Cyclical Dynamics in Idiosyncratic Labor Market Risk

Storesletten, Telmer & Yaron, JPE 2004
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Outline

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   - Motivation
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Idiosyncratic Risk and Macroeconomics

- Quantitative macroeconomic literature has changed:
  - *Past:* Exclusive focus on aggregate dynamics;
  - *Present:* Incorporate distribution of allocations across individual economic actors;
- Central to our understanding:
  - What sources of risk do agents face?
  - What sources of insurance are available?
- Why is this interesting?
  - *Macro-Finance:* Market incompleteness and asset pricing;
  - *Household Finance:* Idiosyncratic risk and portfolio choice;
  - *Macro-Labor:* Social security design.
What does this paper do?

- Estimates a model of labor earnings that allows for time-variation in the variance of individual-specific component;
- Documents countercyclical cross-sectional variance of idiosyncratic earnings risk in US data;
- Incorporates macroeconomic data back to 1930, by conducting estimation on age-dependent moments;

Why is this useful?

- Better understanding of the nature of uninsurable idiosyncratic labor earnings risk;
- Process for earnings risk will be an input into other models.
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Interested in a model of idiosyncratic labor income risk;

A competitive model of labor earnings: \( \text{wage}_t = MPL^i_t \)

1. Assume worker paid marginal product of labor at market wage;
2. Assume constant hours offered by each individual;
3. Thus lower individual earnings must reflect lower productivity.
Model of Labor Earnings

- Interested in a model of idiosyncratic labor income risk;
- A competitive model of labor earnings: \( \text{wage}_t = MPL^i_t \)
  1. Assume worker paid marginal product of labor at market wage;
  2. Assume constant hours offered by each individual;
  3. Thus lower individual earnings must reflect lower productivity.

\[
\text{wage}_t = MPL^i_t \\
\Rightarrow \text{wage}_t = \frac{(1 - \alpha_n) \text{output}^i_t}{\text{efficiency}^i_t \cdot \text{hours}} \\
\Rightarrow \text{labor earnings}^i_t = \text{wage}_t \cdot \text{efficiency}^i_t \cdot \text{hours}
\]
Condition on age \((h)\) too:

\[
labor\ earnings^h_{it} = wage_t \cdot efficiency^h_{it} \cdot \text{hours}
\]
Condition on age \((h)\) too:

\[
labor \ earnings_{it}^h = wage_t \cdot efficiency_{it}^h \cdot \text{hours}
\]

Model labor efficiency as follows:

\[
\text{efficiency}_{it}^h \equiv \exp \left[ f(x_{it}^h) + u_{it}^h \right]
\]

- \(x_{it}^h\) are individual-age specific characteristics (education, etc.);
- \(f\) deterministically maps characteristics into efficiency;
- \(u_{it}^h\) reflects individual-age specific efficiency shock.
Thus our model for individual earnings:

$$E_{it}^h = \text{wage}_t \cdot \exp \left[ f(x_{it}^h) + u_{it}^h \right] \cdot \overline{\text{hours}}$$

$$\implies \ln E_{it}^h = A_t + f(x_{it}^h) + u_{it}^h$$

Aggregate shock Characteristics Idiosyncratic shock
Thus our model for individual earnings:

\[ E_{it}^h = \text{wage}_t \cdot \exp \left[ f(x_{it}^h) + u_{it}^h \right] \cdot \text{hours} \]

\[ \Rightarrow \ln E_{it}^h = A_t + f(x_{it}^h) + u_{it}^h \]

Aggregate shock  Characteristics  Idiosyncratic shock

What do we need next?

1. Structure for \( A_t \) and \( f(\cdot) \) \( \Rightarrow \) \( \{ u_{it}^h \}_{h,t} \);
2. Statistical representation for residual \( (u_{it}^h) \) to better understand nature of idiosyncratic risk.
Assumptions on Labor Efficiency

\[ \ln E_{it}^h = A_t + f(x_{it}^h) + u_{it}^h \]

1. Model \( A_t \) as a year dummy variable;
Assumptions on Labor Efficiency

\[ \ln E_{it}^h = A_t + f(x_{it}^h) + u_{it}^h \]

1. Model \( A_t \) as a year dummy variable;
2. Deterministic component of efficiency:

\[ f(x_{it}^h) = \beta \cdot [1, h, h^2, h^3, \text{education}_{it}, (\text{family size})_{it}] + \epsilon \]

- This function is invariant over time and across individuals.
Assumptions on Labor Efficiency

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\]

   - This function is invariant over time and across individuals.

3. Idiosyncratic labor efficiency risk \( u_{it}^h \):
   - Permanent and transitory component;
   - Volatility of permanent component allowed to time-vary.
Statistical Representation of Idiosyncratic Risk

\[ u_{it}^h = \alpha_i + z_{it}^h + \epsilon_{it} \]

- Fixed effect: \( \alpha_i \sim (0, \sigma_\alpha^2) \)
  - Time invariant and drawn once at birth;

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Statistical Representation of Idiosyncratic Risk

\[ u_{it}^h = \alpha_i + z_{it}^h + \epsilon_{it} \]

1. Fixed effect: \( \alpha_i \sim (0, \sigma^2_{\alpha}) \)
   - Time invariant and drawn once at birth;

2. Permanent component: \( z_{it}^h = \rho z_{i,t-1}^h + \eta_{it}, \quad z_{i,t}^0 \equiv 0 \)
   - Volatility of permanent shock: \( \eta_{it} \sim (0, \sigma^2_t) \)

\[ \sigma^2_t = \begin{cases} 
\sigma^2_E, & \text{if “Aggregate expansion”} \\
\sigma^2_C, & \text{if “Aggregate contraction”}
\end{cases} \]
Statistical Representation of Idiosyncratic Risk

\[ u_{it}^h = \alpha_i + z_{it}^h + \epsilon_{it} \]

1. Fixed effect: \( \alpha_i \sim (0, \sigma_{\alpha}^2) \)
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2. Permanent component: \( z_{it}^h = \rho z_{i,t-1}^h + \eta_{it}, \ z_{i,t}^0 \equiv 0 \)
   - Volatility of permanent shock: \( \eta_{it} \sim (0, \sigma_t^2) \)

\[ \sigma_t^2 = \begin{cases} \sigma_E^2, & \text{if "Aggregate expansion"} \\ \sigma_C^2, & \text{if "Aggregate contraction"} \end{cases} \]

3. Transitory component: \( \epsilon_{it} \sim (0, \sigma_{\epsilon}^2) \)
   - All shocks mutually independent and i.i.d. Normal;
   - Is Normality assumption necessary here?

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Cyclical Dynamics in Idiosyncratic Labor Market Risk
Panel Study of Income Dynamics (PSID) 1968 - 1993;
- Longitudinal panel tracks fixed cross-section of individuals;
- Information on earnings and transfers to the household;
- Time-$t$ panel contains individuals from different cohorts (i.e., birth years $c$) and ages $(h)$, since $t = c + h$;

What does the time-series of x-sectional moments look like?
- First pass: average across age.
Counter-Cyclical Volatility: First Pass

Let $\varphi_h$ population share of age $h$;

Plot of age-pooled cross-sectional (detrended) mean earnings and variance of idiosyncratic risk:

1. $\text{mean}_t^X = \sum_h \varphi_h \frac{1}{N_{ht}} \sum_{i=1}^{N_{ht}} \ln \hat{E}_{it}^h$

2. $\text{std}_t^X = \sum_h \varphi_h \frac{1}{N_{ht}} \sum_{i=1}^{N_{ht}} (\hat{u}_{it}^h)^2$

Evidence of counter-cyclical cross-sectional variance ($\rho_{\mu,\sigma} = -0.74$), however, age-pooled magnitude too small.

Figure: Age-pooled X-sectional moments
Incorporating More Macroeconomic Data

- Consider “age” & “cohort” effects to overcome short time dimension of PSID:
  - Incorporate macroeconomic history back to 1930;
- Differences in x-sectional variance of cohorts identifies business-cycle variation in variance of permanent shock:
  - Cohort A (born 1910) will have worked during more recessions that B (born 1930);
  - Evident in earnings inequality ($\sigma_A[h] > \sigma_B[h]$), if:
    1. $\rho \approx 1$
    2. $\sigma_C > \sigma_E$
Want to estimate $\theta \equiv (\rho, \sigma_E, \sigma_C, \sigma_\alpha, \sigma_\epsilon)$;

- GMM on age-dependent moments;
- First, understand what is driving results and parameter identification.
Identification: Intuition

- Recall process for idiosyncratic earnings risk:

\[ u_{it}^h = \alpha_i + z_{it}^h + \epsilon_{it} = \alpha_i + \epsilon_{it} + \sum_{j=0}^{h-1} \rho^j \eta_{t-j} \]

- Consider age-dependent cross-sectional variance:

\[ \text{Var}_t^x[u_{it}^h] = \sigma^2_{\alpha} + \sigma^2_{\epsilon} + \sum_{j=0}^{h-1} \rho^{2j} \sigma^2_t \sigma_{t-j} \]

1. **Age effects**: Identify \( \rho, \sigma_{\alpha}, \sigma_{\epsilon}, \) and some average of \( \sigma_E \) & \( \sigma_C \);
2. **Cohort effects**: Disentangle \( \sigma_E \) from \( \sigma_C \).
Identification: Age Effects

\[
\text{Var}_t^x [u_{it}^h] = \sigma_\alpha^2 + \sigma_\epsilon^2 + \sum_{j=0}^{h-1} \rho^{2j} \sigma_{t-j}^2
\]

- Integrate over time and \(x\)-section:

\[
\sigma(h) = \frac{1}{T} \sum_t \frac{1}{N_{ht}} \sum_{i=1}^{N_{ht}} (u_{it}^h)^2
\]

- Intercept identifies \(\sigma_\alpha^2 + \sigma_\epsilon^2\);
  - One autocovariance separates;
- Linear profile identifies \(\rho\) and average of \(\sigma_E^2\) & \(\sigma_C^2\).

**Figure:** Sample age-specific \(x\)-sectional variance
Identification: Cohort Effects

\[ \text{Var}_t^x[u_{it}^h] = \text{const.} + \sum_{j=0}^{h-1} \rho^{2j} \left[ I\{t-j=E\} \sigma_E^2 + I\{t-j=C\} \sigma_C^2 \right] \]

- Each cohort (e.g. born in 1930) has its own fraction of working years in contraction (x-axis);
- Plot x-sectional variance of each cohort/history (y-axis):
  - Consistent with \( \sigma_C^2 > \sigma_E^2 \);
  - History permits separate identification of \( \sigma_E^2 \) & \( \sigma_C^2 \).

Figure: Cohort-specific X-sectional variance
Identification: Cohort Effects ($\rho = 1$)

\[ \rho = 1 \implies \frac{1}{h} \text{Var}_t^x[u^h_{it}] = \frac{\sigma^2_\alpha + \sigma^2_\epsilon}{h} + \sigma^2_E + \left(\sigma^2_C - \sigma^2_E\right) f_{h,t} \]

- Same plot, but divide data by $h$;
- Let $f_{h,t}$ fraction of years in bust;
- If $\rho = 1$, slope $= \left(\sigma^2_C - \sigma^2_E\right)$.

**Figure:** Age normalized cohort-specific X-sectional variance
GMM Estimation

- Need to jointly estimate \( (\beta, \theta) \) of:

\[
f(x^h_{it}) = \beta \cdot [1, h, h^2, h^3, \text{education}_{it}, (\text{family size})_{it}] + \epsilon
\]

\[
u^h_{it} = \alpha_i + z^h_{it} + \epsilon_{it}
\]

- Already argued that age-dependent cross-sectional variances and autocovariances are sufficient to identify \( \theta \);

- They perform estimation two ways:
  1. Exactly identified GMM using time-averaged \( h \)-moments;
  2. GMM using primitive \((h, t)\)-moments.
Robust evidence of high persistence & countercyclical volatility of idiosyncratic earnings risk!

Stdev of persistent shock 70%↑ in contraction vs. expansion.
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Conclusion

1. Estimates competitive model of labor earnings with particular statistical representation of idiosyncratic risk:
   - Idiosyncratic component has permanent & transitory shocks;
   - Volatility of perm. shock can increase in recession;

2. Incorporation of cohort effects (macroeconomic history) to extend panel data back to 1930 and facilitate identification:
   - Achieved by doing estimation on age-dependent moments;

3. Robust evidence regarding shocks idiosyncratic earnings:
   - Highly persistent component;
   - Countercyclical volatility of persistent component;

4. Many interesting applications in macro-finance/labor.
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In previous picture, from 1968-93, the largest change in the age-pooled x-sectional volatility of earnings was 10%.

However, estimates in paper suggest a change of about 75%!

Why this inconsistency?

- Age-pooled vol. is closely related to unconditional moment;
- Paper estimates correspond to conditional distribution;

Paper confirms that large changes in the conditional variance are consistent with small changes in the age-pooled x-section:

- Algebraically;
- Monte Carlo experiment.
Applications of CCV

1. Incomplete markets and asset pricing:
   - Market price of risk (Krueger & Lustig, JET, 2009);
   - Can account for up to 25% of empirical equity premium in otherwise standard OLG general equilibrium incomplete markets model (STY, RED, 2007);

2. Portfolio choice:
   - Stock market participation puzzle (Lynch & Tan, JFE forth.);

3. Macro-Labor:
Fact: Earnings inequality (x-sectional variance) has increased since 1980;

We are interested in dynamics of earnings inequality with age;

Earnings inequality must have risen due to either:

1. *Time Effects*: Changes in economic environment causes changes in inequality within every age group;
2. *Cohort Effects*: Younger cohorts more unequally endowed with labor market skills than older cohorts.
Time or Cohort Effects?

- **Problem:** $\text{age}_t \equiv t - c \implies$ impossible to separately identify age, time & cohort effects!
- **What do people assume?**
  1. Age, time & cohort effects are additively separable;
  2. Only 2/3 of these effects are operable;
Problem: \( \text{age}_t \equiv t - c \implies \text{impossible to separately identify age, time \& cohort effects!} \)

What do people assume?

1. Age, time \& cohort effects are additively separable;
2. Only 2/3 of these effects are operable;

STY ignore time effects and focus on cohort effects:

- This is key for identifying \((\sigma_E, \sigma_C)\);

Heathcote et al. (JEEA, 2005; RED, 2010):

- Age profiles look very different depending on choice;
- Data suggests cohort effects are less important!
Old argument in the literature on labor income processes:

1. Individuals face very persistent income shocks and have similar life-cycle profiles (MacCurdy, JPE, 1982):
   - Restrict $\beta_i = 0$ and estimate persistent $z_{it}^h$ (this paper!);

2. Shocks are modestly persistent and face individual-specific profiles (Lillard & Weiss, 1979):
   - Unrestricted $\beta_i$ and low estimated persistence;
   - Age autocovariances and consumption suggest this is more suitable specification (Guvenen, AER, 2007; RED, 2009);
   - Implications not yet investigated by macro-finance literature.