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Is College Worth It For Me?
Beliefs, Funding, and Higher Education

Sergio Barrera
University of Minnesota

Motivation

- Gaps persist in Bachelor's degree attainment,

  - BA attainment by race 2020: White 35%; Black 21%; Hispanic 15%. (National Center of Education Statistics)

  - BA attainment for early 80s cohorts: top income quartile 54%; bottom quartile 9%. (Dynarski 2011)

- High academic scoring youth not enrolling and completing college could be costly (Hsieh, Hurst, Klenow, Jones 2020).

- Information frictions have been shown to create underinvestment in higher education (Arcidiacono, Aucejo, Maurel, Ransom 2016). Examples Financial Examples Beliefs

Motivation Continued

- Gaps persist in enrollment and application behavior even for high academic scoring youth (Hoxby and Avery 2012).

    - Behavior most consistent with low socioeconomic status (SES) high scorers poorly informed about college. (Hoxby and Turner 2012).

    - Low SES College enrollment increased through information campaign (Dynarski, Libassi, Michelmore, Owen 2018).

    - Beliefs about ability can explain 45 % of droupout for mostly low SES youth at Berea College. (Stinebrickner & Stinebrickner 2012).

Research Question

1. Role of Differences in beliefs about ability in generating gaps in BA attainment for "High Scoring" youth by demographics.
   - Black, Hispanic, low socioeconomic status (SES) vs White high SES.

2. Which policy is more efficient at decreasing gaps in BA attainment independent of ability?
   - Recruiting Policy: Target Info and funding to low SES High Scorers.
   - Free College for all: Net Tuition zero for everyone.
   - Tracking System: Info on Prob Successful in College to all.
   - Efficiency: Mismatch- under and over investment in Edu.

- Answer depends on importance of information frictions, proportion of high scorers by demographic.

Strategy

- Estimate a dynamic discrete choice model with

  1. Latent earnings/ability type.

  2. Credit frictions with differences in financial assistance.

  3. Differences in subjective beliefs about earnings/ability type.

  4. Learning through grades.

Main Findings

- In Quantitative Model
    1. Beliefs: 38-49 % of BA gap; Hispanic, Low SES High Scorers
        - Almost no statistically significant role for Black High Scorers.
        - Financial resources important for all.

    2. Targeted subsidies and info best at closing overall gaps (close by 25-42% depending on comparison group).
        - Free College for All: decreases gaps at lower rate through Non High Scorers.
        - Better Info for all: increases inequality, due to distribution of High Scorers.

- **Implications:** More representation with better scholarships, recruiting, guidance counseling.
    - But gaps will persist; differences K-12, HH environment, college experiences.

Contribution to the literature

1. **Beliefs, learning, dropout in college:** Stinebrickner & Stinebrickner 2012, 2014; Wiswall & Zafar 2015.

   - Subjective beliefs data, study major choice, dropout in college.

   - Single college panel data, no earnings or enrollment.

   . .

2. **Structural Education Models:** Heckman, Cunha Navarro 2005; Navarro & Zhou 2017.

   - Policy analysis with info/credit frictions.

   - US panel data with earnings, no beliefs, estimate info sets.

- Bridge two together, study enrollment & completion, use US panel data with beliefs and earnings (Arcidiacono, Aucejo, Maurel, Ransom 2016).

- First: Study role of info frictions in inequality by race, ethnicity, SES.

Data Description and Patterns

- **Data Sources**: NLSY97: Panel data, cohorts born 1980-1984, oversamples Hispanic, Black Americans.

- Use data on
    - HH net worth, parental education
    - Race, ethnicity, geography
    - Cognitive and non cognitive ability measures
    - Financial assistance, grades in college
    - Beliefs about college outcomes
    - Actual earnings, GPA, and educational attainment

Summary Statistics

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Empirical Patterns

- In the NLSY97
  1. Holding financial resources, family background, human capital constant, more optimism correlated with more enrollment/completion. College Outcomes

  2. Continuation lower every grade level for more pessimistic youth. Non Continuation Pattern

  3. Holding human capital, HH net worth constant, optimism correlated with parental education, race, ethnicity. Belief Regression
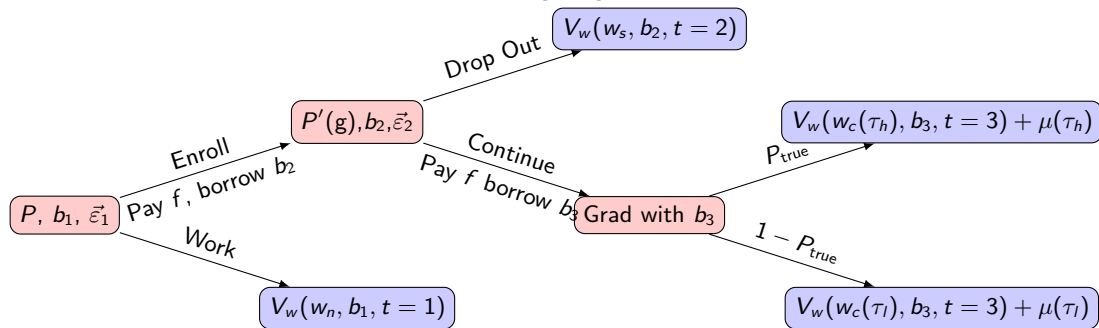
Model and Data

- To match data, in model enrollment/completion probability must increase with financial assistance, beliefs, and human capital.

- To capture HH net worth, parental education, race, ethnicity, human capital patterns

    1. Parental Edu $\rightarrow$ subjective beliefs, financial assistance, true prob High Scorer, non pecuniary utility.

    2. Parental Wealth $\rightarrow$ financial assistance, true prob High Scorer.

    3. Race Ethnicity $\rightarrow$ financial assistance, true prob High Scorer, non pecuniary utility.

    4. Human Capital $\rightarrow$ true prob High Scorer.
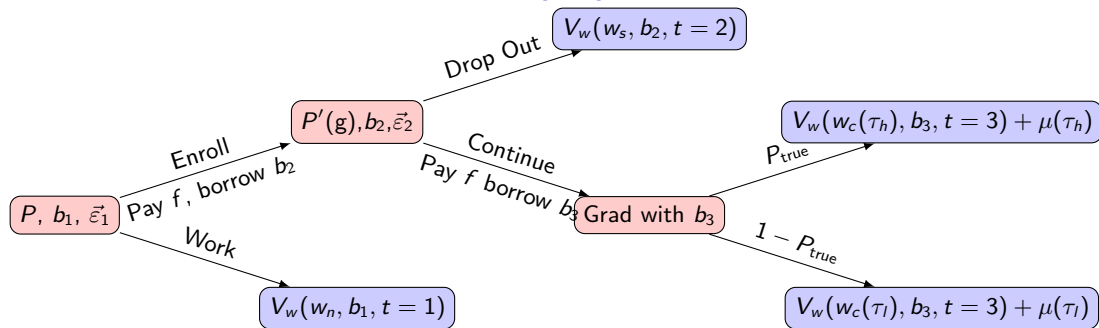
Model Framework

- Discrete Choice, Finite Horizon, 24 periods, period length 2 years.

- Three stages: enroll/work, continue/exit, realize post college earnings and work.

- Agents don't know type $\tau \in \{\tau_l, \tau_h\}$ that determines earnings $w_c(\tau)$, GPA g, and post college non pecuniary utility $\mu(\tau)$.

- Agents begin with prior P for $\tau = \tau_h$, update P through grades.

- Each period agents borrow. Student borrowing limit stricter than worker's.

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Timeline

$$V_w(w_s, b_2, t = 2)$$

Drop Out

$$P'(g), b_2, \vec{\varepsilon}_2$$

Enroll
Pay f, borrow b_2

Continue
Pay f borrow b_s

$$P, b_1, \vec{\varepsilon}_1$$

Work

Grad with b_3

$$V_w(w_c(\tau_h), b_3, t = 3) + \mu(\tau_h)$$

P_{true}

$1 - P_{true}$

$$V_w(w_n, b_1, t = 1)$$

$$V_w(w_c(\tau_l), b_3, t = 3) + \mu(\tau_l)$$

- Stage 1, (t=1): Begin belief P, asset b_1, taste shocks $\vec{\varepsilon}_1$; enroll or work and earn w_n.

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Timeline

- Stage 1, (t=1): Begin belief P, asset b_1, taste shocks $\vec{\varepsilon}_1$; enroll or work and earn w_n.
- Stage 2 (t=2): Realize GPA g, Update to $P'(g)$, debt b_2, taste shocks $\vec{\varepsilon}_2$; continue or work and earn w_s.

Timeline
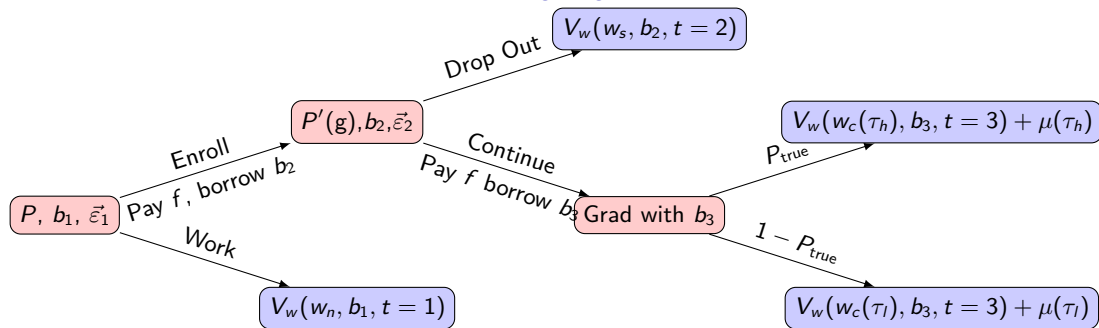
- Stage 1, (t=1): Begin belief P, asset b_1, taste shocks $\vec{\varepsilon}_1$; enroll or work and earn w_n.
- Stage 2 (t=2): Realize GPA g, Update to $P'(g)$, debt b_2, taste shocks $\vec{\varepsilon}_2$; continue or work and earn w_s.
- Stage 3, (t=3,...,T): Complete College with debt b_3, Prob P_{true} earn $w_c(\tau_h)$, $(1\text{-}P_{\text{true}})$ earn $w_c(\tau_l)$.

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Stage 1: Enrollment Decision

- Begin with asset b_1 belief P, non pecuniary utility $\vec{\varepsilon}_1 = (\varepsilon_{c,1}, \varepsilon_{w,1})$, decide to enroll or work until T.

$$(3) \quad V_1(P, b_1, f_1, \vec{\varepsilon}_1) = \max\{V_w(w_n, b_1, 1) + \varepsilon_{w,1}, V_{c,1}(P, f_1, b_1) + \varepsilon_{c,1}\}$$

$$s.t.$$

$$V_{c,1}(P, f_1, b_1) = \max_{b_2 \geq -\tilde{B}_{s,1}} [u(Rb_1 - f_1 - b_2) + \beta \mathbb{E}_{g,\varepsilon}(V_2(P'(g, P), f_2, b_2, \varepsilon_{c,2}, \varepsilon_{w,2})) \, | P \,]$$

- $\varepsilon_{c,1}, \varepsilon_{w,1}$ are iid Type 1 Extreme Value and $\tilde{B}_1^s > \tilde{B}_1(w)$ `Workers Problem`

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Belief Updating

- Beliefs updated after realizing GPA g_k for $k = l, m, h$ by Bayes Rule.

$$P'(g_k, P) = \frac{P\pi_{k,h}}{P\pi_{k,h} + (1 - P)\pi_{k,l}}$$

- Where $\pi_{k,j} = Prob(g_k|\text{type} = j)$

Stage 2: Continue/Exit Decision

- Agents begin with P', and assets b_2, realize $\vec{\varepsilon}_2 = (\varepsilon_{c,2}, \varepsilon_{w,2})$, and make school continuation/exit decision.

$$(5) \quad V_2(P', f_2, b_2, \vec{\varepsilon}_2) = \max\{V_w(w_s, b_2, 2) + \varepsilon_{w,2}, V_{c,2}(P', f_2, b_2) + \epsilon_{c,2}\}$$
$$s.t.$$

$$V_{c,2}(P', f_2, b_2) = \max_{b_3 \geq -\tilde{B}_{s,2}} [u(Rb_2 - f_2 - b_3) + \beta(P'[V_w(w_c(\tau_h), b_3) + \mu(\tau_h)]$$
$$+ \quad (1 - P')[V_w(w_c(\tau_l), b_3) + \mu(\tau_l)]) \ ]$$

- $\varepsilon_{c,2}, \varepsilon_{w,2}$ are iid Type 1 Extreme Value and $\tilde{B}_2^s > \tilde{B}_2(w)$ Workers Problem

Model Implications

- Depending on parameterization the model predicts

  1. Probability of enrollment increases with belief of being "High Scorer" and reductions in net tuition. Enrollment

  2. Conditional on enrollment, probability of college continuation increases with better GPA. Completion

  3. Probability of Degree attainment increases with belief of being "High Scorer" and reductions in Net tuition. Degree Attainment

Model Implications

- Depending on parameterization the model predicts
    1. Probability of enrollment increases with belief of being "High Scorer" and reductions in net tuition. (Enrollment)
    2. Conditional on enrollment, probability of college continuation increases with better GPA. (Completion)
    3. Probability of Degree attainment increases with belief of being "High Scorer" and reductions in Net tuition. (Degree Attainment)

Model Calibration and Estimation

Table: Preset Parameters

Parameter	Set Value	Description
β	0.94	Discount rate
σ	2.0	Coeff. of Rel Risk Aversion
$(1 + r)$	β^{-1}	Int rate
T	24	Number of periods of 2 years
$B_{c,1}$	\$16,600	College Borrowing limits pd 1
$B_{c,2}$	\$35,600	College Borrowing limits pd 2
b_0	\$0.00	Starting Assets

- First preset parameters to those above.

- Externally estimate financial assistance, earnings, true probability of type, grade probability given type using Finite Mixture Model. External Specification

- Internally estimate distribution of subjective beliefs, non pecuniary utility, and tuition sticker price. Internal Specification   Identification Strategy

Results: Estimation

- Earnings increase with education regardless of type, with high college earnings highest. (Estimated Earnings)

- Prob of high grades, higher for high type. Prob of low and med grades higher for low type. (Type Cond Grades)

- High scorers pessimistic about subjective prob high type. Low scorers optimistic relative to "true" estimate from FMM. (Beliefs vs True)
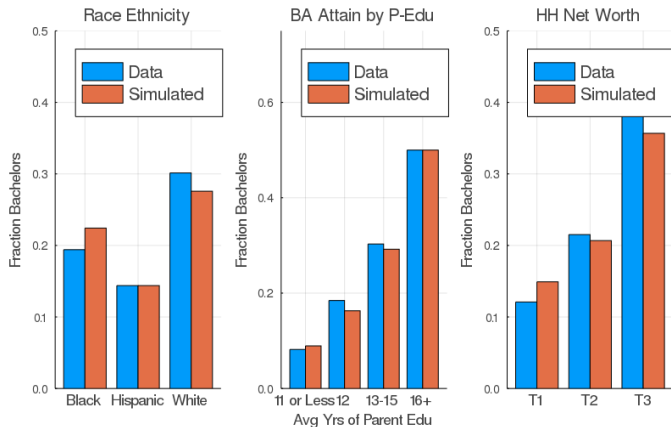
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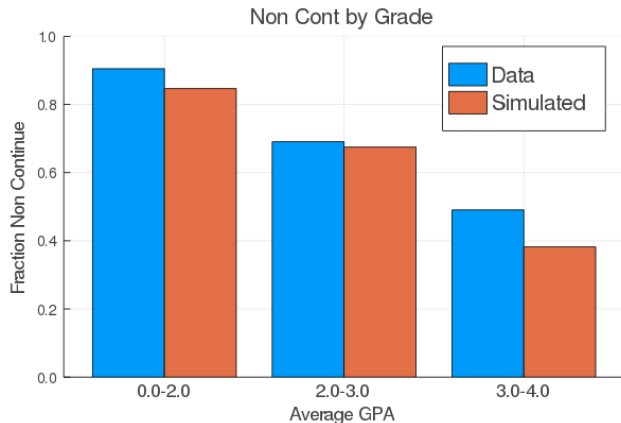0000000

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Targeted Moments: Degree Attainment

Figure: Fit of the Estimated Model: Enrollment, BA attainment, where Blue comes from the NLSY97 and Orange is simulated from the estimated quantitative model.

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Targeted Moments: Non Continuation by Grade

Figure: Fit of the Estimated Model: Non Continuation by GPA level, where Blue comes from the NLSY97 and Orange is simulated from the estimated quantitative model.

Decomposition and Policy Counterfactuals

1. First use the model to decompose inequality for Predicted High Scorers.
   - Predicted: only from data available before college completion.
   - Compare Black, Hispanic, Low SES to White High SES.

2. Then compare universal vs targeted policies on inequality/mismatch.
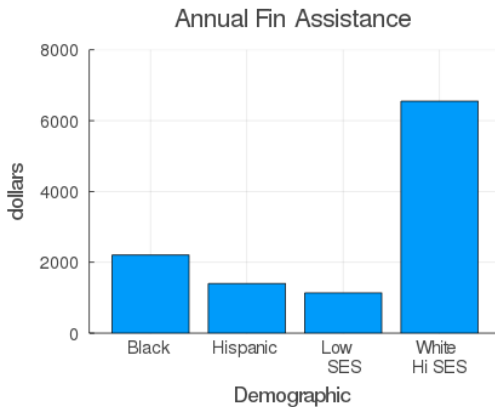
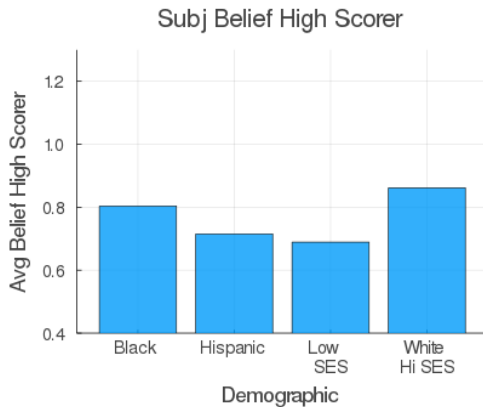# Difference in Important Variables

Figure: Estimated variables relating to causal mechanism by demographic group. Total financial assistance is the sum of family assistance and govt/college aid.

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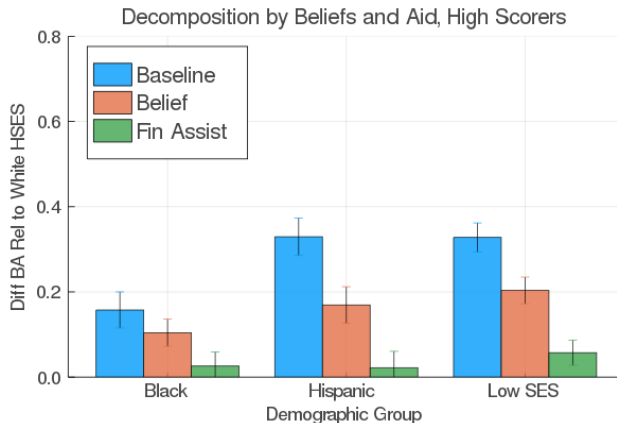
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Decomposition: High Scorers

Figure: Difference in bachelors attainment relative to White High SES High Scorers after sequentially equalizing variables. Std errors are bootstrapped std errors.

Decomposition Continued

Table: Mechanism Decomposition: High Scorers

Demographic	(1) Baseline	(2) Beliefs Equal	(3) Fin Assist Equal
Black			
Difference	15.8 (4.24)	10.4 (3.19)	2.6* (3.32)
% Explained		33 % (20.4)	50%* (11.22)
Hispanic			
Difference	33 (4.39)	16.9* (4.29)	2.2* (3.85)
% Explained		49 %* (13.67)	45%* (6.34)
Low SES			
Difference	32.8 (3.39)	20.5* (3.13)	5.7* (2.96)
% Explained		38%* (10.97)	45%* (6.17)
White High SES Bachelor's attain	56		

Table : Shows the percentage of the gap relative White High SES High Scorers explained by each mechanism for each demographic group.

Counterfactual Exercise

- Which policy is more efficient at decreasing gaps in BA attainment independent of ability?

    - Recruiting Policy: Target Info and funding to low SES High Scorers.

    - Free College for all: Net Tuition zero for everyone.

    - Tracking System: Info on Prob Successful in College to all.

- Mismatch: How do these policies affect enrollment by scorer type?

    - Model predict Under investment all High Scorers. [Under investmen]
    - Over investment of Low Scorers. [Overinvestment]
    - Overall effect depends on dist High Scorers by demographics. [Overall Inefficiency]

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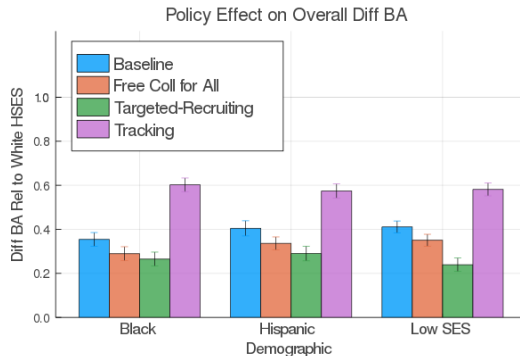oooo
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Inequality by Policy

Figure: Difference in bachelors attainment relative to White High SES High Scorers after Policy Enaction. Std errors are bootstrapped std errors.

Policy Values

Efficiency Policy

Table: Mismatch: Percentage of Population Switch with Type Knowledge

Policy	% Pop Mismatched Overall	% Pop Mismatched High-Scorer	% Pop Mismatched Low-Scorer
Baseline	27.1 %	21.3 %	5.8 %
Free College For All	30.5%	21.5 %	9.1 %
Tracking: Info for All	4.4 %	4.1 %	0.3 %
Targeted: Recruiting	19.1%	13.3 %	5.9%

Conclusion

- Subjective Beliefs play a role in college completion gaps for Hispanic, Low SES High Scorers.

- Information friction leads to over and underinvestment in education for all groups.

- Targeted subsidies and information close gaps further than other policies, benefit students with most to gain.

- Although information and subsidies can narrow gaps, they will remain persistent as long as there are gaps in early childhood human capital investment and college experience.

Patterns in the Data: Full Sample

Table: Summary Statistics by Parent Education

VARIABLES	(1) All	(2) Lt 12	(3) 12	(4) 13-15	(5) 16 +
Enrolled in College	0.717	0.447	0.614	0.814	0.944
Bachelors or More	0.301	0.0787	0.208	0.359	0.544
Hispanic	0.116	0.285	0.092	0.062	0.056
Black	0.146	0.191	0.212	0.114	0.082
Avg Parent Edu	13.02	10.10	12.00	13.77	16.00
HH Net Worth ($1000s)	185.8	53.53	123.8	201.7	375.8
Pct Peers ColPlan	66.5	58.2	62.3	69.7	75.2
Prob Enroll	0.751	0.572	0.713	0.812	0.882
Prob Degree	0.777	0.633	0.691	0.840	0.917
College GPA	2.65	2.21	2.62	2.68	2.98
Total Govt/Inst Aid ($1000s)	2.3	2.40	1.68	1.93	2.29
Total Fam Aid ($1000s)	1.64	0.42	0.85	1.64	3.01
ASVAB AFQT	54.73	32.47	49.53	60.13	75.08
Ever Stole	0.0671	0.0928	0.0492	0.0750	0.0422
Ever Violence	0.161	0.233	0.176	0.147	0.0903
Ever Sex before 15	0.182	0.295	0.210	0.152	0.0845
Sample Size	2133	586	493	736	318

Patterns in the Data: Full Sample

Table: Summary Statistics by Race Ethnicity

VARIABLES	(1) All	(2) White	(3) Hispanic	(4) Black
Enrolled in College	0.717	0.740	0.626	0.670
Bachelors or More	0.301	0.336	0.171	0.222
Parent Edu Lt 12	0.220	0.158	0.541	0.288
Parent Edu 12	0.216	0.202	0.176	0.313
Parent Edu 13-15	0.388	0.434	0.200	0.302
Parent Edu 16+	0.176	0.205	0.083	0.098
Avg Parent Edu	13.02	13.43	11.15	12.37
HH Net Worth ($1000s)	185.8	226.4	80.68	56.04
Pct Peers ColPlan	66.5	68.7	60.8	68.5
Prob Enroll	0.751	0.758	0.734	0.732
Prob Degree	0.777	0.793	0.679	0.767
College GPA	2.65	2.79	2.41	2.14
Total Govt/Inst Aid ($1000s)	2.3	1.96	1.65	2.71
Total Fam Aid ($1000s)	1.64	1.92	0.96	0.60
ASVAB AFQT	54.73	61.20	40.32	32.15
Ever Stole	0.0671	0.0608	0.0943	0.0779
Ever Violence	0.161	0.141	0.165	0.265
Ever Sex before 15	0.182	0.145	0.186	0.375
Sample Size	2133	1188	404	541

Patterns in the Data: Beliefs

Table: Measured Beliefs

VARIABLES	(1) Pct Chance Deg by 30	(2) Prob Enroll
Parent Edu	0.0267***	0.0282***
	(0.0046)	(0.0058)
HH Net Worth	0.0001***	0.0001**
	(0.0000)	(0.0000)
ASVAB AFQT	0.0022***	0.0022***
	(0.0004)	(0.0004)
Peers Coll Plan About 25%	0.0812	0.1289*
	(0.0709)	(0.0766)
Peers Coll Plan About 50%	0.1110*	0.1314*
	(0.0671)	(0.0692)
Peers Coll Plan About 75%	0.1662**	0.1562**
	(0.0670)	(0.0695)
Peers Coll Plan more than 90%	0.2117***	0.1954***
	(0.0675)	(0.0691)
Female	0.0767***	0.0117
	(0.0168)	(0.0205)
Hispanic	0.0435	0.1174***
	(0.0268)	(0.0323)
Black	0.0978***	0.1071***
	(0.0246)	(0.0312)
Geography & Birth Year Controls	Yes	Yes
Non Cognitive Controls	Yes	Yes
Observations	1,143	1,139
R-squared	0.2614	0.2304

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Empirical Facts   Fin Aid Reg

Patterns in the Data: Financial Assistance

Table: Financial Assistance

VARIABLES	(1) Any Family Aid	(2) Total Fam Aid	(3) Any Govt/Inst Aid	(4) Total Govt/Inst Aid
Parent Edu	0.0346***	0.1854***	-0.0006	-0.0793
	(0.0072)	(0.0607)	(0.0078)	(0.0751)
HH Net Worth	0.0003***	0.0050***	-0.0002***	0.0001
	(0.0001)	(0.0009)	(0.0001)	(0.0007)
ASVAB AFQT	0.0030***	0.0114**	0.0022***	0.0216***
	(0.0006)	(0.0045)	(0.0006)	(0.0067)
Female	0.0322	-0.0604	0.0574**	0.2054
	(0.0249)	(0.2464)	(0.0276)	(0.3452)
Hispanic	0.0198	0.5455*	0.0995**	-0.5875
	(0.0403)	(0.3057)	(0.0441)	(0.5116)
Black	-0.0134	0.0212	0.1932***	0.9796**
	(0.0393)	(0.2425)	(0.0386)	(0.4450)
Geography & Birth Year Controls	Yes	Yes	Yes	Yes
Non Cognitive Controls	Yes	Yes	Yes	Yes
Observations	1,467	929	1,467	940
R-squared	0.1478	0.2416	0.0503	0.0379

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Belief Regression

Patterns in the Data: Higher Education Outcomes

Table: College Outcomes

VARIABLES	(1) Ever Enrolled	(2) Bachelors Attained	(3) Complete College
Parent Edu	0.0292***	0.0375***	0.0427***
	(0.0048)	(0.0056)	(0.0070)
HH Net Worth ($1000s)	0.0001**	0.0002***	0.0001*
	(0.0000)	(0.0001)	(0.0001)
ASVAB AFQT	0.0055***	0.0057***	0.0035***
	(0.0004)	(0.0004)	(0.0006)
Prob Degree	0.3226***	0.2151***	0.2164***
	(0.0280)	(0.0283)	(0.0491)
Female	0.0831***	0.0847***	0.0411*
	(0.0164)	(0.0186)	(0.0237)
Hispanic	0.0812***	0.0535*	0.0525
	(0.0286)	(0.0286)	(0.0381)
Black	0.1700***	0.1487***	0.1732***
	(0.0261)	(0.0256)	(0.0350)
College GPA			0.1803***
			(0.0152)
Total Govt/Inst Aid ($1000s)			0.0058**
			(0.0027)
Total Fam Aid ($1000s)			0.0075**
			(0.0035)
Total Stud Loan ($1000s)			-0.0081**
			(0.0036)
Geography Controls & Birth Year	Yes	Yes	Yes
Non Cognitive Controls	Yes	Yes	Yes
Observations	2,133	2,133	1,467
R-squared	0.3499	0.3612	0.3240

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Empirical Facts

Patterns in the Data: Earnings

Figure: Earnings by EDU and Differences in Log Returns to School
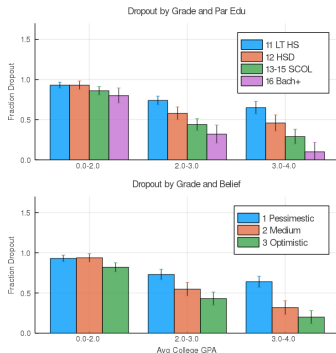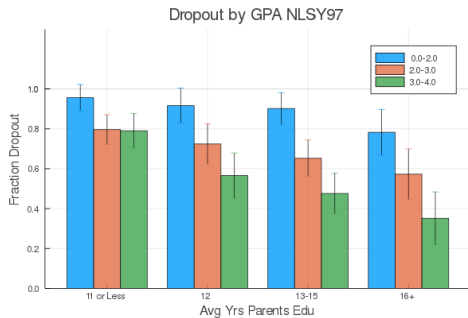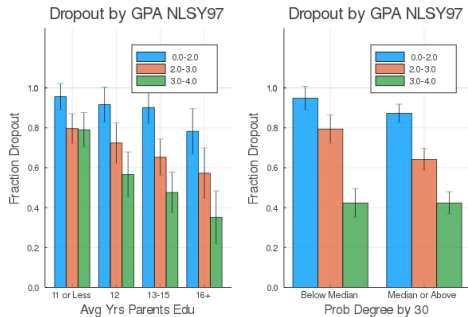
Patterns in the Data: Dropout by Par Edu & Belief

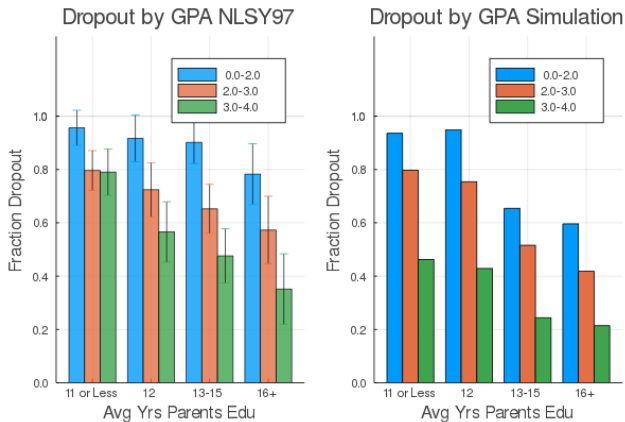Figure: Dropout Rates Conditioned on Grades/Parent Edu and Beliefs

Dropout by Parental Education

Dropout by Measured Belief

Targeted Moments: Dropout by Grade and Parent Edu

Targeted Moments: Indirect Inference Targets

Table: Indirect Inference OLS Targets

VARIABLES	(1) Enrolled Data	(2) Enrolled Sim	(3) Continue Data	(4) Continue Sim
Intercept	0.303	0.261	-0.068	-0.012
	(0.0307)	(0.069)	(0.0502)	(0.036)
High Belief	0.223	0.200		
	(0.019)	(0.027)		
Fin Assist T2	0.150	0.141	0.072	0.056
	(0.024)	(0.024)	(0.034)	(0.008)
Fin Assist T3	0.286	0.247	0.095	0.083
	(0.030)	(0.036)	(0.0403)	(0.0134)
Parent HSD			0.0767	0.064
			(0.0390)	(0.027)
Parent SCOL			0.128	0.134
			(0.0379)	(0.025)
Parent Bach	0.070	0.023	0.216	0.235
	(0.031)	(0.015)	(0.0478)	(0.027)
White	0.150	0.112	0.015	0.025
	(0.0257)	(0.037)	(0.036)	(0.022)
Hispanic	0.104	0.052	-0.016	-0.001
	(0.032)	(0.048)	(0.044)	(0.024)
GPA Med			0.214	0.154
			(0.0348)	(0.015)
GPA High			0.3724	0.412
			(0.0371)	(0.026)

Targeted Graph

Results

Table: Key Internal Parameter Results

Parameter	Description	Estimate
$\gamma_{p,0}$	Belief Constant	0.0134
		(0.0127)
$\gamma_{p,b}$	Belief: Meas Belief	0.869
		(0.0092)
$\gamma_{p,h}$	Belief: P-Edu HSD	0.034
		(0.0118)
$\gamma_{p,s}$	Belief: P-Edu SCOL	0.030
		(0.0097)
$\gamma_{p,c}$	Belief: P-Edu Bach	0.059
		(0.0118)
$\mu_{e,0}$	Non Pecun Util: Black 1st Gen Col Stud	-0.000088
		(0.000041)
$\mu_{e,C}$	Non Pecun Util: Col Edu Parents	0.000039
		(0.000032)
$\mu_{e,W}$	Non Pecun Util: White	0.000051
		(0.00003)
$\mu_{e,H}$	Non Pecun Util: Hispanic	0.000014
		(0.00003)
$\mu_c(\tau_h)$	Non Pecun Util high	0.00053
		(0.000066)
$\mu_c(\tau_l)$	Non Pecun Util high	-0.0031
		(0.000278)
t_1	Tuition Pd 1	$7430
		(63.36)
t_2	Tuiton Pd 2	$6946
		(60.84)

Externally Estimated Parameters

- Financial assist, $j = Gov, Coll$, $f_{i,j}$, $\vec{X}_i$ includes parent edu, wealth, and demographics. `Estimation Strategy`

$$(9) \qquad \ln(f_{i,j}) = \vec{X}_i \vec{\beta}_{j,x} + \epsilon_{j,i}$$

- FMM with two latent types externally estimate.

$$(10) \qquad Prob(\tau = \tau_h | \vec{X}_i; \vec{Z}_i) = \frac{exp(\vec{X}_i \vec{\beta}_p)}{1 + exp(\vec{X}_i \vec{\beta}_p)}$$

$$(11) \qquad \ln(w_{i,s}) = \beta_{w,0} + \beta_{w,s} SCOL + \beta_{w,c} COL + \beta_{w,c,\tau} Col * \tau + \epsilon_{w,i}$$

$$(12) \qquad \pi(g|\tau) = \frac{exp(\gamma_{g,0} + \gamma_{g,\tau}\tau)}{\sum_{k=l,m,h} exp(\gamma_{k,0} + \gamma_{k,\tau}\tau)}$$

Externally Estimation Continued

- Measurement equations for $Z_{i,j}^*$ ASVAB Arithmetic Reasoning, Paragraph Comprehension, Word Knowledge, Math Knowledge, violence, theft, sex at young ages.

$$(13) \quad Z_{i,j}^* = \alpha_{z,j}\tau_i + \eta_{z,j}X_i + \varepsilon_{z,j} \quad j \in \{1,\ldots,J_c\}$$

- Allowing for binary, continuous variables

$$Z_{i,j} = \begin{cases} Z_{i,j}^* & \text{if } Z_{i,j}^* \text{ is continuous} \\ \mathbf{1}(Z_{i,j}^*) & \text{if } Z_{i,j}^*, \text{ is binary} \end{cases}$$

- Max simulated likelihood

$$(14) \quad \max \sum_i \ln[P(\tau_h)f(\vec{Z}_i, w_i, g_i; \tau_h, X_i, s) + (1 - P(\tau_h)f(\vec{Z}_i, w_i, g_i; \tau_h, X_i, s))]$$

Estimation Strategy

Internally Estimated Moments

- Internally estimated parameters
    1. distribution of initial subjective beliefs of being type τ_h

        $$P = \gamma_{p,0} + \gamma_{p,b}\text{Meas Beliefs} + \gamma_{p,h}\text{Par HSD} + \gamma_{p,s}\text{Par SCOL} + \gamma_{p,s}\text{Par Bach} + \sigma_p\eta_p$$

    2. Constant and scale of Weibull shocks $(\mu_e, \sigma_{e,t})$.
    3. non pecuniary utility by τ, $\mu_c(\tau)$.
    4. and the price of tuition each period, f_1, f_2.

- Indirect Inference: Estimate 16 parameters by matching 16 OLS coefficients.
    1. enrollment by measured belief, financial aid, parental education.
    2. continuation by average gpa, financial aid, and parental education

Estimation Strategy

Identification

Table: Identification Strategy

Parameters	Target	Description
$\vec{\gamma}_p, \sigma_p, \mu_c(\tau)$	Dropout by grade; Enrollment by belief, Par EDU	Dist of subj belief Non pecun utility by type
f_1, f_2	Enrollment & Dropout by financial aid level	Tuition period 1, and period 2
$\mu_e, \sigma_{c,t}$	Coefficient of parant edu, race, ethnicity on Enrollment, completion	Non pecun utility by race, ethnicity, parent edu Scale parameters non pecun utility

Estimation Strategy

Model Predictions
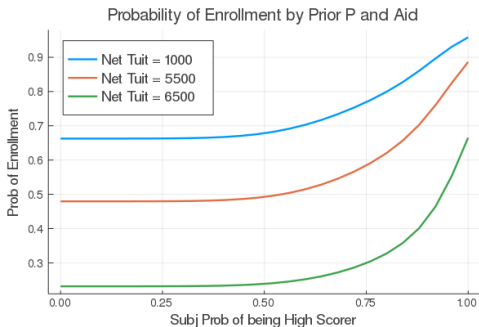
Figure: Model predicted probability of college enrollment by Net Tuition and Prior Belief of being "High Achiever"

Model Implications
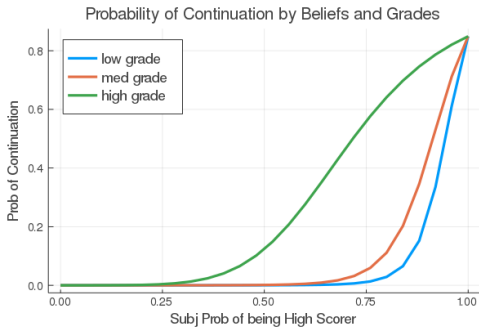
Model Predictions

Figure: Model predicted probability of College Continuation by average GPA
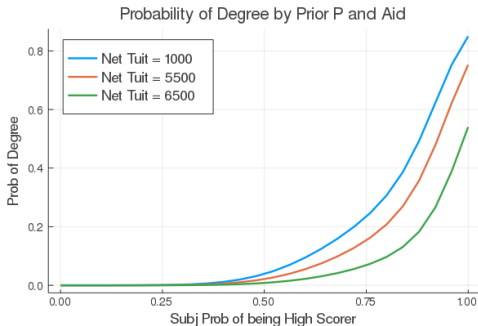
Model Predictions

Figure: Model predicted probability of Bachelor's attainment, enrollment and completion, by Net Tuition and Prior Belief of being "High Achiever"

Model Implications

Motivation Continued

- Literature has focused on financial explanations or early childhood human capital.

  1. Rising Tuition (Turner 2004)
  2. Financial Assistance (Dynarski 2001)
  3. Credit Constraints (Lochner & Monge Naranjo 2011)
  4. Parental Investments in Human Capital (Cunha & Heckman 2007)

Motivation

- Gaps by parental income exists among high ability youth with access to funding (Hoxby & Avery 2012). Evidence suggests this is partly due to differences in subjective beliefs.

    1. Enrollment: Acceptance Probability
       (Dynarski, Michelmore, Libassi, & Owens, 2020; Hoxby & Turner 2012).

    2. Enrollment: Net Cost
       (Bettinger, Long, Oreopoulis, & Sanbonmatsu 2012)

    3. Dropout: Ability and earnings
       (Stinebrickner & Stinebrickner 2012; Wiswall & Zafar 2015)

    Motivation

Workers Problem

- Work problem in stages 1-3.

$$(1) \quad V_w(w, b, t) = \max_{\{b_n \geq -\tilde{B}_n(w)\}_{n=t}^{T}} \sum_{n=t}^{T} \beta^{n-t} u(w + Rb_n - b_{n+1})$$

- Per period utility is CRRA

$$(2) \quad u(c) = \frac{c^{1-\gamma} - 1}{1 - \gamma}$$

- Borrowing constraints

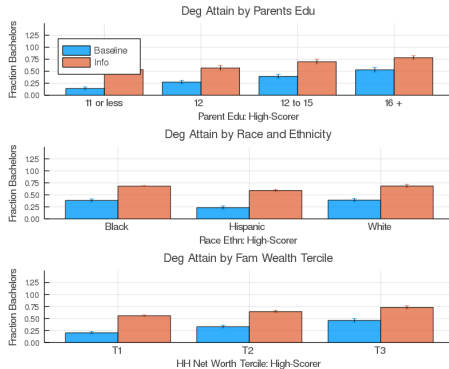$$\tilde{B}_T = 0 \qquad \tilde{B}_{T-n}(w) = \frac{w + \tilde{B}_{T-n+1}(w)}{1 + r}$$
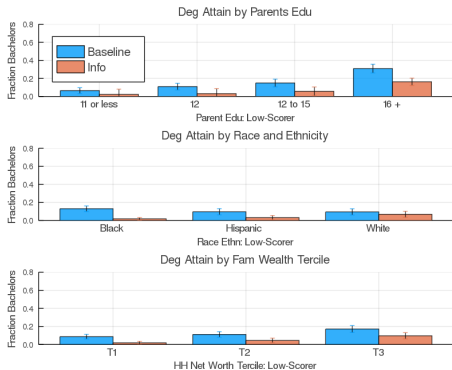
Stage 1 Stage 2

Inefficiency: High Scorers

Figure: BA attainment baseline vs if agents knew their type.

Inefficiency: Low Scorers

Figure: BA attainment baseline vs if agents knew their type.

Counterfactual
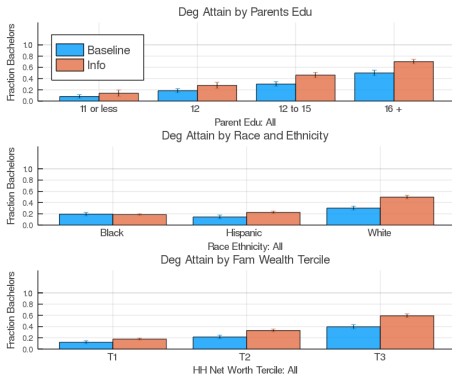
Inefficiency Aggregate Results

Figure: BA attainment baseline vs if agents knew their type.

Results: Average Earnings

Table: External Estimation Results: Average Earnings

Parameter	Estimated Annual Value	Description
w_n	\$29,584	Non College Earnings
w_s	\$45,026	Some College Earnings
$w_s(\tau_l)$	\$51,277	Low type college earnings
$w_s(\tau_h)$	\$65,841	High type college earnings

Table 5: Expected value of earnings from Finite Mixture Model by education realization.
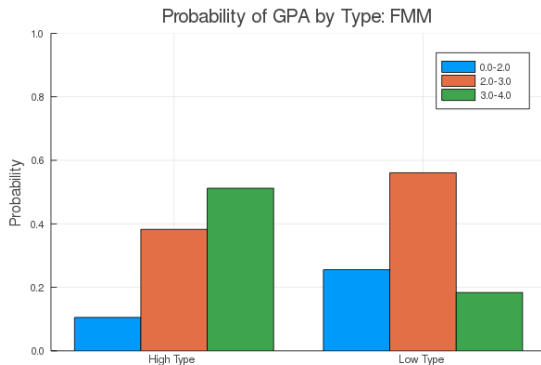
Results Est

Estimation Results

Figure: Predicted College GPA category by latent "Scorer" type.
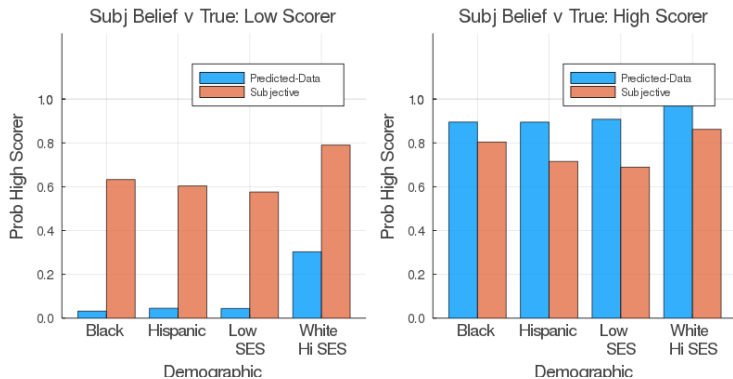
Estimation Results: Beliefs vs True

Figure: Difference in FMM estimate Prob High vs Subj Belief by Scorer type.

Efficiency Policy

Table: Policy Effect on Overall Inequality

Demographic	Baseline	Free College For All for All	Tracking: Info to All to All	Recruiting: Targeted Info & Free
Black				
Difference	35.4 (3.11)	28.95* (3.16)	60.22* (3.10)	26.5* (3.18)
% Change in Gap Relative to Baseline		-18.3* % (8.59)	70%* (8.43)	-25.2 % * (8.65)
Hispanic				
Difference	40.5 (3.45)	33.6* (2.94)	57.42* (3.23)	29.02* (3.33)
% Change in Gap Relative to Baseline		-16.9 %* (7.04)	42%* (7.74)	-28.26%* (7.96)
Low SES				
Difference	41.1 (2.69)	35.05* (2.71)	58.2* (2.95)	23.9* (3.08)
% Change in Gap Relative to Baseline		-14.7% (6.38)	41.5%* (6.95)	-41.8%* (7.27)
White High SES Bachelor's attain	54.8			