Adverse Selection and Human Capital Accumulation

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(*Preliminary and Incomplete*)

Questions

- Can adverse selection explain the positive relation between schooling and wealth conditional on ability?
- Can a revenue-neutral debt-forgiveness policy be Pareto Improving?

Preview of Results

- Positive:
  - Contracting in labor market after investment/debt choice → some agents lack full insurance against schooling risk → schooling is risky investment → schooling depends on wealth.

- Normative:
  - "Bad" agents exert negative externality on "able" agents → competitive equilibria may not be constrained efficient.
  - Debt forgiveness raises tax burden on "able" agents *but raises consumption of "bad" types* → reduces externality → allows more insurance for "able" types → can be Pareto Improving.

Positive side seems to be consistent with some other contracting models. Normative is unique to adverse selection environment.

Plan

1. Literature
2. Model (L-M meets R-S meets G-S-W)
3. Frictionless solution
4. Issues of existence and optimality with Adverse Selection
5. Positive Results
6. Policy Experiment

Starting Point - Lochner and Monge (AER, 2011)

- Document the following data facts:
  1. Conditional on family income, college attendance is strongly increasing in ability.
  2. Conditional on ability, college attendance is strongly increasing in family income (and wealth) for recent cohorts.

- How much can a human capital investment model with imperfect credit markets account for these facts?
  - Noncontingent bonds and exogenous borrowing constraint model does not work.
  - L-M introduce borrowing constraints based on GSL programs which explicitly tie credit to investment in education and where there is limited repayment enforcement for private student credit.
  - The costs of default are higher for individuals with greater earnings capacity so private lenders are willing to extend more credit to individuals that invest more in their skills and/or exhibit higher ability.

Model Overview

- As in Lochner and Monge (AER, 2011), two-period-lived agents who borrow in noncontingent bonds and invest in schooling in the first period, then work in the second period.
  - Ex-ante heterogeneity in (observable) ability, deterministic returns to schooling.
- As in Rothschild and Stiglitz (QJE, 1976), two types of agents where unobservable type determines the probability of successful production in the second period.
- As in Guerrieri, Shimer, and Wright (ECMTA, 2010) competitive search guarantees existence of a separating equilibrium.
  - Parameter values that imply nonexistence in Rothschild and Stiglitz $\rightarrow$ constrained inefficiency in GSW and role for gov't policy.
- Where our model fits: unobservable abilities, observable stochastic returns to schooling, noncontingent debt, no borrowing constraints (just incentive compatibility).

Model

- Agents are endowed with wealth $\omega \in W$ and ability $A \in \{a, b\}$.
- For any wealth level, fraction of type A given by μ_A.
- At $t = 0$, agents choose schooling s and debt/savings d at return R.
- At $t = 1$, stochastic output of a matched agent is given by

$$F(A, s) = \begin{cases} f_h(s) & \text{with probability } A \\ f_l(s) & \text{with probability } 1 - A \end{cases}$$

  where $f(s)$ is increasing and concave with $f_h(s) > f_l(s)$.
- In private info economy, A is unobservable (but (s, d) are). Still, you cannot infer the agent's type from output realization for identical levels of schooling.
- Type a are "able" since $a > b$.

Model - cont.

- Preferences given by $U_A = u(c_0) + \beta E_A [u(c_1)]$, $u'(c_t) > 0, u''(c_t) < 0$
- At $t = 1$, an agent may exogenously change type given by ϵ_A. This implies $t = 0$ signalling is imperfect at $t = 1$.
- At $t = 1$, firms post menus of contracts $Y = (y^a, y^b)$ that specify consumption in both states of the world conditional on reported type. It costs k to post such a menu.
- Market tightness (firm to agent) ratio is denoted $\Theta(Y)$
- An agent matches with a firm with probability $\mu(\Theta(Y))$ and a firm matches with an agent with probability $\eta(\Theta(Y))$ with $\mu(\Theta(Y)) = \eta(\Theta(Y))\Theta(Y)$.
- A particularly simple form of the matching technology obtains when k is sufficiently small and agents match with certainty.

Model - cont.

- The expected profit for a firm from delivering consumption $y = (c_h, c_l)$ to a worker of type A with debt d and schooling s is:

$$\pi_A(y, s, d) = Af_h(s) + (1 - A)f_l(s) - Ac_h - (1 - A)c_l - R \cdot d$$

- Call the set of incentive compatible menus

$$\mathbb{C} = \{Y | \mathbb{E}_A(u(c^A)) \geq \mathbb{E}_{-A}(u(c^{-A})) \text{ for } A \in \{a, b\}\}$$

- Firms choose $Y \in \mathbb{C}$ to maximize the expected value of profits net of posting costs

$$\Pi(Y, s, d) = \eta(\Theta(Y)) \left(\gamma_a(Y, s, d)\pi_a(y_a, s, d) + \gamma_b(Y, s, d)\pi_b(y_b, s, d)\right) - k$$

where $\gamma_A(Y, s, d)$ is the fraction of applicants to contract Y who are of type A. These are equilibrium objects.

Model Timing

- $t = 0$:
  1. Agents choose s, d.
- $t = 1$:
  1. Firms post contracts y.
  2. ϵ_A realized.
  3. Agents match with firms.
  4. Production is realized and loans repaid.

Labor Market without Frictions

- At $t = 1$, the frictionless (costless matching, full info, fixed types) contract solves

$$
\begin{aligned}
V_A(s,d) &= \max_{c_h, c_l} Au(c_h) + (1-A)u(c_l) \qquad (1) \\
& \quad s.t. \\
\pi_A(c_h, c_l, s, d) &\geq 0
\end{aligned}
$$

- Consumption is perfectly smoothed for each type. That is, if $\mathbb{E}_A(x) \equiv Ax_h + (1-a)x_l$, then

$$c_h^A = c_l^A = c^A = \mathbb{E}_A(f(s)) - Rd. \qquad (2)$$

- And thus: $V_A(s,d) = u\left(\mathbb{E}_A(f(s)) - Rd\right)$

Frictionless Diagram

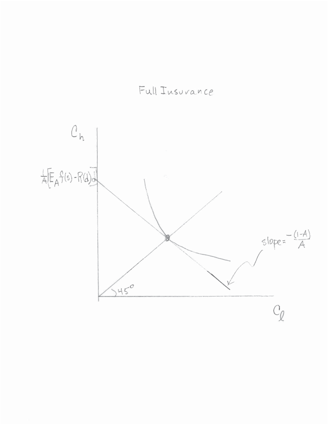
- The firm's zero profit line $\pi_A(c_h, c_l, s, d) = 0$ is given by

$$c_h = \frac{1}{A}\left[\mathbb{E}_A\left(f(s)\right) - Rd\right] - \frac{(1-A)}{A} \cdot c_l$$

- The agent's indifference curve is given by

$$\frac{dc_h}{dc_l}\Big|_{dU_A=0} = \frac{-(1-A)}{A} \cdot \frac{u'(c_l)}{u'(c_h)}$$

Fig 1. Frictionless Allocation



Human Capital Investment Decision Without Frictions

- At $t = 0$, debt and human capital decisions solve:

$$\max_{d,s} u(\omega + d - s) + \beta V_A(s, d)$$

- With $R = \beta^{-1}$ we have first order conditions:

$$\begin{aligned} u'(\omega + d - s) &= \beta \mathbb{E}_A(f'(s)) u'(c^A) \\ u'(\omega + d - s) &= u'(c^A) \end{aligned}$$

- Therefore human capital investment is *independent* of ω and solves:

$$\beta \mathbb{E}_A(f'(s^A)) = 1$$

Adverse Selection- Labor Market Equilibrium

A competitive search equilibrium is $\{V_A(s,d)\}_{A=a,b}$ for all (s,d), a measure λ on $\mathbb{C}$ with support $\bar{\mathbb{C}}$, a function Θ on $\mathbb{C}$, and a function $\Gamma(Y) = (\gamma_i(Y))_{i=L,H}$ on $\mathbb{C}$ such that:

I. Firms maximize profits and free entry: $\forall Y \in \mathbb{C}$,

$$\Pi(Y,s,d) \leq 0$$

with equality if $Y \in \bar{\mathbb{C}}$.

II. Agents' search is optimal and generates $V_A(s,d)$.

$$V_A(s,d) = \max_{Y \in \mathbb{C}} \mu(\Theta(Y))\mathbb{E}_A u(c^A)$$

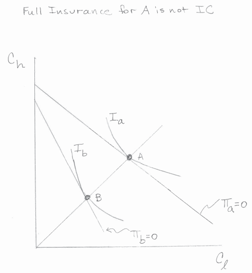
with $V_A(s,d) = \mathbb{E}_A\left(u(f(s) - \beta^{-1}d)\right)$ if $\bar{\mathbb{C}} = \emptyset$. For any $Y \in \bar{\mathbb{C}}$ and A, $V_A(s,d) \geq f(\Theta(Y))\mathbb{E}_A\left(u(c^A)\right)$ with equality if $\Theta(Y) < \infty$ and $\gamma_A(Y) > 0$. Also, if $\mathbb{E}_A\left(u(c^A)\right) < \mathbb{E}_A\left(u(f(s) - \beta^{-1}d\right)$ then either $\Theta(Y) = \infty$ or $\gamma_A(Y) = 0$.

III. The market clears.

$$\int_{\bar{\mathbb{C}}} \frac{\gamma_a(Y)}{\Theta(Y)} d\lambda(\{Y\}) \leq \tau_A(s,d)$$

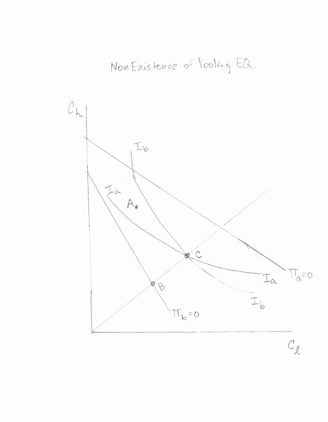
with equality if $V_A(s,d) > \mathbb{E}_A\left(u(f(s) - \beta^{-1}d)\right)$.

Fig 2. Why Full Insurance Fails



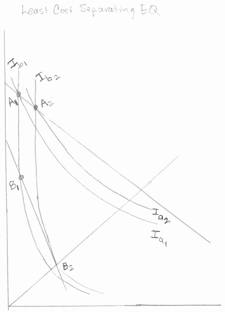
A is preferred to B by the b-type, so giving the a-type the FI allocation violates IC for type b.

Fig 3. Non-Existence of Pooling EQ



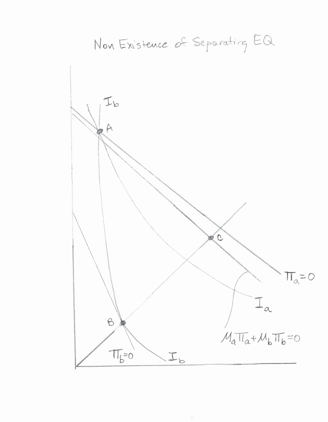
Suppose all firms are offering the pooling allocation C. Then a firm who offers point A to a-types and B for b-types will make profits since they will only attract a-types and they make profits on each a-type. $C \succ_b B$ and $A \succ_a C$.

Fig 4. Least Cost Separating EQ



Suppose all firms are offering (A_1, B_1). Then a firm could offer $(A_2 - \epsilon, B_2)$ for some small $\epsilon > 0$. They would attract everybody, break even on $b-$types and profit on $a-$types.

Fig 5. Non-Existence of Separating EQ



Suppose that all firms are offering (A, B). Then a firm could offer $(C-\epsilon, C-\epsilon)$ for some $\epsilon > 0$. This would attract all agents and give positive profits. The firm loses money on b-types but makes it up (plus more) on the volume of a-types.

Verifying Conditions of G-S-W

In order to guarantee existence and find simple programming problems to characterize equilibria, we need to verify three conditions:

1. Firms make weakly more profits from $a-$types than $b-$types. That is, for any y, $\pi_a(y) \geq \pi_b(y)$. This holds for contracts with $c_h - c_\ell < f_h(s) - f_\ell(s)$.
2. For any given contract, we can (locally) find another one that is more profitable for firms to offer to $a-$types without delivering more utility to $b-$types. Accomplished by reducing consumption in each state of the world appropriately.
3. For any given contract, we can (locally) find another one that is more preferred by $a-$types and less preferred by $b-$types. Possible since $a-$type has flatter indifference curves in (c_ℓ, c_h) space.

Labor Market Programming Problems

In addition to guaranteeing existence, competitive search gives algorithm for finding allocations:

- Type b remains undistorted and gets utility:

$$V_b(s,d) = u\left(\mathbb{E}_b\left(f(s)\right) - d\beta^{-1}\right)$$

- Type a's problem is:

$$\begin{aligned} V_a(s,d) = & \quad \max_{c_h, c_l} \mathbb{E}_a(u(c)) \\ & \quad \text{s.t.} \\ \pi_a(s,d) \equiv & \quad \mathbb{E}_a\left(f(s)\right) - \mathbb{E}_a\left(c\right) - d\beta^{-1} \geq 0 \\ \mathbb{E}_b\left(u(c)\right) \leq & \quad V_b(s,d) \end{aligned}$$

- At the optimum, both constraints bind. Thus the type a allocation is given by the solution to those two equalities.

Human Capital Investment Decision With Adverse Selection

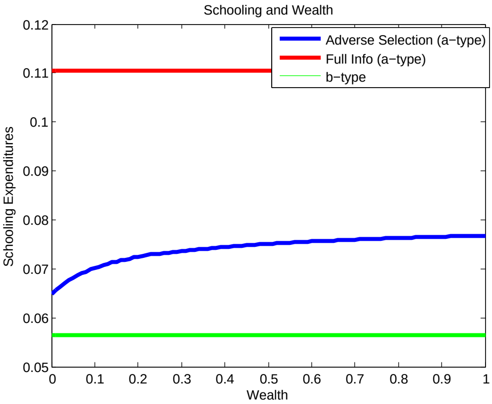
- As $\epsilon \to 0$, type a's first order and envelope conditions are:

$$
\begin{aligned}
u'(\omega + d - s) &= \beta \frac{\partial V_a}{\partial s}(s, d)) \\
u'(\omega + d - s) &= -\beta \frac{\partial V_a}{\partial d}(s, d) \\
\frac{\partial V_a}{\partial d} &= -\beta^{-1}(\zeta + \theta u'(c_b)) \\
\frac{\partial V_a}{\partial s} &= \mathbb{E}_a(f'(s))\zeta + \theta u'(c_b)\mathbb{E}_b(f'(s))
\end{aligned}
$$

- Therefore human capital investment is lower than in full information case:

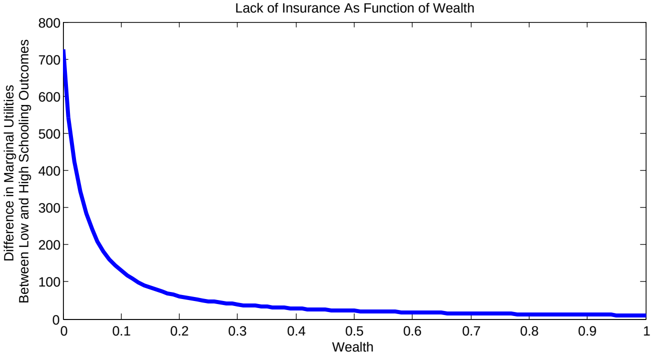
$$
\beta \mathbb{E}_a(f'(s)) \left(\frac{\zeta + \theta u'(c^b) \frac{\mathbb{E}_b(f'(s))}{\mathbb{E}_a(f'(s))}}{\zeta + \theta u'(c_b))} \right) = 1
$$

Numerical Example: Positive Predictions



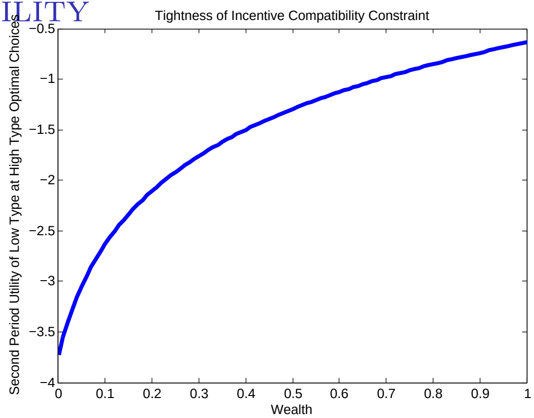
No general proof to sign $\frac{\partial s}{\partial \omega}$, but conjecture that it is positive. Verified in numerical examples.

Numerical Example: Wealth and Insurance



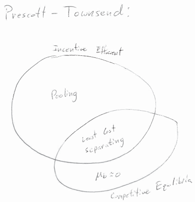
Intuition: without full insurance, schooling is a risky investment. Higher wealth → lower debt, which allows for more insurance → schooling is less risky

Numerical Example: Wealth and Incentive Compatibility



Higher wealth agents take less debt which raises $b-$type consumption (thus utility) which slackens IC constraint and allows for more insurance.

Fig 6. Rationale for Policy Experiment



In Rothschild Stiglitz there is non-existence where this model has constrained inefficiency. Pooling allocations are constrained efficient but not competitive equilibria. Debt forgiveness in unproductive states can be pareto improving in the region of constrained inefficient, competitive equilibria.

Policy

- Assume that fraction χ of debt repayments is forgiven in the event that schooling is unsuccessful.
- This is paid for by taxing those who are successful. Total payments for unsuccessful students is $T = (\tau_a(1-a) + \tau_b(1-b))(1-\chi)\frac{d}{\beta}$ and total revenues from taxing successful workers is $\text{REV} = (\tau_a a + \tau_b b)\, t$.
- Thus, taxes per capita are given by $t = \phi(1-\chi)\frac{d}{\beta}$ where ϕ is the ratio of low schooling returns to high schooling returns:

$$\phi \equiv \frac{(\pi_a(1-a) + \pi_b(1-b))}{(\pi_a a + \pi_b b)}.$$

Policy

- We seek conditions to guarantee $\frac{\partial V_a}{\partial \chi}(s,d) < 0$.
- First solve for $\frac{\partial c_h^a}{\partial \chi}$ and $\frac{\partial c_\ell^a}{\partial \chi}$ from:

$$\begin{aligned} \mathbb{E}_a\left(f(s)\right) - \mathbb{E}_a\left(c\right) - d\beta^{-1} &= 0 \\ \mathbb{E}_b\left(u(c)\right) &= V_b(s,d) \end{aligned}$$

- This gives $\frac{\partial V_a}{\partial \chi}(s,d)$ as function of schooling and debt
- After copious algebra, can find nec. and sufficient condition:

$$\frac{a(1+\phi)-1}{b(1+\phi)-1} > -\frac{a(1-a)(u'(c_\ell^a)-u'(c_h^a))}{u'(c_h^a)u'(c_\ell^a)(a-b)}u'(c^b)$$

The Role of Competition

Some natural questions in constrained inefficient economies:

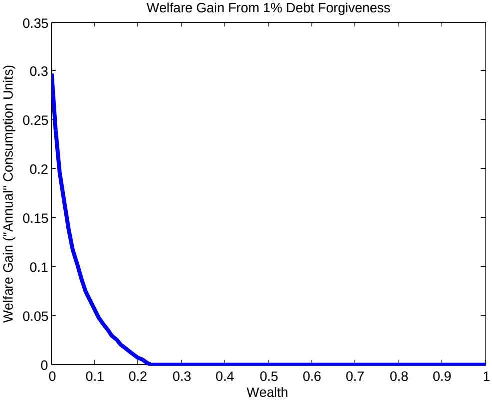
- Why can policy be Pareto improving?
  - Pooling allocation Pareto dominates CE allocation
  - Debt forgivenes pushes CE allocacation closer to pooling
  - Does this by raising $b-$type utility, which allows more insurance for $a-$type
- Can institutions other than government implement better allocations?
  - Must find ways of dropping contract-by-contract profit maximization
  - Labor market monopsonies (company towns)
  - More broadly, perhaps coalitions (as in Boyd and Prescott 1986)

Policy Intuition

$$\frac{a(1+\phi)-1}{b(1+\phi)-1} > -\frac{a(1-a)(u'(c_\ell^a)-u'(c_h^a))}{u'(c_h^a)u'(c_\ell^a)(a-b)}u'(c^b)$$

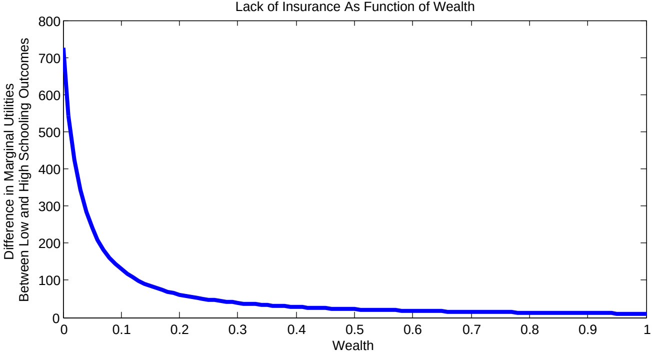
1. Condition that $a > b$ ensures that $b(1+\phi)-1 < 0$
2. If fraction of low types choosing (s, d) approaches zero, $\phi \to \frac{1-a}{a}$ and the LHS $\to 0$. CE is Constrained Inefficient and policy Pareto Improving
3. Policy improves insurance, which is more valuable if $u'(c_\ell^a) - u'(c_h^a)$ is large.
4. Insurance improves because $b-$type receives more consumption which slackens the $b - type$ IC. The higher is $u'(c^b)$, the more is this constraint slackened.

Numerical Example: Welfare Gains and Wealth



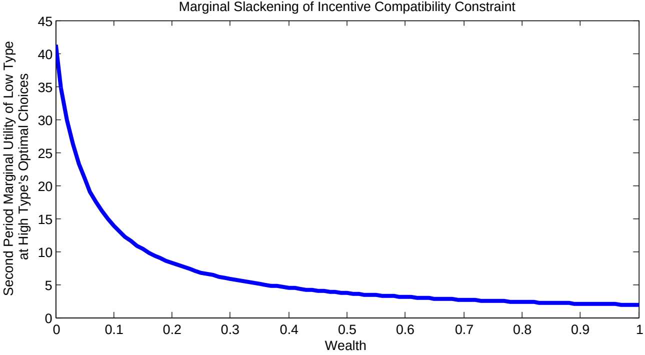
$$\frac{a(1+\phi)-1}{b(1+\phi)-1} > -\frac{a(1-a)(u'(c_\ell^a)-u'(c_h^a))}{u'(c_h^a)u'(c_\ell^a)(a-b)}u'(c^b)$$

Numerical Example: Welfare Gains and Insurance



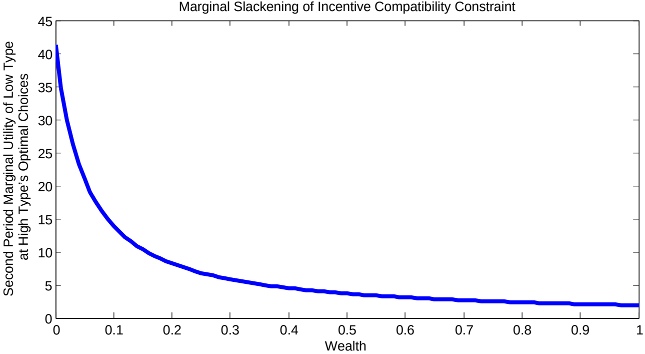
$$\frac{a(1+\phi)-1}{b(1+\phi)-1} > -\frac{a(1-a)\left(u'(c_\ell^a)-u'(c_h^a)\right)}{u'(c_h^a)u'(c_\ell^a)(a-b)}u'(c^b)$$

Numerical Example: Welfare Gains and Incentive Compatibility



$$\frac{a(1+\phi)-1}{b(1+\phi)-1} > -\frac{a(1-a)(u'(c_\ell^a)-u'(c_h^a))}{u'(c_h^a)u'(c_\ell^a)(a-b)}u'(c^b)$$

Numerical Example: Welfare Gains and Incentive Compatibility



$$\frac{a(1+\phi)-1}{b(1+\phi)-1} > -\frac{a(1-a)(u'(c_\ell^a)-u'(c_h^a))}{u'(c_h^a)u'(c_\ell^a)(a-b)}u'(c^b)$$

Summary

- Positive:
  - Adverse selection in labor market reduces insurance against schooling risk
  - Schooling is riskier investment, therefore less is chosen than under full info
  - Schooling rising with wealth
  - $--$ More wealth $\rightarrow$ less debt $\rightarrow$ looser IC $\rightarrow$ more insurance
  - Note- Prediction rests on $a-$types (observably: high education) being less insured, consistent with residual wage inequality (Lemieux 2006)

- Normative:
  - Competitive allocation can be constrained inefficient (opposed to moral hazard environments)
  - Debt forgivess can be Pareto Improving
  - $--$ Transfers consumption to low output state $\rightarrow$ increases $b-$type expected consumption $\rightarrow$ slackens IC $\rightarrow$ increases insurance for $a-$type

To do (lots)

- Schooling affects probability of success, ie $a(s) > b(s)$ *and* $a'(s) > b'(s)$
- Expand second period to full life cycle
- Richer heterogenity
  - Differences in costs of schooling $\rightarrow$ Spence type signaling
  - Differences in discount factors
  - Others?
- How does policy example relate to actual policy?
- Other suggestions?