Posted Compensation Inequality

Xuanli Zhu
Keio University

August 31, 2023

Roadmap

Introduction

Data

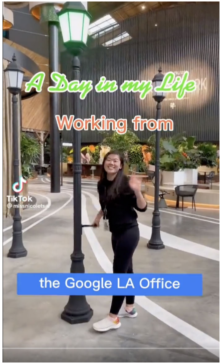
Empirical Facts

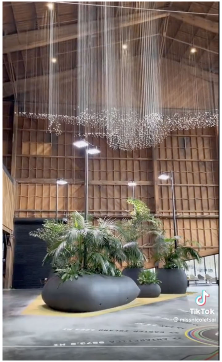
Discussion

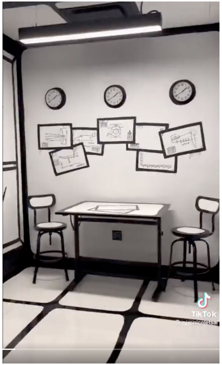
A Simple Theory

Conclusion

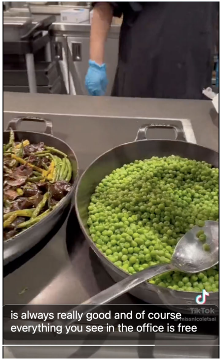
A Vignette


A Day in my Life
Working from
TikTok
the Google LA Office

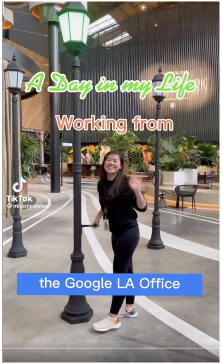

TikTok

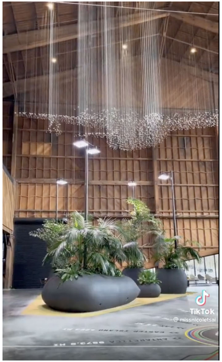

TikTok

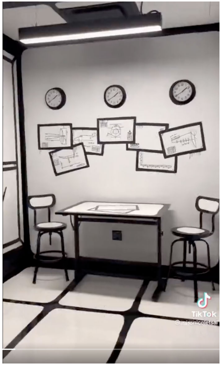

CLEAN
TikTok
@missnicoletsai

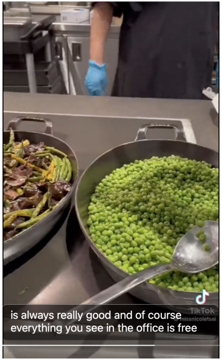

is always really good and of course
everything you see in the office is free
TikTok

A Vignette









$\longrightarrow$ Compensating Differential?

Research Questions

Empirical:

1. What consists non-wage compensations in today's labor market?
2. Do firms distinguish in their provision of amenities/disamenities? How?
3. What are their impact on wage disparity?

Research Questions

Empirical:

1. What consists non-wage compensations in today's labor market?
2. Do firms distinguish in their provision of amenities/disamenities? How?
3. What are their impact on wage disparity?

Theoretical:

1. Do observed firms' provision patterns consisting with existing theories?
2. Why empirical tests of compensating differential often fail?
3. What are general implications of non-wage compensations on labor market?

What This Paper Does

1. Investigate the provision patterns & wage effects of non-wage compensation (both pecuniary & nonpecuniary) by using job ads/vacancy data
    - Difficult to observe in census/survey data
    - Extract info from job texts using (basic) ML methods
    - Find stylized patterns in the data
    - Discuss the inconsistency between findings and existing theories

What This Paper Does

1. Investigate the provision patterns & wage effects of non-wage compensation (both pecuniary & nonpecuniary) by using job ads/vacancy data
   - Difficult to observe in census/survey data
   - Extract info from job texts using (basic) ML methods
   - Find stylized patterns in the data
   - Discuss the inconsistency between findings and existing theories
2. Construct a new & simple theory to rationalize our empirical findings
   - Extend the idea of compensating differential with a new force
   - Reconcile our empirical findings and offer important implications

Preview of Empirical Findings

1. Firms use common non-wage compensations to attract job seekers:
   - insurance; work-time; additional pay; environment; other fringe benefits
2. Non-wage compensations can predict posted wages, but mainly through their correlations with job/firm qualities
3. Diff firms in diff jobs have distinct compensation-provision patterns
   - High-wage firms w/ high-skill jobs: general better except leisure
   - Low-wage firms w/ low-skill jobs: general worse except leisure
4. Hedonic regression shows mixed results of compensating differential
   - Yes in low-wage firms; No in high-wage firms

Preview of Empirical Findings

1. Firms use common non-wage compensations to attract job seekers:
   - insurance; work-time; additional pay; environment; other fringe benefits
2. Non-wage compensations can predict posted wages, but mainly through their correlations with job/firm qualities
3. Diff firms in diff jobs have distinct compensation-provision patterns
   - High-wage firms w/ high-skill jobs: general better except leisure
   - Low-wage firms w/ low-skill jobs: general worse except leisure
4. Hedonic regression shows mixed results of compensating differential
   - Yes in low-wage firms; No in high-wage firms

$\rightarrow$ These findings are inconsistent with the views of existing theories

Preview of Theoretical Model

- We suggest a new theory that extends Compensating Differential with ”Efficiency Compensation” and productivity-based firm-worker Sorting

- Key idea:
  1. Many compensations observed in data are (in)efficiency compensation
  2. The level of efficiency depends on firm & worker productivity

- Mechanism: A new channel works in addition to compensating differential
  1. When a compensation is efficient, it counteracts compensating differential effect
  2. When a compensation is inefficient, it magnifies compensating differential effect
  3. Extent of this (in)efficiency channel depends on firm-worker productivity sorting

Preview of Theoretical Model

- We suggest a new theory that extends Compensating Differential with ”Efficiency Compensation” and productivity-based firm-worker Sorting
- Key idea:
  1. Many compensations observed in data are (in)efficiency compensation
  2. The level of efficiency depends on firm & worker productivity
- Mechanism: A new channel works in addition to compensating differential
  1. When a compensation is efficient, it counteracts compensating differential effect
  2. When a compensation is inefficient, it magnifies compensating differential effect
  3. Extent of this (in)efficiency channel depends on firm-worker productivity sorting

→ This simple modification reconciles all findings and generates many important general implications

Related Literature

1. Literature on Compensating Differential:
    - Classic: Rosen (1974); Brown (1980); Rosen (1986); Hwang et al. (1992)
    - Recent: Mas and Pallais (2017); Maestas et al. (2018); Wissmann (2022) / Sorkin (2018); Taber and Vejlin (2020); Lamadon et al. (2022)

      $\rightarrow$ New insights & New theory that reconciles existed empirical failures
2. Literature on Compensation Provision:
    - Theory: Rosen (1974, 1986); Hwang et al. (1998); Hamermesh (1999); Mortensen (2005); Dey and Flinn (2005); Bonhomme and Jolivet (2009)
    - Empirical: Sockin (2022); Lachowska et al. (2022); Bana et al. (2022); Lamadon et al. (2022)

      $\rightarrow$ New evidences & New theory that explains those new evidences
3. Literature on Efficiency Wage:
    - Salop and Salop (1976); Shapiro and Stiglitz (1984); Katz (1986); Krueger and Summers (1988); Bloesch et al. (2021)

      $\rightarrow$ Apply the insights to a more suitable place: ”Efficiency Compensation”

Roadmap

Introduction

Data

Empirical Facts

Discussion

A Simple Theory

Conclusion

Data Source

`Lagou.com`: the largest IT-centered online job board in China

- Over 6 million job vacancies between 2013 and 2020 ▸ vacancy trend
- Mainly jobs in the occupations demanded by IT-producing/using firms and are (routine or non-rountine) cognitive: Computer, Design & Media, Business Operation, Financial & Law, Sales, Admin ▸ occupation classification
- Like other vacancy data, biased to young/low-experienced & high education workers/jobs in large cities ▸ summary statistics
- Vacancy information: job name, posted wage, location, requirements on education and experience, job task&skill description, **job benefits**, firm name, ... ▸ vacancy sample
- Final Sample after cleaning: 4 million job vacancies ▸ sample cleaning

Posted Compensation/Amenity Information

- Pros:
  1. Hard to observe in census or survey data
  2. Compensations or amenities that firms regard as important to attract workers
  3. Also observe detailed job information

- Cons:
  1. Not a full list of the compensations that a firm offer
  2. Mainly amenities, rare disamenities (strategic hiding?)
  3. Maybe cheap talk?

- Our empirical results will be mainly descriptive & exploratory
  - No priori, let the data speak
  - Find stylized facts of patterns & correlations in the data
  - Shed new insights in thinking theories

Unstructured Text Data

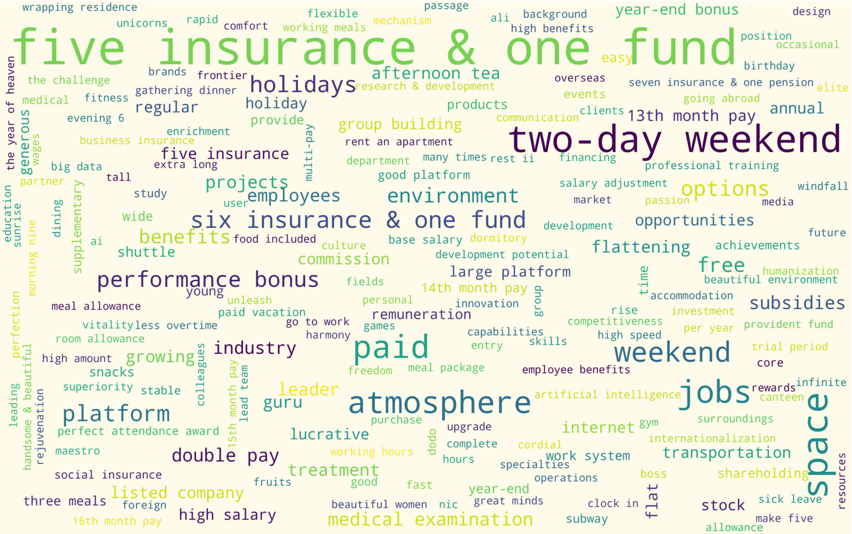
- V: full vocabulary set with 110,000+ tokens/features (i.e. words or terms)
- $V_{\text{comp}} \subset V$: compensation vocabulary set with 13,000+ features
  - Not all uniques: synonyms, different versions, typos
  - Common words or stop words
  - Irrelevant texts
- $\mathbf{C}_{\text{comp}} \in \mathbb{R}^{N \times |V_{\text{comp}}|}$: an indicator matrix to run regression
- So, high-dimensional data $\rightarrow$ (basic) Machine Learning methods

Roadmap

Q1: What are the non-wage compensations that firms use to attract workers?

Fact 1: Firms Provide ”Common” Non-wage Compensations

◂ chinese



insurance&fund; leisure; growth potential, bonus, environment, fringe benefits, ...

Q2: How do non-wage compensations affect wage?

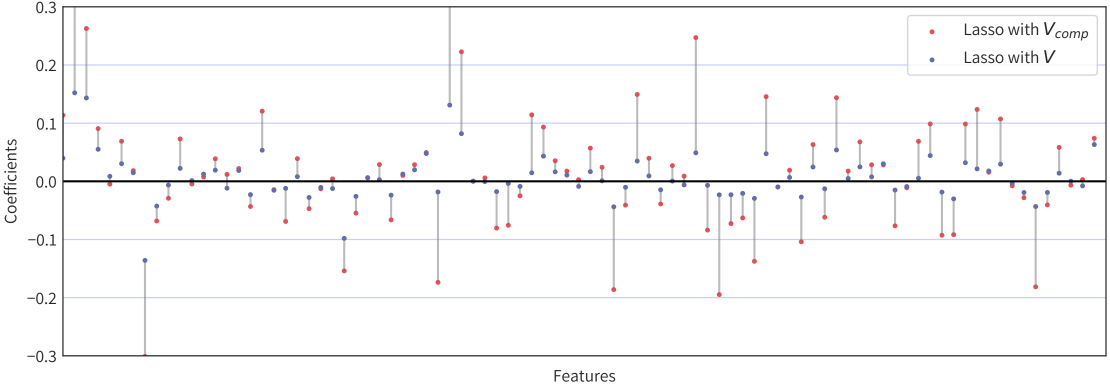
Lasso Regression using V_{comp}: Top Features (Frequency $> 1\%$)

lasso details

	Top Positive			Top Negative		
	token	coef	freq	token	coeff	freq
1	14th month pay	.331	.013	five insurance	-.301	.020
2	large platform	.310	.016	commission	-.195	.022
3	three meals	.263	.013	young	-.186	.012
4	technology	.247	.025	easy	-.181	.014
5	guru	.223	.024	training	-.174	.018
6	flexibility	.149	.091	two-day weekend	-.154	.140
7	options	.146	.043	promotion	-.138	.068
8	shuttle	.144	.015	events	-.104	.010
9	remuneration	.124	.015	holiday	-.093	.017
10	six insurance & one fund	.121	.050	holidays	-.092	.046
11	platform	.114	.046	provide	-.084	.012
12	13th month pay	.114	.021	jobs	-.080	.097
13	supplementary	.107	.011	achievements	-.077	.010
14	stock	.099	.017	work system	-.076	.012
15	salary	.099	.025	travel	-.073	.058
16	good platform	.093	.010	entrepreneurship	-.069	.013
17	listed company	.091	.023	five insurance & one fund	-.068	.261
18	high salary	.074	.018	employees	-.066	.029
19	products	.073	.012	time	-.063	.012
20	lucrative	.069	.018	environment	-.062	.038
21	shareholding	.069	.012	double pay	-.055	.032
22	benefits	.068	.035	office	-.047	.018
23	motivation	.063	.016	company	-.043	.050
24	projects	.058	.030	wide	-.041	.012
25	year-end bonus	.057	.042	snacks	-.041	.013
26	team	.050	.108	growing	-.039	.025

Fact 2a: Firm Non-wage Compensations Correlated With Job Attributes

◂ Lasso top features using V



◂ All V'_{comp}

Fact 2b: Compensations Explain Wage Differentials Through Linkage with (Both Job and) Firm Heterogeneity

posted wage regression details

$\ln w_{i,j,t} = \theta_i + \psi_j + \delta_i + \iota_t + \epsilon_i$

	With δ		Without δ	
	Comp.	Share	Comp.	Share
$\mathrm{Var}(\ln w)$	.362	-	.362	-
$\mathrm{Var}(\theta_i)$	.158	.437	.163	.450
$\mathrm{Var}(\psi_j)$	.046	.128	.049	.136
$\mathrm{Var}(\delta_i)$	.002	.004		
$\mathrm{Var}(\epsilon_i)$	.097	.269	.098	.272
$2\,\mathrm{Cov}(\theta_i, \psi_j)$	.049	.137	.052	.142
$2\,\mathrm{Cov}(\delta_i, \theta_i)$	.006	.017		
$2\,\mathrm{Cov}(\delta_i, \psi_j)$	.003	.008		
$\mathrm{Corr}(\theta_i, \psi_j)$	.289		.288	
$\mathrm{Corr}(\delta_i, \theta_i)$	.193			
$\mathrm{Corr}(\delta_i, \psi_j)$	.174			
Obs	3998840		3998840	
Firm	86165		86165	

Fact 2b: Compensations Explain Wage Differentials Through Linkage with (Both Job and) Firm Heterogeneity

posted wage regression details

Interpretation of the δ terms depends on how the amenity-wage relationship is modeled

	With δ		Without δ	
	Comp.	Share	Comp.	Share
$\mathrm{Var}(\ln w)$	.362	-	.362	-
$\mathrm{Var}(\theta_i)$	.158	.437	.163	.450
$\mathrm{Var}(\psi_j)$	.046	.128	.049	.136
$\mathrm{Var}(\delta_i)$	.002	.004		
$\mathrm{Var}(\epsilon_i)$	.097	.269	.098	.272
$2\,\mathrm{Cov}(\theta_i, \psi_j)$	.049	.137	.052	.142
$2\,\mathrm{Cov}(\delta_i, \theta_i)$	.006	.017		
$2\,\mathrm{Cov}(\delta_i, \psi_j)$	.003	.008		
$\mathrm{Corr}(\theta_i, \psi_j)$	.289		.288	
$\mathrm{Corr}(\delta_i, \theta_i)$	.193			
$\mathrm{Corr}(\delta_i, \psi_j)$	.174			
Obs	3998840		3998840	
Firm	86165		86165	

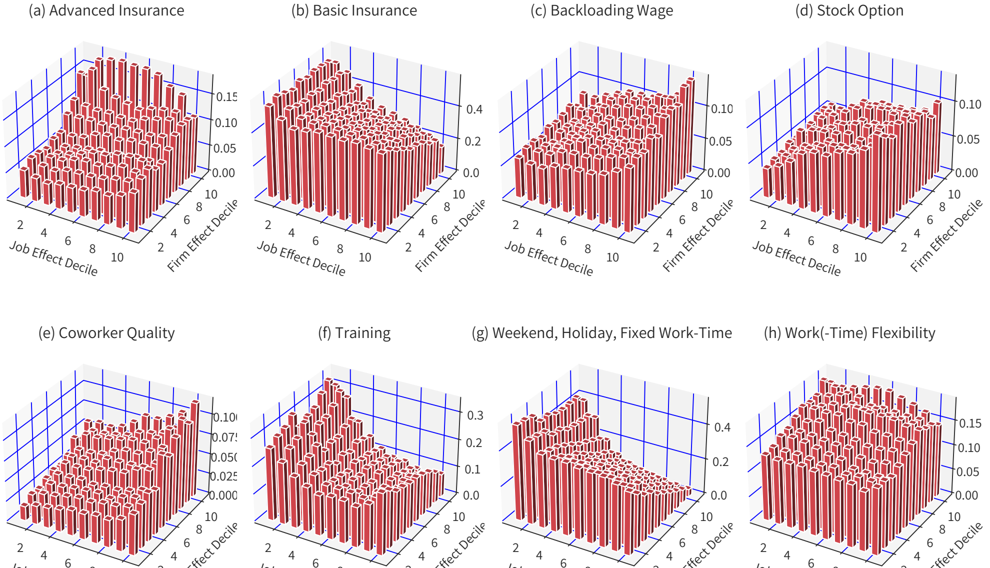
Q3: How exactly firms & jobs vary in their compensation provision?

Gather Important Types and Check Occurrence

- We can take a direct look on if high/low wage firms or jobs are accompanied with low/high valued amenities
- We do this by selecting a set of major, well-defined, and economic important compensations from V_{comp} based on the frequency & Lasso coefficient
- We gather all relevant terms by checking proximate terms in the embedding space of a work-embedding model trained on the whole job texts
- We then examine how the occurrence ratio for each type differ across different firms & jobs

Fact 3: Systematic Differences in Compensation Provision Across Firms and Jobs

◂ more types



Q4: What if we test for compensating differential using hedonic regression?

Fact 4: Hedonic Regression Results are Mixed but in A Systematic Way

	(1)	(2)	(3)
Advanced Insurance	.117**	.087**	.014**
	(.001)	(.001)	(.001)
Backloading Wage	.054**	.030**	.010**
	(.001)	(.001)	(.001)
Stock Option	.114**	.058**	.087**
	(.001)	(.001)	(.001)
Coworker Quality	.140**	.059**	.024**
	(.001)	(.001)	(.001)
Work-Flexibility	.046**	.032**	.010**
	(.001)	(.001)	(.001)
Basic Insurance	-.062**	-.046**	-.025**
	(.000)	(.000)	(.000)
Training	-.057**	-.012**	-.003**
	(.001)	(.001)	(.001)
Work-Time	-.113**	-.081**	-.021**
	(.001)	(.000)	(.000)
Education FE	✓	✓	✓
Experience FE	✓	✓	✓
Year FE	✓	✓	✓
$\mathbf{C}_{\backslash comp}$		✓	✓
Firm FE			✓
Adj. R^2	.506	.633	.738
No. Obs	3998840	3998840	3998840

Roadmap

Summary of Empirical Findings & Implications on Theory

1. Most non-wage compensations in the labor market are common stuffs: insurance, work-time, extra pay, workplace, ...
   $\rightarrow$ endogenous rather than exogenous variations in firm cost functions (& variations in worker preference?)

Summary of Empirical Findings & Implications on Theory

1. Most non-wage compensations in the labor market are common stuffs: insurance, work-time, extra pay, workplace, ...
   $\rightarrow$ endogenous rather than exogenous variations in firm cost functions (& variations in worker preference?)

2. Non-wage compensations explain posted wage variance not via their own variations, but via their correlations with job/firm effects
   $\rightarrow$ sorting is productivity-based; limited importance of compensating differential or co-determination with wage

Summary of Empirical Findings & Implications on Theory

1. Most non-wage compensations in the labor market are common stuffs: insurance, work-time, extra pay, workplace, ...
   $\rightarrow$ endogenous rather than exogenous variations in firm cost functions (& variations in worker preference?)

2. Non-wage compensations explain posted wage variance not via their own variations, but via their correlations with job/firm effects
   $\rightarrow$ sorting is productivity-based; limited importance of compensating differential or co-determination with wage

3. Firms in different jobs vary significantly in their compensation-provision patterns
   $\rightarrow$ important mechanism of compensation provision linked with firm/worker quality

Summary of Empirical Findings & Implications on Theory

1. Most non-wage compensations in the labor market are common stuffs: insurance, work-time, extra pay, workplace, ...
   $\rightarrow$ endogenous rather than exogenous variations in firm cost functions (& variations in worker preference?)

2. Non-wage compensations explain posted wage variance not via their own variations, but via their correlations with job/firm effects
   $\rightarrow$ sorting is productivity-based; limited importance of compensating differential or co-determination with wage

3. Firms in different jobs vary significantly in their compensation-provision patterns
   $\rightarrow$ important mechanism of compensation provision linked with firm/worker quality

4. Hedonic regression shows systemically mixed results of compensating differential for compensations provided by diff firms in diff jobs
   $\rightarrow$ reason of the empirical failures linked with the provision patterns

The Phantom of Unobserved Worker Ability

- Yes, there still could be unobserved worker ability not-captured which cause bias in the estimation above (Rosen, 1986; Hwang et al., 1992)

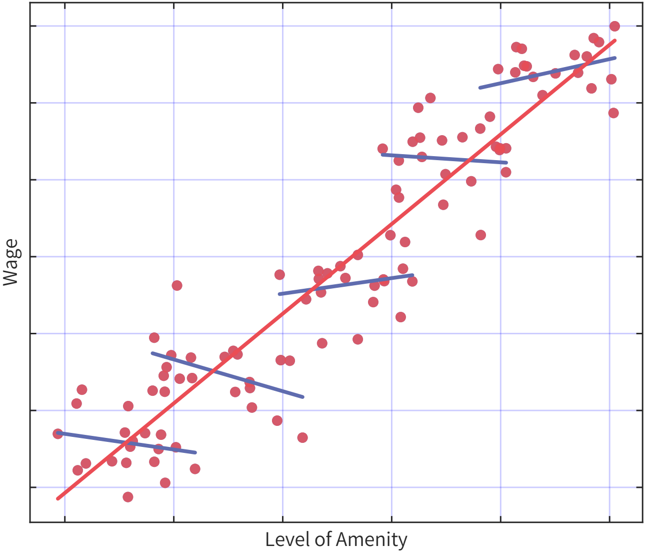
The Phantom of Unobserved Worker Ability

- Yes, there still could be unobserved worker ability not-captured which cause bias in the estimation above (Rosen, 1986; Hwang et al., 1992)
- But would unobserved skill heterogeneity matter so much?
  - In our job vacancy data, the usually-unobserved job heterogeneity accounts for additional 5 percent of the posted wage variances
  - Unobserved job heterogeneity is typtically positively correlated with observed job heterogeneity

The Phantom of Unobserved Worker Ability

- Yes, there still could be unobserved worker ability not-captured which cause bias in the estimation above (Rosen, 1986; Hwang et al., 1992)
- But would unobserved skill heterogeneity matter so much?
  - In our job vacancy data, the usually-unobserved job heterogeneity accounts for additional 5 percent of the posted wage variances
  - Unobserved job heterogeneity is typtically positively correlated with observed job heterogeneity
- Perhaps compensation differential is not the sole or the major force?
  - The toughness of the omitted-variable problem indicates other dominant mechanism of compensating dispersion

Unobserved Worker Ability → Compensation Inequality?



Can Existing Theories Explain Positive Wage-Amenity Relationship?

- Hwang et al. (1992); Mortensen (2005): income effect
- Hwang et al. (1998): firms with low amenity-providing cost use both better amenity and higher wage to attract workers

Can Existing Theories Explain Positive Wage-Amenity Relationship?

- Hwang et al. (1992); Mortensen (2005): income effect
- Hwang et al. (1998): firms with low amenity-providing cost use both better amenity and higher wage to attract workers
- Problem 1: income effect cannot explain why it is low-pay firms provide leisure but not high-pay firms (e.g. notorious 996 working culture in Chinese IT industry)
- Problem 2: amenity-producing cost cannot explain why it is high-pay firms provide many superior amenities like insurance or backloading wages
- Problem 3: sorting is purely from exogenous heterogenous amenity-producing costs (and/or heterogenous worker preference) or wage-queue tradeoff

Can Existing Theories Explain Positive Wage-Amenity Relationship?

- Hwang et al. (1992); Mortensen (2005): income effect
- Hwang et al. (1998): firms with low amenity-providing cost use both better amenity and higher wage to attract workers
- Problem 1: income effect cannot explain why it is low-pay firms provide leisure but not high-pay firms (e.g. notorious 996 working culture in Chinese IT industry)
- Problem 2: amenity-producing cost cannot explain why it is high-pay firms provide many superior amenities like insurance or backloading wages
- Problem 3: sorting is purely from exogenous heterogenous amenity-producing costs (and/or heterogenous worker preference) or wage-queue tradeoff

$\rightarrow$ Our new model reconciles all these from a simple yet new angle

Roadmap

Model Overview

- Workers: heterogeneous in productivity; homogenous in preference
- Firms: heterogeneous in productivity; homogenous in (dis)amenity prod func
- Firm-worker sorting is thus solely based on productivity
  - In the classic Rosen model, sorting purely on worker preference & firm cost
  - Reality is likely a mix and depends on demographics (Lentz et al., 2021)
  - We use O-Ring structure, so workers-sorting & only ex-post firm heterogeneity
- Key element: Non-wage compensations can be ”(in)efficient”
  - Motivation: our observation; efficiency wage & its critiques; Dey and Flinn (2005)
  - Various micro-foundations: here the simplest way—”inducing effort”
  - Extra feature: the level of (in)efficiency depends on productivity sorting
  - We set one efficient amenity and one inefficient amenity for illustration

Model Setting: Worker

- A continuum of worker with heterogenous productivity $q \in [0, 1]$ and additively separable (quasi-linear) utility function $U(C, a, h) = C + \phi_a a - \frac{h^{1+\phi_h}}{1+\phi_h}$
  - C is monetary consumption
  - $a \in \{0, 1\}$ is the indicator of a discrete amenity, e.g. insurance
  - h is a continuous disamenity, e.g. additional working hour

Model Setting: Firm

- Firms are ex-ante homogenous with O-Ring production function: $Y_j = AN_j^{1+\alpha} \prod_{i=1}^{N_j} q_i e(a,h)$
  - N is assumed to be fixed exogenously ◂ can relax
  - Compensations are (in)efficient: $e(a,h) = 1 + \gamma_a a + \frac{h^{\gamma_h}}{\gamma_h}$ *(microfoundations: e.g. less exogenous or endogenous exit(Hwang et al., 1998; Dey and Flinn, 2005); convexity in hour productivity (Goldin, 2014))*
  - Firm pay direct cost κ for a and compensate wage w for h

Competitive Equilibrium & Matching

- Competitive equilibrium in this economy is defined as an assignment of worker types to firms and a utility schedule, $u(q)$ such that
  - Firms maximize their profits
  - Labor market clears

- Complementary production function & additively separable utility function ensure positive assortative matching (PAM) even under imperfect transferable utility
  $\rightarrow$ each firm will employ workers with same q

Firms' Optimal Choices

- A firm chooses $\{q, a, h, w\}$ to maximize profit s.t. market utility schedule ◂ firm problem

- $a^* = \begin{cases} 1, & \text{if } q \geq q_a \\ 0, & \text{if } q < q_a \end{cases}$, and $\underbrace{AN^\alpha q_a^N \gamma_a + \phi_a}_{\text{mb}} = \underbrace{\kappa}_{\text{mc}}$
  - If a is not efficient, i.e. $\gamma_a = 0$, return back to the canonical compensating differential
  - If unit cost is $q\kappa$, higher q firms are still more likely to provide a

- $h^* = \left(AN^\alpha q^N\right)^{\frac{1}{1+\phi_h-\gamma_h}}$ increases in q
  - $h^*(q)$ will be fully compensated by $w(q)$, thus provision cost ex-post depends on q

Market Wage

market utility

- $w(q) = \begin{cases} \bar{A}q^N + \underbrace{\gamma_a \bar{A}q^N - \kappa}_{\text{wage effect of } a} + \underbrace{\frac{\left(\bar{A}q^N\right)^{1+\omega}}{(1+\omega)(1+\gamma_h)} + \frac{\left(\bar{A}q^N\right)^{\omega}}{1+\gamma_h}}_{\text{wage effect of } h}, & \text{if } q \geq q_a \\ \bar{A}q^N + \underbrace{\frac{\left(\bar{A}q^N\right)^{1+\omega}}{(1+\omega)(1+\gamma_h)} + \frac{\left(\bar{A}q^N\right)^{\omega}}{1+\gamma_h}}_{\text{wage effect of } h}, & \text{if } q < q_a \end{cases}$
    - Recall $\gamma_a \bar{A}q^N - \kappa = -\phi_a$ when $q = q_a$ and can be positive when $q \uparrow$
      $\rightarrow$ offsetting compensating differential
    - $\frac{\left(\bar{A}q^N\right)^{1+\omega}}{(1+\omega)(1+\gamma_h)}$ is the efficiency gain from h; $\frac{\left(\bar{A}q^N\right)^{\omega}}{1+\gamma_h}$ is the compensation for h
      $\rightarrow$ magnifying compensating differential

Model Implications 1. Compensating Differential

1.1 Compensating effects can be confounded with productivity effects

- Esp. for the up-end labor market where (in)efficiency forces are strong

1.2 The result of an empirical test on compensating differential will depend on the targeted labor market

- If focusing on low-end labor market (close to q_a or $q < q_a$ with imperfectly mandated policies) $\rightarrow$ easy to find clear evidence
- If focusing on board or high-end labor market (& with heterogeneous usage in efficiency compensation or imperfect matching) $\rightarrow$ tests likely to fail

1.3 Available variations for wage-amenity packages can be limited conditional on worker

- Depends on exogenous heterogeneity v.s. endogenous heterogeneity
- Constrains on both low-end and high-end markets

$\rightarrow$ Field/choice experiments (WtP) or RCT-like experiments (exogenous variations) not necessarily capture the whole picture of how labor market works

Model Implications 2. Labor Market Inequality

2 Efficiency compensations can enlarge both utility dispersion & wage dispersion
  - Ignoring non-wage compensations can underestimate labor market inequality
  - Moreover those compensations per se can actually be the drivers of wage inequality

$\rightarrow$ Increased sorting or better use of efficiency compensations increases wage inequality

Model Implications 3. Job Mobility & Choice

3.1 The set of non-wage compensations that can justify job moves to low wage-premium firms is likely limited to inefficient amenities

- Work-time/effort is the most likely culprit for moving downgrade

3.2 Greater compensating than just ”compensating differential”

- A worker with a ϕ_h shock would suffer not only traditional compensation differential but also a worse matching & an inferior package of other compensations
- Again, available choices for wage-amenities packages are limited

$\rightarrow$ Potential implications for gender wage gap and etc.

Roadmap

Take-Away Message

1. Think explicitly about non-wage compensations: insurance/fund, work-time, pay schemes, work environment, fringe benefits, ...
   $\rightarrow$ empirical focus & policy targets & intuition when back-out revealed preference
2. Different Firms in different jobs have distinct provision patterns
   $\rightarrow$ compensating differential $\neq$ provision inequality
3. (In)Efficiency compensations & productivity sorting reconciles empirical findings and generates important implications
   $\rightarrow$ high-wage firms can also offer better compensations without wage discounts

Appendix

Future Plan/Possibility

- Model the posted compensation as a discrete choice of firms?
- Interact/Distinguish with the income effect?
- Allow for heterogeneous preference and multi-dimensional sorting?
- Allow for search frictions and mismatch?
- Bring the model implications to the data?
- Combine with worker self-reporting data?
- Test if the similar empirical facts in the Japanese Data?

Shortcomings & Some Reliefs

Back Intro Back Data

- Vacancy data may be selective or less representative
  - Vacancy data is incline to young and more educated workers, esp. here
  - Not all jobs on the internet or different post frequency than job composition

  (Valid issue for all vacancy data; Extent is an empirical question; With dev and structural transform, more and more likely to become the dominant cases; help to consider the aging worker cases)

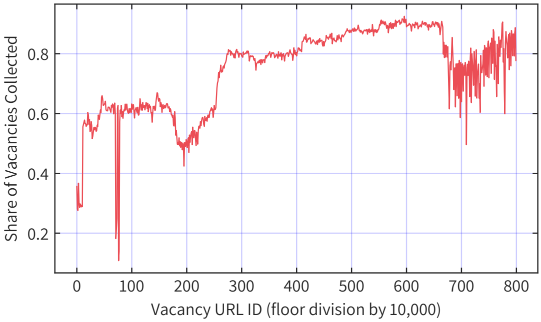
- Our wage measure incorporates variation in hours
  - One might worry that those efficient compensations are solely compensating more working hours

  (Often additional pay for overtime hours; Variation is limited comparing to wage; Inequality is often considered on overall compensation level; Need to think hour and wage as a package)

Trends on Collected Vacancies

◂ Back

# of Vacancies by Posted Month



% of Vacancies by Post ID Chunks

A Sample Vacancy

Back Intro Back Data

Job Title
iOS开发工程师

Wage
18k-22k
(该职位已下线)

深圳 / 经验1年以下 / 本科及以上 / web前端 / 全职
内容资讯 短视频
Basic Job Info

收藏 已下线

完善在线简历
上传附件简历

字节跳动 2018-09-10 发布于拉勾网
Post Info

查看原职位详情

职位诱惑:
Job Benefits
六险一金，弹性工作，免费三餐，餐补，租房补贴，带薪休假，扁平管理，晋升空间，团队氛围好

职位描述:
Job Description and Reqirement

职位职责:
1、负责产品迭代改进及移动新产品的开发;
2、参与 APP 性能、体验优化及质量监控评估体系建设;
3、参与客户端基础组件及架构设计, 推进研发效率;
4、参与 hybrid 容器搭建，插件、React Native 等动态技术调研。

职位要求:
1、本科及以上学历，计算机相关专业;
2、热爱计算机科学和互联网技术，对移动产品有浓厚兴趣;
3、扎实的数据结构和算法基础；精通至少一门编程语言，包括但不限于：Objective-C、Swift、C、C++、Java;
4、熟悉 iOS平台原理，具备将产品逻辑抽象为技术方案的能力;
5、关注用户体验，能够积极把技术转化到用户体验改进上;
6、对新技术保持热情，具备良好的分析、解决问题的能力。

工作地址
深圳 - 南山区 - 广东省深圳市南山区南海大道2163号来福士广场15层
Work Address 查看地图

Firm Info
ByteDance 字节跳动
字节跳动
内容资讯,短视频
D轮及以上
2000人以上
http://www.bytedance.com

Sample Cleaning ◂ Back

- Drop vacancies with not full-time jobs, outlier wages, job descriptions less than 20 words, nonChinese content
- Drop vacancies in 2013
- Drop vacancies from firms with less than 10 posts and from all the locations that have less than 1000 vacancies
- Drop duplicated vacancies based on job descriptions and education and experience requirements
- Drop vacancies with occupations not in selected major occupations

Data: Occupation Classification ◂ Back

- No ready-for-use occupation classification
- Match to a set of selected 6-digit occupations (”minor”) in six 2-digit occupations (”major”) in U.S. SOC 2018
- Key idea: an occupation is defined by a bundle of skills and tasks
- 1st step: for each occupation choose several exclusive keywords, and find the set of just-match vacancies as the ”learning” sample
- 2nd step: use the ”learning” group to train a Naive Bayes classifier based on the job titles and job descriptions
- 3rd step: apply the trained classifier to both the ”unknown” sample and the ”learning” sample ▸ confusion matrix

Data: Summary Statistics ◂ Back

	Pooled	Major Occupation					
	-	Computer	Design_ Media	Business_ Operations	Financial_ Legal	Sales	Admin
Vacancy #	3,999,005	1,330,001	561,236	1,162,404	214,661	452,771	277,932
- share	1.00	.33	.14	.29	.05	.11	.07
Avg # Words	108.91	104.26	103.05	115.60	110.69	120.31	95.09
Wage (1k CNY):							
- Mean	13.64	17.38	10.68	14.19	11.95	10.21	6.32
- SD	9.24	9.79	6.31	9.52	9.19	6.53	3.90
Firm:							
- #	86,330	67,369	68,092	78,244	41,285	58,847	59,016
- Avg Posts	46.32	19.74	8.24	14.86	5.20	7.69	4.71
- Median Posts	20.0	9.0	4.0	6.0	2.0	3.0	2.0
Firm Size (share):							
- -15	.03	.03	.05	.02	.02	.03	.03
- 15-50	.18	.17	.25	.16	.15	.19	.20
- 50-150	.23	.21	.26	.22	.22	.23	.26
- 150-500	.21	.21	.21	.22	.23	.20	.23
- 500-2000	.15	.16	.12	.16	.18	.15	.14
- 2000+	.20	.23	.11	.22	.21	.19	.13
Education (share):							
- Vocational College	.33	.24	.38	.29	.27	.51	.52
- Bachelor	.54	.66	.47	.61	.63	.22	.24
- Master/Doctor	.01	.02	.00	.01	.03	.00	.00
- Not Specified	.12	.08	.15	.09	.07	.27	.23
Experience (share):							
- 0	.22	.12	.21	.16	.25	.48	.50
- 1-3	.37	.33	.48	.37	.36	.31	.38
- 3-5	.31	.41	.25	.33	.26	.16	.10
- 5-10	.11	.14	.05	.14	.13	.05	.03

What Are The Non-Wage Compensations That Firms Post?

Back

insurance&fund; leisure; growth potential, bonus, environment, fringe benefits, ...

Lasso Regression ◂ Back

- Two purposes: (i) a first look of the wage-amenity relationship (ii) shrink features
- Run a Lasso regression of log posted wage $\ln w$ on an indicator matrix $\mathbf{C}_{\text{comp}} \in \mathbb{R}^{N \times |V_{\text{comp}}|}$
  - Use BIC to tune the Lasso penalization hyper-parameter ▸ lasso details
- It shrinks V_{comp} to a vocabulary subset V'_{comp} with only 800 features (and $\mathbf{C}_{\text{comp}}$ to $\mathbf{C}'_{\text{comp}}$)
- Inference & Robustness:
  - Coefficients are in general not interpretable due to multicollinearity & flexibility
  - Use subsampling to do inference, results are robust ▸ subsampling
- Conduct same Lasso regression for $\mathbf{C} \in \mathbb{R}^{N \times |V|}$, and inspect top features & changes

Lasso Regressions

Back

- Lasso regression (L1 penalization):
  $\hat{\zeta} = \arg\min_{\zeta} \sum_{i=1}^{N} \left(\ln w_i - \sum_{k=1}^{K} c_{ik}\zeta_k \right)^2 + \lambda \sum_{k=1}^{K} |\zeta_k|$
- BIC as the criterion to gauge the hyperparameter λ:
  $\min \mathrm{BIC}(\lambda) = \frac{\| \ln \mathbf{w} - \mathbf{C}\hat{\zeta}_\lambda \|^2}{\sigma^2} + \widehat{df}_\lambda \log N$
- Inference via subsampling (10x10)

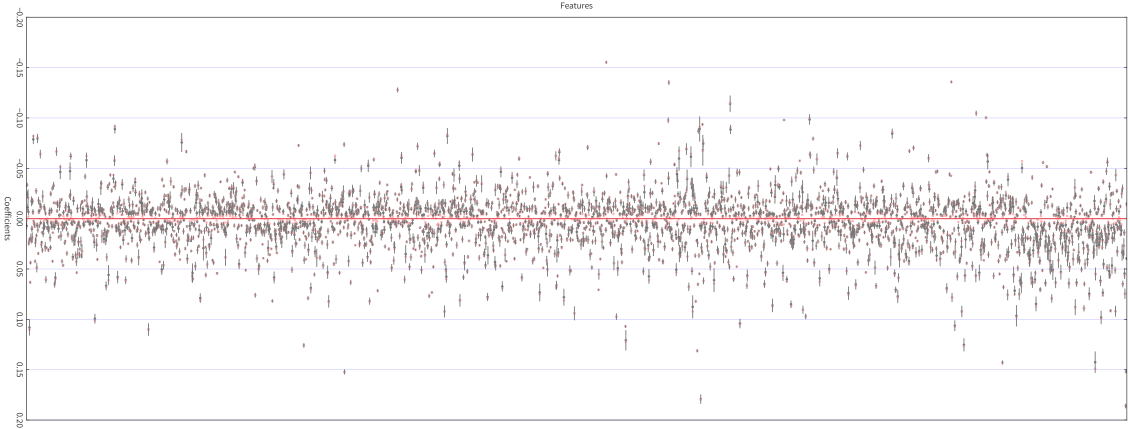
Lasso Regression using V: Top Features (Frequency $> 1\%$)

back

	Top Positive			Top Negative		
	token	coef	freq	token	coeff	freq
1	14th month pay	.152	.014	freshmen	-.155	.018
2	three meals	.143	.014	five insurance	-.136	.030
3	large platform	.131	.019	graduates	-.128	.033
4	master degree	.126	.015	vocational major	-.100	.036
5	lead	.107	.041	two-day weekend	-.098	.166
6	c++	.092	.051	vocational college	-.094	.148
7	algorithm	.082	.061	assistant	-.079	.011
8	guru	.082	.028	customer service	-.075	.030
9	famous	.079	.019	social insurance	-.073	.028
10	machine learning	.077	.016	accounting	-.071	.019
11	formation	.076	.013	accommodation	-.067	.016
12	undergraduate	.074	.319	administration	-.067	.027
13	overseas	.072	.026	commissioner	-.063	.011
14	react	.072	.020	taobao	-.059	.015
15	development	.071	.374	assistance	-.058	.164
16	undergraduate	.066	.029	ps	-.056	.029
17	high salary	.063	.028	ltd.	-.056	.012
18	landing	.060	.067	installation	-.055	.020
19	strategy	.057	.047	photoshop	-.052	.039
20	live streaming	.056	.014	careful	-.050	.032
21	listed company	.055	.027	hardworking	-.050	.032
22	large scale	.055	.072	verification	-.048	.011
23	responsibilities	.055	.048	human resources	-.047	.032
24	shuttle	.054	.018	website	-.047	.090
25	finance	.054	.070	any major	-.047	.020
26	six insurance & one fund	.053	.055	humanization	-.046	.012

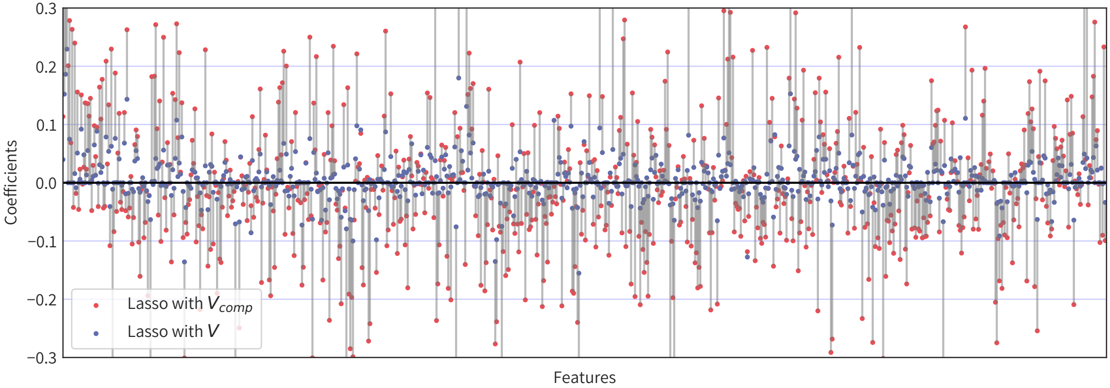
Confidence Intervals on Lasso Coefficients via Subsampling

Back



Compare Lasso Coefficients

◂ Back

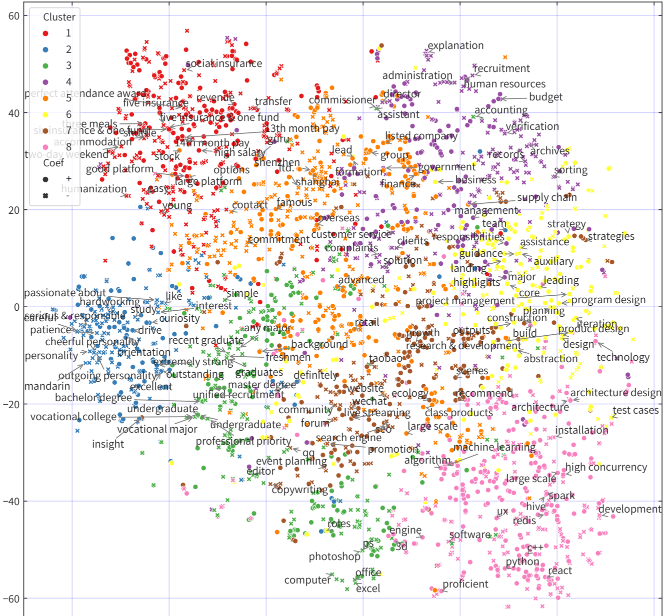


Posted-Wage Regression ◂ Back

- So the predictive power of non-wage compensations in part comes from their correlation with job skills/tasks; What about firms?
- Posted wage regression: $\ln w_{i,j,t} = \theta_i + \psi_j + \delta_i + \iota_t + \epsilon_i$
  - $\theta_i \equiv X_i \beta$ (job/worker effect), $X_i = \{\text{EDU}_i, \text{EXP}_i, \mathbf{c}'_{i,\setminus \text{comp}}\}$
  - ψ_j (firm fixed effect)
  - $\delta_i \equiv \mathbf{c}'_{i,\text{comp}} \gamma$ (compensation effect)
  - ι_t (year fixed effect)
  - In practice, further dimensional reduction on $\mathbf{c}'_{i,\setminus \text{comp}}$ & $\mathbf{c}'_{i,\text{comp}}$ using PLS
  - This posted wage regression does a similar job to the AKM framework (Zhu, 2022)
- Variance decomposition: $\text{var}(\ln w_i) =$ $\text{var}(\theta_i) + \text{var}(\psi_j) + \text{var}(\delta_i) + 2\,\text{cov}(\theta_i, \psi_j) + 2\,\text{cov}(\theta_i, \delta_i) + 2\,\text{cov}(\psi_j, \delta_i) + \text{var}(\epsilon_i)$

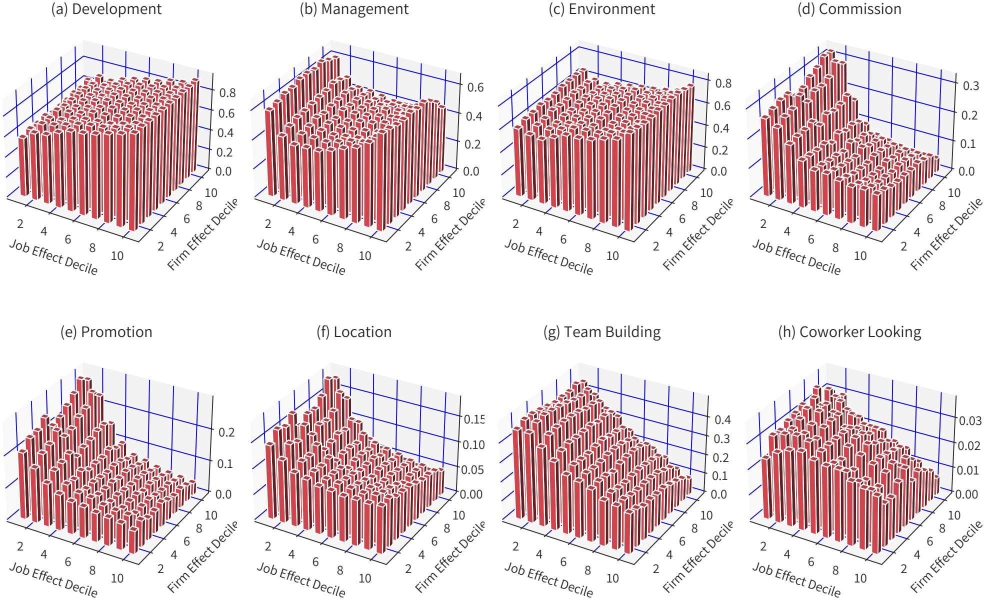
Feature Clustering: Visualization

◂ Back



Compensation Occurrence (More)

Back



Hedonic Regression

	Pooled	Computer	Design_ Media	Admin
	(1)	(2)	(3)	(4)
Advanced Insurance	.014**	.016**	.009**	.002
	(.001)	(.001)	(.002)	(.003)
Backloading Wage	.010**	.013**	.022**	.011**
	(.001)	(.001)	(.002)	(.002)
Stock Option	.087**	.068**	.060**	.040**
	(.001)	(.001)	(.002)	(.003)
Coworker Quality	.024**	.016**	.005*	.008+
	(.001)	(.001)	(.002)	(.004)
Work-Flexibility	.010**	.007**	.009**	.005**
	(.001)	(.001)	(.001)	(.002)
Basic Insurance	-.025**	-.024**	-.017**	-.013**
	(.000)	(.001)	(.001)	(.001)
Training	-.003**	-.019**	-.003	.013**
	(.001)	(.001)	(.002)	(.002)
Work-Time	-.021**	-.018**	-.020**	-.022**
	(.000)	(.001)	(.001)	(.001)
Education FE	✓	✓	✓	✓
Experience FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
$\Xi_2, \ldots, \Xi_8$	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓
Adj. R^2	.738	.748	.730	.657
No. Obs	3998840	1325260	548808	260364

Firms' Problem
Back

- Firm problem: $$\max_{\{q_i\}_{i=1}^N, a, h, w(q)} AN^{1+\alpha} \prod_{i=1}^{N} q_i e(a,h) - \sum_{i=1}^{N} w(q_i) - a\kappa N$$
$$\text{s.t.} \quad w(q) + \phi_a a - \frac{h^{1+\phi_h}}{1+\phi_h} \geq u(q) \quad \forall q \in \{q_i\}_{i=1}^N$$
  - Complementary production function & additively separable utility function ensure positive assortative matching (PAM) even under imperfect transferable utility
  $\rightarrow$ a firm will employ workers with same q

- Rewrite the firm problem given equilibrium allocation:
$$\max_{q,a,h} AN^{1+\alpha} q^N (1 + \gamma_a a + \tfrac{h^{\gamma_h}}{\gamma_h}) - N\left(u(q) - \phi_a a + \tfrac{h^{1+\phi_h}}{1+\phi_h}\right) - a\kappa N$$

- FOCs: $$AN^{1+\alpha} q^{N-1} e(a,h) = u'(q)$$
$$AN^{\alpha} q^N h^{\gamma_h - 1} = h^{\phi_h}$$

Market Utility Profile

Back

- $$u(q) = \begin{cases} \frac{\left(\bar{A}q^N\right)^{1+\omega}}{(1+\omega)(1+\gamma_h)} + (1+\gamma_a)\bar{A}q^N + u_a, & \text{if } q \geq q_a \\ \frac{\left(\bar{A}q^N\right)^{1+\omega}}{(1+\omega)(1+\gamma_h)} + \bar{A}q^N + u_0, & \text{if } q < q_a \end{cases}$$
    - where $\bar{A} \equiv AN^{\alpha}$, $\omega = \frac{1+\gamma_h}{1+\phi_h-\gamma_h}$, $u_0 = 0$, and $u_a = \phi_a - \kappa$.

If Firm Size Is Endogenous (Typical O-Ring Results) ◂ Back

- N is also a choice of the firm
- Additional FOC: $AN^{\alpha} q^{N} e(a,h)\,(1+\alpha+N\ln(q)) = w + ac$
- Optimal choice on firm size: $N(q) = \frac{1+\alpha}{-\ln(q)}$
- Firm size increases in productivity q and is irrelevant to the choices of amenities
- All the relationships between productivity and amenity provision can be now directly translate to the firm size