The Price of Experience

Hyeok Jeong, Yong Kim, Iourii Manovskii
**Motivation**

**Observation:** Market return to experience highly correlated with average labor market experience.

**Question:** To what extent do demographic trends (supply-side changes) drive changes in the market price of experience?
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Correlations:

- U.S. PSID, 1968-1996: $\rho = -0.75$
- Swedish SAF, 1975-1995: $\rho = -0.97$
- Danish data, 1980-2003: $\rho = -0.80$

Market return to experience measured as $\beta_t$ from Mincer wage regression in repeated cross-sections:

$$\log(w_{it}) = \beta_t \text{Experience}_{it} + \gamma_t C_{it} + \varepsilon,$$

$C_{it}$ a vector of control variables.
Motivation, cont.
Approach

▶ Assume workers are endowed with two distinct and complimentary production inputs: labor and experience.
▶ Efficiency units of labor and experience are only inputs to production.
▶ Competitive market pricing: factor prices determined by marginal products.
▶ Relative price of experience determined by relative stock of experience to labor.
▶ CRS production technology: output, effective labor, and effective experience across workers consistently aggregate.
▶ Estimate parameters of production technology, efficiency experience/labor schedules from individual wage equation.
Evaluation

- Do model estimated parameters support hypothesis of complementarity between experience and labor?
- If so, how does “experience premium” derived from the aggregate production technology compare with that estimated from the data?
Workers

- Time is discrete
- Worker is endowed with one unit of labor each year.
- Worker of age $j$ accumulates experience $e$ for each year she works more than threshold $h$:

$$
    e = \sum_{k=0}^{j} I(h_k > h)
$$

- Effective factor inputs of agent determined by “life-efficiency schedules” that depend on age $(j)$ and education $(e)$
- Labor input: $\lambda_L(j, s)$
- Experience input: $\lambda_E(j, s) \cdot e$
Workers, cont.

- Let $R_{Et}$ and $R_{Lt}$ denote the market prices of experience and labor.
- Individual productivity term $z_{it}$
- Earnings:

$$y_{it} = \left[ R_{Lt} \lambda_L(j_{it}, s_{it}) + R_{Et} \lambda_E(j_{it}, s_{it}) e_{it} \right] h_{it} z_{it}$$

$$= R_{Lt}(j_{it}, s_{it}) \left[ 1 + \frac{R_{Et}}{R_{Lt}} \frac{\lambda_E(j_{it}, s_{it})}{\lambda_L(j_{it}, s_{it})} e_{it} \right] h_{it} z_{it}$$

- Experience premium: $\Pi_{Et} \equiv \frac{R_{Et}}{R_{Lt}}$.
- Relative life-cycle efficiency schedule of experience:

$$\lambda_{E/L}(j_{it}, s_{it}) \equiv \frac{\lambda_E(j_{it}, s_{it})}{\lambda_L(j_{it}, s_{it})}$$
Technology

- CRS production technology mapping aggregate stock of labor $L_t$ and aggregate stock of experience $E_t$ into aggregate earnings $Y_t$:

$$Y_t = A_t G(L_t, E_t)$$

where $A_t$ represents the aggregate productivity of the composite labor/experience input.

- Euler’s theorem:

$$Y_t = A_t (G_{L_t} L_t + G_{E_t} E_t),$$

where $G_{E_t} = \frac{\partial G}{\partial E_t}$ and $G_{L_t} = \frac{\partial G}{\partial L_t}$

- Competitive factor prices:

$$R_{L_t} = A_t G_{L_t}$$

$$R_{E_t} = A_t G_{E_t}$$
Aggregation

Sum individual earnings equation over individuals $i$ for a given $t$:

$$\sum_i y_{it} = R_L t \sum_i \lambda_L (j_{it}, s_{it}) z_{it} h_{it} + R_E \sum_i \lambda_E (j_{it}, s_{it}) z_{it} h_{it} e_{it}$$

$$= A_t G_{L_t} L_t + A_t G_{E_t} E_t$$

$$= Y_t$$

where

$$L_t = \sum_i \lambda_L (j_{it}, s_{it}) z_{it} h_{it}$$

$$E_t = \sum_i \lambda_E (j_{it}, s_{it}) e_{it} z_{it} h_{it}$$
Complementarity

- Assume $G$ is CES:

\[
Y_t = A_t \left( L_t^\mu + \delta E_t^\mu \right)^{\frac{1}{\mu}}
\]

- $\mu \leq 1 \Rightarrow$: necessary condition for relative factor supply to determine relative factor prices.
Log wage equation

Combine aggregate production function with individual earnings equation:

\[ \ln w_{it} = \ln A_t + \ln G_{Lt} + \ln \lambda_L(j_{it}, s_{it}) + \ln \left[ 1 + \Pi_{E_t} \lambda_{E/L}(j_{it}, s_{it}) e_{it} \right] + \ln z_{it} \]

where

\[ w_t = \frac{y_{it}}{h_{it}} \]

\[ G_{Lt} = \left( 1 + \delta \left( \frac{E_t}{L_t} \right)^\mu \right)^{\frac{1}{\mu} - 1} \]

\[ \Pi_{E_t} = \delta \left( \frac{E_t}{L_t} \right)^{\mu - 1} \]
Life-cycle efficiency schedules

- Life-cycle efficiency schedules for labor and experience:
  \[
  \lambda_L(j, s) = \exp(\lambda_{L,1}(s)j + \lambda_{L,2}(s)j^2)
  \]
  \[
  \lambda_E(j, s) = \exp(\lambda_{E,1}(s)j + \lambda_{E,2}(s)j^2)
  \]

- Relative life-cycle efficiency schedule of experience:
  \[
  \lambda_{E/L}(j, s) = \exp (\lambda_{E/L,1}(s)j - \lambda_{E/L,2}(s)j^2)
  \]
  where
  \[
  \lambda_{E/L,1}(s) = \lambda_{E,1}(s) - \lambda_{L,1}(s)
  \]
  \[
  \lambda_{E/L,2}(s) = \lambda_{E,2}(s) - \lambda_{L,2}(s)
  \]

- Individual productivity:
  \[
  \ln z_{it} = \alpha_t \chi_{it}
  \]
  where \( \chi_{it} \) is a vector of observables.
Fully parametrized log wage equation

Substitute efficiency schedules into log wage equation:

\[
\ln w_{it} = \ln A_t + \ln G_{Lt} + \left( \lambda_{L,1}(s_{it})j_{it} + \lambda_{L,2}(s_{it})j_{it}^2 \right)
+ \ln \left[ 1 + \delta \left( \frac{E_t}{L_t} \right)^{\mu-1} \exp \left( \lambda_{E/L,1}(s_{it})j_{it} + \lambda_{E/L,2}(s_{it})j_{it}^2 \right) e_{it} \right]
+ \alpha t \chi_{it} + \varepsilon_{it}
\]
Identification of aggregate parameters

- Given the measurement of $E_t$ and $L_t$, variation of experience premium $\Pi_{E_t}$ in relation to relative factor endowment $\frac{E_t}{L_t}$.
- Correlation between $\Pi_{E_t}$ and $\frac{E_t}{L_t}$ identifies $\mu$.
- Average magnitude of $\Pi_{E_t}$ relative to $\frac{E_t}{L_t}$ identifies $\delta$, subject to scale factor.
- Normalize $\lambda_E(0, s) = \lambda_L(0, s) = 1$. 
Two-step estimation

First stage:
Estimate life-cycle efficiency parameters and time-varying coefficients \((\hat{\alpha}_t, \hat{D}_t, \text{and } \hat{\Pi}_E_t)\) from the following equation:

\[
\ln w_{it} = D_t + (\lambda_{L,1}(s_{it})j_{it} + \lambda_{L,2}(s_{it})j_{it}^2) + \ln \left[ 1 + \Pi_E \exp \left( \lambda_{E/L,1}(s_{it})j_{it} + \lambda_{E/L,2}(s_{it})j_{it}^2 \right)e_{it} \right] + \alpha_t \chi_{it} + \varepsilon_{it}
\]

where \(D_t \equiv \ln A_t + \ln G_{L_t}\) and \(\Pi_E \equiv \delta \left( \frac{E_t}{L_t} \right)^{\mu - 1}\)

From first-stage estimates:

- Obtain \(\hat{\lambda}_E(j, s)\) from

\[
\hat{\lambda}_E(j, s) = \hat{\lambda}_{E/L}(j, s)\hat{\lambda}_L(j, s)
\]

- Then

\[
\hat{L}_t = \sum_i \hat{\lambda}_L(j_{it}, s_{it})\hat{z}_{it}h_{it}, \quad \hat{E}_t = \sum_i \hat{\lambda}_E(j_{it}, s_{it})\hat{z}_{it}h_{it}e_{it}
\]
Two-stage estimation, cont.

**Second stage:** Use first-stage estimates to estimate $\mu$ and $\delta$ from the following equation:

\[
\ln w_{it} = \hat{D}_t + \left( \hat{\lambda}_{L,1}(s_{it})j_{it} + \hat{\lambda}_{L,2}(s_{it})j_{it}^2 \right) \\
+ \ln \left[ 1 + \delta \left( \frac{\hat{E}_t}{\hat{L}_t} \right)^{\mu-1} \exp \left( \hat{\lambda}_{E/L,1}(s_{it})j_{it} + \hat{\lambda}_{E/L,2}(s_{it})j_{it}^2 \right) e_{it} \right] \\
+ \hat{\alpha}_t \chi_{it} + \varepsilon_{it}
\]
Data

- Use actual experience rather than potential experience: important for separately identifying the returns to experience.
- Variation in experience premium and experience-labor ratio comes from across time.
- Robustness: U.S. census
- Impute actual experience from PSID estimates.
- Variation in experience premium and experience-labor ratio comes from across states.
Life Cycle Efficiency Schedules
Technology parameters

Table 1: PSID estimates of technology parameters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Second Stage</th>
<th>Full Estimation</th>
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<tbody>
<tr>
<td></td>
<td>Estimate</td>
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<td>$\mu$</td>
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<td>$\delta$</td>
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<td>RMSE</td>
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Correlation between experience premium $\hat{\Pi}_{E_t}$ and experience-labor ratio $\hat{E_t}/\hat{L_t}$ estimated from first stage: -0.96
Actual vs. Predicted Experience Premium

- Actual experience premium: $\hat{\Pi}_{E_t}$ estimated in the first stage.
- Predicted experience premium: Analytic expression for $\Pi_{E_t}$ evaluated at estimated technology parameters $\hat{\mu}$ and $\hat{\delta}$, and estimated aggregate experience/labor ratio, $\hat{E}_t/\hat{L}_t$.
- Correlation is 0.97