

The Option Value of Occupations

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25 Highest Paid Occupations in the US

+ *future* jobs \implies option value

Sources: [U.S. News](#), [CNN Money](#), [Investopedia](#)

What I do & find

1. **Model** job mobility within and across occupations

Wage schedules, wage offers, labor market frictions, amenities, switching costs

2. **Estimate** substantial heterogeneity in the flow vs. option value of occupations

Low-skill occs. have high flow value / high-skill occs. have high option value

3. **Simulate** occupational wage trajectories

Starting in bottom-wage high-skill occ. jobs \gg top-wage low-skill occ. jobs

Trajectories

Literature

Opportunities vs. choices

Individual works in a job (occupation a , wage i), enjoys flow utility u_{ai}

Their wage may increase/decrease from i to w at rate χ_{ai}^{aw}

They may separate from their job at rate δ_a

They may receive a job offer from occupation o at rate λ_a^o

- Wage offer $w \sim f^o$
- Stochastic switching cost \tilde{c}_a^o \implies accept offer if $V_{ow} - \tilde{c}_a^o > V_{ai}$

Employed in occupation a earning wage i :

$$V_{ai} = \underbrace{\frac{u_{ai}}{\Gamma}}_{\text{flow value}} + \underbrace{\frac{\mathbb{E}_w [\chi_{ai}^{aw} V_{aw}]}{\Gamma} + \frac{\delta_a V_n}{\Gamma}}_{\text{continuation value}} + \underbrace{\frac{\mathbb{E}_{o,w,\tilde{c}} [\lambda_a^o \max\{V_{ow} - \tilde{c}_a^o, V_{ai}\}]}{\Gamma}}_{\text{option value}}$$

$$\Gamma = \sum_o \lambda_a^o + \sum_w \chi_{ai}^{aw} + \delta_a + \rho$$

$$\tilde{c}_a^o \sim \text{Logistic}(c_a^o) \quad (\text{cf. Arcidiacono, Gyetvai, Maurel, and Jardim, 2023})$$

$$\rho V_{ai} = u_{ai} + \sum_w \chi_{ai}^{aw} (V_{aw} - V_{ai}) + \delta_a (V_n - V_{ai}) - \sum_{o,w} \lambda_a^o \log (1 - p_{ai}^{ow}) f^{ow}$$

where $p_{ai}^{ow} = \frac{\exp(V_{ow} - V_{ai} - c_a^o)}{1 + \exp(V_{ow} - V_{ai} - c_a^o)}$

$$\text{hazard} = \underbrace{\Pr(\text{offer arrives})}_{\text{opportunities}} \times \underbrace{\Pr(\text{offer is accepted})}_{\text{choices}}$$

Separating **opportunities** from **choices**

- Frequent offers \implies wait for a high-wage offer $\implies \uparrow$ transitions at high wages
- Strong preferences \implies accept any wage offer $\implies \uparrow$ transitions at all wages

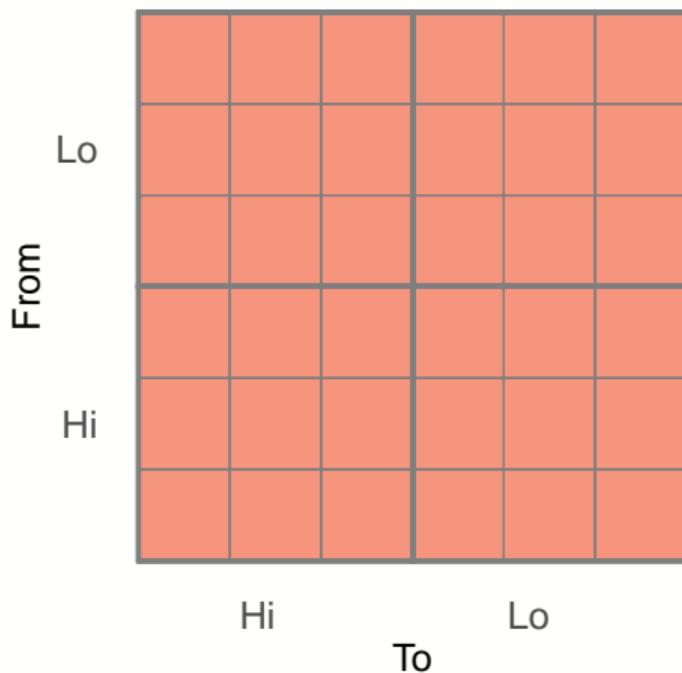
Offered wages (opportunities)

Identification

Identifying variation

Hazards across destination jobs

Job-to-job hazards



Offered wage distributions

Hi

Lo



Derivation

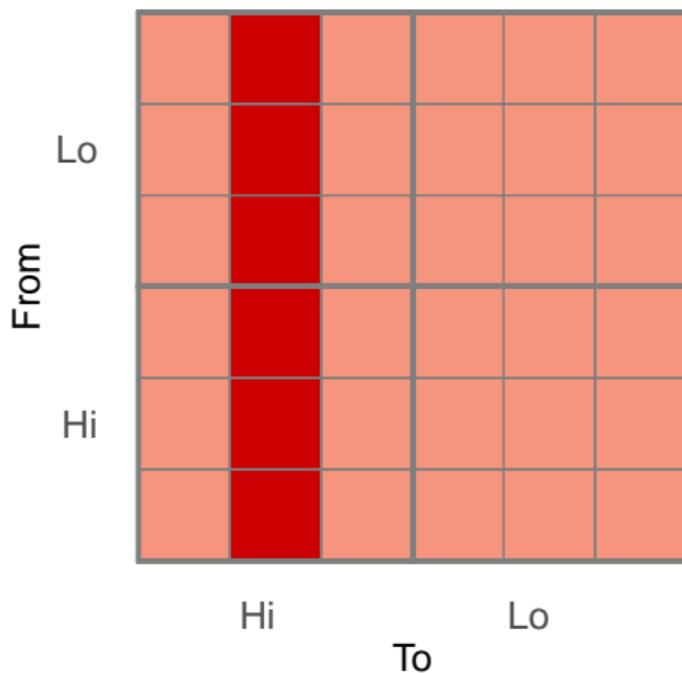
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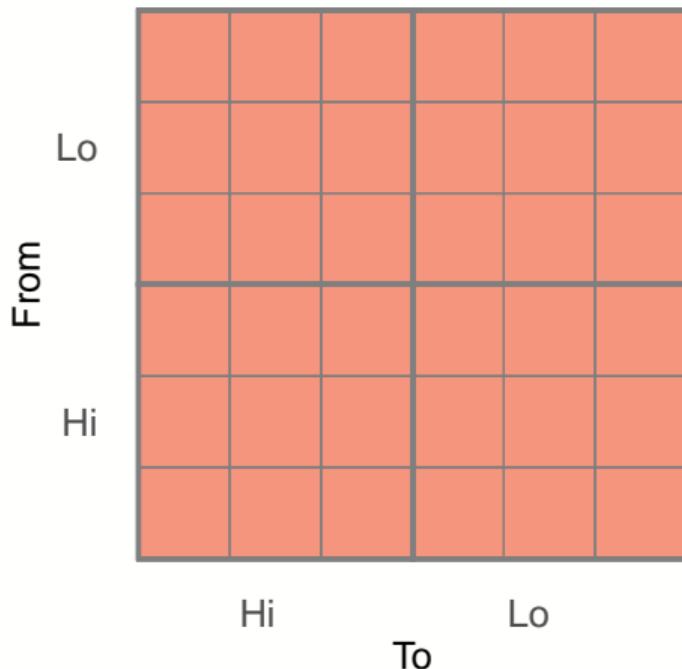
Offer arrival rates (opportunities)

Identification

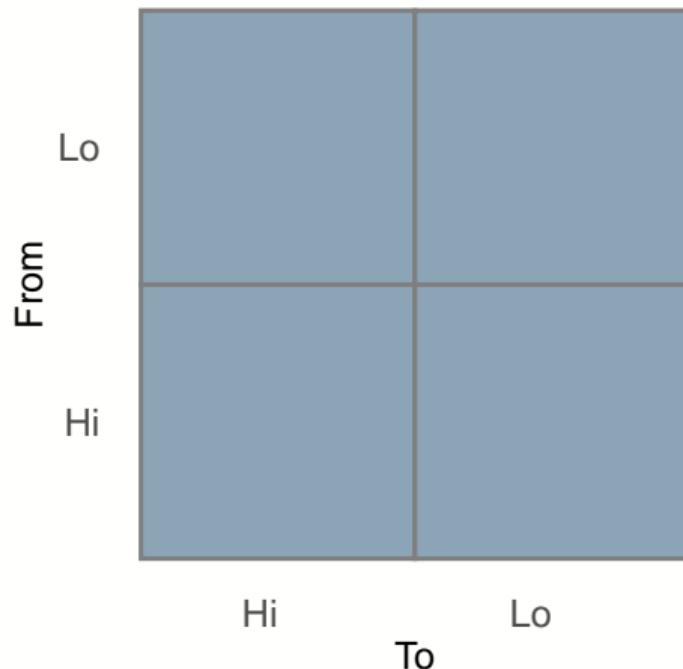
Identifying variation

Hazards across origin and destination occupations at high wages

Job-to-job hazards



Offer arrival rates



Derivation

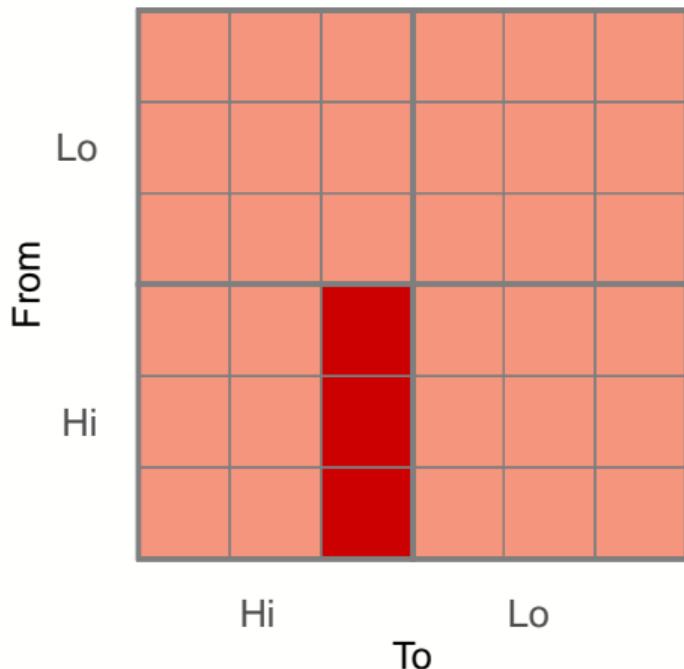
Offer arrival rates (opportunities)

Identification

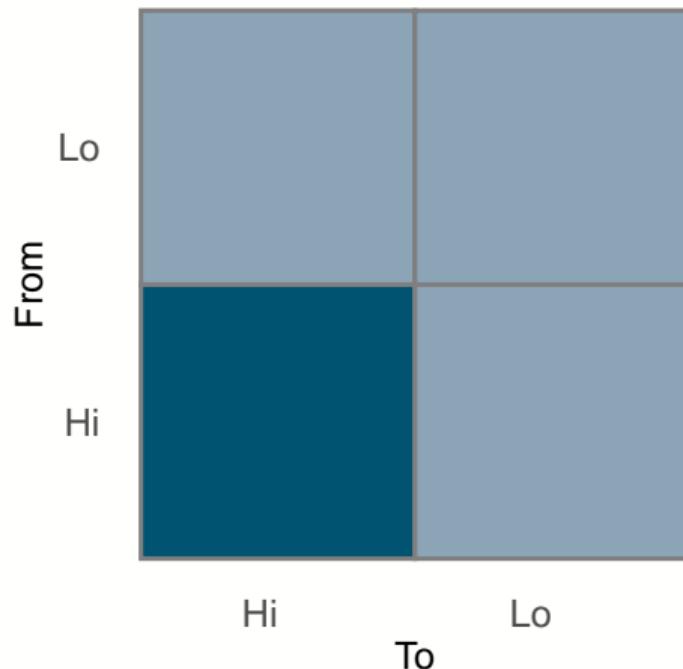
Identifying variation

Hazards across origin and destination occupations at high wages

Job-to-job hazards



Offer arrival rates



Derivation

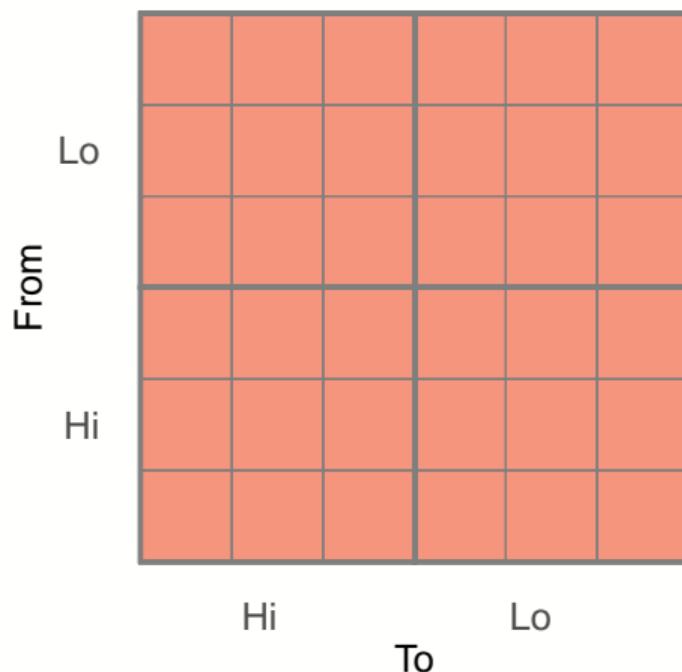
Flow utilities (choices)

Identification

Identifying variation

Hazards across origin and destination jobs

Job-to-job hazards



Flow utility

Hi

Lo



Derivation

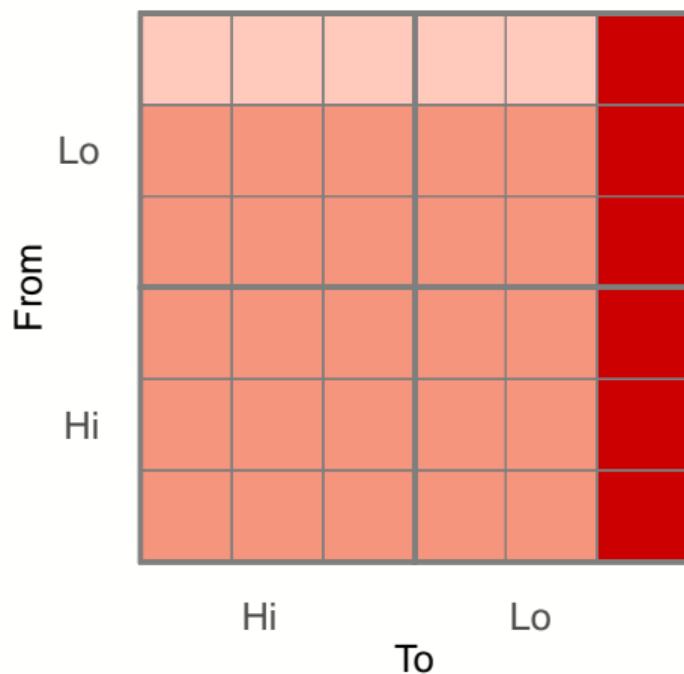
Flow utilities (choices)

Identification

Identifying variation

Hazards across origin and destination jobs

Job-to-job hazards



Flow utility

Hi

Lo



Wage bin

Derivation

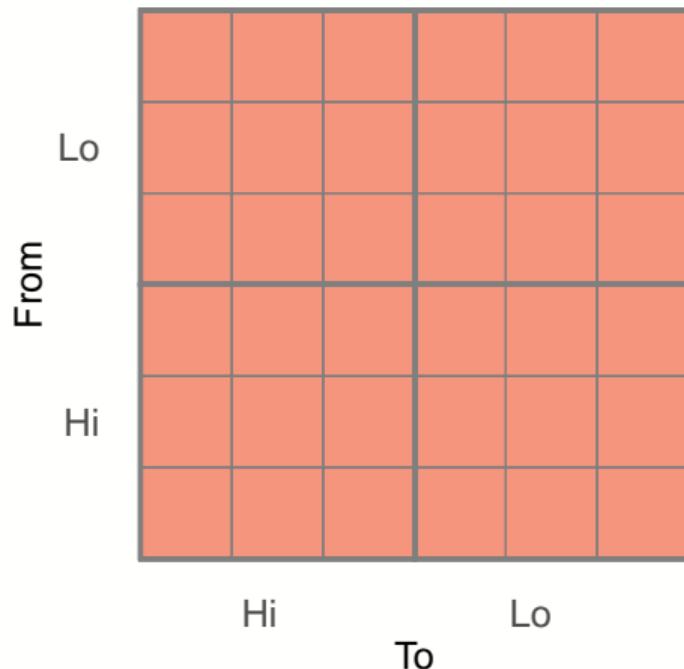
Switching costs (choices)

Identification

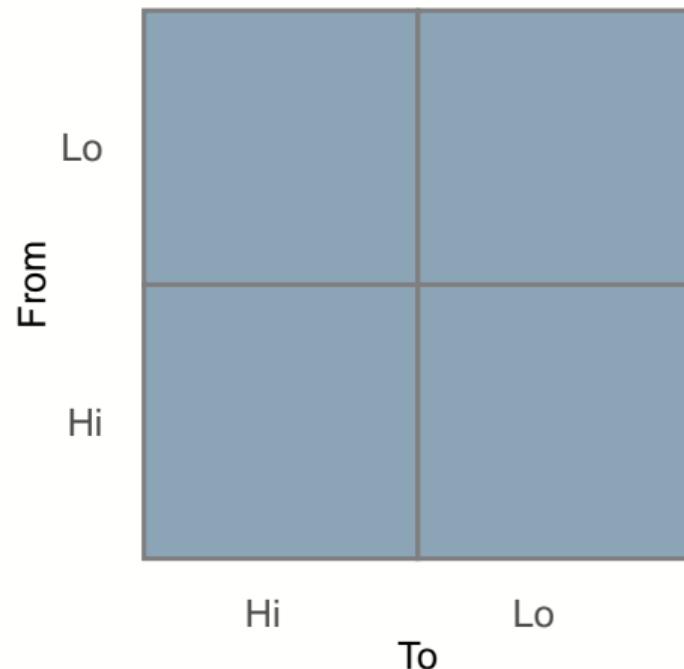
Identifying variation

Hazards across origin and destination occupations at all wages

Job-to-job hazards



Switching costs



Structure
Derivation

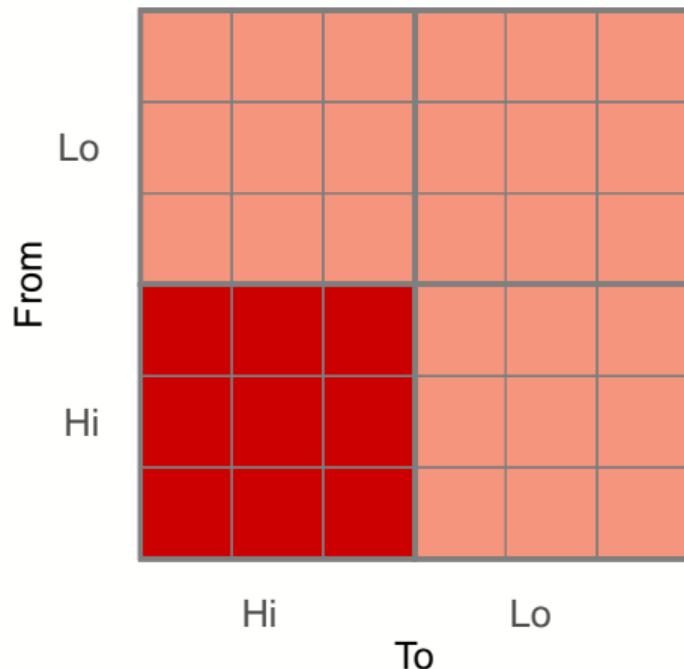
Switching costs (choices)

Identification

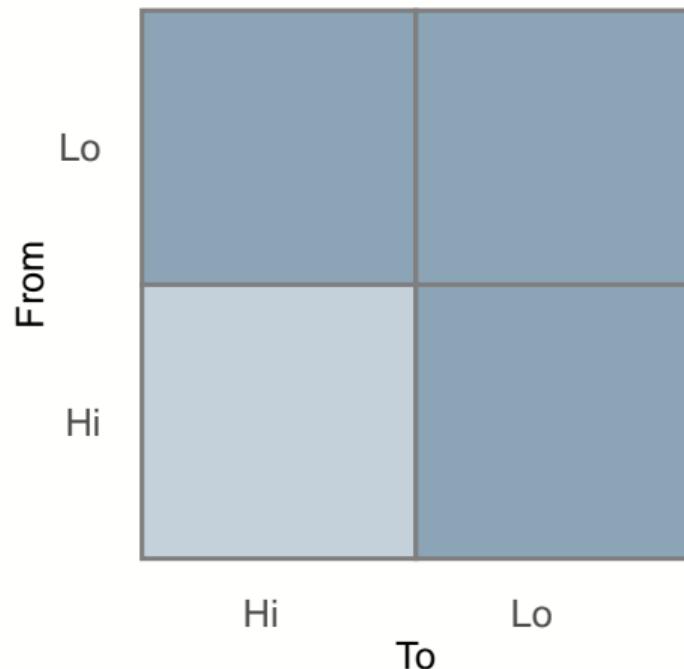
Identifying variation

Hazards across origin and destination occupations at all wages

Job-to-job hazards



Switching costs



Structure
Derivation

2003–2017, 50% “de facto random” sample

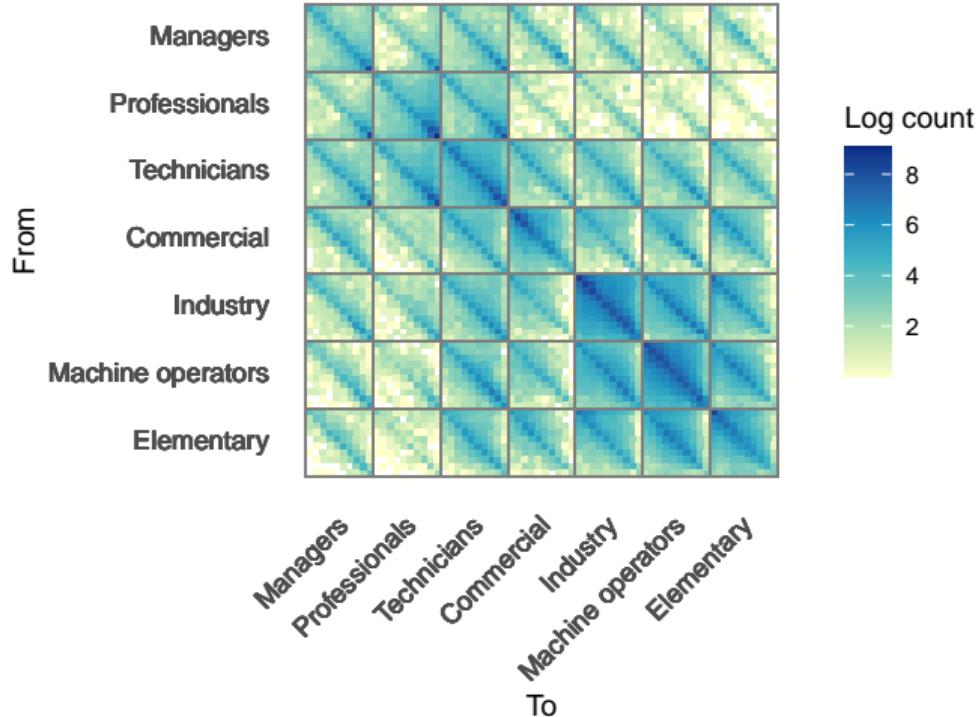
- 5 million individuals, 900 thousand firms per year
- Estimation sample: 22–50 males → 5 million job spells

1. (Virtually) continuous-time data
2. Reliable occupational classification → high vs. low-skill occupations

Various versions used in Koren and Tenreyro (2013 AER), Halpern, Koren, and Szeidl (2015 AER), DellaVigna, Lindner, Reizer, and Schmieder (2017 QJE), Harasztosi and Lindner (2019 AER), Verner and Gyöngyösi (2020 AER)

Observed EE transitions

Estimation



Estimation procedure

Estimation

Two-stage MLE, competing risks with exponential hazards and two-sided censoring

1. Estimate wage change rates χ and separation rates δ
2. Estimate hazards, imposing structure

Formulas

Likelihood

$$L(\mathbf{h}) = L \left(\underbrace{\lambda f}_{\text{Pr(offer arrives)}} \times \underbrace{p(\lambda, f, u, c, \hat{\chi}, \hat{\delta})}_{\text{Pr(offer is accepted)}} \right)$$

CCPs come from iterating the value function to a fixed point

VFI

Additional structure on offered wages, switching costs, flow utilities

f c u

Unobserved heterogeneity types (not today)

Reduced EM algorithm

Global optim

Labor market frictions

Estimates



More results

The flow vs. option value of occupations

Estimates

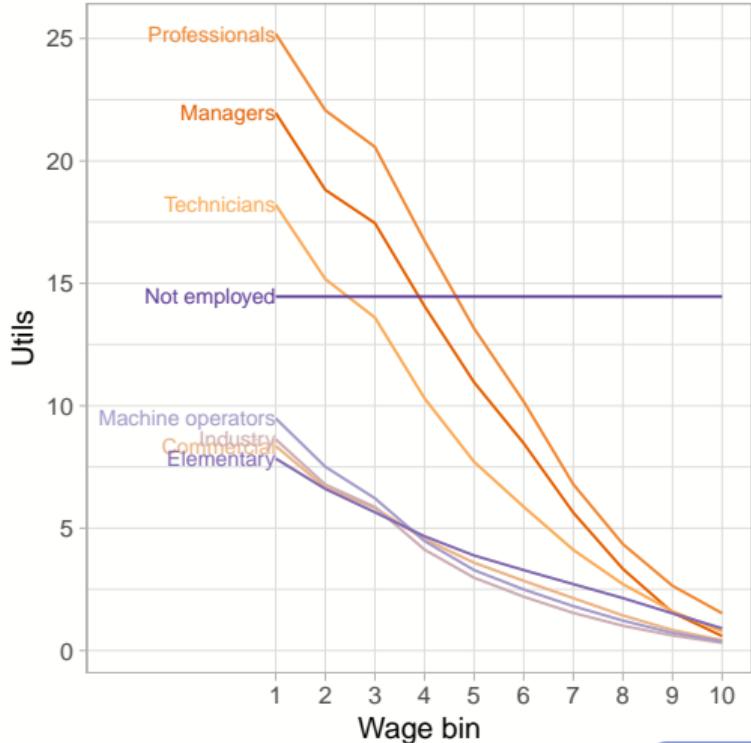
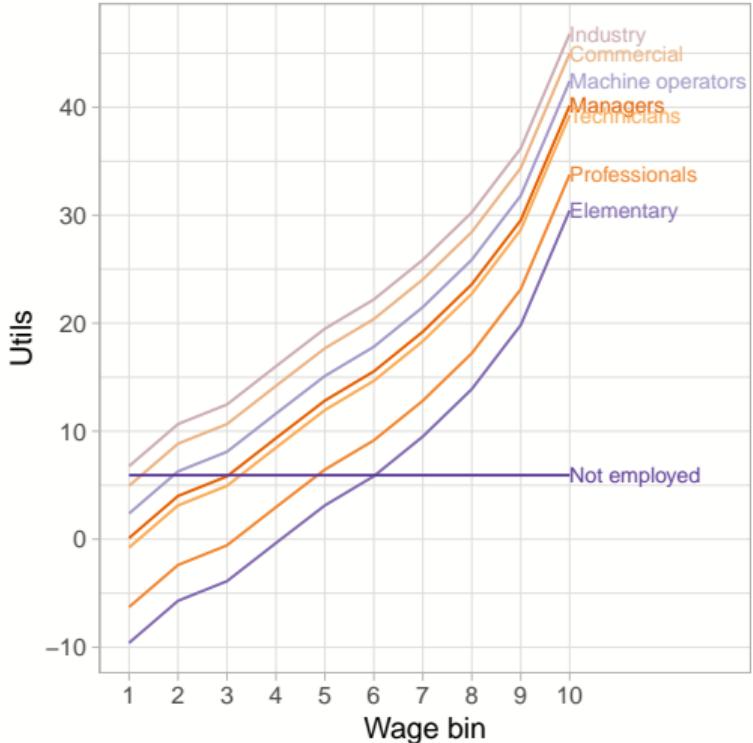
<i>Occupation</i>	<i>Mean flow value</i>	<i>Mean option value</i>	<i>Option / flow</i>
Professionals	9.6	12.3	1.280
Managers	16.0	10.3	0.642
Elementary	6.3	3.9	0.621
Technicians	15.1	8.0	0.529
Machine operators	18.3	3.8	0.206
Commercial	20.9	3.7	0.176
Industry	22.7	3.4	0.150

Formulas

Comp. difftl's

The flow vs. option value of jobs

Estimates

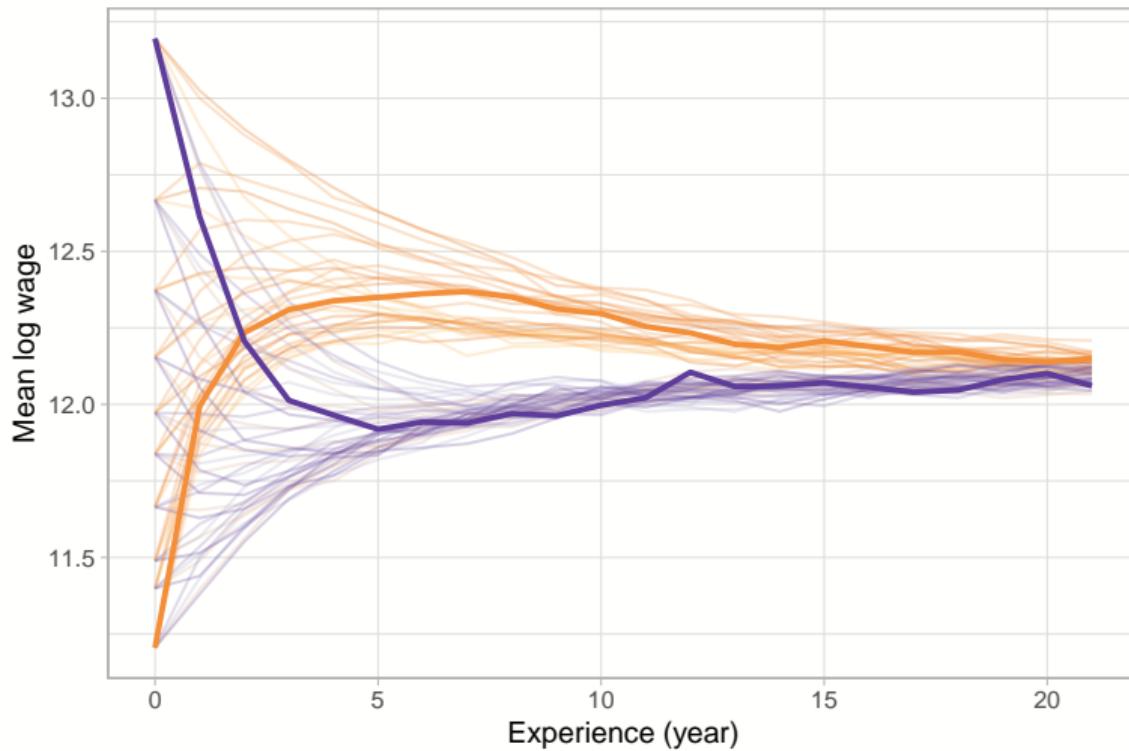


Formulas

Comp. difftl's

Simulating job trajectories

Counterfactuals



Procedure

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More at attilagyetyai.com

Additional Slides

Literature

Career decisions

Keane and Wolpin (1997), Neal (1999), Sullivan and To (2014), ...

Occupational choice

Miller (1984), McCall (1990), Antonovics and Golan (2012), ...

Heterogeneity in job search

Postel-Vinay and Robin (2002), Cahuc, Postel-Vinay, and Robin (2006), Taber and Vejlin (2020), ...

Option values

Rust (1987), Arcidiacono (2004), Stange (2012), ...

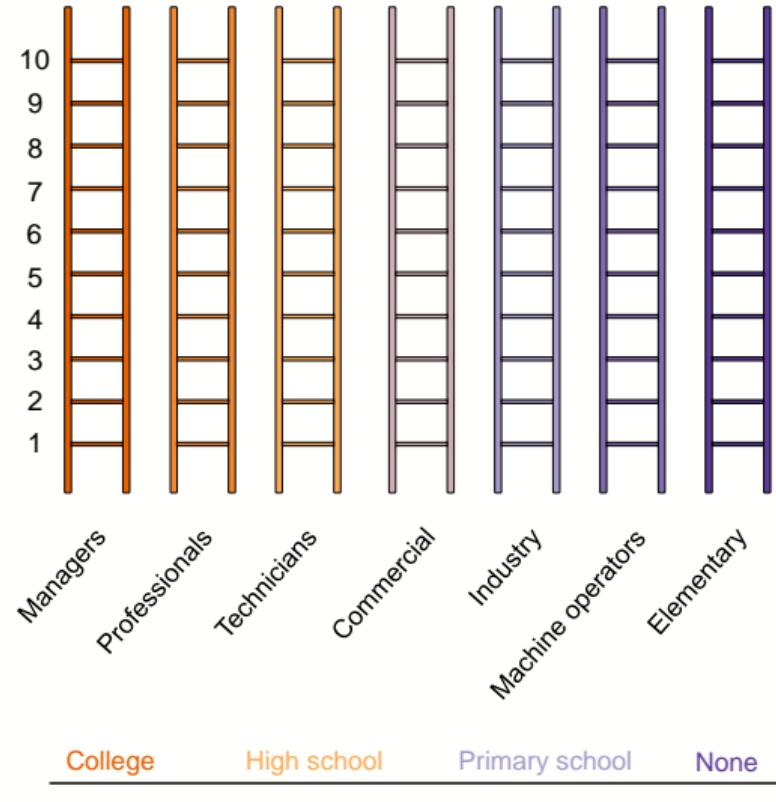
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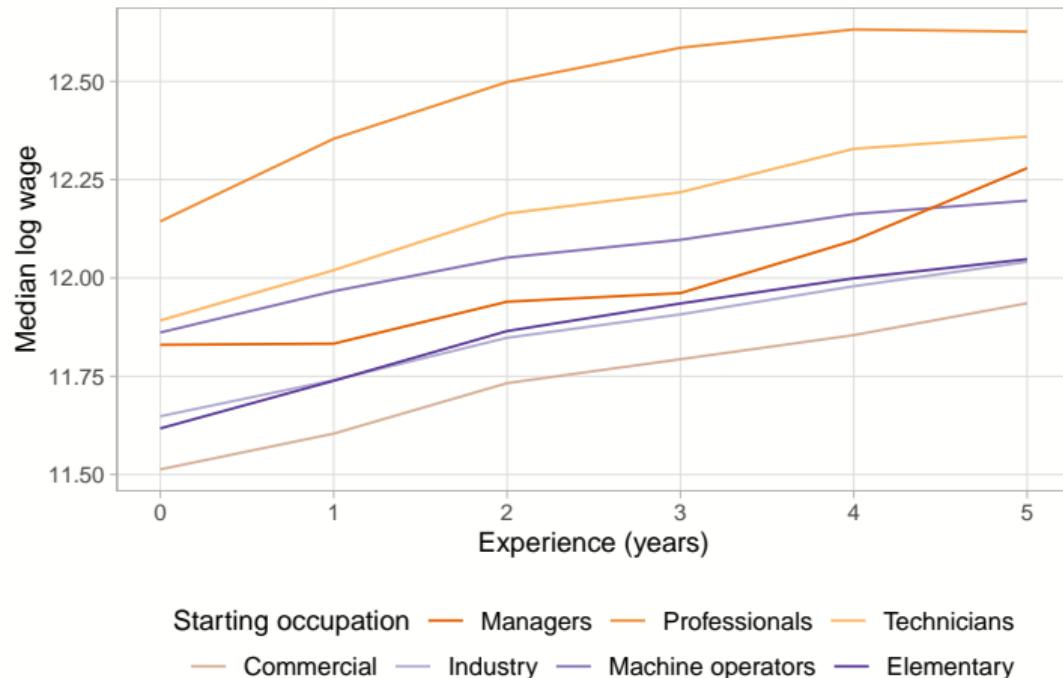
Occupational ladders and skill levels



Skill levels and most frequent occupations

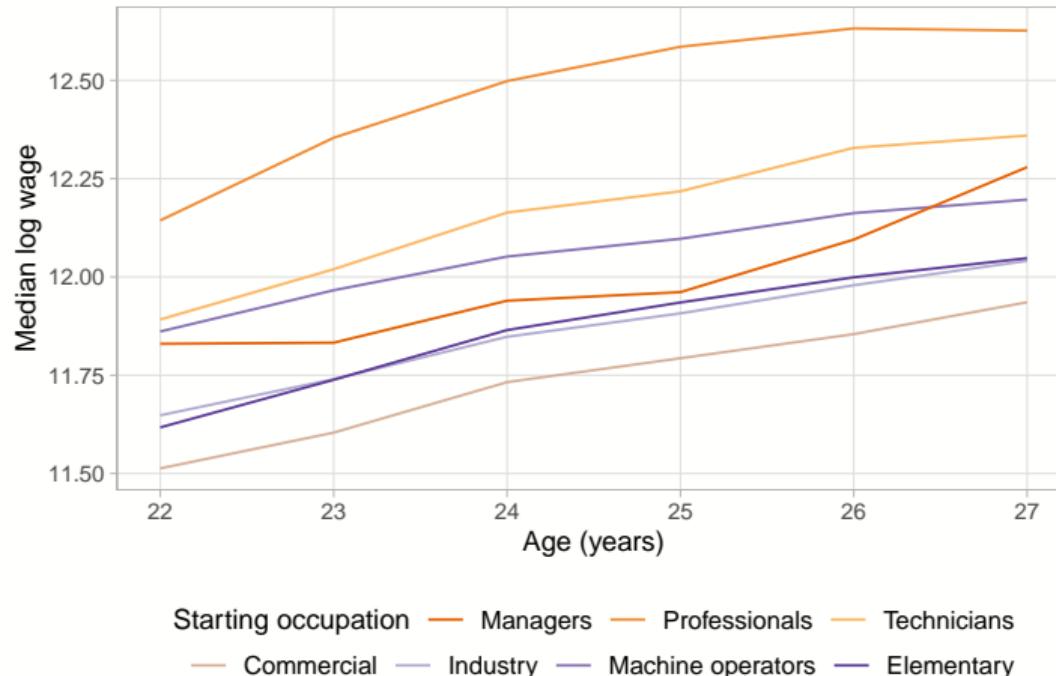
1-Managers College+HS	Managing directors Legislators	4-Commercial Primary	Catering Services
2-Professionals College	STEM Business, legal, and soc. sci.	5-Industry Primary	Metal and electrical ind. Construction
3-Technicians High school	STEM Business	6-Machine operators Primary	Drivers Assemblers
		7-Elementary	Elementary

Occupations capture diverging wage trajectories

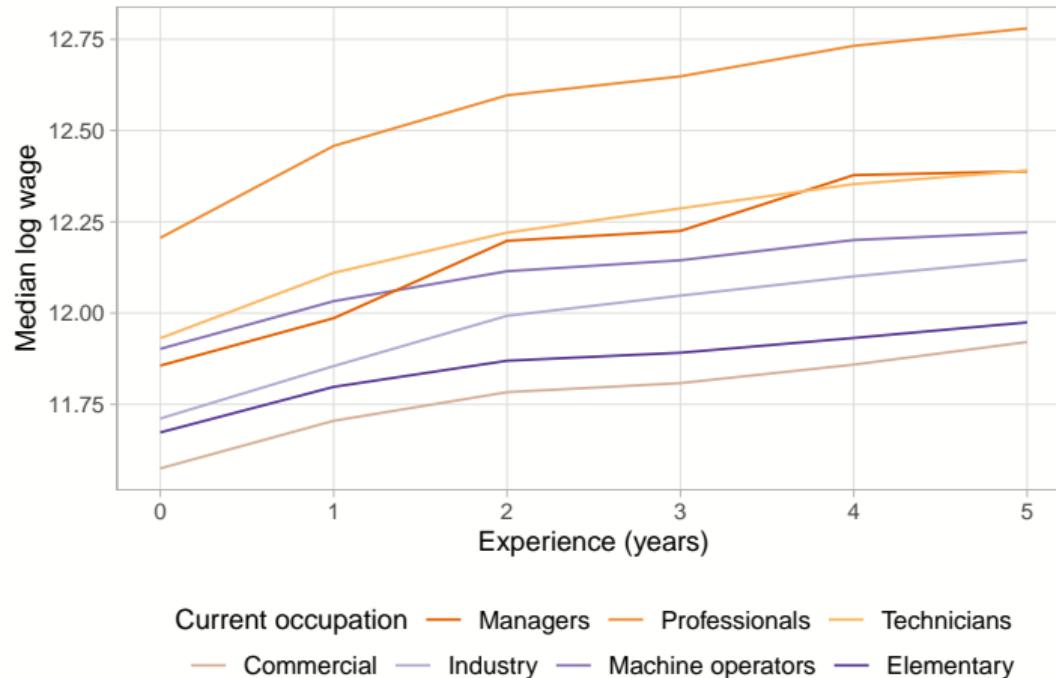


- By age
- By first occ.
- By current occ.
- Data
- Job ladders
- Transition matrix
- ◀ Back

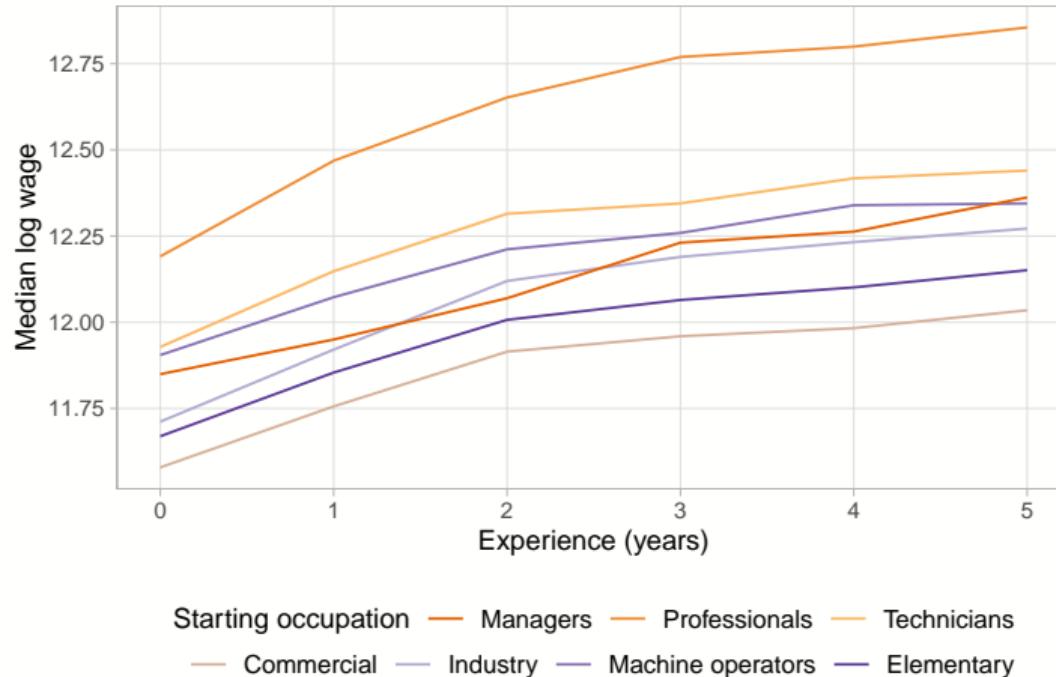
Occupations capture diverging wage trajectories



Occupations capture diverging wage trajectories



Occupations capture diverging wage trajectories



Flow / continuation / option value-formulas

$$V_{ai} = \underbrace{\frac{u_{ai}}{\rho}}_{\text{flow value}} + \underbrace{\frac{\sum_w \chi_{ai}^{aw} (V_{aw} - V_{ai})}{\rho}}_{\text{continuation value}} + \underbrace{\frac{\delta_a (V_n - V_{ai})}{\rho} - \underbrace{\frac{\sum_{o,w} \lambda_a^o \log(1 - p_{ai}^{ow}) f^{ow}}{\rho}}_{\text{option value}}}_{\text{continuation value}}$$

Idea: compare hazards of moving to the same job as the current one. Differential rates across wages are due to differences in offer propensity.

Note that $p_{ai}^{ai} = p_{aj}^{aj}$ for all a, i, j

$$p_{ai}^{ai} = \frac{\exp(V_{ai} - V_{ai} - c_a^a)}{1 + \exp(V_{ai} - V_{ai} - c_a^a)} = \frac{\exp(-c_a^a)}{1 + \exp(-c_a^a)}$$

Therefore

$$\begin{aligned} \frac{h_{ai}^{ai}}{h_{aj}^{aj}} &= \frac{\lambda_a^a p_{ai}^{ai} f_{ai}^{ai}}{\lambda_a^a p_{aj}^{aj} f_{aj}^{aj}} = \frac{f_{ai}^{ai}}{f_{aj}^{aj}} \\ \implies \textcolor{red}{f^{ai}} &= \frac{h_{ai}^{ai}}{\sum_w h_{aw}^{aw}} \end{aligned}$$

Very simple estimation is appealing to wider audience

Idea: the odds of accepting an offer plus its reverse needs to be equal for all wages

Log odds of accepting offers can be written in two ways:

1. Plugging in structural parameters for CCPs:

$$\varpi_{ai}^{bj} = \log \left(\frac{p_{ai}^{bj}}{1 - p_{ai}^{bj}} \right) = \log \left(\frac{h_{ai}^{bj}}{\lambda_a^b f^{bj} - h_{ai}^{bj}} \right)$$

Only unknown is $\lambda_a^b \implies \varpi_{ai}^{bj} \equiv \varpi_{ai}^{bj}(\lambda_a^b)$

2. Plugging in value functions for CCPs:

$$\varpi_{ai}^{bj} = \log \left(\frac{p_{ai}^{bj}}{1 - p_{ai}^{bj}} \right) = V_{bj} - V_{ai} - c_a^b$$

First, offer arrives from same occupation:

$$\begin{aligned}\varpi_{ai}^{aj} &= V_{aj} - V_{ai} - c_a^a \\ \implies \varpi_{ai}^{aj} + \varpi_{aj}^{ai} &= \varpi_{ak}^{a\ell} + \varpi_{a\ell}^{ak} \implies \lambda_a^a \text{ from any } (i, j, k, \ell) \text{ 4-tuple}\end{aligned}$$

Next, offer arrives from another occupation:

$$\begin{aligned}\varpi_{ai}^{bj} &= V_{bj} - V_{ai} - c_a^b \\ \implies \varpi_{ai}^{bj} + \varpi_{bj}^{ai} &= \varpi_{ak}^{b\ell} + \varpi_{b\ell}^{ak} \implies \lambda_a^b, \lambda_b^a \text{ from any two } (i, j, k, \ell), (i', j', k', \ell') \text{ 4-tuples}\end{aligned}$$

Idea: having identified the offered wages and arrival rates, CCPs map to hazards

By the hazard definition,

$$\begin{aligned} h_{ai}^{bj} &= \lambda_a^b p_{ai}^{bj} f^{bj} \\ \implies p_{ai}^{bj} &= \frac{h_{ai}^{bj}}{\lambda_a^b f^{bj}} \end{aligned}$$

Idea: remaining parameters come from changes across wages vs. occupations

Plug the structural parameters in the values in the log odds:

$$\begin{aligned}\varpi_{ai}^{bj} &= V_{bj} - V_{ai} - c_a^b \\ &= \frac{1}{\delta_b + \rho} \left(u_{bj} + \sum_w \chi_{bj}^{bw} (\varpi_{bj}^{bw} + c_b^b) - \sum_{o,w} \lambda_b^o \log(1 - p_{bj}^{ow}) f^{ow} \right) \\ &\quad - \frac{1}{\delta_a + \rho} \left(u_{ai} + \sum_w \chi_{ai}^{aw} (\varpi_{ai}^{aw} + c_a^a) - \sum_{o,w} \lambda_a^o \log(1 - p_{ai}^{ow}) f^{ow} \right) \\ &\quad + \frac{\delta_b - \delta_a}{(\delta_b + \rho)(\delta_a + \rho)} \left(u_n - \sum_{o,w} \lambda_n^o \log(1 - p_n^{ow}) f^{ow} \right) - c_a^b\end{aligned}$$

This expression is linear in u_{bj} , u_{ai} , u_n , and c_a^b

We can write this in matrix form as

$$\kappa = A\theta \quad \Rightarrow \quad \theta = A^+ \kappa$$

Additional structure: relative symmetry along skill content

Skill content of origin occupation	Elementary (1)	α_1^5	α_1^4	α_1^3	α_1^2	α_1^2	α_1^2	α_1^2	
Machine operators (2)		α_2^5	α_2^4	α_2^3	α_2^2	α_2^2	α_2^2		
Industry (2)		α_2^5	α_2^4	α_2^3	α_2^2	α_2^2			
Commercial (2)		α_2^5	α_2^4	α_2^3	α_2^2				
Office clerks (2)		α_2^5	α_2^4	α_2^3					
Technicians (3)		α_3^5	α_3^4						
Professionals (4)		α_4^5							
Managers (5)									

Skill content of destination occupation

Estimating wage change rates χ and separation rates δ

Estimation

$$(\hat{\chi}_{ai}^{aw})_r = \frac{\sum_\ell q_{\ell r} \sum_s \mathbb{1}(a_s = a, i_s = i, d_s = WW, j_s = w)}{\sum_\ell q_{\ell r} \sum_s \mathbb{1}(a_s = a, i_s = i) t_s}$$

$$(\hat{\delta}_a)_r = \frac{\sum_\ell q_{\ell r} \sum_s \mathbb{1}(a_s = a, d_s = EN)}{\sum_\ell q_{\ell r} \sum_s \mathbb{1}(a_s = a) t_s}$$

◀ Back

Likelihood contribution of a single spell s :

$$L_s(h) = \prod_{a,i} \prod_{b,j} \left[\left(h_{ai}^{bj} \right)^{\mathbb{1}(b_s=b, j_s=j)} \exp \left(-h_{ai}^{bj} t_s \right) \right]^{\mathbb{1}(a_s=a, i_s=i)}$$

Full likelihood:

$$L(h) = \sum_{\iota=1}^I \sum_{s=1}^{S_\iota} \log L_s(h)$$

Imposing structure:

$$L(\lambda, f, u, c) = \sum_{\iota=1}^I \sum_{s=1}^{S_\iota} \log L_s(\lambda f p(\lambda, f, u, c, \hat{\chi}, \hat{\delta}))$$

*m*th iteration:

$$\left(\sum_o \lambda_a^o + \sum_w \chi_{ai}^{aw} + \delta_a + \rho \right) V_{ai}^{(m)} = u_{ai} + \sum_o \lambda_a^o V_{ai}^{(m-1)} + \sum_w \chi_{ai}^{aw} V_{aw}^{(m-1)} + \delta_a V_n^{(m-1)} + \sum_{o,w} \lambda_a^o \log \left(1 + \exp \left(V_{ow}^{(m-1)} - V_{ai}^{(m-1)} - c_a^b \right) \right) f^{ow}$$

I calculate the CCPs as

$$p_{ai}^{bj} = \frac{\exp \left(V_{bj}^* - V_{ai}^* - c_a^b \right)}{1 + \exp \left(V_{bj}^* - V_{ai}^* - c_a^b \right)}$$

1. Estimate posterior type distribution using reduced-form full loglikelihood:

$$\max \sum_{\iota} \log \left[\sum_r \pi_r \left(\underline{L}_{\iota r} \prod_s \tilde{L}_{sr} \right) \right] \rightsquigarrow q_{\iota r}$$

2. Calculate wage change rates, job separation rates:

$$(\hat{\chi}_{ai}^{aw})_r = \frac{\sum_{\iota} q_{\iota r} \sum_s \mathbb{1}(a_s = a, i_s = i, d_s = WW, j_s = w)}{\sum_{\iota} q_{\iota r} \sum_s \mathbb{1}(a_s = a, i_s = i) t_s}, \quad (\hat{\delta}_a)_r = \frac{\sum_{\iota} q_{\iota r} \sum_s \mathbb{1}(a_s = a, d_s = EN)}{\sum_{\iota} q_{\iota r} \sum_s \mathbb{1}(a_s = a) t_s}$$

3. Estimate remaining structural parameters using expected complete loglikelihood:

$$\max \sum_{\iota} \sum_r q_{\iota r} \sum_s \log L_{sr}(\lambda f p(\lambda, f, u, c, \hat{\chi}, \hat{\delta}))$$

Cutoffs:

$$\phi_w = \begin{cases} \theta_1^\phi & \text{for } w = 1 \\ \phi_{w-1} + \exp(\theta_2^\phi + \theta_3^\phi \log w_w + \theta_4^\phi \log w_w^2) & \text{for } w > 1 \end{cases}$$

Logit structure:

$$f^{ow} = \begin{cases} \Lambda(\phi_w + \theta^o) & \text{for } w = 1 \\ \Lambda(\phi_w + \theta^o) - \Lambda(\phi_{w-1} + \theta^o) & \text{for } 1 < w < W \\ 1 - \Lambda(\phi_{W-1} + \theta^o) & \text{for } w = W \end{cases}$$

1. Optimize from “reasonable” starting values ($R = 1$)
2. Evaluate objective function in a Sobol sequence near local optimum
 - 1,000 points, $\pm 50\%$ vicinity
3. If higher value found, optimize using corresponding arg max as starting values
If not, global optimum found

Iterate steps 2-3 until convergence

Offered wages

Estimates

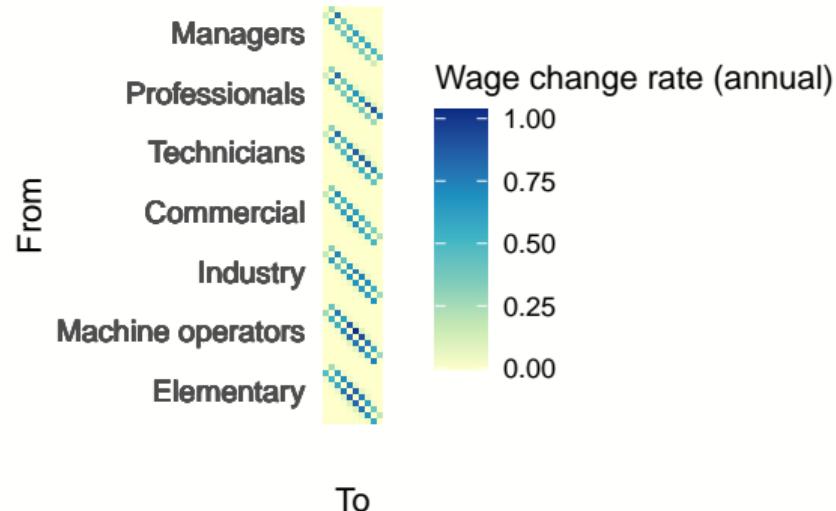


Structure

◀ Back

Wage change rates

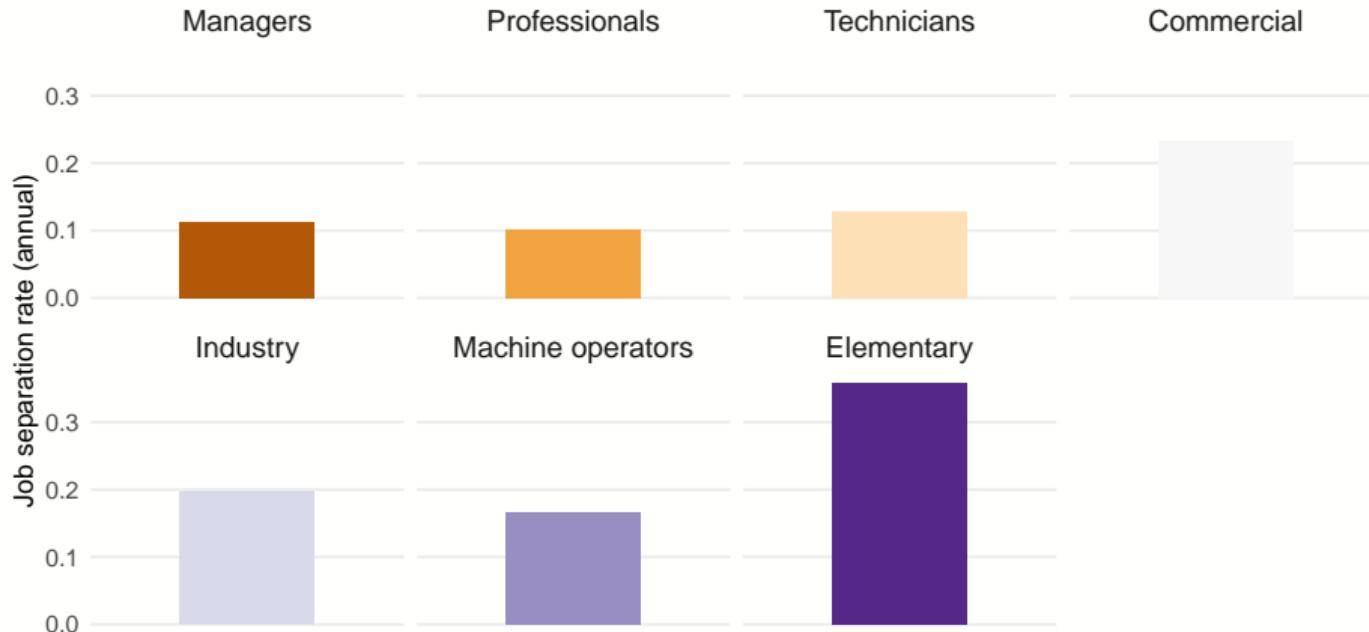
Estimates



◀ Back

Job separation rates

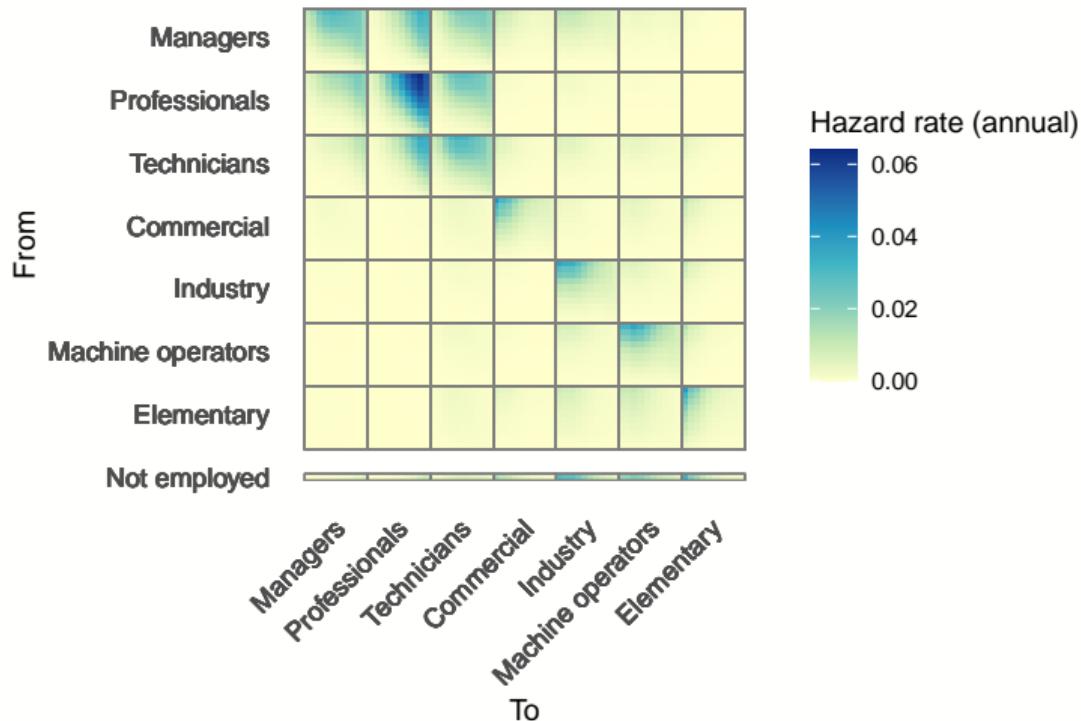
Estimates



◀ Back

Hazards

Estimates



◀ Back

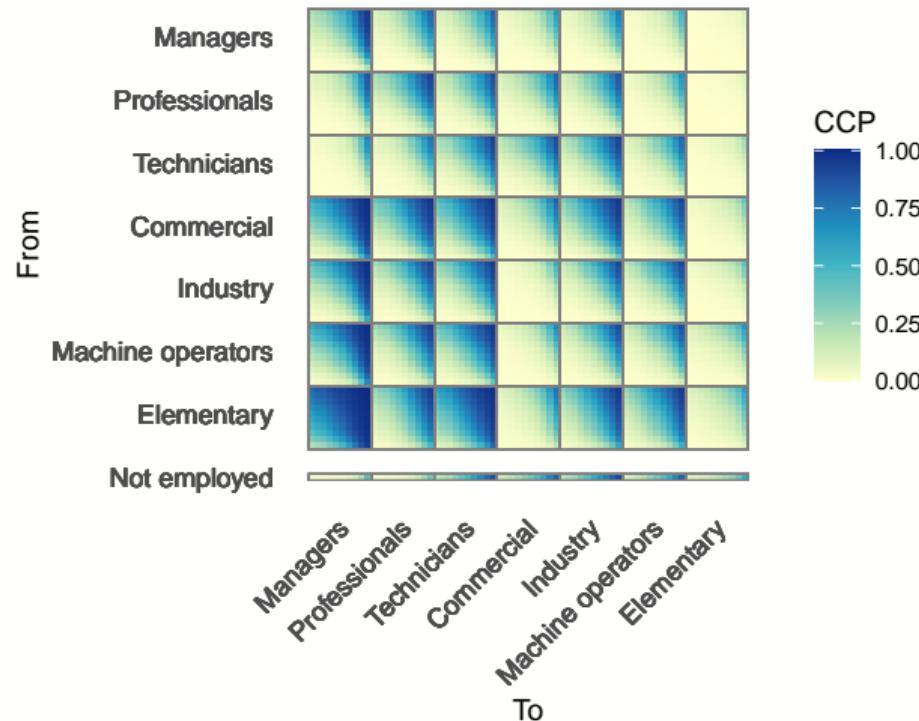
Offer arrival rates

Estimates

From	To							Total
	Managers	Professionals	Technicians	Commercial	Industry	Machine operators	Elementary	
Managers	0.54	0.40	0.62	0.72	0.71	0.44	0.62	4.05
Professionals	0.66	0.63	0.53	0.06	0.08	0.08	0.13	2.19
Technicians	0.57	0.47	0.49	0.12	0.11	0.18	0.57	2.51
Commercial	0.02	0.01	0.04	0.96	0.04	0.10	0.65	1.81
Industry	0.01	0.01	0.03	0.16	0.73	0.11	0.53	1.58
Machine operators	0.00	0.00	0.03	0.09	0.17	0.83	0.29	1.42
Elementary	0.00	0.00	0.03	0.18	0.10	0.14	0.94	1.39
Not employed	0.36	0.24	0.12	0.31	0.57	0.70	1.01	3.31

(annual rates)

◀ Back



Mean switching costs

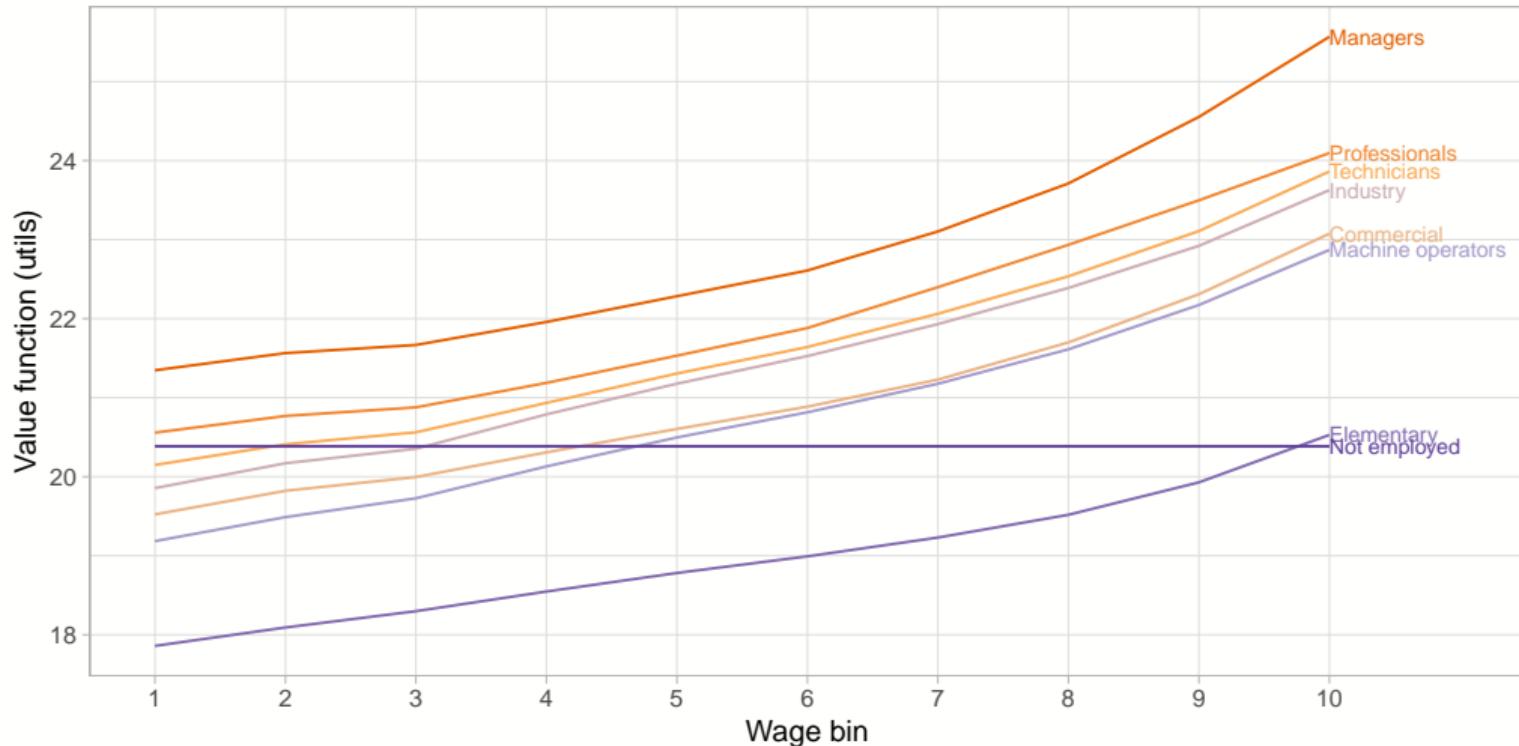
Estimates

From	Managers	Professionals	Technicians	Commercial	Industry	Machine operators	Elementary	Not employed
To	Managers	Professionals	Technicians	Commercial	Industry	Machine operators	Elementary	
Managers	1.21	1.28	1.01	1.20	1.28	1.45	1.20	
Professionals	3.18	1.16	1.24	1.01	1.26	1.64	2.06	
Technicians	4.50	2.71	1.15	0.73	1.01	1.21	1.29	
Commercial	1.60	1.46	0.83	2.05	1.00	1.01	1.43	
Industry	1.71	1.82	1.15	3.05	1.56	0.75	1.01	
Machine operators	1.94	2.36	1.38	3.07	2.28	1.73	0.80	
Elementary	2.10	3.59	1.95	3.97	2.82	2.22	2.24	
Not employed	5.42	4.21	1.33	1.01	1.01	1.01	0.00	
(utils)								

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Value functions

Estimates



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Compensating differentials

Estimates

How much would a median-wage worker in occupation a have to be compensated to accept a machine operator job?

$$\psi_a + \beta \log \bar{w}_a = \psi_{MO} + \beta \log w_a^{MO}$$

Occupation	β	ψ_a	Comp. diff.
Managers	1.01	-0.20	0.89
Professionals		-0.52	0.65
Technicians		-0.24	0.85
Commercial		0.04	1.14
Industry		0.13	1.24
Machine operators		-0.09	-
Elementary		-0.69	0.55

◀ Back

0. Initialize G individuals in each occupation and wage bin ($G = 1,000$)
1. Draw exponential durations using hazards h , wage change rates χ , and job separation rates δ
2. Take minimum duration (competing hazards), record new job

Repeat steps 1-2 until 45 years of cumulative durations are drawn