Human Capital Risk, Contract Enforcement, and the Macroeconomy

Tom Krebs
University of Mannheim

Moritz Kuhn
University of Bonn

Mark Wright
UCLA
General Issue:

- For many households (the young), human capital is the most important part of total wealth.

- Human capital is an asset with three characteristics:
  i) risky (health risk, labor market risk)
  ii) heterogeneous ex-ante returns (young vs old)
  iii) non-pledgeable

- We argue that these three characteristics imply an interesting risk-insurance relationship: young households are the most exposed to human capital risk, but also the least insured.
This Paper – Contributions

• We show analytically that young (high-return) households are the most exposed to human capital risk and also the least insured

• We establish this risk-insurance pattern in life-insurance data from SCF

• We show that a calibrated macro model can quantitatively match this fact

• We show that welfare cost of under-insurance of young households is substantial and discuss policy implication
Intuition

- Households with high expected human capital returns (young) choose to invest a lot in human capital

- These households therefore have high risk exposure and large demand for insurance

- With complete markets and perfect contract enforcement, these households will borrow and be perfectly insured

- With limited contract enforcement (US bankruptcy law), these households are borrowing constrained and under-insured
• We develop a tractable macro model with human capital risk and limited contract enforcement

• We show that the endogenous (and infinite-dimensional) wealth distribution is not a relevant state variable

• We show that the constraint set of household decision problem is convex
Production

\[ Y_t = F(K_t, H_t) \]

\( Y_t \): aggregate output
\( K_t \): aggregate stock of physical capital
\( H_t \): aggregate stock of human capital

Profit maximization:

\[ r_{kt} = r_k(\tilde{K}_t) \]

\[ r_{ht} = r_h(\tilde{K}_t) \]

\( r_k \): rental rate of physical capital
\( r_h \): rental rate of human capital
\( \tilde{K}_t = K_t/H_t \): aggregate "capital-to-labor ratio"
Expected lifetime utility of individual household:

\[ U(\{c_t\}) = \sum_{t=0}^{\infty} \beta^t \sum_{s^t} \ln c_t(s^t) \pi(s^t|s_0) \]

\( s_t = (s_{1t}, \ldots, s_{nt}) \): exogenous part of individual state
\( s^t = (s_1, \ldots, s_t) \): history of individual states
\( \beta = \nu \tilde{\beta} \): effective discount factor
\( \nu \): probability that household continues to exists

Assumption:

\{s_t\} is Markov – no aggregate risk
Examples

1. Simple example: $s_t = (s_{1t}, s_{2t})$
   - $s_{1t} \in \{\text{young, old}\}$: persistent type
   - $s_{2t} \in \{\text{good, bad}\}$: i.i.d. human capital risk

2. Quantitative Analysis: $s_t = (s_{1t}, s_{2t}, s_{3t})$
   - $s_{1t} \in \{23, \ldots, 60, \text{transition, retirement}\}$ – life-cycle
   - $s_{2t}$: death of an adult household member (widowhood)
   - $s_{3t}$: all other human capital risk (labor market risk, disability risk)
**Budget Constraint**

\[
c_t + i_{ht} + \sum_{s_{t+1}} q(s_{t+1}|s_t) a_{t+1}(s_{t+1}) = r_h h_t + a_t(s_t)
\]

\[
h_{t+1} = (1 - \delta_h(s_t)) h_t + i_{ht}
\]

\(\delta_h(s_t)\): state-dependent “depreciation rate”

- can be positive or negative
- captures human capital risk (ex-post shocks) and ex-ante heterogeneity in human capital returns
- constant MP to human capital investment at household level
Participation Constraint (Default)

\[
\sum_{n=0}^{\infty} \beta^n \ln c_{t+n}(s^{t+n}) \pi(s^{t+n}|s_t) \geq V_d(h_t, s_t)
\]

\(V_d(.)\): value function in case of default

Consequences of default (along the lines of Chapter 7):

i) all debt is cancelled: \(a_t = 0\)

ii) exclusion from financial markets in the future, \(a_{t+n} = 0\), until stochastically determined future date

iii) no garnishment of labor income
Financial Intermediaries

- no default in equilibrium

- perfect competition: insurance companies and credit companies (banks) make zero profit:

\[ q(s_{t+1}|s_t) = \frac{\pi(s_{t+1}|s_t)}{1 + r_f} \]
Equilibrium

Definition

A (stationary) recursive equilibrium is a family of household plans, \(\{c_t, a_t, h_t\}\), a wage rate, \(r_h\), and an interest rate, \(r_f\), so that

i) production firms maximize profit

ii) financial intermediaries maximize profit

iii) individual households maximize utility subject to the budget and participation constraint; the solution is recursive

iv) market clearing
The budget constraint can be transformed into

\[ x_{t+1} = (1 + r(\theta_t, s_t))x_t - c_t \]

where we have introduced the variables

\[ x_t = h_t + \sum_{s_t} q(s_t|s_{t-1})a_t(s_t) \quad \text{(total wealth)} \]

\[ \theta_t = (\theta_{ht}, \theta_{at}) \quad \text{(portfolio choice)} \]

\[ \theta_{ht} = \frac{h_t}{x_t} , \quad \theta_{at} = \frac{a_t}{x_t} \]
Bellman equation

\[
V(x, \theta, s) = \max_{x', \theta'} \left\{ \ln ((1 + r(\theta, s))x - x') + \beta \sum_{s'} V(x', \theta', s') \pi(s'|s) \right\}
\]

s.t. \[1 = \theta' + \sum_{s'} \frac{\pi(s'|s)\theta'_a(s')}{1 + r_f}\]

\[0 \leq x' \leq (1 + r(\theta, s))x\]

\[V(x', \theta', s') \geq V_d(x', \theta', s')\]
Principle of Optimality and Computation

Let $V_0$ be the (unique) solution to the Bellman equation without participation constraint. Let $T$ be the operator associated with the Bellman equation with participation constraint. Then

i) $\lim_{n \to \infty} T^n V_0 = V_\infty$ exists and is the maximal solution to the Bellman equation with participation constraint

ii) $V_\infty$ is the value function of the sequential household maximization problem.
The value function, $V$, has the functional form

$$V(x, \theta, s) = \tilde{V}(s) + \frac{1}{1-\beta} \ln(1 + r(\theta, s)) + \frac{1}{1-\beta} \ln x$$

and the corresponding optimal policy functions are linear in total wealth

$$c(x, \theta, s) = (1 - \beta)(1 + r(\theta, s))x$$

$$x'(x, \theta, s) = \beta(1 + r(\theta, s))x$$

$$\theta'(x, \theta, s) = \theta'(s)$$
Proof (idea)

By induction using the previous result and the fact that the value function after default has the functional form

\[ V_d(x, \theta, s) = \tilde{V}_d(s) + \frac{1}{1 - \beta} \ln (1 + r(\theta, s)) + \frac{1}{1 - \beta} \ln x \]
Proposition: Tractability

A stationary recursive equilibrium can be found by solving a finite-dimensional fixed-point problem that is independent of the wealth distribution (though the relative wealth distribution across types still matters)

Proof (idea): Apply previous result and transform market clearing conditions
Proposition: Risk-Insurance Correlation

Consider the simple economy described in more details in the paper. Define the following two insurance measures:

\[ I_1(s_1) = 1 - \frac{\sigma [c_{t+1}/c_t | s_1]}{\sigma [c_{aut,t+1}/c_{aut,t} | s_1]} \quad s_1 \in \{\text{young, old}\} \]

\[ I_2(s_1) = \frac{\theta_a(s_1, \text{bad}) - E[\theta_a | s_1]}{\eta(\text{bad}) \theta_h(s_1)} \quad s_1 \in \{\text{young, old}\} \]

We then have:

\[ \theta_h(\text{young}) \geq \theta_h(\text{old}) \]

\[ I_1(\text{young}) \leq I_1(\text{old}) \]

\[ I_2(\text{young}) \leq I_2(\text{old}) \]
Quantitative analysis

- $s_t = (s_{1t}, s_{2t}, s_{3t})$

- Life-cycle model: $s_1 \in \{23, \ldots, 60, \text{transition, retirement}\}$
  Expected depreciation rate (productivity) of human capital investment depends on age $s_1$

- $s_{2t}$: human capital risk I – death of a household member (widowhood)

- $s_{3t}$: human capital risk II – everything else (labor market risk, disability risk)
Calibration

- Choose age-dependent depreciation rates to match the life-cycle profile of median earnings (growth)

- Choose human capital risk $s_2$ to be consistent with empirical evidence on human capital (labor income) loss in the cases of death of a family member – consequences of widowhood

- Choose human capital risk $s_3$ so that implied labor income process is consistent with estimates of the empirical literature on labor income risk
Data: Survey of Consumer Finance

- Repeated cross-section; every three years

- Household-level data

- We use data on labor income, net worth (financial wealth), and life insurance

- We use surveys 1992-2007

- We always compute median value from the data (conditional on age)
Figure 1: Life-cycle profile of log labor income
Figure 2: Life-cycle profile of labor income growth
The calibrated model provides a good quantitative account of the “observed” human capital choice over the life-cycle

\[
\text{human capital choice} = \frac{\text{net worth}}{\text{labor income}}
\]
Figure 3: Life-cycle profile of portfolio choice
Calibrated model implies a substantial increase in insurance measures $I_1$ and $I_2$ over the life-cycle.

We construct an empirical insurance measure

$$\tilde{I}_2 = \frac{\text{insurance payout}}{\eta(\text{bad}) \times (\text{current earnings}) \times \text{PVF}}$$

$\eta(\text{bad})$: fraction of human capital lost

The empirical insurance measure $\tilde{I}_2$ increases with age.

Calibrated model matches the intensive margin of the life-insurance data well.
Figure 4: Life-cycle profile of consumption insurance
Figure 7: Life-cycle profile of life insurance
Result 3

- Extended model with heterogeneity in family structure (for example, number of kids) and therefore heterogeneity in $\eta(\text{bad})$

- Some families have no need for life-insurance, $\eta(\text{bad}) = 0$, and some families need life insurance, $\eta(\text{bad}) > 0$ drawn from a fixed distribution

- The fraction of families with $\eta(\text{bad}) = 0$ decreases with age

- Extended model matches both intensive and extensive margin of life-insurance data
Figure 10: Life-cycle profile of life insurance (extended model)
Result 4

Calibrated model is consistent with the empirical life-cycle profile of consumption inequality.
Figure 6: Life-cycle profile of consumption inequality
Calibrated model implies substantial welfare costs of under-insurance for the young – equivalent to almost 4 percent of lifetime consumption for 23-old household
Figure 5: Life-cycle profile of welfare cost of under-insurance
Policy Implications

What type of policy reform would lead to a welfare-improving increase in insurance and human capital investment?

- subsidize credit – but ensure that households in default do not have access to the subsidy (not in paper)

- more stringent bankruptcy code – garnish labor income (in paper)