

The Option Value of Occupations

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+ *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

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 :

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

option value

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

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

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

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

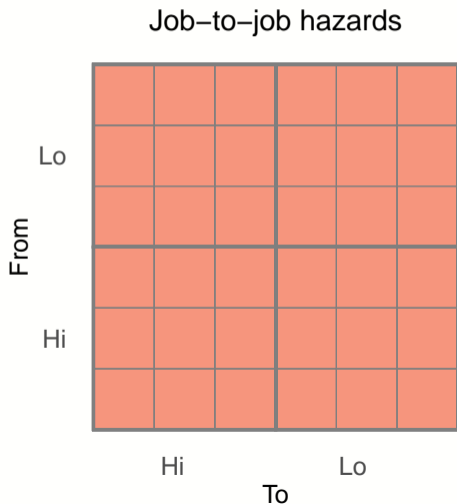
$$\text{hazard} = \underbrace{\text{Pr}(\text{offer arrives})}_{\text{opportunities}} \times \underbrace{\text{Pr}(\text{offer is accepted})}_{\text{choices}}$$

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

Identifying variation

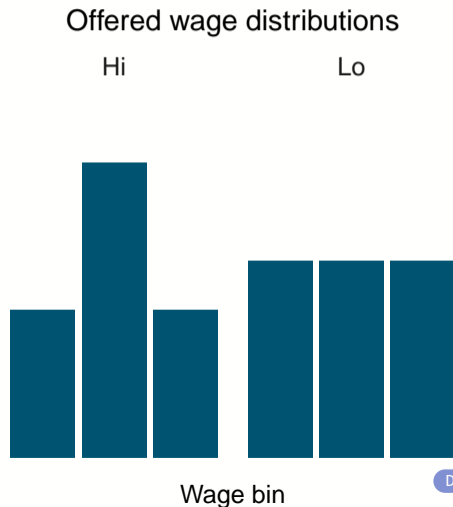
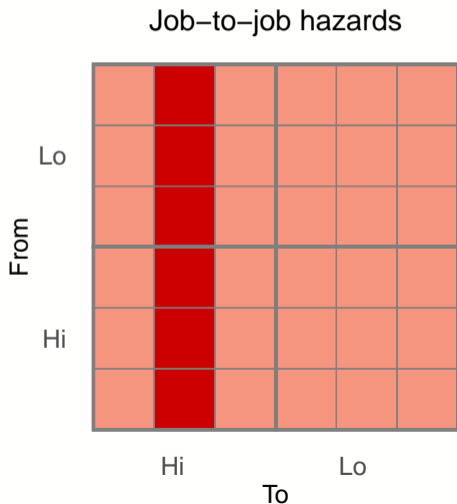
Hazards across destination jobs



Offered wage distributions



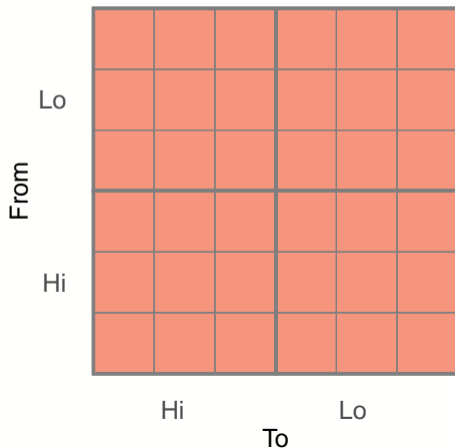
Identifying variation Hazards across destination jobs



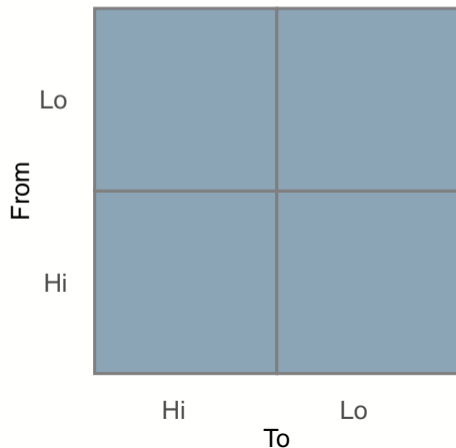
Identifying variation

Hazards across origin and destination occupations at high wages

Job-to-job hazards



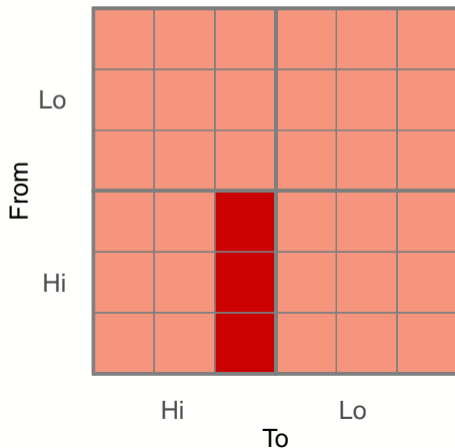
Offer arrival rates



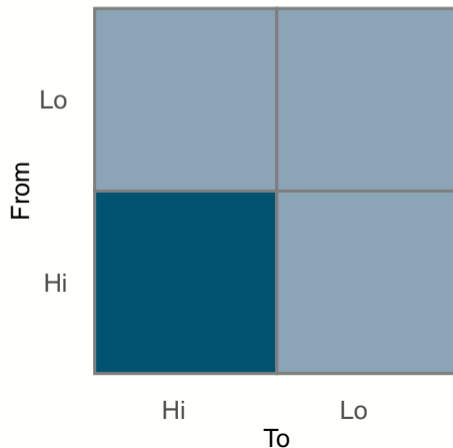
Identifying variation

Hazards across origin and destination occupations at high wages

Job-to-job hazards

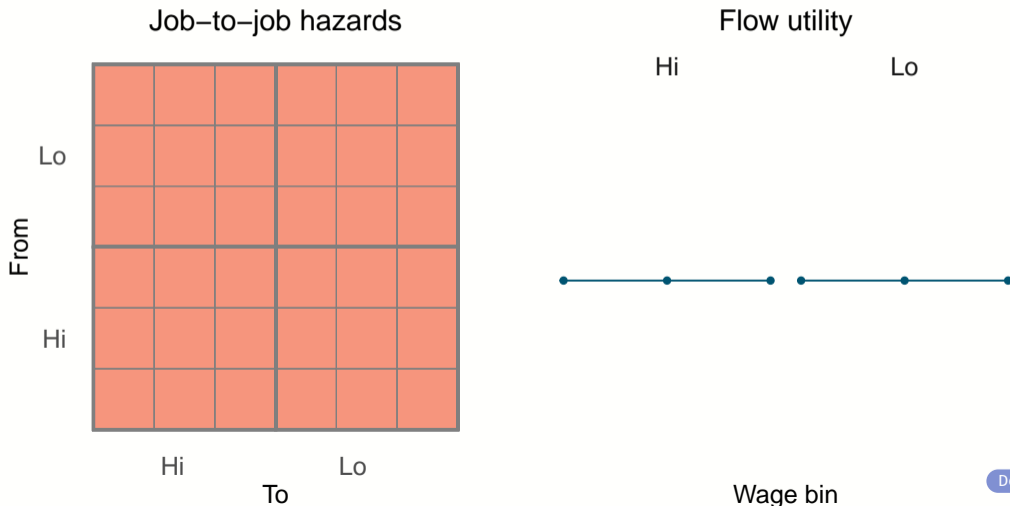


Offer arrival rates



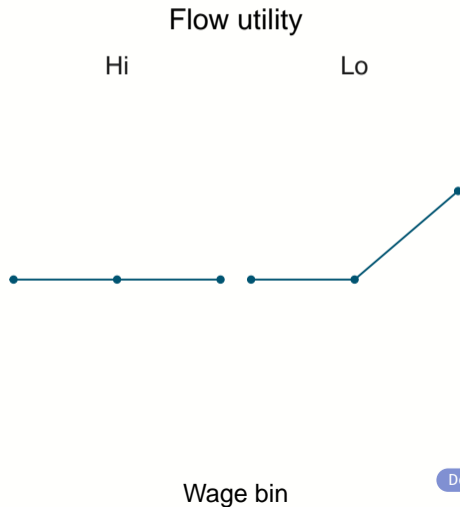
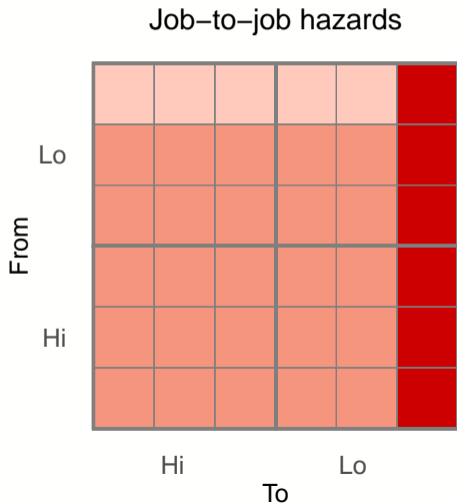
Identifying variation

Hazards across origin and destination jobs



Identifying variation

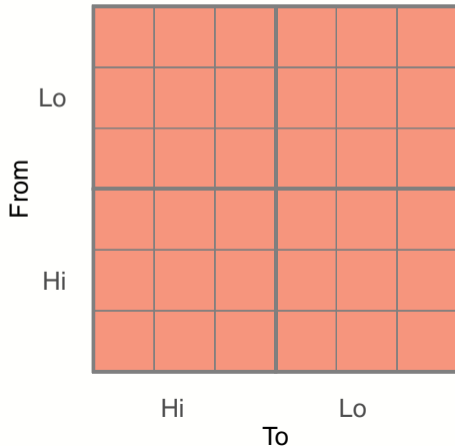
Hazards across origin and destination jobs



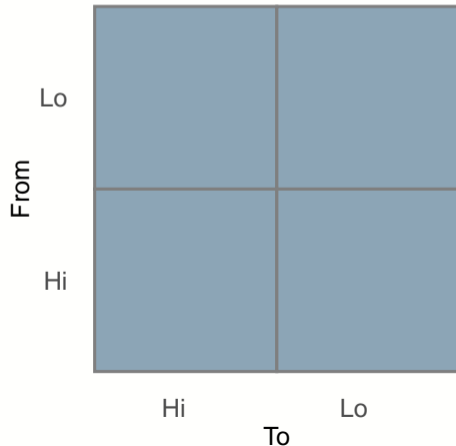
Identifying variation

Hazards across origin and destination occupations at all wages

Job-to-job hazards



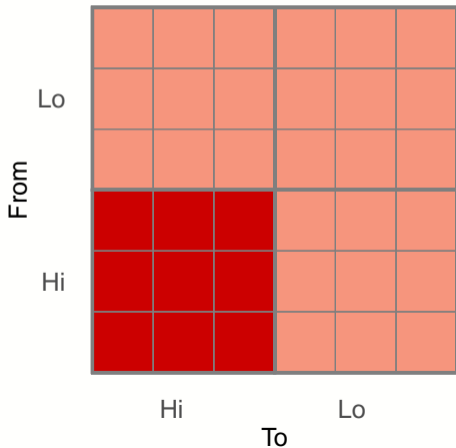
Switching costs



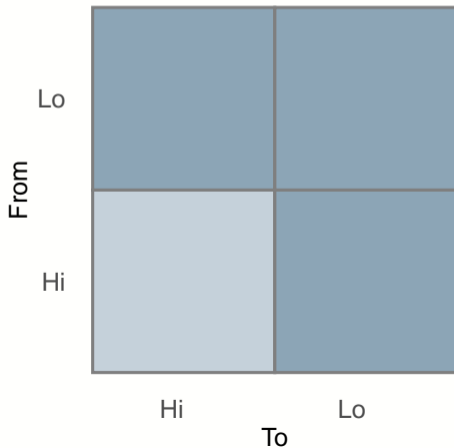
Identifying variation

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Job-to-job hazards



Switching costs



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

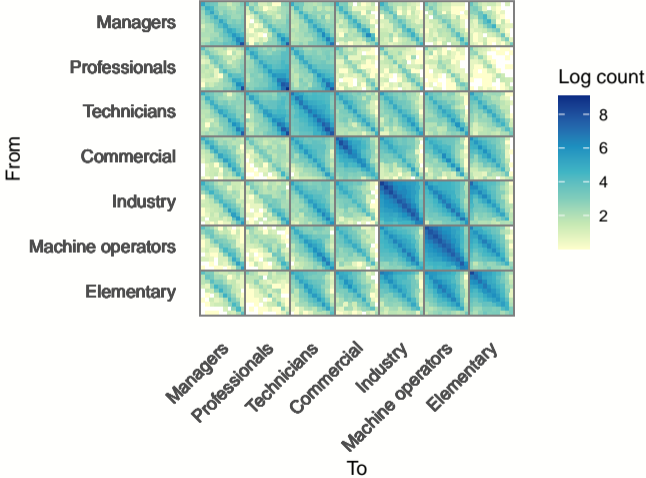
- 5 million individuals, 900 thousand firms per year
- Estimation sample: 22–50 males → 5 million job spells

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



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



The flow vs. option value of occupations

Estimates

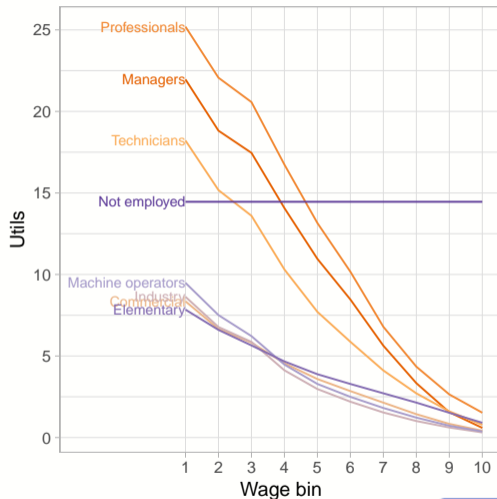
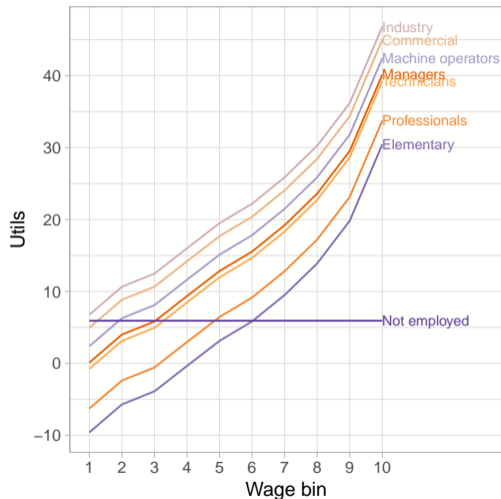
<i>Occupation</i>	<i>Mean flow value</i>	<i>Mean option value</i>	<i>Option / flow</i>
Professionals	9.6	12.3	1.280
Managers	16.0	10.3	0.642
Elementary	6.3	3.9	0.621
Technicians	15.1	8.0	0.529
Machine operators	18.3	3.8	0.206
Commercial	20.9	3.7	0.176
Industry	22.7	3.4	0.150

Formulas

Comp. diff'l's

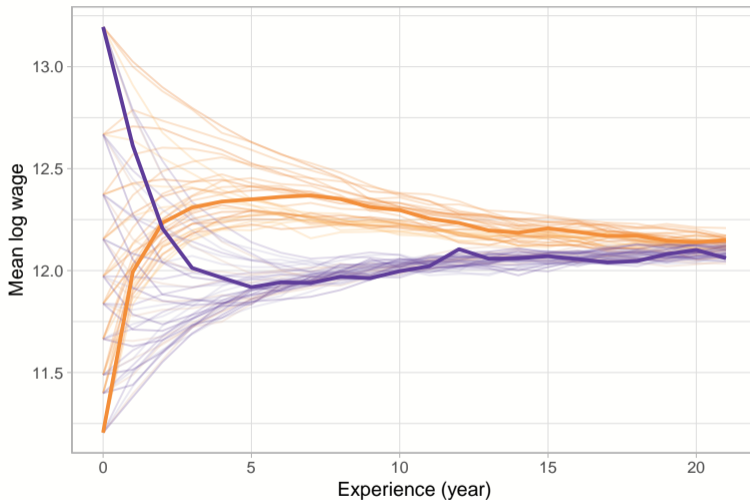
The flow vs. option value of jobs

Estimates



Formulas

Comp. diff'l's



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More at attilagyetvai.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), ...

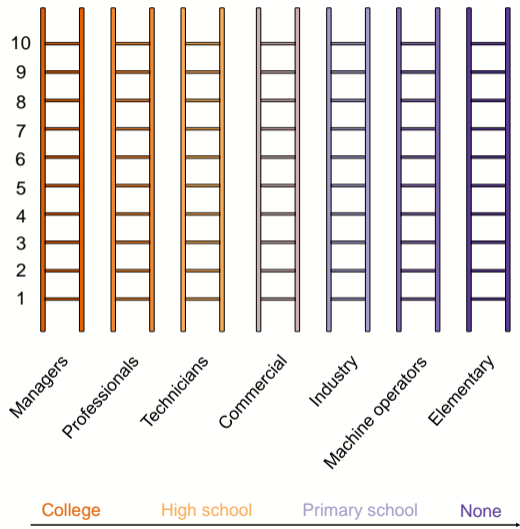
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Occupational ladders and skill levels



2-digit occs.

◀ Back

Skill levels and most frequent occupations

1-Managers College+HS

Managing directors
Legislators

2-Professionals College

STEM
Business, legal, and soc. sci.

3-Technicians High school

STEM
Business

4-Commercial Primary

Catering
Services

5-Industry Primary

Metal and electrical ind.
Construction

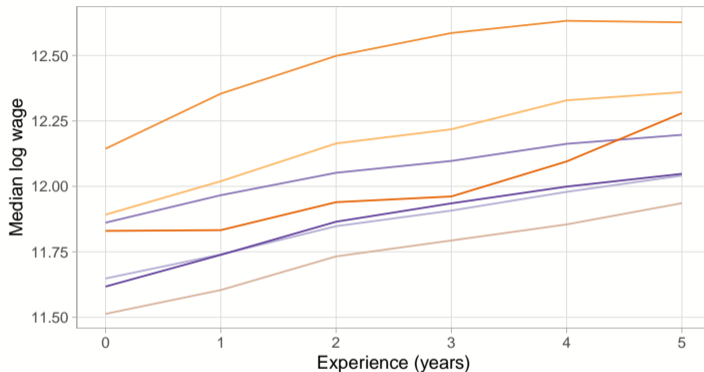
6-Machine operators Primary

Drivers
Assemblers

7-Elementary

Elementary

Occupations capture diverging wage trajectories



Starting occupation — Managers — Professionals — Technicians
— Commercial — Industry — Machine operators — Elementary

By age

By first occ.

By current occ.

Data

Job ladders

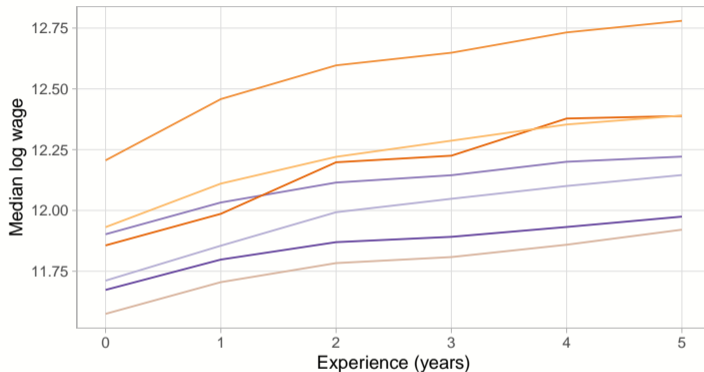
Transition matrix

◀ Back

Occupations capture diverging wage trajectories

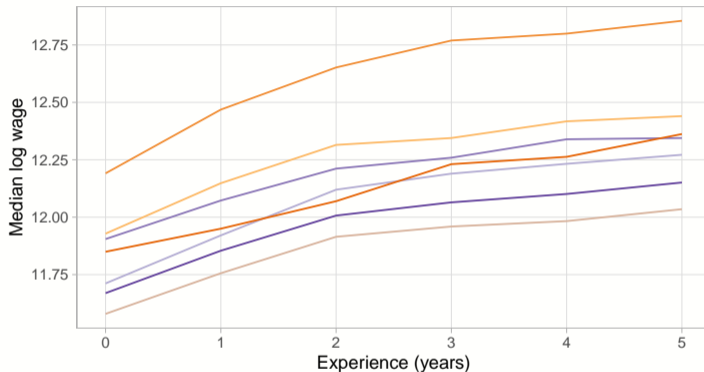


Occupations capture diverging wage trajectories



Current occupation — Managers — Professionals — Technicians
— Commercial — Industry — Machine operators — Elementary

Occupations capture diverging wage trajectories



Starting occupation — Managers — Professionals — Technicians
— Commercial — Industry — Machine operators — Elementary

Flow / continuation / option value—formulas

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

option 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

$$\frac{h_{ai}^{ai}}{h_{aj}^{aj}} = \frac{\lambda_a^a p_{ai}^{ai} f^{ai}}{\lambda_a^a p_{aj}^{aj} f^{aj}} = \frac{f^{ai}}{f^{aj}}$$

$$\Rightarrow f^{ai} = \frac{h_{ai}^{ai}}{\sum_w h_{aw}^{aw}}$$

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:

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

Next, offer arrives from another occupation:

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

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

By the hazard definition,

$$h_{ai}^{bj} = \lambda_a^b p_{ai}^{bj} f^{bj}$$
$$\Rightarrow p_{ai}^{bj} = \frac{h_{ai}^{bj}}{\lambda_a^b f^{bj}}$$

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

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

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)								
		Managers (5)	Professionals (4)	Technicians (3)	Office clerks (2)	Commercial (2)	Industry (2)	Machine operators (2)	Elementary (1)
		Skill content of destination occupation							

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

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

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:

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

Imposing structure:

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

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:

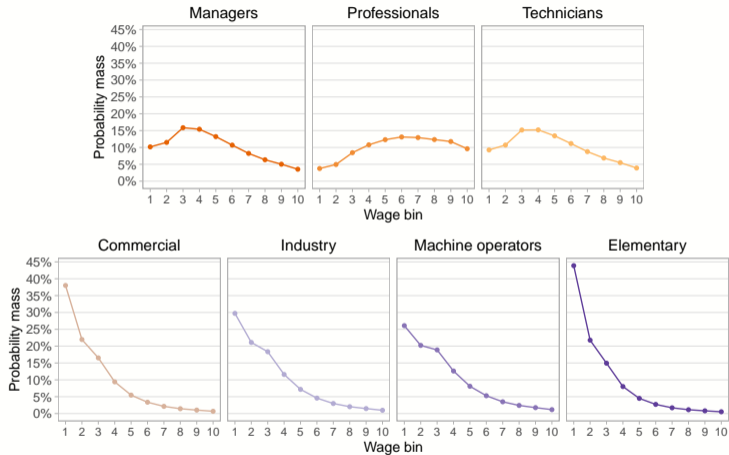
$$\phi_w = \begin{cases} \theta_1^\phi & \text{for } w = 1 \\ \phi_{w-1} + \exp(\theta_2^\phi + \theta_3^\phi \log w_w + \theta_4^\phi \log w_w^2) & \text{for } w > 1 \end{cases}$$

Logit structure:

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

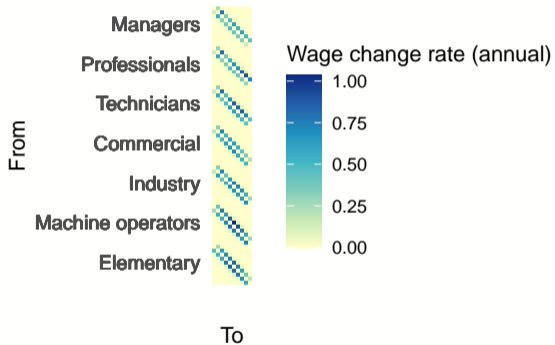
1. Optimize from “reasonable” starting values ($R = 1$)
2. Evaluate objective function in a Sobol sequence near local optimum
 - 1,000 points, $\pm 50\%$ vicinity
3. If higher value found, optimize using corresponding arg max as starting values
If not, global optimum found

Iterate steps 2-3 until convergence



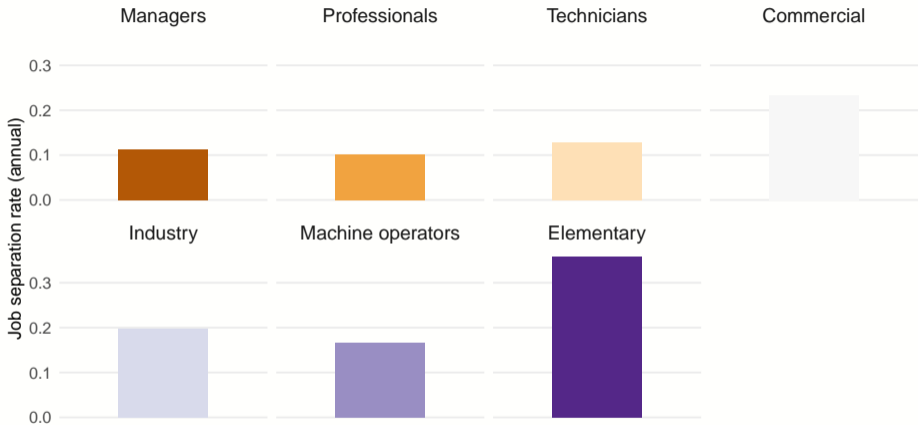
Wage change rates

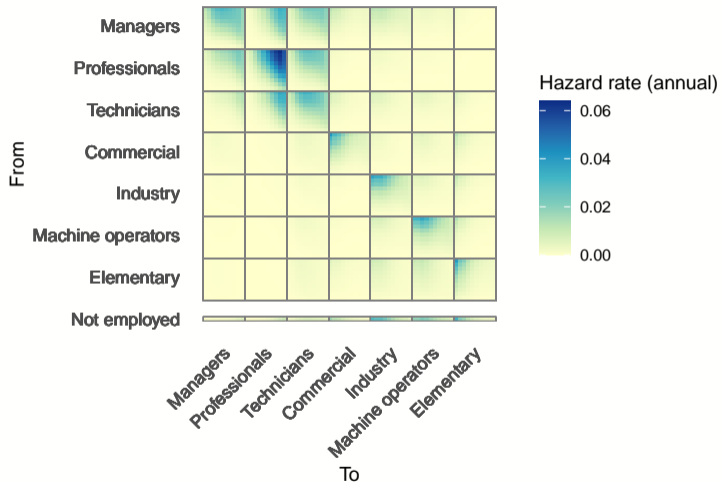
Estimates



Job separation rates

Estimates

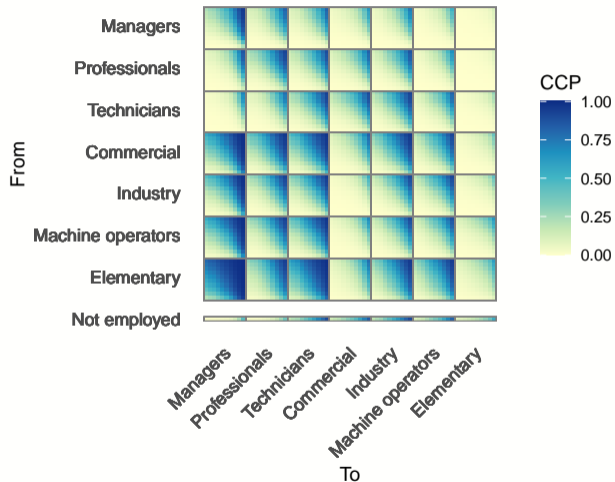




Offer arrival rates

Estimates

From	Managers	Professionals	Technicians	Commercial	Industry	Machine operators	Elementary	
	0.54	0.40	0.62	0.72	0.71	0.44	0.62	4.05
	0.66	0.63	0.53	0.06	0.08	0.08	0.13	2.19
	0.57	0.47	0.49	0.12	0.11	0.18	0.57	2.51
	0.02	0.01	0.04	0.96	0.04	0.10	0.65	1.81
	0.01	0.01	0.03	0.16	0.73	0.11	0.53	1.58
	0.00	0.00	0.03	0.09	0.17	0.83	0.29	1.42
	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
To								
(annual rates)								



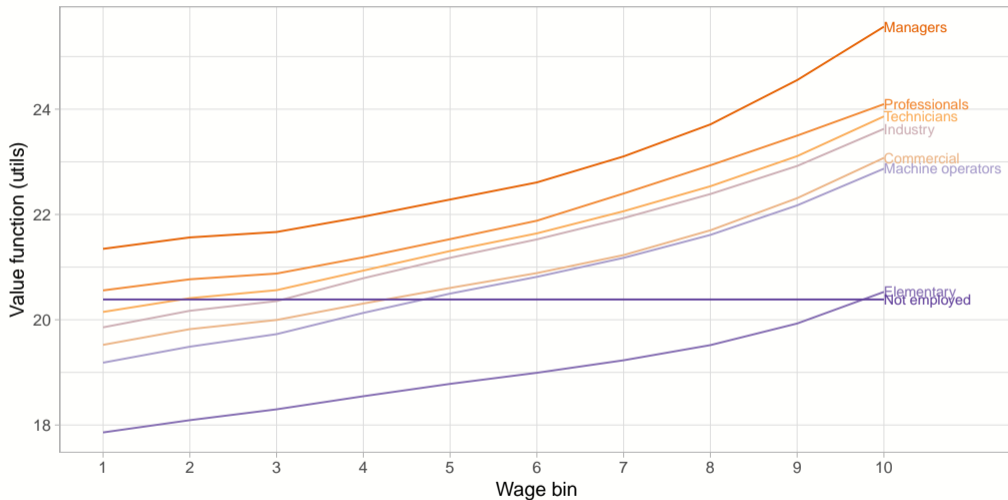
Mean switching costs

Estimates

From	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
		To						
		Managers Professionals Technicians Commercial Industry Machine operators Elementary						
		(utils)						

Value functions

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

- o. 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