Implications of General and Specific Productivity Growth in a Matching Model

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Objective of the Paper

- Long-run productivity growth may affect long-run unemployment rate
  - OECD countries since the 1970s: Unemployment $\uparrow$, Growth $\downarrow$
  - some formal evidences
    (e.g. Blanchard and Wolfers (2000), Pissarides and Vallanti (2007))
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- We incorporate two new features to overcome this result
Workers CRRA utility, long-term contracts
New Features, New Channels

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  - Separations $\downarrow \Rightarrow \text{Unemployment } \downarrow$
These two new channels generate a substantial negative impact of growth on unemployment
Main Findings

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- Specific productivity growth tends to
  - reduce unemployment and lengthen workers’ tenure
  - make these variables more responsive to changes in growth rates
Basic Environment

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- A worker
  - is born and starts getting matched at $T_A = -1$
  - enters the labor force and starts consuming at $T_A = 0$
  - retires at $T_A = \bar{T}$ and receives value $V^R$
  - has CRRA preference, so lifetime utility is

$$E_{-1} \sum_{T_A=0}^{\bar{T} - 1} \beta^{T_A} \frac{C^{1-\sigma}}{1-\sigma} + \beta^{\bar{T}} V^R$$
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- Firms can borrow/lend at an interest rate $r$. Workers can't.
Mass of new matches is $m(u, s)$, fixed cost of posting a vacancy
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A firm/worker match produces $A\Psi_t(T_A, T_T)$
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$A \in [A, \bar{A}]$ is the idiosyncratic productivity of the match

- $A = \bar{A}$ for a new match
- with probability $\lambda$, $A$ remains constant
- with probability $1 - \lambda$, new $A$ drawn from an i.i.d. distribution
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$\Psi_t(T_A, T_T) = (1 + g)^t(1 + g)^{\alpha(T_T - T_A)}$ is a worker’s productivity

- $T_A$: age, $T_T$: tenure
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- $T_A$: age, $T_T$: tenure

$\alpha$ (degree of specificity) common to all matches

1. General Productivity Growth: $\alpha = 0$
2. Specific Productivity Growth: $\alpha > 0$
Evolution of a Worker’s Productivity

General (\(\alpha = 0\))

\[
\log \Psi^I = \log \Psi^O
\]

\[
\log(1 + g)
\]

\(\Psi^O\) grows at rate \(g\)

Specific (\(\alpha > 0\))

\[
\log \Psi^I
\]

\[
\log \Psi^O
\]

\[
(1 - \alpha) \log(1 + g)
\]

\(\Psi^I\): worker's productivity in the current match

\(\Psi^O\): worker's productivity outside the current match
A firm and a worker matched at date $t$ write a contract

$$\{ C_s(\{ A_z \}_{z=t+1}^{s}, T_A) \}_{s=t+1}^{\tilde{T}-1-T_A+t}$$
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\[ \{ C_s(\{A_z\}_{z=t+1}^s, T_A) \}_{s=t+1}^{T-1-T_A+t} \]

Neither party can commit to the contract
A firm and a worker matched at date $t$ write a contract

$$\begin{align*}
\{C_s(\{A_z\}_{z=t+1}^s, T_A)\}_{s=t+1}^\tilde{T} = T_A + t
\end{align*}$$

Neither party can commit to the contract

The firm can fire the worker by paying firing costs $F_t$

- $F_t = F$ if $A$ changes, $= \infty$ if $A$ doesn’t
Labor Contract

- A firm and a worker matched at date $t$ write a contract
  \[
  \{ C_s(\{A_z\}_{z=t+1}^s, \, T_A) \}_{s=t+1}^{\tilde{T}_1-T_A+t}
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- The firm can fire the worker by paying firing costs $F_t$
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- The worker can quit, become unemployed and search for a new job
  - receives benefits during unemployment
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- The firm can fire the worker by paying firing costs $F_t$
  - $F_t = F$ if $A$ changes, $= \infty$ if $A$ doesn’t
- The worker can quit, become unemployed and search for a new job
  - receives benefits during unemployment
- The match may terminate each period as
  - an **exogenous separation** occurs with probability $\gamma$
  - an **endogenous separation** occurs iff

\[
\Pi_t(A, V_t^{un}(T_A), T_A, T_T) < -F_t
\]
Optimal contract maximizes the firm’s value of the match, s.t.

- participation constraint of the firm and the worker
- initial promised value to the worker, determined by Nash bargaining
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Can formulate a recursive optimal contract in detrended variables
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- participation constraint of the firm and the worker
- initial promised value to the worker, determined by Nash bargaining

Can formulate a recursive optimal contract in detrended variables

Can define stationary recursive equilibrium in a standard fashion
- Model closed by zero profit condition for posting a vacancy
Analytical Results - Wage Rule

Proposition

The path of wage $C_t$ is described as

$$C_{t+1} = C_t[\beta(1 + r)]^{1/\sigma} \quad \text{if neither PC binds}$$

$$\geq C_t[\beta(1 + r)]^{1/\sigma} \quad \text{if worker’s PC binds}$$

$$\leq C_t[\beta(1 + r)]^{1/\sigma} \quad \text{if firm’s PC binds}$$
Analytical Results - Threshold Productivity

Proposition

(1) For all \((T_A, T_T)\), there exists a threshold \(A^*_{T_A, T_T}\), such that an endogenous separation occurs iff newly drawn \(A < A^*_{T_A, T_T}\).

(2) \(A^*_{T_A, T_T}\) is non-increasing in tenure \(T_T\).

(1) Threshold property for \(A\) (standard result in literature)
(2) For a given \(T_A\), the hazard rate of separation falls in tenure

• consistent with e.g. Mincer and Jovanovic (1982), Pries (2004)
Vary $g$ under different values of $\alpha$ (degree of specificity)

In the stationary equilibrium

- how do unemployment and workers’ tenure vary?
- how do results depend on $\alpha$?
Specific productivity growth \((\alpha > 0)\) may reduce UE rate despite being "inferior" technology.
### Effect on UE of a 1% Fall in Annual TFP Growth

<table>
<thead>
<tr>
<th>Empirical Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blanchard and Wolfers (2000)</td>
</tr>
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<td>Pissarides and Vallanti (2007)</td>
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<table>
<thead>
<tr>
<th>Models</th>
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<tbody>
<tr>
<td>Channel in Standard MP Model</td>
</tr>
<tr>
<td>(Pissarides and Vallanti (2007))</td>
</tr>
<tr>
<td>Our Model</td>
</tr>
<tr>
<td>Intertemporal Consumption Smoothing</td>
</tr>
<tr>
<td>+ Specific Productivity Growth</td>
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<td>( \alpha = 0.1 )</td>
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<td>( \alpha = 0.3 )</td>
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\[ \alpha = 0.1 \]
\[ \alpha = 0.3 \]
Results: Growth Rate and Median Tenure

- Growth slowdown reduces job security
- Specific productivity growth lengthens workers’ tenure
Conclusion

Our two new channels generate a substantial impact of growth on unemployment and tenure
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- Larger specificity of productivity growth tends to:
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- Larger specificity of productivity growth tends to:
  - reduce unemployment and lengthen workers’ tenure
  - make these variables more responsive to changes in $g$

- These features may help account for, e.g.,
  - longer tenure and historically lower unemployment in Europe and Japan
  - surge of unemployment in Europe
  - changes to "lifetime employment" in Japan
Appendix A: Related Literature

1. Dynamic Labor Contract under Limited Commitment

2. Growth and Unemployment
   (a) Pissarides (2000): Theoretical Channel - "Capitalization effect"
      Intuition: Faster growth increases the PV of output from a match
      Negative impact of TFP growth on unemployment in data
      "Capitalization effect" too small to explain this

3. General and Specific Human Capital
   Mincer (1993), Mincer and Danninger (2000)
   Less separations/unemployment in high productivity growth sectors
   Explanation based on specific human capital
Appendix B: Recursive Optimal Contract

- Adequate assumptions on parameter growth allows formulating a recursive optimal contract in detrended variables (in lower case)
- When the match continues, the firm solves

\[
\pi(A, v, T_A, T_T) = \max_{c,v'(A')} \left\{ A\psi(T_A, T_T) - c \\
+ \left[ (1 - \gamma)(1 + g)/(1 + r) \right] E[\hat{\pi}(A, v'(A'), T_A + 1, T_T + 1)] \right\}
\]

s.t. \[ u(c) + \beta(1 + g)^{1-\sigma} E[\hat{u}(A, v'(A'), T_A + 1, T_T + 1)] = v(PK) \]
\[ \pi(A', v'(A'), T_A + 1, T_T + 1) \geq -f \] \hspace{1cm} \text{(PC-F)}
\[ v'(A') \geq v^{un}(T_A + 1), \quad \forall A' \in [A, \bar{A}] \] \hspace{1cm} \text{(PC-W)}

- \( E[\hat{\pi}] \) and \( E[\hat{u}] \) are the firm and the worker’s continuation values
Appendix C: Continuation Values I

- Define

\[ g^e(A, T_A, T_T) = 1 \text{ if } \pi(A, \nu^{un}(T_A), T_A, T_T) < -f \]
\[ = 0 \text{ otherwise} \]

- For \( T_A \in [0, \bar{T} - 2] \),

\[
E[\hat{\pi}(A, \nu'(A'), T_A + 1, T_T + 1)] \equiv \lambda \pi(A, \nu'(A), T_A + 1, T_T + 1) \\
+ (1 - \lambda) \left( \int_A^{\bar{A}} \left[ (1 - g^e(A', T_A + 1, T_T + 1)) \cdot \pi(A', \nu'(A'), T_A + 1, T_T + 1) \\
+ g^e(A', T_A + 1, T_T + 1))(-f) \right] dG(A') \right)
\]
Appendix C: Continuation Values II

\[ E[\hat{u}(A, v'(A'), T_A + 1, T_T + 1)] \equiv (1 - \gamma) \left[ \lambda v'(A) \right. \]
\[ + (1 - \lambda) \int_{A}^{\bar{A}} (1 - g^e(A', T_A + 1, T_T + 1)) v'(A') dG(A') \left. \right] \]
\[ + \left[ (1 - \gamma)(1 - \lambda) \int_{A}^{\bar{A}} g^e(A', T_A + 1, T_T + 1) dG(A') + \gamma \right] v^{un}(T_A + 1) \]

For \( T_A = \bar{T} - 1 \), \( E[\hat{\pi}] = 0 \) and \( E[\hat{u}] = v^R \), where \( v^R \) is the value of retirement.
Appendix D: Complete Definition of a Stationary Recursive Equilibrium 1

**Definition**

A stationary recursive equilibrium is

- A list of functions
  \[ \pi(A, \nu, T_A, T_T), \ g^e(A, T_A, T_T), \ g^c(A, \nu, T_A, T_T), \ g^{\nu'}(A') (A, \nu, T_A, T_T) \]
- \( \bar{T} \) vectors \( \nu^{un} \) and \( \nu^{new} \)
- Probabilities \( p \) and \( q \),
- Stationary distributions of workers \( \mu^{un}(T_A), \mu^{em}(A, \nu, T_A, T_T) \) for \( T_A \in \{0, \ldots, \bar{T} - 1\} \), \( T_T \in \{0, \ldots, T_A\} \), such that:
Appendix D: Complete Definition of a Stationary Recursive Equilibrium II

1. The value function $\pi(A, \nu, T_A, T_T)$ solves the Bellman equation, the policy functions $g^c(A, \nu, T_A, T_T)$ and $g^{v'(A')}(A, \nu, T_A, T_T)$ are optimal, and $g^e(A, T_A, T_T)$ is as defined in Appendix C.

2. The value of an unemployed worker with $T_A$ is given by

$$
\nu^u(T_A) = u(b^u(T_A)) + \beta(1 + g)^{1-\sigma}[\rho \nu^{new}(T_A + 1) \\
+ (1 - \rho) \nu^u(T_A + 1)], \ T_A \in \{0, ..., \bar{T} - 2\}
$$

$$
\nu^u(\bar{T} - 1) = u(b^u(T_A)) + \beta(1 + g)^{1-\sigma} \nu^R
$$

3. The non-detrended value of a new worker with $T_A$ solves the Nash bargaining problem:

$$
V_t^{new}(T_A) = \arg \max_{\nu} \{\Pi_t(\bar{A}, \nu, T_A, 0)^\theta (V - V_t^{un}(T_A))^{1-\theta}\}
$$

$s.t. \ \Pi_t(\bar{A}, \nu, T_A, 0) \geq 0, \ V \geq V_t^{un}(T_A)$
A zero profit condition for posting a vacancy holds:

$$\phi = q \frac{1 + g \mu^{nb} \pi^{new}(0) + \sum_{T_A=0}^{\bar{T}-2} \mu^{un}(T_A) \pi^{new}(T_A + 1)}{1 + r} \mu^{nb} + \sum_{T_A=0}^{\bar{T}-2} \mu^{un}(T_A)$$

where $\mu^{nb} = 1/\bar{T}$ and

$$\pi^{new}(T_A) \equiv \pi(\bar{A}, \nu^{new}(T_A), T_A, 0)$$

The probabilities of finding a job, $p$, and of filling a vacancy, $q$, are consistent with the matching function,

$$p = \frac{m(u, s)}{u}, \quad q = \frac{m(u, s)}{s}$$

The distributions of workers $\mu^{un}(T_A)$ and $\mu^{em}(A, \nu, T_A, T_T)$ satisfy the laws of motion described in Appendix E.
For $T_A = 0$,

$$\mu^{un}(T_A) = (1 - p)\mu^{nb}$$

$$\mu^{em}(A, \nu, T_A, T_T) = p\mu^{nb} \text{ for } (A, \nu, T_T) = (\bar{A}, \nu^{new}(T_A), 0)$$

$$= 0 \text{ otherwise}$$

For $T_A \in \{1, \ldots, \bar{T} - 1\}$,

$$\mu^{un}(T_A) = (1 - p)\mu^{un}(T_A - 1)$$

$$+ \sum_{T_T=0}^{T_A} \left\{ \int_{A}^{\bar{A}} \int_{V} \left[ \gamma + (1 - \gamma)(1 - \lambda) \cdot \int_{A}^{\bar{A}} g^e(A', T_A, T_T)dG(A') \right] \mu^{em}(A, \nu, T_A - 1, T_T - 1) d\nu dA \right\}$$
Moreover, for \( T_T = 0 \),

\[
\mu^{em}(A, \nu, T_A, T_T) = p\mu^{un}(T_A - 1) \text{ for } (A, \nu) = (\bar{A}, \nu^{new}(T_A))
\]

\[= 0 \text{ otherwise} \]

and for \( T_T \in \{1, \ldots, T_A\} \),

\[
\mu^{em}(A, \nu, T_A, T_T) = (1 - \gamma) \cdot \left\{ \lambda \int_{\{\tilde{\nu} \in V | g^{v'}(A)(\tilde{A}, \tilde{\nu}, T_A - 1, T_T - 1) = \nu\}} \mu^{em}(A, \tilde{\nu}, T_A - 1, T_T - 1) d\tilde{\nu} \\
+ (1 - \lambda) g(A)(1 - g^e(A, T_A, T_T)) \cdot \int_{\bar{A}} \int_{A} \int_{\{\tilde{\nu} \in V | g^{v'}(\tilde{A}, \tilde{\nu}, T_A - 1, T_T - 1) = \nu\}} \mu^{em}(\tilde{A}, \tilde{\nu}, T_A - 1, T_T - 1) d\tilde{\nu} d\tilde{A} \right\}
\]
Appendix F: Calibration

We assume

- Matching function \( m(u, s) = B u^\kappa s^{1-\kappa} \)
- \( A \sim U[A, \bar{A}] \)

We calibrate the model to match following targets from the U.S. data in the baseline case (\( g = 0.005, \gamma = 0.025, \alpha = 0 \))

- \( u/s \) ratio (obtained from job-finding and vacancy-filling rate) of 1.3153
- Unemployment rate of 5.5%
- Ratio of unemployment benefits to wages of 40%
### Parameters Selected with no Empirical Counterpart

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta$</td>
<td>0.5</td>
<td>Firm’s bargaining power</td>
</tr>
<tr>
<td>$[A, \bar{A}]$</td>
<td>[1, 3]</td>
<td>Range of idiosyncratic productivity</td>
</tr>
</tbody>
</table>

### Parameters Calibrated without Solving the Model

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<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
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<tbody>
<tr>
<td>$\sigma$</td>
<td>2</td>
<td>Coefficient of risk aversion</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.99</td>
<td>Discount factor</td>
</tr>
<tr>
<td>$r$</td>
<td>$1/\beta - 1$</td>
<td>Interest rate</td>
</tr>
<tr>
<td>$\bar{T}$</td>
<td>160</td>
<td>Number of periods in labor force</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>0.4</td>
<td>Unemployment elasticity in matching function</td>
</tr>
<tr>
<td>$B$</td>
<td>0.7776</td>
<td>Scale in matching function</td>
</tr>
<tr>
<td>$f$</td>
<td>0</td>
<td>Firing Costs</td>
</tr>
</tbody>
</table>

### Parameters Selected by Solving the Model

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<thead>
<tr>
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<tbody>
<tr>
<td>$\lambda$</td>
<td>0.844</td>
<td>Persistence in match productivity</td>
</tr>
<tr>
<td>$\phi$</td>
<td>4.725</td>
<td>Cost of posting a vacancy</td>
</tr>
<tr>
<td>$b_0$</td>
<td>0.82</td>
<td>Unemployment benefits for $T_A = 0$</td>
</tr>
</tbody>
</table>
Appendix G: Computational Procedure

(1) Guess $u/s$
(2) Compute VFs and PFs backwards from $T_A = \bar{T} - 1$.
Compute $\pi^{\text{new}}(T_A)$ and $\nu^{\text{new}}(T_A)$ from Nash bargaining.
(3) Check the zero profit condition. If not satisfied, go back to (1) and iterate until convergence.