Who Benefits from College and the Stock Market?

Kartik Athreya[1] Felicia Ionescu[2] Urvi Neelakantan[1]
Ivan Vidangos[2]

[1]Federal Reserve Bank of Richmond

[2]Federal Reserve Board

Third European Workshop on Household Finance
May 11-12, 2018

The views expressed here are those of the authors and should not be interpreted as reflecting the views of the Board of Governors, the Federal Reserve Bank of Richmond or the Federal Reserve System.

- College and stocks: two risky investments with similar average yields
- Returns to college vary by individual type, returns to the stock market do not
- Direct subsidies reduce college costs irrespective of type, stock purchases not subsidized

Does the power of college to increase well-being exceed that of stocks, as large subsidies to the former suggest?

What We Do

- Measure the heterogeneity in the value of access to college and stocks across individual types
- Examine who might prefer the equivalent of the current college subsidy as a stock index fund available at retirement

What We Find

- **Value of Access to College**: Average of individual utility gains about 3 percent in consumption-equivalent terms
  - Variation in gains also large
    - little impact for nearly *half* the population
    - substantial gain (11 percent) for the top ability quartile
- **Value of Access to Stocks**: Average of individual utility gains also about 3 percent
  - More than half the population would, all else equal, prefer the stock-index retirement fund to the current direct subsidy to college

Heterogeneity in US College Returns

- Average returns to college completion high in the US: lifetime earnings of college graduates twice those of high school graduates (Goldin and Katz, 2007)
- Noncompletion prevalent: roughly half of all enrollees in public 4-year colleges fail to complete (Bound et al, 2010)
- Completion probability correlated with individual traits
  - High positive correlation with measures of ability and preparedness such as transcript data (Hendricks and Leukhina, 2017)

$\Rightarrow$ **Returns to college likely vary greatly by individual types**

College Subsidies

- College subsidized in several ways, notably directly through reduced tuition (particularly in-state at public schools)
- This increases affordability for *all* enrollees

$\Rightarrow$ **If returns to college heterogeneous, so too is value of subsidy**

Model

- Build on Huggett, Ventura, and Yaron (2006, 2011)...
  - Standard life-cycle consumption-savings model with uninsurable, idiosyncratic labor-income risk
  - Ex-ante heterogeneity in learning ability, initial human capital, and initial wealth
  - Human capital investment over the life cycle as in Ben-Porath
- ...to include college and a stock market
  - Human capital investment early in life using a rich model of college
  - Portfolio allocation between a risky and a risk-free asset

How We Use Model

- Derive joint distribution of learning ability, initial human capital, and initial financial wealth that delivers empirically-accurate heterogeneity in earnings and college behavior
- Compare outcomes in baseline economy to economies in which investment options differ
  - No college economy
  - No stocks economy
- Use the two counterfactuals to measure individual-level variation in the valuation of these investment opportunities
- Consider subsidies to stocks instead of college subsidies

Related Literature

- Human capital
  - Ben-Porath (1967); Huggett, Ventura, Yaron (2006, 2011)
- College
  - Athreya and Eberly (2013); Chatterjee and Ionescu (2012); Hendricks and Leukhina (2014); Abbott et al (2016)
- Stocks
  - Athreya, Ionescu, Neelakantan (2018); Cocco, Gomes, Maenhout (2005); Constantinides, Donaldson, Mehra (2002); Davis, Kubler, Willen (2006)

Environment

- Discrete time: $t = 1, ..., J, .., T$
- At $t = 1$ agents differ in learning ability, a, initial human capital, h_1, and initial assets, x_1
- Youth
  - Decide whether to invest in college (at $t = 1$)
  - If they do invest, they face completion probability $\pi(h_5(h_1, a))$ realized at end of college period ($t = 5$)
  - Can finance college with wealth, non-defaultable student loan debt, d_t, non-defaultable borrowing, b_t, and grants $\kappa(a, x_1)$
- Throughout Life
  - Divide time between work and human capital accumulation
  - Allocate available resources between consumption, c_t, risky asset, s_t, and risk-free asset, b_t
  - Can borrow using non-defaultable debt, b_t

Preferences

- Standard time-separable CRRA utility
- Household chooses consumption $\{c_t\}_{t=1}^{T}$ to solve

$$\max_{(\{c_t\}\in\Pi(\Psi_0))} E_0 \sum_{t=1}^{T} \beta^{t-1} \frac{c_t^{1-\sigma}}{1-\sigma},$$

$\Pi(\Psi_0)$ denotes the space of all feasible combinations $\{c_t\}_{t=1}^{T}$, given initial state $\Psi_0 \equiv \{a, h_1, x_1\}$

Human Capital and Earnings

- Human capital evolves according to

$$h_{t+1} = h_t(1-\delta^e) + a(h_t l_t)^\alpha \text{ with } \alpha \in (0,1) \text{ and } e \in NC, CG$$

- Labor income (earnings)

$$y_{it} = w_t^e h_{it}(1-l_{it})z_{it}^e$$

$$\begin{aligned} w_t^e &= (1+g^e)^{t-1} \\ z_{it}^e &= u_{it}^e + \epsilon_{it}^e \\ u_{it}^e &= \rho^e u_{i,t-1}^e + \nu_{it}^e \\ \nu_{it}^e &\sim N(0, \sigma_\nu^{e2}) \\ \epsilon_{it}^e &\sim N(0, \sigma_\epsilon^{e2}) \end{aligned}$$

- Means tested transfer income

$$\tau_{it}(t, y_{it}, x_{it}) = \max\{0, \underline{\tau} - (\max(0, x_{it}) + y_{it})\}$$

Financial Wealth

- Risk-free asset b_t
  - Savings ($b_t \geq 0$) earn risk-free rate R_f
  - Borrowing ($b_t < 0$) at rate $R_b = R_f + \phi$, non-defaultable, and subject to a limit $\underline{b}$
- Risky asset s_t
  - Earns return $R_{s,t+1} = R_f + \mu + \eta_{t+1}$
    - μ is mean excess return
    - Innovation to excess return $\eta_{t+1} \sim N(0, \sigma_\eta^2)$ iid
  - Short sales constraint $s \geq 0$
- Financial wealth

$$x_{t+1} = R_j b_{t+1} + R_{s,t+1} s_{t+1}$$

with $R_j = R_f$ if $b \geq 0$ and $R_j = R_b$ if $b < 0$

Retiree's Problem

- Agents retire at $t = J + 1$

$$V^R(t, a, b, s, y_J) = \sup_{c, b', s'} \{ \frac{c^{1-\sigma}}{1-\sigma} + \beta V^R(t+1, a, b', s', y_J) \}$$

where

$$\begin{aligned} c + b' + s' &\leq \varphi^e(y_J + \tau_J) + R_j b + R_s s,\ e \in NC, CG \\ b' &\geq \underline{b} \\ s' &\geq 0 \end{aligned}$$

Problem During Working Life: No College Path

$$V^{HS}(t,a,h,b,s,z) = \sup_{l,c,b',s'} \{\frac{c_t^{1-\sigma}}{1-\sigma} + \beta EV^{HS}(t+1,a,h',b',s',z')\}$$

where

$$\begin{aligned} c + b' + s' &\leq w(1-l)hz + R_j b + R_s s + \tau(t,y,x) \text{ for } t = 1,..,J-1 \\ l &\in [0,1] \\ h' &= h(1-\delta) + a(hl)^{\alpha} \\ b' &\geq \underline{b} \\ s' &\geq 0 \end{aligned}$$

Problem During Working Life: College Path

$$V^e(t,a,h,b,s,z) = \max_{l,c,b',s'} \{\frac{c_t^{1-\sigma}}{1-\sigma} + \beta EV^e(t+1,a,h',b',s',z')\}, e = CG, SC$$

where

$$\begin{aligned}
c + b' + s' &\leq w(1-l)hz + R_j b + R_s s + \tau(t,y,x) \text{ for } t = P+1,..,J-1 \\
c + b' + s' &\leq w(1-l)hz + R_j b + R_s s + \tau(t,y,x) - p(x_1) \text{ for } t = 5,..,P \\
l &\in [0,1] \\
h' &= h(1-\delta) + a(hl)^\alpha \\
b' &\geq \underline{b} \\
s' &\geq 0
\end{aligned}$$

$$p = \frac{d(x)}{\sum_{t=1}^{P-5} \frac{1}{R_g^t}}$$

Problem in College

- $V^C(5, a, h, b, s, z) =$
  $\pi(h_5)V^{CG}(5, a, h, b, s, z) + (1 - \pi(h_5))V^{SC}(5, a, h, b, s, z)$
- $$V^C(t, a, h, b, s, z) = \max_{l, b', s'} \left[\frac{c^{1-\sigma}}{1-\sigma} + \beta V^C(t+1, a, h^{'}, b^{'}, s^{'}, z^{'}) \right]$$

  where

$$\begin{aligned} c + b^{'} + s^{'} &= w_{col}(1-l) + R_j b + R_s s + \frac{d}{4} - \frac{\hat{d}}{4} \\ h' &= h(1-\delta) + a(hl)^{\alpha} \\ d &\leq \min[d_{max}, max[\bar{d} - x, 0]] \end{aligned}$$

- Education decision

$$\max[V^C(1, a, h, x), V^{HS}(1, a, h, x)]$$

Data

- Annual earnings for male household heads from 1964-2014 waves of March Current Population Survey (CPS)
  - Create life-cycle profiles of Mean, Dispersion (Gini), and Skewness (Mean/Median), controlling for calendar-year effects
- Financial assets and debt from 1989-2013 waves (triennial) of the Survey of Consumer Finances (SCF)
  - Create life-cycle profiles of asset levels and stock market participation, controlling for time effects.
- Data on college enrollment and completion (by wealth level) from the Beginning Postsecondary Students Longitudinal Study (BPS) of the National Center of Education Statistics (NCES) and the National Education Longitudinal Study (NELS:1988)

Parameters

Parameter	Name	Value
T	Model periods (years)	58
J	Working periods (after college)	34
β	Discount factor	0.96
σ	Coeff. of risk aversion	3
R_f	Risk-free rate	1.02
R_b	Borrowing rate	1.11
$\underline{b}$	Borrowing limit	\$17,000
μ	Mean equity premium	0.06
σ_η	Stdev. of innovations to stock returns	0.157
α	Human capital production function elasticity	0.7
g_{NC}, g_{CG}	Growth rate of rental rate of human capital	0.01, 0.02
δ_{NC}, δ_{CG}	Human capital depreciation rate	0.021, 0.038
ψ_{NC}, ψ_{CG}	Fraction of income in retirement	0.682, 0.93
$\underline{\tau}$	Minimal income level	\$17, 936
$(\rho_{NC}, \sigma^2_{\nu NC}, \sigma^2_{\epsilon NC})$	Earnings shocks no college	(0.951, 0.055, 0.017)
$(\rho_{CG}, \sigma^2_{\nu CG}, \sigma^2_{\epsilon CG})$	Earnings shocks college	(0.945, 0.052, 0.02)
$(\mu_a, \sigma_a, \mu_h, \sigma_h, \varrho_{ah})$	Parameters for joint distribution of ability and initial human capital	(0.44, 0.75, 77, 33, 0.71)
$\hat{d}$	Annual direct cost of college	\$7,100
$\bar{d}$	Annual full cost of college	\$53,454
d_{max}	Limit on student loans	\$23,000
w_{col}	Wage during college	\$17,700

Calibration of the Initial Distribution

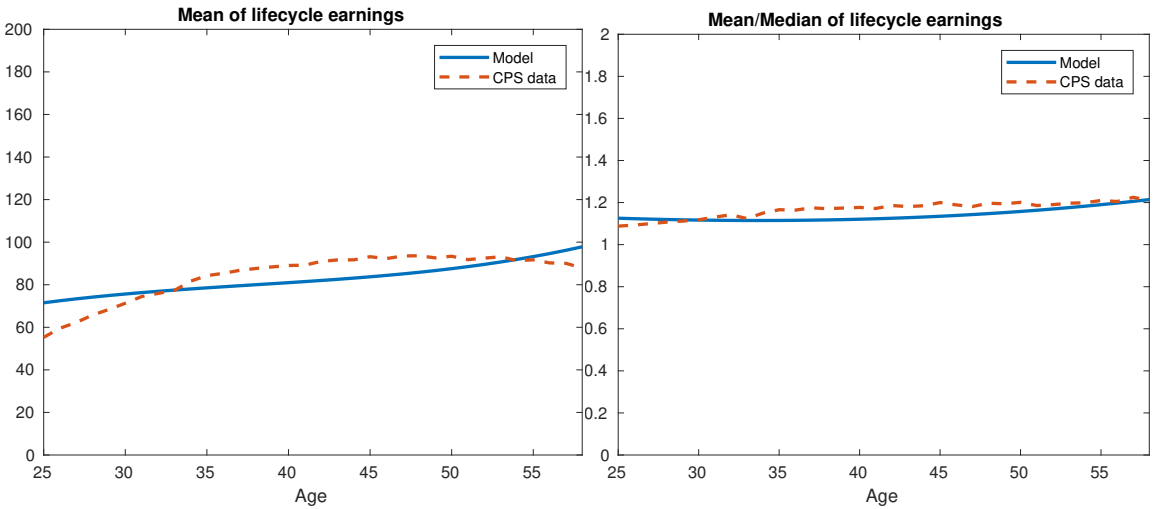
- Parametric approach: joint log-normal distribution characterized by the vector of parameters $\gamma = (\mu_a, \sigma_a, \mu_h, \sigma_h, \rho_{ah})$
  - Find γ that solves

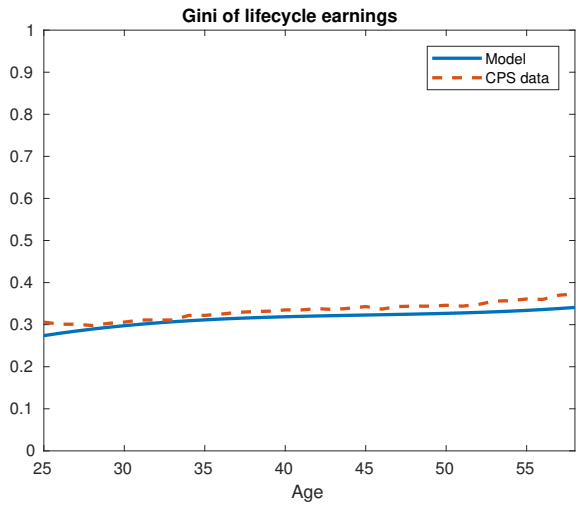
$$\min_{\gamma} \left(\sum_{j=5}^{J} |log(m_j/m_j(\gamma))|^2 + |log(g_j/g_j(\gamma))|^2 + |log(d_j/d_j(\gamma))|^2 \right)$$

- The model produces $\rho_{ah} = 0.71$.
- Pick correlations $\rho_{ax} = 0.42$ and $\rho_{xh} = 0.55$ to match college enrollment and completion

Targeted Moments

Earnings





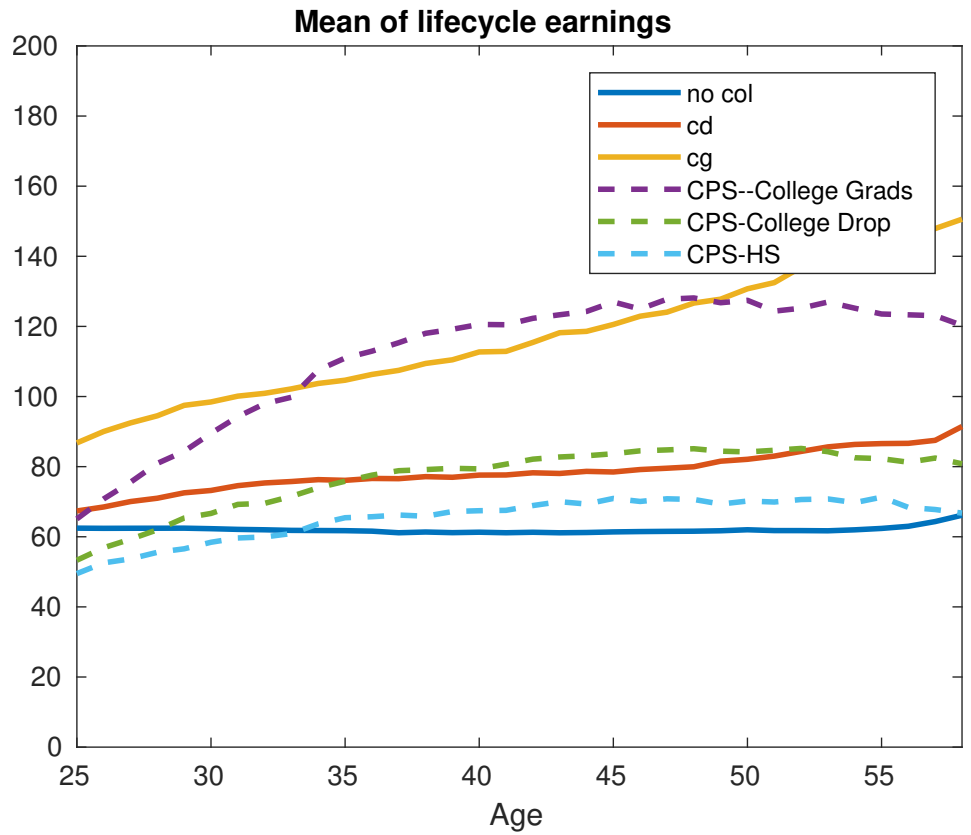
Targeted Moments

Enrollment and Completion

Initial wealth	Benchmark	Data (BPS)
College Enrollment	**54**	**47**
Low	35	34
Medium	55	47
High	74	62
College Completion	**49**	**45**
Low	43	37
Medium	49	45
High	57	60

Non-targeted Moments

Earnings by Education Group



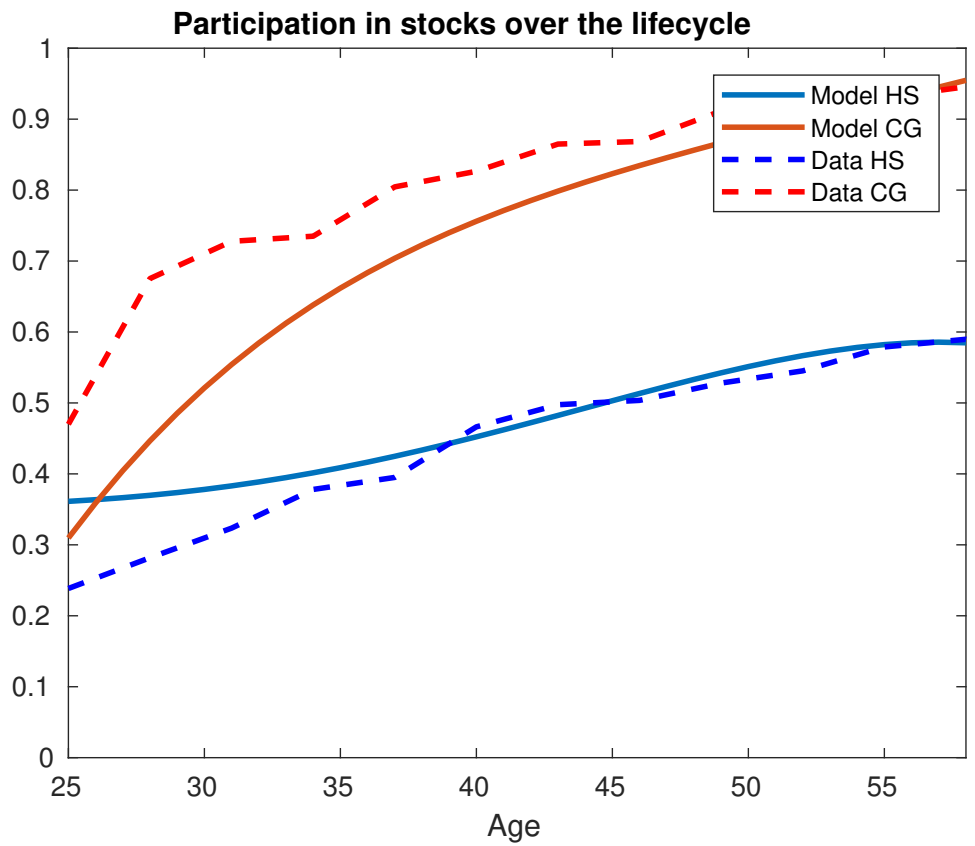
Non-targeted Moments

Enrollment and Completion by Characteristics

Characteristic	Ability	Initial Human Capital	Data: SAT scores
College Enrollment			
Low	9	26	53
Medium	63	65	65
High	85	64	85
College Completion			
Low	20	27	30
Medium	42	48	50
High	64	68	69

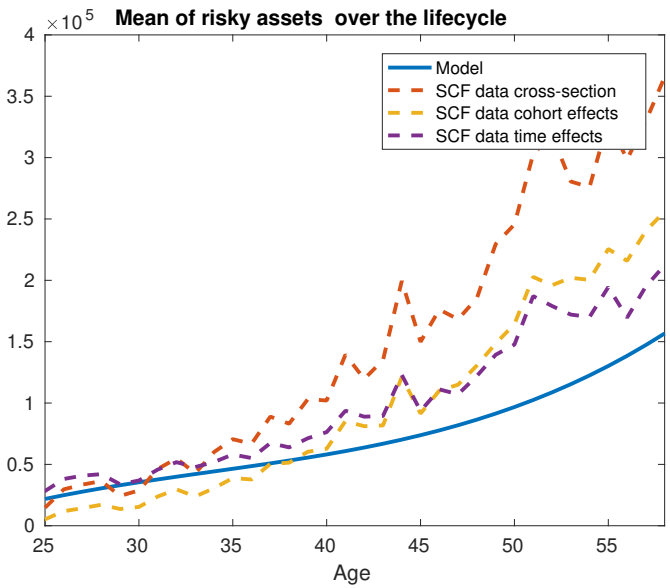
Non-targeted Moments

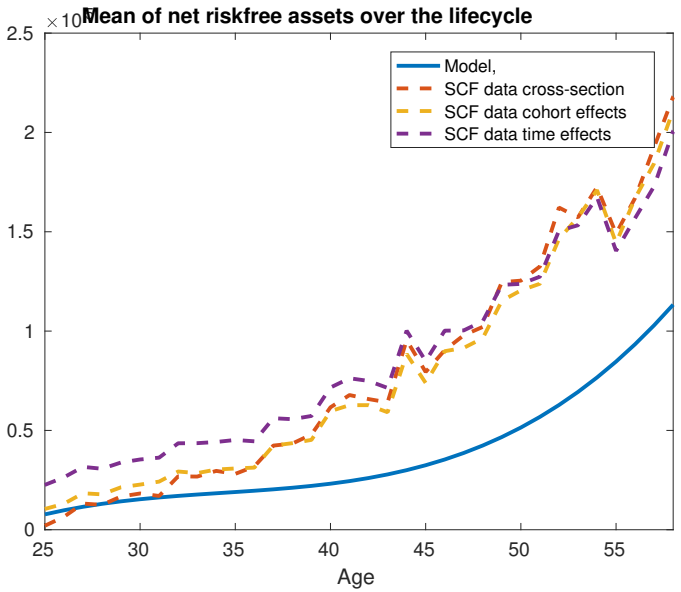
Stock Market Participation over the Life Cycle



Non-targeted Moments

Life-Cycle Wealth Accumulation





Who benefits from college and the stock market?

Mean of Lifetime	Benchmark	No College	No Stocks
Earnings	1	0.913	1.11
Wealth	1	0.903	1.12
Utility	1	0.972	0.973

College is second best for many

	Enrollment		Completion	
Characteristic	Benchmark	No Stocks	Benchmark	No Stocks
Ability				
Low	9	68	20	29
Medium	63	100	42	42
High	85	100	64	65
Initial Human Capital				
Low	26	72	27	27
Medium	65	97	48	39
High	64	100	68	63
Initial Wealth				
Low	35	80	43	40
Medium	55	94	49	44
High	74	100	57	51

Heterogeneous Types, Heterogeneous Gains: Earnings

	Benchmark	No College	No Stocks
Ability			
Low	1	1	1.10
Middle	1	0.86	1.19
High	1	0.94	1.03
Initial human capital			
Low	1	0.85	1.06
Middle	1	0.90	1.14
High	1	0.94	1.09
Initial wealth			
Low	1	0.93	1.13
Middle	1	0.91	1.12
High	1	0.90	1.08

Effect of the Subsidy on Lifetime Earnings and Wealth

Relative to Benchmark

	Benchmark	Stocks subsidy ($85,000)
Earnings	1	0.94
Wealth	1	0.93
Utility	1	1.015

Subsidy Reallocation and College Enrollment and Completion

	Enrollment		Completion	
Characteristic	Benchmark	Stock Subsidy	Benchmark	Stock Subsidy
Ability				
Low	9	0.5	20	0
Medium	63	4	42	43
High	85	79	64	65
Initial Human Capital				
Low	26	1	27	36
Medium	65	16	48	54
High	64	52	68	69
Initial Wealth				
Low	35	5	43	56
Medium	55	20	49	62
High	74	44	57	66

Summary

- **What We Do**: Construct rich model of human capital accumulation and portfolio choice to measure variation in the value of college and stocks across individuals
- **Value of Access to College**: Average of individual utility gains about 3 percent in consumption-equivalent terms
  - Variation in gains also large
    - little impact for nearly *half* the population
    - substantial gain (11 percent) for the top ability quartile
- **Value of Access to Stocks**: Average of individual utility gains also about 3 percent
  - More than half the population would, all else equal, prefer the stock-index retirement fund to the current direct subsidy to college

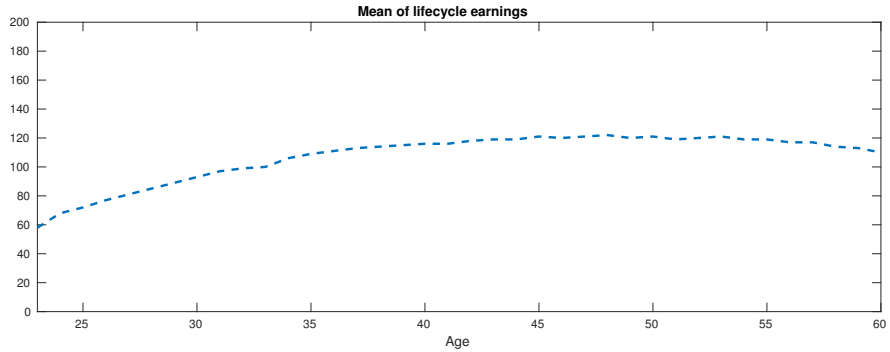
Caution

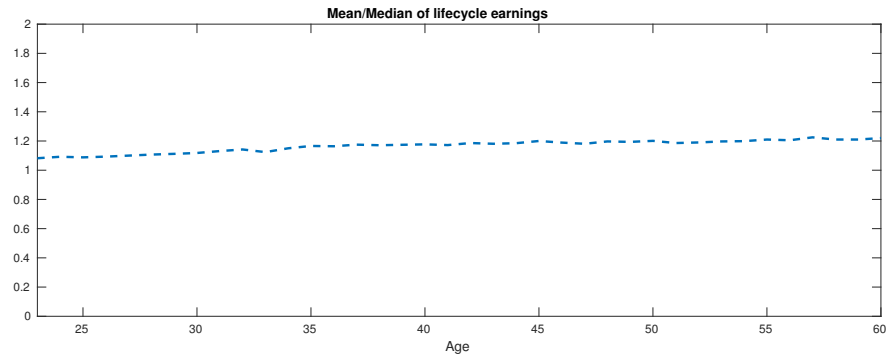
- Goal of paper is to measure individuals' valuations of investment options under current circumstances, not to assess economy-wide changes in policy

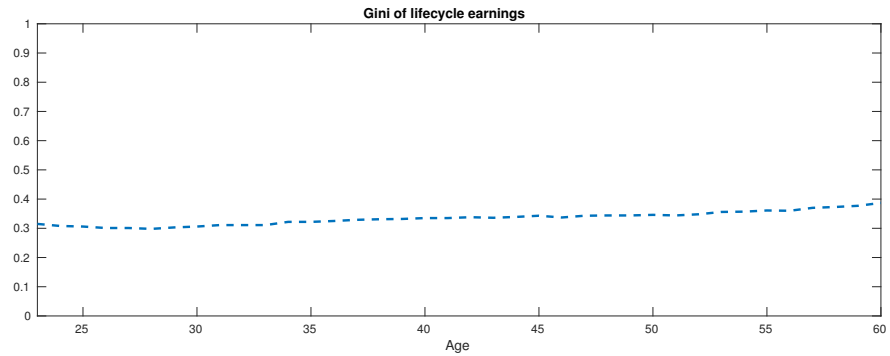
Data: Earnings

- March Current Population Survey (CPS)
- Annual wage and salary income for male household heads with at least a high school diploma for calendar years 1963-2013 (survey years 1964-2014)
- Restrict sample to individuals who worked at least 12 weeks in reference year and earned at least $1,000 (in 2014 dollars)
- Weight data to represent US population; weights renormalized to keep population constant at 2014 value
- Use data to construct lifecycle profiles for mean, Gini, and mean/median ratio of earnings
  - Control for time effects by regressing on full set of year and age indicators
  - Normalize age coefficients at age 40 value

Estimated Average Life Cycle Earnings Statistics



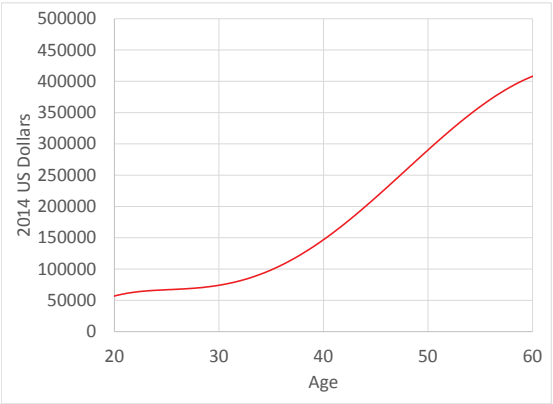




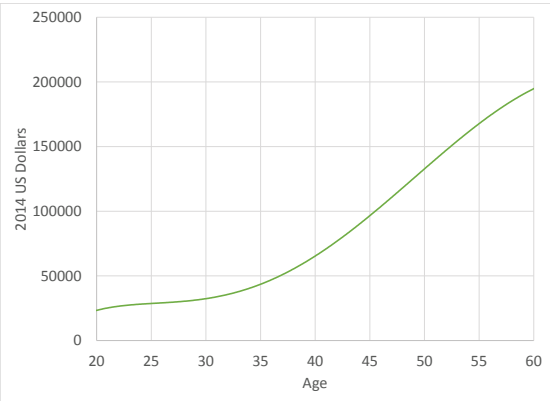
Data: Wealth

- Obtain wealth data from 1989-2013 waves (triennial) of the Survey of Consumer Finances (SCF)
- Separate financial assets into risky and risk-free
  - Risky assets include stocks, both directly held and amounts in mutual funds, IRAs/Keoghs, thrift-type retirement accounts, and other managed assets
- Like for earnings, construct lifecycle profiles controlling for time effects
  - Use 2013 as base year

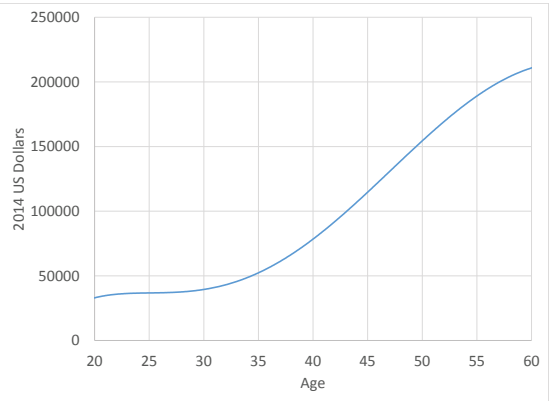
Estimated Average Life-Cycle Assets (SCF)



Total



Risky



Risk-free

Data: Enrollment and Completion I

- College enrollment and completion data from the National Education Longitudinal Study of 1988 (NELS:88) and the Beginning Postsecondary Students Longitudinal Study (BPS) (both from the National Center for Education Statistics)
- NELS
  - Nationally representative sample of US 8th-graders first surveyed in 1988
  - Follow-up surveys in 1990, 1992, 1994, and 2000
  - We use the third follow-up survey when most respondents completed high school to observe their post-secondary choice

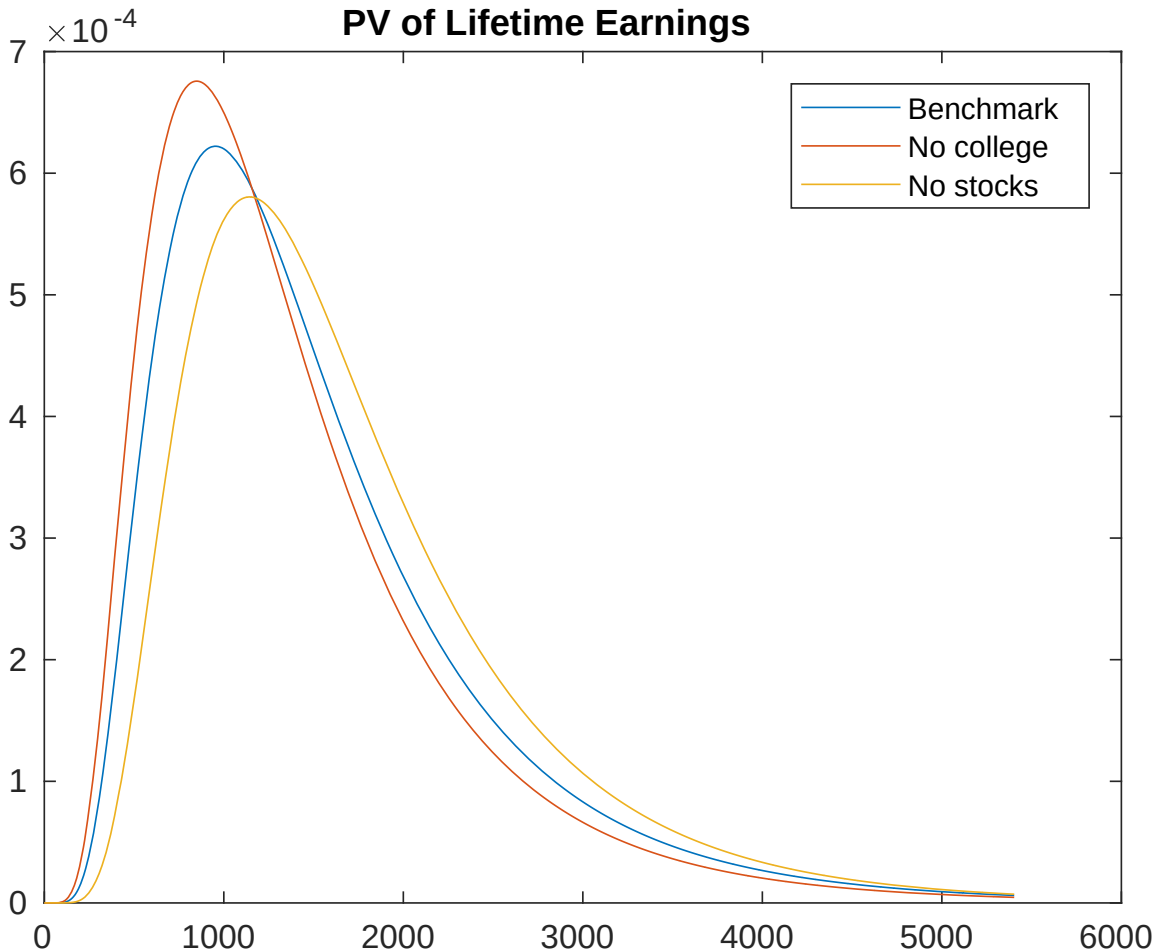
Data: Enrollment and Completion II

- BPS
  - Cohorts include beginners in post-secondary schools surveyed at three points in time: in their first year and then three and six years after starting post-secondary education
  - Data includes student demographics, school experiences, persistence, borrowing/repayment of student loans, and degree attainment
  - Our sample consists of students aged 20-30 who enroll in a four-year college following high school graduation

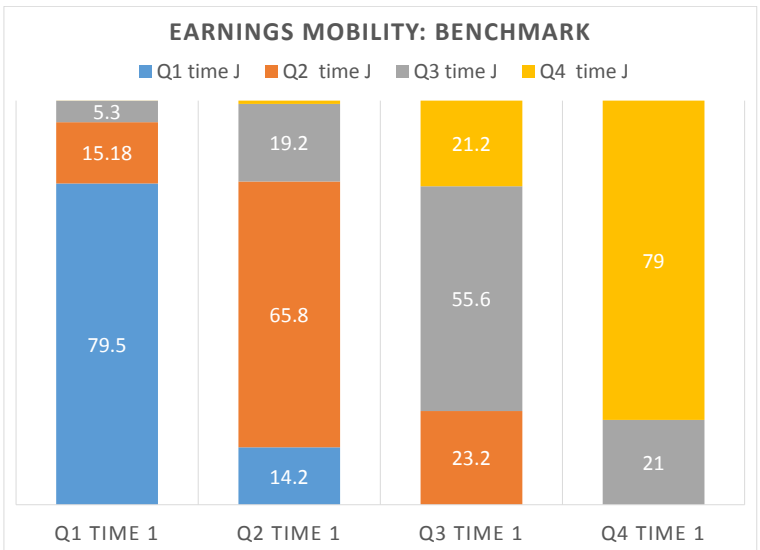
Grades and College Completion

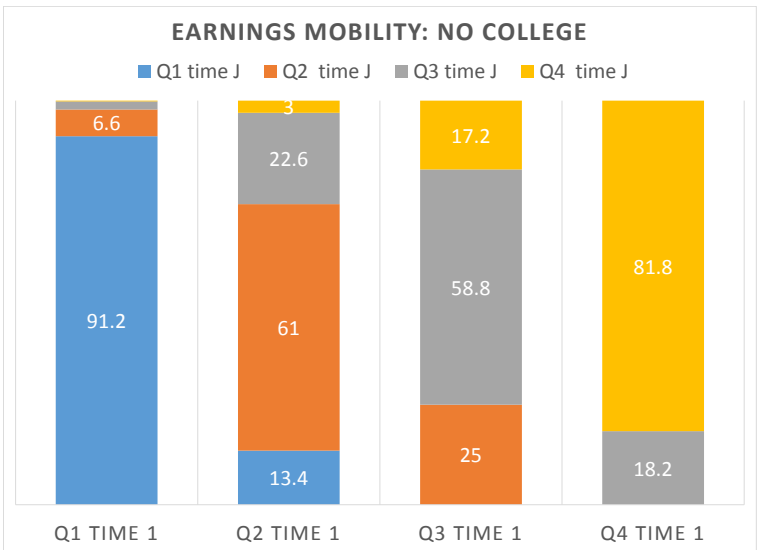
Completion rate	Grades
0.07	grades C and D
0.30	mostly Cs
0.45	mostly Bs and Cs
0.56	mostly Bs
0.67	mostly Bs and As
0.70	mostly As

Changes in Lifetime Earnings

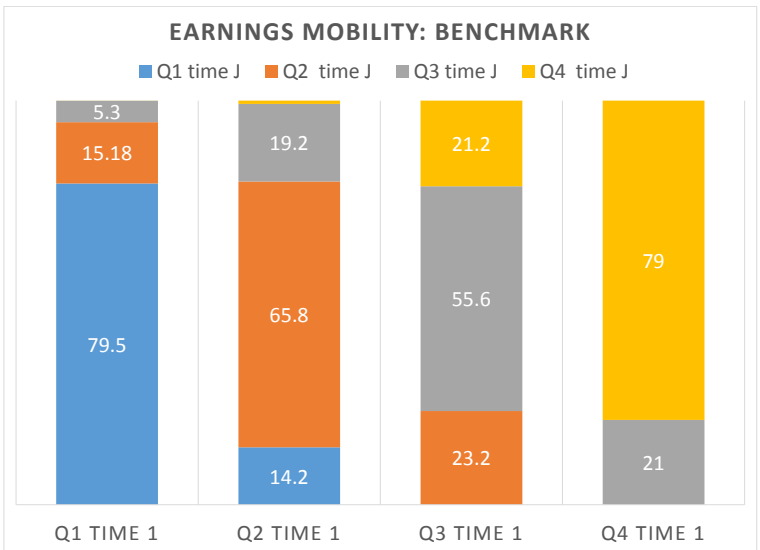


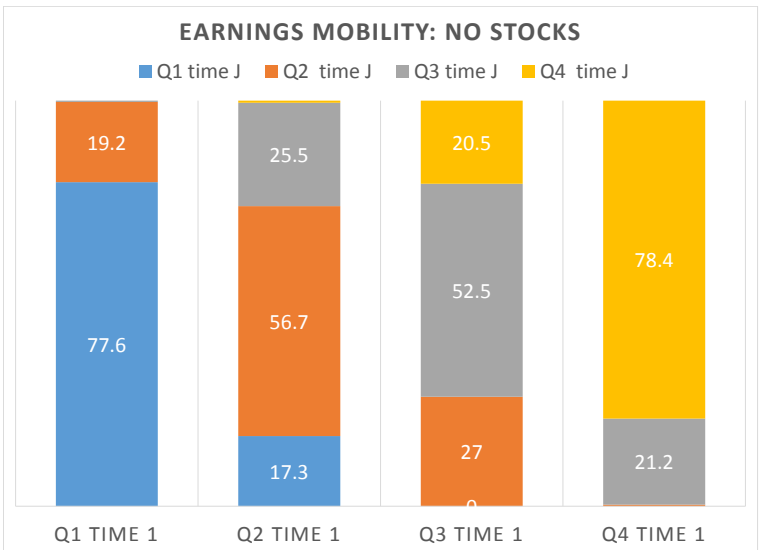
Earnings Mobility: Benchmark vs. No College





Earnings Mobility: Benchmark vs. No Stocks





Upward Mobility and Heterogeneity

	Baseline	No College	No Stocks
Ability			
Q1	0.1	0.2	13.6
Q2	1.5	2.9	20.5
Q3	19.0	15.4	27.5
Q4	79.4	81.5	40.0
Initial Wealth			
Q1	11.0	0.2	13.8
Q2	18.5	3.0	19.3
Q3	27.8	12.3	26.9
Q4	42.7	84.5	39.0

- Note: Probability of being in the top earnings quartile at the end of working life conditional on being in the bottom earnings quartile at the start of life.

Effect of Subsidy Reallocation on Earnings

	Benchmark	Stocks Subsidy
Ability		
Low	1	1.02
Middle	1	0.88
High	1	0.97
Initial human capital		
Low	1	1.3
Middle	1	0.83
High	1	0.96
Initial wealth		
Low	1	0.73
Middle	1	0.77
High	1	1.32

Earnings Mobility: Benchmark vs. Stocks Subsidy