# 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
  - Almost half 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 student borrowers, 67% experienced delinquency or default on their student loans by 2017
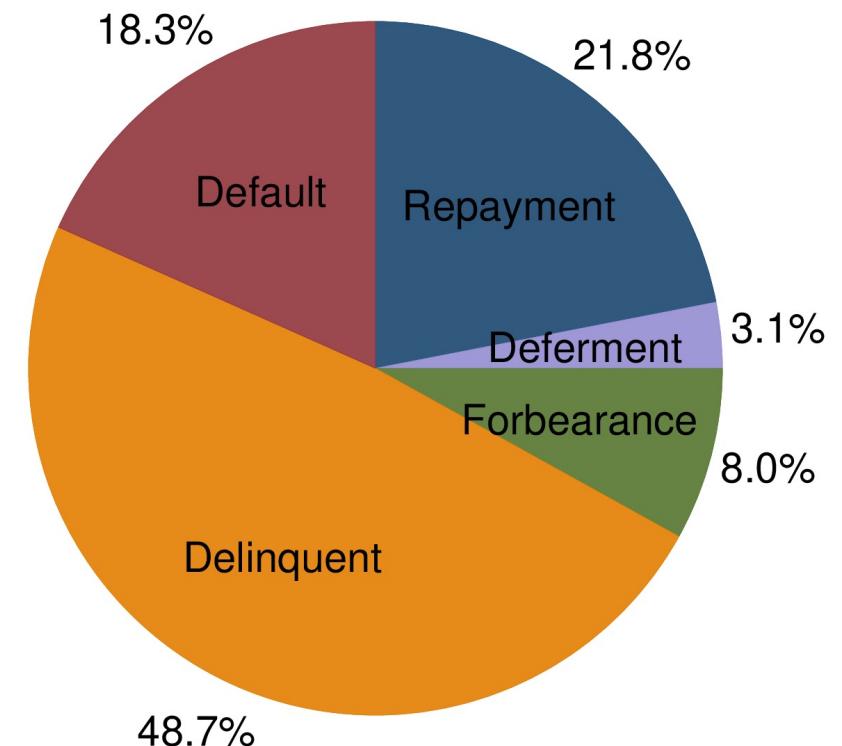


Most severe non-repayment event within six years of enrollment

# 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

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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

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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 > earnings disincentive

# 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)

# 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**

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# Model of Market Unraveling



Value ($)

Each type $\theta$'s privately
expected earnings, $E[y|\theta]$

"Type" $\theta$ = quantile of privately expected earnings

Fraction of Market Enrolled, $\theta$

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



Example: suppose $E[y|\theta]$ is uniformly distributed between \$20K and \$80K

E[y|θ]

Value (\$)

Fraction of Market Enrolled, $\theta$

# Willingness to Accept: $WTA(\theta)$



A hypothetical contract offers lump sum of $\eta\lambda$ in exchange for an $\eta$-share "stake" in post-college earnings, $\eta y$

$\eta$: "size" of the contract
$\lambda$: "valuation" or "share price"

WTA(θ): the minimum offer ($\lambda$) that type $\theta$ is **willing to accept** to give up a share of future earnings ($y$)

E[y|θ]

Risk Discount: $-cov\left(y, \frac{u_y}{E[u_y|\theta]}|\theta\right)$

WTA(θ)

$$WTA(\theta) = \frac{E[yu_y|\theta]}{E[u_y|\theta]}$$

Risk-averse borrowers are willing to accept lump sum financing that is lower than what they expect to pay out of post-college earnings

Note: sufficient to consider "small" contracts, $d\eta$, because the first dollar of insurance provides the highest potential market surplus (Hendren 2017)

Benchmark assumption: $R = 0$, so $u_{y_1}(\theta) = E[u_{y_2}|\theta]$

Value ($)

Fraction of Market Enrolled, $\theta$

# Can Financiers Make Profits?



Median borrower expects to earn $50K

But contract $\lambda$ also attracts those expecting lower earnings

$E[y|\theta]$

$WTA(\theta)$

Suppose financier sets price so that 50% are willing to accept

Benchmark assumption: unidimensional heterogeneity, so $WTA(\theta) > WTA(\theta') \Leftrightarrow E[y|\theta] > E[y|\theta']$

Value ($)

100K
80K
60K
40K
$\lambda$
20K
0

0          0.25          0.50          0.75          1

Fraction of Market Enrolled, $\theta$

# Average Value Curve, $AV(\theta)$



AV(θ): The **average value** of expected $y$ among those willing to accept less than $WTA(\theta)$

Financier obtains average $y$ of those willing to accept, or 35K

$$AV(\theta) = E[y|\theta' \leq \theta]$$

E[y|θ]

AV(θ)
WTA(θ)

Note: $AV(\theta)$ is unaffected by any behavioral response to small contracts
(Hendren 2017; Shavell 1979)

$\Rightarrow$ **Moral hazard alone cannot explain market existence**

Value ($)

Fraction of Market Enrolled, $\theta$

# Can Financiers Make Profits?

- E[y|θ]
- AV(θ)
- WTA(θ)

Financier can make positive profits

Value ($): 100K, 80K, 60K, 40K, 20K, 0

Fraction of Market Enrolled, θ: 0, 0.25, 0.50, 0.75, 1

# Can Financiers Make Profits? Scenario #2



Now suppose borrowers have more *private information*, so predicted earnings vary more across borrowers

$E[y|\theta] \sim U[0,100K]$

E[y|θ]

E[y|θ]

Value ($)

100K

80K

60K

40K

20K

0

0

0.25

0.50

0.75

1

Fraction of Market Enrolled, $\theta$

# Can Financiers Make Profits? Scenario #2

Financier can meet median borrower's WTA by offering the same contract, $\lambda$

But $\lambda$ now exceeds the average expected earnings among those who would accept

$\Rightarrow$ **profits < 0**

E[y|θ]

WTA(θ)

AV(θ)

Value ($)

Fraction of Market Enrolled, $\theta$

# Can Financiers Make Profits? Scenario #2



**Unraveling Condition:** If $WTA(\theta) > AV(\theta)$ for all $\theta$, then there exists no value of $\lambda$ such that financier profits are positive

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

E[y|θ]

WTA(θ)

AV(θ)

λ

Market unravels as no valuation allows financer to make positive profits

Could offer a lower $\lambda$
But then fewer are willing to accept
and profits are still negative

Value ($)

100K

80K

60K

40K

20K

0

Fraction of Market Enrolled, $\theta$

0     0.25     0.50     0.75     1

# 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     ⎱ (continuous $y$)
2. *Completion-Contingent Loan*:     $y$ = complete degree
3. *Employment-Contingent Loan*:     $y$ = employed     (binary $y$)
4. *Dischargeable Loan*:     $y$ = no delinquency
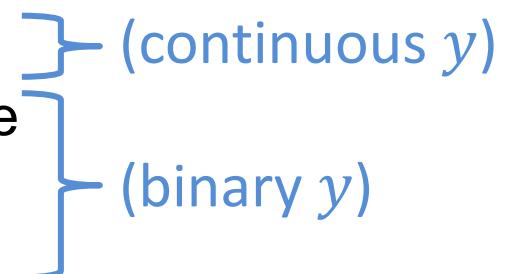
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# Data: Beginning Postsecondary Students Survey (BPS)

- 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

- $X$: Observable information about borrowers that financiers could use to price contracts

# 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
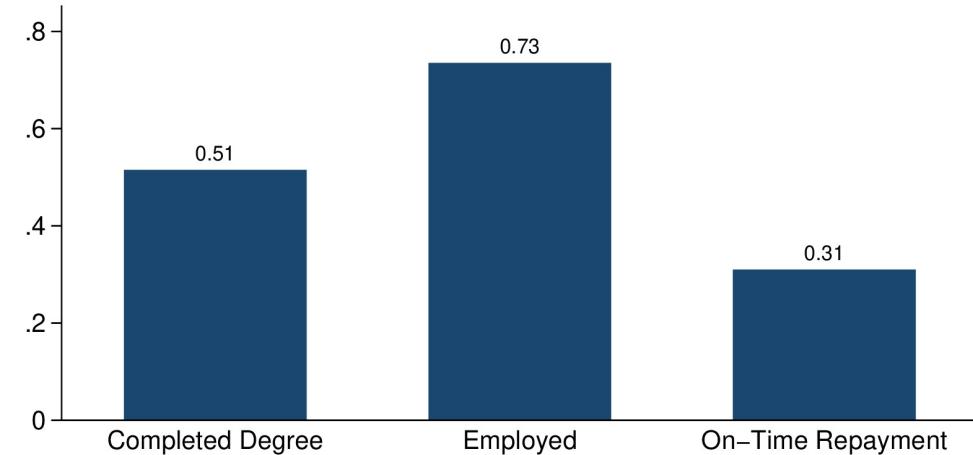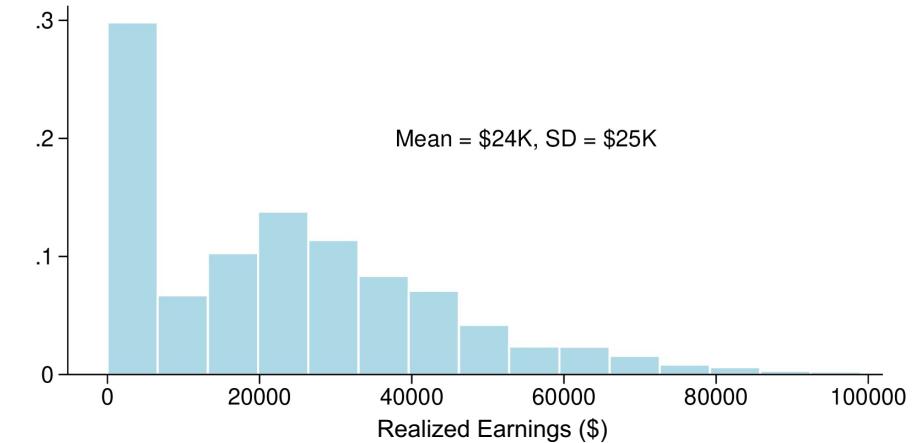
# Empirical Approach Relies on Three Types of Variables

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

- $Z$: Subjective elicitations of future outcomes
  - 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?"*

# 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

- $X$: 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)*

# Do Elicitations Predict Outcomes?
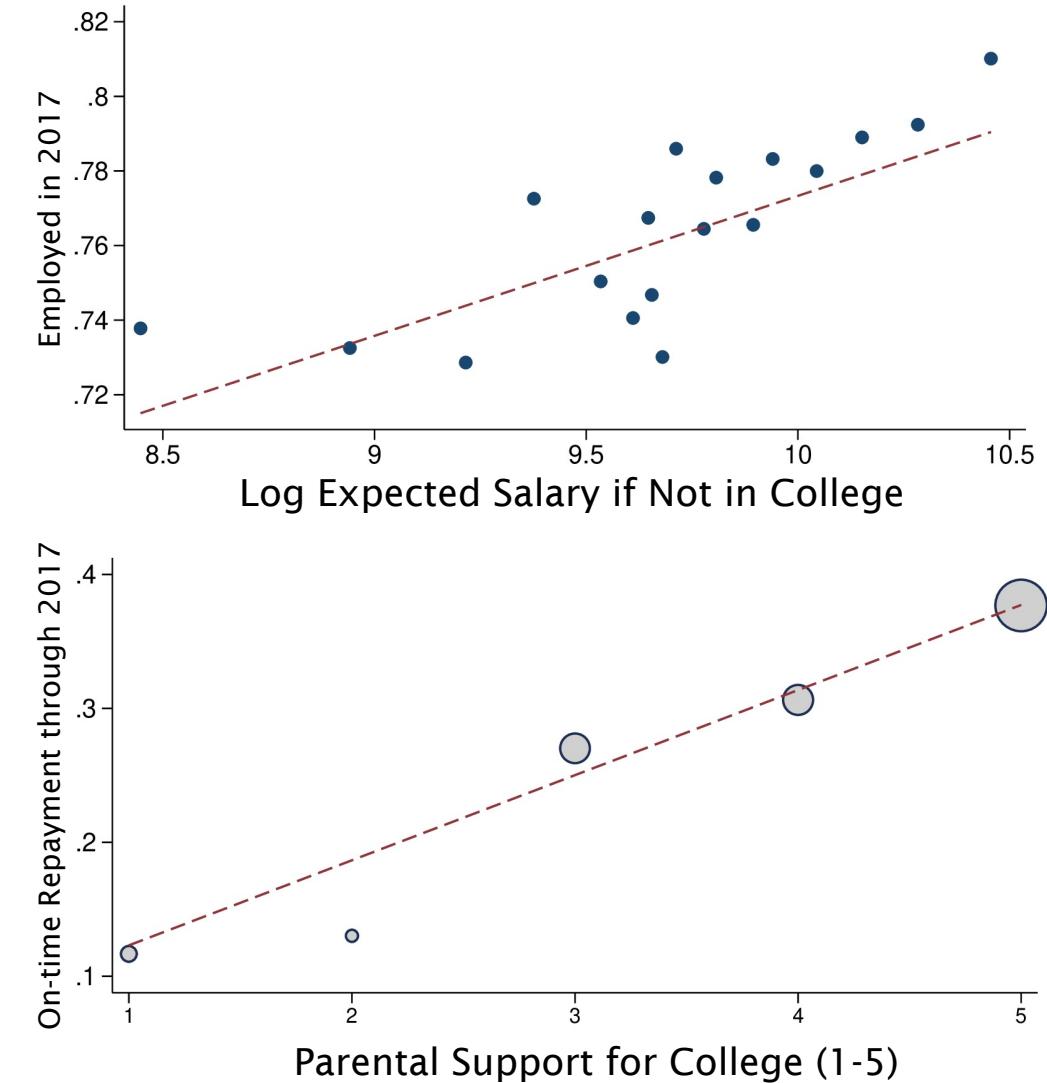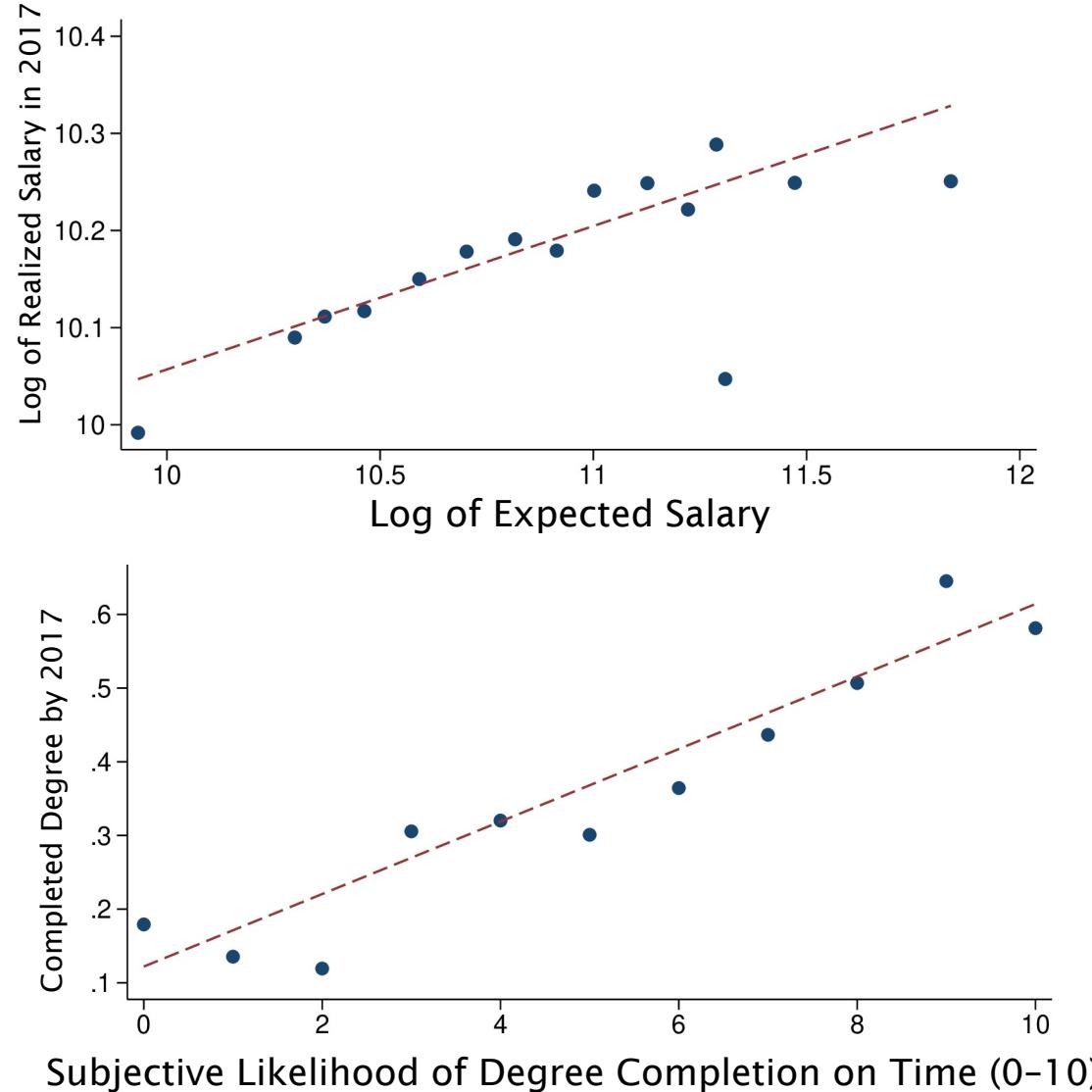


How about conditional on observables, $X$, that financiers might use to price the contracts?

## 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 | 0.003 | 0.002 | 0.001 | 0.001 | 0.001 |
| R-squared | 0.009 | 0.067 | 0.101 | 0.104 | 0.119 | 0.123 |
| 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 | 0.029 | 0.028 | 0.028 | 0.028 | 0.026 |
| R-squared | 0.045 | 0.215 | 0.222 | 0.239 | 0.249 | 0.264 |
| 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 | 0.008 | 0.007 | 0.007 | 0.006 | 0.006 |
| R-squared | 0.012 | 0.026 | 0.035 | 0.038 | 0.042 | 0.046 |
| 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 | 0.014 | 0.014 | 0.015 | 0.015 | 0.014 |
| R-squared | 0.030 | 0.114 | 0.123 | 0.136 | 0.144 | 0.155 |
| 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

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# Lower Bound on Magnitude of Private Information
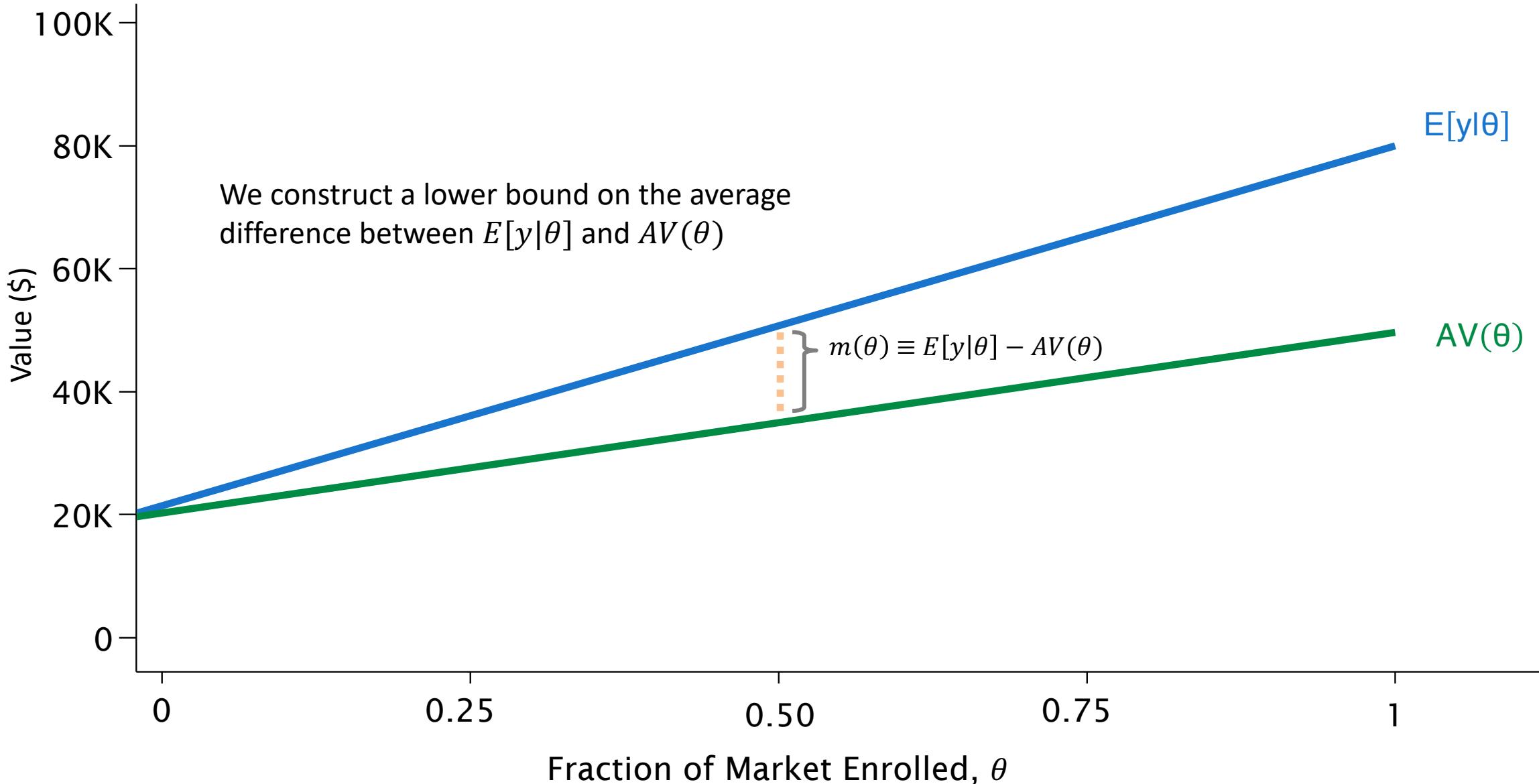


We construct a lower bound on the average difference between $E[y|\theta]$ and $AV(\theta)$

$m(\theta) \equiv E[y|\theta] - AV(\theta)$

$E[y|\theta]$

$AV(\theta)$

Value ($)

Fraction of Market Enrolled, $\theta$

# Lower Bound on Magnitude of Private Information

We estimate a non-parametric **lower bound on average magnitude,** $E[m(\theta)]$

Construct residual predictions from elicitations, $r_i \equiv E[Y|X_i, Z_i] - E[Y|X_i]$

**Result:** If $Z$ contains no more info than $\theta$, then
$$E[E[-r|r < r_i]] \le E[m(\theta)]$$

$E[y|\theta]$

$AV(\theta)$

$\left. \right\} \; m(\theta)$

Value ($)

Fraction of Market Enrolled, $\theta$
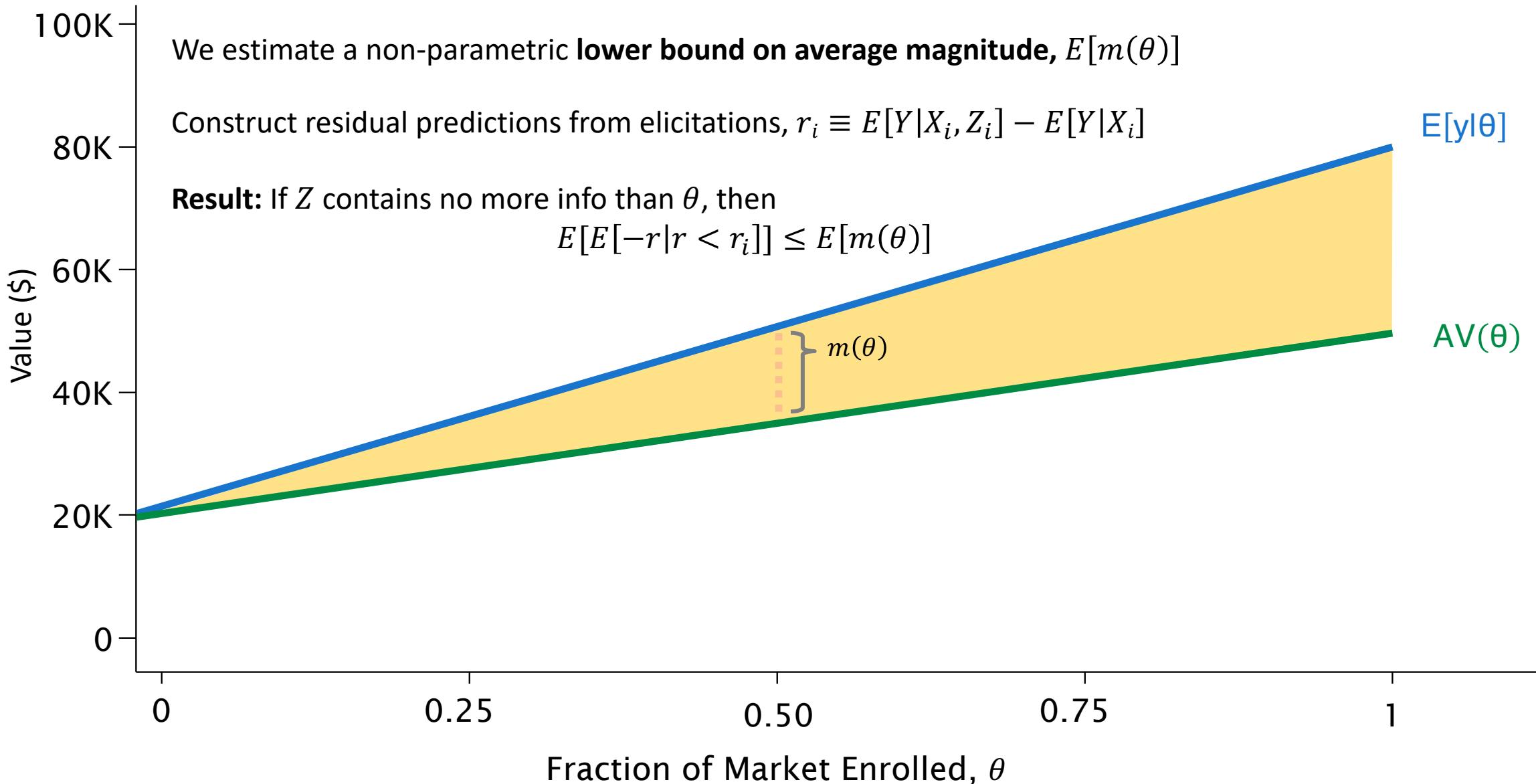
# Lower-Bound on Magnitude of Private Information

| | Category | | | | |
|---|---|---|---|---|---|
| | (1)<br>*No Public Info* | (2)<br>*Institution + Academic* | (3)<br>*Institution + Academic*<br>*+ Performance +*<br>*Demographics* | (4)<br>*Institution + Academic*<br>*+ Performance +*<br>*Demographics +*<br>*Parental* | (5)<br>*Institution + Academic*<br>*+ Performance +*<br>*Demographics +*<br>*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
    - $\approx$ $0.27 loss for $1 earnings-equity

- Large discounts for other markets as well:
    - $\approx$ $0.47 loss for $1 completion-contingent loan
    - $\approx$ $0.18 loss for $1 employment-contingent loan
    - $\approx$ $0.72 loss for $1 dischargeable loan

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

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

2. Estimate distribution of $\mu_\theta$, conditional on observables, $X$

3. Calculate $AV(\theta) \equiv E[y|\mu_{\theta'} \le \mu_\theta]$

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

Realized outcome, $y$:

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

Belief

Elicitation, $z$:

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

estimated using IV and second elicitation

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

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

2. Estimate distribution of $\mu_\theta$, conditional on observables, $X$

   - Continuous $y$: 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.  Identify relationship between beliefs, $\mu_\theta \equiv E[y|\theta]$, and elicitations, $Z$

2.  Estimate distribution of $\mu_\theta$, conditional on observables, $X$

**CDF of Privately Expected Earnings**
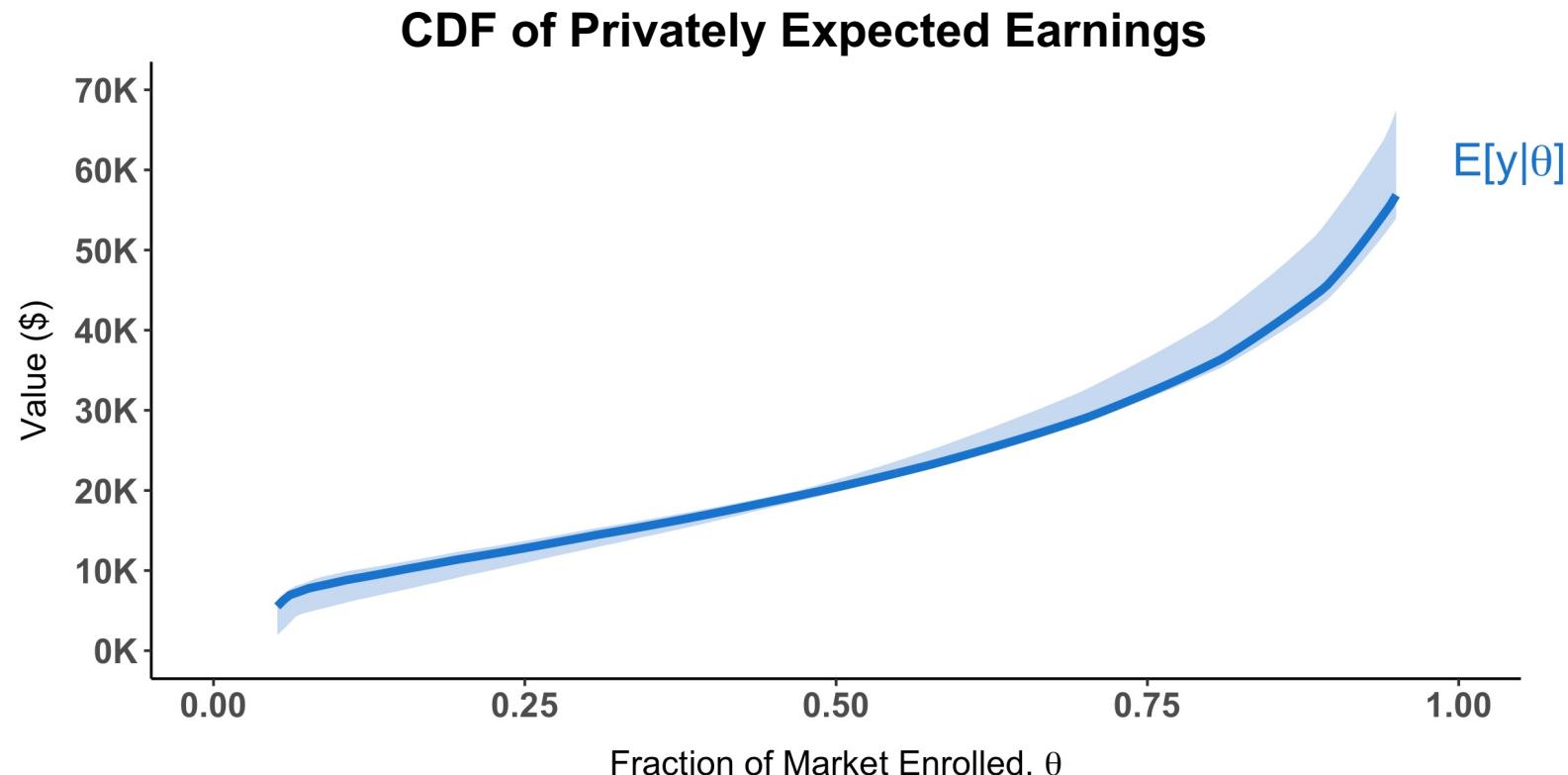
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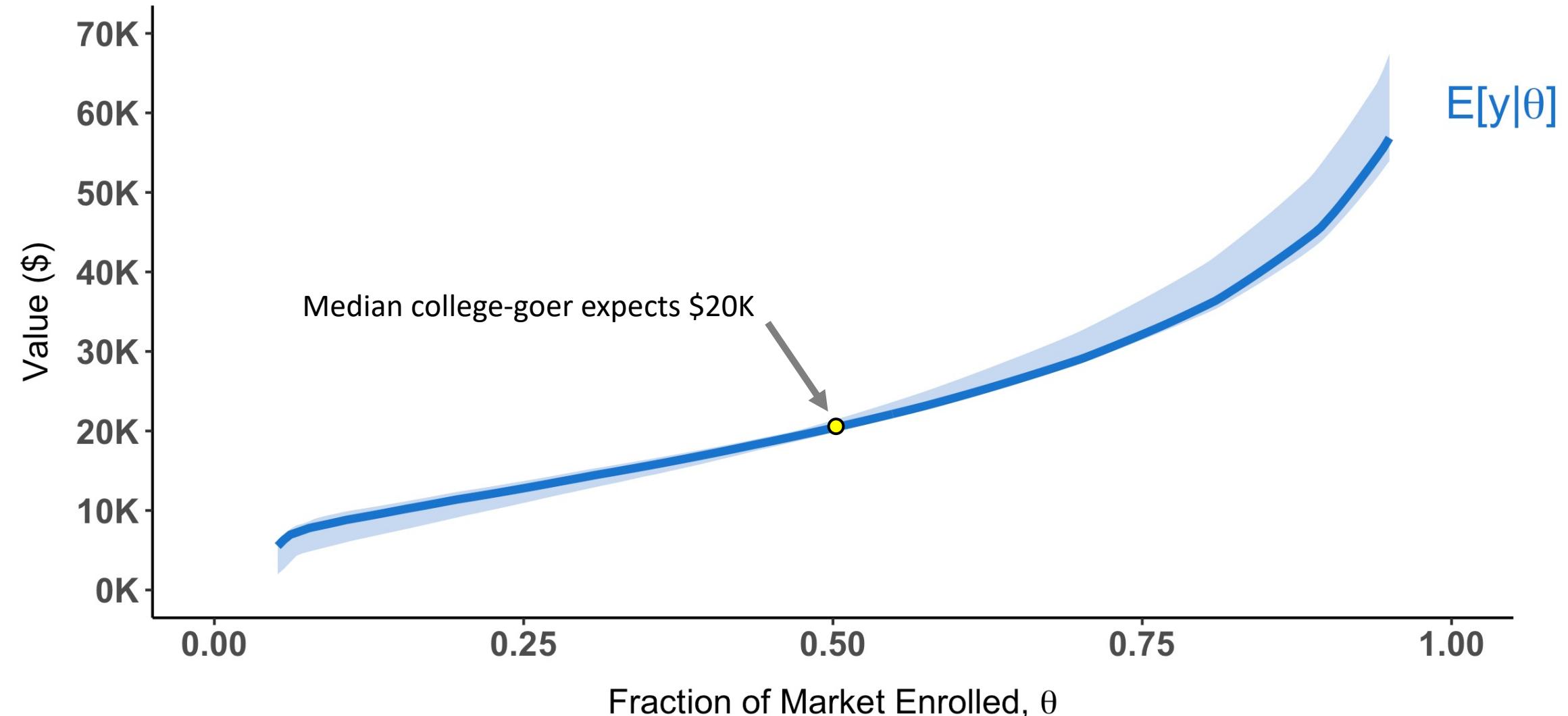
# Unraveling of the Earnings-Equity Market

# Unraveling of the Earnings-Equity Market



**Median college-goer must give up 40% of their expected earnings to make their equity contract profitable**

Median college-goer expects $20K

A stake in their earnings is worth $12K to financiers

$E[y|\theta]$

$AV(\theta)$

Value ($)

70K
60K
50K
40K
30K
20K
10K
0K

0.00    0.25    0.50    0.75    1.00

Fraction of Market Enrolled, $\theta$

# Unraveling of the Earnings-Equity Market



Estimates of WTA(θ) assuming $u_2(c) = \frac{c^{1-\sigma}}{1-\sigma}$ with $\sigma = 2$

E[y|θ]

WTA(θ)

AV(θ)

Median individual's WTA is $16K

Market unravels

A stake in their earnings is worth
$12K to financiers $\Longrightarrow$ **Financier loses 25% of investment**

Value ($)

70K
60K
50K
40K
30K
20K
10K
0K

0.00          0.25          0.50          0.75          1.00

Fraction of Market Enrolled, θ

# Unraveling of Completion-Contingent Loan Market

$E[y|\theta]$

$WTA(\theta)$

$AV(\theta)$

Median individual's WTA is $0.53

The average value of those with below-median graduation likelihood is $0.34

Value

Fraction of Market Enrolled, $\theta$
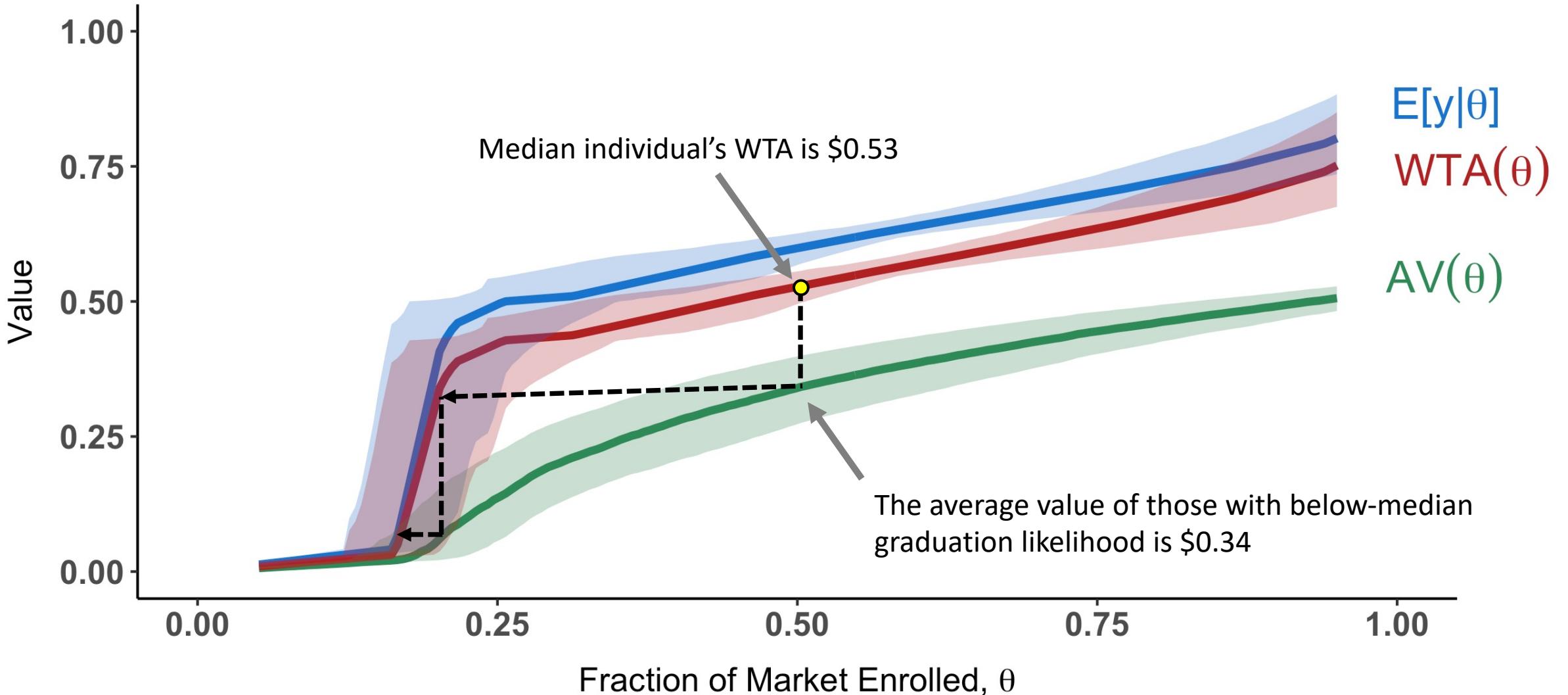
# Unraveling of Employment-Contingent Loan Market

Median individual's WTA is $0.69

The average value of those with below-median employment likelihood is $0.61

$E[y|\theta]$
$WTA(\theta)$
$AV(\theta)$

Value

Fraction of Market Enrolled, $\theta$
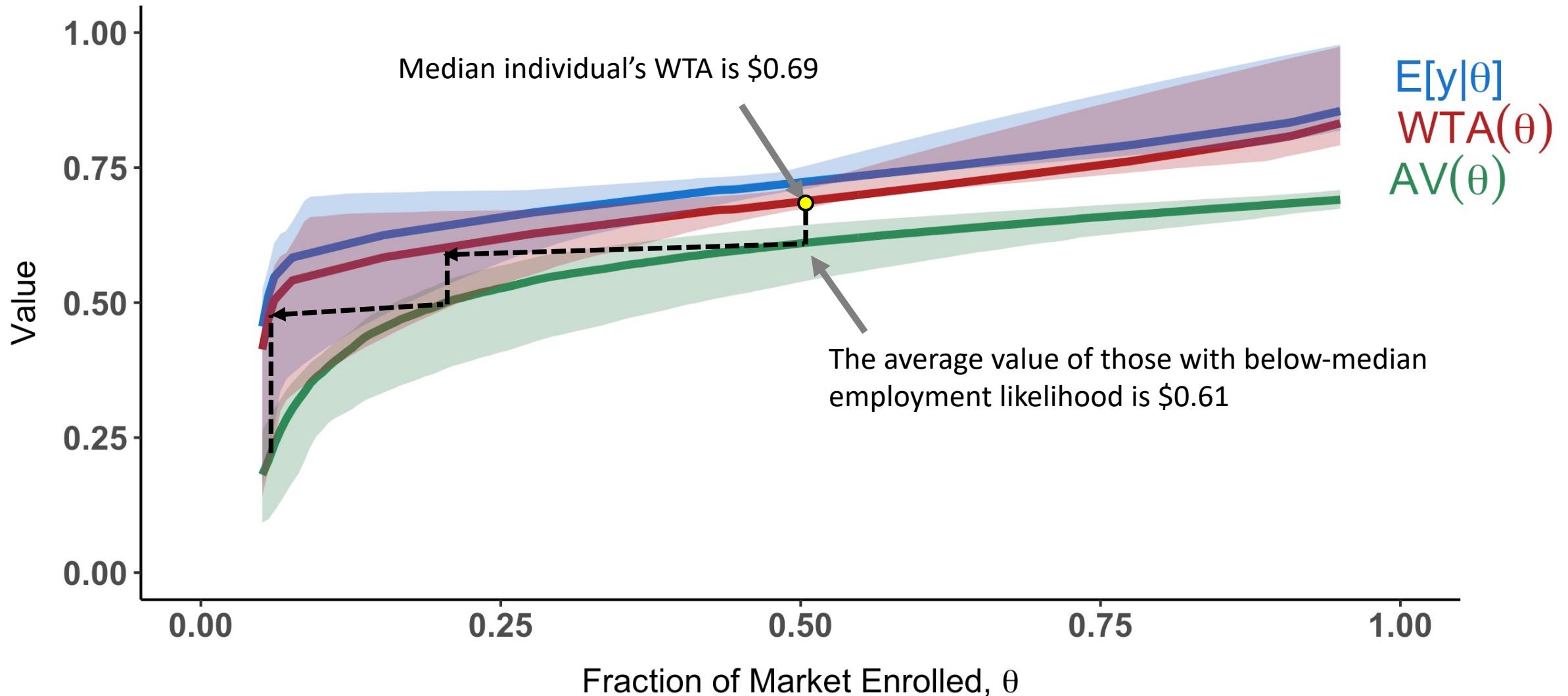
# Unraveling of Dischargeable Debt Market
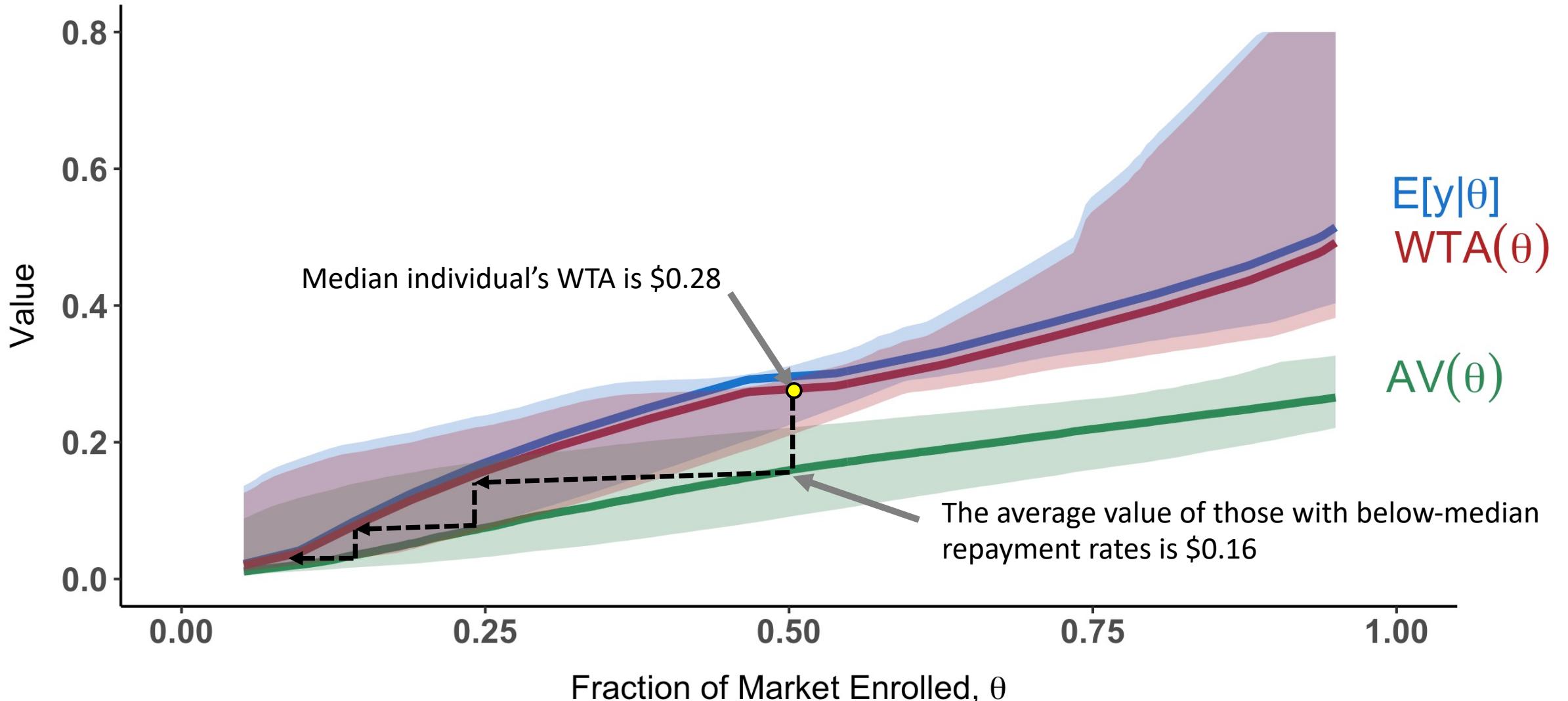
- $E[y|\theta]$
- $WTA(\theta)$
- $AV(\theta)$

Median individual's WTA is $0.28

The average value of those with below-median repayment rates is $0.16

**Value** (y-axis)

**Fraction of Market Enrolled, $\theta$** (x-axis)

# 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**

# 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 $\lambda$.
  - 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
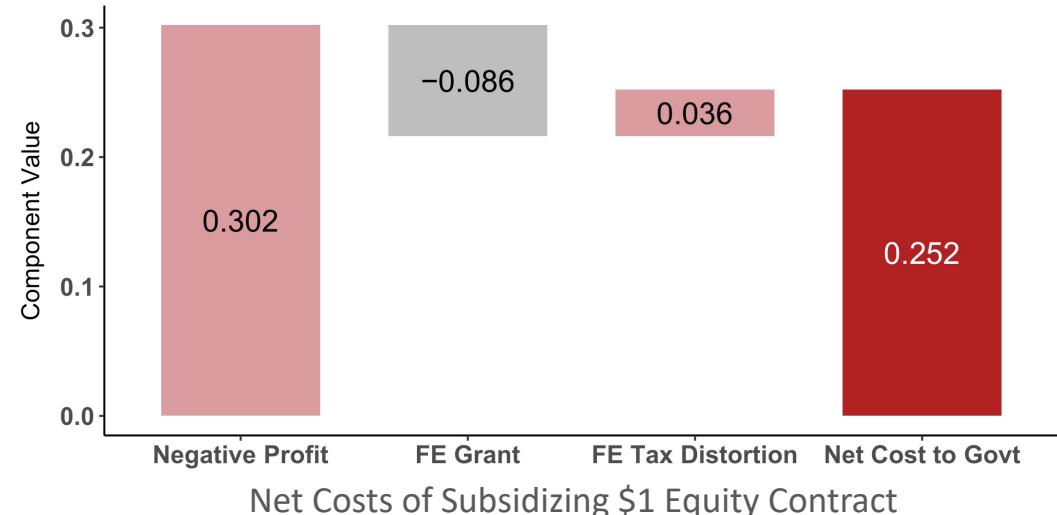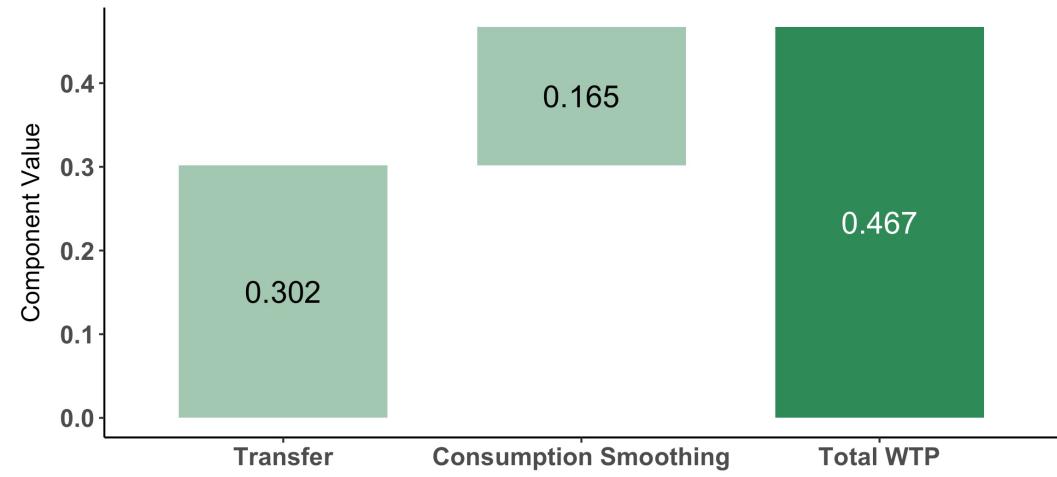
# Measuring the Welfare Impact Using the MVPF
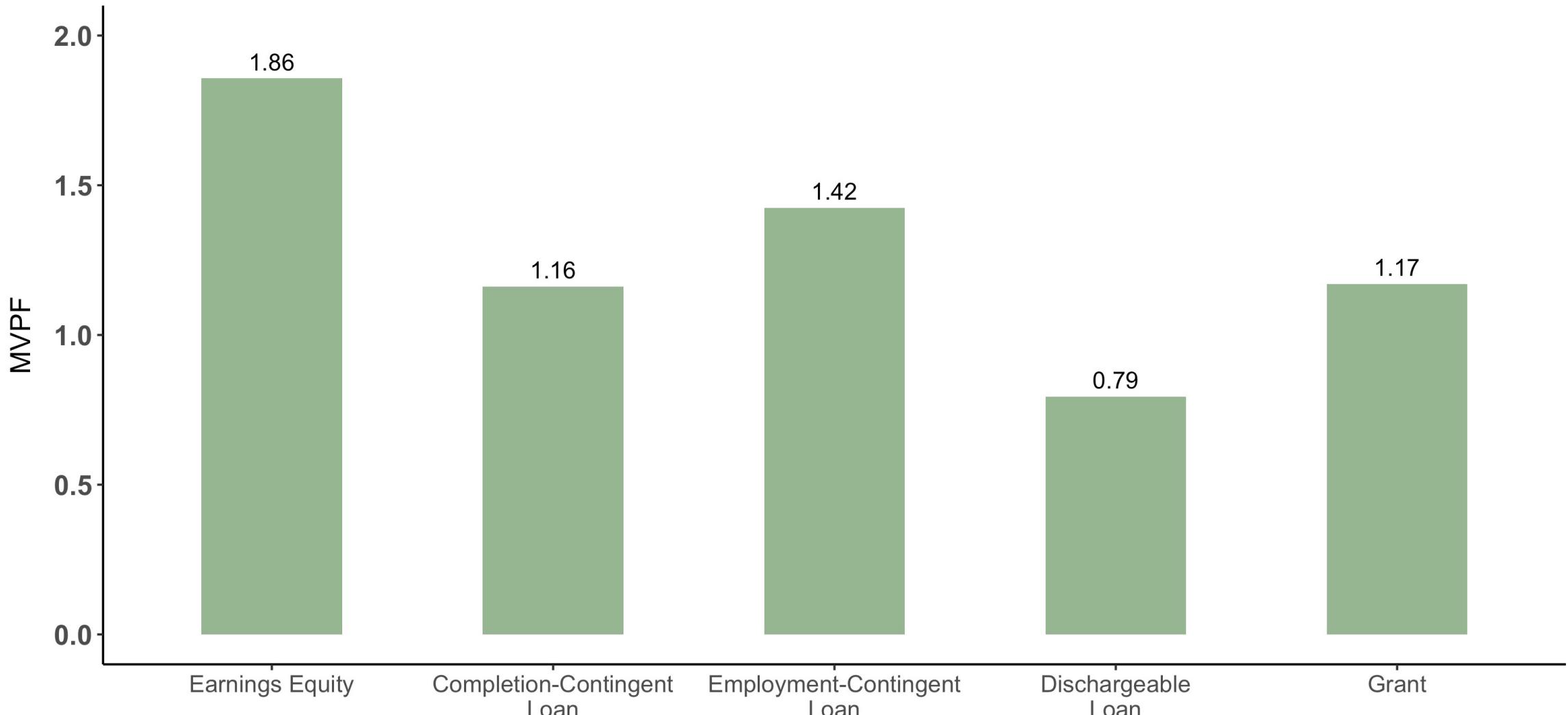
# Conclusion

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

  1. *Earnings-Equity Contract*
  2. *Completion-Contingent Loan*
  3. *Employment-Contingent Loan*
  4. *Dischargeable Loan*

- Suggests a high value to government policies promoting student loan alternatives

- Unraveling results and empirical approach may extend to other settings:
  - Income insurance / compensation schemes
  - Small-business investments
  - Union formation / collective action settings

- More generally, results suggest market frictions inhibit economic opportunity

# 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 |

# 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 |

# 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 |

# 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 (0.009) | 0.073 (0.010) | 0.078 (0.010) | 0.092 (0.010) | 0.108 (0.011) |
| | RMSE | 0.641 (0.012) | 0.638 (0.013) | 0.636 (0.012) | 0.631 (0.012) | 0.626 (0.012) |
| | MAE | 0.464 (0.007) | 0.461 (0.007) | 0.460 (0.007) | 0.455 (0.007) | 0.453 (0.007) |
| Panel B: Dropout | Pseudo $R^2$ | 0.096 (0.013) | 0.157 (0.008) | 0.166 (0.007) | 0.170 (0.007) | 0.231 (0.007) |
| | ROC | 0.742 (0.006) | 0.761 (0.006) | 0.768 (0.006) | 0.770 (0.006) | 0.813 (0.005) |
| | Accuracy | 0.684 (0.006) | 0.697 (0.006) | 0.701 (0.006) | 0.704 (0.006) | 0.741 (0.005) |
| Panel C: On-Time Repayment | Pseudo $R^2$ | 0.060 (0.014) | 0.133 (0.011) | 0.155 (0.010) | 0.158 (0.010) | 0.170 (0.009) |
| | ROC | 0.723 (0.008) | 0.758 (0.008) | 0.773 (0.008) | 0.775 (0.008) | 0.785 (0.007) |
| | Accuracy | 0.755 (0.006) | 0.763 (0.006) | 0.761 (0.006) | 0.763 (0.006) | 0.766 (0.006) |
| Panel D: Employment | Pseudo $R^2$ | -0.110 (0.022) | 0.002 (0.007) | 0.021 (0.006) | 0.027 (0.006) | 0.042 (0.005) |
| | ROC | 0.565 (0.009) | 0.596 (0.009) | 0.610 (0.009) | 0.621 (0.009) | 0.640 (0.009) |
| | Accuracy | 0.700 (0.006) | 0.719 (0.006) | 0.719 (0.006) | 0.721 (0.006) | 0.723 (0.006) |

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

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

- Realized outcome, $y$:

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

    – Assumes beliefs are unbiased: $\mu_\theta = E[y|\theta]$
    – Assumes "expectational error" ($\epsilon$) 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
    – $\gamma$ is estimated using IV and second elicitation, $z'$
        • **Identification assumption:** measurement error is orthogonal: $cov(z', v|\theta) = 0$

# γ Estimation

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

# 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 $E[y|X]$.

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

# 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 $\rightarrow$ $h_j(\cdot)$ 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 $y$
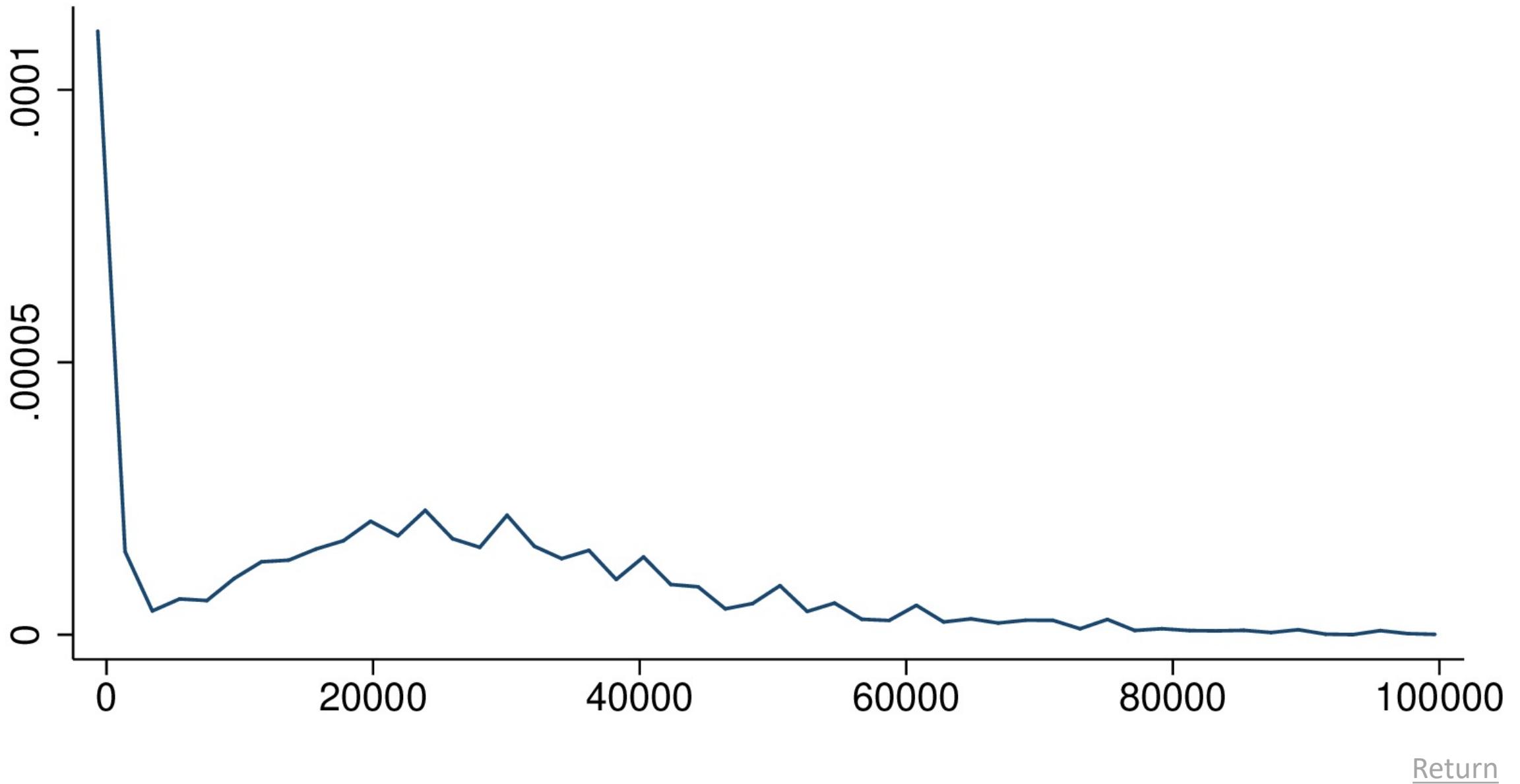
# How Much are Borrowers Willing to Accept?

- 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)

# Preference Heterogeneity



Legend:
- σ=2 (solid)
- σ~U[1,3] (dotted)
- σ~U[0,4] (dashed)

Curves labeled: WTA(θ), AV(θ)

X-axis: Fraction of Market Enrolled, θ

Y-axis: Value ($)
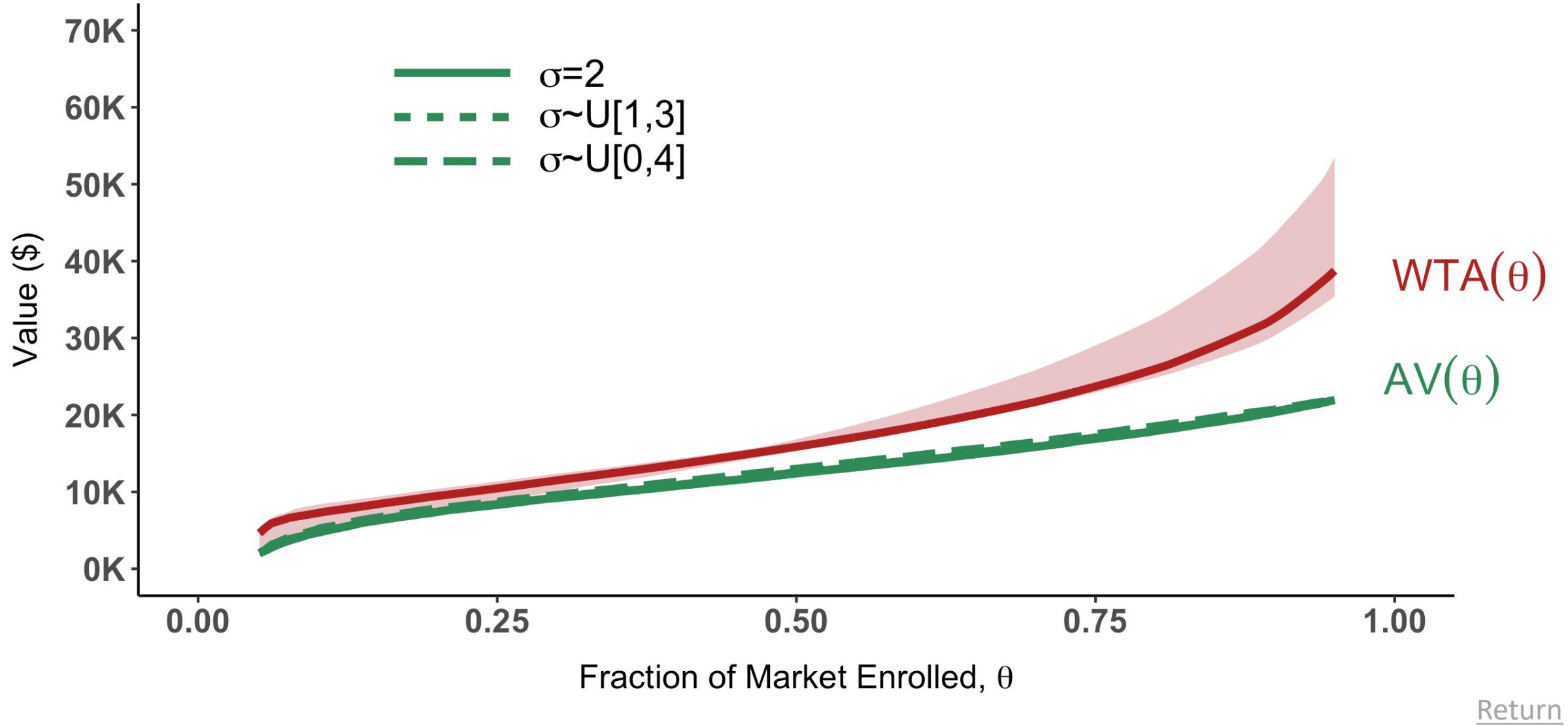
# WTA Under Alternative Risk Aversion and Interest Rates

Value ($)

Fraction of Market Enrolled, $\theta$

$\sigma=1, \Delta R=0$

$\sigma=2, \Delta R=0$

$\sigma=2, \Delta R=0.1$

$\sigma=3, \Delta R=0$

$AV(\theta)$
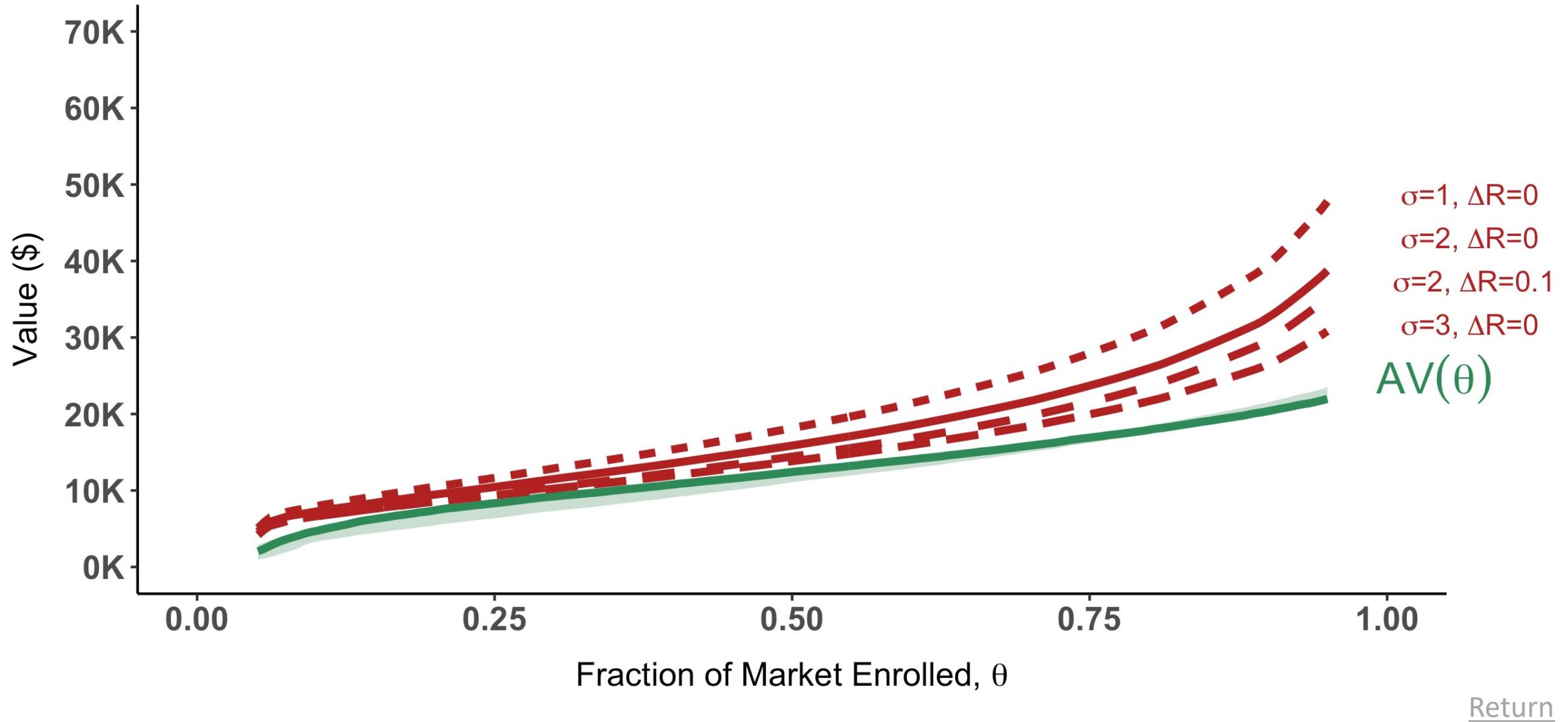
# Measuring the MVPF: Borrowers' Benefits

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

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

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

 - *Transfer*: Net transfer from financer $\rightarrow$ individual with type $\theta$ (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 $\theta$ and calibration of $WTA(\theta)$

# Measuring the MVPF: Net Cost to Government

- Net cost to government for equity contract:

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

$$=\ \lambda - E[y|\theta] - \lambda \frac{\tau}{\Pr\{\theta \leq \theta_\lambda\}} \frac{dE[y^L]}{dg} + \frac{\tau}{1-\tau} \lambda E[y|\theta \leq \theta_\lambda] \epsilon_{y,1-\tau}$$

Transfer  Impact of \$$\lambda$ in College on Lifetime Earnings  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)