Endogenous TFP, Labor Market Policies and Loss of Skills

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Motivation

- Large differences in TFP among OECD countries
  - What determines TFP?

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  - If more, longer unemployment spells

    $\Rightarrow$ economy less productive

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    ⇒ affect TFP
- Unemployed workers suffer large productivity losses
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    ⇒ economy less productive
- Question:
  - TFP with search frictions & skill loss during unemp?
  - Effect of labor market policies on TFP and u?

Why skill loss?

- 1960-1995
  - high UI in EU vs US
  - $u \uparrow$ in EU, $u \sim$ constant in US
  - TFP $\uparrow$ in EU relative to US

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  & role of policy (UI) successful, if UI $\uparrow$
  $\Rightarrow$ better/productive matches formed
  $\Rightarrow$ TFP $\uparrow$

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- Theories emphasizing average productivity
  & role of policy (UI) successful, if UI $\uparrow$
  $\Rightarrow$ better/productive matches formed
  $\Rightarrow$ TFP $\uparrow$
- However, 1995-onwards
  - UI $=$ or $\uparrow$ in EU vs US
  - $u \sim$ constant or $\uparrow$ in EU, $\sim$ constant in US
  - TFP $\downarrow$ in EU relative to US

This paper

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- Aggregate production, TFP determined by
  - Productivity of matches formed/active
    $\rightarrow$ reservation productivity
  - Aggregate distribution of skills
    $\rightarrow$ job finding rate, reservation productivity

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- Job finding rate, reservation productivity
  $\rightarrow$ "sufficient" statistics for TFP

Main results

- Two opposing channels
  - Average productivity
    - reservation productivity ↑

      ⇒ raises TFP (average matches more productive)
  - Skill channel
    - Reservation productivity and job finding rate

      ⇒ compositional effect on skill distribution

      ⇒ affect TFP
- Effects of UI
  - small on skill distribution, large on reserv value ⇒ TFP ↑
  - large on distribution, small on reserv value ⇒ TFP ↓
- Additional mechanism joint behavior of UI, u, TFP
  - Quantitatively, skill loss affect impact of UI? (wip...)

Related literature

- TFP and labor market frictions
  - Lagos (2006 RESTUD), Marimon Zilibotti (1999 EJ), Ortego-Marti (2017 EER), Petrosky-Nadeau (2013 JET)
- Search and skill loss
  - Pissarides (1992 QJE), Lungqvist Sargent (1998 JPE), Doppelt (2019 RED), Ortego-Marti (2016 JME, 2017 MD)
- Development accounting, no search
  - Caselli (2005), Bils & Klenow (2000 AER), Hall & Jones (1999 QJE), Klenow & Rodriguez-Clare (1997 JME), Lagakos (2016 JPE), Prescott (IER 1998), Restuccia et al (2008 JME)

Related literature

- Job displacement
  - Addison & Portugal (1989 JLE), Topel (1990 CRNC), Ruhm (1991 AER), Jacobson et al (1993 AER), Neal (1995 JLE), Stevens (1997 JLE), Couch & Placzek (2010 AER), von Wachter et al
- Loss of skills, further evidence
  - motherhood and earnings: Mincer (1979 JPE), Mincer & Ofek (1982 JHE)
  - test scores: Estin Gustavsson (2008)
  - breaks in production: health services, David & Brachet (2011 AEJ Micro), Hockenberry (2014 JHE); data entry, Globerson et al (1989 IIE); mechanical assembly, Bailey (1989 MS); car radio production, Shafer (2001 MS)

Environment

- Model builds on Mortensen Pissarides (1994), Lagos (2006)
- Time continuous, discount rate r
- Agents, risk averse
  - Workers
  - Firms
- Firms post vacancies to find workers
- Unemployed workers search for jobs

Search & matching frictions

- Matching function $m(u, v)$
  - Unemployed u, vacancies v
  - Market tightness $\theta = v/u$
- Finding rates
  - Workers: $\theta q(\theta) = \frac{m(u,v)}{u}$
  - Firms: $q(\theta) = \frac{m(u,v)}{v}$
- Exogenous separation at rate s
- Workers leave labor force/die at rate μ
  - Ensures stationarity of endogenous skill distribution

Production function, firm level

- Lagos (2006), Houtthaker (1955)
  - fixed proportion technologies/Leontieff
- Match production technology: $f(x, n, k) = x \min(n, k)$
  - x: match quality, $x \sim G(.)$
  - n: hours
  - k: capital
- Poisson rate λ

  $\rightarrow$ shock to match quality, new draw from $G(.)$
- k capture scale of operation
  - assumption, all projects same scale

Skill loss

- Workers suffer skill loss during unemployment

- Two skill levels: H, L
  - Workers born H
  - If H unemployed

    $\rightarrow$ become L at rate σ
  - Emperical evidence

    $\rightarrow$ skill loss v persistent, does not wash away
  - Tractable, closed form endogenous TFP

    (but can be generalized)

- Low skill L output
  - $\delta f(x, n, k)$, with $0 < \delta < 1$

Endogenous skill distribution

- Skill distribution

  $\rightarrow$ TFP through agg human capital

- Unemployed: u_H, u_L

- Employed: e_H, e_L

- Skill distribution
  - Unemployed: $\Delta_u = u_H/u$
  - Employed: $\Delta_e = e_H/e$

Bellman equations: unemployed workers

- Non-market time
  - H unemp workers: b
  - L unemp workers: $b\delta$

- Bellman unemployed

$$(r+\mu)U_H = b + \theta q(\theta)\int \max\{W_H(z) - U_H, 0\}dG(z) + \sigma(U_L - U_H)$$

$$(r+\mu)U_L = b\delta + \theta q(\theta)\int \max\{W_L(z) - U_L, 0\}dG(z)$$

Bellman equations: employed workers

- Wages $w_i(x)$, $i = H, L$

- Bellman employed, $i = H, L$

$$(r + \mu)W_i(x) = w_i(x) + \lambda \int \max\{W_i(z) - U_H, 0\} dG(z) - (\lambda + s)(W_i(x) - U_i)$$

Bellman equations: firms

- Profits $\pi_i(x)$, $i = H, L$
- Bellman filled job, $i = H, L$

$$(r+\mu)J_i(x) = \pi_i(x) + \lambda \int \max\{J_i(z) - V, 0\} dG(z) - (\lambda + s)(J_i(x) - V),$$

- Bellman vacancy

$$rV = -ck + q(\theta)[\Delta_u \int \max\{J_H(z) - V, 0\} dG(z) + (1-\Delta_u) \int \max\{J_L(z) - V, 0\} dG(z)]$$

- Assume
  - free entry for vacancies $\Rightarrow V = 0$
  - capital must be pre-installed, rental cost c

Firms profits, H workers

- Similar to Lagos (2006)
- Revenue: $f(x, n, k)$
- Costs:
  - Rental cost of capital: ck
  - Variable cost: ϕn
  - "Fixed" cost: $C(x, \phi)k = \max\{\phi - x, 0\}$

    $\rightarrow$ non-increasing in x is enough, Lagos (2006)

$$\Rightarrow \pi_H(x) = f(x, n, k) - w_H(x) - ck - \phi n - C(x, \phi)k$$

Firms profits, L workers

- Revenue: $\delta f(x,n,k)$

- Tractability, costs proportional too (not essential)
  - Rental cost of capital: δck
  - Variable cost: $\delta\phi n$
  - "Fixed" cost: $\delta C(x,\phi)k$

$$\Rightarrow \pi_L(x) = \delta f(x,n,k) - w_L(x) - c\delta k - \phi\delta n - \delta C(x,\phi)k$$

- If assume same costs

  $\rightarrow$ larger effect of skill loss on TFP (share $L\uparrow$)

Equilibrium

- Optimal hours

$$n(x) = \begin{cases} k, & \text{if } \phi < x \\ 0, & \text{if } \phi \geq x \end{cases}$$

- Note: choice of hours

  $\neq$ job destruction decision (hoarding possible)

- Profits

$$\pi^H(x) = (x - c - \phi)k - w^H(x).$$
$$\pi^L(x) = (x - c - \phi)\delta k - w^L(x).$$

Surplus

- Surplus: $S^i(x) = J^i(x) + W^i(x) - U^i - V$, $i = L, H$
  - Increasing in x
  - $\exists!$ R_i such that $S^i(R_i) = 0$, $i \in \{H, L\}$

- Assume NB over wages,

  β worker bargaining strength

$$w_i(x) = \underset{w_i(x)}{\arg\max} \left[W_i(x) - U_i\right]^{\beta} \left[J_i(x) - V\right]^{1-\beta}.$$

- Wages

$$w_H(x) = \beta(x - c - \phi)k + (1 - \beta)(r + \mu)U_H \;, \; \forall x \geq R_H$$

$$w_L(x) = \beta(x - c - \phi)\delta k + (1 - \beta)(r + \mu)U_L \;, \; \forall x \geq R_L$$

Reservation values

Proposition

The reservation productivity is larger for workers with low human capital, i.e. $R_H \leq R_L$

- Useful to derive aggregate TFP.
- Intuition: match with $H \rightarrow$ larger surplus

  $\Rightarrow$ firm and worker willing to form less productive matches

  $\Rightarrow$ better matches required with L worker for > 0 surplus
- $\delta = 1 \Rightarrow R_L = R_H$

Equilibrium

- Equilibrium $\{\theta, R_L, R_H, \Delta_u, \Delta_e\}$ satisfies
  - Job Creation Condition (JC):

    $\Rightarrow$ Free Entry $V = 0$

  - Job Destruction Conditions (JDH, JDL):

    $\Rightarrow S^H(R_H) = 0$, $S^L(R_L) = 0$

  - Distributions Δ_u, Δ_e stationary

- Set $\delta = 1$ (no skill loss)

  $\Rightarrow$ Lagos (2006)

Job Creation Condition

$$\frac{c}{q(\theta)} =$$

$$= \frac{(1-\beta)\left[\Delta_u \int_{R_H} (z - R_H) dG(z) + (1-\Delta_u)\delta \int_{R_L} (z - R_L) dG(z)\right]}{r + \mu + \lambda + s}$$

- Intuition
  - Post vacancies until

    expected vacancy cost = expected value of filled job

Job Destruction Conditions

$$(R_H - \phi - c)k + \lambda \int_{R_H} \frac{z - R_H}{r + \mu + \lambda + s} k dG(z) - (r + \mu)U_H = 0$$

$$(R_L - \phi - c)\delta k + \lambda \int_{R_L} \frac{z - R_L}{r + \mu + \lambda + s} k dG(z) - (r + \mu)U_L = 0$$

where

$$(r + \mu)U_L = b\delta + \beta f(\theta) \int_{R_L} \frac{z - R_L}{r + \mu + s + \lambda} \delta k dG(z)$$

$$U_H = \beta(\theta) \left(\frac{r + \mu}{r + \mu + \sigma} \right) \int_{R_H} \frac{z - R_H}{r + \mu + s + \lambda} k dG(z)$$
$$+ \frac{\sigma}{r + \mu + \sigma} \beta f(\theta) \int_{R_L} \frac{z - R_L}{r + \mu + s + \lambda} \delta k dG(z) + \left(\frac{r + \mu + \delta\sigma}{r + \mu + \sigma} \right) b$$

Endogenous distributions

- From flow equation + stationarity

$$\Delta_u = \frac{\mu[f(\theta)(1 - G(R_L)) + s + \lambda G(R_L) + \mu]}{\mu[f(\theta)(1 - G(R_L)) + s + \lambda G(R_L) + \mu] + \sigma(s + \lambda G(R_L) + \mu)}$$

$$\Delta_e = \frac{1}{1 + \frac{e_L}{e_H}}$$

where

$$\frac{e_L}{e_H} = \frac{1 - G(R_L)}{1 - G(R_H)} \cdot \frac{\sigma}{\mu} \cdot \frac{s + \lambda G(R_H) + \mu}{f(\theta)(1 - G(R_L)) + s + \lambda G(R_L) + \mu}$$

Existence and uniqueness

Proposition

Assume $\eta < \bar{\eta}$ and $\underline{\theta} < \bar{\theta}$. Then the equilibrium exists and is unique

Intuition

- Implicit theorem

  $\Rightarrow$ can express $R_L = R_L(\theta)$ using JD for L workers

- Reduce equilibrium to one JD, one JC

- First condition ensures JC downward sloping

  If η "too large", u distribution improves too much when $\theta \uparrow$

- Second condition similar to Lagos (2006), ensures crossing

Aggregation: Preview

- Aggregate, TFP depends on
  - match quality
  - human capital distribution
- R_L, R_H, θ "sufficient" statistics
  - uniquely determine TFP
- Lagos (2006) $\rightarrow$ TFP determined by match quality
- With skill loss $\rightarrow$ TFP depends on match quality *and* human capital

Distribution of match quality

- CDF observed match quality: $\tilde{G}^H(.)$, $\tilde{G}^L(.)$
- Flow equation, $i \in \{H, L\}, \forall x \geq R_i$

$$\begin{aligned}\frac{d[\tilde{G}^i(x)e^i]}{dt} =& \lambda e^H[1 - \tilde{G}^i(x)][G(x) - G(R^i)] \\ &+ f(\theta)u^i[G(x) - G(R^i)] - \lambda e^i \tilde{G}^i(x)[1 - G(x)] \\ &- \lambda e^i \tilde{G}^i(x) G(R^i) - (s + \mu) e^i \tilde{G}^i(x)\end{aligned}$$

- Steady-state, $d[\tilde{G}^i(x)e^i]/dt = 0$

$$\tilde{G}^i(x) = \frac{G(x) - G(R^i)}{1 - G(R^i)}, \text{ for } i \in \{H, L\}. \tag{1}$$

Aggregation

- Follow Lagos (2006) method
- Aggregate output, capital, hours/labor: Y, K, N
  - Relationship b/w aggregate variables?
- Aggregate capital: K

$$K = [1 - (1-\theta)u]k$$

$\Rightarrow$ Effective capital $K_e = \frac{1-u}{1-(1-\theta)u} K$

Aggregating output

- Firm with worker $i \in \{H, L\}$ produces if
  - $x \geq R_i$ (job active/created)
  - $x \geq \phi$ (>0 hours)
- Define: $\mu_i = \max\{R_i, \phi\}$, $i \in \{H, L\}$
- Aggregate output

$$
\begin{aligned}
Y =&(1-\Delta_e)(1-u)\int_{\mu_L} \delta f(x, n(x), k) d\tilde{G}^L(x) \\
&+ \Delta_e(1-u)\int_{\mu_H} f(x, n(x), k) d\tilde{G}^H(x).
\end{aligned}
$$

Aggregating hours

- Similarly, aggregate hours N

$$N = (1-u)\Delta_e \int_{\mu_H} n(x) d\tilde{G}^H(x) + (1-u)(1-\Delta_e) \int_{\mu_L} n(x) d\tilde{G}^L(x)$$

Distribution match quality

- Assume $G(.) \sim$ Pareto, $\varepsilon > 0$, $\alpha > 1$

$$G(x) = \begin{cases} 0 & \text{, if } x < \varepsilon \\ 1 - \left(\frac{\varepsilon}{x}\right) & \text{, if } \varepsilon \leq x \end{cases}$$

- Distribution, observed matches

$$\tilde{G}^i(x) = \begin{cases} 0 & \text{, if } x < R_i \\ 1 - \left(\frac{R_i}{x}\right) & \text{, if } R_i \leq x \end{cases}$$

Proposition

Let $\gamma \equiv 1/\alpha$. The economy's aggregate production function $Y = F(K_e, N)$ satisfies

$$Y = F(K_e, N) = AK_e^{\gamma} N^{1-\gamma},$$

where A is the economy's TFP, with

$$A = \begin{cases} A_l = \frac{\Delta_e R_H^{\frac{1}{\gamma}} + (1-\Delta_e) R_L^{\frac{1}{\gamma}} \delta}{\left[\Delta_e R_H^{\frac{1}{\gamma}} + (1-\Delta_e) R_L^{\frac{1}{\gamma}}\right]^{1-\gamma}} \cdot \frac{1}{1-\gamma} & , \text{ if } R_H < R_L \leq \phi \\ A_m = \frac{\Delta_e R_H^{\frac{1}{\gamma}} + (1-\Delta_e) R_L \delta \phi^{\frac{1}{\gamma}-1}}{\left[\Delta_e R_H^{\frac{1}{\gamma}} + (1-\Delta_e) \phi^{\frac{1}{\gamma}}\right]^{1-\gamma}} \cdot \frac{1}{1-\gamma} & , \text{ if } R_H < \phi < R_L \\ A_h = [\Delta_e R_H + (1-\Delta_e)\delta R_L] \cdot \frac{1}{1-\gamma} & , \text{ if } \phi \leq R_H < R_L \end{cases}$$

Discussion

- Lagos (2006)
  - R sufficient statistic for TFP

- Skill loss
  - R **and** θ (job finding rate) sufficient statistics for TFP

Discussion

- Lagos (2006)

$$A = \frac{R}{1-\gamma}$$

- Skill loss

$$A = \begin{cases} A_l = \frac{\Delta_e R_H^{\frac{1}{\gamma}} + (1-\Delta_e) R_L^{\frac{1}{\gamma}} \delta}{\left[\Delta_e R_H^{\frac{1}{\gamma}} + (1-\Delta_e) R_L^{\frac{1}{\gamma}}\right]^{1-\gamma}} \cdot \frac{1}{1-\gamma}, \text{ if } R_H < R_L \leq \phi \\ A_m = \frac{\Delta_e R_H^{\frac{1}{\gamma}} + (1-\Delta_e) R_L \delta \phi^{\frac{1}{\gamma}-1}}{\left[\Delta_e R_H^{\frac{1}{\gamma}} + (1-\Delta_e) \phi^{\frac{1}{\gamma}}\right]^{1-\gamma}} \cdot \frac{1}{1-\gamma}, \text{ if } R_H < \phi < R_L \\ A_h = \left[\Delta_e R_H + (1-\Delta_e)\delta R_L\right] \cdot \frac{1}{1-\gamma}, \text{ if } \phi \leq R_H < R_L \end{cases}$$

- $\delta = 1$ (no skill loss) $\Rightarrow$ Lagos (2006)

Skill channel

- No skill loss
  - If $R \uparrow \Rightarrow$ TFP $\uparrow$
  - Two economies with same R

    $\Rightarrow$ same TFP, even if job finding rates very $\neq$

Skill channel

- No skill loss
  - If $R \uparrow \Rightarrow$ TFP $\uparrow$
  - Two economies with same R

    $\Rightarrow$ same TFP, even if job finding rates very $\neq$
- With skill loss, further channel
  - TFP depends on skill distribution Δ^e

    & match quality (i.e. R_i)
  - If skill distribution improves $\Delta^e \uparrow$

    $\Rightarrow$ TFP $A \uparrow$ ($\frac{\partial A}{\partial \Delta^e} > 0$)

Skill channel

- No skill loss
  - If $R \uparrow \Rightarrow$ TFP $\uparrow$
  - Two economies with same R

    $\Rightarrow$ same TFP, even if job finding rates very $\neq$
- With skill loss, further channel
  - TFP depends on skill distribution Δ^e

    & match quality (i.e. R_i)
  - If skill distribution improves $\Delta^e \uparrow$

    $\Rightarrow$ TFP $A \uparrow$ ($\frac{\partial A}{\partial \Delta^e} > 0$)
- Distribution Δ^e determined by both
  - Job finding rate $f(\theta)$
  - Reservation values R_H, R_L ($\frac{\partial \Delta^e}{\partial R_L} > 0$, $\frac{\partial \Delta^e}{\partial R_H} < 0$)

Labor market policies

- Advantage w/ method in Lagos (2006)
  - R "sufficient" statistic

    $\rightarrow$ uniquely determines TFP
  - Effect of labor mkt policies?

    Need effect on R alone $\Rightarrow$ TFP
  - If policy $\uparrow R \Rightarrow$ TFP $\uparrow$
- Same with skill loss, except

  $\rightarrow$ sufficient statistics: R **and** $f(\theta)$ (skill channel)
- If policy $\uparrow R$ but $\downarrow$ distribution Δ_e (e.g. if job finding $\downarrow$)

  $\Rightarrow$ overall effect depends on relative size

Labor market policies

- Policies
  - UI ($R_i \uparrow$, $\theta \downarrow$)
  - Hiring subsidy ($R_i \uparrow$, $\theta \uparrow$)
  - Employment subsidy ($R_i \downarrow$, $\theta \uparrow$)
  - Firing tax ($R_i \downarrow$, $\theta \downarrow$)
- In particular, UI may lower TFP
  - Non-linear/monotonic effect of UI on TFP

Skill channel and policy

- EU-US unemployment and TFP behavior

- Labor policy (UI) may raise TFP if
  - raises reservation productivity
  - small effect on job finding rate, skill distribution

- If policy starts affecting skill distribution

  $\Rightarrow$ may reduce TFP *and* raise unemployment

Conclusion

- Model of endogenous TFP à la Lagos (2006)
- TFP depends
  - Average productivity formed/active matches
  - Skill distribution
- Sufficient statistics
  - reservation productivities
  - job finding rate
- Skill channel $\Rightarrow$ policy can lower TFP

  even if average match quality $\uparrow$
- Next step: Quantitative exercise
  - Quantitative effect of mkt policy w/ skill loss?