Opportunity Unraveled: Private Information and Missing Markets for Human Capital

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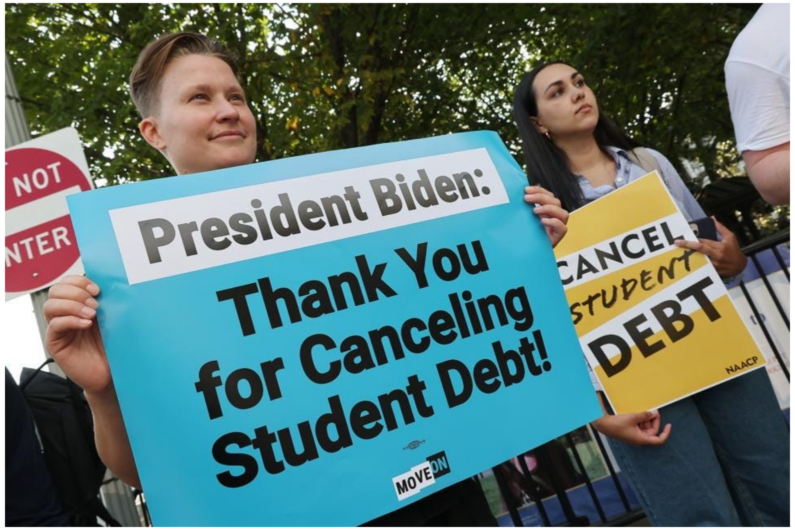
Going to College in the US is Risky

- Investing in college in the US carries high returns but also high risks
  - 49% of 2012 college enrollees failed to complete their degrees within six years
  - Among those who graduated, 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
  - Among 2012 first-year borrowers, 67% experienced delinquency or default on their student loans by 2017



Source: "Millions Of Student Loan Borrowers Will Get Refunds Of Payments Under Biden's Loan Forgiveness Initiative" Forbes.com

- Are there a better ways to finance human capital investments?

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 often exist in private markets for *physical* capital investment

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

This Paper: Adverse Selection has Unraveled Markets for College Financing

1. Develop model of human-capital financing to characterize market existence under private information
   - Clarify role of adverse selection vs. biased beliefs, moral hazard, and other forces
   - Two curves determine market (non-)existence (Akerlof, 1970; Einav et al., 2010)
     - **"Willingness to Accept" (WTA):** minimum amount one requires for a claim on future outcome
     - **"Average Value" (AV):** average future outcomes among those willing to accept worse contracts
     - Market unravels when $WTA > AV$: No one is willing to accept the average value of worse risks

This Paper: Adverse Selection has Unraveled Markets for College-Financing

1. Develop model of human-capital financing to characterize market existence under private information

2. Provide evidence of private information using subjective elicitations as noisy and potentially biased measures of beliefs
   - Survey data elicits beliefs of first-year college students (e.g., “What salary do you expect to earn?”)
   - Find elicitations predict realized outcomes conditional on rich set of publicly observable characteristics

This Paper: Adverse Selection has Unraveled Markets for College-Financing

1. Develop model of human-capital financing to characterize market existence under private information

2. Provide evidence of private information using subjective elicitations as noisy and potentially biased measures of beliefs

3. Empirically test unraveling condition (WTA>AV) using estimated belief distributions
    - In all four market settings, we find WTA>AV $\Longrightarrow$ market unravels
    - Example: Earnings-equity market
        - Median student would have to repay \$1.64 (PDV) in expectation for every \$1 of financing to make the contract profitable, but is only willing to repay \$1.21 (PDV)
    - Extensions for biased beliefs, heterogeneous preferences, and outside credit options

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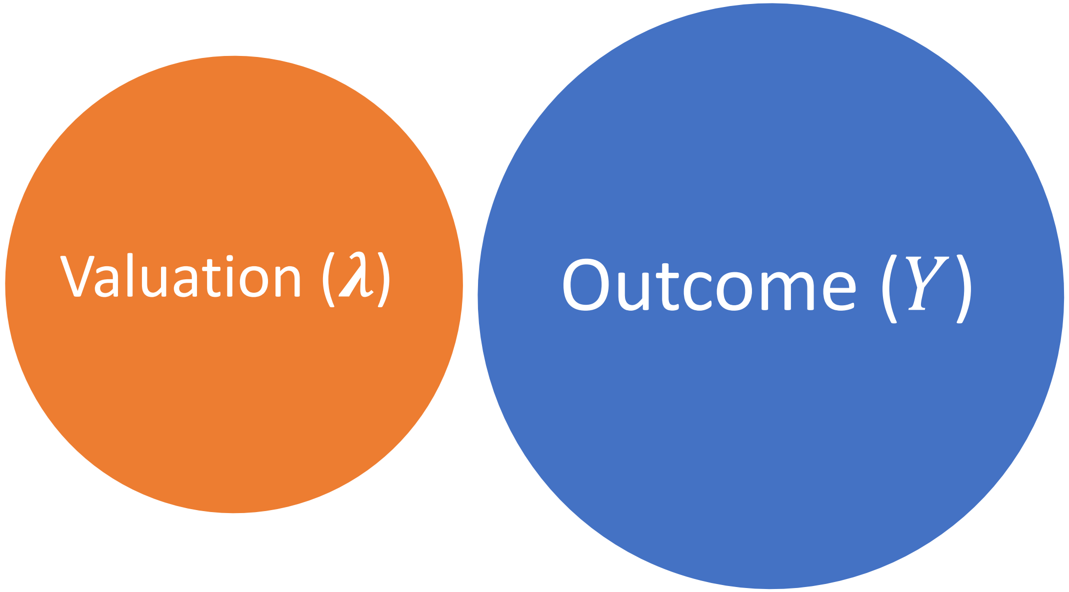
4. Measure welfare impact of government subsidies to open up these markets
   - Estimate the marginal value of public funds ($MVPF \equiv \frac{Benefits}{Net\ Govt\ Cost}$) of subsidies for these contracts
   - Estimates of equity MVPF $\in [1.2, \infty)$, depending on potential responses in human-capital investment

Outline

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

Model of Market Unraveling

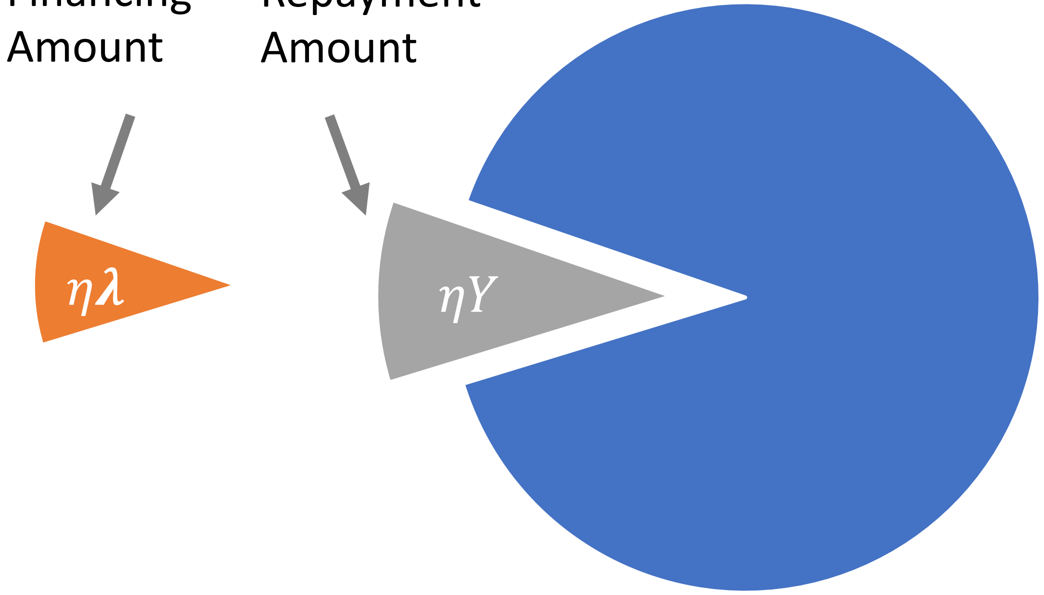


- Suppose financiers can offer a contract that buys some "stake" in individual outcome Y (e.g., earnings)
  - Offers $\$\eta\lambda$ in lump-sum college financing
  - Requires payment of ηY after college

Contract Terms

λ: valuation or "share price"

Model of Market Unraveling



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  - Offers $\$\eta\lambda$ in lump-sum college financing
  - Requires payment of ηY after college

Contract Terms

$\boldsymbol{\lambda}$: valuation or "share price"
$\boldsymbol{\eta}$: "size" of claim on Y

- Contract structure describes variety of financial products
  - **Continuous $\boldsymbol{Y}$ ⇒ Equity contract**: Individual "sells" claim on Y; repays η-share of Y
  - **Binary $\boldsymbol{Y}$ ⇒ State-contingent loan:** Individual borrows $\$\eta\lambda$, repays $\$\eta$ only if $Y = 1$
- Market existence: does there exist some (η, λ) that yields positive profits?
  - Sufficient to consider "small" contracts ($\eta \to 0$) because the first dollar of insurance provides the highest potential market surplus (Hendren 2017)

  → The terms or "price" of the contract is captured by a single parameter—valuation (λ)

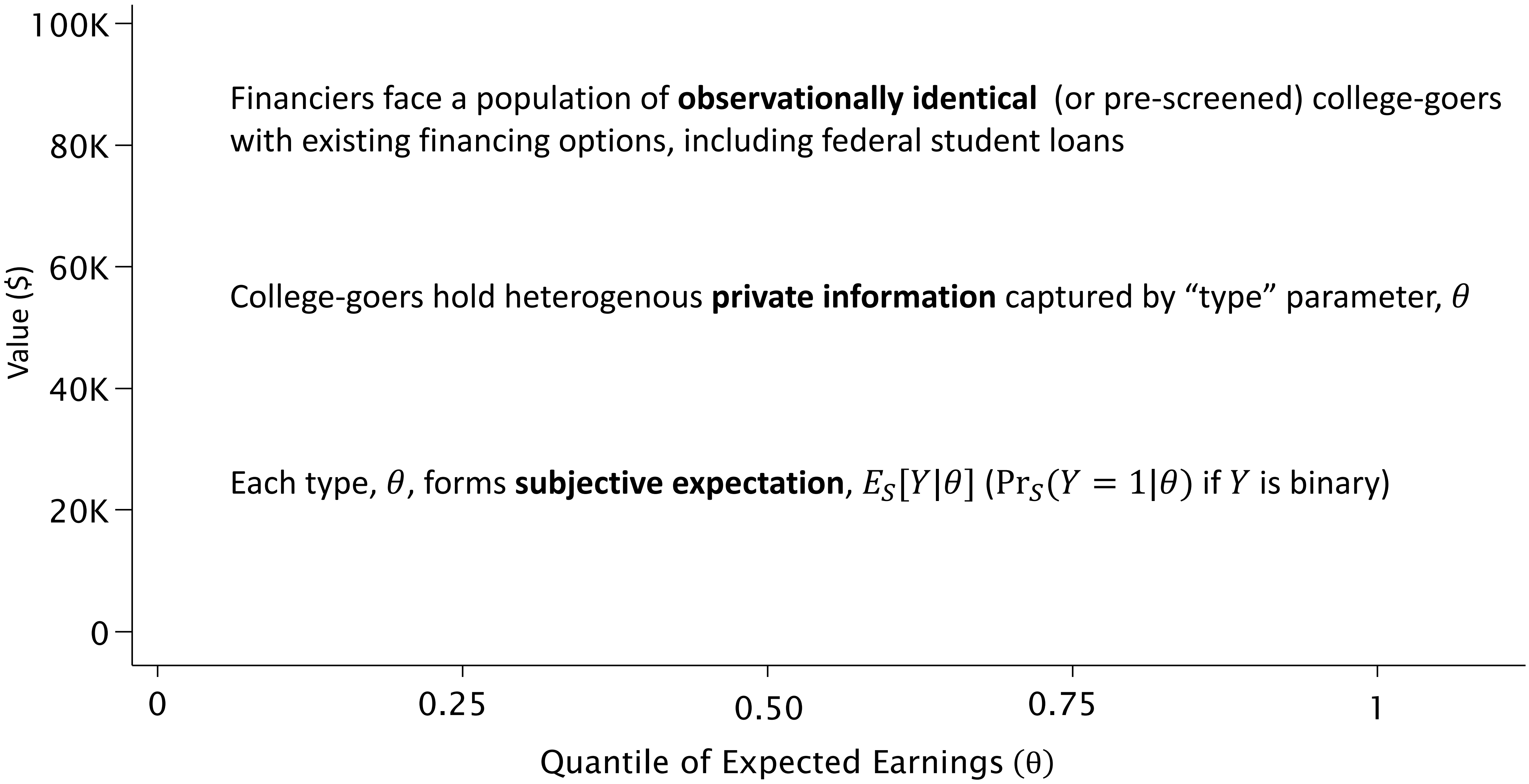
  → Behavioral responses (e.g., moral hazard) cannot explain market non-existence (Hendren 2017; Shavell 1979)
    - Selling a small claim of Y ⟹ small behavioral response ⟹ small effect on profits (Details)

Model of Market Unraveling

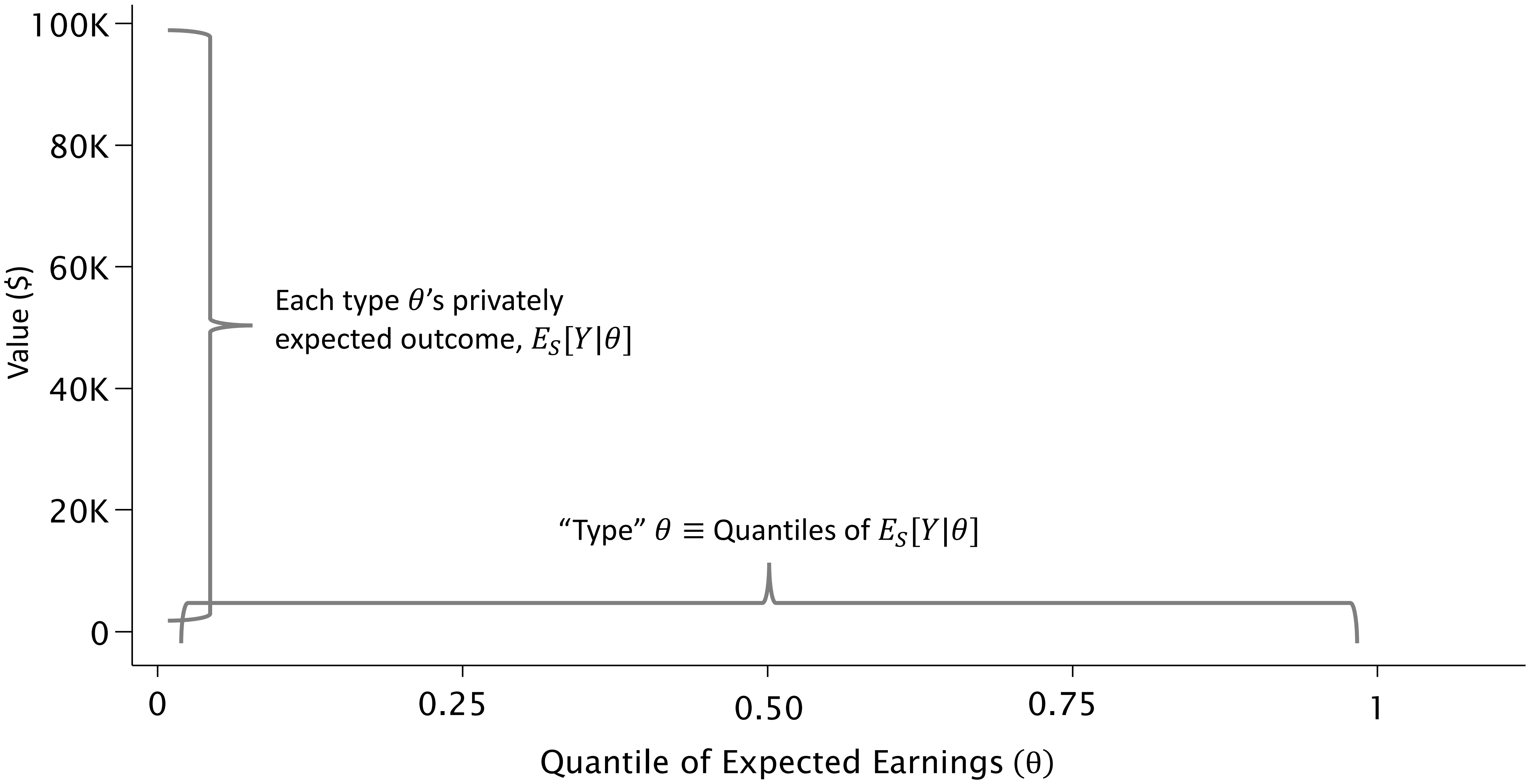
Financiers face a population of **observationally identical** (or pre-screened) college-goers with existing financing options, including federal student loans

College-goers hold heterogenous **private information** captured by “type” parameter, θ

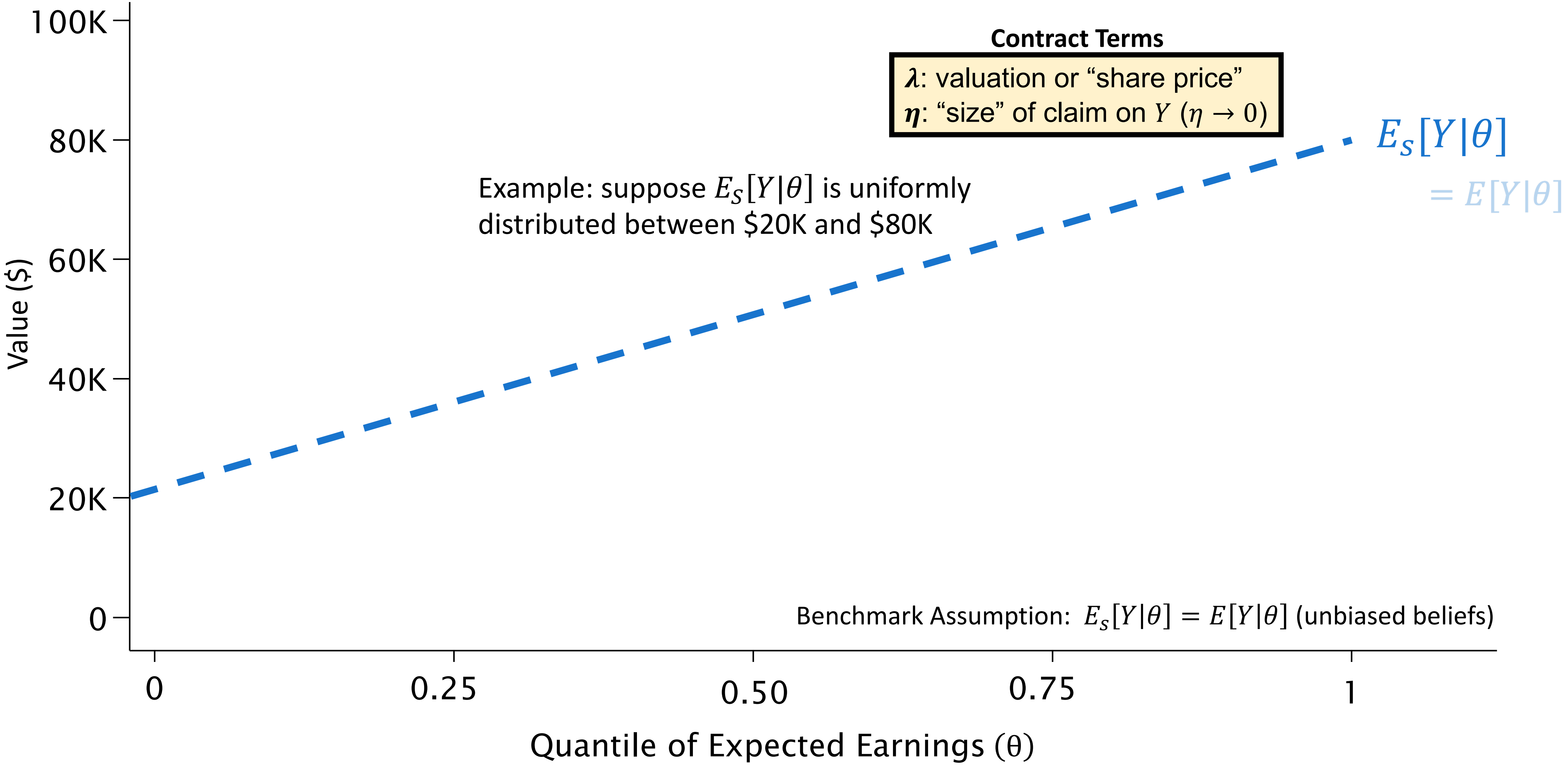
Each type, θ, forms **subjective expectation**, $E_S[Y|\theta]$ ($\Pr_S(Y = 1|\theta)$ if Y is binary)



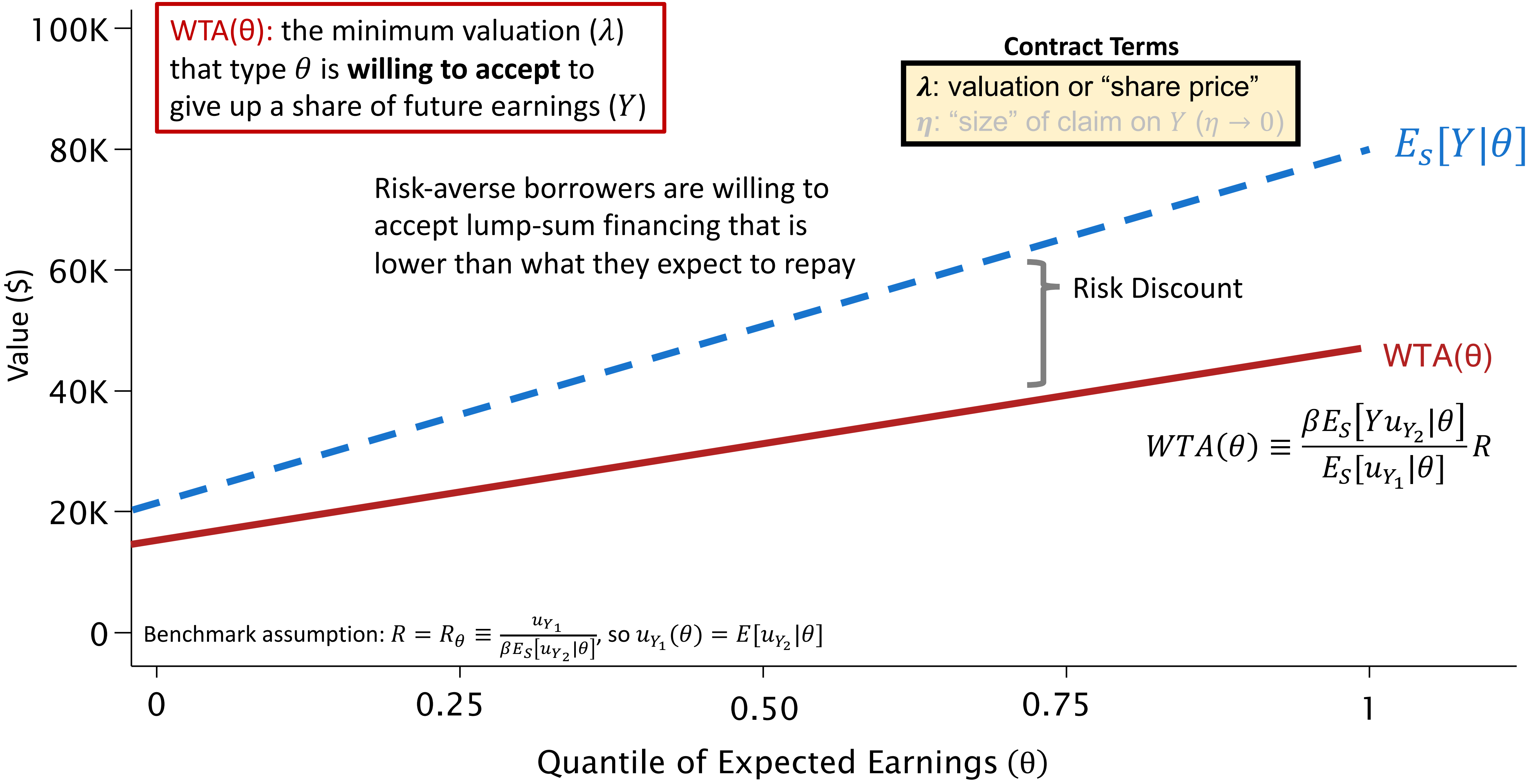
Model of Market Unraveling



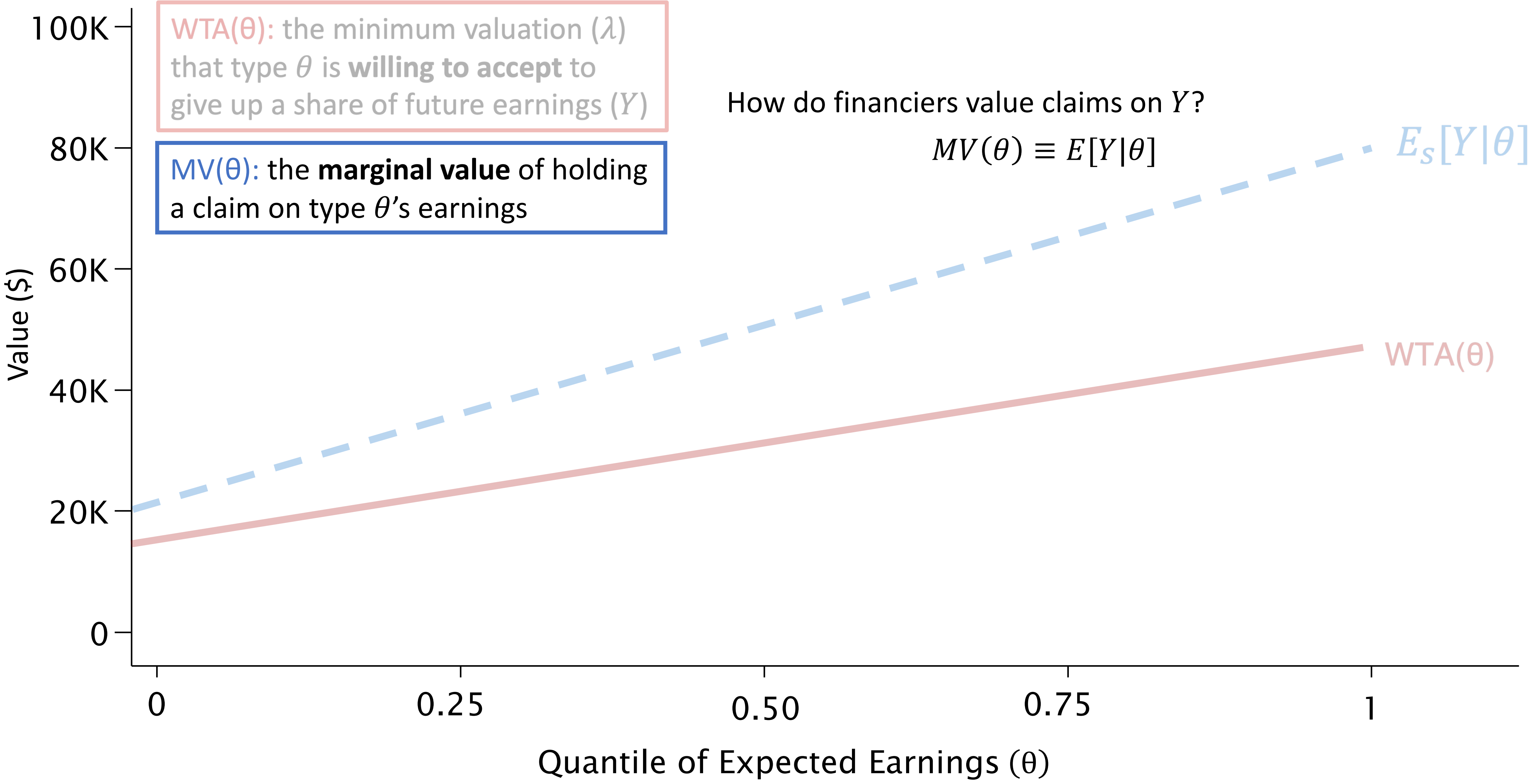
Privately Expected Earnings: $E_S[Y|\theta]$



Willingness to Accept: $WTA(\theta)$



Marginal Value: $MV(\theta)$



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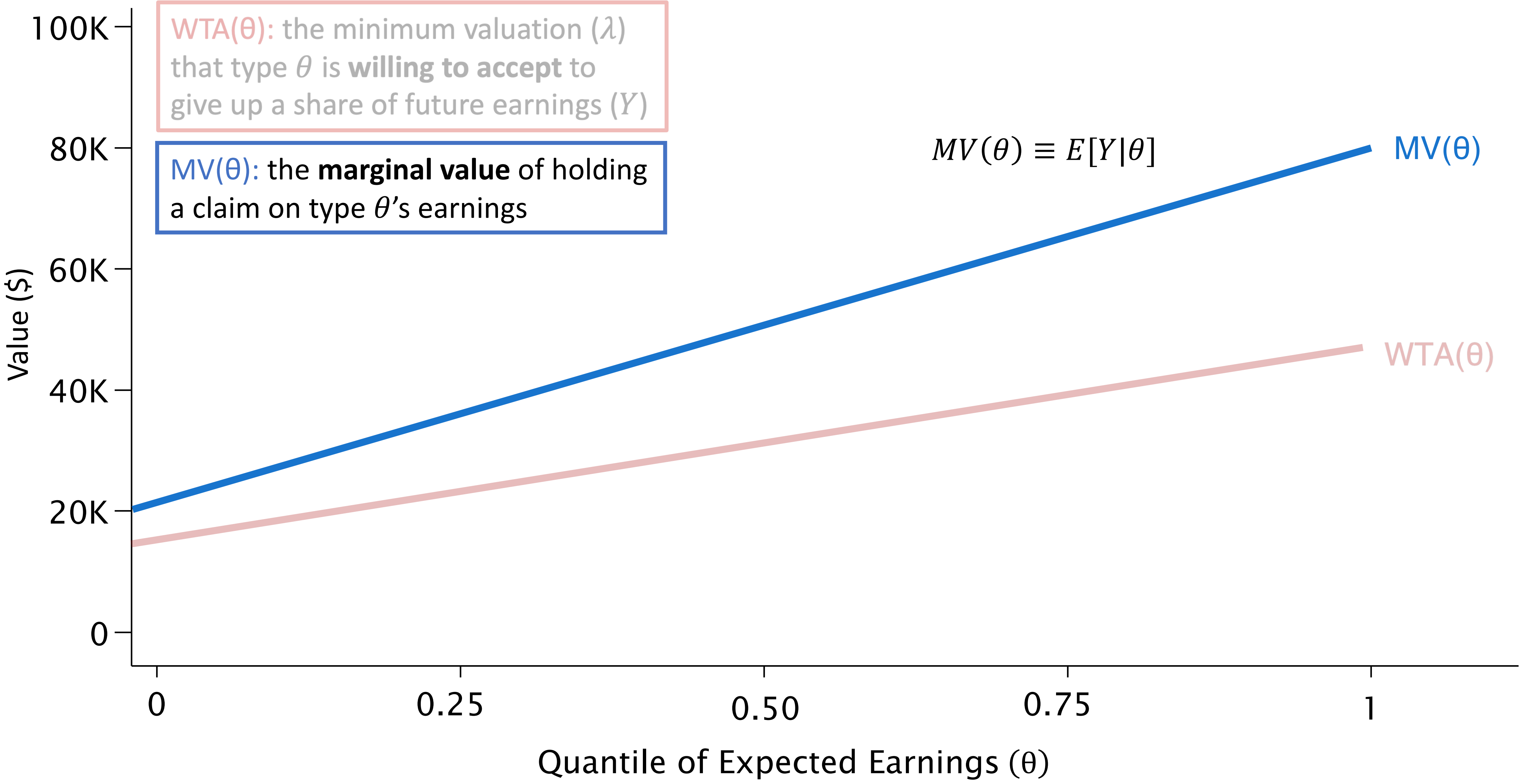
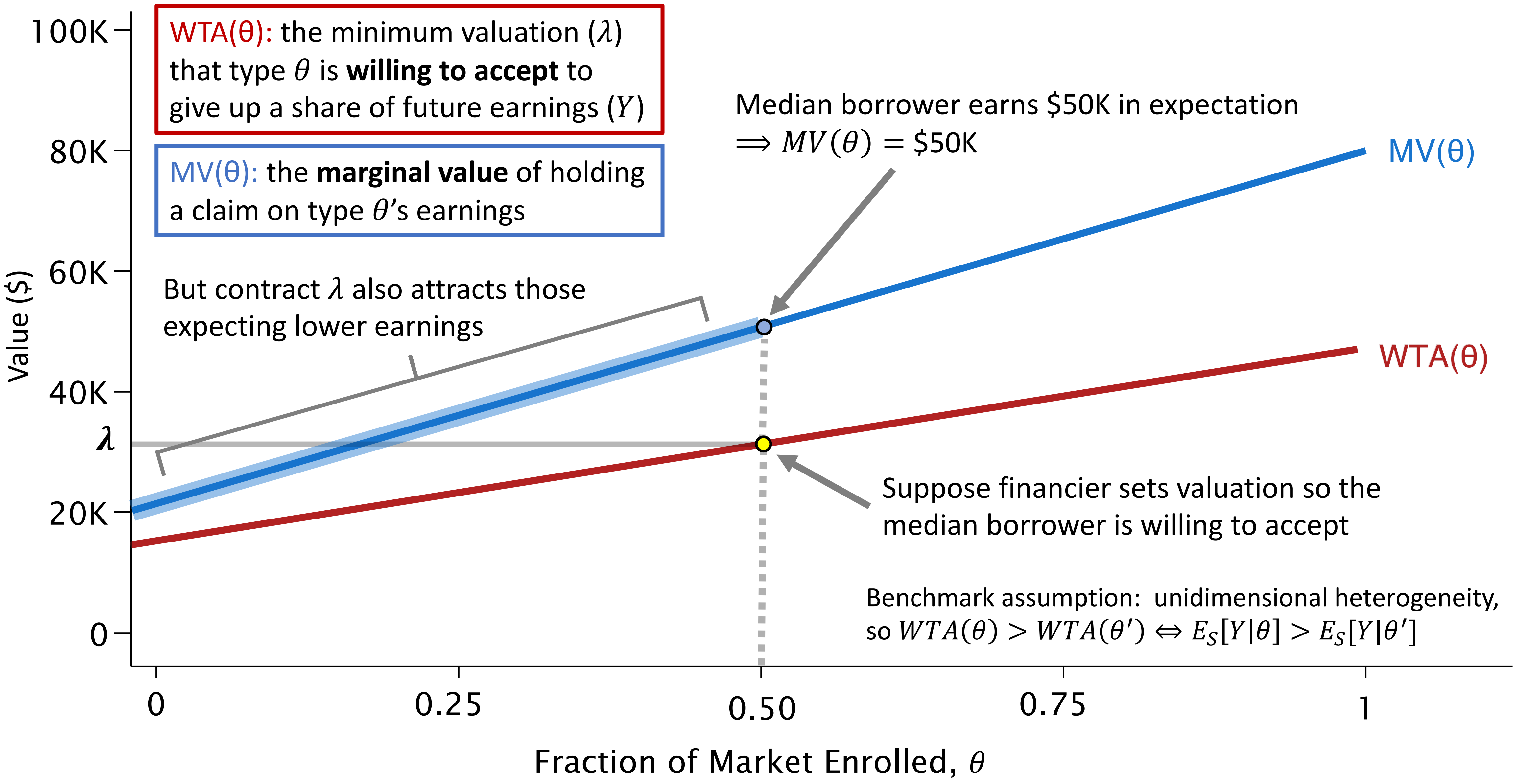
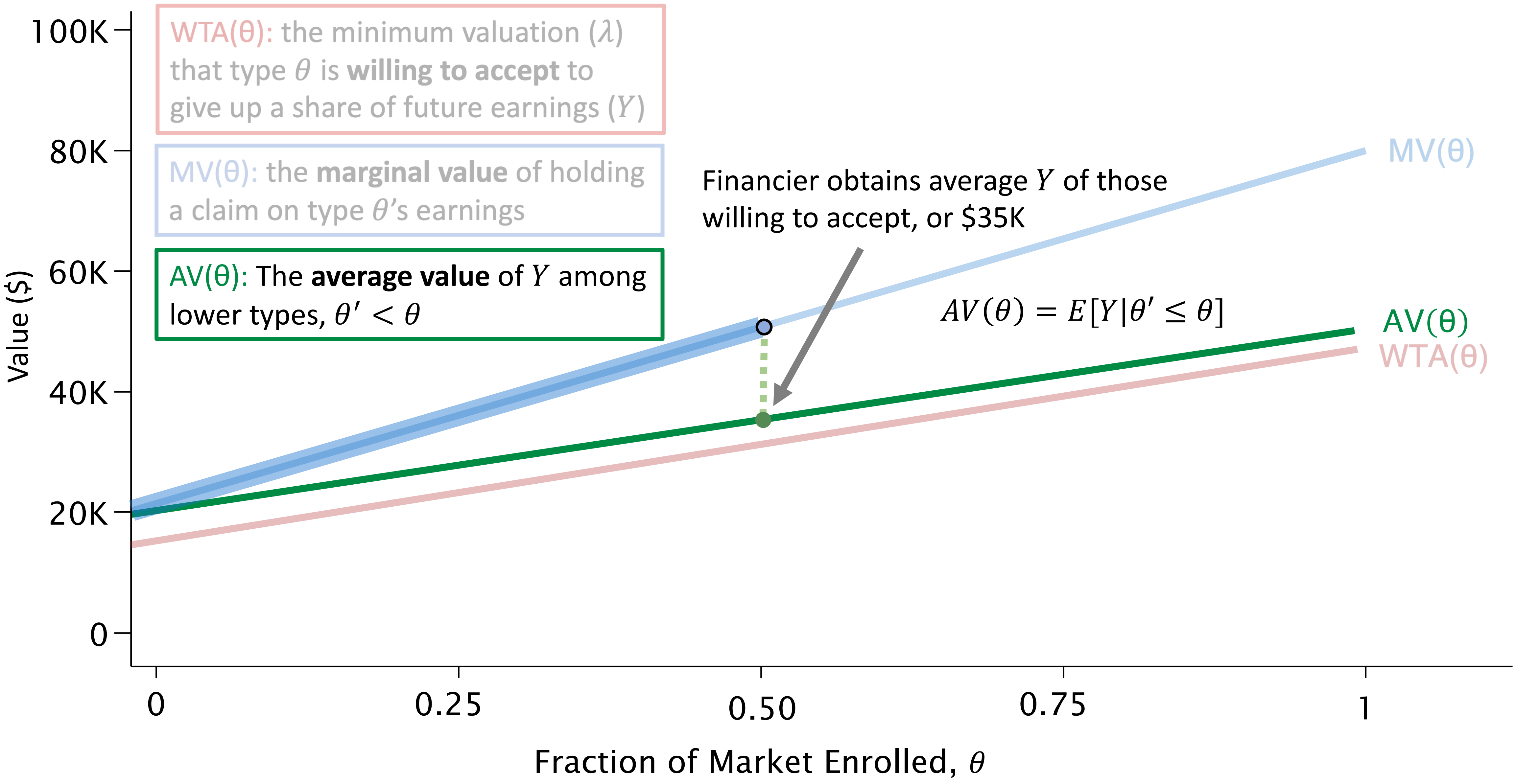


Can Financiers Make Profits?



Average Value, $AV(\theta)$



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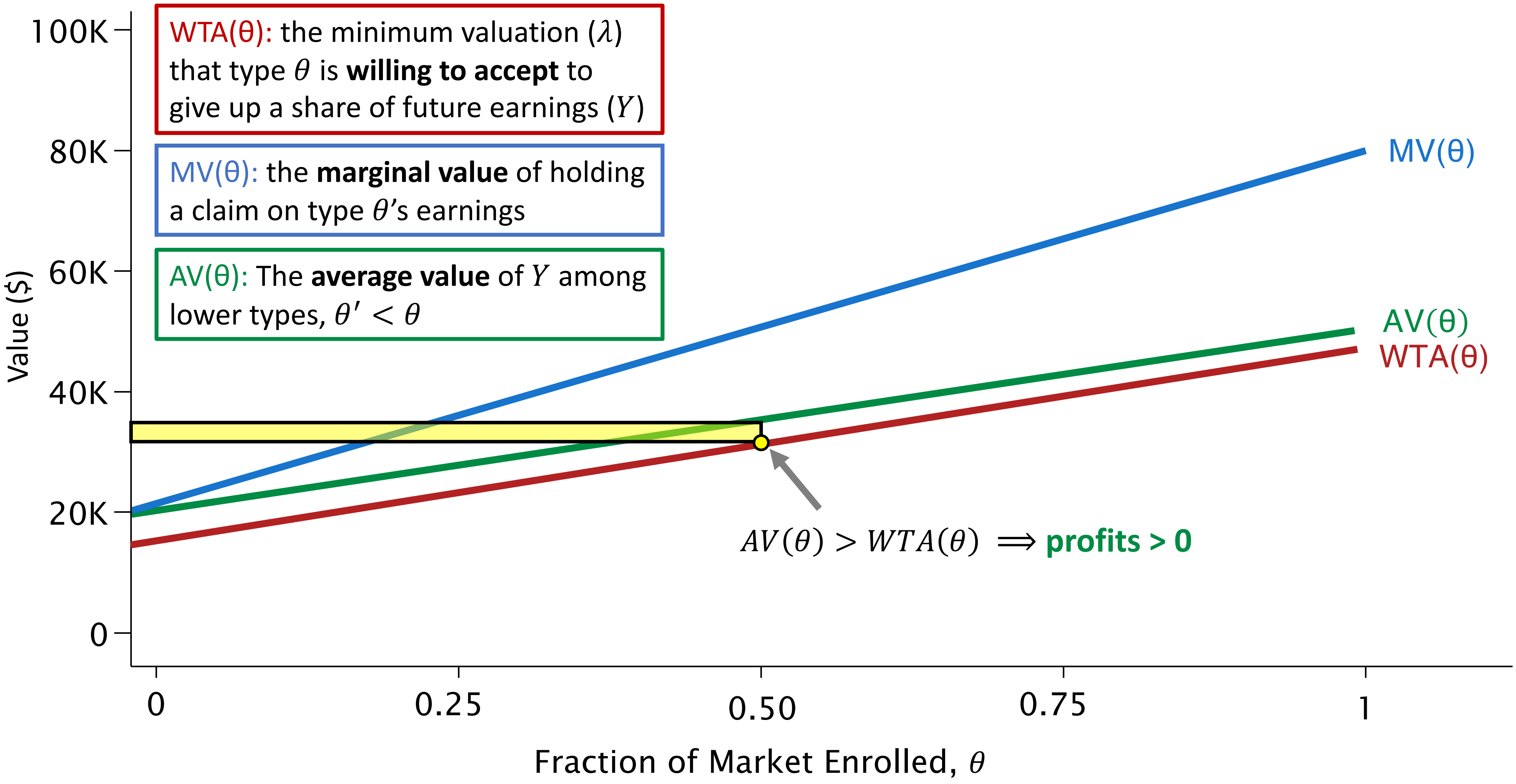
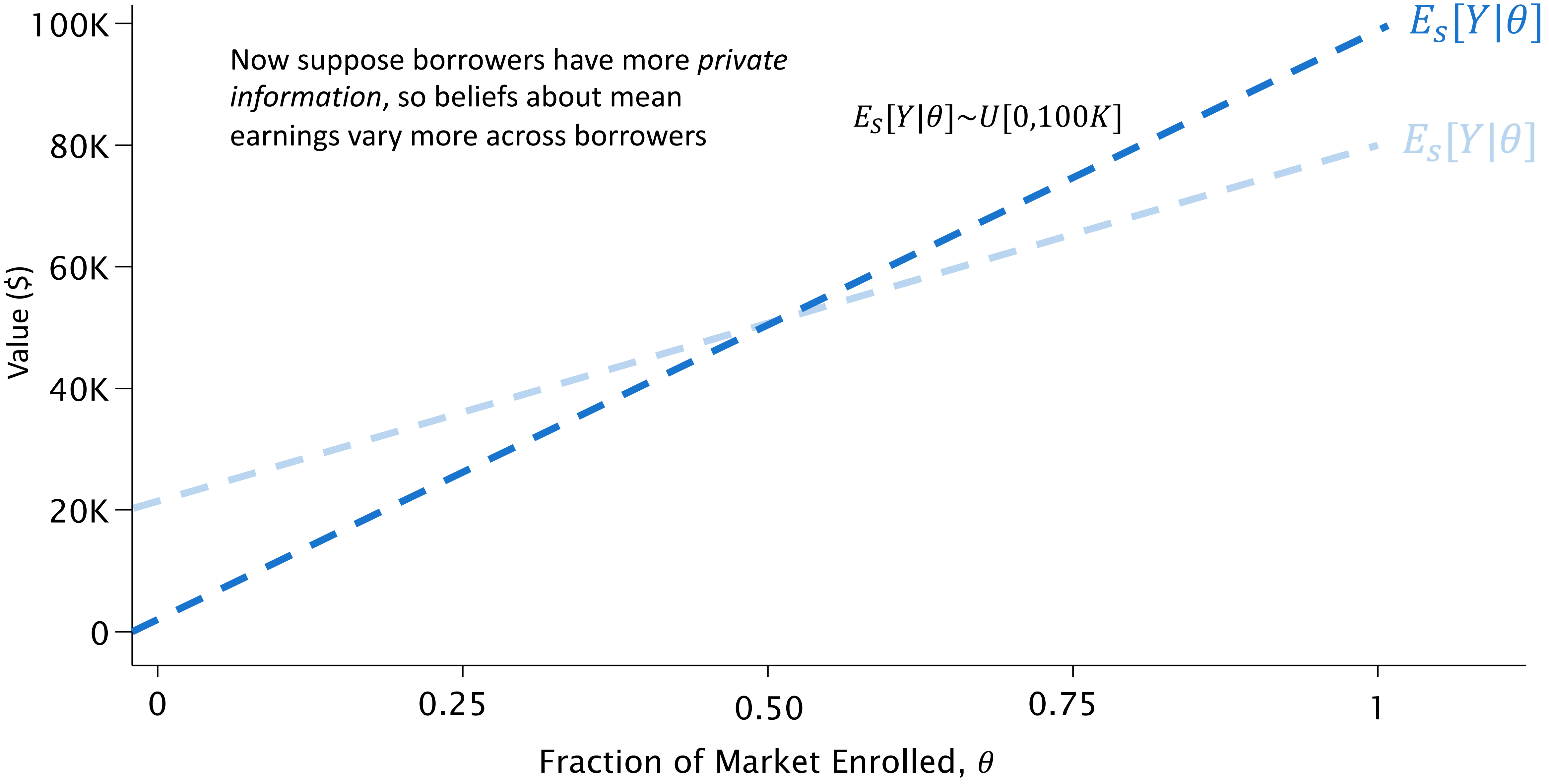


Can Financiers Make Profits? Scenario #2



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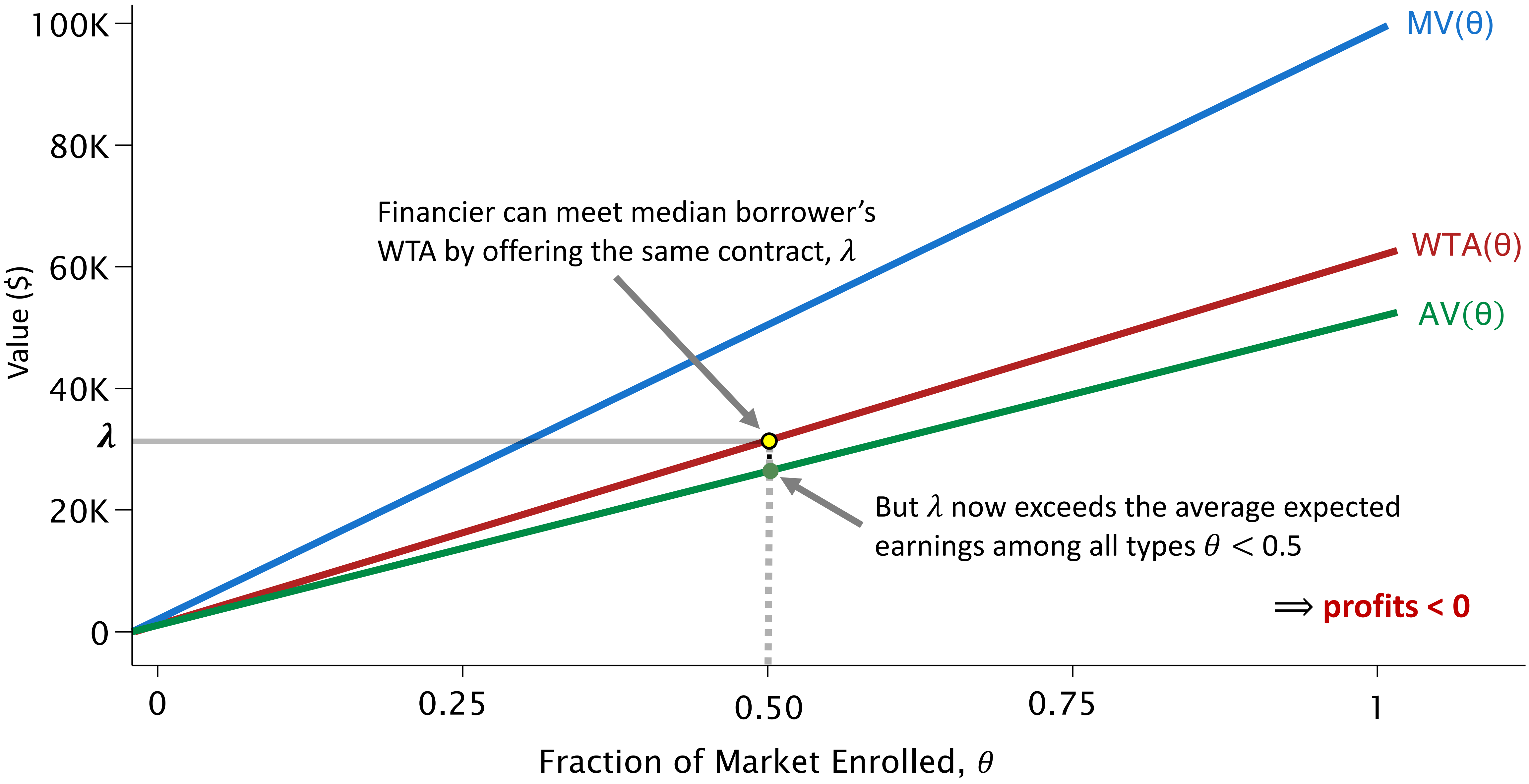

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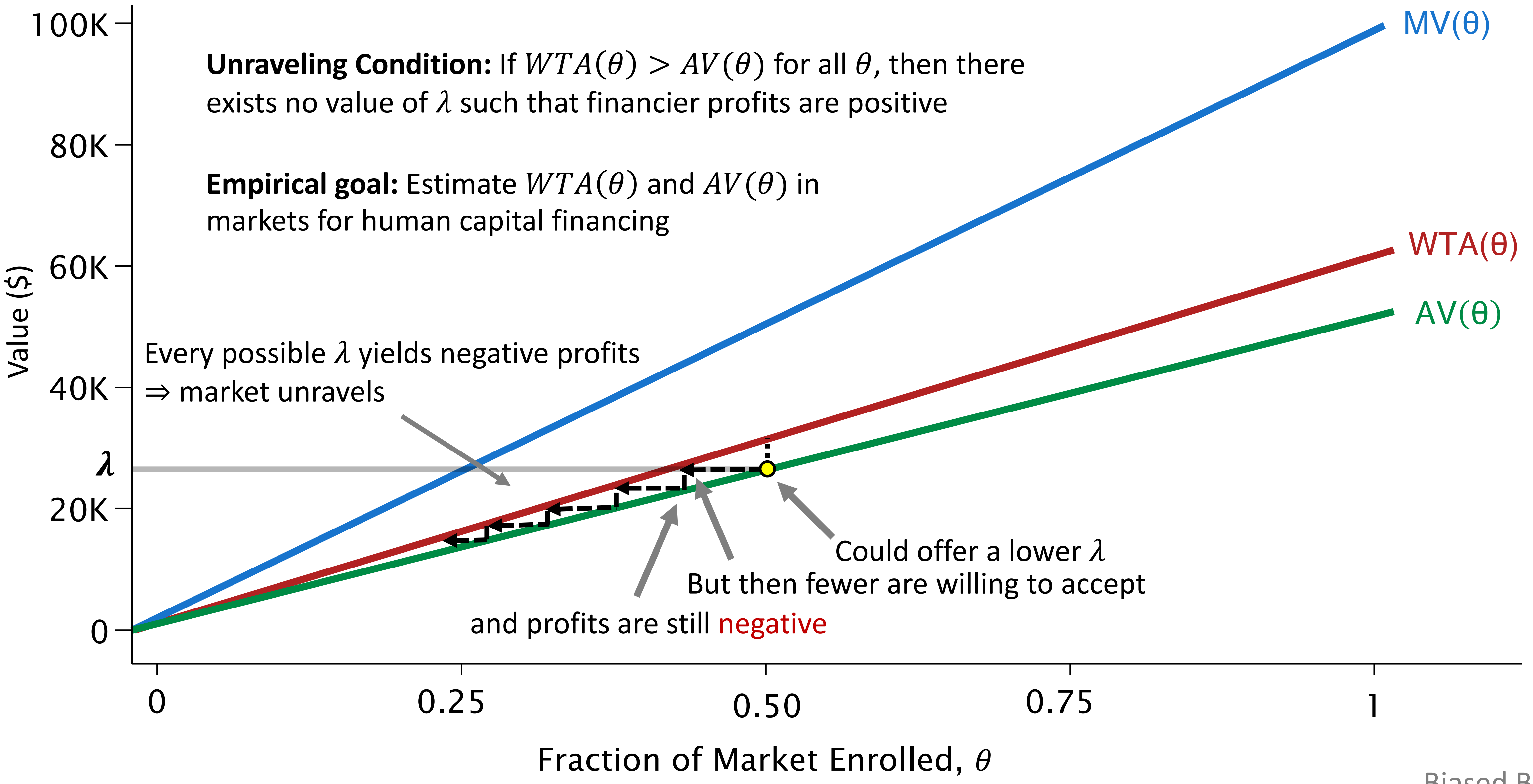

Biased Beliefs

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 $Y = Earnings$
2. Completion-Contingent Loan $Y = Complete\ Degree$
3. Employment-Contingent Loan $Y = Employment$
4. Dischargeable Loan $Y = No\ Default$

(continuous Y) — market 1

(binary Y) — markets 2–4

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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)

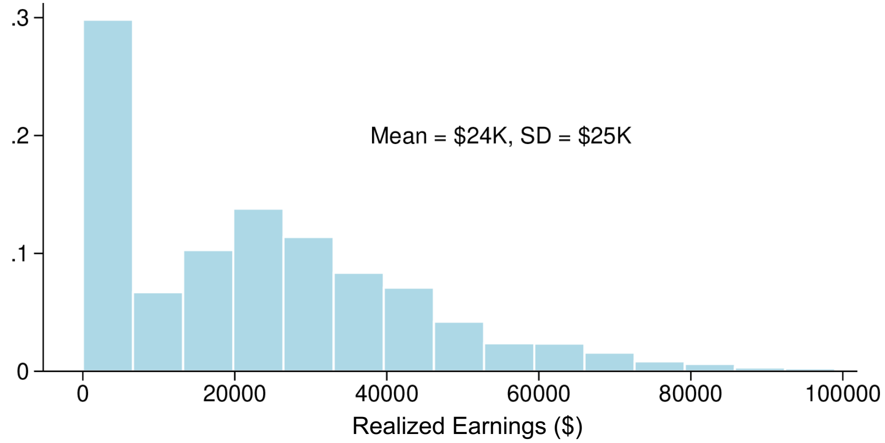
Empirical Approach Relies on Three Types of Variables

- Y: Outcomes corresponding to each of the four hypothetical markets we consider
- Z: Subjective elicitations of future outcomes (not verifiable to the financier)
- X: Observable information about borrowers that financiers could use to price contracts

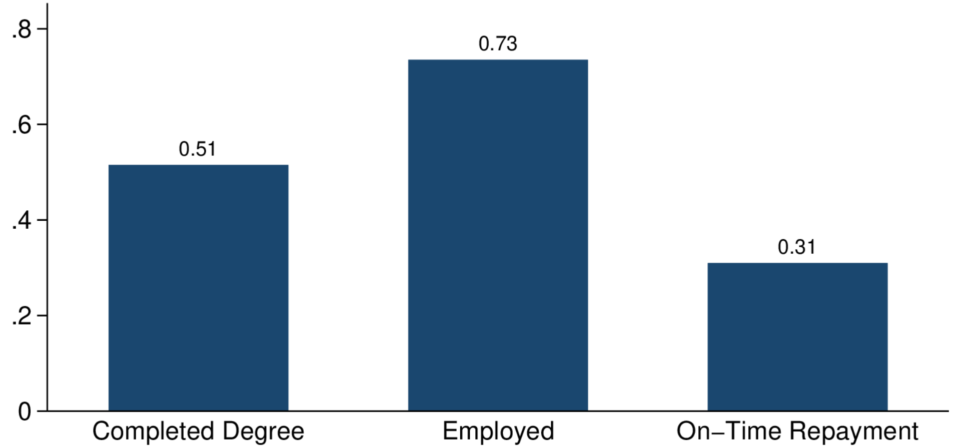
Summary Statistics

Empirical Approach Relies on Three Types of Variables

- Y: Outcomes corresponding to each of the four 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



Summary Statistics

Empirical Approach Relies on Three Types of Variables

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

- Z: Subjective elicitations of future outcomes (not verifiable to financier)
  - 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?"*

Note the elicitations do not correspond exactly to outcomes, Y

Summary Statistics

Empirical Approach Relies on Three Types of Variables

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

- Z: Subjective elicitations of future outcomes (not verifiable to the financier)

- X: Observable information about borrowers that financiers could use to price contracts
  - **Academic Characteristics:** degree type (BA, AA), field of study, years since HS (exact major FE)
  - **Institution Characteristics:** college enrollment, admit rate, tuition, degree offerings, region, urban/rural, avg. demographics, avg. test scores (institution FE)
  - **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

Reduced-Form Evidence of Private Information

We use outcomes ($\boldsymbol{Y}$), elicitations ($\boldsymbol{Z}$), and observables ($\boldsymbol{X}$) to shed light on three questions

1. Do elicitations (Z) reflect college-goers' *private information* about future outcomes?

2. Is the *magnitude* of private information in Z enough to potentially unravel markets?

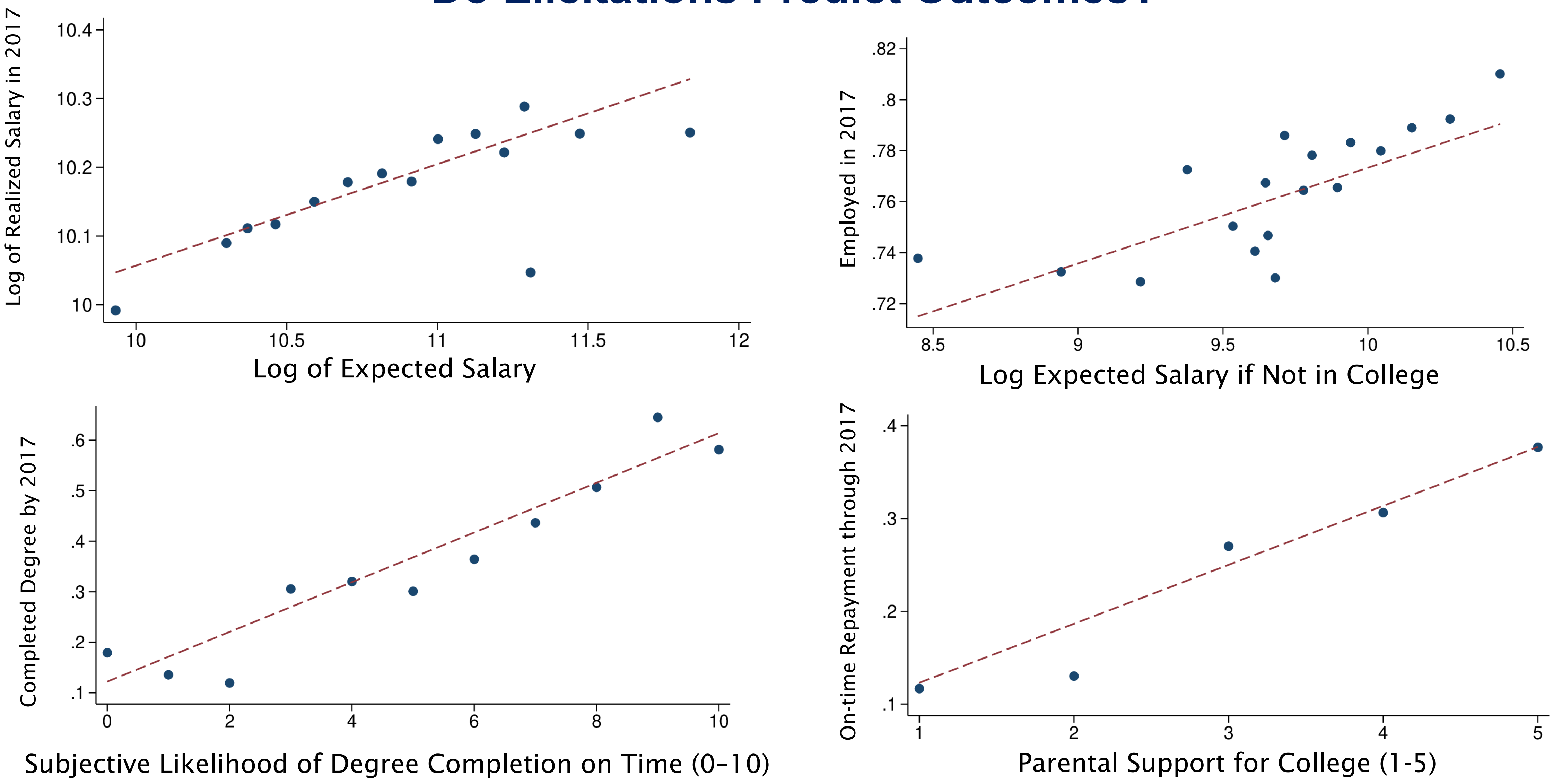
3. Would college-goers use the information in Z to make financial decisions?

1. Existence of Private information

- **Assumption:** $\boldsymbol{E}[Y|\boldsymbol{\theta}, \boldsymbol{Z}, \boldsymbol{X}] = \boldsymbol{E}[Y|\boldsymbol{\theta}, \boldsymbol{Z}]$
  - $\boldsymbol{Z}$ contains no more information about Y than do people's information set, θ

- **Result:** If $\boldsymbol{Z}$ predicts Y conditional on $\boldsymbol{X}$, then so does private information, $\boldsymbol{\theta}$
  - Regressing Y on Z conditional on X provides a test for private information
  - Begin with tests using just a single elicitation in each setting

Do Elicitations Predict Outcomes?



How about conditional on observables, X, that financiers might use to price the contracts?

Do Elicitations Predict Outcomes Conditional on X?

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Log Salary	β Log Expected Salary	0.176***	0.101***	0.0794***	0.0764***	0.0751***	0.0726***	0.0844***	0.0857***	0.0722***
		(0.0233)	(0.0241)	(0.0244)	(0.0242)	(0.0241)	(0.0240)	(0.0219)	(0.0282)	(0.0217)
	N	11610	11610	11610	11610	11610	11610	11520	8580	11520
Panel B: Degree Completion	β On-Time Completion	0.492***	0.436***	0.359***	0.336***	0.339***	0.328***	0.320***	0.341***	0.316***
	Likelihood	(0.0223)	(0.0226)	(0.0221)	(0.0221)	(0.0221)	(0.0219)	(0.0217)	(0.0250)	(0.0217)
	N	18870	18870	18870	18870	18870	18870	18820	15610	18820
Panel C: Employment	β Log Expected Salary	0.0313***	0.0239**	0.0220**	0.0207*	0.0192*	0.0185*	0.0155	0.00731	0.0152
	if No College	(0.0107)	(0.0106)	(0.0107)	(0.0106)	(0.0106)	(0.0105)	(0.0102)	(0.0123)	(0.0102)
	N	13640	13640	13640	13640	13640	13640	13580	10530	13580
Panel D: On-Time Repayment	β Supportive Parents	0.254***	0.172***	0.131***	0.119***	0.116***	0.109***	0.100***	0.0828***	0.102***
		(0.0202)	(0.0200)	(0.0200)	(0.0197)	(0.0198)	(0.0195)	(0.0189)	(0.0201)	(0.0188)
	N	13660	13660	13660	13660	13660	13660	13580	10700	13580
Control Categories	Academic		X	X	X	X	X	X	X	X
	Institution			X	X	X	X	X	X	X
	Performance				X	X	X	X	X	X
	Demographics					X	X	X	X	X
	Parental						X	X	X	X
	Institution FE							X	X	X
	Institution × Major FE								X	
	Protected									X

Out-of-Sample Predictions

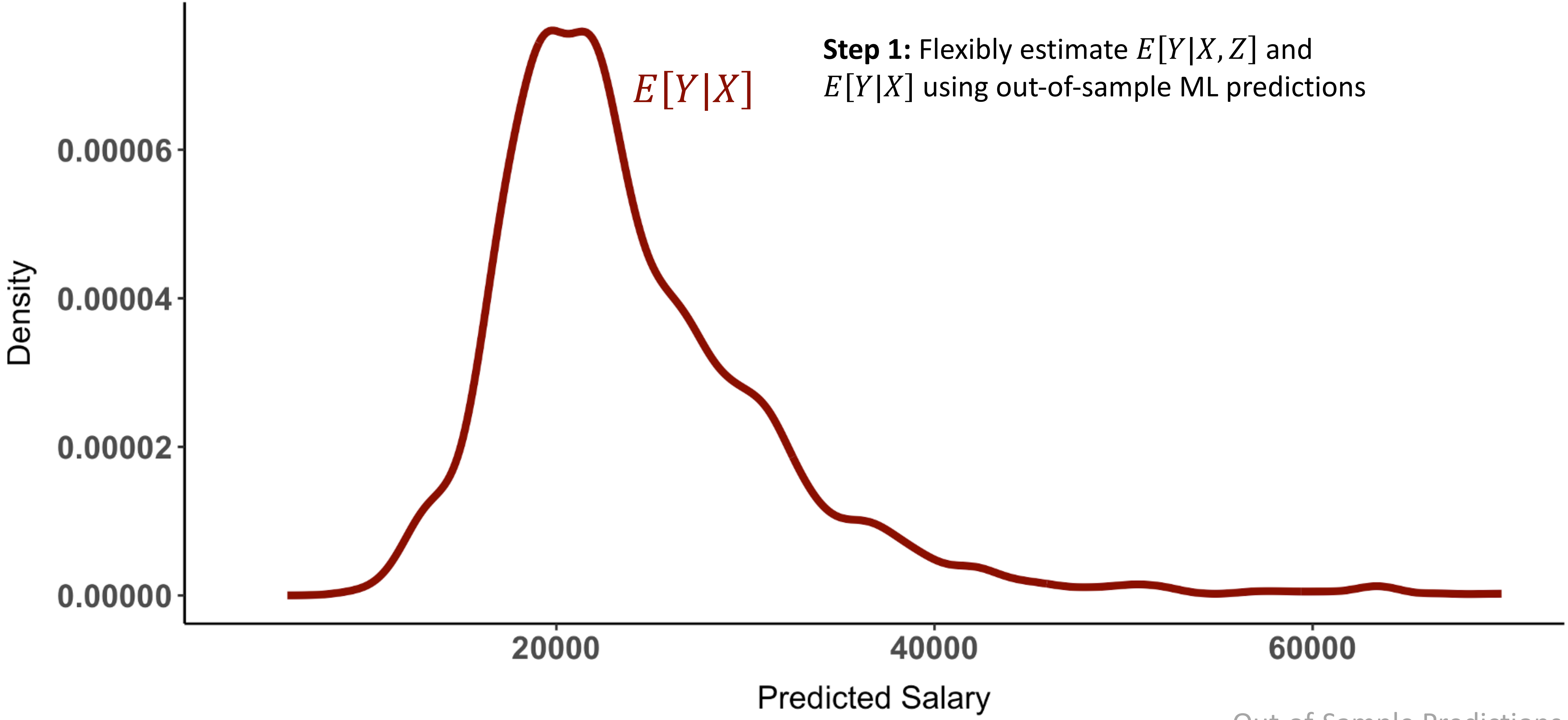
2. Quantifying Private Information in Z

- Rejecting $H_0: \beta_Z = 0$ suggests elicitations contain “some” private information
- How much private information is contained in Z?
- Is it “enough” to make markets unravel?

Answering these questions requires measuring the **magnitude of information** in Z

Distribution of Conditional Expectations, $E[Y|X,Z]$ and $E[Y|X]$

Academic + Institution Controls



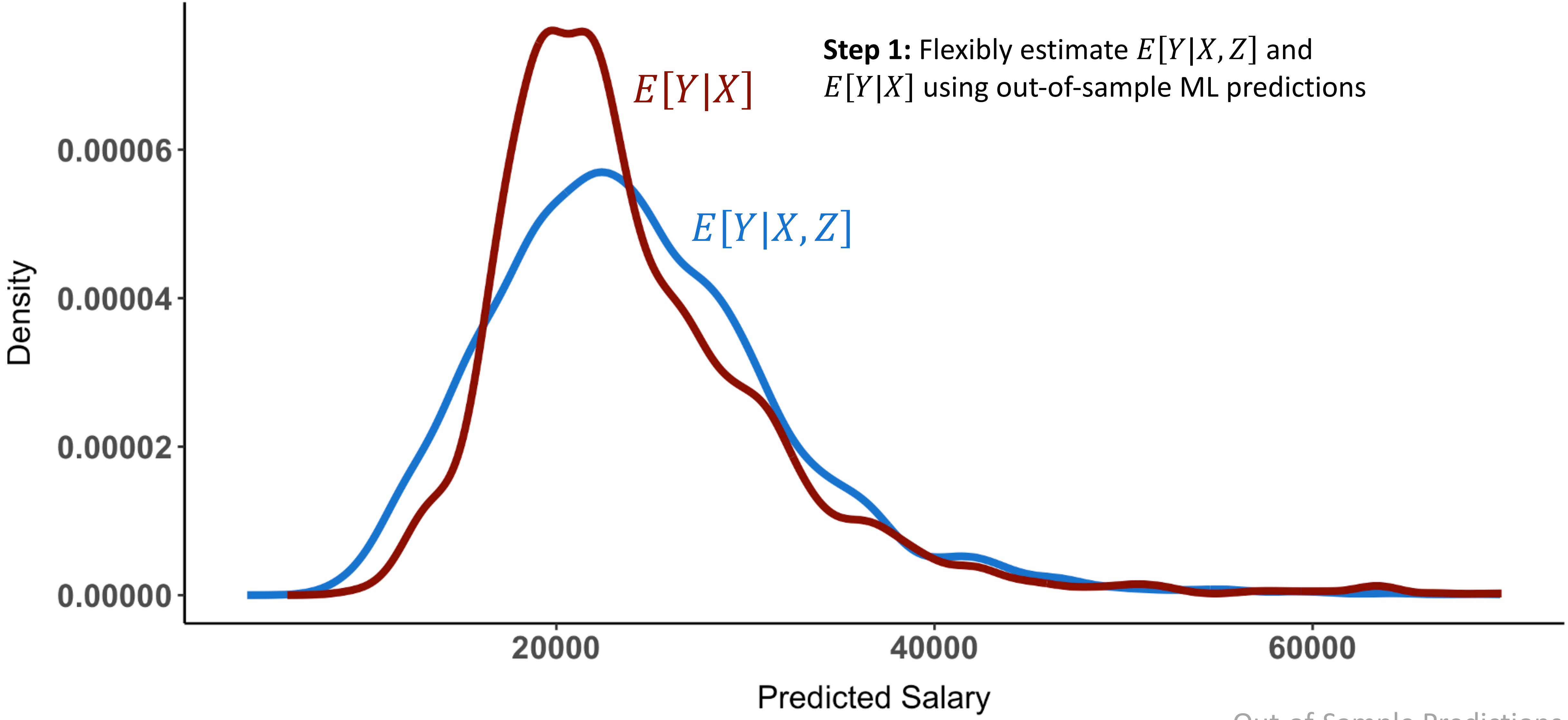
Step 1: Flexibly estimate $E[Y|X,Z]$ and $E[Y|X]$ using out-of-sample ML predictions

X = Academic control set

Out-of-Sample Predictions

Distribution of Conditional Expectations, $E[Y|X,Z]$ and $E[Y|X]$

Academic + Institution Controls



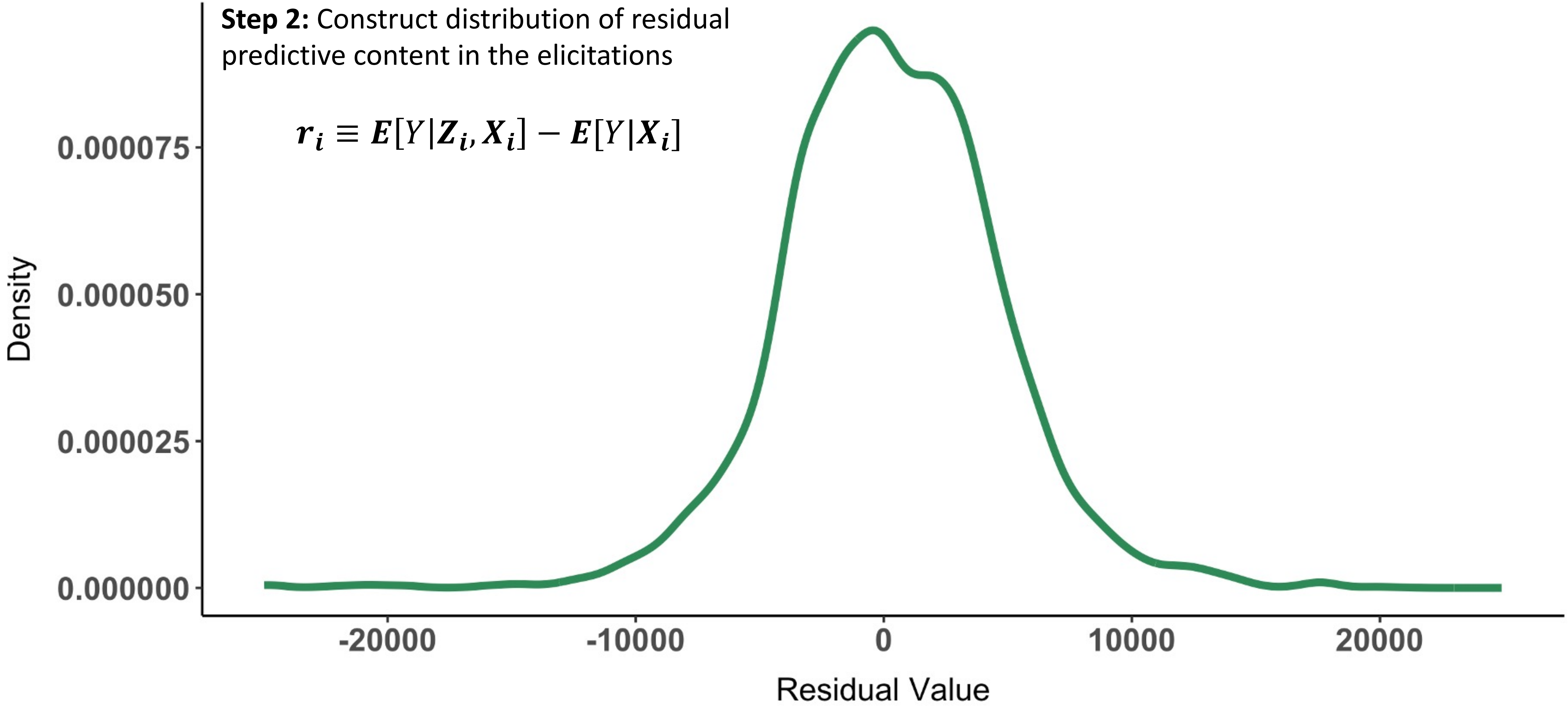
Step 1: Flexibly estimate $E[Y|X,Z]$ and $E[Y|X]$ using out-of-sample ML predictions

Out-of-Sample Predictions

Distribution of Residual Predictions, $r \equiv E[Y|Z,X] - E[Y|X]$

Step 2: Construct distribution of residual predictive content in the elicitations

$$r_i \equiv E[Y|Z_i, X_i] - E[Y|X_i]$$



Magnitude of Information in Elicitations (m^Z)

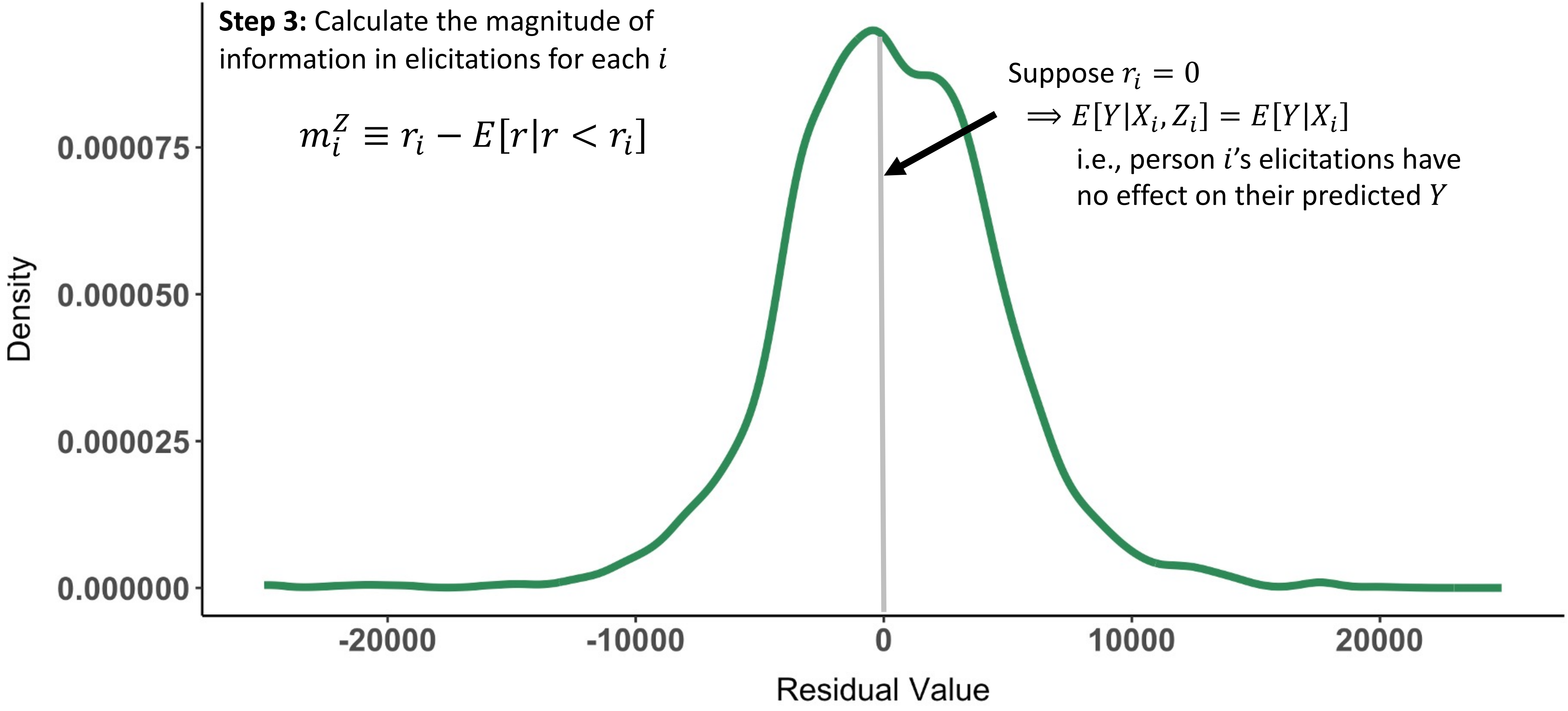
Step 3: Calculate the magnitude of information in elicitations for each i

$$m_i^Z \equiv r_i - E[r|r < r_i]$$

Suppose $r_i = 0$

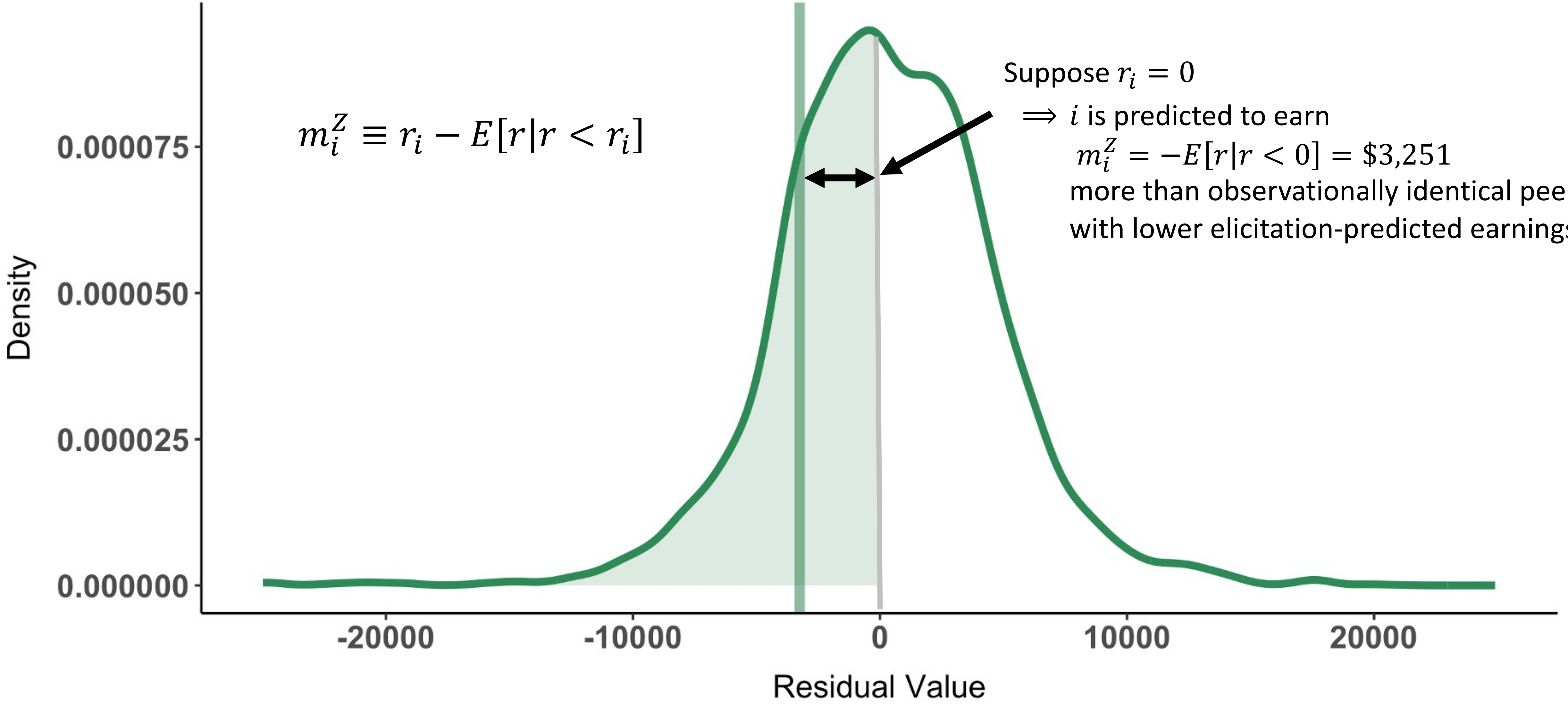
$\implies E[Y|X_i, Z_i] = E[Y|X_i]$

i.e., person i's elicitations have no effect on their predicted Y



Magnitude of Information in Elicitations (m^Z)

$$m_i^Z \equiv r_i - E[r|r < r_i]$$

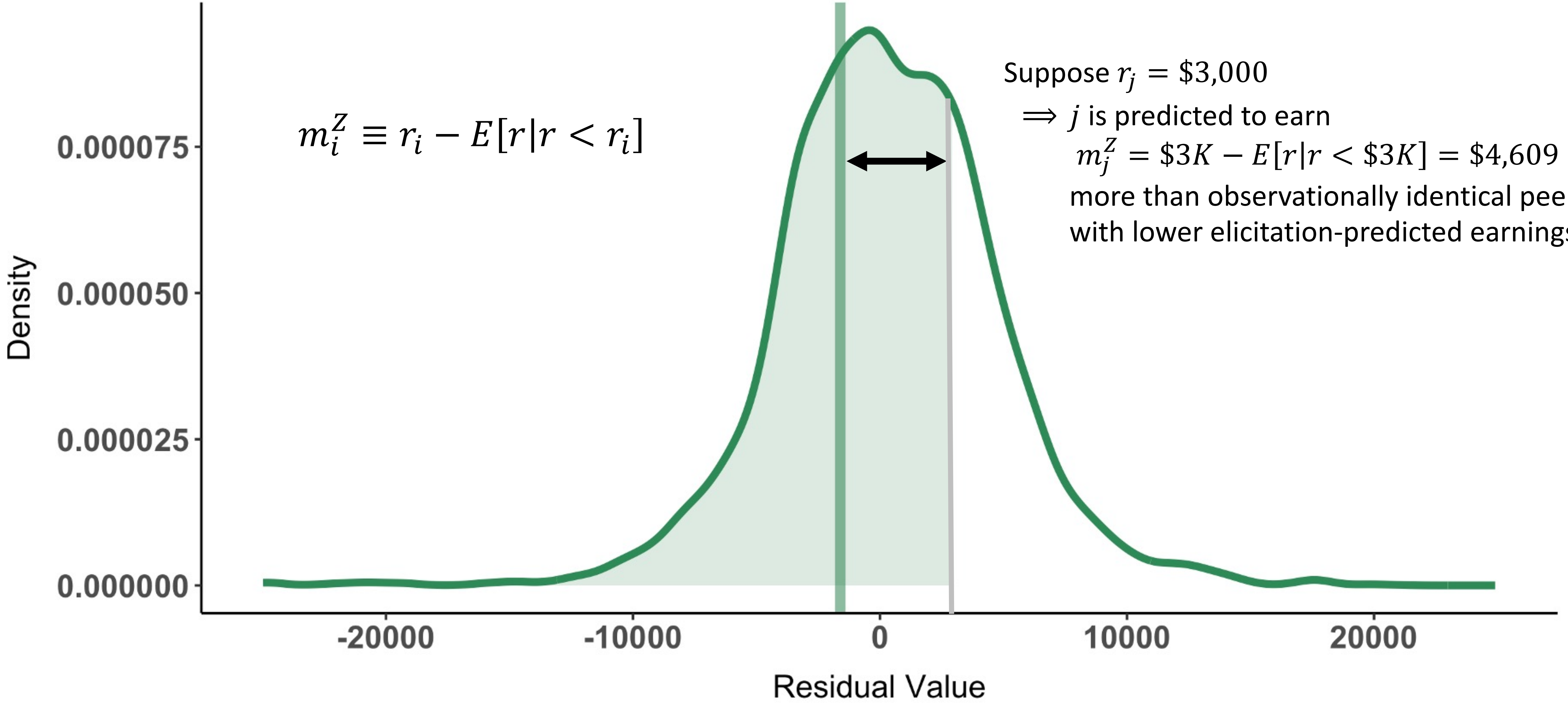


Suppose $r_i = 0$

$\Longrightarrow$ i is predicted to earn $m_i^Z = -E[r|r < 0] = \$3{,}251$ more than observationally identical peers with lower elicitation-predicted earnings

Magnitude of Information in Elicitations (m^Z)

$$m_i^Z \equiv r_i - E[r|r < r_i]$$



Suppose $r_j = \$3{,}000$

$\Longrightarrow$ j is predicted to earn

$m_j^Z = \$3K - E[r|r < \$3K] = \$4{,}609$

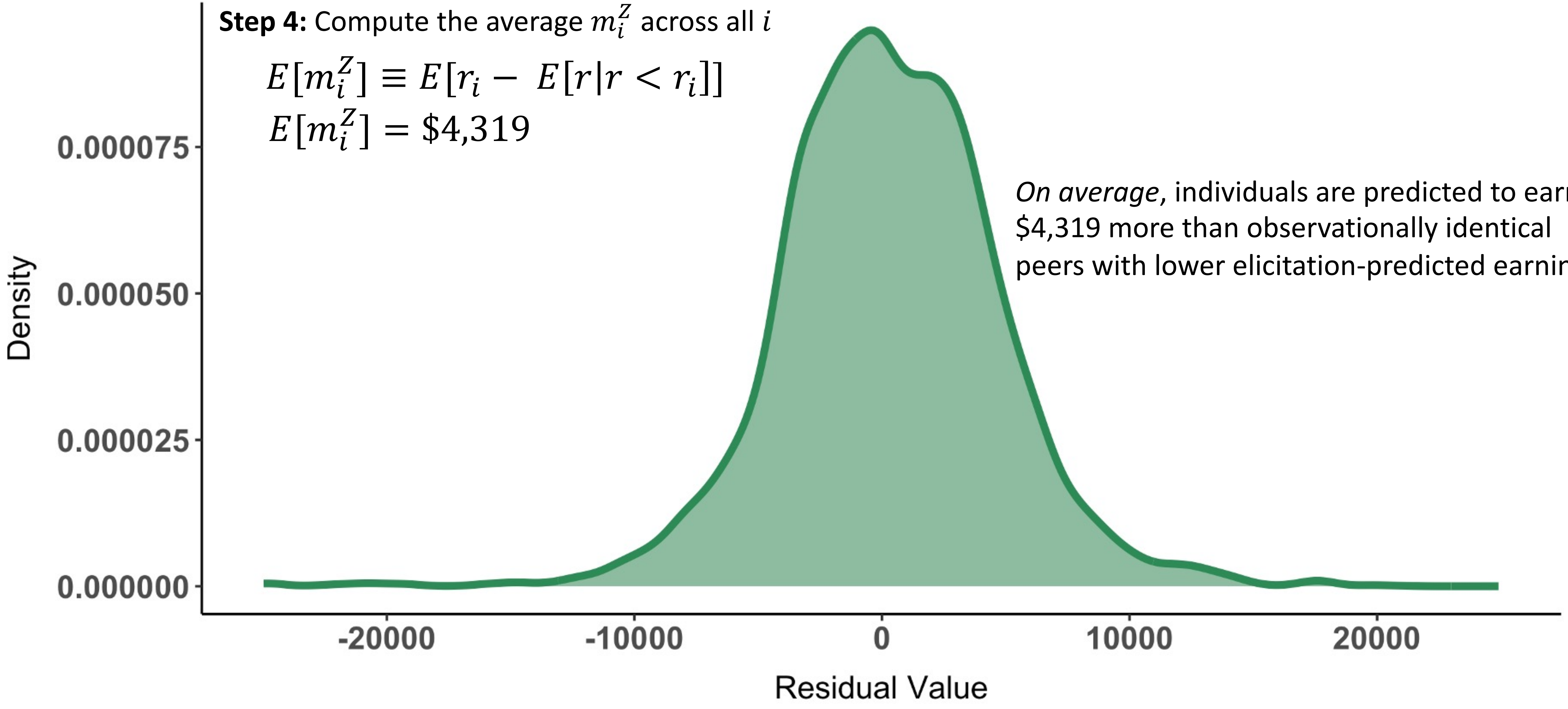
more than observationally identical peers with lower elicitation-predicted earnings

Average Magnitude of Information in Elicitations ($E[m^Z]$)

Step 4: Compute the average m_i^Z across all i

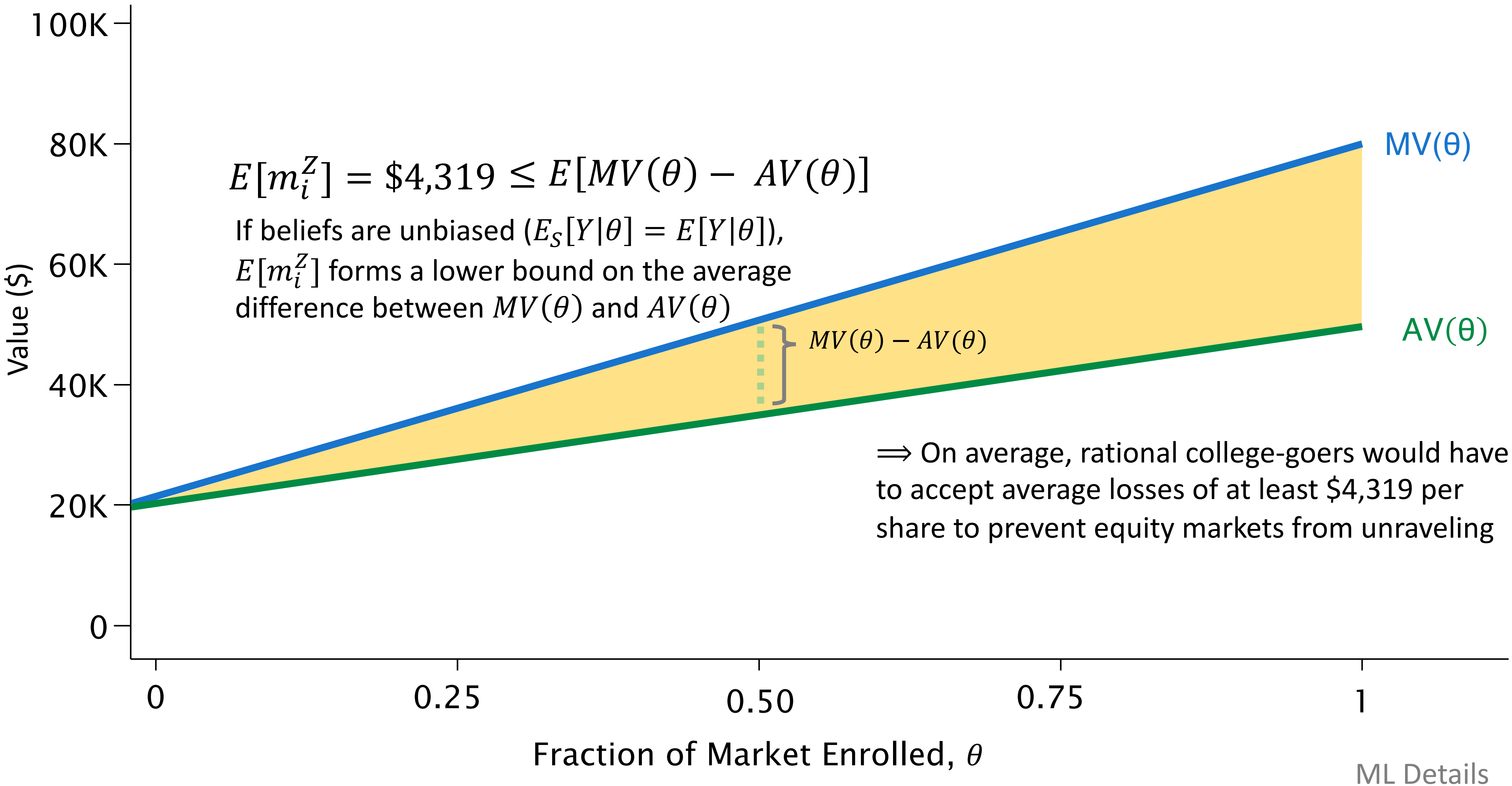
$$E[m_i^Z] \equiv E[r_i - E[r|r < r_i]]$$

$$E[m_i^Z] = \$4{,}319$$



On average, individuals are predicted to earn \$4,319 more than observationally identical peers with lower elicitation-predicted earnings.

Theoretical Interpretation: Lower-Bound on $E[MV(\theta) - AV(\theta)]$



ML Details

Lower-Bound on Magnitude of Private Information

	Category				
	(1) *No Public Info*	(2) *Academic + Institution*	(3) *Academic + Institution + Performance + Demographics*	(4) *Academic + Institution + Performance + Demographics + Parental*	(5) *Academic + Institution + Performance + Demographics + Parental + Protected*
Earnings Equity	5256	4319	3247	2691	2413
Completion-Contingent Loan	0.22	0.15	0.12	0.11	0.11
Employment-Contingent Loan	0.12	0.10	0.06	0.05	0.05
Dischargeable Loan	0.12	0.11	0.06	0.04	0.04

- Mean salary of $24K implies average person must repay at least **$1.22** per $1 of financing to cover cost of worse risks adversely selecting contract

- Large average discounts for other markets as well:

  ≈ Must repay **$1.42** per $1 of completion-contingent loan

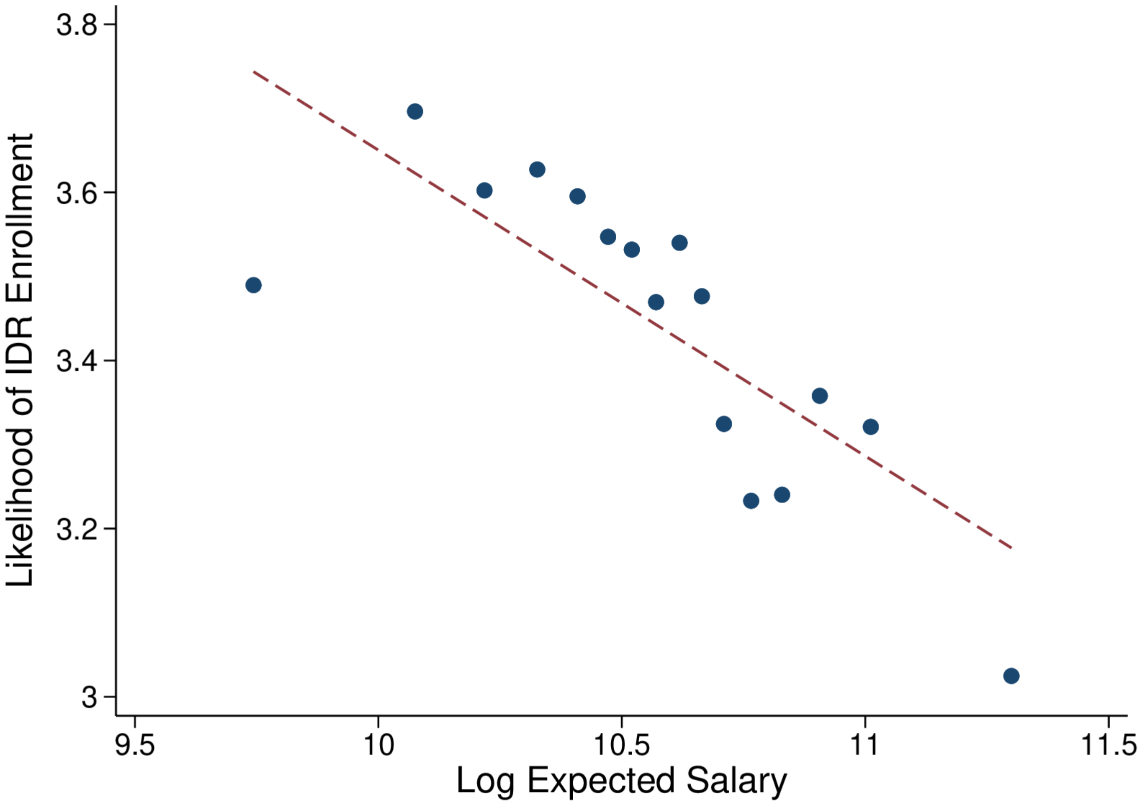
  ≈ Must repay **$1.16** loss for $1 employment-contingent loan

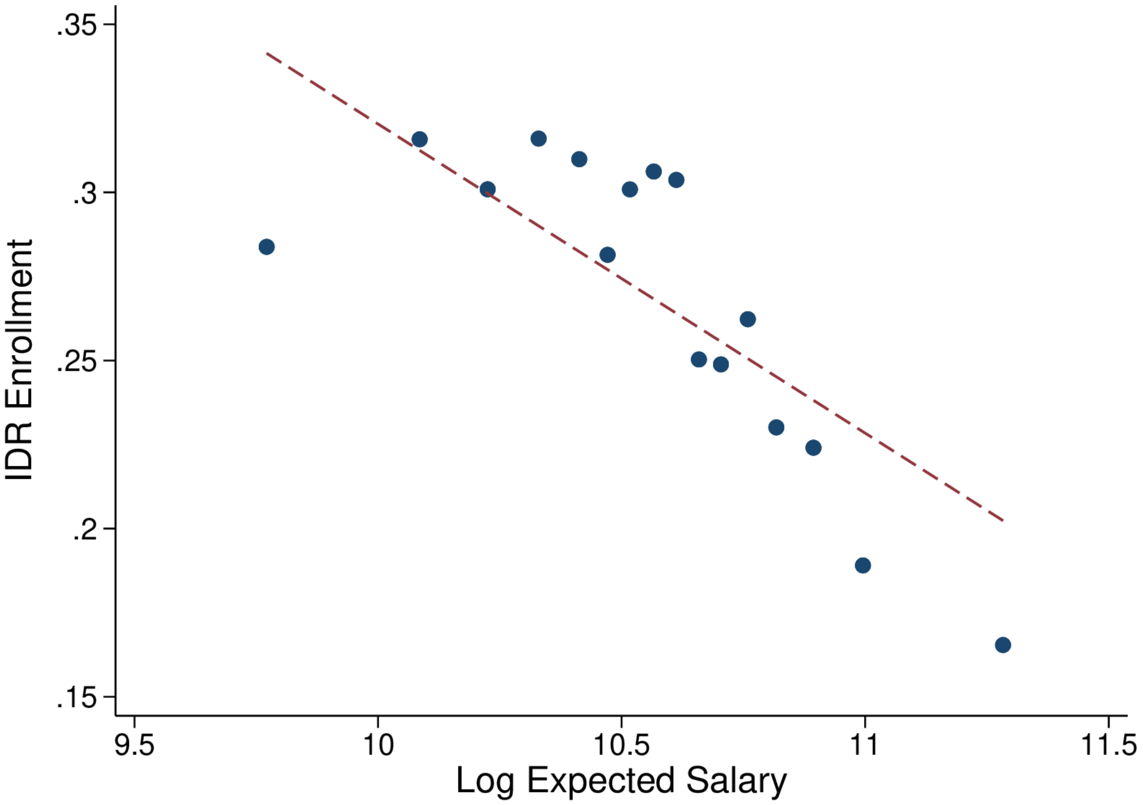
  ≈ Must repay **$1.55** loss for $1 dischargeable loan

3. How would the information in Z be used in financial markets?

- Z contains private information, but would that information be used in contract choices?
- Cannot observe contract decisions in non-existent equity markets
- But we can observe decisions in a similar context: **income-driven repayment (IDR)**
  - IDR is a public program that lowers student loan payments to 10-15% of monthly income
  - IDR is distinct from earnings-equity contracts, but both provide income-contingent benefits
- Do those who expect lower earnings plan to enroll in IDR?

Those Expecting Higher Salaries Are Less Likely to (Expect to) Enroll in IDR





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

Estimating $AV(\theta)$ and $WTA(\theta)$ Curves

1. Specify relationship between beliefs, $\mu_\theta \equiv E[y|\theta]$, and elicitations, Z

2. Estimate distribution of μ_θ, conditional on observables, X

3. Calculate $AV(\theta) \equiv E[Y|\mu_{\theta'} \leq \mu_\theta]$ and $WTA(\theta) \equiv \frac{E[Yu_2|\theta]}{u_2(\theta)}$

- General strategy: infer beliefs from joint distribution of elicitations (Z) and outcomes (Y), conditional on observables (X)
- Builds 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 beliefs

Estimating $AV(\theta)$ and $WTA(\theta)$ Curves

1. Specify relationship between beliefs, $\mu_\theta \equiv E[y|\theta]$, and elicitations, Z

Realized outcome, y:

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

Belief

Elicitation, z:

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

Estimating $AV(\theta)$ and $WTA(\theta)$ Curves

1. Specify relationship between beliefs, $\mu_\theta \equiv E[y|\theta]$, and elicitations, Z

Realized outcome, y:

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

- Assume beliefs are rational: $\mu_\theta = E[y|\theta]$
- For continuous y, assume "expectational error" (ϵ) is homoscedastic, $\epsilon \sim f(\epsilon)$ for all θ

Elicitation, z:

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

- z can be biased ($\alpha \neq 0$), imperfect ($\gamma \neq 1$), and noisy ($\sigma_v > 1$) in beliefs
- γ is estimated using IV and second elicitation, z' (Details/Results)
  - **Identification assumption:** measurement error is orthogonal: $cov(z', v|\theta) = 0$
  - z' =Average income among college grads in respondent's expected 3-digit occupation in 2012 → $\gamma = 0.7$

Estimating $AV(\theta)$ and $WTA(\theta)$ Curves

1. Specify relationship between beliefs, $\mu_\theta \equiv E[y|\theta]$, and elicitations, Z

2. Estimate distribution of μ_θ, conditional on observables, X

   - Continuous y (log salary): Non-parametric $\hat{G}(\mu_\theta)$ using a linear deconvolution (Bonhomme & Robin 2010)

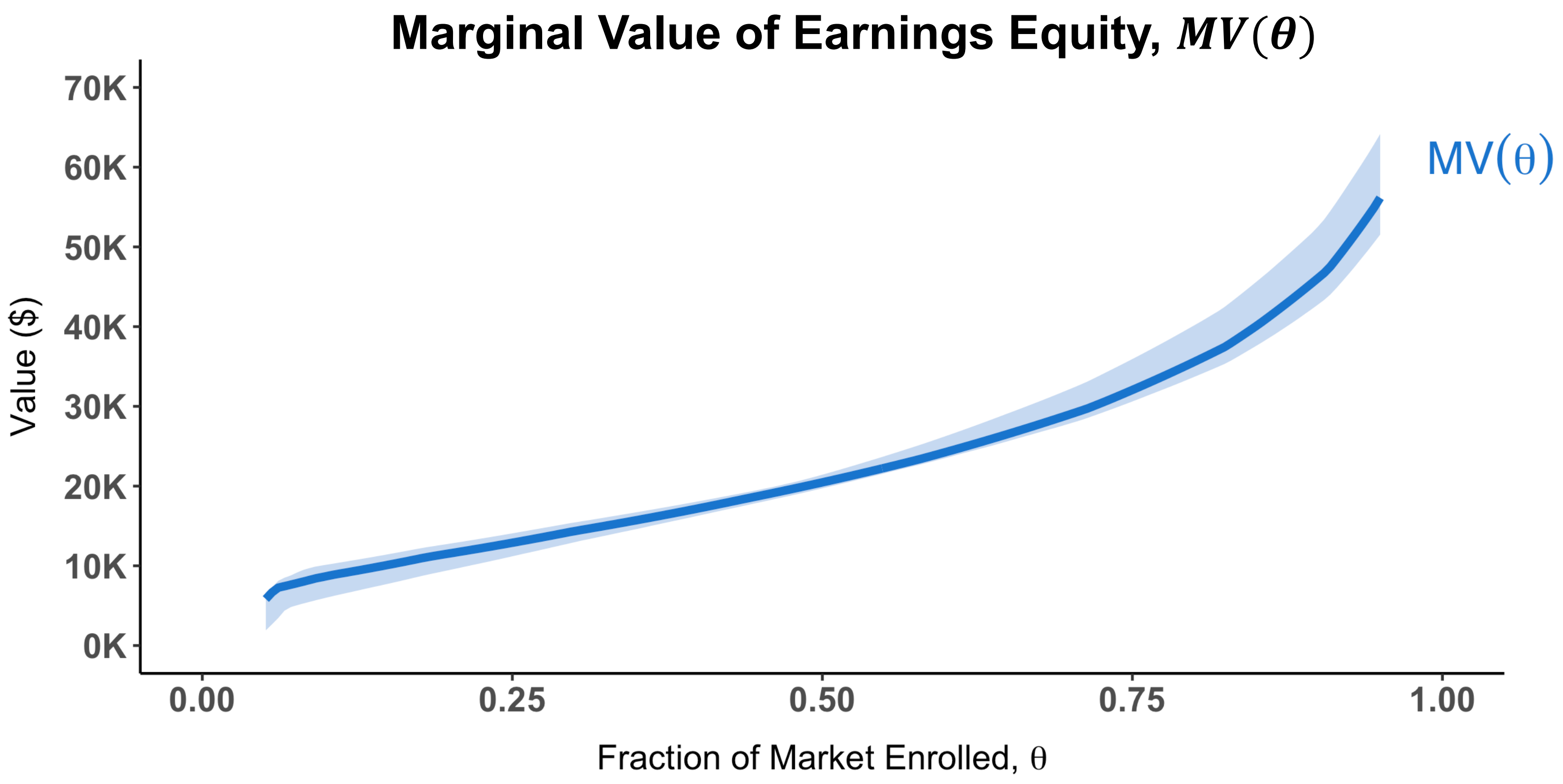
   - Binary y: Semi-parametric $\hat{G}(\mu_\theta)$ using MLE, where $G(\mu_\theta) = \sum_j \xi_j \mathbf{1}\{\mu_\theta \leq a_j\}$

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

Estimating $AV(\theta)$ and $WTA(\theta)$ Curves

1. Specify relationship between beliefs, $\mu_\theta \equiv E_s[y|\theta]$, and elicitations, Z

2. Estimate distribution of μ_θ, conditional on observables, X



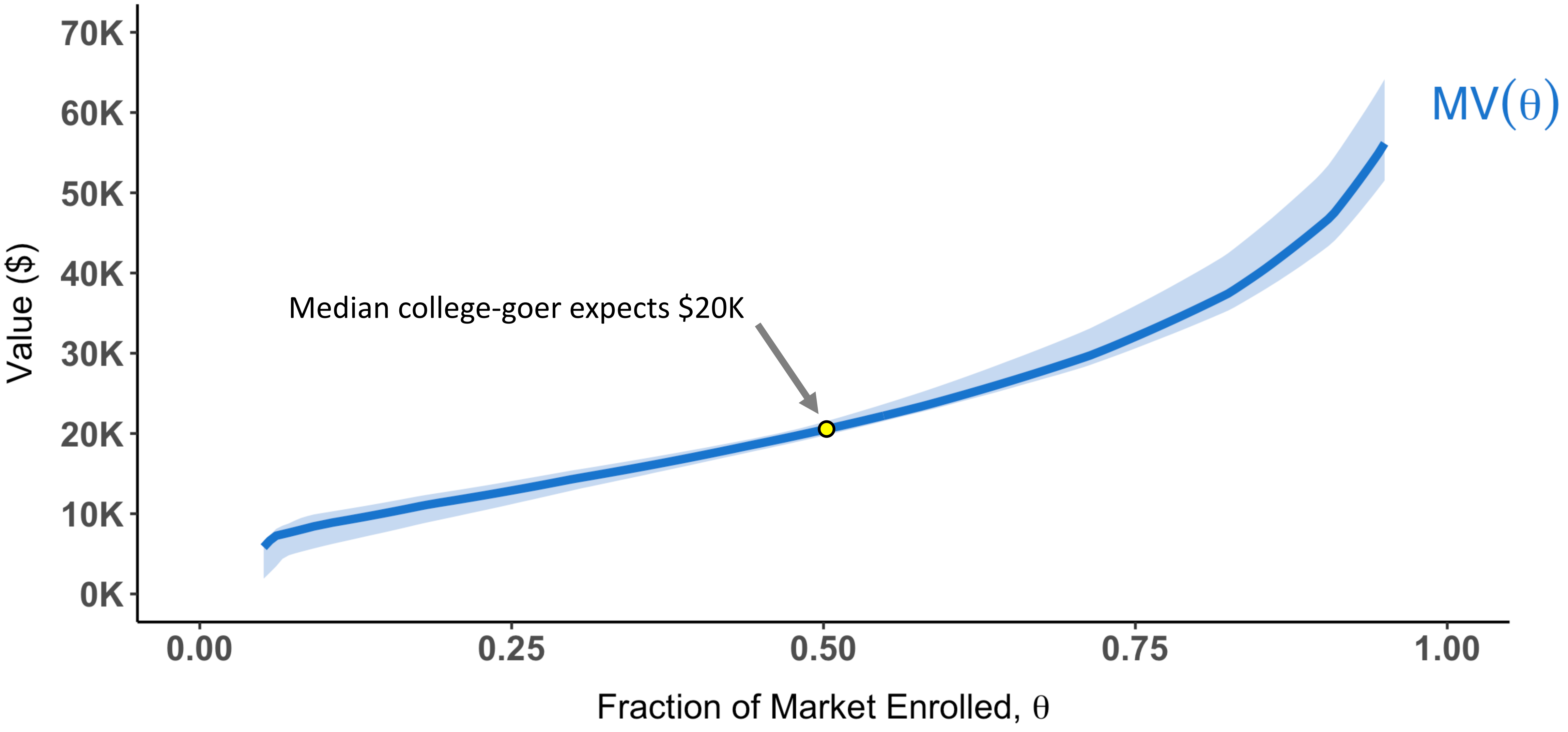
Estimating $AV(\theta)$ and $WTA(\theta)$ Curves

1. Specify relationship between beliefs, $\mu_\theta \equiv E_s[y|\theta]$, and elicitations, Z

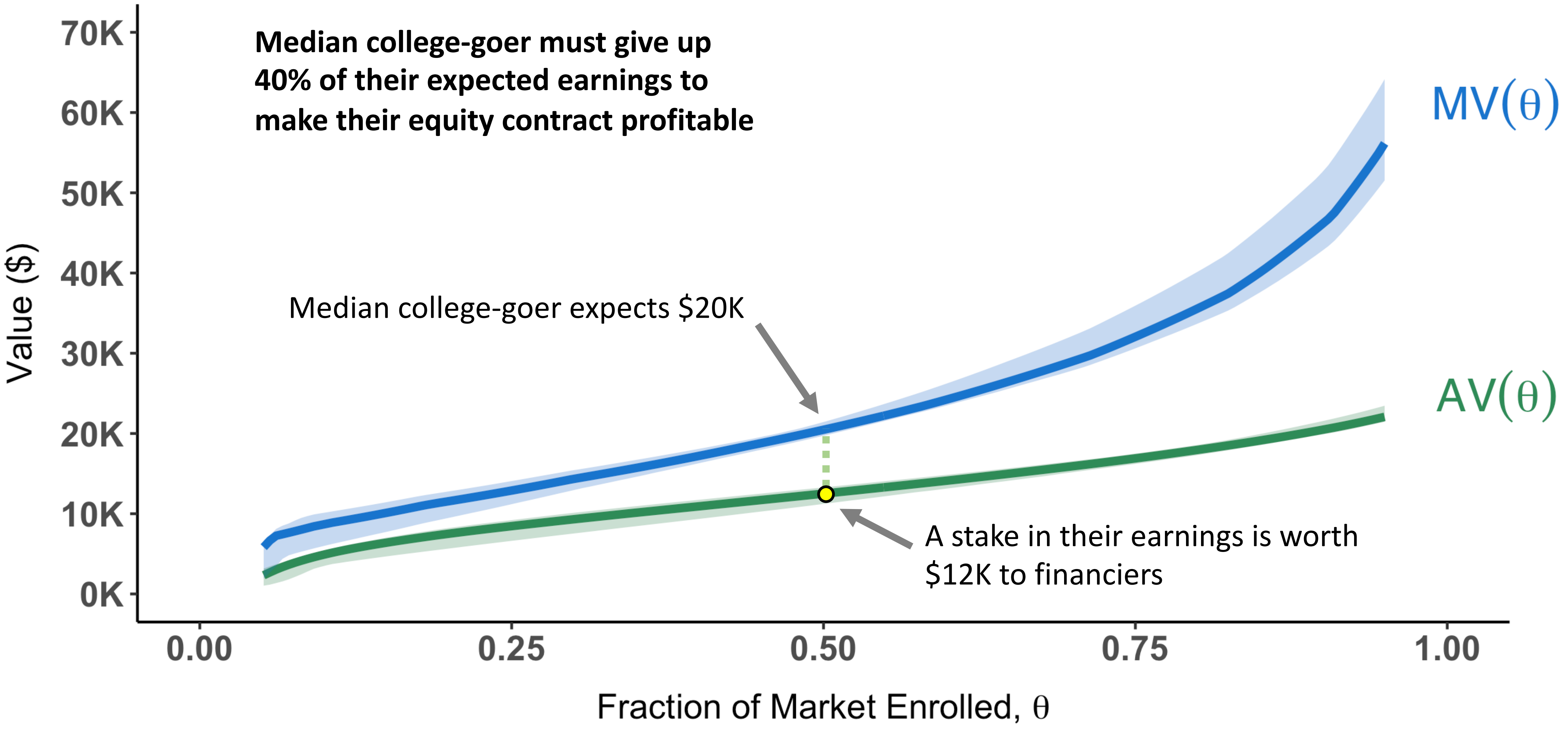
2. Estimate distribution of μ_θ, conditional on observables, X

3. Calculate $AV(\theta) \equiv E[Y|\mu_{\theta'} \leq \mu_\theta]$ and $WTA(\theta) \equiv \frac{E[Yu_2|\theta]}{u_2(\theta)}$
   - Baseline $\widehat{WTA}(\theta)$ assumes $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$ with $\sigma = 2$
   - $\frac{dc}{dy}$ 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)

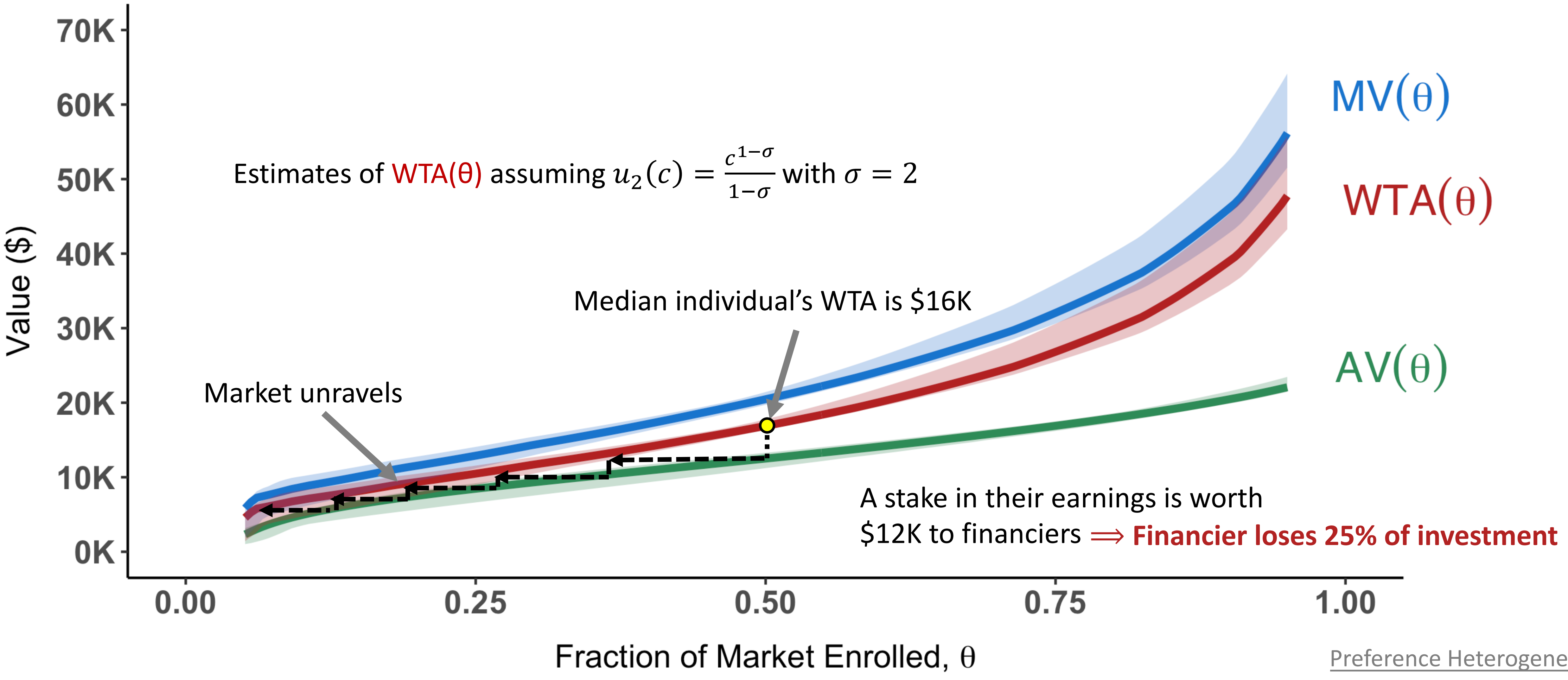
Marginal Value of Earnings Equity, $MV(\theta)$



Average Value of Earnings Equity, $AV(\theta)$



Unraveling of the Earnings-Equity Market

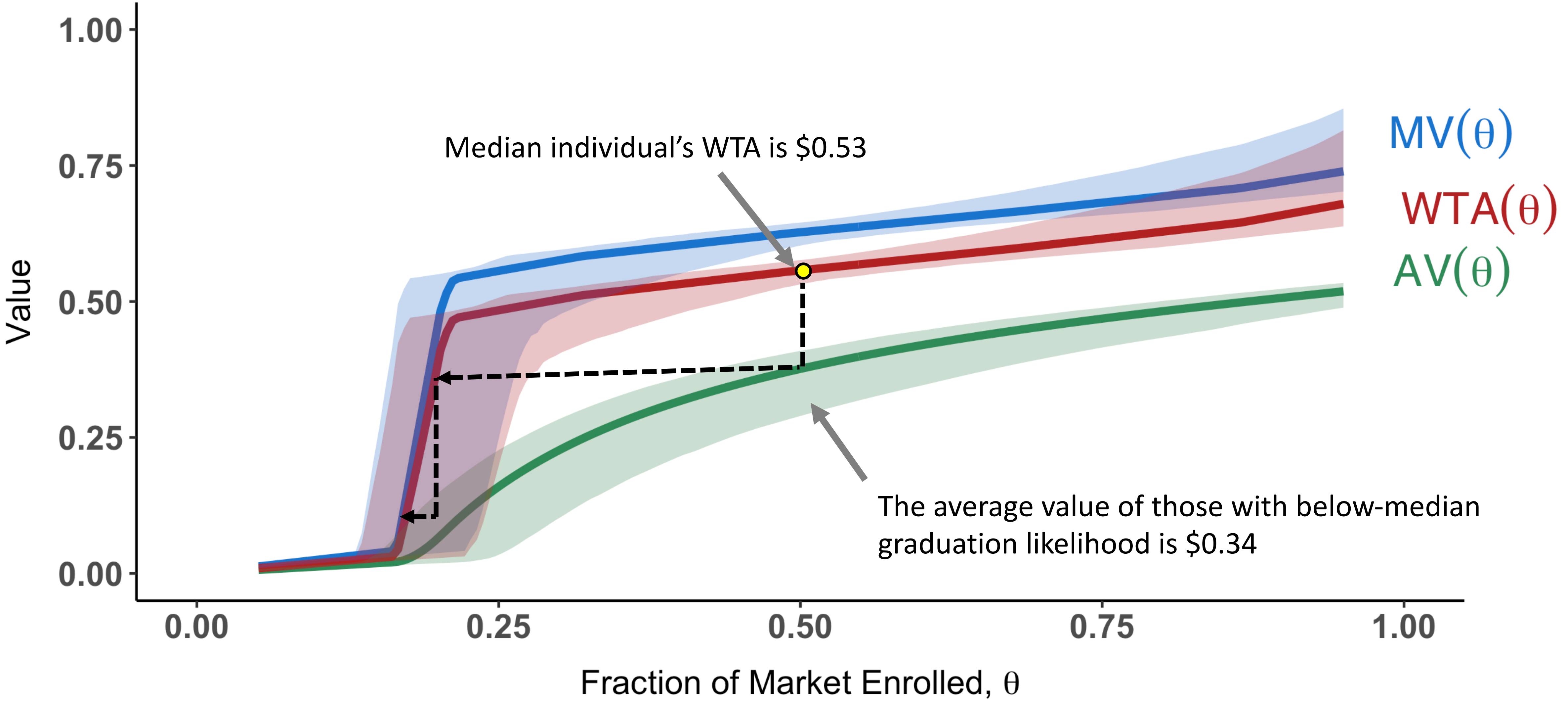


Preference Heterogeneity

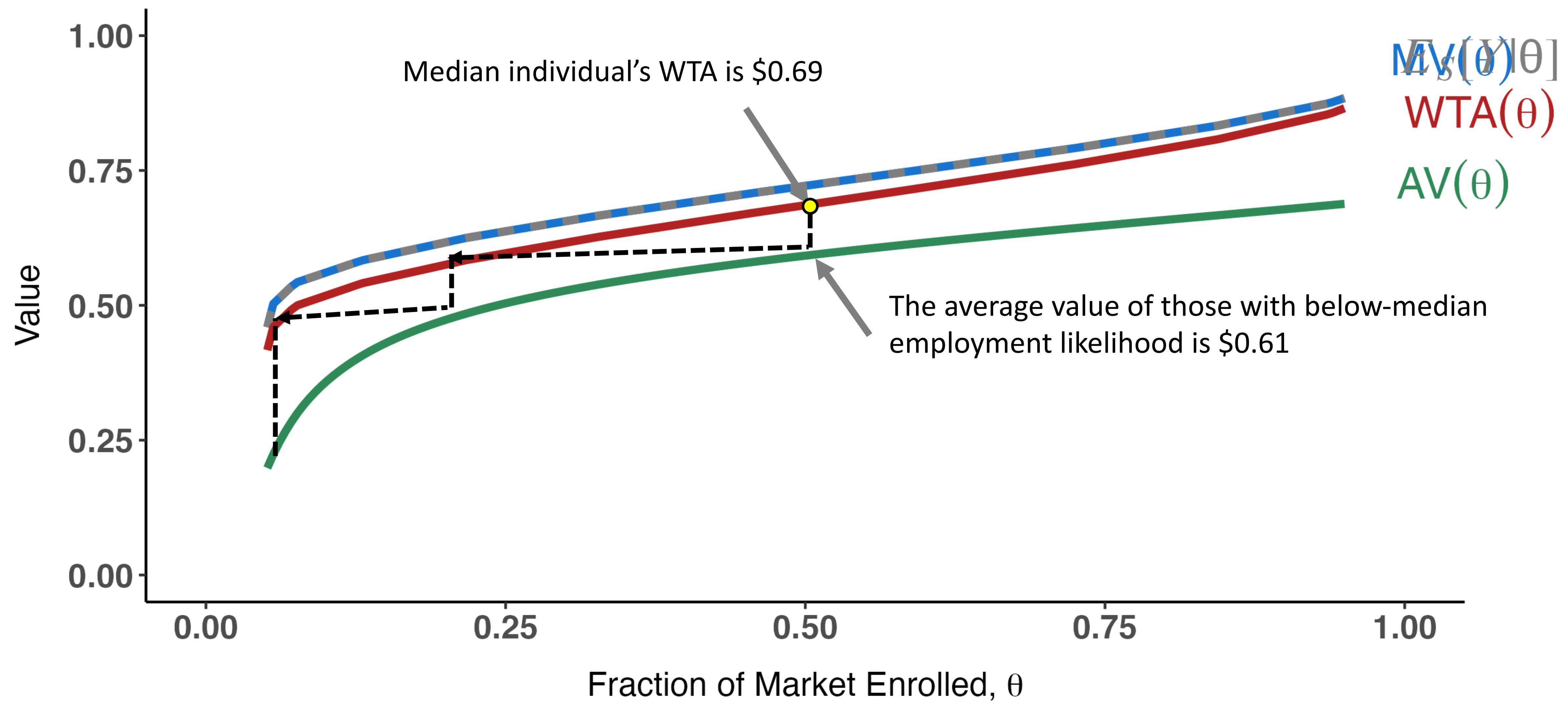
Estimation Details

Alt. Interest Rates

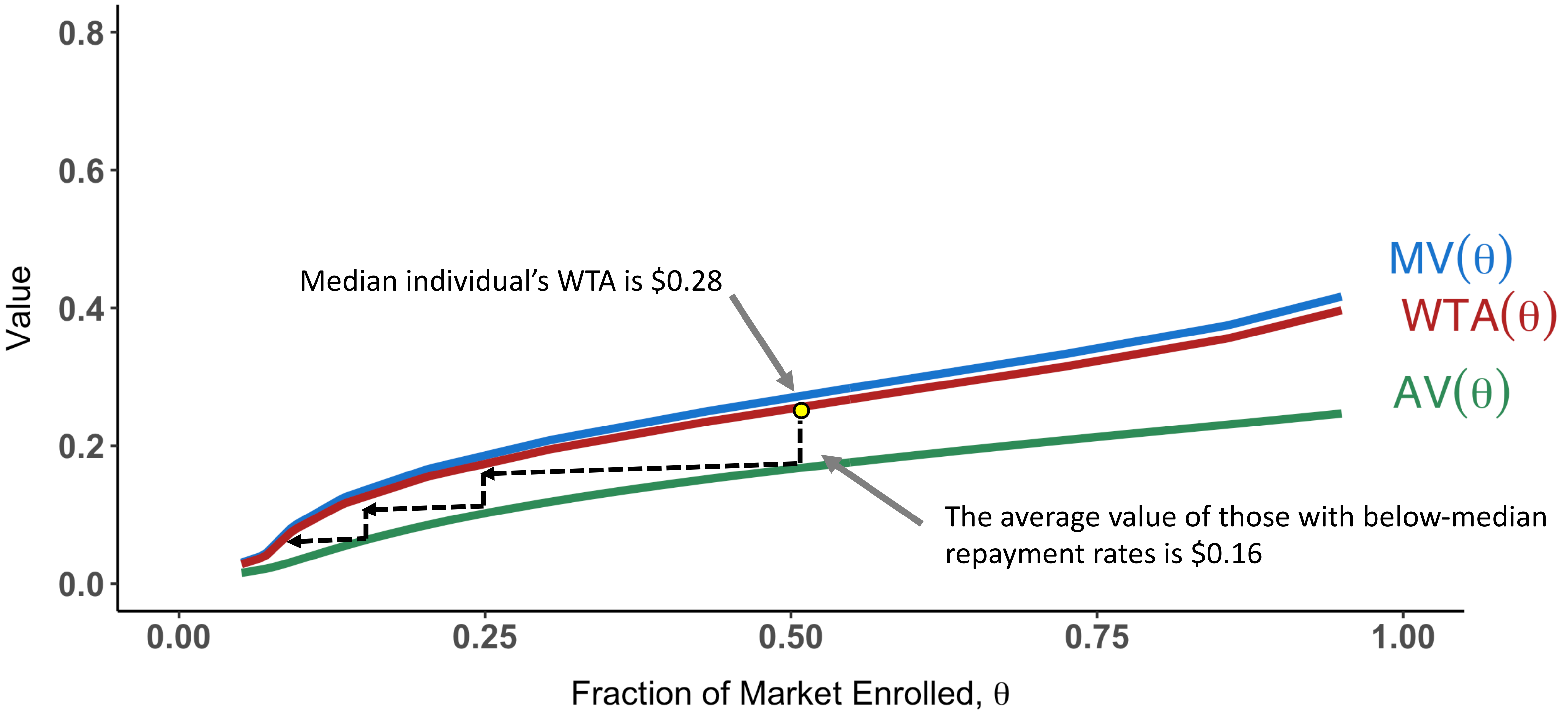
Unraveling of Completion-Contingent Loan Market



Unraveling of Employment-Contingent Loan Market



Unraveling of Dischargeable Debt Market



Biased Beliefs

- Our main specification assumes beliefs are rational:

$$E_S[Y|\theta] = E[Y|\theta]$$

$\Rightarrow$ college-goers would make contract decisions using unbiased predictions of Y

- What if college-goers hold **biased beliefs**?
  - e.g., over-optimism about future earnings (Arcidiacono et al 2020; Reuben et al 2017)
- "Rational beliefs" specification allows for biases, but assumes beliefs would *rationally update* under financial incentives (Lucas 1972; Wiswall and Zafar 2021)
- Alternative specification: explicitly model and identify $E_S[Y|\theta] \neq E[Y|\theta]$

Biased Beliefs: Identification

Rational Beliefs

Assumption

$\boldsymbol{Y}$ is unbiased measure of $\boldsymbol{E_S[Y|\theta]}$

$$E[Y|\theta] = E_S[Y|\theta]$$

⇒ college-goers would make contract decisions using unbiased predictions of Y

- Allows for indirect mapping between beliefs and elicitations: $E[Z|\theta] \neq E_S[Y|\theta]$
- Beliefs can be "rationalized" (Lucas 1972)

Potentially Biased Beliefs

Assumption

$\boldsymbol{Z}$ is unbiased measure of $\boldsymbol{E_S[Y|\theta]}$

$$E[Z|\theta] = E_S[Y|\theta]$$

⇒ college-goers would make contract decisions using predictions implied by Z (minus noise)

- Allows for biased beliefs: $E[Y|\theta] \neq E_S[Y|\theta]$
- Requires direct correspondence between elicitation and outcome
  - e.g., Z_{Salary} ="Salary I expect to earn in 2017"
- Still allows for mean-zero elicitation error

Biased Beliefs: Identification

Rational Beliefs

Assumption

Y is unbiased measure of $E_S[Y|\theta]$

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

Belief

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

Potentially Biased Beliefs

Assumption

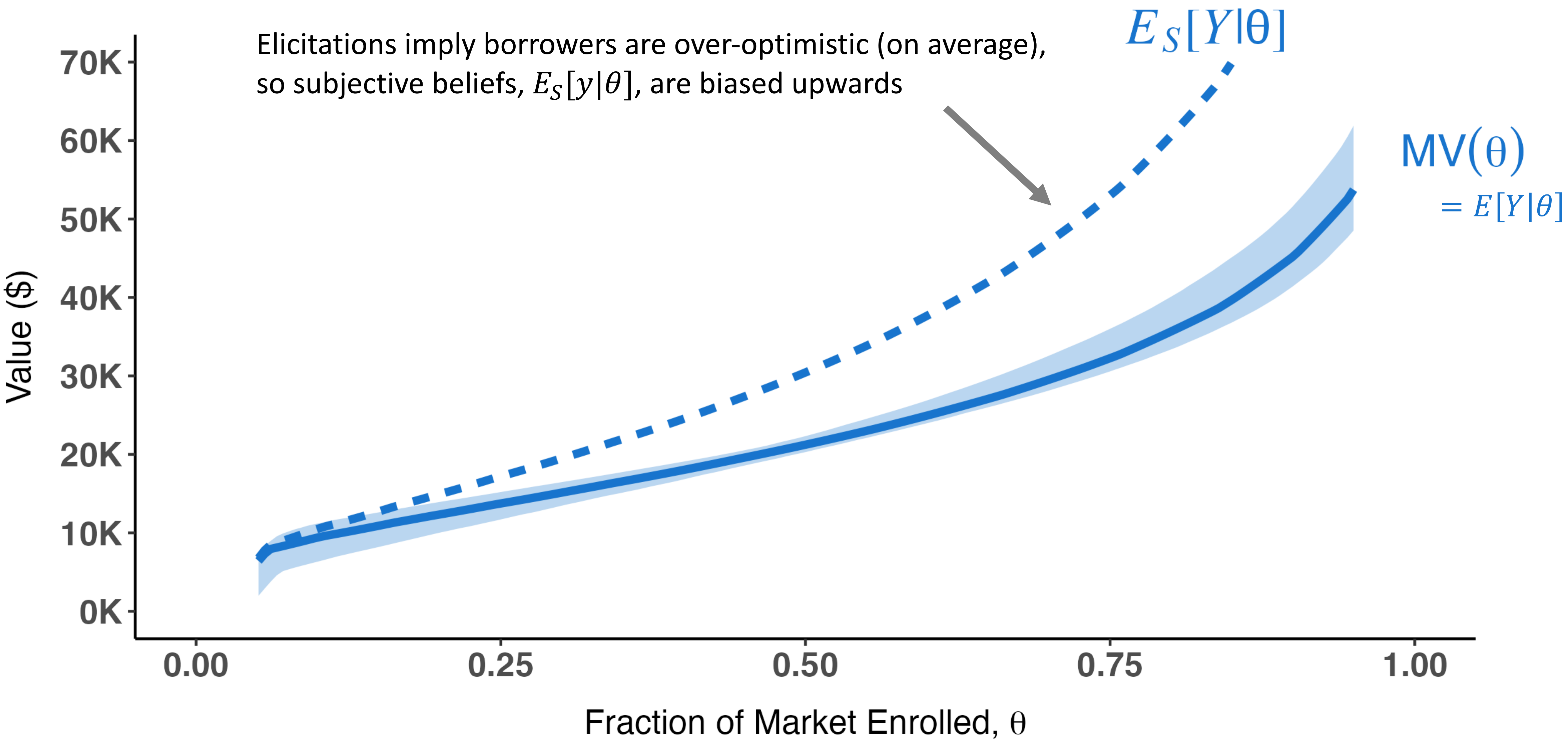
Z is unbiased measure of $E_S[Y|\theta]$

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

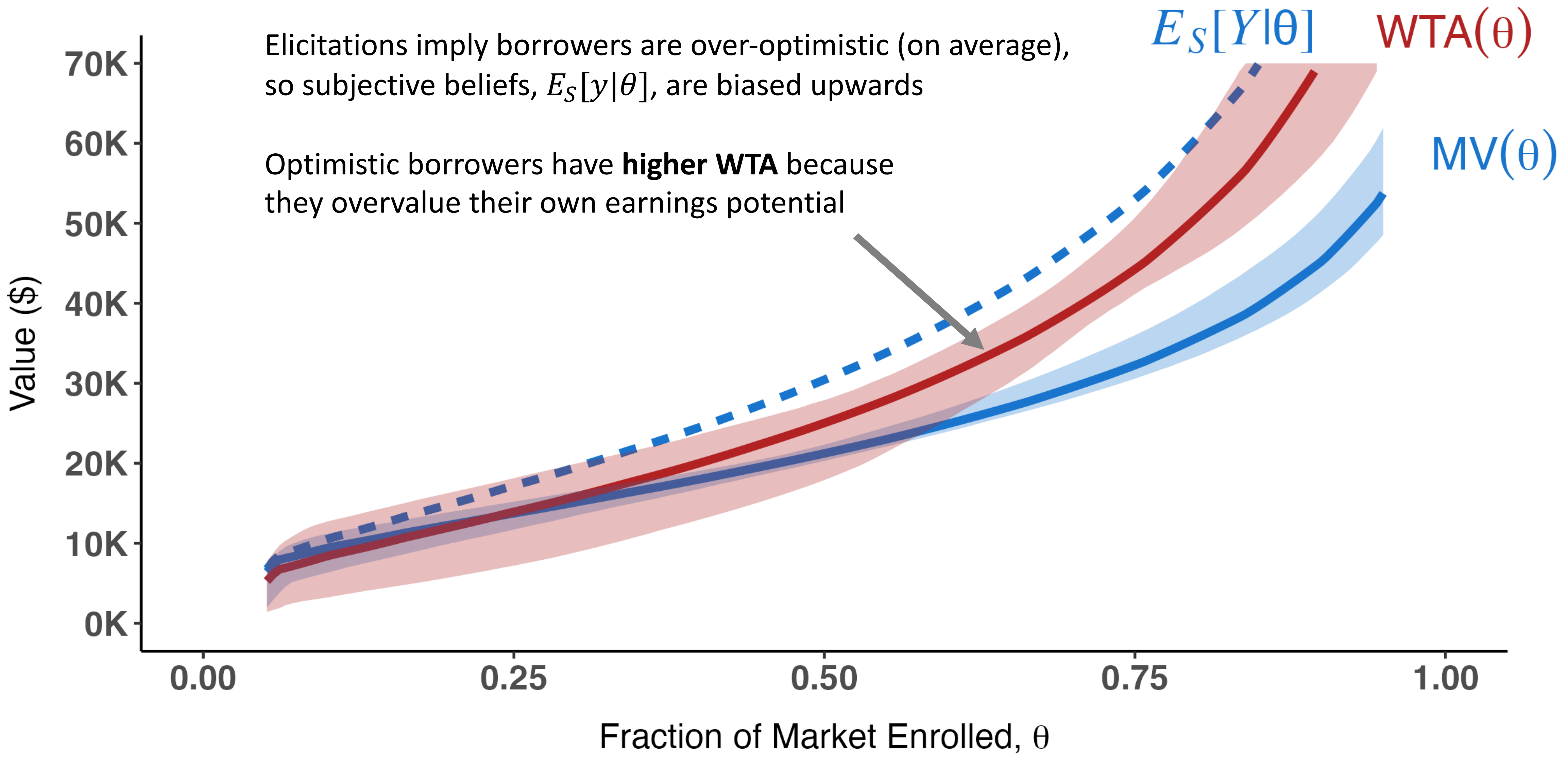
Belief

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

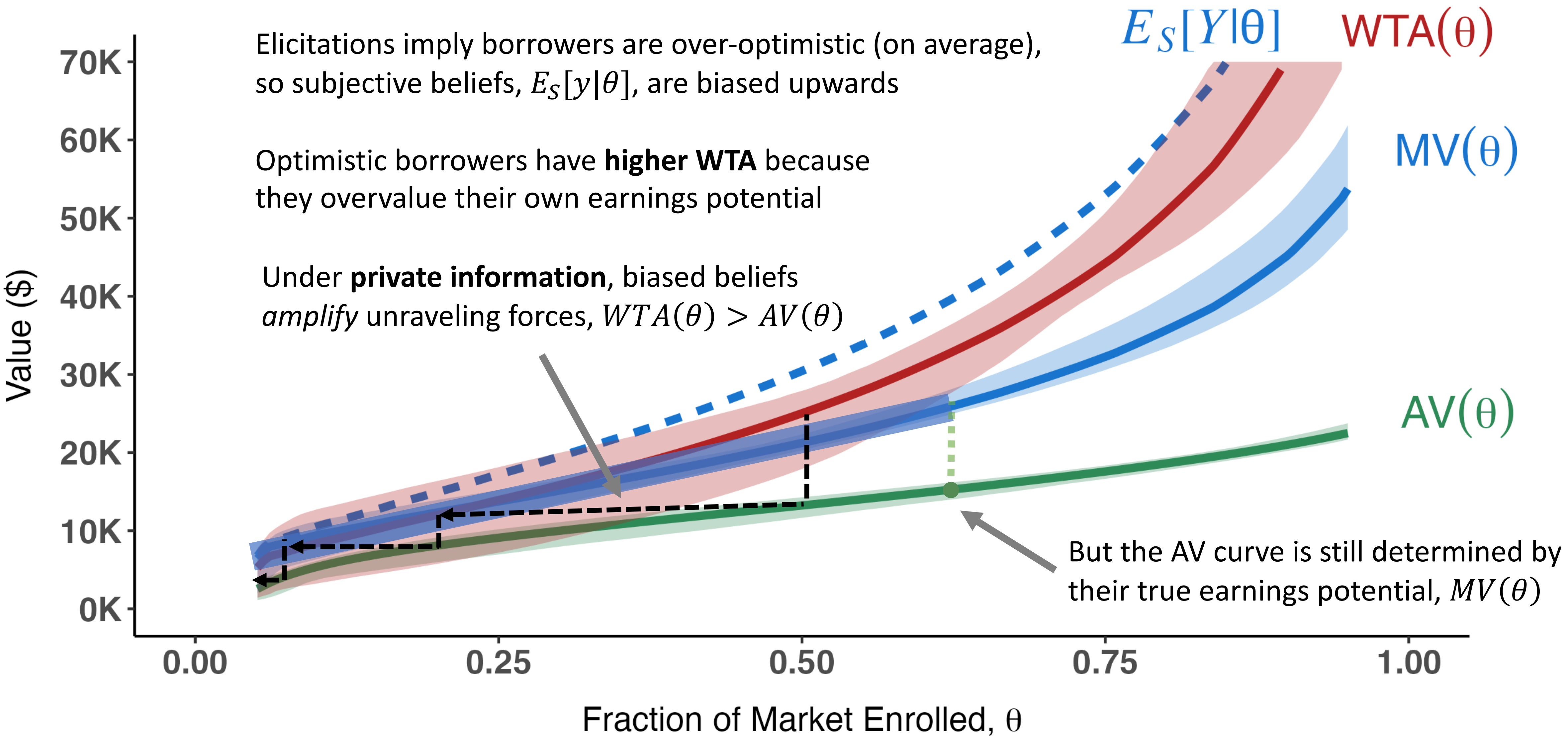
Unraveling of the Earnings-Equity Market (Biased Beliefs)



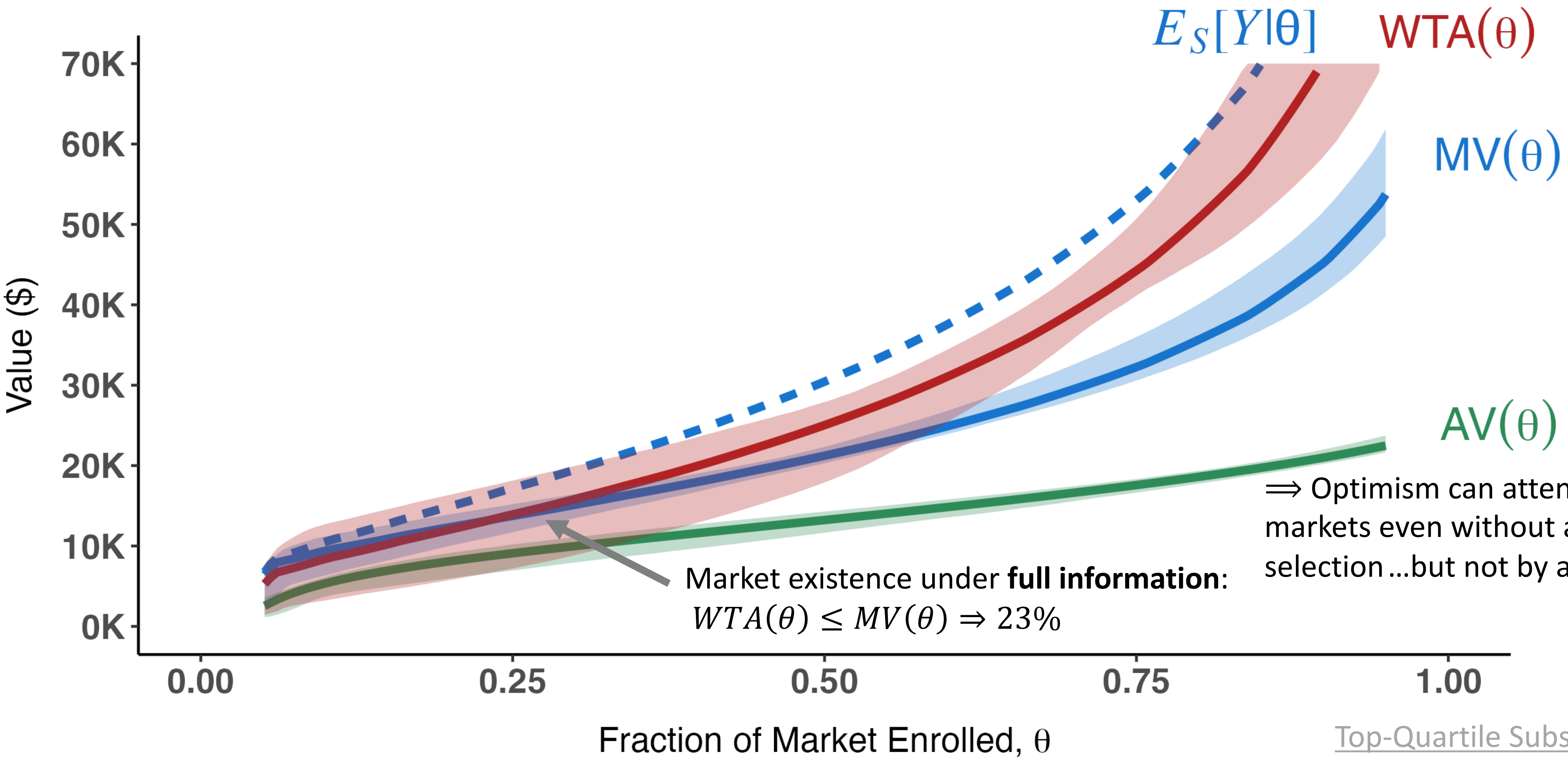
Unraveling of the Earnings-Equity Market (Biased Beliefs)



Unraveling of the Earnings-Equity Market (Biased Beliefs)



Unraveling of the Earnings-Equity Market (Biased Beliefs)



$\Longrightarrow$ Optimism can attenuate markets even without adverse selection…but not by as much

Top-Quartile Subsample

Completion-Contingent Loan

Outline

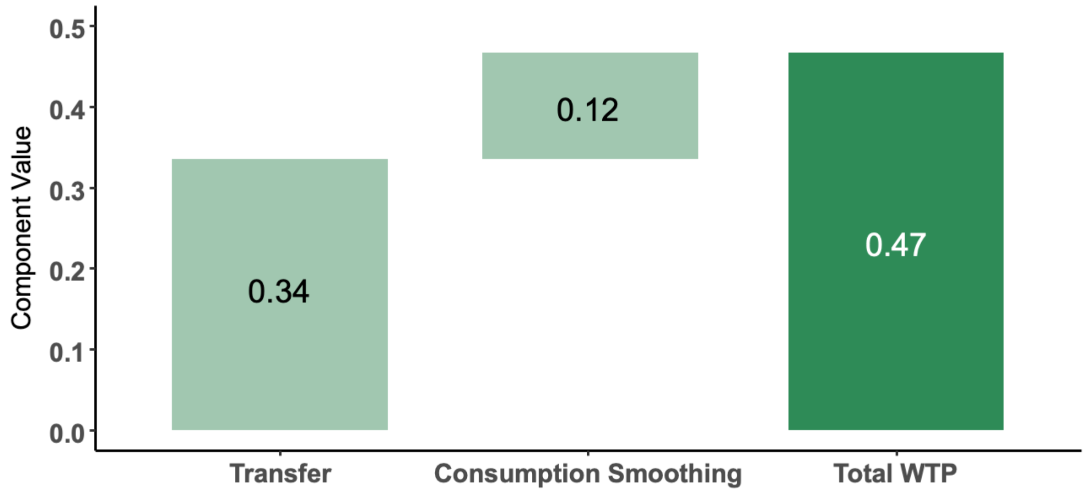
Measuring the Welfare Impact Using the MVPF

- **Marginal Value of Public Funds (MVPF)** on government subsidies for each contract:

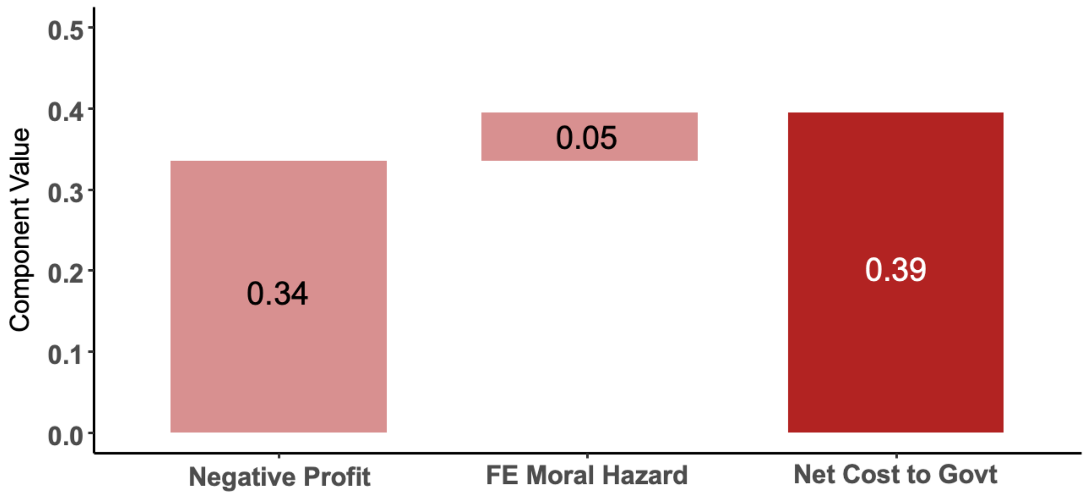
$$MVPF = \frac{Benefits}{Net\ Cost\ to\ Govt}$$

- $Benefits$: The aggregate amount borrowers would be willing to pay for the option to contract λ.
  - Net transfer from subsidy
  - Smoothing benefit from mitigating risk

- $Net\ Cost\ to\ Govt$: The aggregate amount spent, less program revenue or increased tax receipts
  - Net transfer from subsidy
  - Fiscal externalities from behavioral responses



Benefits of Subsidizing $1 Equity Contract



Net Costs of Subsidizing $1 Equity Contract

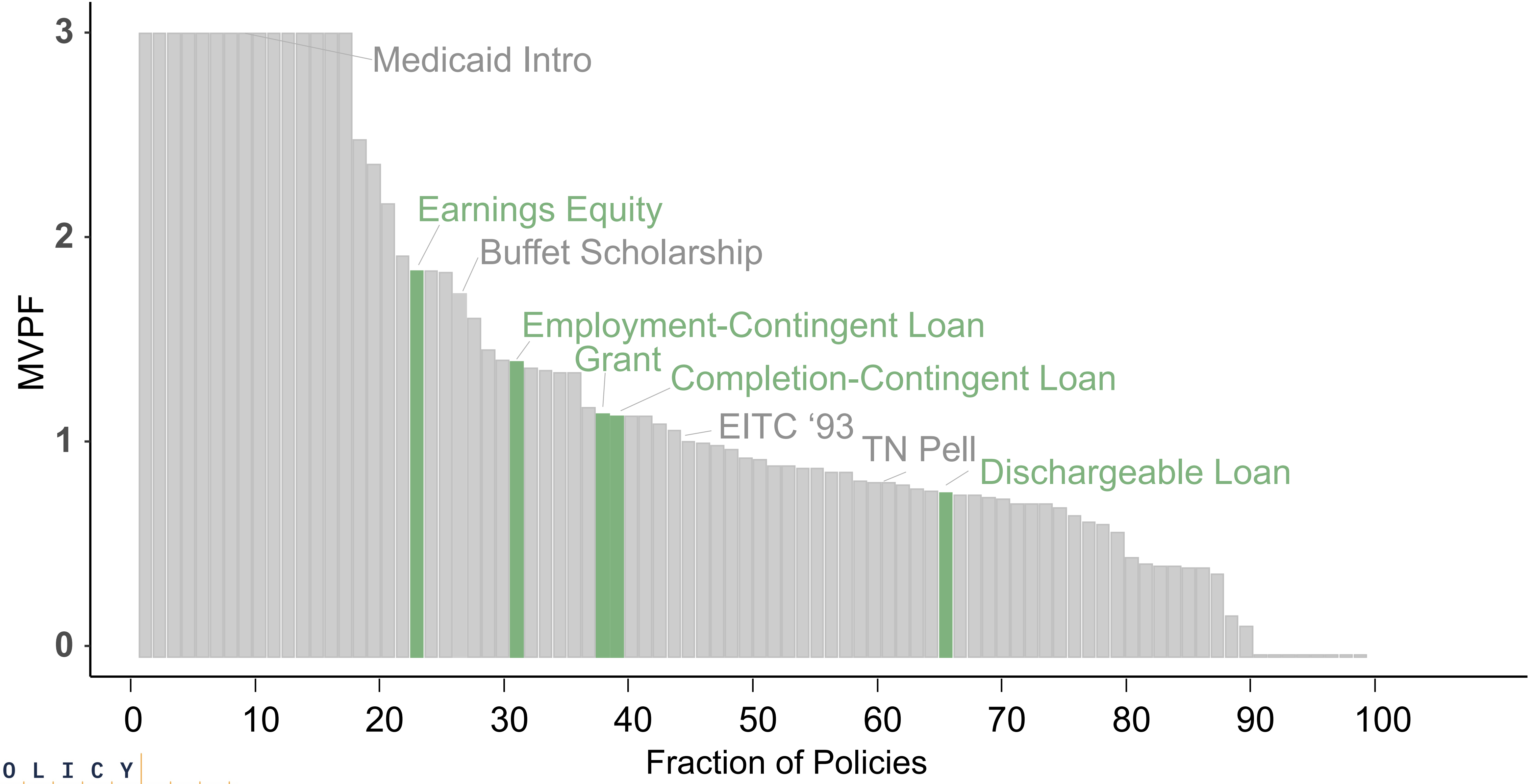
MVPF Details

MVPF Results

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
								No Human Capital Effects		*Human Capital Effects*	
Selection On...		Take-up	Transfer	Consumption Smoothing	WTP	FE Moral Hazard	FE Human Capital	Cost to Govt	MVPF	Cost to Govt	MVPF
Rational Beliefs	Earnings Equity	0.72	0.34	0.12	0.47	-0.05	0.45	0.39	1.19	-0.05	∞
		(0.01)	(0.03)	(0.01)	(0.03)	(0.00)	(0.01)	(0.03)	(0.04)	(0.03)	–
	Completion-Contingent Loan	0.52	0.27	0.10	0.37	-0.13	0.35	0.40	0.92	0.05	7.14
		(0.02)	(0.03)	(0.00)	(0.03)	(0.00)	(0.01)	(0.04)	(0.01)	(0.04)	–
	Employment-Contingent Loan	0.55	0.11	0.05	0.17	-0.10	0.36	0.21	0.78	-0.15	∞
		(0.03)	(0.05)	(0.00)	(0.05)	(0.00)	(0.01)	(0.05)	(0.04)	(0.06)	–
	Dischargeable Loan	0.44	0.60	0.03	0.63	-0.29	0.31	0.90	0.70	0.58	1.08
		(0.03)	(0.12)	(0.01)	(0.11)	(0.01)	(0.01)	(0.13)	(0.03)	(0.14)	(0.07)
	Grant	1.00	1.00	0.00	1.00	0.00	0.68	1.00	1.00	0.32	3.12
		–	–	–	–	–	–	–	–	–	–
Biased Beliefs	Earnings Equity	0.52	0.45	0.13	0.58	-0.04	0.35	0.49	1.17	0.14	4.11
		(0.04)	(0.05)	(0.05)	(0.10)	(0.00)	(0.02)	(0.04)	(0.09)	(0.06)	–

- MVPFs are generally greater than one, and largest for earnings-equity contract
- Magnitudes depend on how additional financing options influence human-capital investments

Comparison to MVPFs of Other Policies in the Policy Impacts Library



POLICY IMPACTS

Conclusion

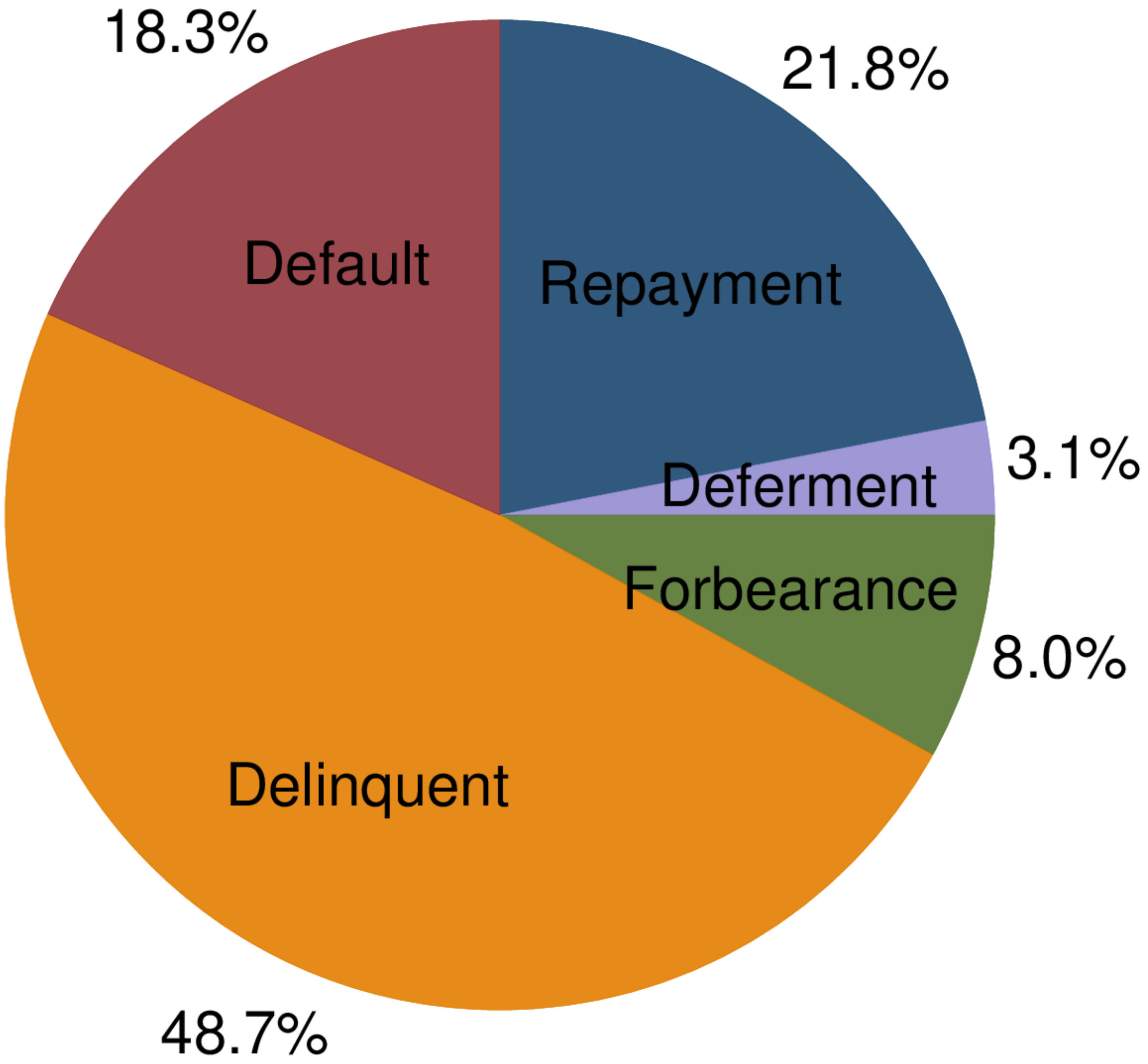
- Evidence of unraveling in several markets for financial contracts that mitigate college-going risks

- Suggests a high value to government policies promoting student loan alternatives, especially opt-in equity contracts

- Unraveling results and empirical approach may extend to other settings:
  - Household credit markets
  - Wage contracts
  - Other sources of idiosyncratic income risk

- More generally, results suggest that information frictions limit financial options and inhibit economic opportunity

Going to College in the US is Risky

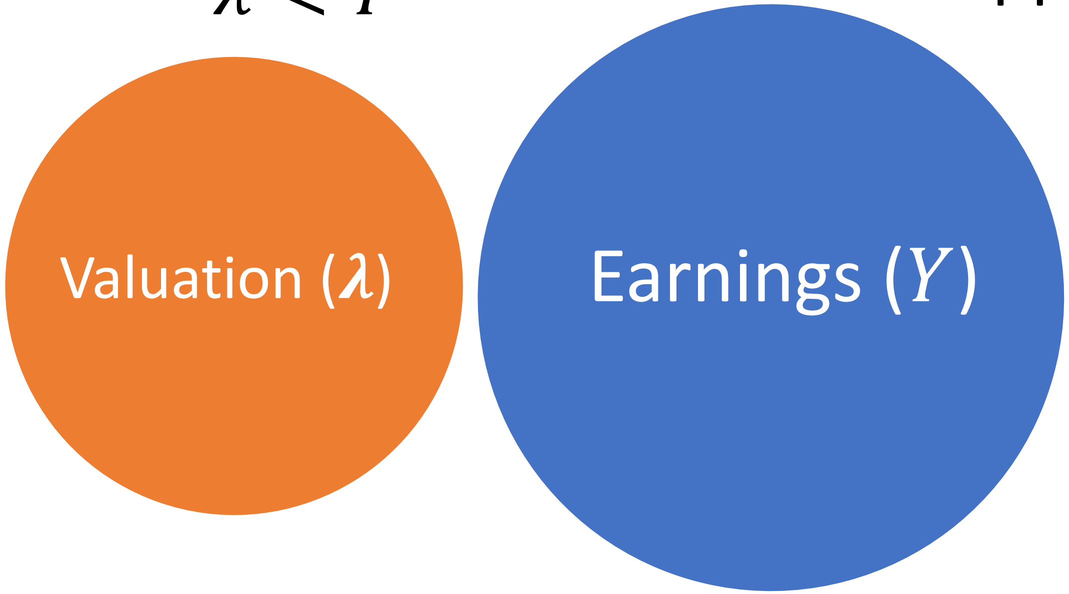


Most severe non-repayment event within six years of enrollment

Return

$\lambda < Y$

Suppose $\boldsymbol{\eta = 10\%}$

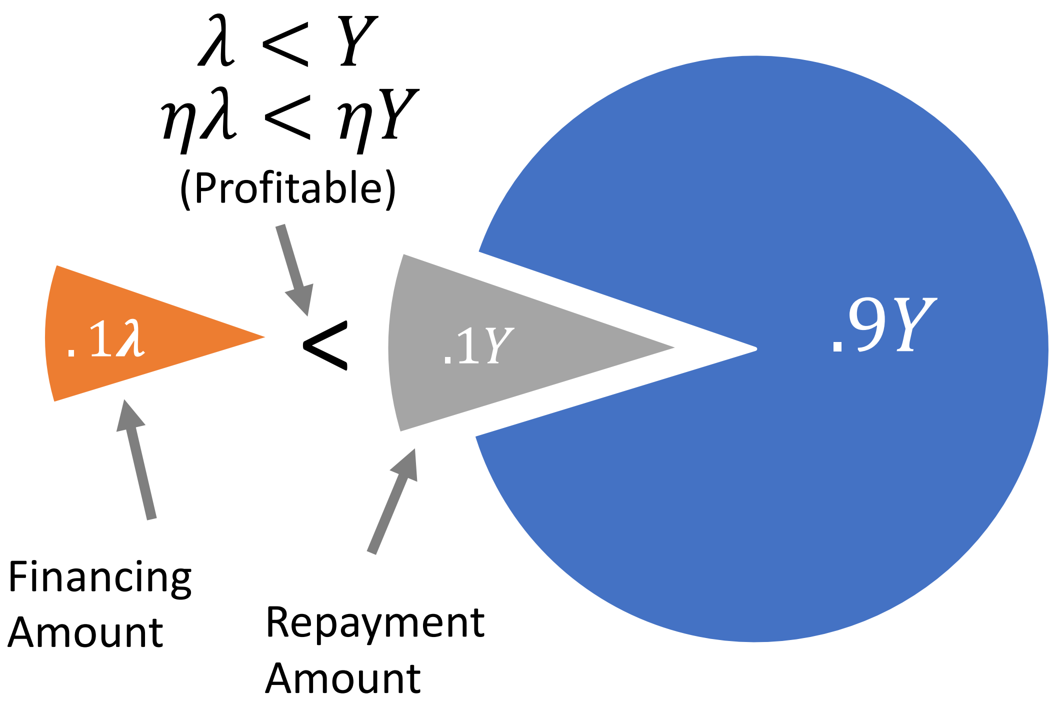


Contract Terms

$\boldsymbol{\lambda}$: valuation or "share price"
$\boldsymbol{\eta}$: "size" of claim on Y

Return

$\eta = 10\%$



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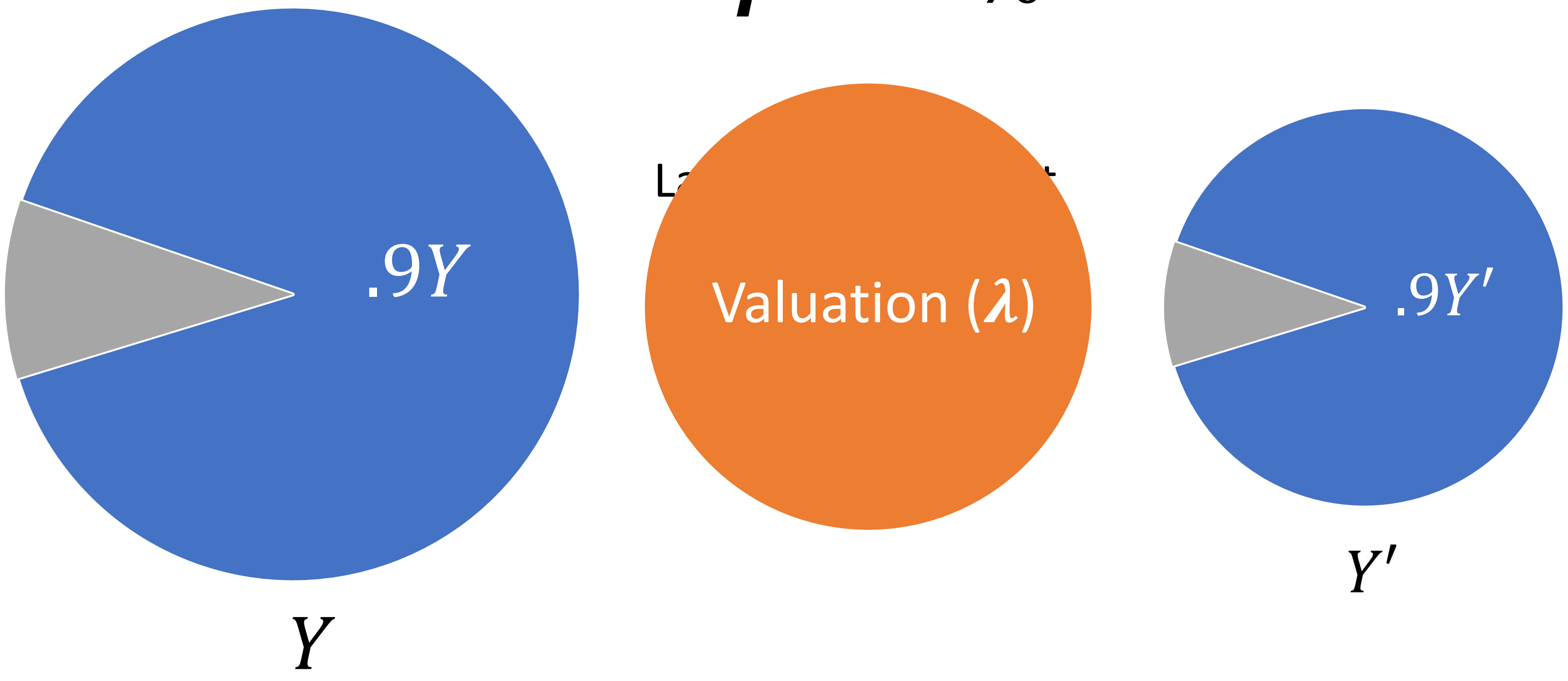
Return

$\boldsymbol{\eta = 10\%}$

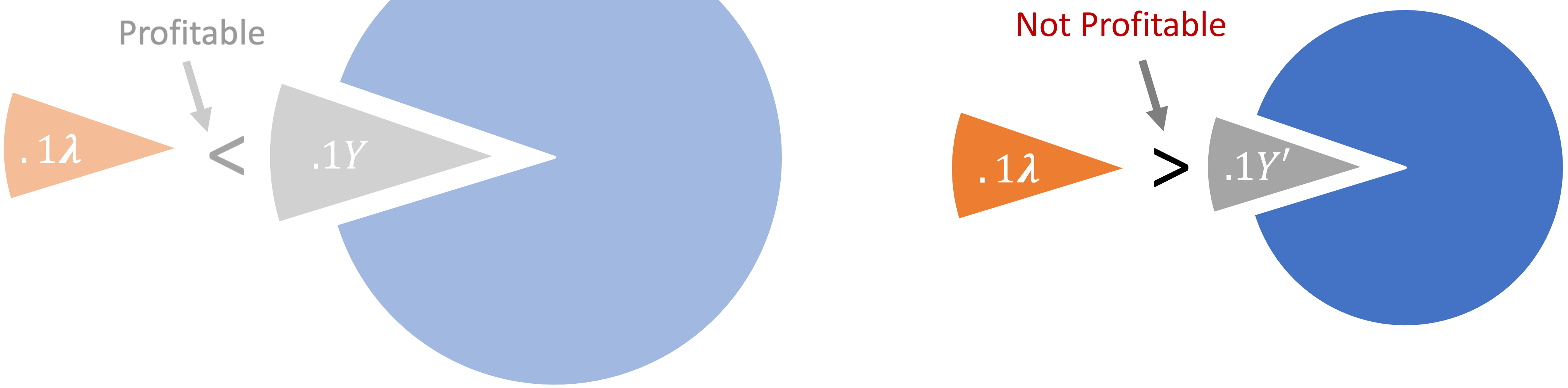


But if the borrower only keeps 90% of their income, the contract could induce a behavioral response…

…which might reduce total earnings below the contract's valuation, $Y' < \lambda$

Return

$$\boldsymbol{\eta = 10\%}$$



But if the borrower only keeps 90% of their income, the contract could induce a behavioral response…

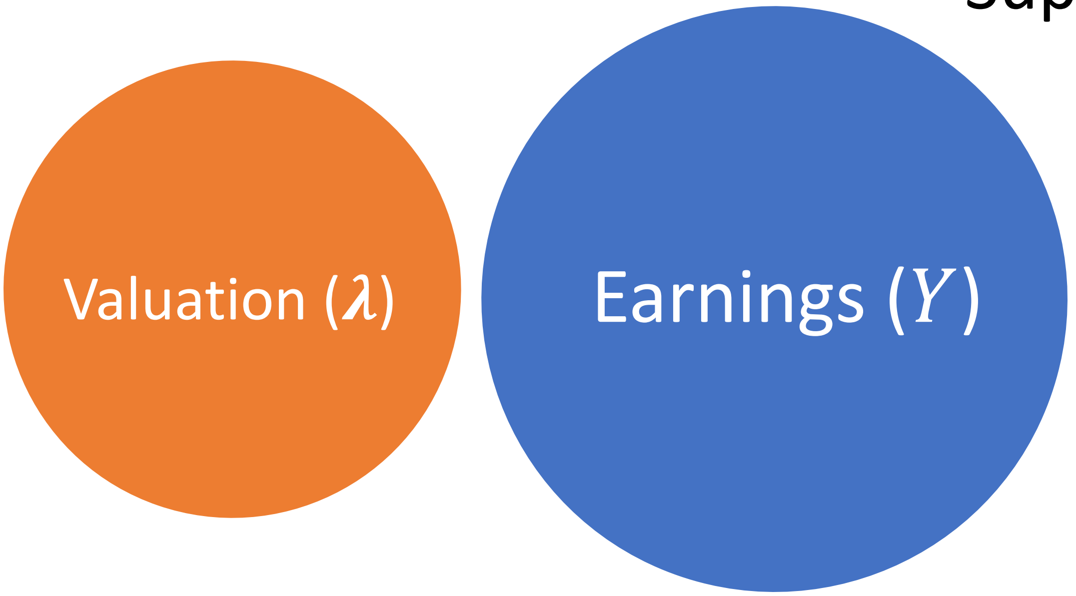
…which might reduce total earnings below the contract's valuation, $Y' < \lambda$

$\Rightarrow$ profits < 0

Return

$\Rightarrow$ Moral hazard might make $\eta = 10\%$ equity contracts unprofitable
$\not\Rightarrow$ Moral hazard makes any equity contract unprofitable…

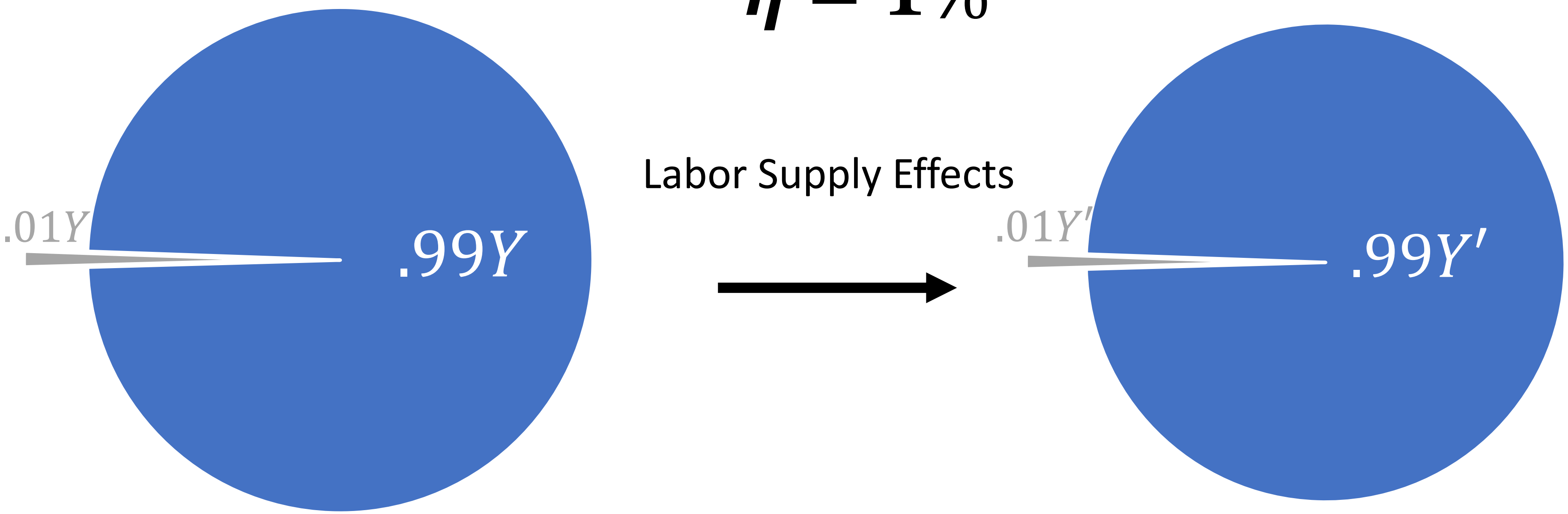
Suppose $\boldsymbol{\eta = 1\%}$



Return

If the borrower keeps *99%* of their income, the same labor-supply elasticity would induce a **much smaller behavioral response**…

$$\boldsymbol{\eta = 1\%}$$

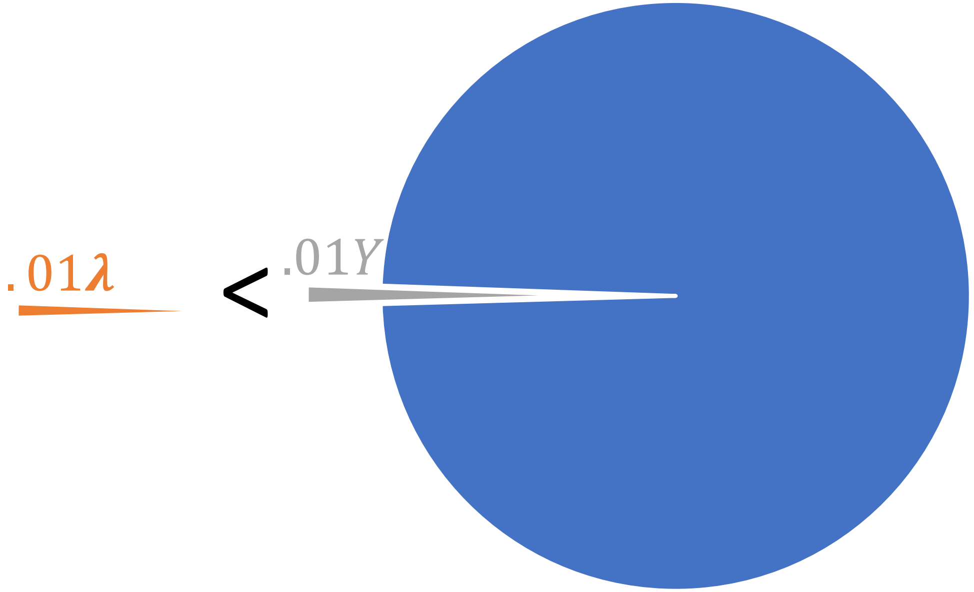


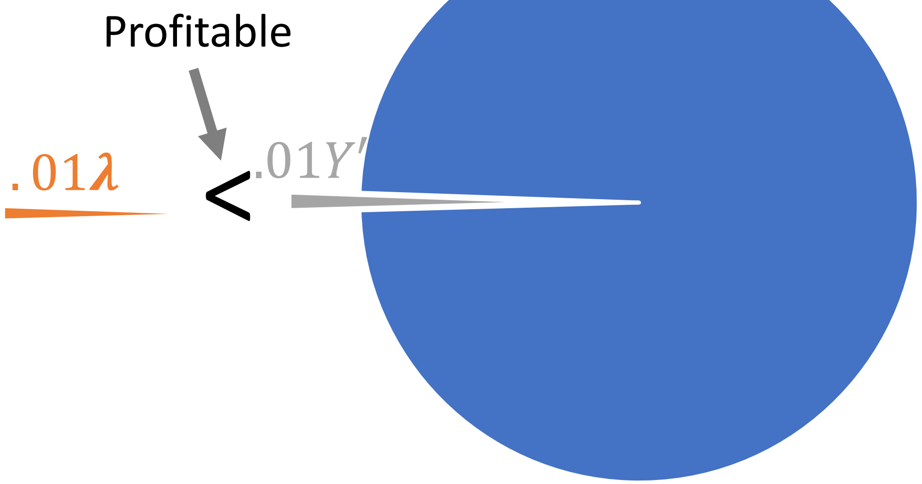
Return

If the borrower keeps *99%* of their income, the same labor-supply elasticity would induce a **much smaller behavioral response**…

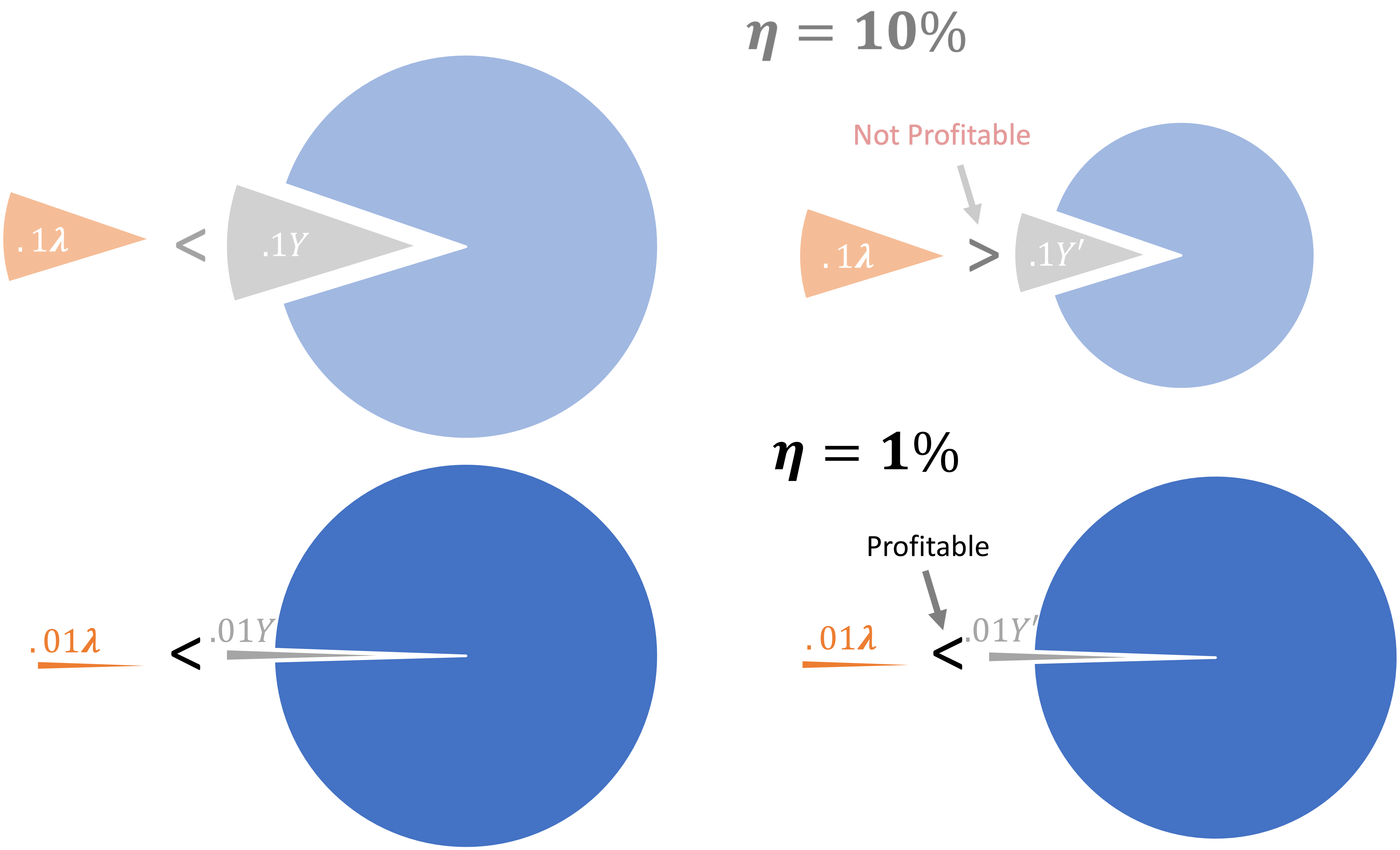
…which has a negligible impact on the financier's profits.

$$\eta = 1\%$$

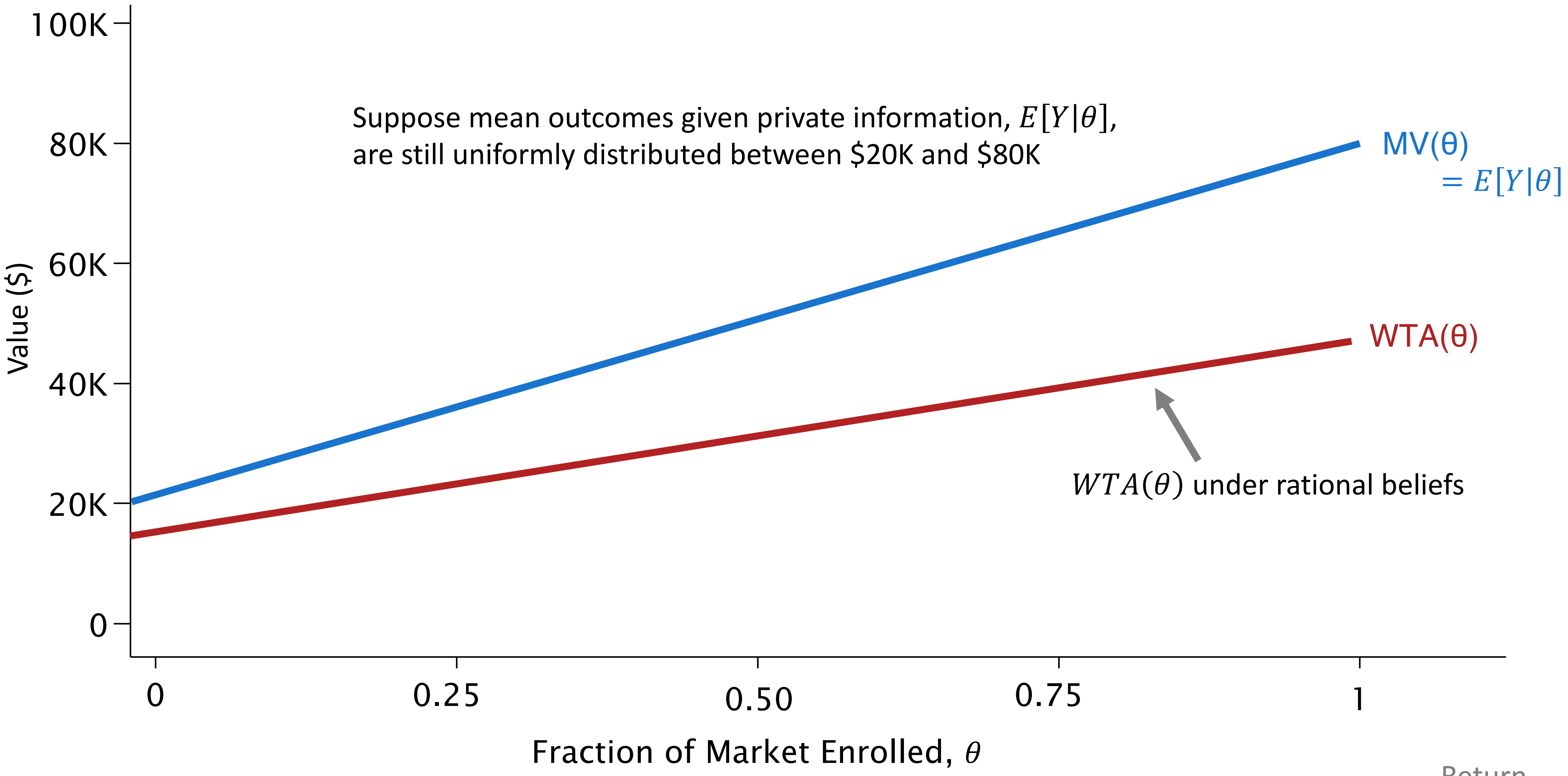




Return

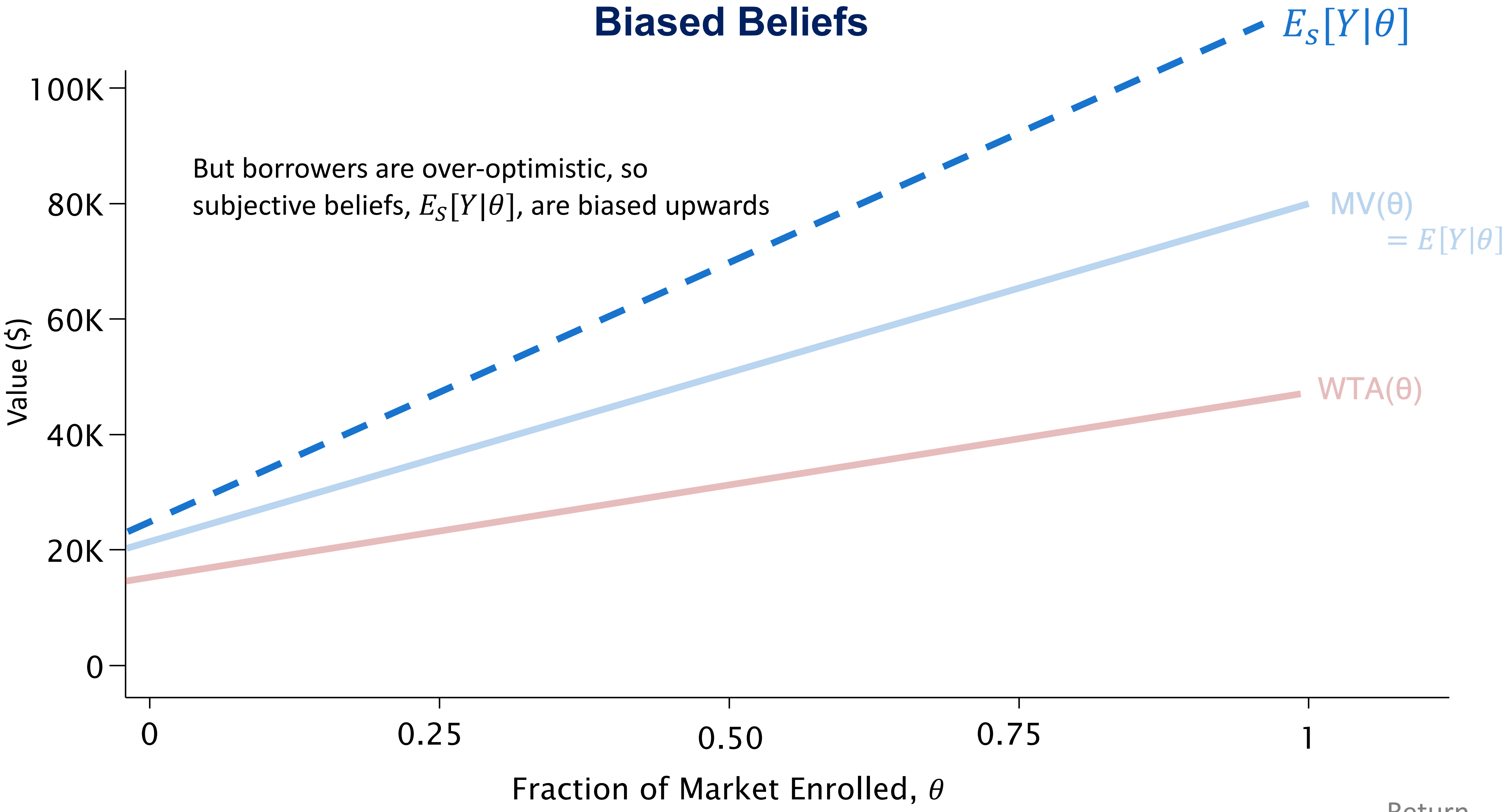

$\eta = 10\%$
$.1\lambda$ < $.1Y$
Not Profitable
$.1\lambda$ > $.1Y'$
$\eta = 1\%$
$.01\lambda$ < $.01Y$
Profitable
$.01\lambda$ < $.01Y'$

Biased Beliefs



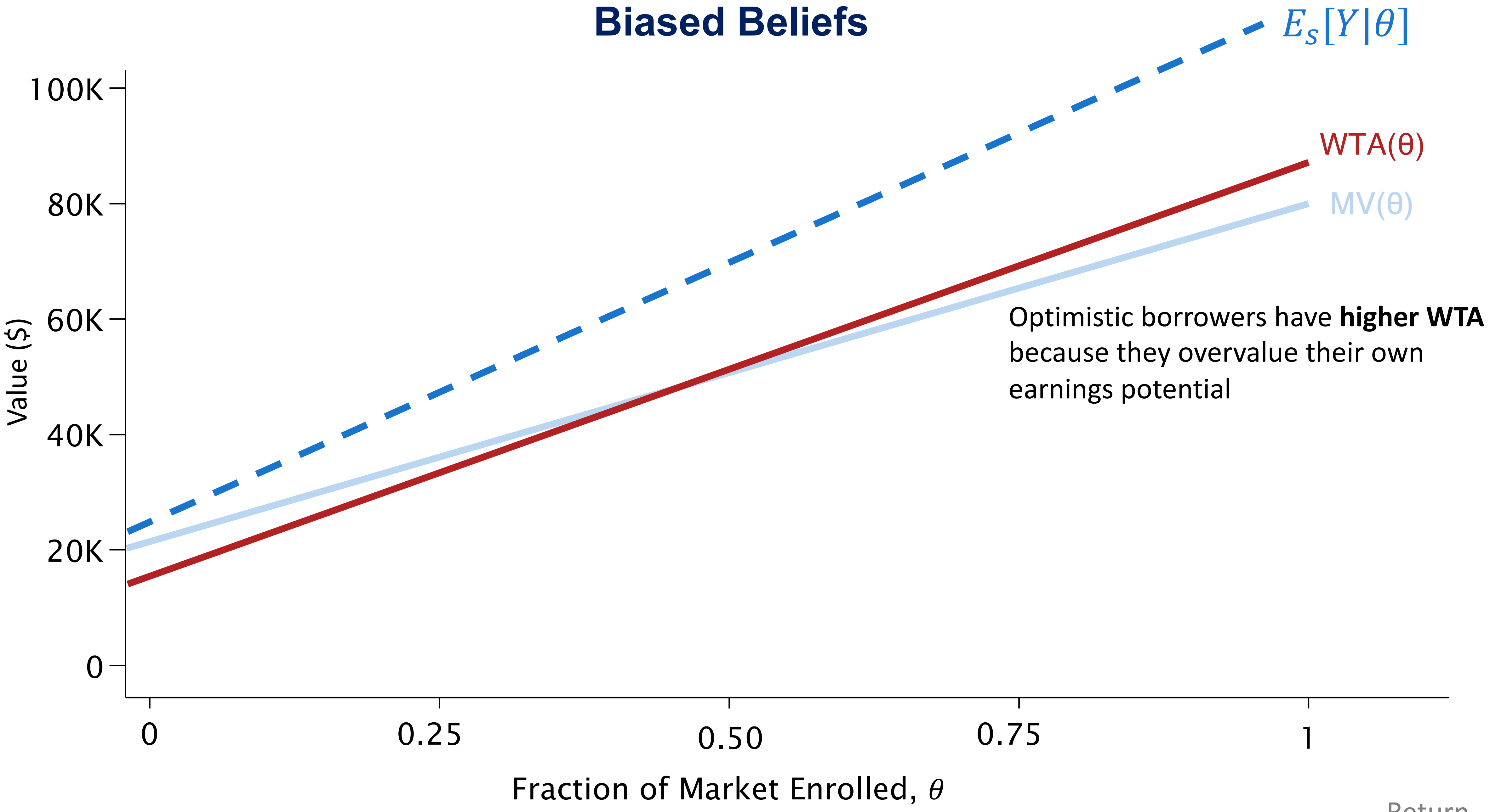
Return

Biased Beliefs



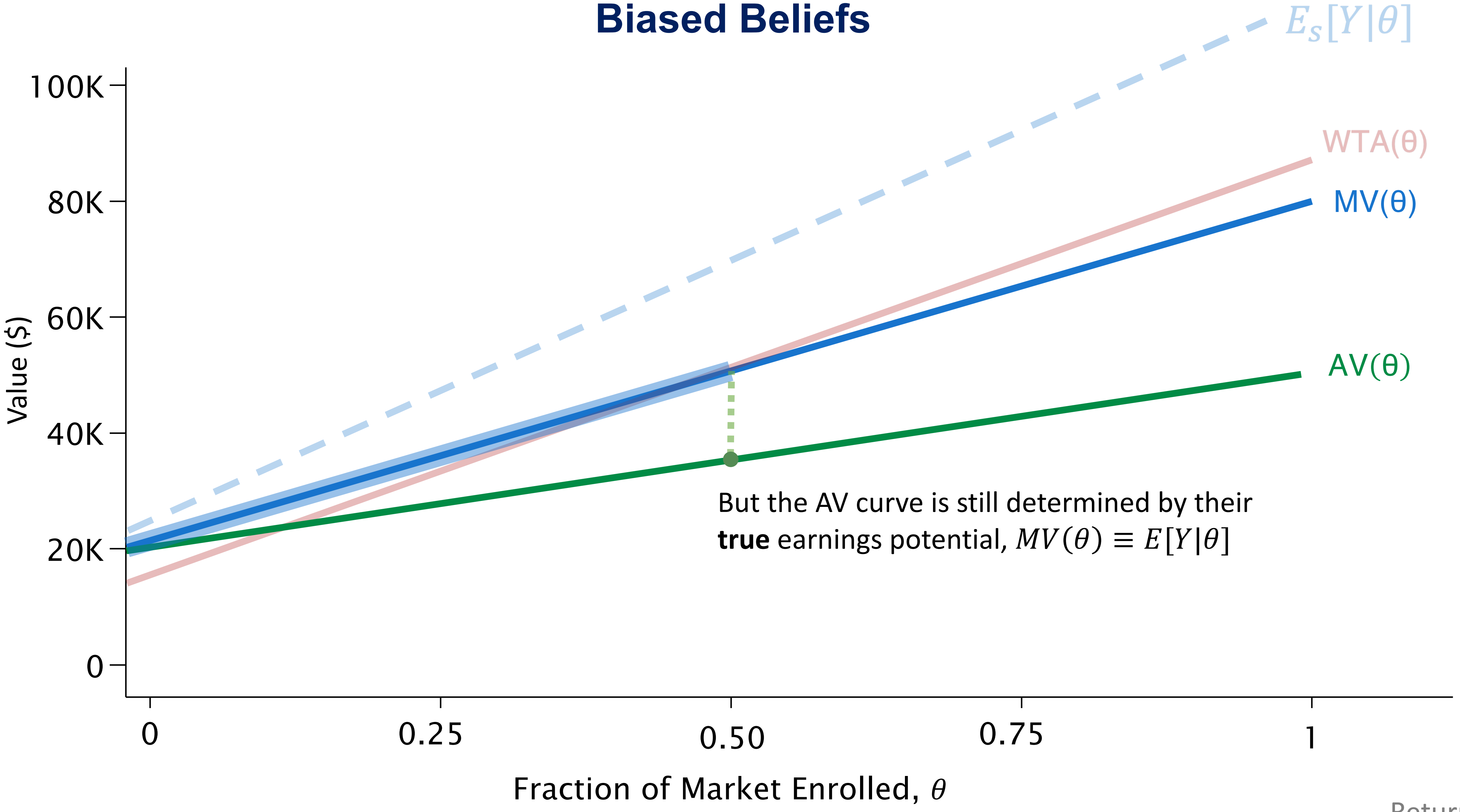
Return

Biased Beliefs



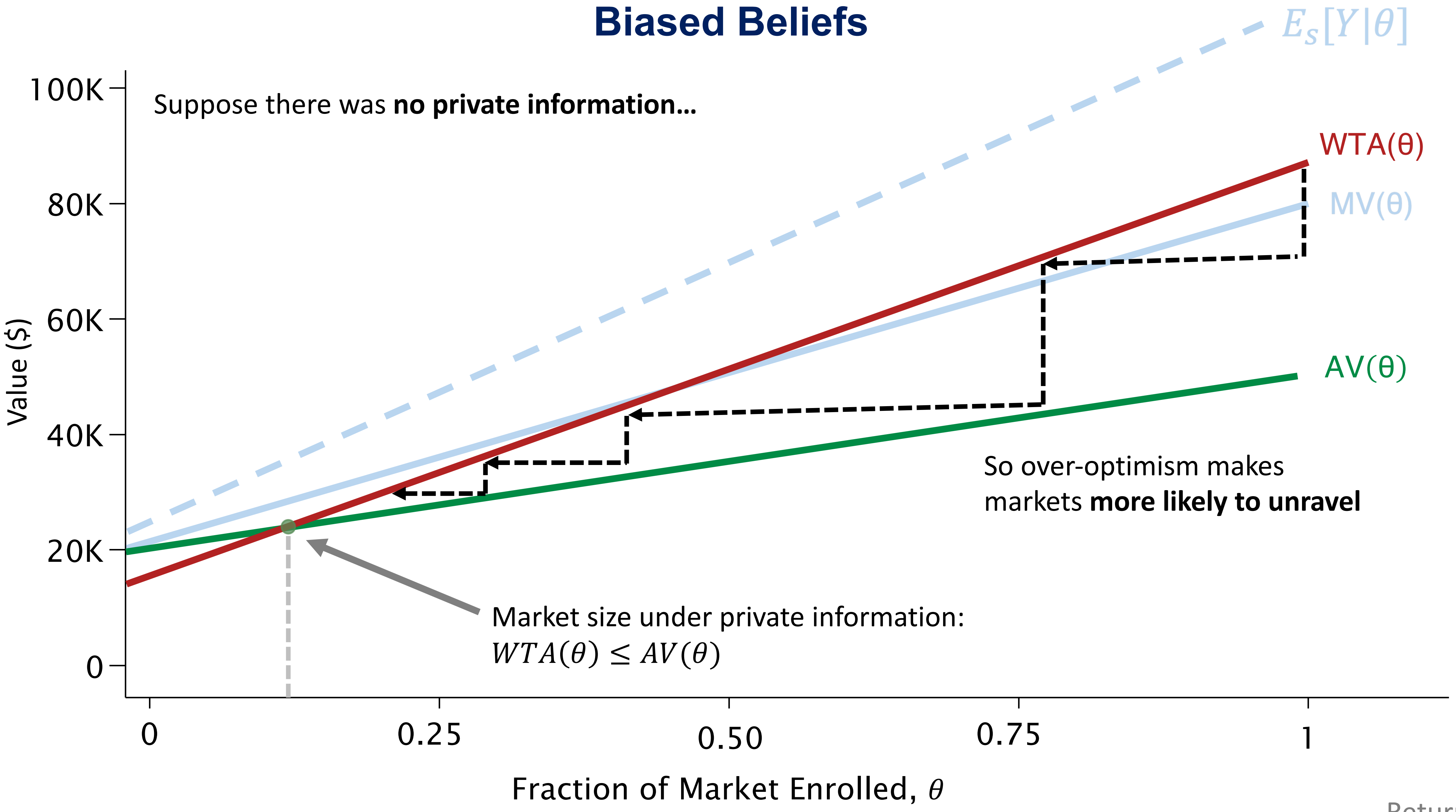
Return

Biased Beliefs



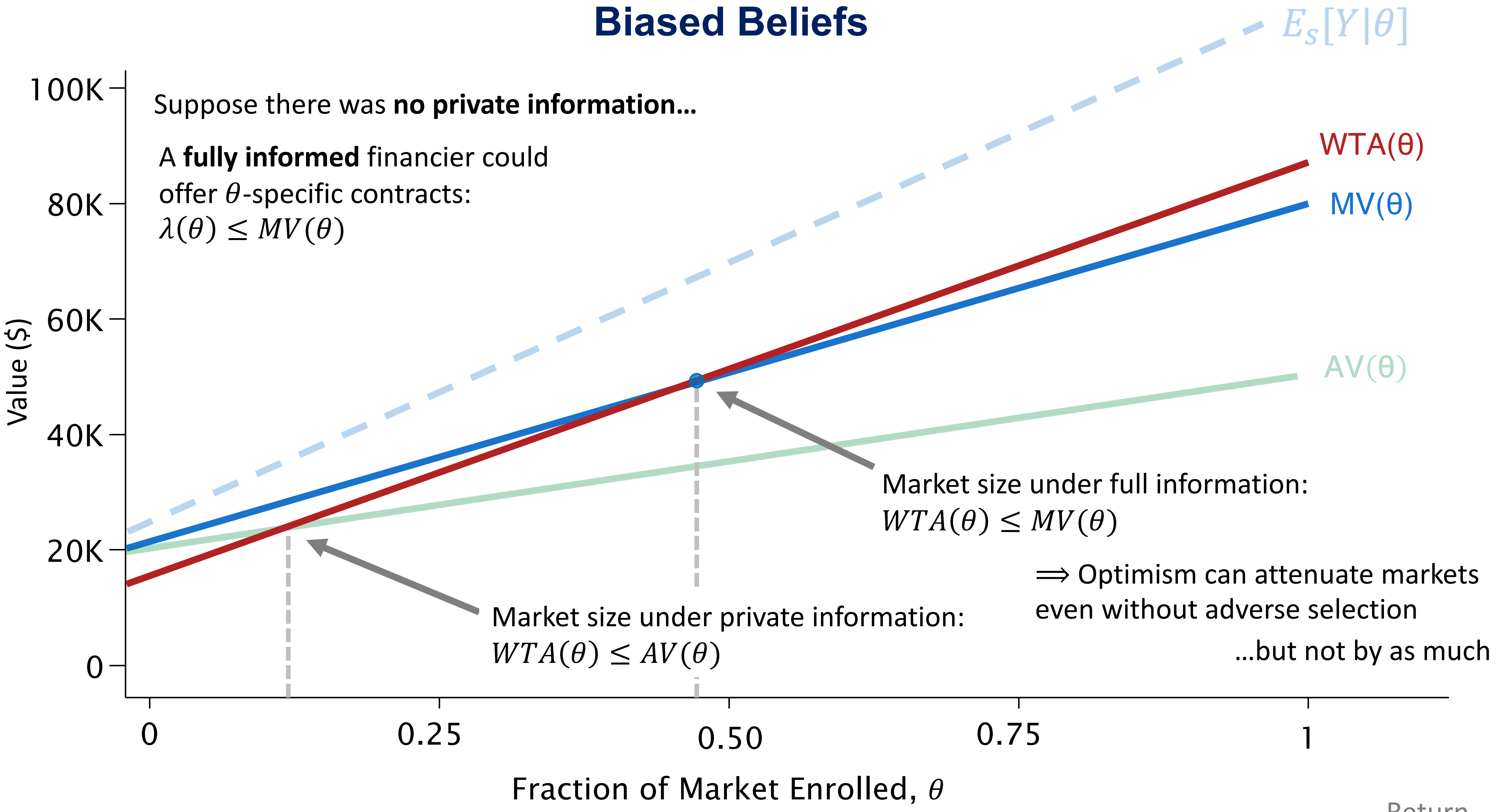
Return

Biased Beliefs



Return

Biased Beliefs



Return

Elicitation Summary Statistics

Category	Variable	Mean	SD
	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
Elicitations	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

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

Observable Variables Summary Statistics (2/2)

Category	Variable	Mean	SD
	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
Institution	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

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

Step 1: Estimate Conditional Expectation Functions, E[Y|X,Z] and E[Y|X]

We use ML techniques to estimate $E[y|X]$ and $E[y|X,Z]$ as flexibly as possible

1. Split data in to 70% training sample and 30% holdout sample

2. Train random forest model using different sets of predictor variables
   - $E[y|X]$: Use public information in training sample to predict y
   - $E[y|X,Z]$: Use public + private information in training sample to predict y

3. Form predictions $E[\widehat{y|X,Z}]$ and $E[\widehat{y|X}]$ using 30% holdout sample

<u>Random Forest Algorithm</u>:

`mtry` chosen using 10-fold cross validation on training set

`ntree` = 5,000

Return

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

Constructing beliefs about salary

1. Use linear deconvolution to recover beliefs about log salary, $\tilde{\mu}_\theta$, and expectational error, ϵ

$$\log y = \tilde{\mu}_\theta + \epsilon$$

2. Recover beliefs of conditional salary

$$E[y > 0|\theta] = \int \exp(\tilde{\mu}_\theta + \epsilon) dF_\epsilon$$

3. Use MLE method to recover beliefs about binary employment, $Pr(y > 0|\theta)$

4. Combine belief estimates of employment and conditional salary

$$E[y|\theta] = Pr(y > 0|\theta) E[y|\theta, y > 0]$$

Single index assumption: those with higher beliefs about employment also have higher expected salaries.

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 $\mathrm{z}_{ij} = h_j(z_{ij}^*)$ where

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

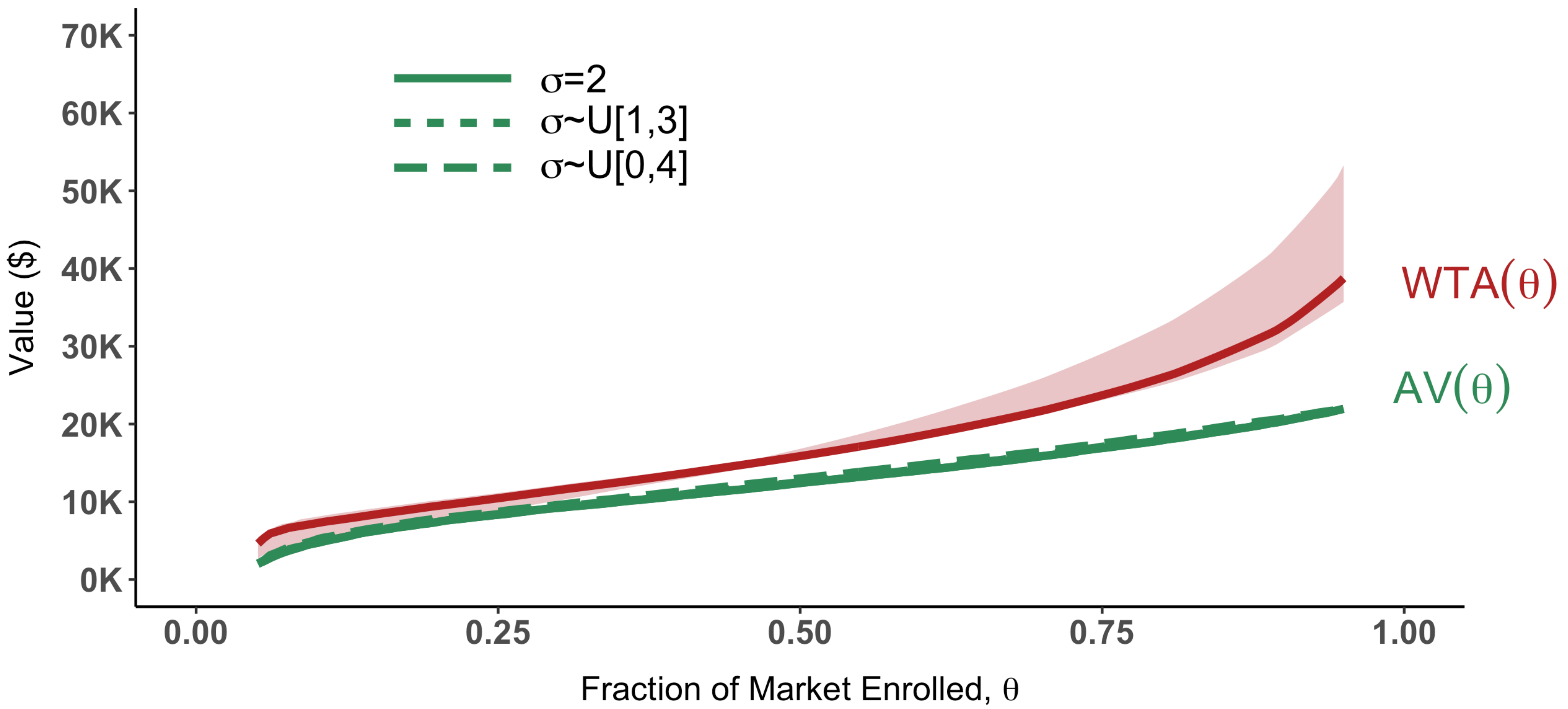
  - $h_j(\cdot)$ depends on setting: e.g. if z on 1-5 scale→ $h_j(\cdot)$ is an ordered probit
  - Allowing $\gamma \neq 1$ allows elicitations to not correspond to outcome y

- 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

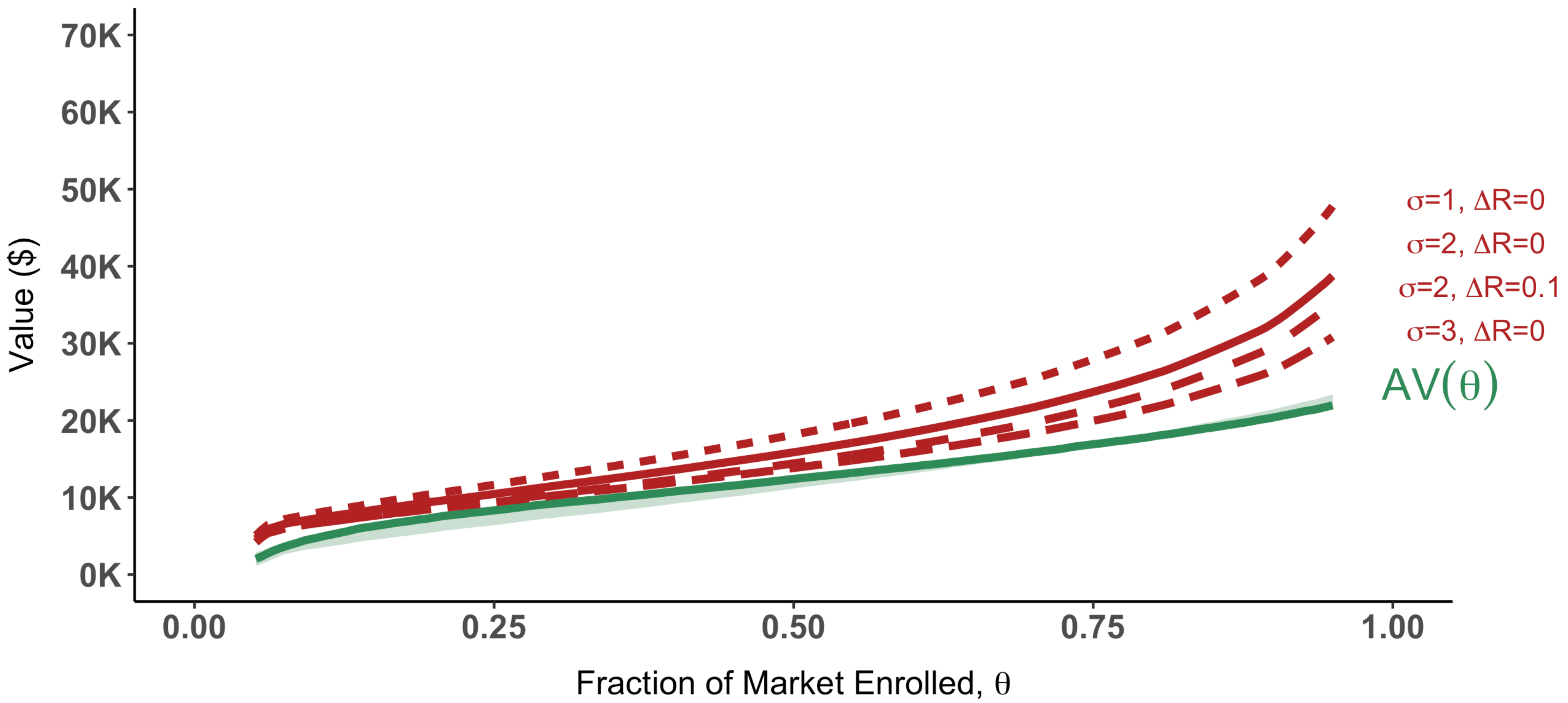
Return

Preference Heterogeneity



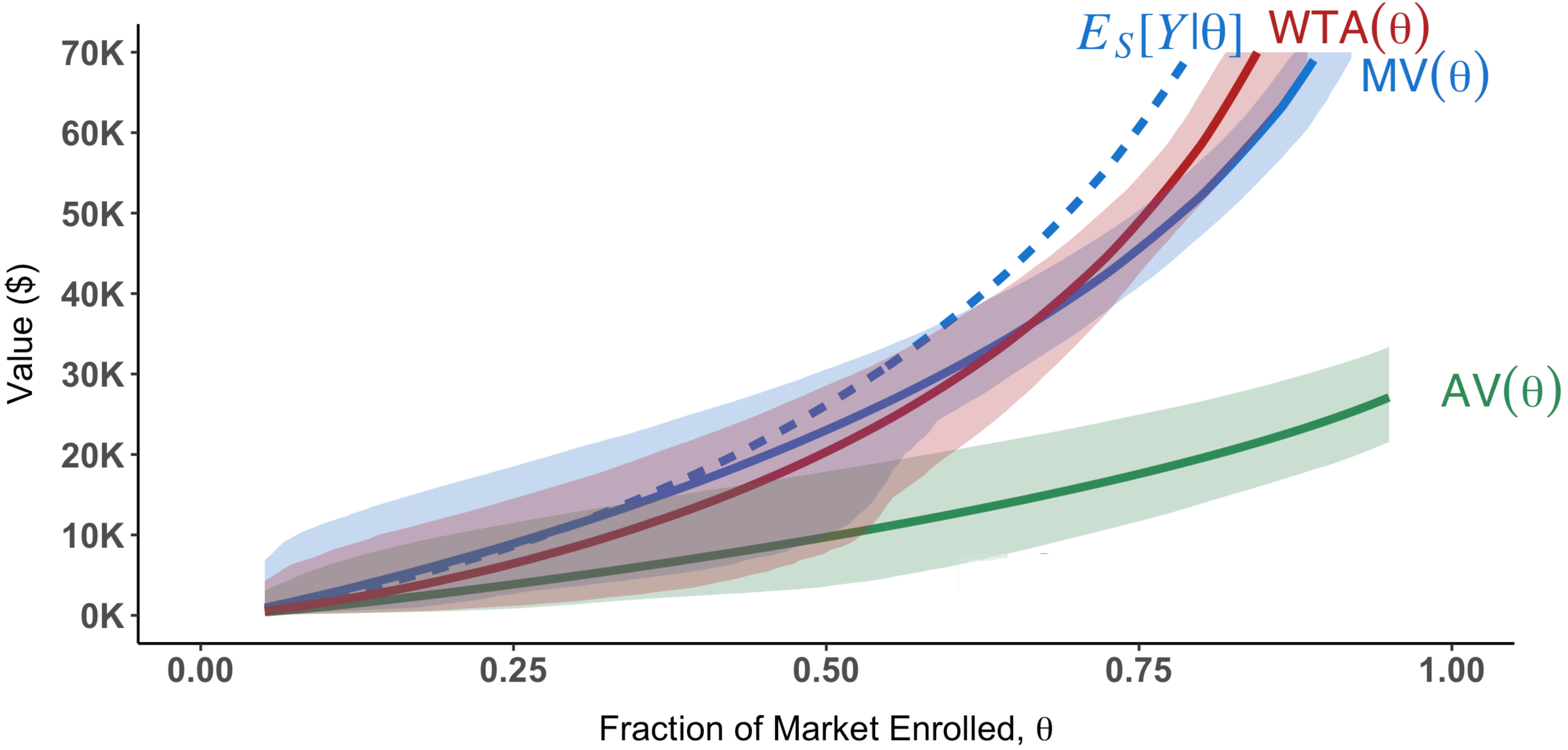
Return

WTA Under Alternative Risk Aversion and Interest Rates



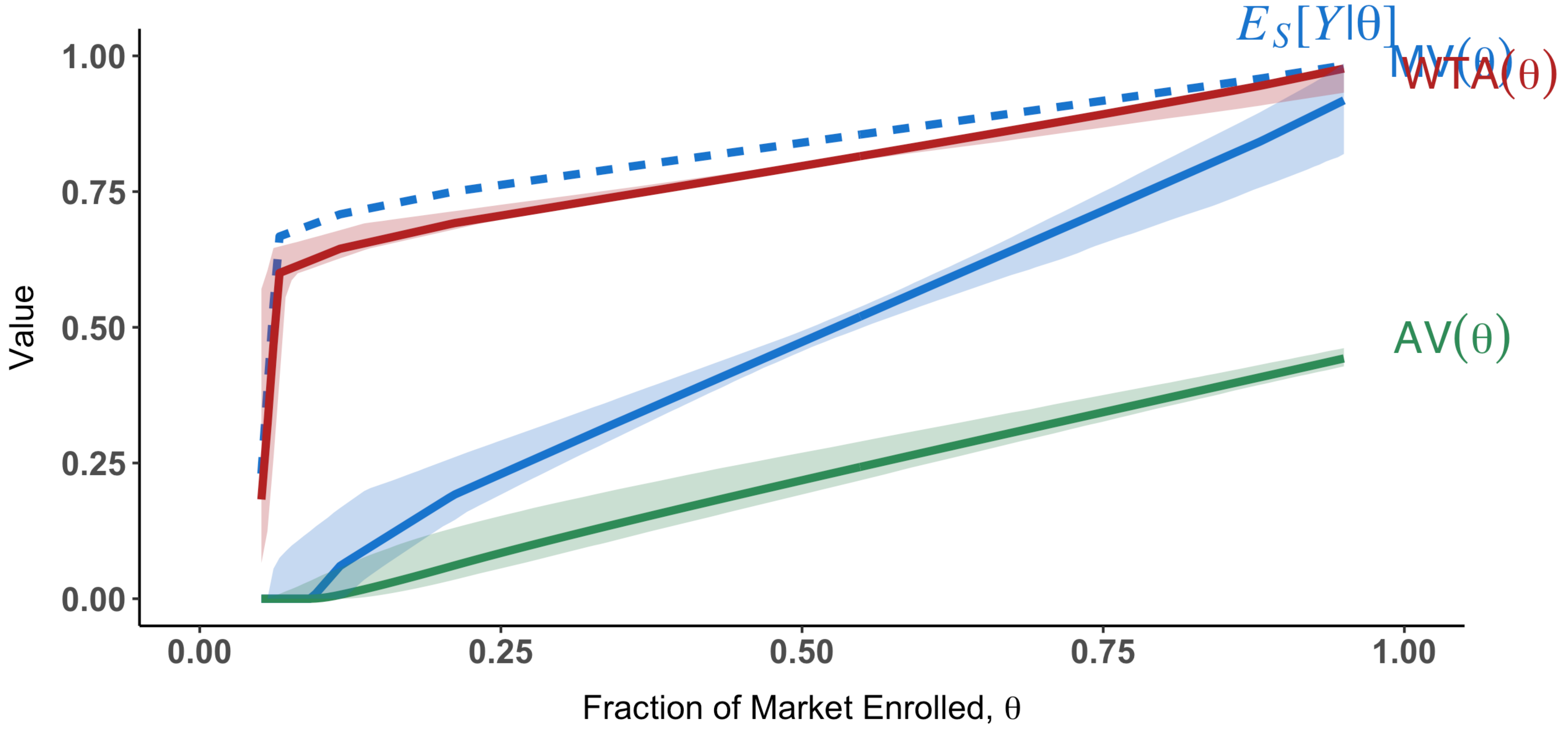
Return

Unraveling of the Earnings-Equity Market (Biased Beliefs): Top-Quartile $E[Y|X]$



Return

Unraveling of Completion-Contingent Loan Market (Biased Beliefs)



Return

Alternative Explanations for Missing Markets

- Moral Hazard
- Outside Credit / Subsidized Student Loans
- Biased Beliefs / Optimism
- Income verification / Enforceability
- Illegal / “Indentured Servitude”

Measuring the MVPF: Borrowers' Benefits

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

$$\begin{aligned} V(\theta) &= \lambda - WTA(\theta) \\ &= \underbrace{\lambda - E[y|\theta]}_{\text{Transfer}} + \underbrace{E[y|\theta] - WTA(\theta)}_{\text{Consumption Smoothing}} \end{aligned}$$

  - *Transfer*: Net transfer from financer $\longrightarrow$ 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 $WTA(\theta)$

Return

Measuring the MVPF: Net Cost to Government

- Net cost to government for equity contract:

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

- 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)

Return

Related Work

- Information asymmetries in household finance:
  - Akerlof (1970); 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)
- Belief measurement and estimation
  - Hendren (2013, 2017); Conlon et al. (2018); Gong et al. (2019); Guvenen (2007); Wiswall and Zafar (2021); Arcidiacono et al. (2020); Stantcheva (2020); Bursztyn et al. (2020)
- Earnings risk and college financing:
  - Friedman (1955); Nerlove (1975); Palacios (2004); Chapman (2006); Field (2009); Barr et al. (2017); Abraham et al. (2018); Bachas (2019); Mumford (2020); Britton and Gruber (2020); Mueller and Yannelis (2020); Herbst (2021); Cox et al. (2018)
- Optimal taxes/subsidies for human capital
  - Mirrlees (1978); Bovenberg and Jacobs (2006); Jacobs and van Wijnbergen (2007); Stantcheva (2017)