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

- 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?
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
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 \( WTA > AV \Rightarrow \) 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
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

4. Measure welfare impact of government subsidies to open up these markets
   • Estimate the marginal value of public funds \( (MVPF \equiv \frac{\text{Benefits}}{\text{Net Govt Cost}}) \) of subsidies for these contracts
   • Estimates of equity MVPF ∈ [1.2, ∞), 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
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 $\eta Y$ after college

**Contract Terms**

$\lambda$: valuation or “share price”
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 $\eta Y$ after college

Contract structure describes variety of financial products
- **Continuous $Y$ ⇒ Equity contract**: Individual “sells” claim on $Y$; repays $\eta$-share of $Y$
- **Binary $Y$ ⇒ State-contingent loan**: Individual borrows $\eta \lambda$, repays $\eta$ only if $Y = 1$

Market existence: does there exist some $(\eta, \lambda)$ 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 ($\lambda$)
  - 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, $\theta$.

Each type, $\theta$, forms **subjective expectation**, $E_S[Y|\theta]$ ($Pr_S(Y = 1|\theta)$ if $Y$ is binary).
Model of Market Unraveling

Each type $\theta$’s privately expected outcome, $E_S[Y|\theta]$.

“Type” $\theta \equiv$ Quantiles of $E_S[Y|\theta]$.
Example: suppose $E_S[Y|\theta]$ is uniformly distributed between $20K$ and $80K$.

Benchmark Assumption: $E_S[Y|\theta] = E[Y|\theta]$ (unbiased beliefs)
Willingness to Accept: $WTA(\theta)$

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

Risk-averse borrowers are willing to accept lump-sum financing that is lower than what they expect to repay.

**Contract Terms**
- $\lambda$: valuation or “share price”
- $\eta$: “size” of claim on $Y$ ($\eta \to 0$)

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

**WTA(\theta):**

$$WTA(\theta) = \frac{\beta E_S [Y u_{Y_2} | \theta]}{E_S [u_{Y_1} | \theta]} R$$

**Quantile of Expected Earnings ($\theta$)**

**WTA(\theta):**

- Benchmark assumption: $R = R_\theta \equiv \frac{u_{Y_1}}{\beta E_S [u_{Y_2} | \theta]}$, so $u_{Y_1}(\theta) = E[u_{Y_2} | \theta]$
How do financiers value claims on $Y$? 

$$MV(\theta) \equiv E[Y|\theta]$$

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

**$MV(\theta)$**: the **marginal value** of holding a claim on type $\theta$’s earnings

Quantile of Expected Earnings ($\theta$)
Marginal Value: $MV(\theta)$

$WTA(\theta)$: the minimum valuation ($\lambda$) that type $\theta$ is willing to accept to give up a share of future earnings ($Y$)

$MV(\theta)$: the marginal value of holding a claim on type $\theta$’s earnings

$MV(\theta) \equiv E[Y|\theta]$

Quantile of Expected Earnings ($\theta$)
Can Financiers Make Profits?

Suppose financier sets valuation so the median borrower is willing to accept

\[ \% = \frac{\text{Median borrower earns } 50\text{K in expectation}}{\text{contract value}} = \frac{50\text{K}}{\text{contract value}} \]

But contract also attracts those expecting lower earnings

Benchmark assumption: unidimensional heterogeneity, so \( WTA(\theta) > WTA(\theta') \iff E_s[Y|\theta] > E_s[Y|\theta'] \)
Average Value, $AV(\theta)$

- **WTA(\theta):** the minimum valuation ($\lambda$) that type $\theta$ is willing to accept to give up a share of future earnings ($Y$)
- **MV(\theta):** the marginal value of holding a claim on type $\theta$'s earnings
- **AV(\theta):** The average value of $Y$ among lower types, $\theta' < \theta$

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

$$AV(\theta) = E[Y|\theta' \leq \theta]$$
Can Financiers Make Profits?

\[ AV(\theta) > WTA(\theta) \implies \text{profits} > 0 \]

- **WTA(\theta):** the minimum valuation (\(\lambda\)) that type \(\theta\) is willing to accept to give up a share of future earnings (\(Y\))
- **MV(\theta):** the marginal value of holding a claim on type \(\theta\)'s earnings
- **AV(\theta):** The average value of \(Y\) among lower types, \(\theta' < \theta\)
Now suppose borrowers have more *private information*, so beliefs about mean earnings vary more across borrowers. $E_s[Y|\theta] \sim U[0, 100K]$.
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 all types $\theta < 0.5$

$\Rightarrow \text{profits} < 0$
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.

Every possible $\lambda$ yields negative profits $\Rightarrow$ market unravels.

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

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**  
   
   \[ Y = \text{Earnings} \]

2. **Completion-Contingent Loan**  
   
   \[ Y = \text{Complete Degree} \]

3. **Employment-Contingent Loan**  
   
   \[ Y = \text{Employment} \]

4. **Dischargeable Loan**  
   
   \[ Y = \text{No Default} \]

   (continuous $Y$)

   (binary $Y$)
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
2012/2017 Beginning Postsecondary Students (BPS) contains three types of variables:

- $Y$: Annual salary from last job held as of June 2017

- $Z$: Subjective elicitions of future salary in 2012 (not verifiable to the financier)
  - “Once you begin working [in EXPECTED OCC], what is your expected yearly salary?”

- $X$: Observable information about borrowers that financiers could use to price contracts
  - e.g., degree type (BA, AA), field of study, years since HS, college enrollment, admit rate, institution, parental characteristics, etc.
Private Information: Evidence from Survey Data

Subjective elicitations \((Z)\) predict realized outcomes \((Y)\), conditional on observable characteristics \((X)\).

- \(\beta = 0.18\)  
  \(SE = 0.02\)

Subjective elicitations \((Z)\) predict realized outcomes \((Y)\), conditional on observable characteristics \((X)\).

- \(\beta = 0.18\)  
  \(SE = 0.02\)

Elicitations \((Z)\) also predict financial decisions with income-contingent benefits like enrollment in income-driven repayment.

- \(\beta = -0.04\)  
  \(SE = 0.004\)

⇒ College-goers hold private information \((\theta)\) about future earnings

⇒ They would likely use their private info in hypothetical contract markets

But is there enough private information to unravel contract markets for claims on \(Y\)?
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<tr>
<th>Panel A: Log Salary</th>
<th>( \beta ) Log Expected Salary</th>
<th>0.176*** (0.0233)</th>
<th>0.101*** (0.0241)</th>
<th>0.0794*** (0.0244)</th>
<th>0.0764*** (0.0242)</th>
<th>0.0751*** (0.0241)</th>
<th>0.0726*** (0.0240)</th>
<th>0.0844*** (0.0219)</th>
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<th>Panel B: Degree Completion</th>
<th>( \beta ) On-Time Completion Likelihood</th>
<th>0.492*** (0.0223)</th>
<th>0.436*** (0.0226)</th>
<th>0.359*** (0.0221)</th>
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<th>Panel C: Employment</th>
<th>( \beta ) Log Expected Salary if No College</th>
<th>0.0313*** (0.0107)</th>
<th>0.0239*** (0.0106)</th>
<th>0.0220** (0.0107)</th>
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<th>Panel D: On-Time Repayment</th>
<th>( \beta ) Supportive Parents</th>
<th>0.254*** (0.0202)</th>
<th>0.172*** (0.0200)</th>
<th>0.131*** (0.0200)</th>
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Lower-Bound on Magnitude of Private Information

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<tr>
<th>Category</th>
<th>(1) No Public Info</th>
<th>(2) Academic + Institution</th>
<th>(3) Academic + Institution + Performance + Demographics</th>
<th>(4) Academic + Institution + Performance + Demographics + Parental</th>
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<td>0.15</td>
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<td>Employment-Contingent Loan</td>
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<td>0.06</td>
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<td>Dischargeable Loan</td>
<td>0.12</td>
<td>0.11</td>
<td>0.06</td>
<td>0.04</td>
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- **Magnitude of Private Information**: Average outcome among those whose elicitation predicted worse outcomes.
  - *On average*, each individual's earnings are $3,000 to $4,000 higher than those of observationally identical peers with lower elicitation-predicted earnings.

- Forms lower bound on the average “discount” required to prevent unraveling \( E[MV(\theta) - AV(\theta)] \)
  - 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.
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
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 $\mu_\theta$, 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, $y$:

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

Elicitation, $z$:

$$z = \alpha + \gamma \mu_\theta + \nu$$
**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” ($\epsilon$) is homoscedastic, $\epsilon \sim f(\epsilon)$ for all $\theta$

   Elicitation, $z$:
   
   $$z = \alpha + \gamma \mu_\theta + \nu$$

   - $z$ can be biased ($\alpha \neq 0$), imperfect ($\gamma \neq 1$), and noisy ($\sigma_\nu > 1$) in beliefs
   - $\gamma$ is estimated using IV and second elicitation, $z'$ [Details/Results]
     - **Identification assumption**: measurement error is orthogonal: $cov(z', \nu|\theta) = 0$
     - $z'$ = Average income among college grads in respondent’s expected 3-digit occupation in 2012 $\rightarrow \gamma = 0.7$
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 $\mu_\theta$, 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 $G(\mu_\theta) = \sum_j \xi_j 1\{\mu_\theta \leq a_j\}$

(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 elicitation, $Z$

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

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

- Value ($) vs. Fraction of Market Enrolled, $\theta$
Estimating $AV(\theta)$ and $WTA(\theta)$ Curves

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

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

3. Calculate $AV(\theta) \equiv E[Y \mid \mu_\theta \leq \mu_\theta]$ and $WTA(\theta) \equiv \frac{E[Yu_2(\theta)]}{u_2(\theta)}$
   
   - Baseline $\overline{WTA}(\theta)$ assumes $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$ with $\sigma = 2$, $\frac{\partial c}{\partial y} = 0.23$ (Ganong et al., 2020)
Marginal Value of Earnings Equity, $MV(\theta)$

Median college-goer expects $20K
Median college-goer expects $20K. A stake in their earnings is worth $12K to financiers.

Median college-goer must give up 40% of their expected earnings to make their equity contract profitable.
Unraveling of the Earnings-Equity Market

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

Median individual’s WTA is $16K$

A stake in their earnings is worth $12K$ to financiers $\Rightarrow$ \textbf{Financier loses 25\% of investment}
**Biased Beliefs**

- Our main specification assumes beliefs are rational:
  \[ E_S[Y|\theta] = E[Y|\theta] \]

  \[ \Rightarrow \text{college-goers would make contract decisions using unbiased predictions of } Y \]

- 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

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

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

⇒ 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”

Potentially Biased Beliefs

Assumption

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

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

⇒ 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
Belief = \langle ^{\\uparrow} + \rangle

Belief = \langle ^{\\uparrow} + \rangle

Assumption

Y is unbiased measure of \( E_S[Y|\theta] \)

\[
y = \mu_\theta + \epsilon
\]

Belief

\[
z = \alpha + \gamma\mu_\theta + \nu
\]

Assumption

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

\[
y = a + b\mu_\theta + \epsilon
\]

Belief

\[
z = \mu_\theta + \nu
\]

Biased Beliefs: Identification

Rational Beliefs

Potentially Biased Beliefs
Unraveling of the Earnings-Equity Market (Biased Beliefs)

Elicitations imply borrowers are over-optimistic (on average), so subjective beliefs, $E_S[y|\theta]$, are biased upwards.
Unraveling of the Earnings-Equity Market (Biased Beliefs)

Elicitations imply borrowers are over-optimistic (on average), so subjective beliefs, $ES[y|\theta]$, are biased upwards.

Optimistic borrowers have higher WTA because they overvalue their own earnings potential.
Elicitations imply borrowers are over-optimistic (on average), so subjective beliefs, $E_S[y|\theta]$, are biased upwards.

Optimistic borrowers have **higher WTA** because they overvalue their own earnings potential. Under *private information*, biased beliefs *amplify* unraveling forces, $WTA(\theta) > AV(\theta)$.

But the AV curve is still determined by their true earnings potential, $MV(\theta)$. 

**Unraveling of the Earnings-Equity Market (Biased Beliefs)**
Unraveling of the Earnings-Equity Market (Biased Beliefs)

Completion - Contingent Loan

Market existence under full information:
\[ WTA(\theta) \leq MV(\theta) \Rightarrow 23\% \]

⇒ Optimism can attenuate markets even without adverse selection ...but not by as much

Top-Quartile Subsample Completion-Contingent Loan
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
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
MVPF Results

<table>
<thead>
<tr>
<th>Selection On...</th>
<th>Take-up</th>
<th>Transfer</th>
<th>Consumption Smoothing</th>
<th>WTP</th>
<th>FE Moral Hazard</th>
<th>FE Human Capital</th>
<th>Cost to Govt</th>
<th>MVPF</th>
<th>Cost to Govt</th>
<th>MVPF</th>
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<tbody>
<tr>
<td>Earnings Equity</td>
<td>0.72</td>
<td>0.34</td>
<td>0.12</td>
<td>0.47</td>
<td>-0.05</td>
<td>0.45</td>
<td>0.39</td>
<td>1.19</td>
<td>-0.05</td>
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<td>(0.01)</td>
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<td>Completion-Contingent Loan</td>
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<td>0.27</td>
<td>0.10</td>
<td>0.37</td>
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<td>(0.00)</td>
<td>(0.05)</td>
<td>(0.00)</td>
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<td>(0.06)</td>
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<td>Dischargeable Loan</td>
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<td>0.03</td>
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<td>-0.29</td>
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</tbody>
</table>

- 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

- Medicaid Intro
- Earnings Equity
- Buffet Scholarship
- Employment-Contingent Loan
- Grant
- Completion-Contingent Loan
- EITC ‘93
- TN Pell
- Dischargeable Loan

Fraction of Policies

MVPF
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