Multidimensional Skills, Sorting, and Human Capital Accumulation

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Introduction

Refresher

Recall:

- study of wage and employment inequality
- classical view of human capital
- heterogeneous skills and requirements
- labour market as mediator

But:

- one catch-all skill
- at odds with intuition
- data much finer

Therefore: heterogeneous, multidimensional worker skills and skill requirements.
Their approach: multidimensional skills (cognitive, manual, interpersonal) and on-the-job learning into search model.

Model

Model

- Match Output is $f(\mathbf{x}, \mathbf{y})$ and depends on the match.
- Skills adjust gradually: $\dot{\mathbf{x}} = \mathbf{g}(\mathbf{x}, \mathbf{y})$
- Skills drawn from distribution $N(\cdot)$
- Exogenous transition rates $(\lambda_0, \lambda_1, \delta, \mu)$
- Utility $w - c(\mathbf{x}, \mathbf{y})$, or $b(\mathbf{x})$
- $P(\mathbf{x}, \mathbf{y})$ is value of firm-worker pair, $U(\mathbf{x})$ value of unemployment, W of wage contract

Worker's share of match surplus is

$$\frac{W - U(\mathbf{x})}{P(\mathbf{x}, \mathbf{y}) - U(\mathbf{x})}$$

Worker gets outside offer, Bertrand competition leads to him staying if $P(\mathbf{x}, \mathbf{y}) \geq P(\mathbf{x}, \mathbf{y}')$ with new wage $W' = \min\{P(\mathbf{x}, \mathbf{y}), P(\mathbf{x}, \mathbf{y}')\}$

Rent sharing and value functions

worker's renegotiated share of match surplus:

$$\sigma(\mathsf{x}, \mathsf{y}, \mathsf{y}') = \frac{P(\mathsf{x}, \mathsf{y}') - U(\mathsf{x})}{P(\mathsf{x}, \mathsf{y}) - U(\mathsf{x})}$$
$$\Leftrightarrow W' = P(\mathsf{x}, \mathsf{y}') = U(\mathsf{x}) + \sigma(\mathsf{x}, \mathsf{y}, \mathsf{y}')[P(\mathsf{x}, \mathsf{y}) - U(\mathsf{x})]$$

assumed to stay constant over time.

Value functions:

$$(r + \mu + \delta)P(\mathsf{x}, \mathsf{y}) = f(\mathsf{x}, \mathsf{y}) - c(\mathsf{x}, \mathsf{y}) + \delta U(\mathsf{x}) + \mathsf{g}(\mathsf{x}, \mathsf{y}) \cdot \nabla_{\mathsf{x}} P(\mathsf{x}, \mathsf{y}) \quad (1)$$

and

$$(r + \mu)U(\mathsf{x}) = b(\mathsf{x}) + \mathsf{g}(\mathsf{x}, 0) \cdot \nabla U(\mathsf{x}) \quad (2)$$

Wage equation

and the wage implementing the W solves:

$$(r+\delta+\mu)W(\mathbf{x},\mathbf{y},\sigma) = w(\mathbf{x},\mathbf{y},\sigma) - c(\mathbf{x},\mathbf{y}) + \delta U(\mathbf{x}) \tag{3}$$
$$+ \lambda_1 \mathbf{E} \max\{0, \min\{P(\mathbf{x},\mathbf{y}), P(\mathbf{x},\mathbf{y}')\} - W(\mathbf{x},\mathbf{y},\sigma)\} + \mathbf{g}(\mathbf{x},\mathbf{y}) \cdot \nabla_{\mathbf{x}} W(\mathbf{x},\mathbf{y},\sigma)$$

Combining all equations gives the wage equation:

$$\begin{aligned} w(\mathbf{x},\mathbf{y},\sigma) =& \sigma f(\mathbf{x},\mathbf{y}) + (1-\sigma) b(\mathbf{x}) + (1-\sigma) c(\mathbf{x},\mathbf{y}) \\ & - \lambda_1 \mathbf{E} \max\{0, \min\{P(\mathbf{x},\mathbf{y}') - P(\mathbf{x},\mathbf{y}), 0\} + (1-\sigma)(P(\mathbf{x},\mathbf{y}) - U(\mathbf{x}))\} \\ & - (1-\sigma)(\mathbf{g}(\mathbf{x},\mathbf{y}) - \mathbf{g}(\mathbf{x},\mathbf{0})) \cdot \nabla U(\mathbf{x}) \end{aligned}$$

Model Analysis - Closed Form

$$\mathbf{g}(\mathbf{x},\mathbf{y}) = \begin{pmatrix} \dot{x}_C \\ \dot{x}_M \\ \dot{x}_I \\ \dot{x}_T \end{pmatrix} = \begin{pmatrix} \gamma_C^u \max\{y_C - x_C, 0\} + \gamma_C^o \min\{y_C - x_C, 0\} \\ \gamma_M^u \max\{y_M - x_M, 0\} + \gamma_M^o \min\{y_M - x_M, 0\} \\ \gamma_I^u \max\{y_I - x_I, 0\} + \gamma_I^o \min\{y_I - x_I, 0\} \\ g x_T \end{pmatrix}$$

and $x_T(t) = x_T(0) \cdot e^{gt}$.

Production function:

$$f(\mathbf{x},\mathbf{y}) = x_T \cdot \left[\varphi(\mathbf{y}) - \sum_{k=C,M,I} \kappa_k^u \min\{x_k - y_k, 0\}^2 \right]$$

And

$$b(\mathbf{x}) = b x_T$$

Model Analysis

Disutility of work:

$$c(\mathbf{x}, \mathbf{y}) = x_T \times \sum_{k=C,M,I} \kappa_k^o \max\left\{x_k - y_k, 0\right\}^2$$

Only positive if overqualified $\rightarrow$ utility cost of being under-matched. Then the match surplus is:

$$P(\mathbf{x}(t), \mathbf{y}) - U(\mathbf{x}) = x_T(t) \times \left\{ \frac{\varphi(\mathbf{y}) - b}{r+\delta+\mu-g} \right.$$
$$\left. - \sum_{k=C,M,I} \left(\frac{\kappa_k^u \min\{x_k(t)-y_k, 0\}^2}{r+\delta+\mu-g+2\gamma_k^u} + \frac{\kappa_k^o \max\{x_k(t)-y_k, 0\}^2}{r+\delta+\mu-g+2\gamma_k^o} \right) \right.$$

First term is the surplus for perfect match, the remaining terms reflect the cost of initial mismatch.

Data & Estimation

Data

Worker-level: NLSY79. PCA and exclusion restrictions of ASVAB, Rotter, Rosenberg, health, social...

Occupational-level: O*NET. Over 200 descriptors reduced to three dimensions by PCA and three exclusion restrictions

1770 males followed for 30 years

Estimation

- By indirect inference, discrete-time approximation.
  Pre-sampling simulation until actual unemployment rate is reached $\rightarrow$ initial state
- $\varphi(\mathbf{y}) = \alpha_T + \alpha_C y_C + \alpha_M y_M + \alpha_I y_I$ assumed.
- Initial specific skills are fully observed.
- Model for general skills: unrestricted correlation
  $x_T(t) =$
  $\exp\left(g \cdot t + \zeta_S \cdot \text{Schooling years} + \zeta_C x_C(0) + \zeta_M x_M(0) + \zeta_I x_I(0) + \varepsilon_0\right)$
- Skill requirements are transforms of O*NET measures:
  $y_k = \widetilde{y}_k^{\xi_k}$, with $\xi_k > 0$
- 32 parameters are estimated by targeting 6 moments (they argue are valid approximations to identification restrictions)

Results

Results

Good model fit to the data and to wage regression coefficients. Then the parameter estimates are:

Table 2: Parameter estimates

production function*							disutility of work*			un. inc.
α_T	α_C	α_M	α_I	κ_C^u	κ_M^u	κ_I^u	κ_C^o	κ_M^o	κ_I^o	b
108.3	117.7	53.8	54.4	3,077.4	473.7	135.5	44.3	201.1	67.7	119.1
(11.4)	(8.55)	(2.78)	(3.91)	(136.6)	(30.5)	(7.07)	(2.08)	(9.94)	(3.29)	(4.99)
				(76.9)	*(20.4)*	*(2.8)*	*(1.1)*	*(8.7)*	*(1.4)*	

skill accumulation function**							general efficiency			
γ_C^u	γ_C^o	γ_M^u	γ_M^o	γ_I^u	γ_I^o	g	ζ_S	ζ_C	ζ_M	ζ_I
0.008	0.003	0.033	0.030	0.001	5.8e − 7	0.002	0.026	0.74	−0.20	0.31
(.001)	(.000)	(.002)	(.002)	(.001)	(.001)	(9e−5)	(.012)	(.198)	(.102)	(.060)
(7.64)	*(17.5)*	*(1.74)*	*(1.90)*	*(56.9)*	*(99,397)*					

sampling distribution***									transition rates		
ξ_C	ξ_M	ξ_I	ρ_{CM}	ρ_{CI}	ρ_{IM}	β_C	β_M	β_I	λ_0	λ_1	δ^{****}
1.03	0.89	0.82	0.21	0.64	−0.47	2.51	1.18	3.00	0.37	0.17	0.02
(.069)	(.057)	(.050)	(.009)	(.021)	(.015)	(.118)	(.043)	(.123)	(.019)	(.008)	(.001)
			(0.20)	*(0.62)*	*(−0.45)*	*(0.29)*	*(0.46)*	*(0.25)*			

Results

Distributions:

- Employers are looking for specialists, and seem to demand fewer cognitive skills than available
- Evolution is towards workers gaining C and losing M on average
- Already limited degree of specialisation regresses further

Sorting & Mismatch:

- Impression of positive sorting and increases with exp $\rightarrow$ comb of workers gradually sorting into jobs for which their skills are suited and adjusting skills to requirements
- Mostly over-skilled in C dimension

Counterfactuals

Counterfactuals

1. How efficient is job acceptance and rejection compared to social planner optimum? Planner internalises future match surplus.

$$\begin{aligned}(r+\delta+\mu)P^*(\mathrm{x},\mathrm{y}) =& f(\mathrm{x},\mathrm{y}) - c(\mathrm{x},\mathrm{y}) + \delta U^*(\mathrm{x}) + \mathrm{g}(\mathrm{x},\mathrm{y})\cdot\nabla_{\mathrm{x}}P^*(\mathrm{x},\mathrm{y}) \\ &+\lambda_1 \mathrm{E}\max\left\{P^*\left(\mathrm{x},\mathrm{y}'\right) - P^*(\mathrm{x},\mathrm{y}),0\right\} \end{aligned} \tag{4}$$

and

$$(r+\mu)U^*(\mathbf{x}) = b(\mathbf{x}) + \mathbf{g}(\mathbf{x},\mathbf{0})\cdot\nabla U^*(\mathbf{x}) + \lambda_0 \mathrm{E}\max\left\{P^*\left(\mathbf{x},\mathbf{y}'\right) - U^*(\mathbf{x}),0\right\} \tag{5}$$

For g(x,y)=0: *E2E* reallocation is efficient, *U2E* is not

For g(x,y)>0: *U2E* (though 2 competing effects) and *E2E* (short-sighted wage gains) smaller for planner. Output gain is very small

Counterfactuals

2. Cost of frictions: First eliminate mismatch, then search frictions. Frictionless output is 40% higher, most of which (35%) is due to direction rather than frequency.

3. Cost of early-career mismatch: what if initial job is most preferred job? $\rightarrow$ career output up by 8-22%. A share is due to initial high unemployment in the data (worst form of mismatch), increases in M and I, but U-shaped in C $\rightarrow$ connection to graduating in a recession.

Summary

Summary

The three different skills are very different productive attributes.

- Manual skills: moderate returns and adjust quickly
- Cognitive: much higher returns, slower to adjust
- Interpersonal: moderate returns, pretty much don't adjust
- Cost of skill-mismatch: very high for C, employing under-qualified in C worker much worse than hiring over-qualified C