment

Go back

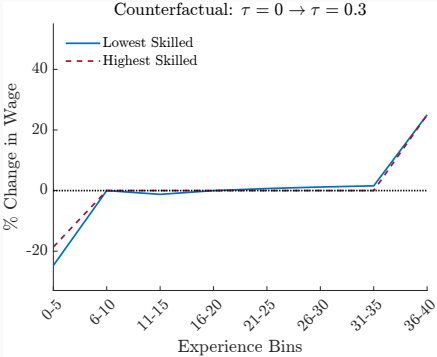


This figure plots employment of workers.

Distributional Effects on Workers across experience bins



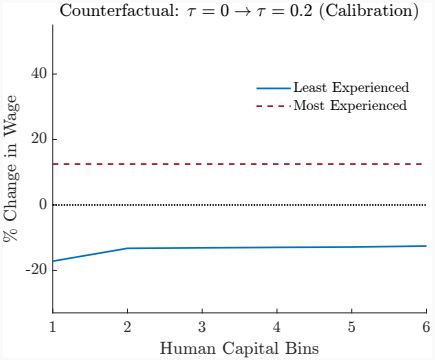
(a) $\tau = 0.2$



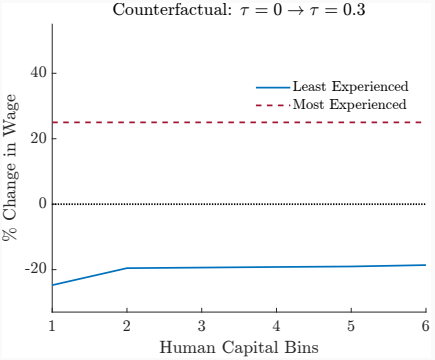
(b) $\tau = 0.3$

Distributional Effects on Workers across human capital bins among youngest workers

Go back



(a) $\tau = 0.2$



(b) $\tau = 0.3$

Table 12: Average tenure and experience: τ changes from zero to 0.3

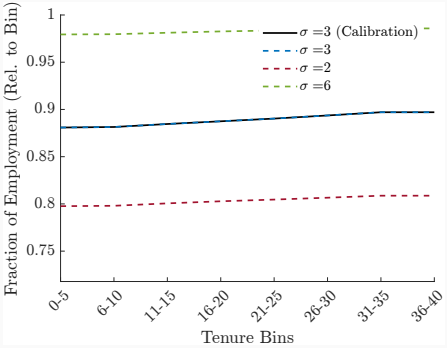
Variable	$\tau = 0$	**Calibration** $\tau = 0.2$	$\tau = 0.3$
Firing Rate	1.17%	0.44%	0.25%
Average Tenure	[14.2;15.4]	[15;15.5]	[15.3;15.6]
Average Experience	[24 20.4]	[22.2 20.7]	[21.5 20.7]
Average Wages (Normalized)	[0.871;1.016]	[0.861;1.018]	[0.876;1.019]

Table 13: Distributional Effects on Firms: τ changes from zero to 0.3

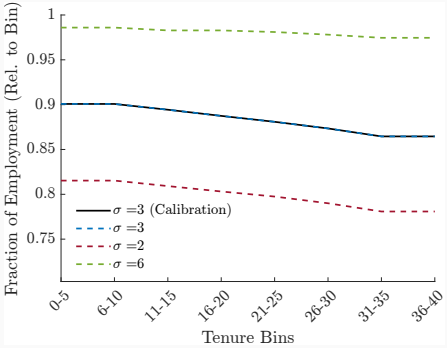
Variable	$\tau = 0$	**Calibration** $\tau = 0.2$	$\tau = 0.3$
Efficiency and Concentration			
Normalized Output	1	1	0.999
Labor Productivity ϕ^h	22.307	22.398	22.588
Labor Productivity ϕ^l	19.135	18.529	17.728
Firm profit ϕ^h $(*10^5)$	1.0282	1.0061 (-2.15%)	0.9844 (-4.26%)
Firm profit ϕ^l $(*10^5)$	0.1061	0.1019 (-3.96%)	0.09965 (-6.08%)
Output Concentration ϕ^h	90.5%	90.3%	89.1%
Employment Concentration ϕ^h	89.1%	88.5%	86.6%
Wage Inequality			
Normalized Standard Deviation of Wage	0.4648	0.4858	0.4978

Robustness: Different σ

- A larger σ intensifies market competition and thus favor productive firms



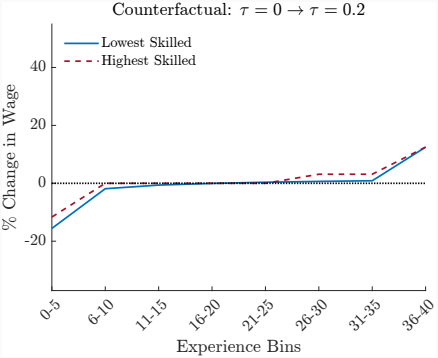
(a) Employment share of large firm by experience



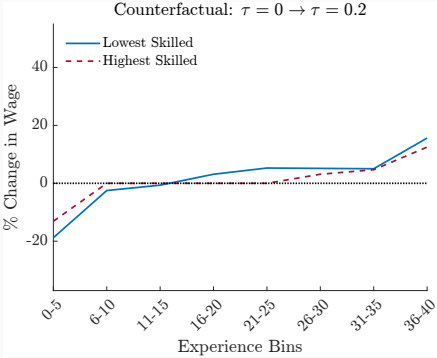
(b) Employment share of large firm by tenure

Robustness: Different σ (cont.)

- However, it does not change counterfactual results of varying τ



(a) $\sigma = 2$



(b) $\sigma = 6$

Outcomes: $\sigma = 2$

Variable	$\tau = 0$	**Calibration** $\tau = 0.2$	$\tau = 0.5$
Firing Rate	1.26%	0.42%	0%
Average Tenure	[14.8;15.3]	[15.3;15.5]	[15.6;15.6]
Average Experience	[22.7 20.4]	[21.6 20.6]	[20.8 20.8]
Average Wages (Normalized)	[0.934;1.016]	[0.924;1.019]	[0.938;1.024]
Efficiency and Concentration			
Normalized Output	1	1	0.994
Labor Productivity ϕ^h	9.386	9.449	9.985
Labor Productivity ϕ^l	8.633	8.395	7.128
Output ϕ^h (%)	82.1 %	81.9 %	78.3 %
Employment ϕ^h (%)	80.9 %	80.1 %	72.1 %
Profits			
Normalized Profits ϕ^h	1.012	1	0.981
Normalized Profits ϕ^l	1.019	1	0.914

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