Opportunity Unraveled: Private Information and Missing Markets for Human Capital

Daniel Herbst

University of Arizona

Nathaniel Hendren

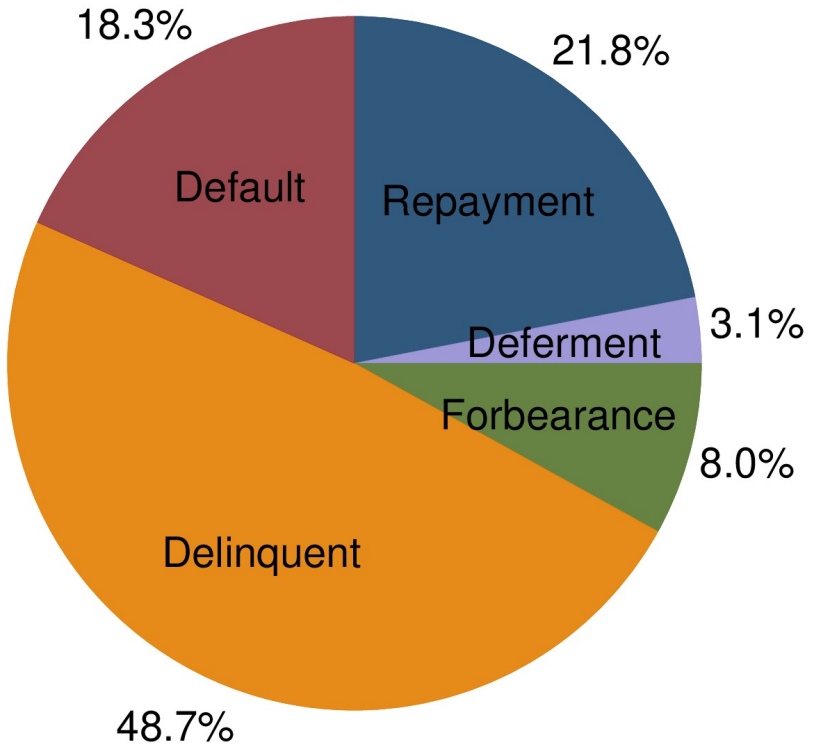
Harvard University and NBER

October 2021

Going to College in the US is Risky

- Investing in college in the US carries high returns but also high risks
  - Almost half of all college students fail to complete their degrees within six years
  - Among 2012 graduates, only 85% find jobs by 2017
  - By age 40, over 15% of college graduates have household incomes below $40,000 per year

- Primary method of financing is student debt, which does little to mitigate this risk
  - $1.7 trillion in outstanding student debt
  - 45 million borrowers
  - ≈1 million defaults each year



Most severe non-repayment event within six years of enrollment

Economists' Solution: Risk-Mitigating Financing for Human Capital

- Economists often promote financial contracts that mitigate college-investment risk:

> *"[Human capital] investment necessarily involves much risk. The device adopted to meet the corresponding problem for other risky investments is equity investment...The counterpart for education would be to `buy' a share in an individual's earnings prospects; to advance him the funds needed to finance his training on condition that he agree to pay the lender a specified fraction of his future earnings."*
>
> *- Milton Friedman (1955)*

1. **Earnings-equity contracts**: Borrower pays X% of earnings
2. **State-contingent debt contracts**: Borrower pays $X only if event occurs
   - **Completion-contingent loan**: Debt forgiveness for college dropouts
   - **Employment-contingent loan**: Debt that's forgiven in unemployment
   - **Dischargeable loan**: Debt that's dischargeable in delinquency/default

Equity and state-contingent debt are common in markets for *physical* capital investment

Research Question: Why don't we see similar financial markets for *human* capital investments?

This Paper: Adverse Selection has Unraveled These Markets

This Paper: Adverse Selection has Unraveled These Markets

1. Develop model of financial markets for human capital to characterize when risk-mitigating financial markets can exist
   - Clarify role of adverse selection vs. other forces such as moral hazard in market existence
   - Two curves determine market (non)existence in the spirit of Akerlof (1970)
     - "Willingness to Accept" (WTA) in exchange for a future share of an outcome
     - "Average value" (AV) of worse risks of future outcomes

This Paper: Adverse Selection has Unraveled These Markets

1. Develop model of financial markets for human capital to characterize when risk-mitigating financial markets can exist

2. Use subjective expectations as noisy/potential biased measures of beliefs about future outcomes to provide evidence of private information
   - Find predictive power of elicitations conditional on rich set of publicly observable characteristics
   - Suggests a potential for adverse selection for markets that insure against these risks

This Paper: Adverse Selection has Unraveled These Markets

1. Develop model of financial markets for human capital to characterize when risk-mitigating financial markets can exist

2. Use subjective expectations as noisy/potential biased measures of beliefs about future outcomes to provide evidence of private information

3. Empirically test unraveling condition (WTA>AV) using subjective elicitations
   - Non-parametric lower bounds and semi-parametric point estimates of unraveling conditions
   - In all four market settings, find WTA>AV so that the market unravels
   - Example: Earnings-equity market
     - Median student would have to repay $1.64 in expectation for every $1 of financing to make the contract profitable, but is only willing to repay $1.28

This Paper: Adverse Selection has Unraveled These Markets

1. Develop model of financial markets for human capital to characterize when risk-mitigating financial markets can exist

2. Use subjective expectations as noisy/potential biased measures of beliefs about future outcomes to provide evidence of private information

3. Empirically test unraveling condition (WTA>AV) using subjective elicitations

4. Measure welfare impact of government subsidies to open up these markets
   - Estimate the $MVPF = \frac{Benefits}{Net\ Govt\ Cost}$ of subsidies for these contracts
   - Should government offer college financing in exchange for higher future tax rate?
   - Find high MVPFs for equity contracts because insurance value > distortionary costs

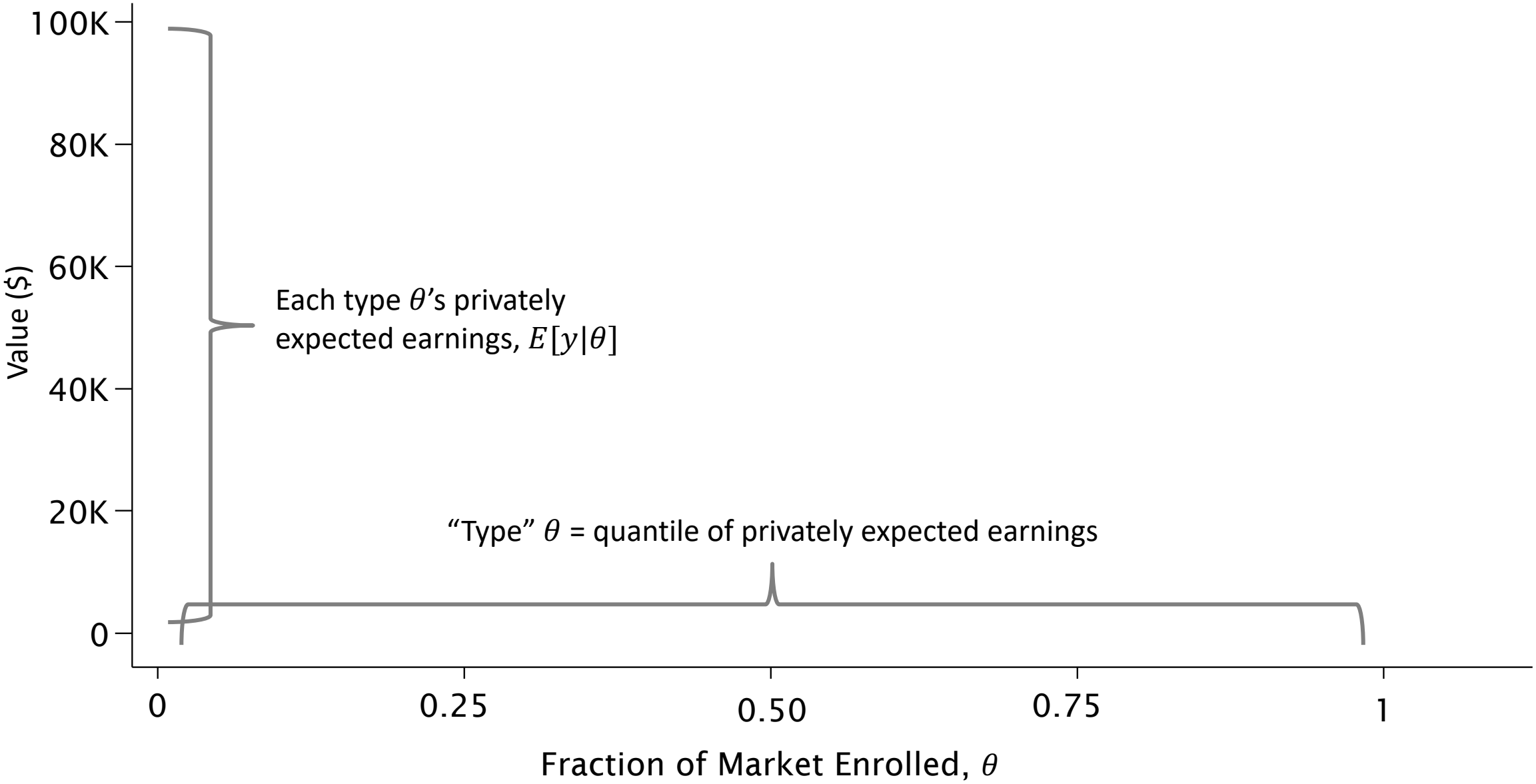
Outline

1. Model of Market Unraveling
2. Data and Reduced Form Evidence of Private Information
3. Lower-Bound on Magnitude of Private Information
4. Estimation of Average Value and Willingness to Accept Curves
5. Welfare Impacts of Government Subsidies

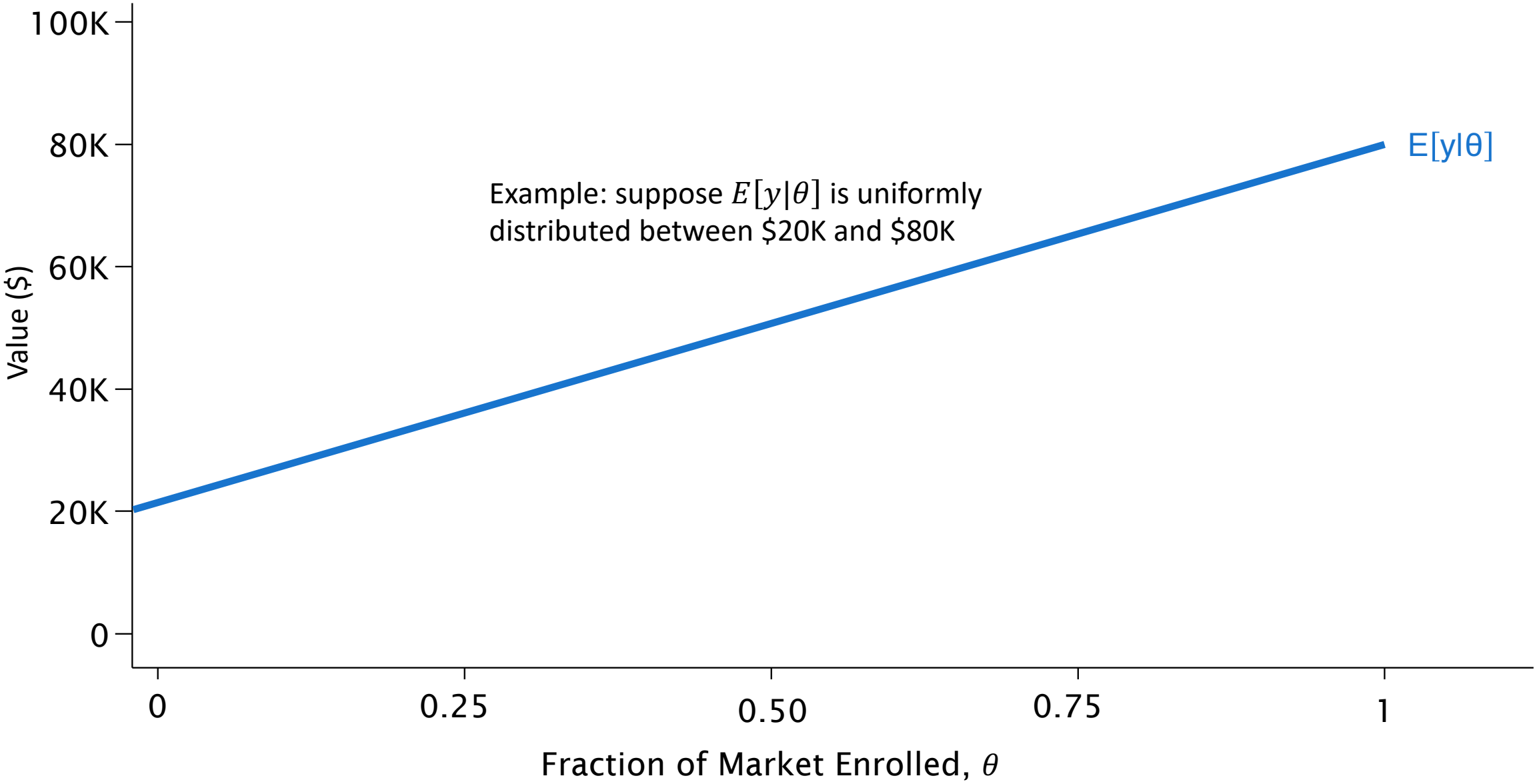
Outline

1. Model of Market Unraveling
2. Data and Reduced Form Evidence of Private Information
3. Lower-Bound on Magnitude of Private Information
4. Estimation of Average Value and Willingness to Accept Curves
5. Welfare Impacts of Government Subsidies

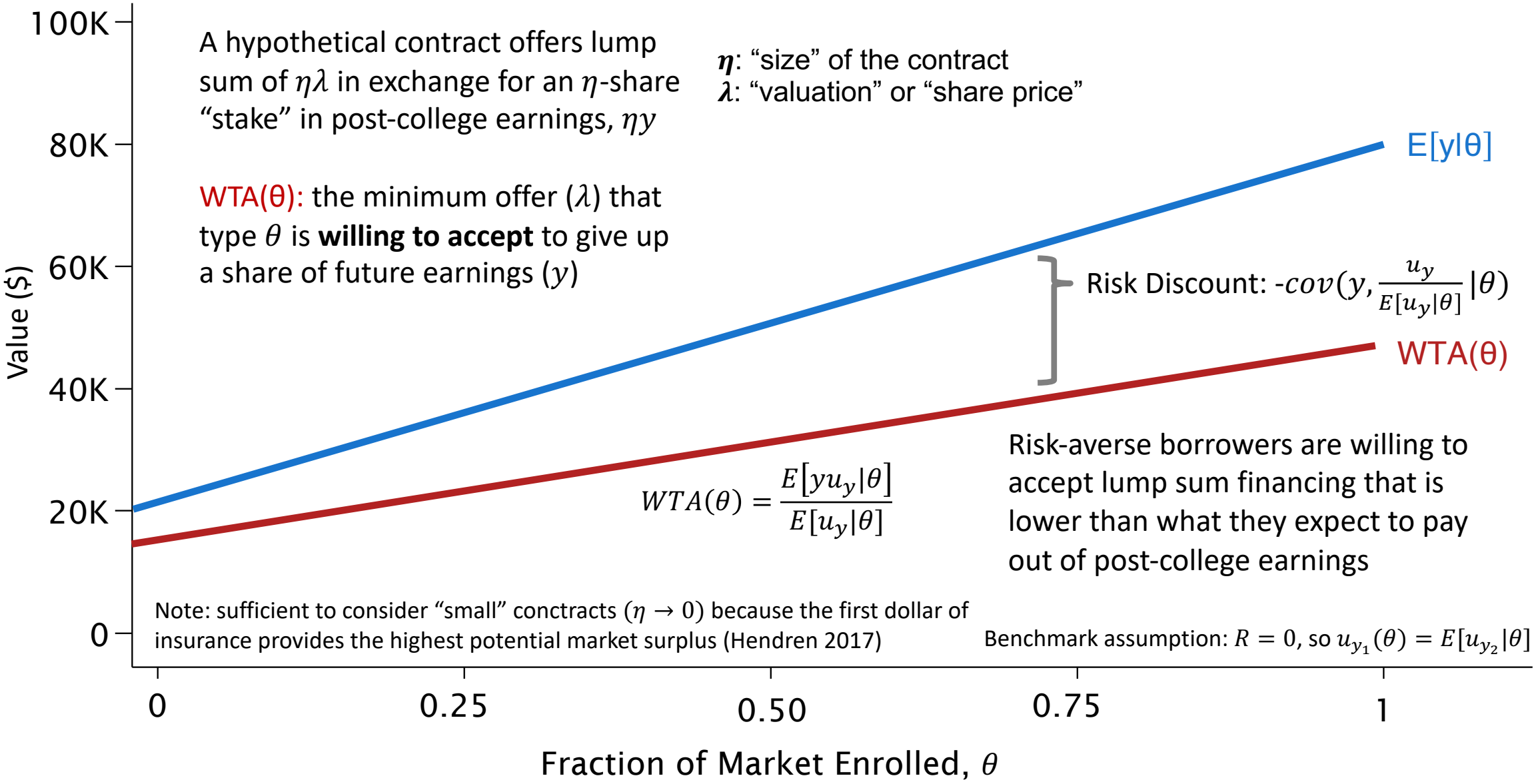
Model of Market Unraveling



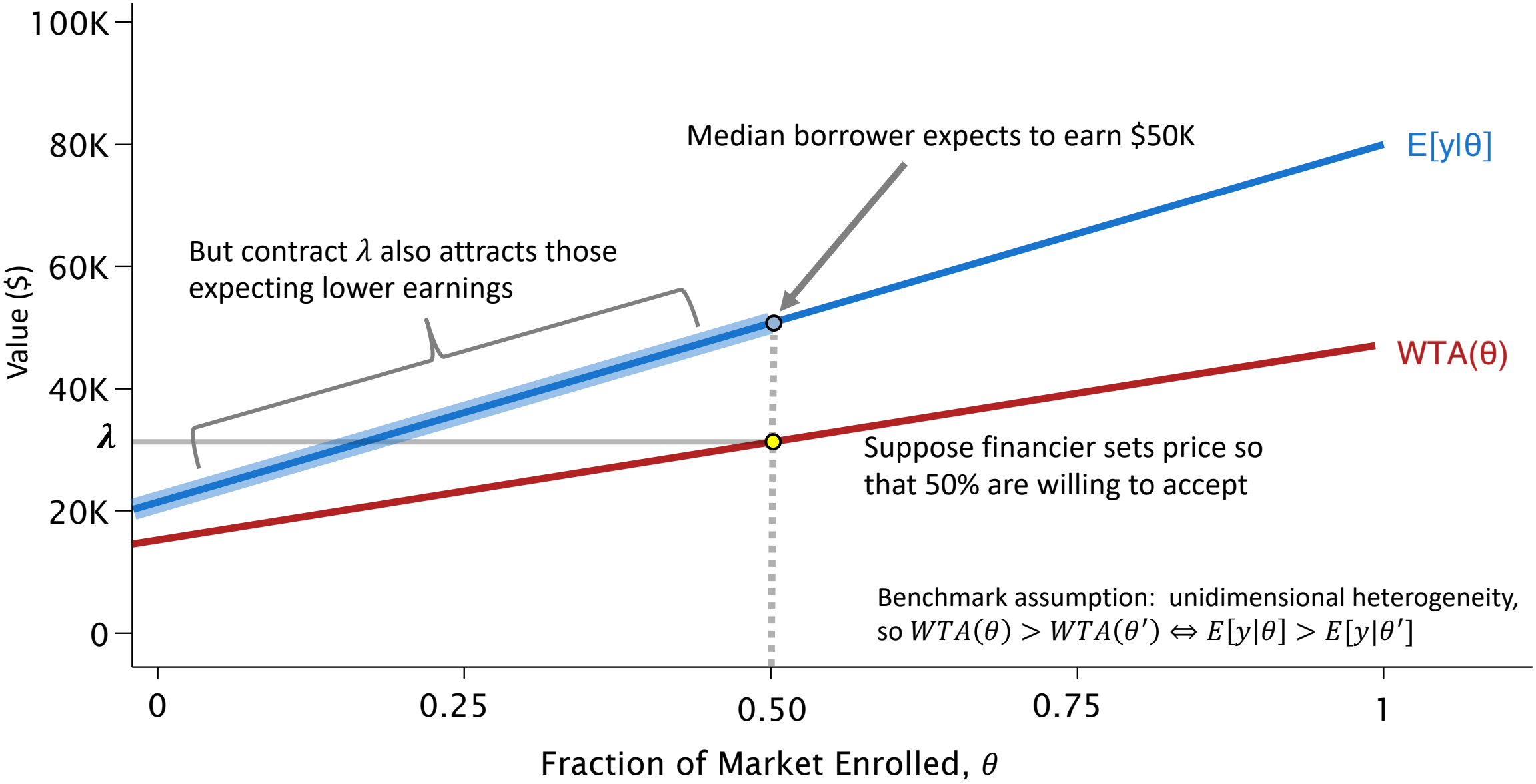
Privately Expected Earnings: $E[y|\theta]$



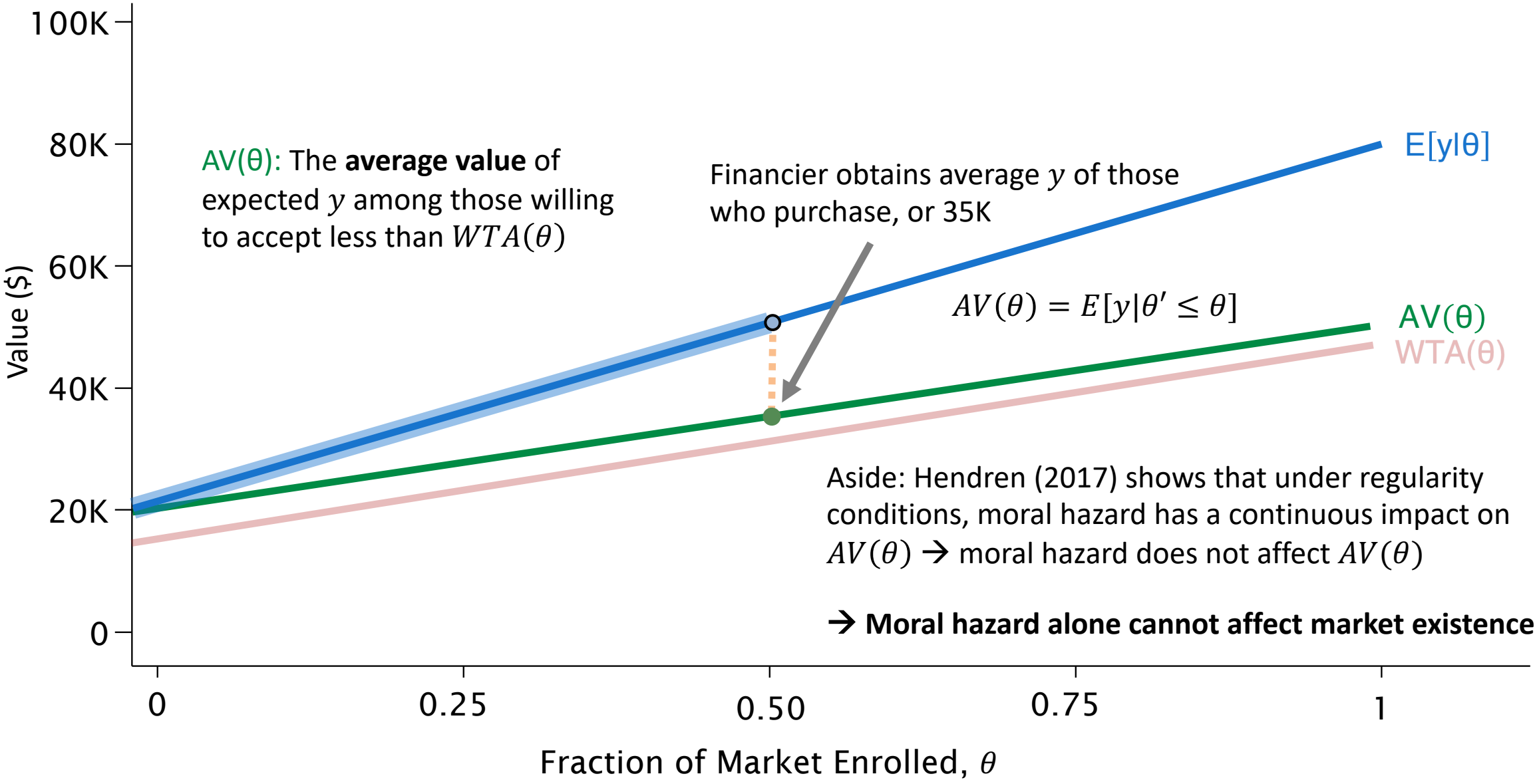
Willingness to Accept: $WTA(\theta)$



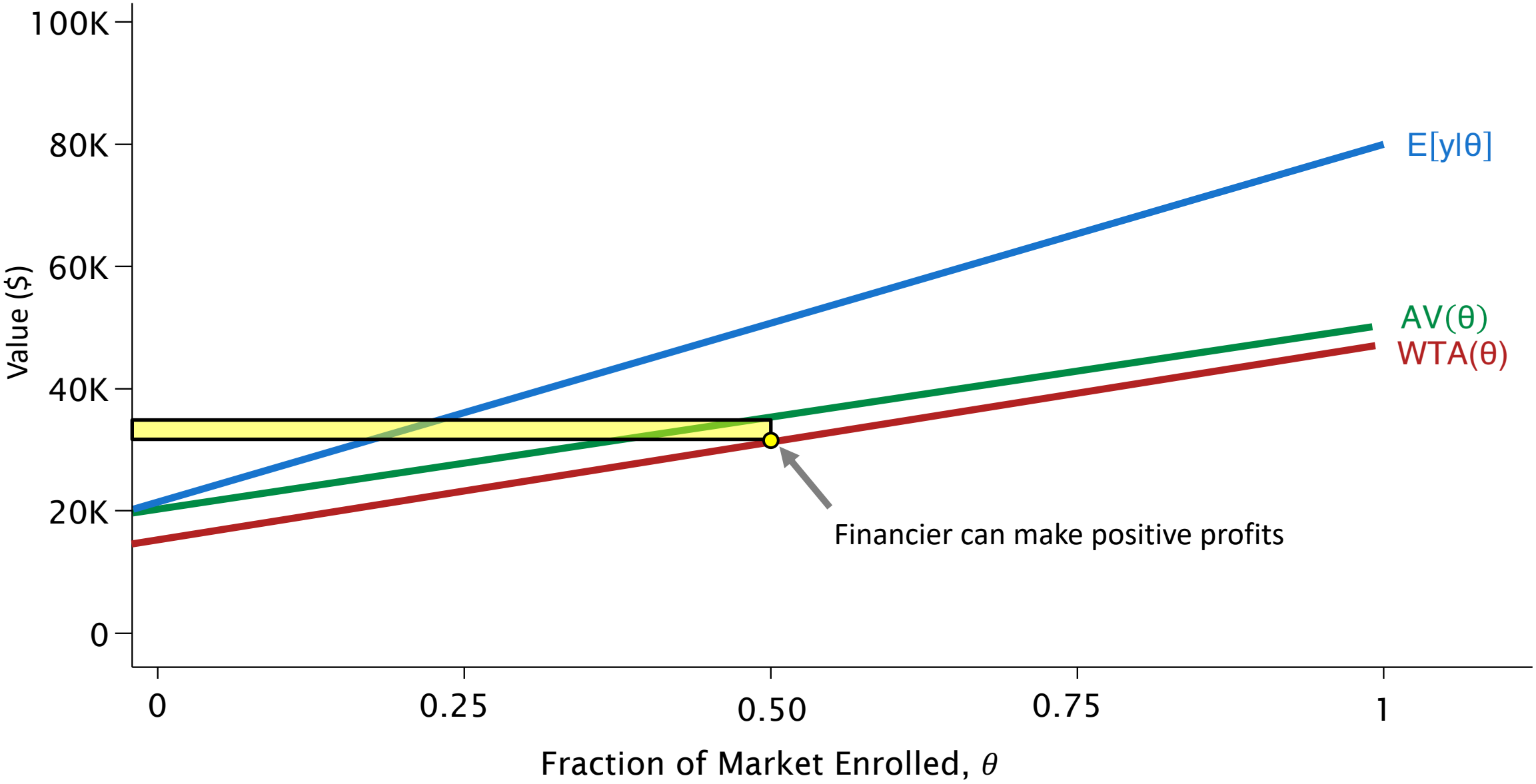
Can Financiers Make Profits?



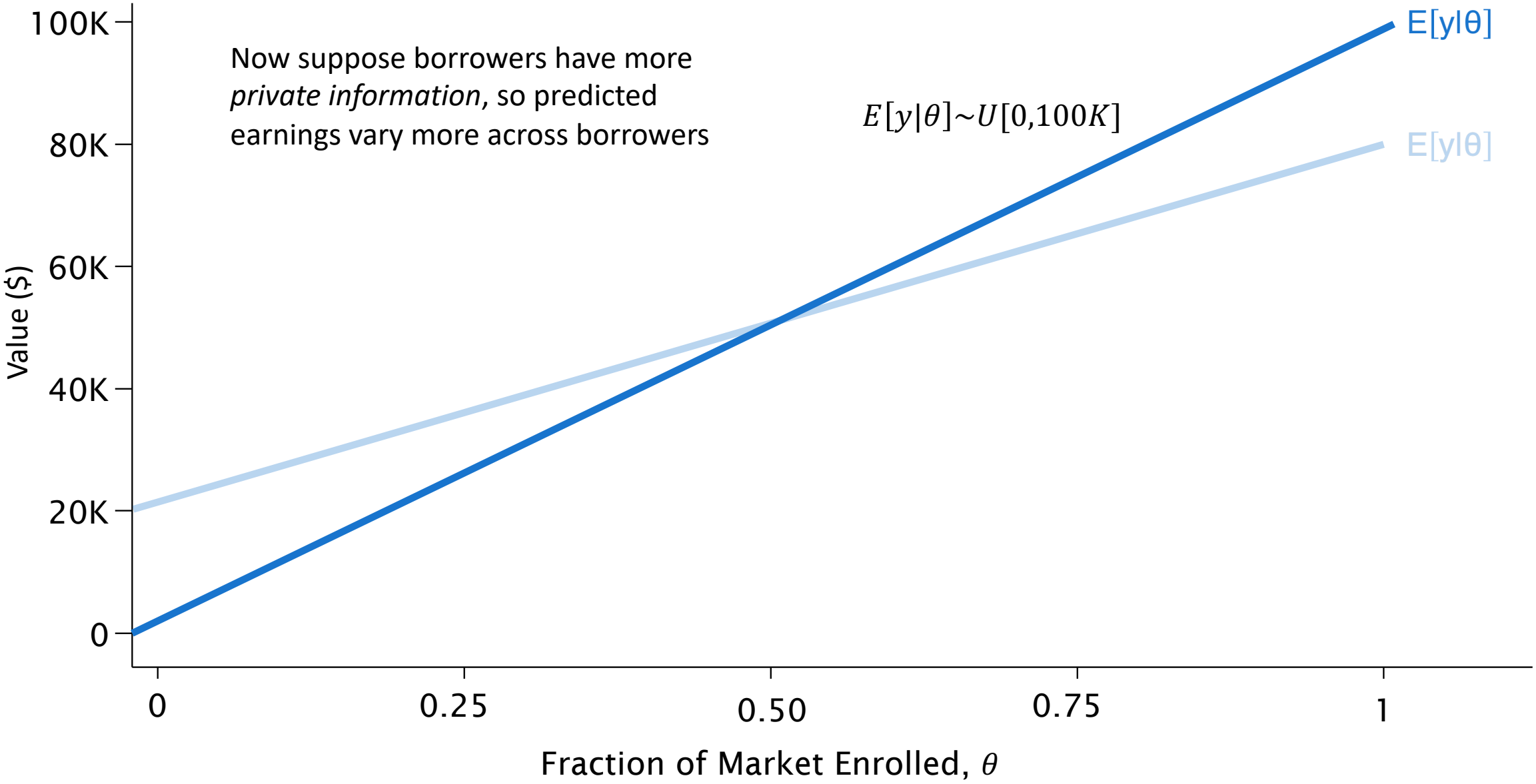
Average Value Curve, $AV(\theta)$



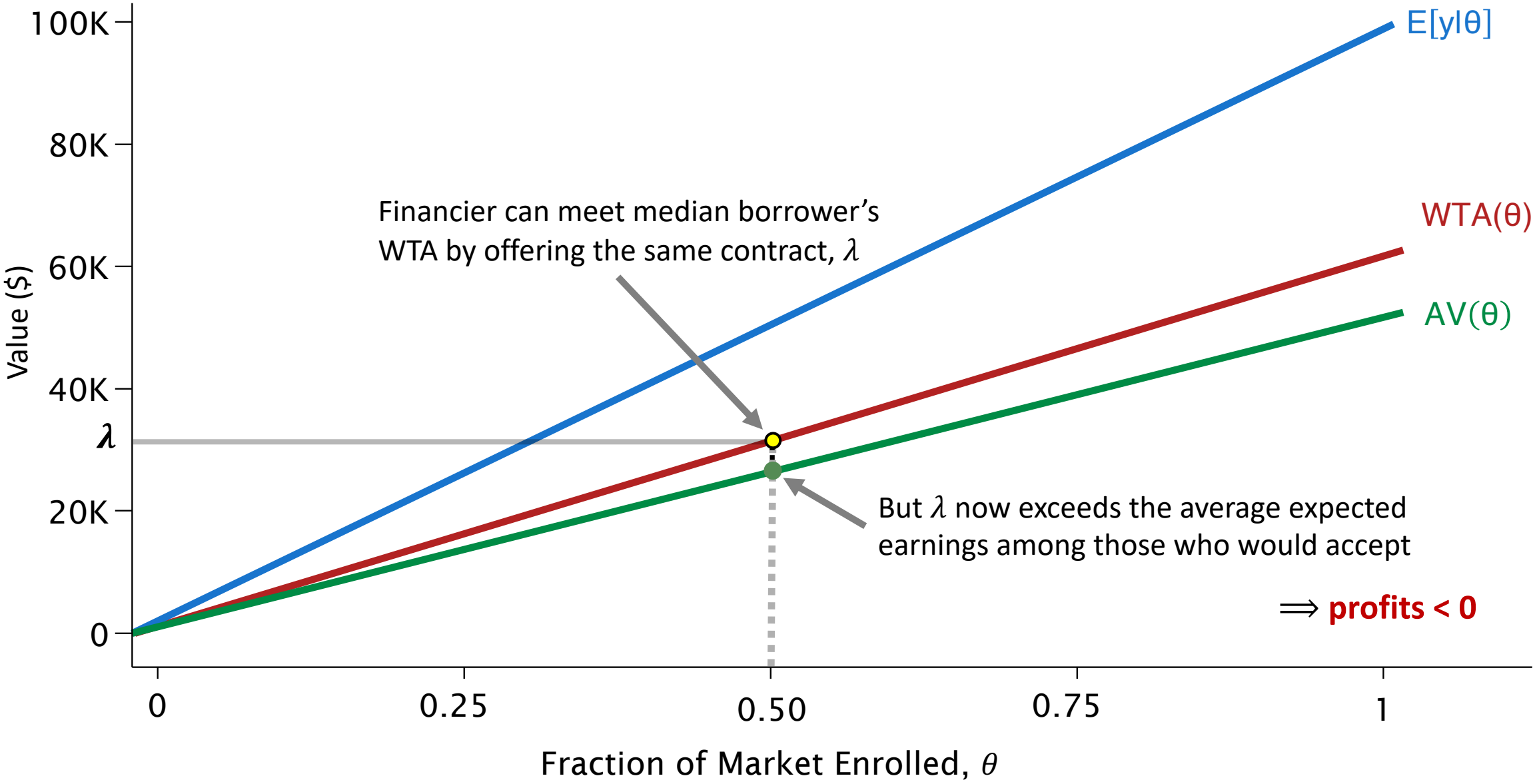
Can Financiers Make Profits?



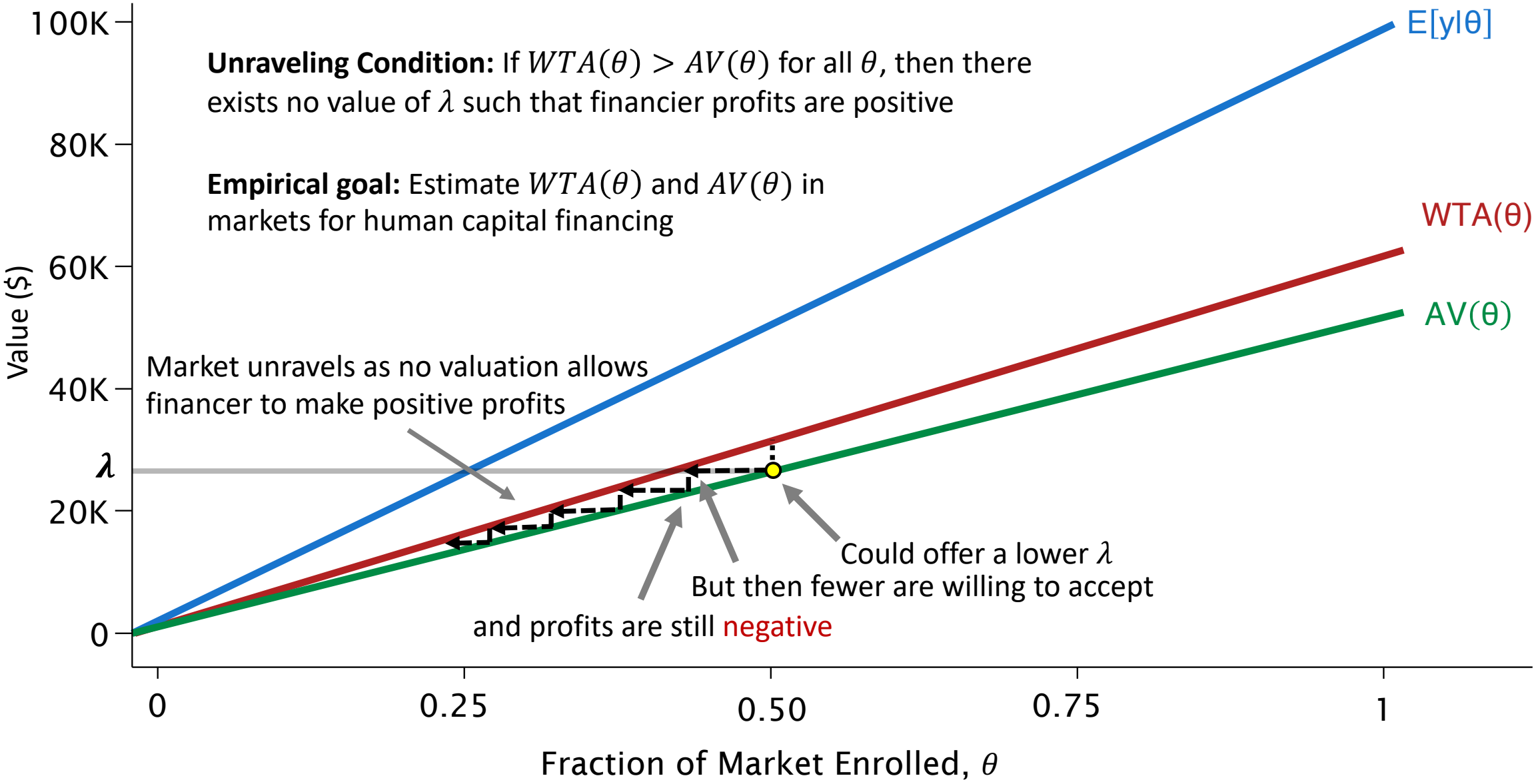
Can Financiers Make Profits? Scenario #2



Can Financiers Make Profits? Scenario #2



Can Financiers Make Profits? Scenario #2



Which Markets Unravel?

Empirical goal: Estimate $WTA(\theta)$ and $AV(\theta)$ in markets for human capital financing

We consider four hypothetical markets:

1. *Earnings-Equity Contract*: y = earnings
2. *Completion-Contingent Loan*: y = complete degree
3. *Employment-Contingent Loan*: y = employed
4. *Dischargeable Loan*: y = no delinquency

(continuous y)

(binary y)

Outline

1. Model of Market Unraveling
2. Data and Reduced Form Evidence of Private Information
3. Lower-Bound on Magnitude of Private Information
4. Estimation of Average Value and Willingness to Accept Curves
5. Welfare Impacts of Government Subsidies

Data: Beginning Postsecondary Students Survey (BPS)

- 2012/2017 Beginning Postsecondary Students (BPS)
  - First-year college students in Spring 2012
  - Follow up in 2017

- Links data across several sources
  1. FAFSA records (parental income, sex, age, etc.)
  2. Administrative loan data (National Student Loan Database System)
  3. Administrative academic information (major, GPA, SAT scores)
  4. Survey data (beliefs, employment outcomes, salary)

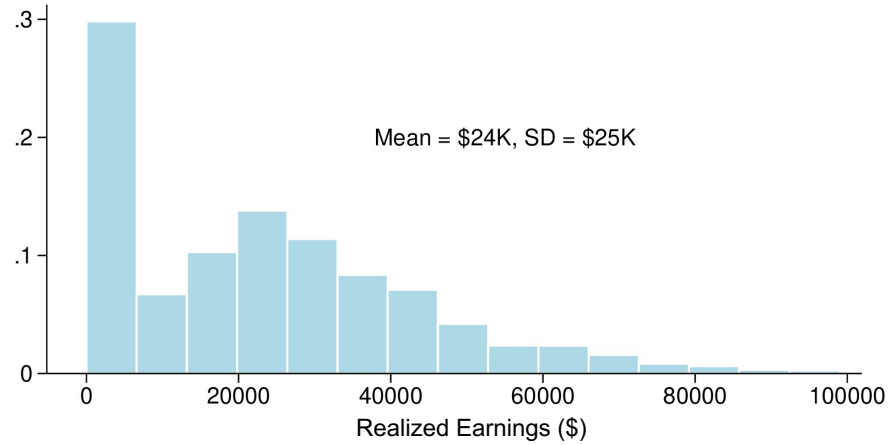
Empirical Approach Relies on Three Types of Variables

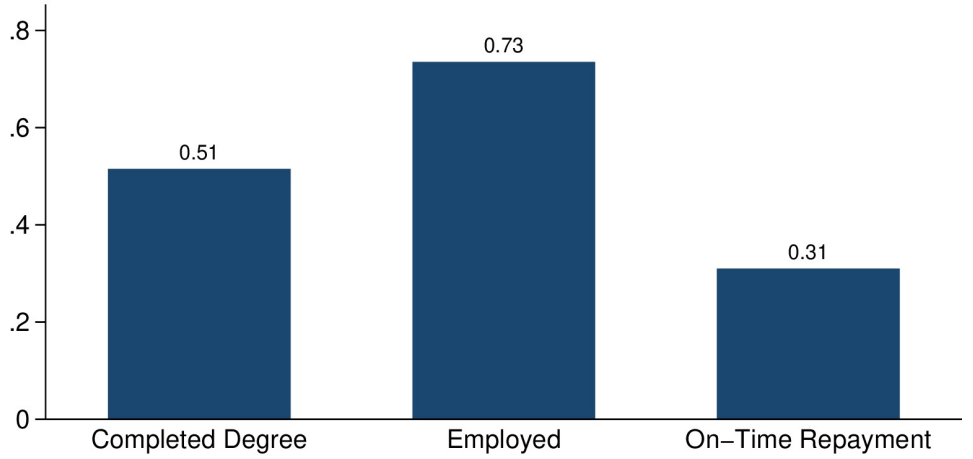
- Y: Outcomes corresponding to each of the 4 hypothetical markets we consider
- Z: Subjective elicitations of future outcomes
- X: Observable information about borrowers that financiers could use to price contracts

Summary Statistics

Empirical Approach Relies on Three Types of Variables

- Y: Outcomes corresponding to each of the 4 hypothetical markets we consider
  - *Earnings-Equity Contract* (continuous y):
    - $y =$ Annual salary from last job held in January and June 2017
  - Three state-contingent debt contracts (binary y):
    - *Completion-Contingent Loan*: $y =$ completed degree by June 2017 (6 years post-enrollment)
    - *Employment-Contingent Loan*: $y =$ held at least one job between January and June 2017
    - *Dischargeable Loan*: $y =$ no delinquencies or defaults on student loans as of June 2017





Empirical Approach Relies on Three Types of Variables

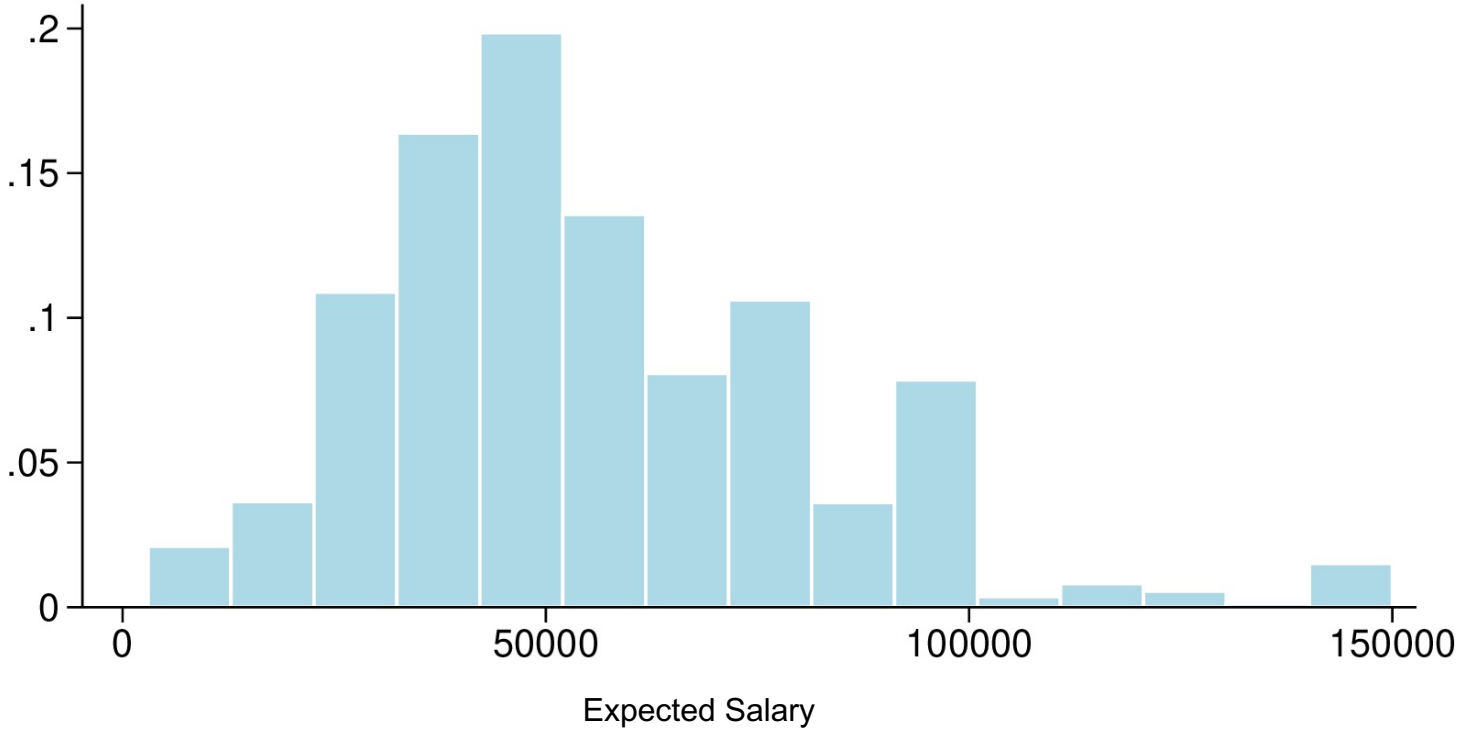
- Y: Outcomes corresponding to each of the 4 hypothetical markets we consider

- Z: Subjective elicitations of future outcomes
  - On-time Degree Completion: *"On a scale from 0-10, how likely is it you will finish your degree by [expected date]"*
  - Occupation: *"What do you think the job title and duties of the occupation you intend to hold will be after having completed your education?"*
  - Employment in Occupation: "*On a scale from 0-10, how likely do you think it is that you will hold a(n) [EXPECTED OCC] job?"*
  - Salary: "*Once you begin working [in EXPECTED OCC], what is your expected yearly salary?"*
  - Expected Salary without College: *How much do you think you would have earned from working if you had not attended college at all in the 2011- 2012 school year?*
  - Parental Support: "*On a scale of 1-5, how much do agree with the following statement: "My parents encourage me to stay in college"*
  - Parental Financial Support: *"Through the end of the 2011-2012 school year (July 1, 2011-June 30, 2012), will your parents (or guardians) have helped you pay for any of your education and living expenses while you are enrolled in school?...How much?"*

Summary Statistics

Empirical Approach Relies on Three Types of Variables

- Y: Outcomes corresponding to each of the 4 hypothetical markets we consider
- Z: Subjective elicitations of future outcomes



Summary Statistics

Empirical Approach Relies on Three Types of Variables

- Y: Outcomes corresponding to each of the 4 hypothetical markets we consider

- Z: Subjective elicitations of future outcomes

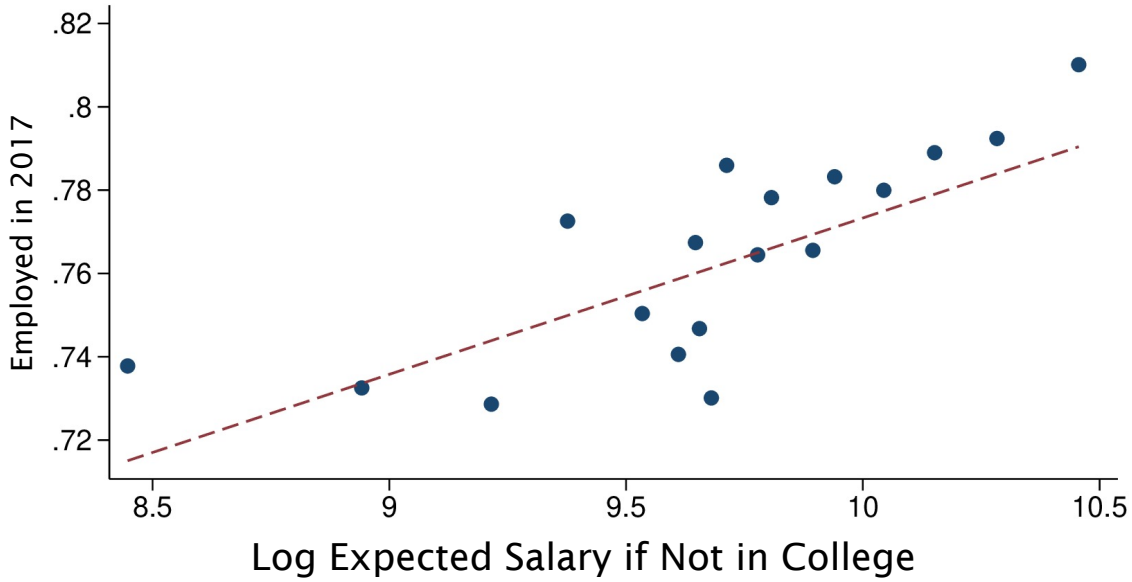
- X: Observable information about borrowers that financiers could use to price contracts
  - **Institutional Characteristics:** enrollment size, admit rate, tuition charged, degree offerings, region, urban/rural, avg. demographics and test scores
  - **Academic Program Characteristics:** degree type (BA, AA), field of study, years since HS
  - **High School Performance Measures:** HS GPA, SAT/ACT (verbal, math, combined)
  - **Demographics:** age, citizenship status, marital status, no. of children, prior state of residence
  - **Parental Characteristics:** marital status, no. of children, annual income, EFC
  - **Protected Classes:** race, gender *(illegal to use in pricing, but we can evaluate its impact)*

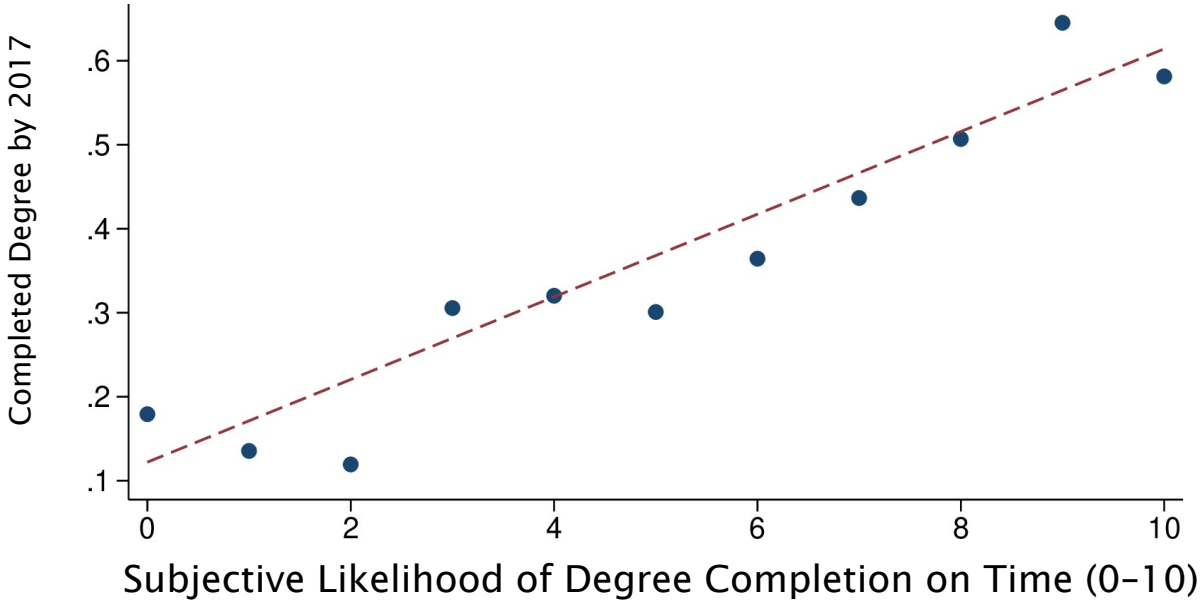
Summary Statistics

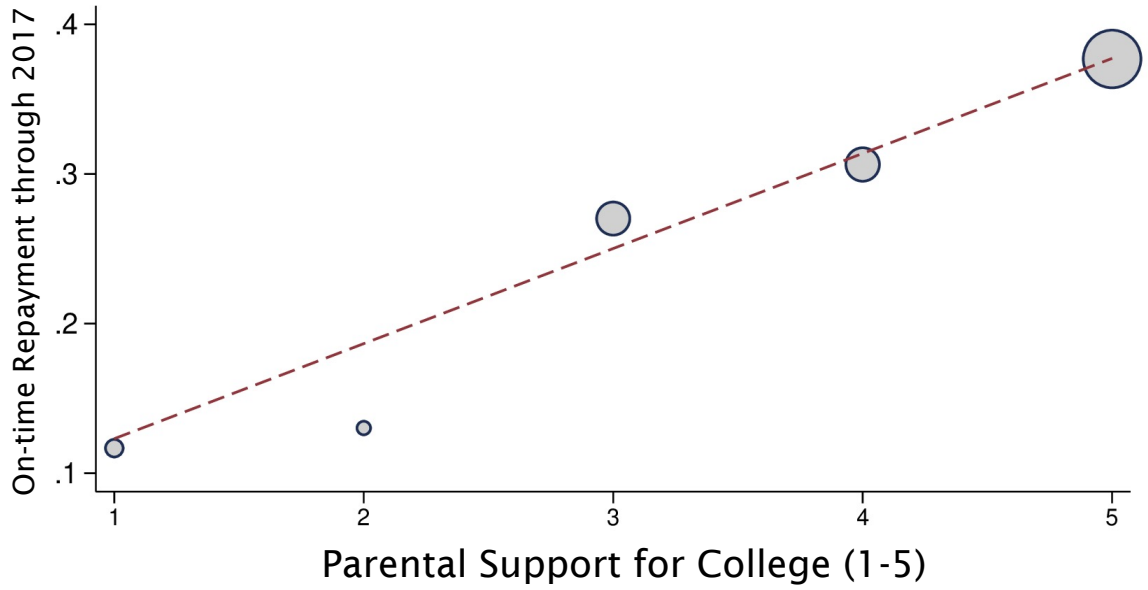
Test for Potential for Adverse Selection

- Begin with simple test for the potential for adverse selection: Are individuals able to predict the outcomes?
  - How about conditional on observables, X, that financiers might use to price the contracts?
- Start with simple binned scatter plots of Y on Z with no controls
- Then run regressions conditional on increasing sets of observables

Future Salary in 2017







Predictive Information in Z Conditional on X: Salary

	(1)	(2)	(3)	(4)	(5)	(6)
	Log Salary	Log Salary	Log Salary	Log Salary	Log Salary	Log Salary
Log Expected Salary	0.113***	0.0602***	0.0446***	0.0432***	0.0327**	0.0314**
	(0.0159)	(0.0159)	(0.0161)	(0.0160)	(0.0158)	(0.0158)
Institution		X	X	X	X	X
Academic			X	X	X	X
Performance				X	X	X
Demographics					X	X
Parental						X
Partial R-Squared	0.009	0.067	0.101	0.104	0.119	0.123
R-squared	0.009	0.003	0.002	0.001	0.001	0.001
N	12580	12580	12580	12580	12580	12580

Predictive Information in Z Conditional on X: Degree Completion

	(1) Degree Completion	(2) Degree Completion	(3) Degree Completion	(4) Degree Completion	(5) Degree Completion	(6) Degree Completion
On-Time Completion Likelihood	0.0492***	0.0365***	0.0364***	0.0345***	0.0343***	0.0332***
	(0.00223)	(0.00223)	(0.00224)	(0.00225)	(0.00221)	(0.00220)
Institution		X	X	X	X	X
Academic			X	X	X	X
Performance				X	X	X
Demographics					X	X
Parental						X
Partial R-Squared	0.045	0.215	0.222	0.239	0.249	0.264
R-squared	0.045	0.029	0.028	0.028	0.028	0.026
N	22340	22340	22340	22340	22340	22340

Predictive Information in Z Conditional on X: Employment

	(1)	(2)	(3)	(4)	(5)	(6)
	Employed	Employed	Employed	Employed	Employed	Employed
Log Expected Salary if No College	0.0313***	0.0243**	0.0212**	0.0199*	0.0175	0.0169
	(0.0107)	(0.0109)	(0.0108)	(0.0107)	(0.0106)	(0.0106)
Institution		X	X	X	X	X
Academic			X	X	X	X
Performance				X	X	X
Demographics					X	X
Parental						X
Partial R-Squared	0.012	0.026	0.035	0.038	0.042	0.046
R-squared	0.012	0.008	0.007	0.007	0.006	0.006
N	17480	17480	17480	17480	17480	17480

Predictive Information in Z Conditional on X: On-Time Repayment

	(1) On-Time Repayment	(2) On-Time Repayment	(3) On-Time Repayment	(4) On-Time Repayment	(5) On-Time Repayment	(6) On-Time Repayment
Supportive Parents	0.0635***	0.0349***	0.0336***	0.0305***	0.0301***	0.0285***
	(0.00505)	(0.00502)	(0.00497)	(0.00491)	(0.00488)	(0.00483)
Institution		X	X	X	X	X
Academic			X	X	X	X
Performance				X	X	X
Demographics					X	X
Parental						X
Partial R-Squared	0.030	0.114	0.123	0.136	0.144	0.155
R-squared	0.030	0.014	0.014	0.015	0.015	0.014
N	15520	15520	15520	15520	15520	15520

Open Questions: Quantifying Private Information

- Individuals have private knowledge about future outcomes
- But is this “enough” private information to cause the market to unravel?
- Need to estimate willingness to accept (WTA) and Average Value (AV) curves

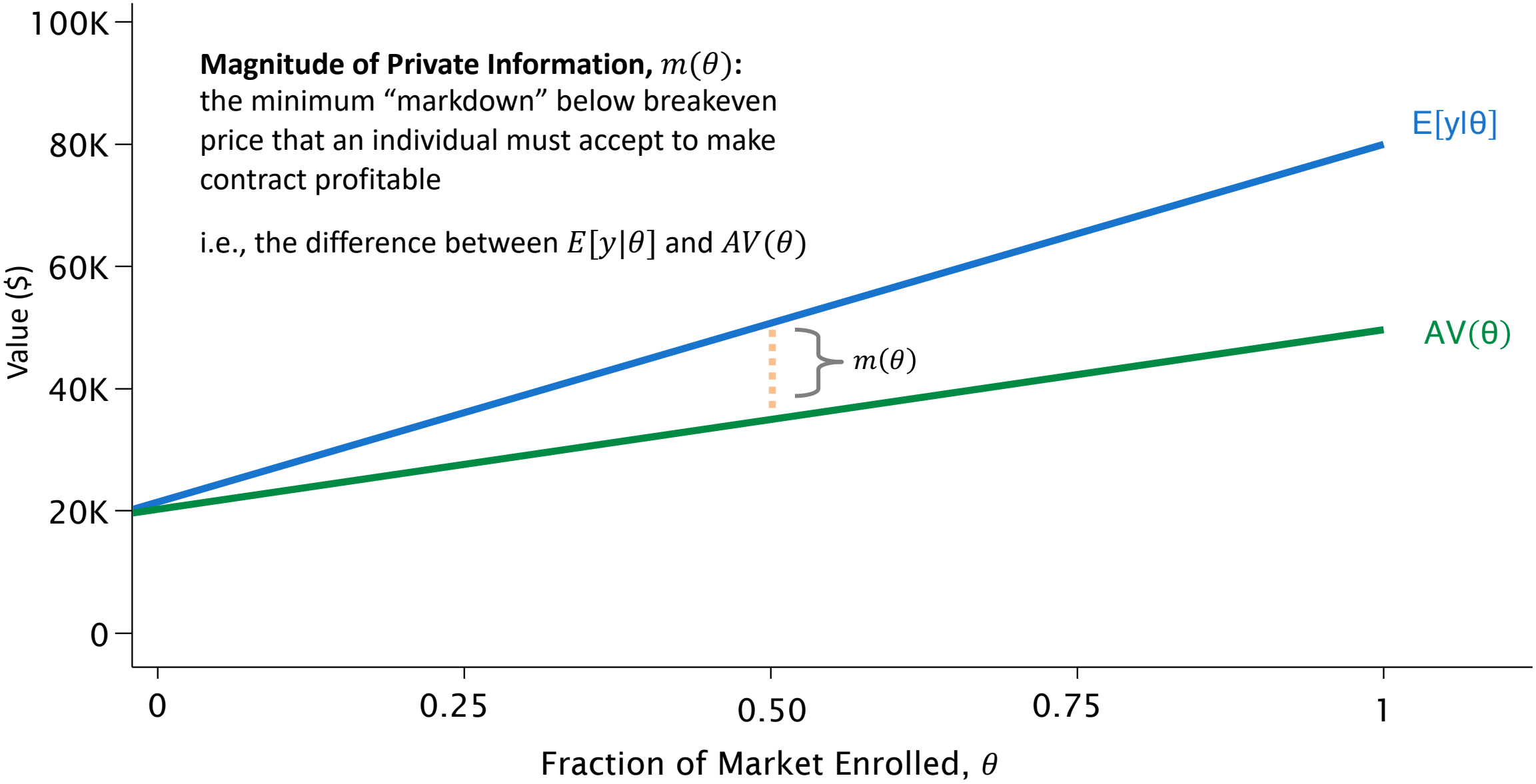
Outline

1. Model of Market Unraveling
2. Data and Reduced Form Evidence of Private Information
3. Lower-Bound on Magnitude of Private Information
4. Estimation of Average Value and Willingness to Accept Curves
5. Welfare Impacts of Government Subsidies

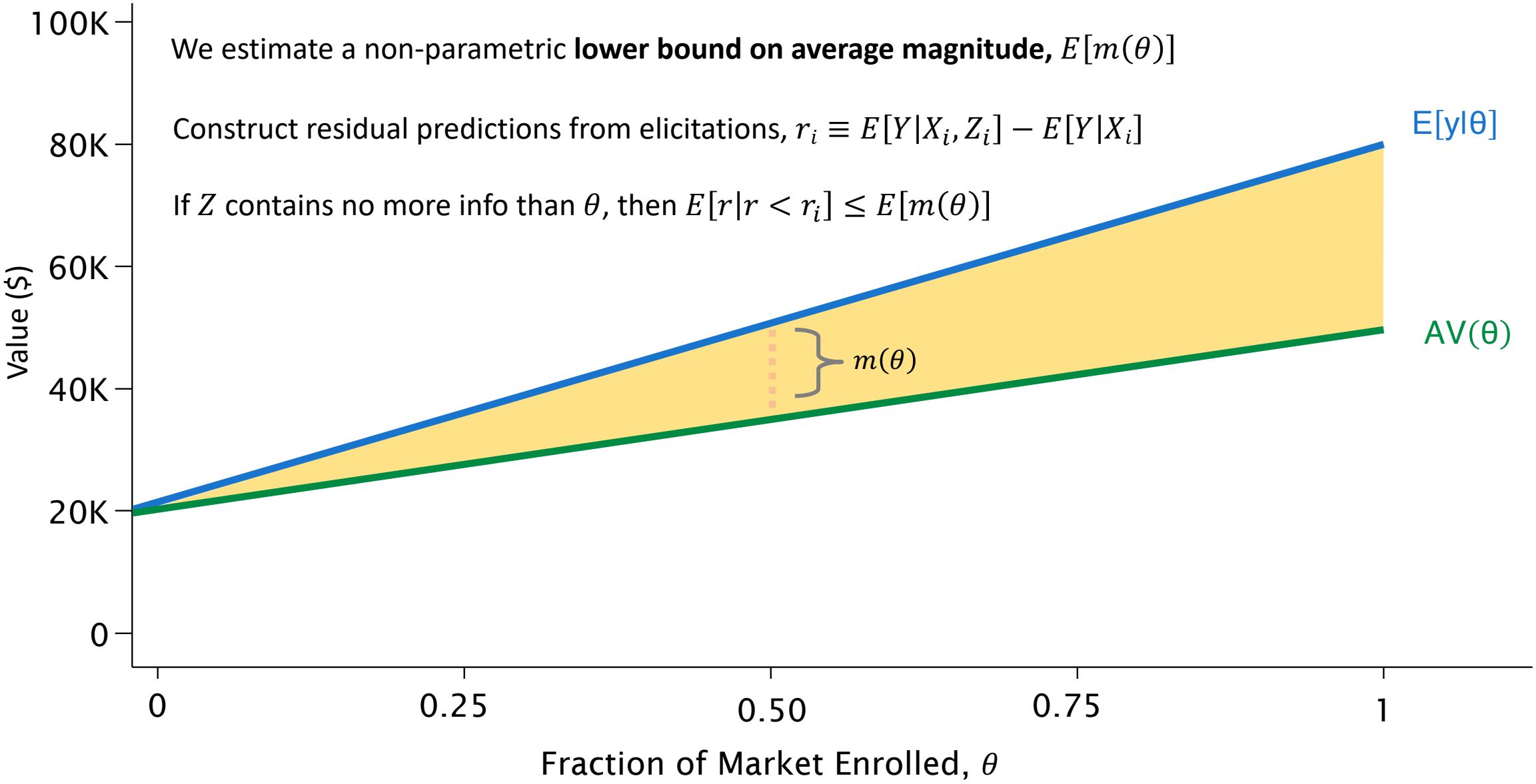
Magnitude of Private Information

Magnitude of Private Information, $m(\theta)$:
the minimum "markdown" below breakeven price that an individual must accept to make contract profitable

i.e., the difference between $E[y|\theta]$ and $AV(\theta)$



Magnitude of Private Information



Lower-Bound on Magnitude of Private Information

	Category				
	(1) *No Public Info*	(2) *Institution + Academic*	(3) *Institution + Academic + Performance + Demographics*	(4) *Institution + Academic + Performance + Demographics + Parental*	(5) *Institution + Academic + Performance + Demographics + Parental + Protected*
Earnings Equity	5765	5314	3797	2907	2381
Completion-Contingent Loan	0.20	0.16	0.13	0.11	0.11
Employment-Contingent Loan	0.09	0.11	0.07	0.05	0.04
Dischargeable Loan	0.13	0.13	0.07	0.05	0.04

- $E[m(\theta)] > \$5{,}314$, or 20% discount relative to average incomes of $24K

Lower-Bound on Magnitude of Private Information

	Category				
	(1) *No Public Info*	(2) *Institution + Academic*	(3) *Institution + Academic + Performance + Demographics*	(4) *Institution + Academic + Performance + Demographics + Parental*	(5) *Institution + Academic + Performance + Demographics + Parental + Protected*
Earnings Equity	5765	5314	3797	2907	2381
Completion-Contingent Loan	0.20	0.16	0.13	0.11	0.11
Employment-Contingent Loan	0.09	0.11	0.07	0.05	0.04
Dischargeable Loan	0.13	0.13	0.07	0.05	0.04

- $E[m(\theta)] > \$5{,}314$, or 20% discount relative to average incomes of \$24K

- Large discounts for other markets as well:
  - ≈ \$0.30 loss for \$1 completion-contingent loan
  - ≈ \$0.15 loss for \$1 employment-contingent loan
  - ≈ \$0.40 loss for \$1 dischargeable loan

Outline

1. Model of Market Unraveling
2. Data and Reduced Form Evidence of Private Information
3. Lower-Bound on Magnitude of Private Information
4. Estimation of Average Value and Willingness to Accept Curves
5. Welfare Impacts of Government Subsidies

Empirical Approach to Estimate $WTA(\theta_\lambda)$ and $AV(\theta_\lambda)$ curves

- Start with $\mathrm{AV}(\theta_\lambda)$ curves, $AV(\theta_\lambda) \equiv E[y|\theta \leq \theta_\lambda]$
- Requires estimation of distribution of $\mu_\theta = E[y|\theta]$
- Approach: use information contained in elicitations, Z, about outcome, Y, conditional on observables, X
- Build on approach in Hendren (2013, 2017), with two key advances:
  - Allow for outcome y to be continuous (e.g. earnings-equity contract)
  - Allow elicitations to not correspond directly to outcomes
- Use results from non-parametric measurement error / identification of factor models (Bonhomme and Robin (2010), Hu and Schennach (2008))

Beliefs' Relationship with Outcomes and Elicitations

Goal: Identify distribution of latent beliefs $g(\mu_\theta)$ from observed outcomes, y, and elicitations, z

- Realized outcome, y:

$$y = \mu_\theta + \epsilon$$

Belief — Uncertainty

- Elicitation, z:

$$z = \alpha + \gamma\mu_\theta + v$$

Bias — Measurement Error

Beliefs' Relationship with Outcomes and Elicitations

Goal: Identify distribution of latent beliefs $g(\mu_\theta)$ from observed outcomes, y, and elicitations, z

- Realized outcome, y:

$$y = \mu_\theta + \epsilon$$

  - Assumes beliefs are unbiased: $\mu_\theta = E[y|\theta]$
  - Assumes "expectational error" (ϵ) is homoscedastic

- Elicitation, z:

$$z = \alpha + \gamma\mu_\theta + v$$

  - z can be biased ($\alpha \neq 0$), imperfect ($\lambda \neq 1$), and noisy ($\sigma_v > 1$) in beliefs
  - γ is estimated using IV and second elicitation, z' (Details/Results)
    - **Identification assumption:** measurement error is orthogonal: $cov(z', v|\theta) = 0$

Estimating Belief Distribution, $g(\mu_\theta)$: Two Cases

1. Continuous y: log salary
   - We estimate $g(\mu_\theta)$ non-parametrically using a linear **deconvolution**

     (Bonhomme & Robin 2010)

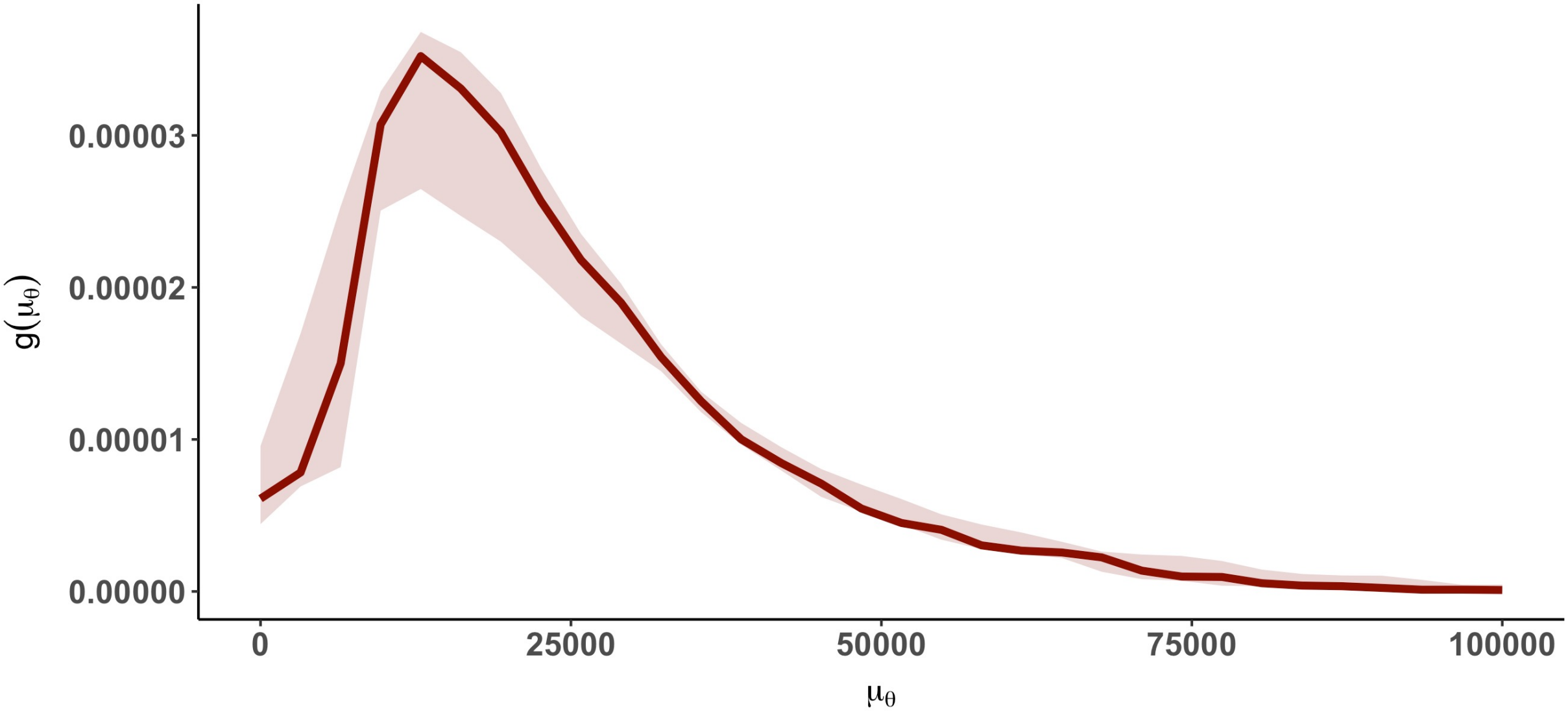
2. Binary y: degree completion, loan repayment, and employment
   - Semi-parametric specification for $g(\mu_\theta)$:

$$G(\mu_\theta) = \sum_j \xi_j \, \mathbf{1}\{\mu_\theta \leq a_j\}$$

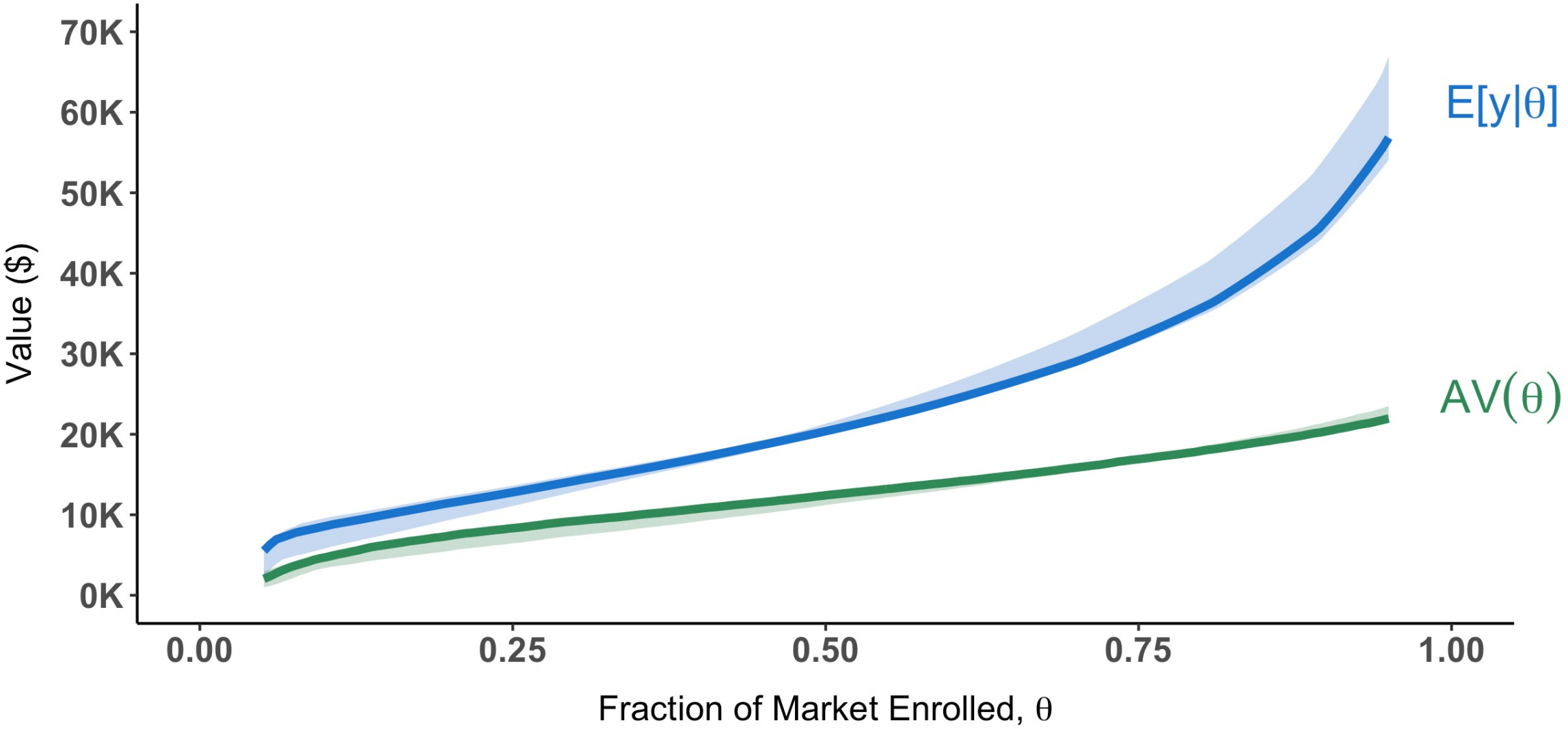
where $\{a_j\}$ is a set of twenty-five evenly-spaced point masses in $[0,1]$.

(Note: In both cases, we allow for conditioning on observables)

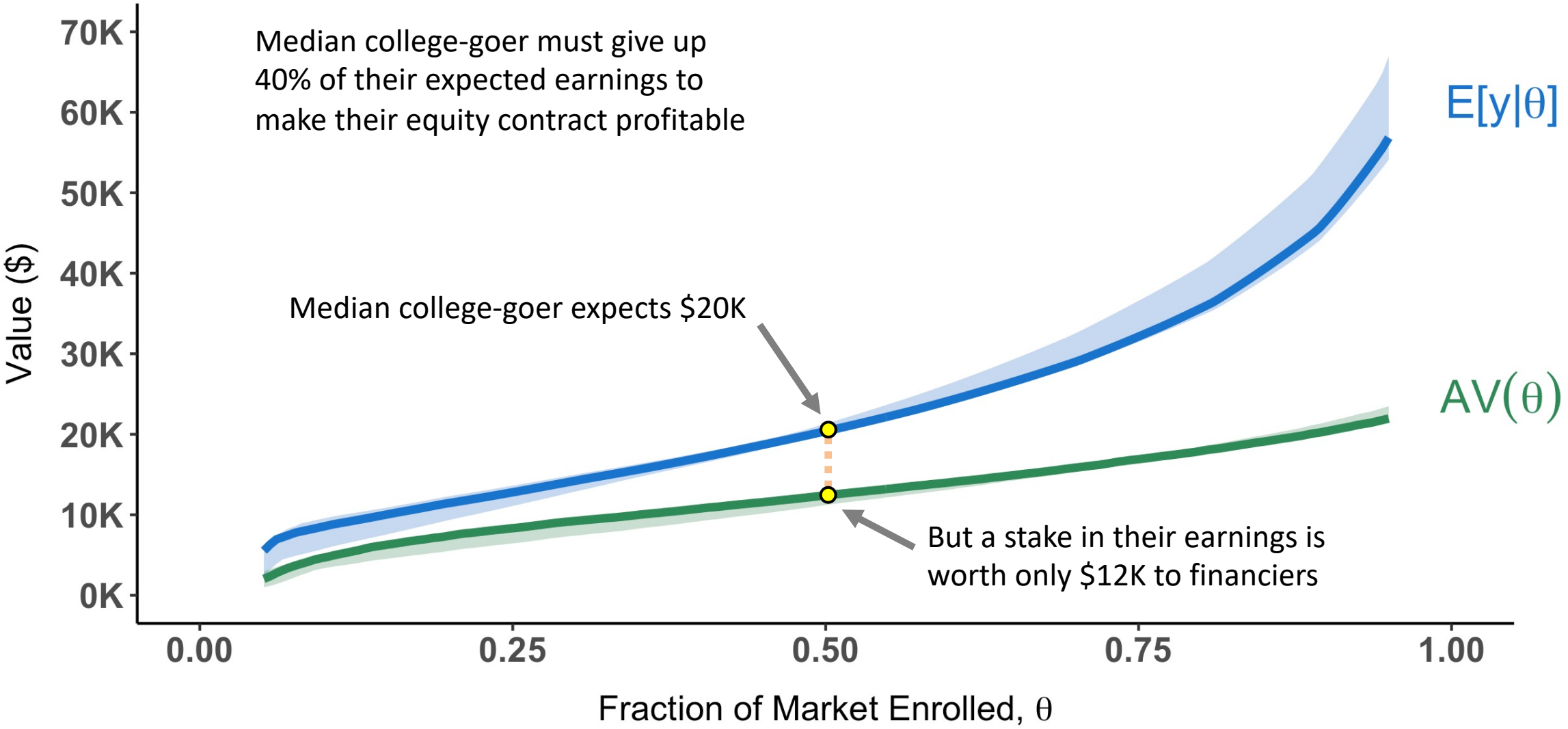
Distribution of Beliefs about Earnings



Average Value for Earnings-Equity Market



Average Value for Earnings-Equity Market



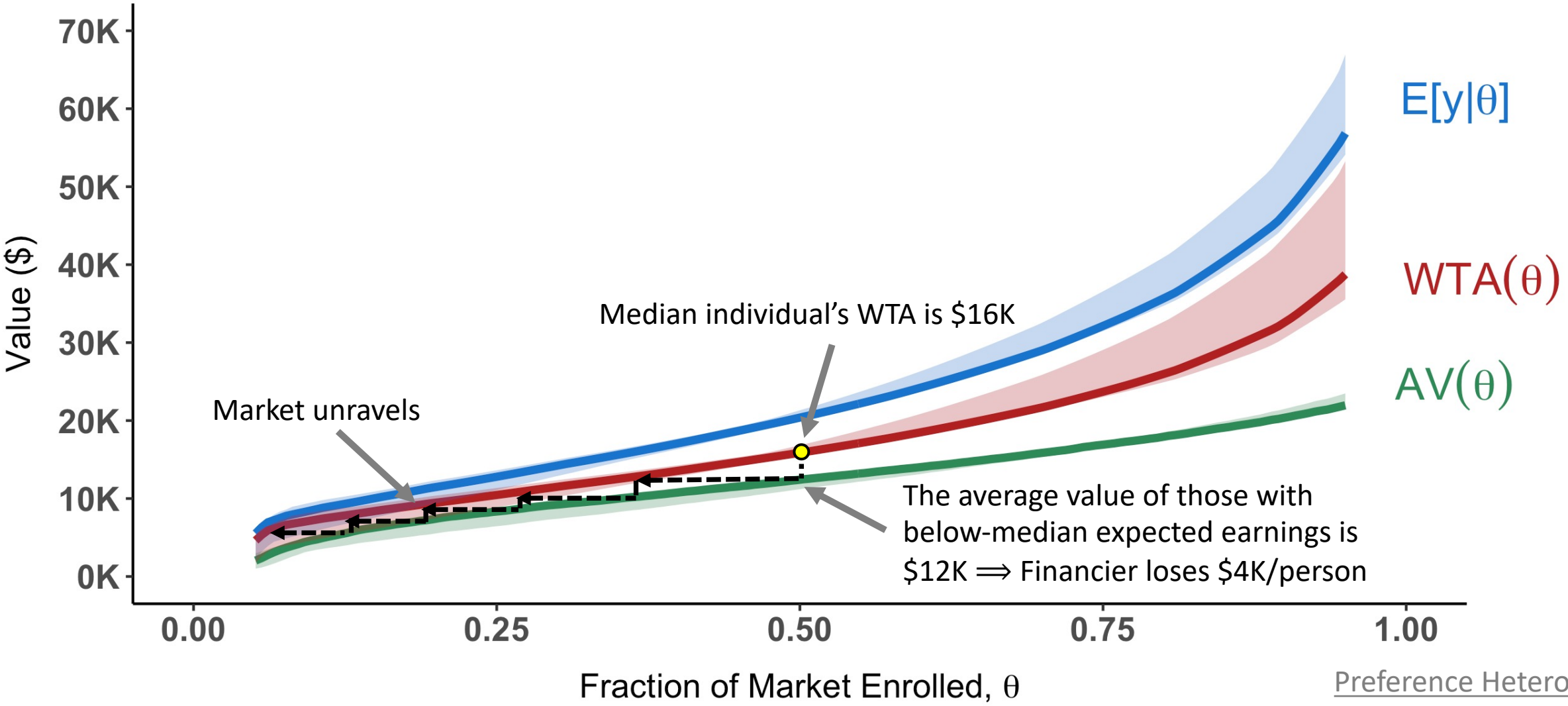
How Much are Borrowers Willing to Accept?

- Recall

$$WTA(\theta) = \frac{E[yu_2|\theta]}{u_2(\theta)}$$

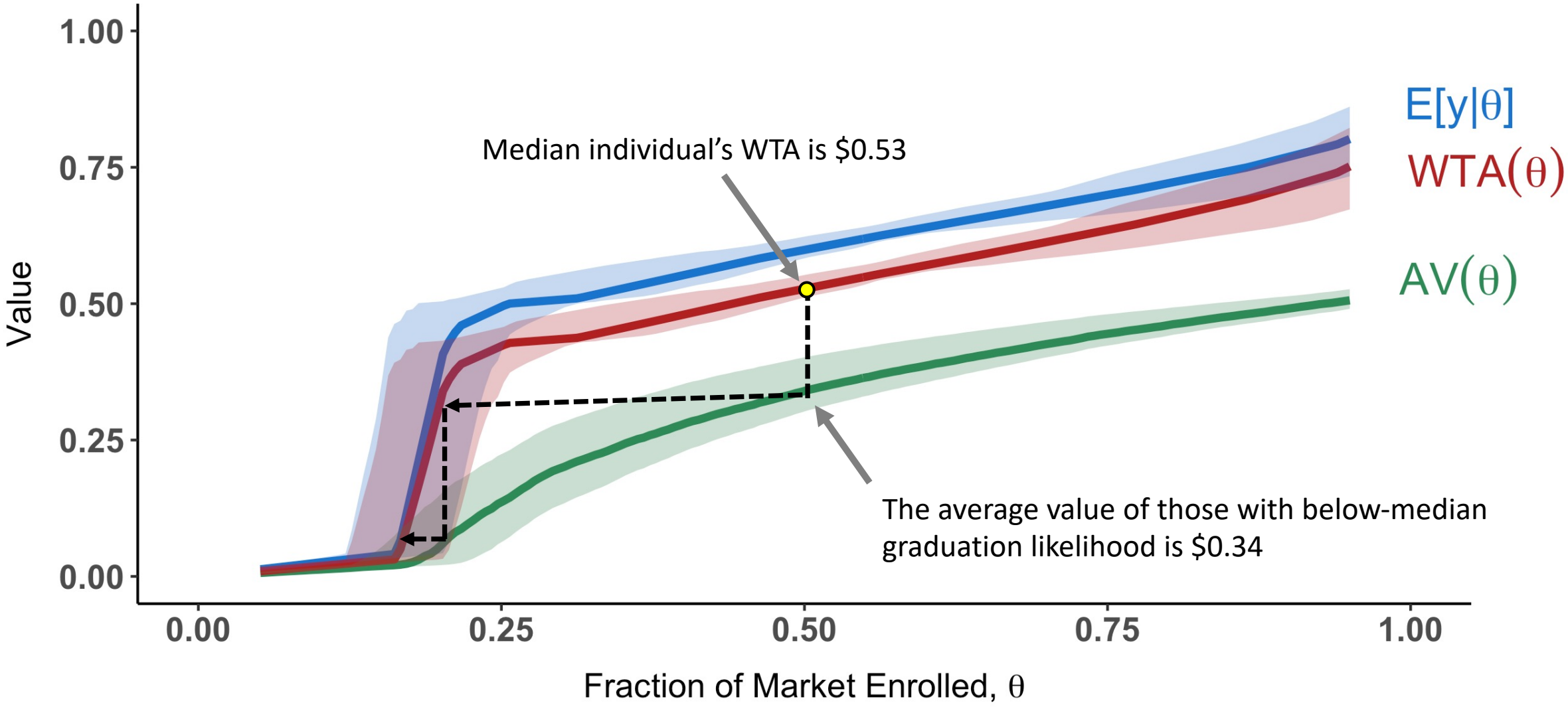
- Three calibration assumptions building on optimal social insurance literature:
  - CRRA preferences: $u_2(c) = c^{-\sigma}$ where baseline $\sigma = 2$
  - $\frac{dc}{dy}$ for each y taken from literature:
    - Earnings: 0.23 (Ganong et al., 2020)
    - Degree completion: 16% (Zimmerman 2014)
    - Employment: 9% (Hendren 2017)
    - Loan Repayment: 5% (Our estimates of consumption response)

Unraveling of Earnings-Equity Market

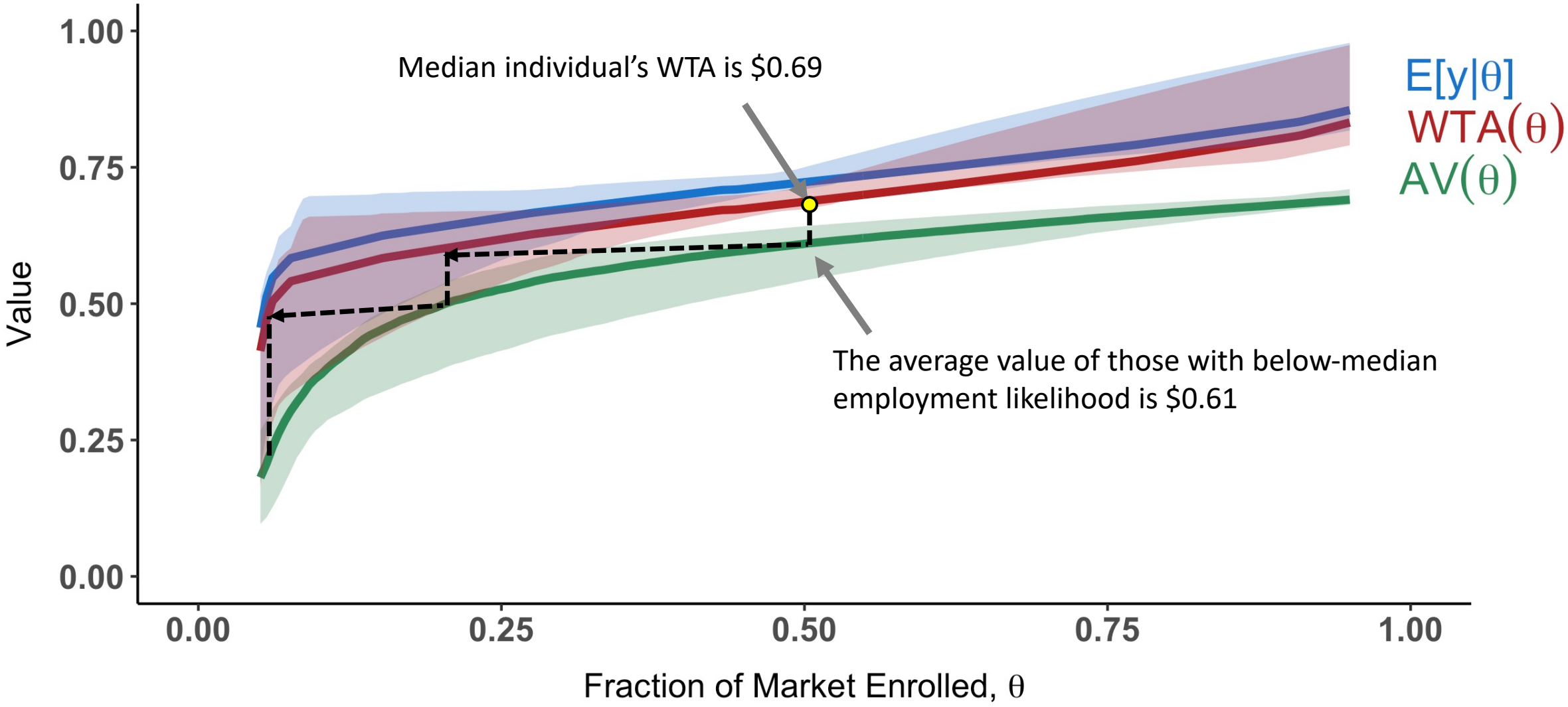


Preference Heterogeneity
Alt. Interest Rates

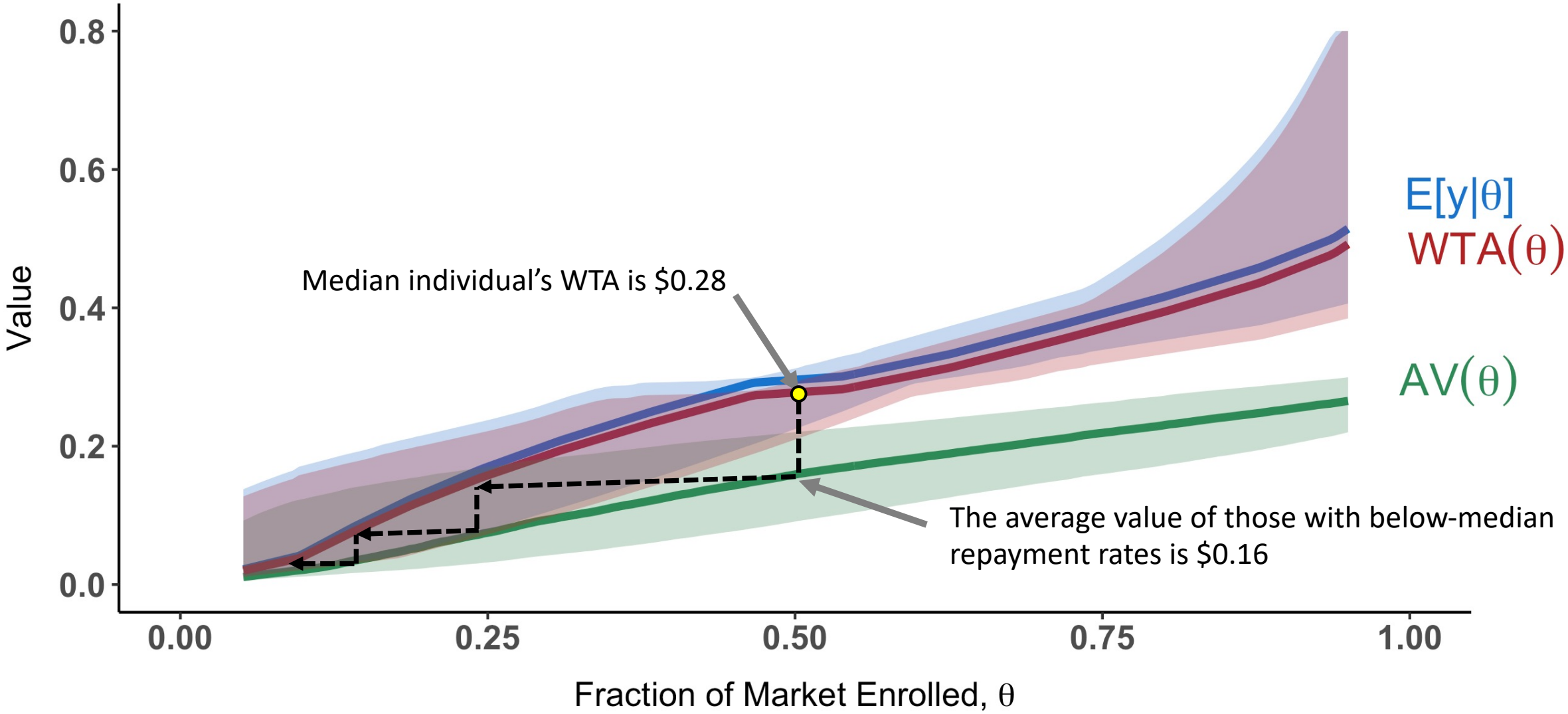
Unraveling of Completion-Contingent Loan Market



Unraveling of Employment-Contingent Loan Market



Unraveling of Dischargeable Debt Market



Outline

1. Model of Market Unraveling
2. Data and Reduced Form Evidence of Private Information
3. Lower-Bound on Magnitude of Private Information
4. Estimation of Average Value and Willingness to Accept Curves
5. **Welfare Impacts of Government Subsidies**

Comparing Welfare Impact of Alternative Policies

- Results suggest markets for risk-mitigating financial contracts have unraveled

- But these contracts may carry large welfare gains
  - $\approx \frac{1}{2}$ of earnings variation reflects ex-ante uncertainty

- Should the government subsidize these losses and open up these markets?
  - Expand income-contingent debt forgiveness?
  - Partial forgiveness for unemployed borrowers?
  - “Front-load” tuition assistance to ease burden among dropouts?
  - Dischargeable student debt in times of financial distress?

- Or should we just eliminate student debt all together?

FEBRUARY 04, 2021

Warren, Schumer, Pressley, Colleagues: President Biden Can and Should Use Executive Action to Cancel up to $50,000 in Federal Student Loan Debt Immediately

At 11 am today. Senator Warren, Leader Schumer and Representatives Pressley, Alma Adams (D-NC), Ilhan Omar (D-MI), and Mondaire Jones (D-N.Y) will hold a press conference reintroducing their resolution. The event will stream live here.

Canceling student debt is the single most effective executive action available to provide massive consumer-driven stimulus

Link to Resolution | Economic Benefits One-Pager | Legal Q&A | Letter on Existing Legal Authorities

Measuring the Welfare Impact Using the MVPF

- Calculate the Marginal Value of Public Funds (MVPF) of government subsidies for each of our four markets of interest

$$MVPF = \frac{Benefits}{Net\ Cost\ to\ Govt}$$

- $Benefits$: The amount borrowers would be willing to pay the right to contract λ.

- $Net\ Cost\ to\ Govt$: Lost profits and fiscal externalities from changes in earnings
  - Pre-existing tax distortions make behavioral responses first order

Measuring the MVPF: Borrowers' Benefits

- Borrower θ's benefit, $V(\theta)$, from contract λ depends on two components:

$$V(\theta) = \lambda - \frac{E[yu_2|\theta]}{u_1(\theta)}$$

$$= \underbrace{\lambda - E[y|\theta]}_{\text{Transfer}} + \underbrace{\lambda E[y|\theta]\text{cov}(-\text{y}, \frac{u_2}{u_1}|\theta)}_{\text{Consumption Smoothing}}$$

  - *Transfer*: Net transfer from financer ⟶ individual with type θ (negative financier's profits)
  - *Consumption smoothing:* risk-premium individuals are WTP for insuring y

- $V(\theta)$ is identified from estimation of distribution of y given θ and calibration of $WTA(\theta)$

Measuring the MVPF: Net Cost to Government

- Net cost to government for equity contract:

$$Net\ Cost\ to\ Govt = \lambda - E[y|\theta] + Fiscal\ Externality$$

$$= \underbrace{\lambda - E[y|\theta]}_{\text{Transfer}} - \underbrace{\lambda \frac{\tau}{\Pr\{\theta \leq \theta_\lambda\}} \frac{dE[y^L]}{dg}}_{\text{Impact of \$}\lambda\text{ in College on Lifetime Earnings}} + \underbrace{\frac{\tau}{1-\tau} \lambda E[y|\theta \leq \theta_\lambda] \epsilon_{y,1-\tau}}_{\text{Impact of Repayment Dis-Incentive on Earnings}}$$

- Net cost to govt depends on two parameters studied in previous literature:
  - Impact of $1 of college financing on lifetime earnings – additional $1000 in loan eligibility → 2.8% increase in ten-year earnings among existing enrollees (Gervais and Ziebarth 2019)
  - Impact of higher tax rate on earnings – elasticity of taxable income w.r.t. after-tax income of 0.3 (Saez Slemrod and Giertz 2012)

MVPF Results

	(1) Take-up	(2) Transfer	(3) Smoothing	(4) WTP	(5) FE Grant	(6) FE Tax Distortion	(7) Cost	(8) MVPF
Earnings Equity	0.79	0.30	0.17	0.47	0.09	-0.04	0.25	1.86
	(0.02)	(0.04)	(0.01)	(0.03)	(0.00)	(0.00)	(0.04)	(0.15)
Completion-Contingent Loan	0.52	0.31	0.10	0.41	0.09	-0.13	0.35	1.16
	(0.01)	(0.03)	(0.00)	(0.03)	(0.00)	(0.00)	(0.03)	(0.03)
Employment-Contingent Loan	0.56	0.11	0.05	0.17	0.10	-0.10	0.12	1.42
	(0.03)	(0.05)	(0.00)	(0.05)	(0.00)	(0.00)	(0.05)	(0.11)
Dischargeable Loan	0.44	0.73	0.02	0.75	0.08	-0.30	0.94	0.79
	(0.09)	(0.13)	(0.01)	(0.12)	(0.01)	(0.01)	(0.13)	(0.02)
Grant	1.00	1.00	0.00	1.00	0.15	-0.00	0.85	1.17
	–	–	–	–	–	–	–	–

Subsidizing equity options for college finance has an MVPF of 1.86,
higher than many other MVPFs in Hendren and Sprung-Keyser (2020)

Conclusion

- Evidence of unraveling in several markets for risk-mitigating financial contracts
  1. *Earnings-Equity Contract*
  2. *Completion-Contingent Loan*
  3. *Employment-Contingent Loan*
  4. *Dischargeable Loan*

- Motivates a high value to government intervention to offer student loan alternatives for college financing

- Empirical approach can be applied to other settings with asymmetric information:
  - Small-business investments
  - Income insurance / compensation schemes
  - Union formation / collective action settings

- Provide step towards finding “optimal” form of public investment in human capital

Related Work

- Subjective probability elicitations to test for market unraveling
  - Hendren (2013, 2017)
  - Our approach allows for continuous outcome (e.g. income) and indirect elicitation-belief relationship

- Information asymmetries in household finance:
  - Stroebel (2016); Gupta and Hansman (2019); Adams, Einav and Levin (2009); Einav, Jenkins and Levin (2012); Dobbie and Skiba (2013); DeFusco, Tang and Yannelis (2020); Karlan and Zinman (2009); Einav et al. (2010)

- Income-contingent college financing:
  - Friedman (1955); Nerlove (1975); Palacios (2004); Chapman (2006); Field (2009); Barr et al. (2017); Abraham et al.(2018); Mumford (2020); Britton and Gruber (2020); Mueller and Yannelis (2020); Herbst (2020)

- Optimal taxes/subsidies for human capital
  - Mirrlees (1978); Bovenberg and Jacobs (2006); Jacobs and van Wijnbergen (2007); Stantcheva (2017)

Elicitation Summary Statistics

Category	Variable	Mean	SD
Elicitations	Ever Completion Likelihood	9.314	1.838
	On-Time Completion Likelihood	8.413	2.103
	Expected Completion Year	2014.3	1.091
	Employment Likelihood	8.159	1.734
	Exp. Occ. Unemployed	0.400	0.0961
	Expected Salary	64124.2	45017.2
	Highest Expected Salary	117308.7	142964.6
	Lowest Expected Salary	43928.3	27018.8
	Expected Salary if No College	17336.0	7825.0
	Exp. Occ. Salary	30080.8	8519.6
	Elicited Discount Factor	0.369	0.321
	Supportive Friends	4.375	0.969
	Supportive Classmates	4.230	1.071
	Supportive Parents	4.228	1.073
	Parent Financial Support	6468.2	9502.7

Return to Z

Observable Variables Summary Statistics (1/2)

Category	Variable	Mean	SD
Academic	BA Program	0.478	0.500
	STEM Major	0.182	0.386
Performance	High School GPA	3.059	0.612
	SAT Score	1009.4	203.8
Demographics	Age	20.52	5.879
	Female	0.565	0.496
	Black	0.177	0.381
	US Citizen	0.946	0.227
	Children	0.120	0.325
	Married	0.0572	0.232
Parental	Parent Education	4.472	2.214
	Parents Married	0.660	0.474
	Parental Income	77702.3	73843.4
	Dependent	0.785	0.411
	EFC	10198.2	16843.8
Financial	Financial Aid	10533.1	12231.6
	Student Debt	3013.1	4166.6

Return to Z

Observable Variables Summary Statistics (2/2)

Category	Variable	Mean	SD
Institution	Four-Year	0.545	0.498
	Private	0.302	0.459
	For-Profit	0.129	0.335
	Enrollment	18262.0	35178.7
	Tuition	9724.1	10967.4
	Share Female	0.573	0.124
	Share Black	0.138	0.163
	Admissions Rate	0.633	0.199
	Completion Rate	0.413	0.245
	Avg. SAT Score	1102.1	137.5
	Md. Parent Income	32289.7	20623.8
	Md. 6-Yr Earnings	29581.9	8131.3

Return to Z

Predictive Performance

Outcome	Statistic	Category (1) *Institution + Academic*	(2) *Institution + Academic + Performance + Demographics*	(3) *Institution + Academic + Performance + Demographics + Parental*	(4) *Institution + Academic + Performance + Demographics + Parental + Protected*	(5) *All Public + Elicitations*
Panel A: Log Salary	R^2	0.068	0.073	0.078	0.092	0.108
		(0.009)	(0.010)	(0.010)	(0.010)	(0.011)
	RMSE	0.641	0.638	0.636	0.631	0.626
		(0.012)	(0.013)	(0.012)	(0.012)	(0.012)
	MAE	0.464	0.461	0.460	0.455	0.453
		(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Panel B: Dropout	Pseudo R^2	0.096	0.157	0.166	0.170	0.231
		(0.013)	(0.008)	(0.007)	(0.007)	(0.007)
	ROC	0.742	0.761	0.768	0.770	0.813
		(0.006)	(0.006)	(0.006)	(0.006)	(0.005)
	Accuracy	0.684	0.697	0.701	0.704	0.741
		(0.006)	(0.006)	(0.006)	(0.006)	(0.005)
Panel C: On-Time Repayment	Pseudo R^2	0.060	0.133	0.155	0.158	0.170
		(0.014)	(0.011)	(0.010)	(0.010)	(0.009)
	ROC	0.723	0.758	0.773	0.775	0.785
		(0.008)	(0.008)	(0.008)	(0.008)	(0.007)
	Accuracy	0.755	0.763	0.761	0.763	0.766
		(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Panel D: Employment	Pseudo R^2	-0.110	0.002	0.021	0.027	0.042
		(0.022)	(0.007)	(0.006)	(0.006)	(0.005)
	ROC	0.565	0.596	0.610	0.621	0.640
		(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
	Accuracy	0.700	0.719	0.719	0.721	0.723
		(0.006)	(0.006)	(0.006)	(0.006)	(0.006)

Return to Z

γ Estimation

(1) Outcome	(2) Elicitation	(3) Instrument	(4) γ-Estimate
Salary	*Log Expected Salary*	*Log Avg. Salary Expected Occ.*	0.69
			(0.16)
Completion	*On-Time Completion Likelihood*	*Supportive Parents*	3.20
			(0.23)
Employment	*Log Expected Salary if No College*	*Avg. Employment Expected Occ.*	0.59
			(0.29)
On-Time Repayment	*Supportive Parents*	*Parents' Financial Support*	1.47
			(0.76)

Return

Estimating Belief Distribution, $g(\mu_\theta)$: Two Cases

1. Continuous y: Residualize y and z by by $E[y \mid X]$ in deconvolution:

$$y^* = y - E[y|X]$$
$$z^* = z - \gamma E[y|X]$$

2. Binary y: allow point-mass in $g(\mu_\theta)$ to depend on $E[y|X]$.

$$G(\mu_\theta) = w \sum_j \xi_j \, \mathbf{1}\{\mu_\theta \leq E[y|X] - a\} + (1-w) \sum_j \xi_j \, \mathbf{1}\{\mu_\theta \leq aj\}$$

Return

Specification for Employment: $f_{Z|\theta}(Z|\theta)$

- Let $Z = (z_1, z_2)$ denote a pair elicitations
- Model elicitation j of individual i, z_{ij} of individual i as $z_{ij} = h_j(z_{ij}^*)$ where

$$z_{ij}^* = a_j + \gamma_j \theta_i + \nu_{ij}$$

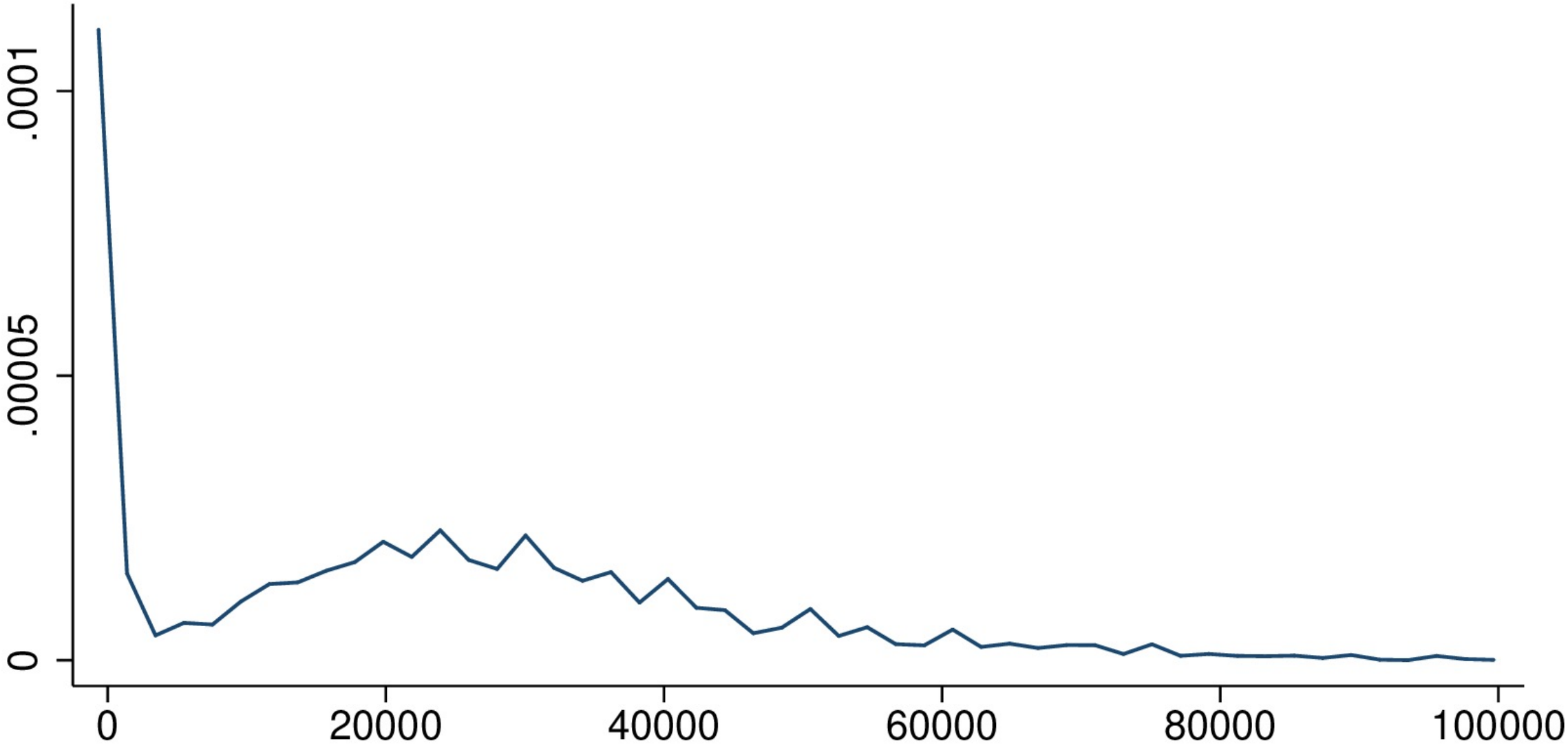
  - $h_j(\cdot)$ depends on setting: e.g. if z on 1-5 scale→ $h_j(\cdot)$ is an ordered probit
  - Allowing $\gamma \neq 1$ allows elicitations to not correspond to outcome y

- Assume measurement error is independent: $\nu_{i1} \perp \nu_{i2}$
  - z_1 is expected salary if not in college; z_2 is average employment rate in expected occupation

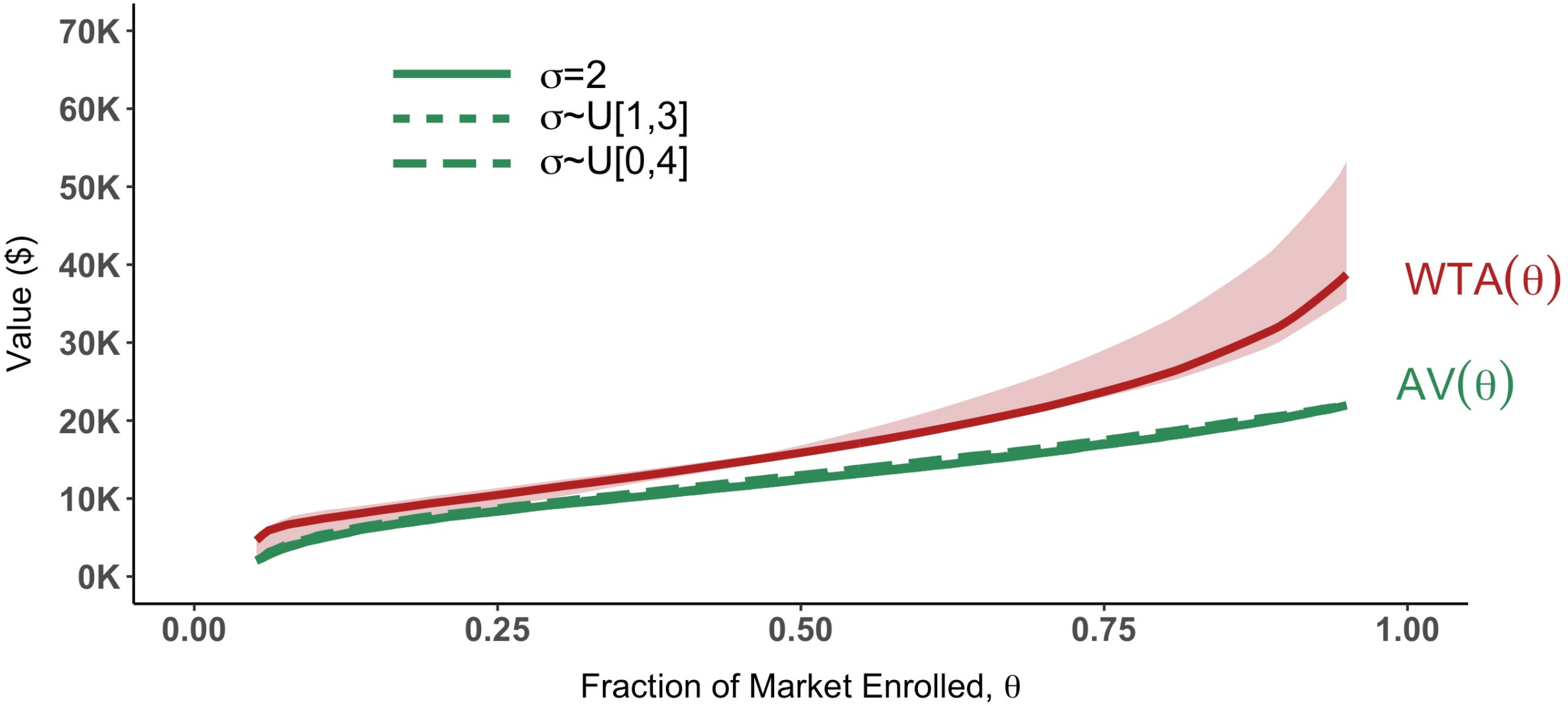
- Estimate distribution of $f_{Y|\theta}(y|\theta)$, $f_{Z|\theta}(Z|\theta)$, $g(\theta)$ using MLE
  - Exploit additional information in distribution of z_2 to recover distributions

Distribution of y

Back

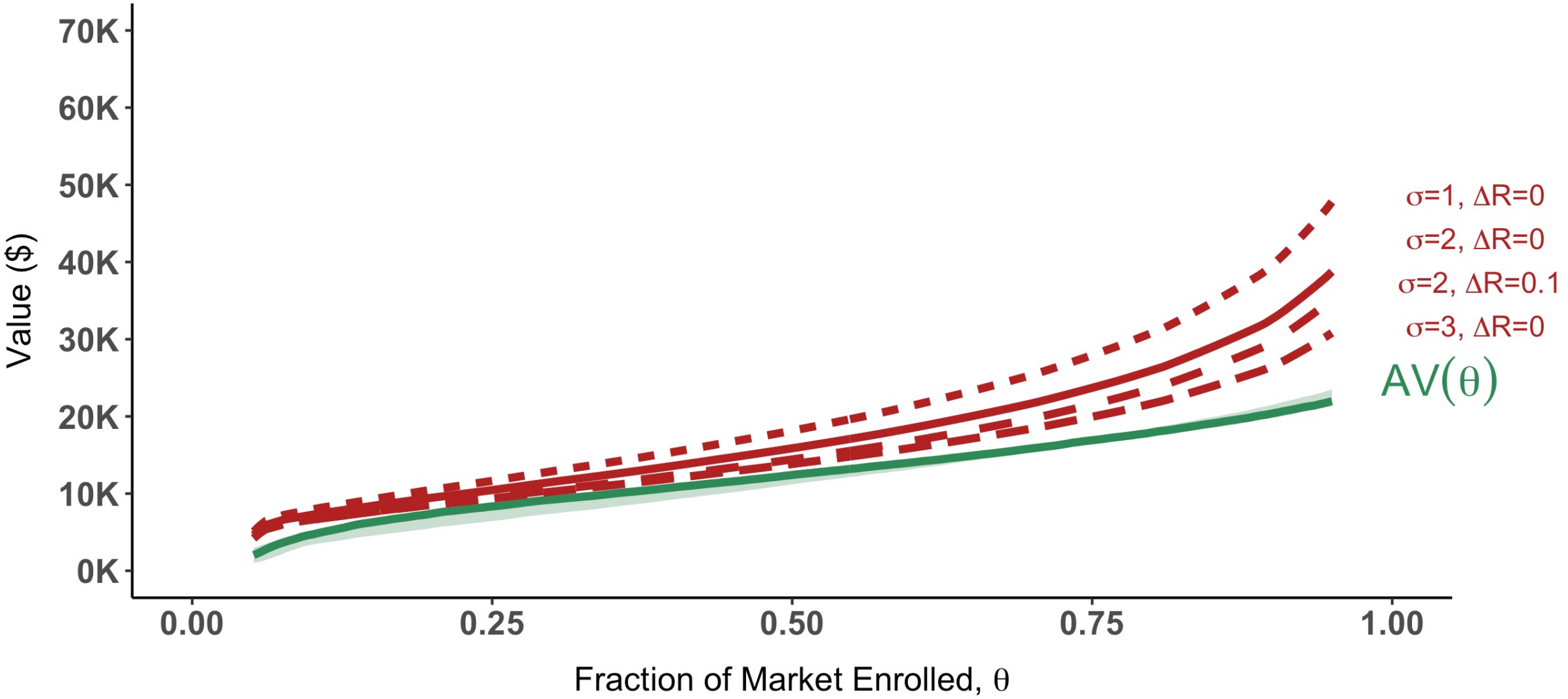


Preference Heterogeneity



Return

WTA Under Alternative Risk Aversion and Interest Rates



Return