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

Sergio Barrera
University of Minnesota

Motivation

- Gaps bachelor's attainment (BA) for high achievers (top quartile ASVAB AFQT).

    - Race: White 64%; Black 59%; Hispanic 52%.

    - HH Net Worth: Top Tercile 71%; Bottom Tercile 42%.

    - Parent Education: Bachelors 80%; High school or less 42%.

Motivation

- Gaps bachelor's attainment (BA) for high achievers (top quartile ASVAB AFQT).

  - Race: White 64%; Black 59%; Hispanic 52%.

  - HH Net Worth: Top Tercile 71%; Bottom Tercile 42%.

  - Parent Education: Bachelors 80%; High school or less 42%.

- Role of credit constraints, rising tuition, and funding well studied.
  (Lochner & Monge Naranjo 2012, Dynarski 2003, Carneiro & Heckman 2002).

- Recent work suggests important role for information frictions.
  (Dynarski, Michelmore, Libassi, & Owen 2021; Hoxby & Turner 2015; Stinebrickner & Stinebrickner 2012; Bettinger, Long, Oreopoulos, & Sanbonmatsu. 2012).

Information Frictions

- This paper: Systematic differences: beliefs about own college success.
  - Performance, earnings, and utility.

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- Why beliefs differ by demographic group?
  -Familiarity, guidance, encouragement from college educated adults or peers.

  (Hoxby and Avery 2012)

  -More adverse shocks that affect performance.

  (DeLuca, Papageorge, Boselovic, Gershenson, Gray, Nerenberg, Sausedo, & Young 2021; Evans, William, Kearney, Perry, & Sullivan 2020)

Information Frictions

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- Why information frictions important?
  -Generate mismatch, suggests less costly policy, effect growth.

  (Hsieh, Hurst, Klenow, Jones 2019)

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Research Question

1. Do differences in beliefs about own success probabilities generate BA gaps for high ability youth?

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2. Which policy is more efficient at decreasing overall gaps in BA?
   - Targeted info and funding only to high ability low SES.
   - Free college for all.
   - Better info for everyone.

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Research Question

1. Do differences in beliefs about own success probabilities generate BA gaps for high ability youth?

2. Which policy is more efficient at decreasing overall gaps in BA?
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   - Free college for all.
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Answer: Beliefs important Hispanic, low-SES youth and Targeted policy more efficient.

Contribution: Document new facts and relax rational expectations prior.

Outline

1. Document empirical facts NLSY97.

2. Describe the model.

3. Show results: decomposition exercise and policy experiment.

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Data Description and Patterns

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

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

Summary Statistics Race   Summary Statistics Par Edu

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Empirical Patterns

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

    2. Exit lower every grade level for more optimistic youth. `Non Continuation Pattern`

    3. Holding human capital, family resources constant, optimism correlated with family and peer background. `Belief Regression`

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Model Elements

- 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 $\tau \in \{\tau_l, \tau_h\}$ that determines earnings $w_c(\tau)$, GPA g, and post college non pecuniary utility $\mu(\tau)$, or true probability, P_{true}, of $\tau = \tau_h$.

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

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

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Model Intuition

- High school senior decision to go to college.

Model Intuition

- High school senior decision to go to college.
  - Knows employment situation w_n, w_s, financial resources and costs $\{f_t\}_{t=1,2}$, current shock $\vec{\varepsilon}_1$, distribution $\vec{\varepsilon}_2$.
  - Uncertain prob of success (P_{true}, grades prob $\pi(g, \tau)$, post college earnings $w_c(\tau)$, utility $\mu(\tau)$), but has belief P.

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- Given P, f_t, $\vec{\varepsilon}_t$, $t = 1, 2$ enrollment decision, borrows b_2. Enroll Stage

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- Given P, f_t, $\vec{\varepsilon}_t$, $t = 1, 2$ enrollment decision, borrows b_2. Enroll Stage

    - After experience, gains information GPA g, updates belief to $P'(g, P)$, realizes shocks $\vec{\varepsilon}_2$.

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    - After experience, gains information GPA g, updates belief to $P'(g, P)$, realizes shocks $\vec{\varepsilon}_2$.

- Given $P'(g, P)$, f_2, $\vec{\varepsilon}_2$, continue decision, borrows b_3. Continuation Stage

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Model Intuition

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- Given P, f_t, $\vec{\varepsilon}_t$, $t = 1, 2$ enrollment decision, borrows b_2. (Enroll Stage)
  - After experience, gains information GPA g, updates belief to $P'(g, P)$, realizes shocks $\vec{\varepsilon}_2$.

- Given $P'(g, P)$, f_2, $\vec{\varepsilon}_2$, continue decision, borrows b_3. (Continuation Stage)

- After graduation, works, pays debt, with experience learns if college worth it τ. (Work Stage)

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Model Calibration and Estimation

- Preset parameters (discount rate, interest rate, student borrowing limit, CRRA).
  Preset Values

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Model Calibration and Estimation

- Preset parameters (discount rate, interest rate, student borrowing limit, CRRA).
  Preset Values

- Externally estimate,
  1. Financial assistance by demographic, OLS.
  2. Earnings $w_n, w_s, w_c(\tau)$, grade distribution $\pi(g, \tau)$, and P_{true}, FMM.
     External Specification   Predicted Earnings   Grades by Type

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Model Calibration and Estimation

- Preset parameters (discount rate, interest rate, student borrowing limit, CRRA).
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     External Specification   Predicted Earnings   Grades by Type

- Internally estimation using indirect inference:
  1. Tuition sticker price, unobserved utility shocks.
  2. Distribution of subjective beliefs, for P.
     -identified matching exit by grade, measured beliefs on enrollment.
     Targeted Moments   Internal Specification   Identification Strategy

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Model Estimation Results

- Matches bachelor's attainment by demographic group, and college non
  continuation by GPA.

  Model Fit   Demographic BA   Non Cont GPA

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Model Estimation Results

- Matches bachelor's attainment by demographic group, and college non continuation by GPA.

  Model Fit   Demographic BA   Non Cont GPA

- High ability, high SES white youth, more optimistic, financial resources.

  Difference Causal Variables

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Model Estimation Results

- Matches bachelor's attainment by demographic group, and college non continuation by GPA.
  Model Fit   Demographic BA   Non Cont GPA

- High ability, high SES white youth, more optimistic, financial resources.
  Difference Causal Variables

- Average beliefs by type for all groups wrong with respect to actual type, true probability from FMM.
  Pred vs Belief

Decomposition and Policy Counterfactuals

1. First use the model to decompose inequality for high scorers.
   - Compare Black, Hispanic, low SES to White High SES.

     Decomp Graph   Difference Causal Variables

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Decomposition and Policy Counterfactuals

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Decomposition and Policy Counterfactuals

1. First use the model to decompose inequality for high scorers.
   - Compare Black, Hispanic, low SES to White High SES.
     Decomp Graph   Difference Causal Variables

2. Then compare efficiency of targeted policy in closing overall gaps vs free college for all and better info for all.
   - Efficiency: College Mismatch - proportion who change BA decision with knowledge of type.
     Policy Graph

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Main Findings

1. Beliefs: Significant 38-49 % of bachelor's gap; Hispanic, Low SES High Scorers
   - Can't reject a belief effect of zero for Black high scorers.
   - However financial resources significant for all (45 -50%).

2. Targeted subsidies and info most efficient at closing overall gaps.
   - Close gaps between 25-42% depending on demographic group.
   - Decrease mismatch by decreasing underinvestment.
   - Universal policies exhibit equity/efficiency trade off.

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Conclusion

- Information frictions lead to underinvestment in higher education for high ability youth from underrepresented backgrounds.

- Focusing on info and funding promising for increasing representation.

- Still important role for human capital disparities.

- Future work examine belief formation process, interaction with human capital, policy interventions.

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Acknowledgements

- I want to acknowledge support for this project from
    1. The AEA Mentorship Program
    2. National Science Foundation
    3. The Tobin Project
    4. Beverly and Richard Fink Graduate Fellowship
    5. Diversity of Views and Experiences Graduate Fellowship

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

Data

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

Data

Patterns in the Data: Beliefs

Table: Measured Beliefs

VARIABLES	(1) Pct Chance Deg by 30	(2) Prob Enroll
Parent Education	0.0267***	0.0282***
	(0.0046)	(0.0058)
HH Net Worth ($1000s)	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)
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 Education	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)
College Belief	0.3226***	0.2151***	0.2164***
	(0.0280)	(0.0283)	(0.0491)
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)
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

Empirical Facts

Patterns in the Data: Exit by Par Edu & Belief

Table 3: Non Continuation Interacted with GPA

VARIABLES	Non Interacted	Interaction GPA 2.0-3.0	Interaction GPA > 3.0
College Belief	0.0775	-0.2604**	-0.2249**
	(0.0543)	(0.1021)	(0.1092)
GPA 2.0-3.0	-0.1513*		
	(0.0859)		
GPA > 3.0	-0.3431***		
	(0.0929)		
Hispanic	-0.0673		
	(0.0492)		
Black	-0.0539		
	(0.0413)		
Parent Education	-0.0179**		
	(0.0089)		
Household Net Worth ($1000s)	-0.00003		
	(0.00007)		
Total Govt/Inst Aid ($1000s)	-0.0179***		
	(0.0042)		
Total Fam Aid ($1000s)	-0.0118		
	(0.0072)		
Total Stud Loan ($1000s)	-0.0057		
	(0.0049)		
Geography, Birth Year, Gender	Yes		
Cognitive and Non cognitive Controls	Yes		
Observations	1,028		
R-squared	0.2576		

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

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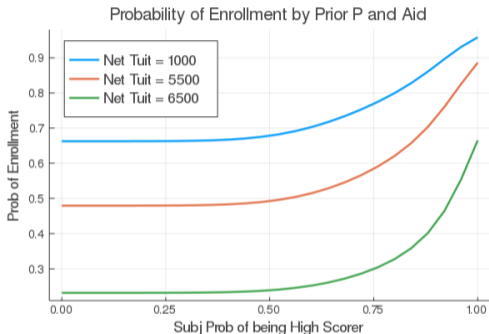
Figure: Model predicted probability of college enrollment by Net Tuition and Prior Belief of being "High Achiever"

Enroll Stage

Model Predictions

Probability of Continuation by Beliefs and Grades
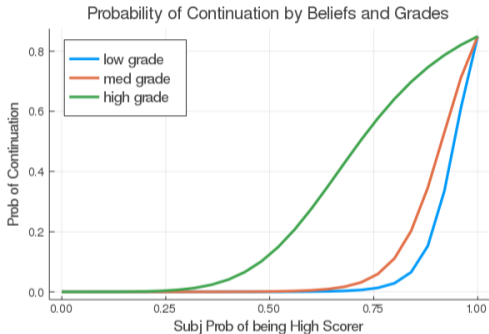
Figure: Model predicted probability of college continuation by average GPA

Continuation Stage
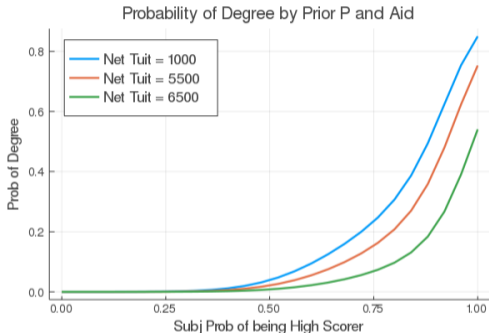
Model Predictions

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

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

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
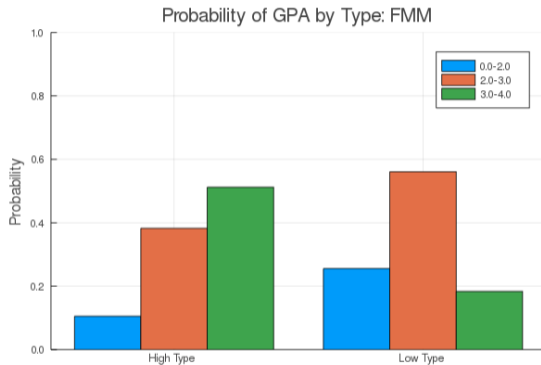
Figure: Predicted College GPA category by latent "Scorer" type.

Estimation Results: Beliefs vs True
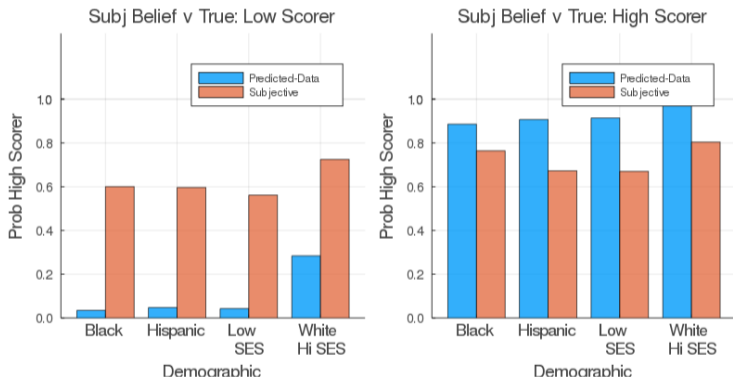
Figure: Difference in FMM estimate Prob High vs Subj Belief by Scorer type.

Retults Est

Efficiency Policy

Table: Policy Effect on Overall Inequality

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

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

Data

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

Data

Patterns in the Data: Earnings

Figure: Earnings by EDU and Differences in Log Returns to School

Targeted Moments: Indirect Inference Targets

Table 22: Indirect Inference OLS Targets

VARIABLES	(1) Enrolled Data	(2) Enrolled Sim	(3) Continue Data	(4) Continue Sim
Intercept	0.376	0.287	-0.068	-0.012
	(0.033)	(0.065)	(0.0502)	(0.032)
High Belief	0.215	0.201		
	(0.019)	(0.027)		
Fin Assist T2	0.150	0.154	0.072	0.075
	(0.024)	(0.027)	(0.034)	(0.009)
Fin Assist T3	0.297	0.301	0.095	0.135
	(0.026)	(0.035)	(0.0403)	(0.014)
First Gen	-0.129	-0.034		
	(0.021)	(0.017)		
Parent HSD			0.077	0.061
			(0.0390)	(0.021)
Parent SCOL			0.128	0.150
			(0.0379)	(0.028)
Parent Bach			0.216	0.235
	(0.031)	(0.015)	(0.0478)	(0.029)
White	0.116	0.067	0.015	0.034
	(0.026)	(0.038)	(0.036)	(0.018)
Hispanic	0.107	0.036	-0.016	0.018
	(0.031)	(0.045)	(0.044)	(0.021)
GPA Med			0.214	0.159
			(0.0348)	(0.015)
GPA High			0.3724	0.424
			(0.0371)	(0.025)

Results

Table: Key Internal Parameter Results

Table 23: Key Internal Parameter Results

Parameter	Description	Estimate
$\gamma_{p,0}$	Belief Constant	0.0057
		(0.0133)
$\gamma_{p,b}$	Belief: Meas Belief	0.88***
		(0.0103)
$\gamma_{p,h}$	Belief: P-Edu HSD	0.026**
		(0.0116)
$\gamma_{p,s}$	Belief: P-Edu SCOL	0.028***
		(0.0103)
$\gamma_{p,c}$	Belief: P-Edu Bach	0.055***
		(0.0102)
σ_p	Belief: Var Error	0.00018***
		(0.000043)
$\mu_{d,0}$	Non Pecun Util: Black 1st Gen Col Stud	-0.000056
		(0.000044)
$\mu_{d,C}$	Non Pecun Util: Col Edu Parents	0.00004
		(0.000037)
$\mu_{d,W}$	Non Pecun Util: White	0.000017
		(0.000028)
$\mu_{d,H}$	Non Pecun Util: Hispanic	0.000023
		(0.000034)
$\sigma_{d,1}$	Non Pecun Util Scale pd 1	0.000043
		(0.000066)
$\sigma_{d,2}$	Non Pecun Util Scale pd 2	0.000027
		(0.000066)
$\mu_c(\tau_h)$	Non Pecun Util high	0.00052***
		(0.000065)
$\mu_c(\tau_l)$	Non Pecun Util high	-0.0028***
		(0.00031)
$tuit_1$	Tuition Pd 1	\$7583.61***
		(120.5)
$tuit_2$	Tuiton Pd 2	\$6972.45***
		(16.05)

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

Externally Estimated Parameters

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

$$(9) \qquad \ln(f_{i,k}) = X_i \beta_{f,k}, + \beta_{f,y} birthyear + \epsilon_{f,k,i}$$

- FMM with two latent types externally estimate.

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

$$(11) \qquad \ln w_{i,s}^* = \mu_{w,0} + \mu_{w,1} 1(s \in (12,16)) + 1(s \geq 16)(\mu_{w,2} + \mu_{w,h} 1(\tau_i = \tau_h)) + \varepsilon_{w,s}$$

$$(12) \qquad \pi(g, \tau) = \frac{exp(\gamma_{g,0} + \gamma_{g,\tau} 1(\tau_i = \tau_h))}{\sum_{k=l,m,h} exp(\gamma_{k,0} + \gamma_{k,\tau} 1(\tau_i = \tau_h))}$$

Externally Estimation Continued

- Measurement equations: ASVAB Arithmetic Reason, Paragraph Comp, Word Knowledge, Math Knowledge, violence, theft, sex at young ages.

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

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

- Max simulated likelihood

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

- FMM estimated true probability of high type

$$(15) \quad P_{\text{true},i} = Prob(\tau_i = \tau_h | \vec{X}_i, \vec{Z}_i, w_i, g_i, s_i) \propto P(\tau_h; \vec{X}_i) \times f(\vec{Z}_i, w_i, g_i; \tau_h, X_i, s)$$

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, $tuit_1, tuit_2$.

- Indirect Inference: Estimate 16 parameters by matching 17 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 5: Key Internal Parameter Results

Parameter	Parameter Description	Target	Target Description
$\gamma_{p,0}$	Belief Constant	$\beta_{C,0}, \beta_{C,G_m}, \beta_{C,G_h}$	Constant, Coefficient med, high GPA on continuation
$\mu_c(\tau)$	Type dependent non pecuniary utility	$\beta_{C,0}, \beta_{C,G_m}, \beta_{C,G_h}$	Constant, Coefficient med, high GPA on continuation
$\gamma_{p,b}$	Belief: Meas Belief	$\beta_{E,B}$	Coefficient Meas Belief on enrollment
$\gamma_{p,h}$	Belief: Parent Education HSD	$\beta_{C,PH}$	Coefficient $Pedu_{hsg}$ on continuation
$\gamma_{p,s}$	Belief: Parent Education SCOL	$\beta_{C,PS}$	Coefficient $Pedu_{scol}$ on continuation
$\gamma_{p,c}$	Belief: Parent Education Bach	$\beta_{C,PB}$	Coefficient $Pedu_{bach}$ on continuation
$\mu_{d,0}$	Non-Pec Util: Black 1st Gen Col Stud	$\beta_{E,0} + \beta_{E,1G}$	Constant and $FirstGen$ Coefficient on enrollment
$\mu_{d,C}$	Non-Pec Util: Col Educated Parents	$\beta_{E,0}$	Constant Coefficient on enrollment
$\mu_{d,W}$	Non Pecun Util: White	$\beta_{E,W}, \beta_{C,W}$	$White$ Coefficient on enrollment,continuation
$\mu_{d,H}$	Non Pecun Util: Hispanic	$\beta_{E,H}, \beta_{C,H}$	$Hisp$ Coefficient on enrollment,continuation
$tuit_1$	Tuition Pd 1	$\beta_{E,F_2}, \beta_{E,F_3}$	$T2(Finaid), T3(Finaid)$ Coefficient on enrollment
$tuit_2$	Tuiton Pd 2	$\beta_{C,F_2}, \beta_{C,F_3}$	$T2(Finaid), T3(Finaid)$ Coefficient on continuation

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.

Estimation Strategy

Estimation Results
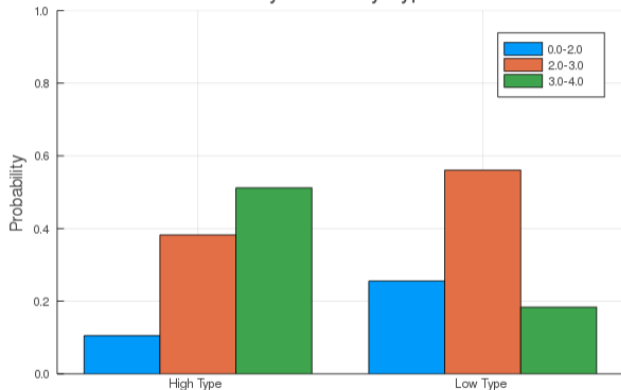
Figure: Predicted College GPA category by latent "Scorer" type.
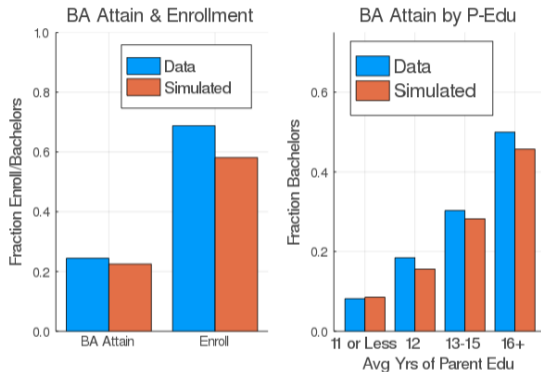
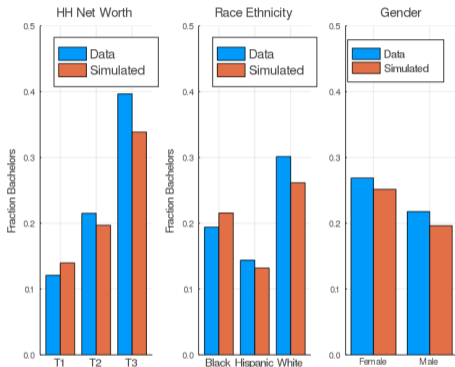# Degree Attainment by Demographic Group

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

Model Estimate

Decomposition Continued

Table 8: Mechanism Decomposition: High Scorers

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

Boot strapped standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Decomposition Graph   Main Questions

Inefficiency: High Scorers

Deg Attain by Parents Edu

Deg Attain by Race and Ethnicity

Deg Attain by Fam Wealth Tercile

Counterfactual
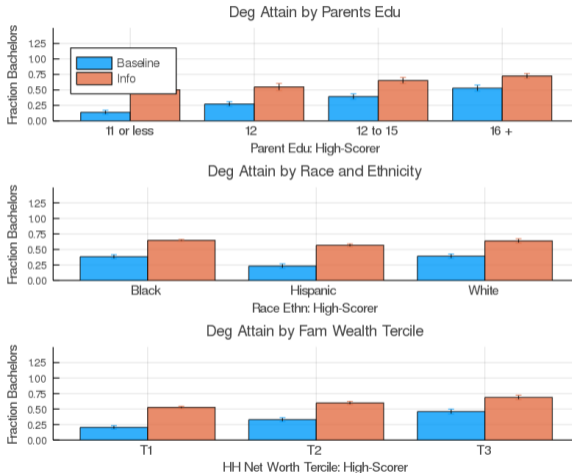
Inefficiency: Low Scorers

Deg Attain by Parents Edu

Deg Attain by Race and Ethnicity

Deg Attain by Fam Wealth Tercile

Counterfactual
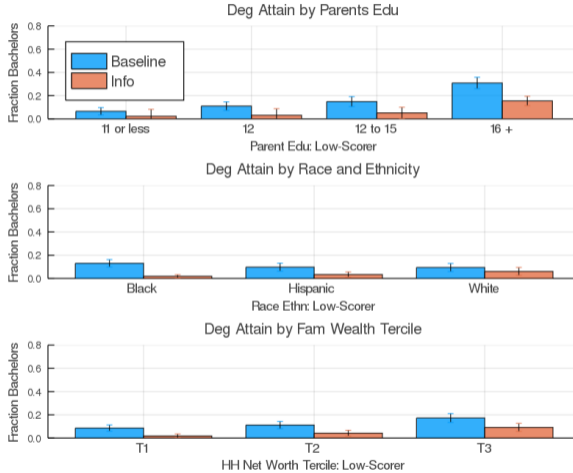
Inefficiency Aggregate Results

Deg Attain by Parents Edu

Deg Attain by Race and Ethnicity

Deg Attain by Fam Wealth Tercile

Counterfactual
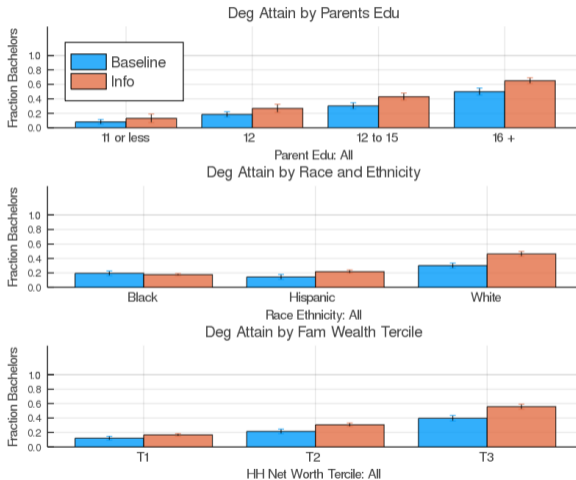
Free Coll For All vs Targeted Policy

Policy Effect on Overall Diff BA
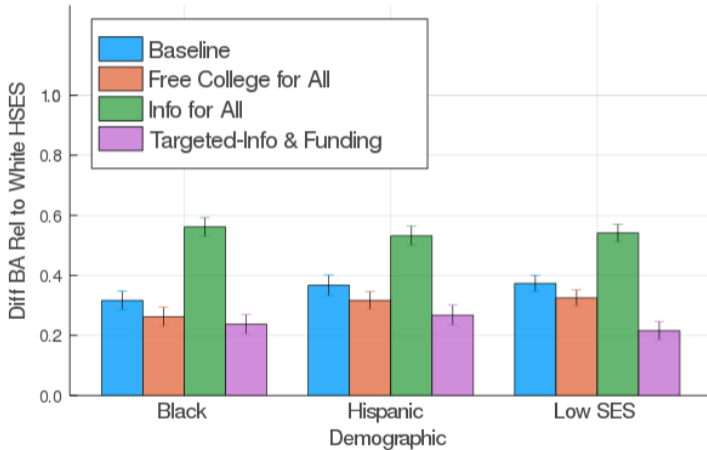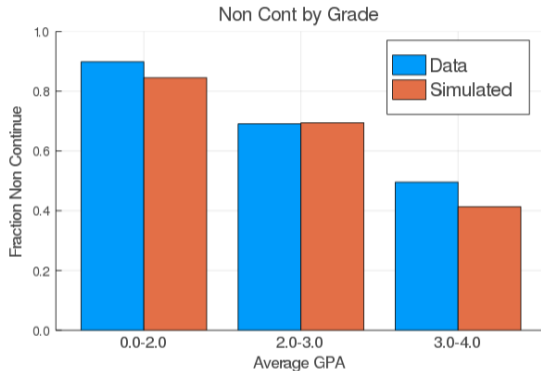
Model Fit: Degree Attainment, Enrollment

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

Model Estimate

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

Estimation Strategy

Model Fit: Degree Attainment by Demographic Group

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

Model Estimate

Model Fit: 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.

Model Estimate

Predicted Type Data vs Estimated Belief
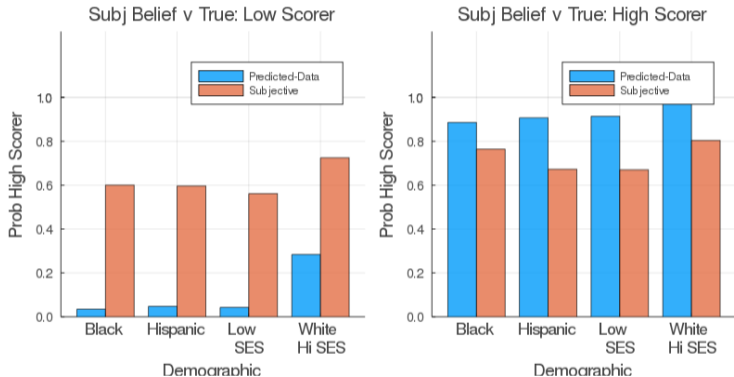
Figure: Compares the mean FMM estimate of prob high-scorer vs the mean subjective belief of being a high-scorer by scorer type.
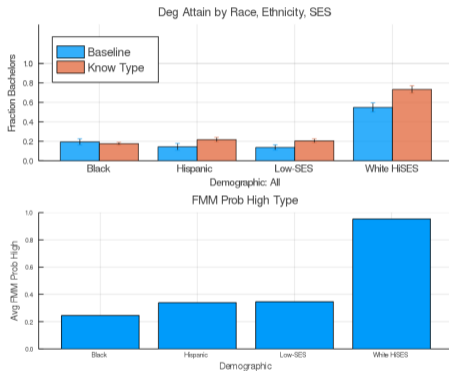
Model Estimate

Mismatch by scorer type
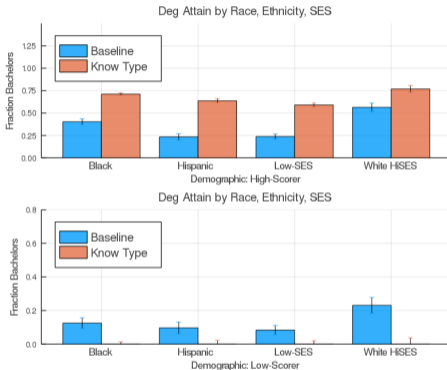
Figure: Shows difference in bachelor's attainment under baseline model and under scenario where youth know their true type with certainty.

Policy Effect

Mismatch Aggregate

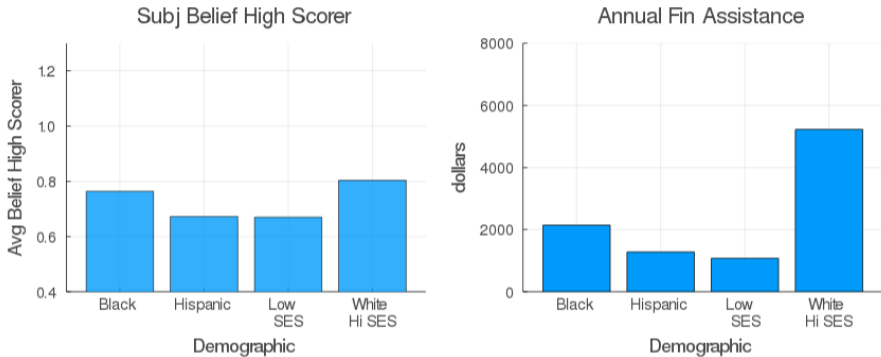Policy Effect

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Difference in Causal Variables

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

Model Estimate

Policy Effect on Inequality

Table 9: Policy Effect on Overall Inequality

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

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

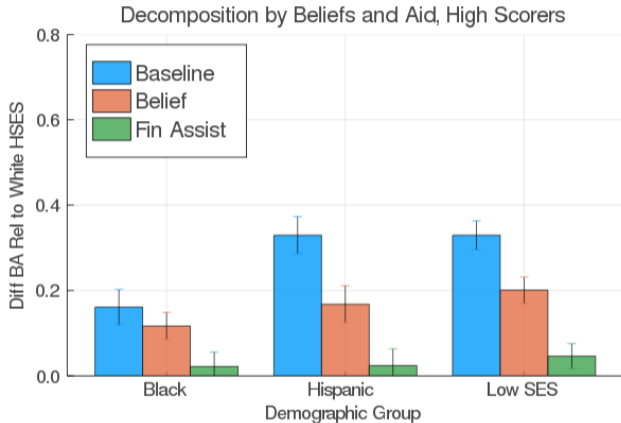# Decomposition: High Scorers

Decomposition by Beliefs and Aid, High Scorers

Figure: Shows relative BA attainment of Black, Hisp, Low SES relative to White High SES High Scorers. Decomposition Table Main Questions
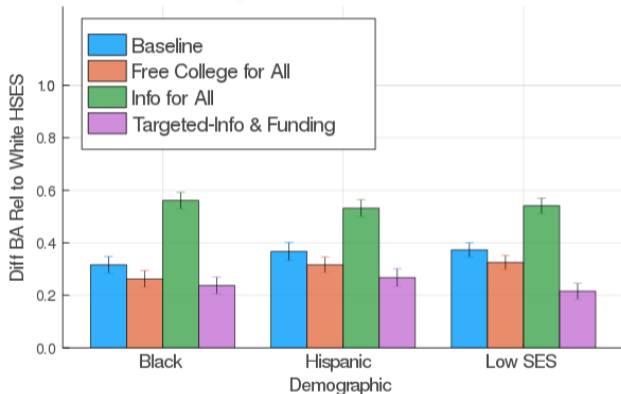
Policy Effect on Inequality

Figure: Shows differences in type independent bachelors attainment relative to high-SES White high-scorers after policy implementation. Standard errors are bootstrapped standard errors.

Mismatch Aggregate   Mismatch Type   Efficiency   Main Questions   Policy Table

Mismatch Policy

Table 10: 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 %
Info for All	4.4 %	4.1 %	0.3 %
Targeted	19.1%	13.3 %	5.9%

Main Questions

Stage 1: Enrollment Decision

- Begin with belief P, net tuition f_1, assets b_1 , and non-pecuniary utility $\vec{\varepsilon}_1 = (\varepsilon_{c,1}, \varepsilon_{w,1})$.

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

$$s.t.$$

$$V_{c,1}(P, f_1, b_1) = \max_{b_2 \geq -\tilde{B}_{s,1}} [u(Rb_1 - f_1 - b_2) + \beta\mathbb{E}_{g,\varepsilon}(V_2(P'(g, P), f_2, b_2, \vec{\varepsilon}_2)) \,|P\,]$$

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

  Enrollment   Model Ingredients

Belief Updating

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

$$P'(g_k, P) = \frac{P \cdot \pi(g_k, \tau_h)}{P \cdot \pi(g_k, \tau_h) + (1 - P) \cdot \pi(g_k, \tau_l)}$$

- Where $\pi(g_k, \tau_h) = Prob(g_k | \tau = \tau_h)$

  Model Ingredients

Stage 2: Continue/Exit Decision

- Begin with belief P', net tuition f_2, debt b_2 , and non-pecuniary utility $\vec{\varepsilon}_2 = (\varepsilon_{c,2}, \varepsilon_{w,2})$.

$$(5) \quad V_2(P', f_2, b_2, \vec{\varepsilon}_2) = \max\{V_w(w_s, b_2, 2) + \varepsilon_{w,2}, V_{c,2}(P', f_2, b_2) + \epsilon_{c,2}\}$$

$$s.t.$$

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

$$+ \quad (1 - P')[V_w(w_c(\tau_l), b_3) + \mu(\tau_l)])]$$

- $\varepsilon_{c,2}, \varepsilon_{w,2}$ are iid Type 1 Extreme Value and $\tilde{B}_2^s > \tilde{B}_2(w)$
  Completion Degree Attainment Model Ingredients

Workers Problem

- Work problem depends on age t.

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

- Per period utility is CRRA

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

- Borrowing constraints

$$\tilde{B}_{T-n}(w) = \sum_{m=1}^n w(1 + r)^{-m} \quad \text{for } n \geq 1 \qquad \tilde{B}_T = 0$$

Model Ingredients