Educational Signaling, Credit Constraints and Inequality Dynamics.

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General Motivation

- The paper is part of an ongoing research interest in education, mobility and inequality dynamics.

- *Occupational Mobility and Wealth Evolution in a Model of Educational Investment with credit market imperfections* (with C. Di Pietro);

  Focus on the consequences of individual heterogeneity (no signaling) for the wealth dynamics and for policy design;

- *On the Causal Effect of Selective Admission Policies on Students' Performances. Evidence from a quasi-experiment in a large Italian University.* (with V. Carrieri and R. Zotti);

  Data suggest (a diff in diff approach) that a more selective admission policy positively affects educational outcomes on average. But: the main channel is NOT through the trivial selection of better individual abilities; it pertains to improved social interactions post enrollment.

Motivation of the paper

- Old tradition for public intervention in education based on efficiency arguments (credit market imperfections) and equity considerations. More recent: view of the education system as a screening device.
- *Credit market imperfections*: main candidate explanation for persistence of status and income across generations. Under-investment.
- *Signaling*: quite influential view of educational investment. Key for interpreting the empirical analysis of "ability bias" and estimation of "returns to schooling". Over-investment.
- Their coexistence complicates interpretation of empirical analysis and the assessment of *public policies*. Important to have a unifying framework.

Research questions

Study the implications of the **co-existence of signaling and credit constraints** for educational investment;

- General questions: is there an issue of quality in human capital investment? How do (imperfect) markets deal with it? What about policies?
  More specifically:

- Q1 (positive): What are the implications for human capital accumulation, for the aggregate dynamics of skill ratio, income inequality and social mobility flows along the development path?

- Q2 (normative): What are the efficiency properties of the market allocation and the implications for public policy?

Outline of the talk

Related Literature

- *Signaling:* tends to create over-investment; observed market returns to education over-state social returns (ability bias in empirical studies).
  Spence (1973), Stiglitz (1975); See Spence (2010) for a survey;

- *Credit Constraints:* create under-investment; market returns under-state social returns to education.
  Ray (1990, 2007), Galor and Zeira (1993), Mookherjee and Ray (2003); See Matsuyama (2010) and Piketty (2010) for a survey.

Related Literature cont.ed

- In this paper: signaling does not occur "in vacuum", determined in households, that are credit constrained.
- Two key Implications:

  1. Signaling in the aggregate educational investment depends on income distribution.

  2. Partial separation of abilities (some pooling in the signaling process) is necessary if some agents are credit constrained and the labor contract is not conditioned on parental income.

Signaling and the Evolution of Income Distribution

Selection process (Signaling) and Income Distribution are *dynamically* intertwined

- Signaling activities depend not only on ability but also on credit constraints and thus on *current* income distribution;
- Future Income distribution depends on current educational investment (future skill supply) as shaped by current signaling activities at the household level, a general equilibrium effect.

Overview of the Results

- Rich dynamics due to compositional effects (income and abilities in the skilled labor force) associated to the evolution of the selection process of abilities;
- Kuznets types of paths tend to occur in the absence of any SBTC;
- Both overinvestment and underinvestment can occur in general. Phases of raising income inequalities associated with underinvestment (negative ability bias on average);
- Competitive equilibrium is constrained Pareto-inefficient irrespectively of under/over investment.
  There exists public policies that are Pareto improving, alter the composition of the educated (in favor of those from poor families). Such interventions also promote upward occupational mobility and equality of opportunity. (Not trivial, cfr. literature, no heterogeneity does not allow compositional effects and can induce Pareto efficiency even in the presence of credit market imperfections).

Model

- Two sectors/occupations: modern (M), traditional (T), no credit market for educational investment;
- To work in sector M, education is necessary ($e = 1$, an indivisibility); an agent with ability n produces $n \cdot e$, and incurs education cost $x(n)$, strictly decreasing, smooth function,
- Agents have heterogeneous ability n drawn i.i.d. from $[0, \bar{n}]$ according to cdf F with continuous and positive density f,
- In sector T all workers produce $v \in (0, En)$.

Generations, Households, Credit Constraints

- Continuum of families indexed $i \in [0,1]$; generations $t = 1, 2, ...$; each household has one parent (i, t) and one child $(i, t+1)$ at t;
- Parent i, t observes ability draw $n_{i,t+1}$ of the child, and decides whether to pay for the child's education, given income;
- Paternalistic altruism: $e = e_{i,t+1} \in \{0, 1\}$ maximizes

$$U(y_{i,t} - e \cdot x(n_{i,t+1})) + V(e \cdot w^e_{t+1} + (1-e)v) \qquad (1)$$

where U, V are smooth, strictly increasing, strictly concave; $y_{it} = e_{it} \cdot w_t + (1 - e_{it})v$ is parent's earning, and w^e_{t+1} denotes anticipated skilled wage at $t+1$.

Skill ratio dynamics

- Ability threshold $n^*(w^e, y)$ at which the parent with income y is indifferent, $n^*(\cdot)$ solves:

$$U(y) - U(y - x(n^*(w^e, y))) = V(w^e) - V(v) \tag{2}$$

- By aggregation we get the evolution of the skill ratio λ:

$$\lambda_{t+1} = \tilde{\lambda}(w_t^e; w_t, \lambda_t); \tag{3}$$

where:

$$\tilde{\lambda}(\cdot) \equiv \lambda_t[1 - F(n^*(w_t^e, w_t))] + (1 - \lambda_t)[1 - F(n^*(w_t^e, v))]$$

Signaling and the Skill premium dynamics

- M sector employers set wages competitively: zero profit given expected quality of the skilled work force, given the household's behavior.

- Wage in the M-sector:

$$w_{t+1} = \tilde{q}(w_t^e; w_t, \lambda_t)$$
$$\equiv \frac{[m(n_M^*(\cdot))\lambda_t[1 - F(n_M^*(\cdot))] + m(n_P^*(\cdot))(1-\lambda_t)[1 - F(n_P^*(\cdot))]}{\lambda_{t+1}}$$

where: $m(n_i^*) \equiv E[n|n \geq n_i^*], i = M, T$, provided $\lambda_{t+1} > 0$, in case $\lambda_{t+1} = 0$, set $w_{t+1} = \bar{n}$.

Comments on the model

- State space includes not only skill ratio λ but also w,
  in standard human capital models (without signaling), skilled wage is a function of skill ratio, so it can be reduced to a dynamic on the skill ratio λ alone,
- so the dynamics can be quite rich and complicated, owing to the interaction of signaling and credit constraints;
- Would be even more complicated and multiplicity of SS may arise if T sector wage also endogenous (we explore an example where v depends on λ, Appendix A);
- If contract terms are conditioned on parental income: negative correlation of income within lineages. Notice that a report on parental background is not incentive compatible, (Appendix B);
- Specify wage expectations next (the definition of the associated competitive equilibrium is standard).

Wage Expectations

- *Static Expectations*: $w^e_{t+1} = w_t$

  Result 1: ESE exists and it is unique

  Competitive equilibrium dynamics recursive with ESE;

- *Rational Expectations*: $w^e_{t+1} = w_{t+1}$

  Result 2: ERE exists, it may not be unique;

- Why multiplicity in ERE?
  Consider an equilibrium, (w, λ) and contemplate $w^e \uparrow$. Then if the incentive effect pulls lots of smart kids from T and a small effect in M (e.g. decisions driven by wealth effects mainly in M) the wage increase can be self-fulfilling in ERE.

Equilibrium Properties

- Owing to wealth effects, parents in M are less selective $n_T^* \geq n_M^*$.
  Consequence: $n_M^*(.; w_t) < w_{t+1}$, marginal type below average;

  Marginal increase in investment in M exerts a negative externality on others in T, conceiving investing. A Gersham effect;

- Marginal investors in T sector have ability that may or may not be higher than average $n_T^*(.; v) \lesseqgtr w_{t+1}$;
  Consequence: Not obvious *a priori* whether additional entry by agents from T improves quality on average, hence wage. Crowding in additional investment from M (a positive externality) possible in general;

THE WAY IN WHICH THESE TWO FORCES BALANCE THROUGH MARKET INCENTIVES WILL SHAPE EQUILIBRIUM DYNAMICS AND STEADY STATE. EFFICIENCY PROPERTIES TOO.

Characterization of the Steady State

Def. A *steady state (SS)* is w^*, λ^* such that: $\lambda^* = \tilde{\lambda}(w^*; w^*, \lambda^*)$ and $w^* = \tilde{q}(w^*; w^*, \lambda^*)$.

Proposition

There exists a unique SS.

No long-run history dependence! Contrast with models with credit constraints and no heterogeneity (and hence no signaling);

Contrast with multiplicity in static adverse selection or signaling models where no need to balance upward and downward mobility flows.

Why uniqueness? Underlying Intuition

- Sketch of the proof: Steady state condition reduces to a fixed point of $w = q(w) \equiv \tilde{q}(w, \lambda(w))$. An analytic property of $\tilde{q}(w)$ is $\tilde{q}'(.) < 0$ at steady state, i.e. uniqueness.

WHY?

(Remember that out of SS as $w \uparrow$ it **may push** $q \uparrow$ **or** $\downarrow$);

- At SS, to keep downward and upward mobility balanced, it holds:

$$\tilde{q}(w, \lambda(w)) = [1 - F(n^R(.))]m(n^R(.)) + F(n^R(.))m(n^P(.))$$

Suppose $w \uparrow$: less selection in both groups, $m(\cdot)$ must $\downarrow$, but the weight of investing kids from T also $\downarrow$: quality must decrease, a contradiction. Gersham law must prevail!

- The argument rests on exogenous v.

Out of SS dynamics

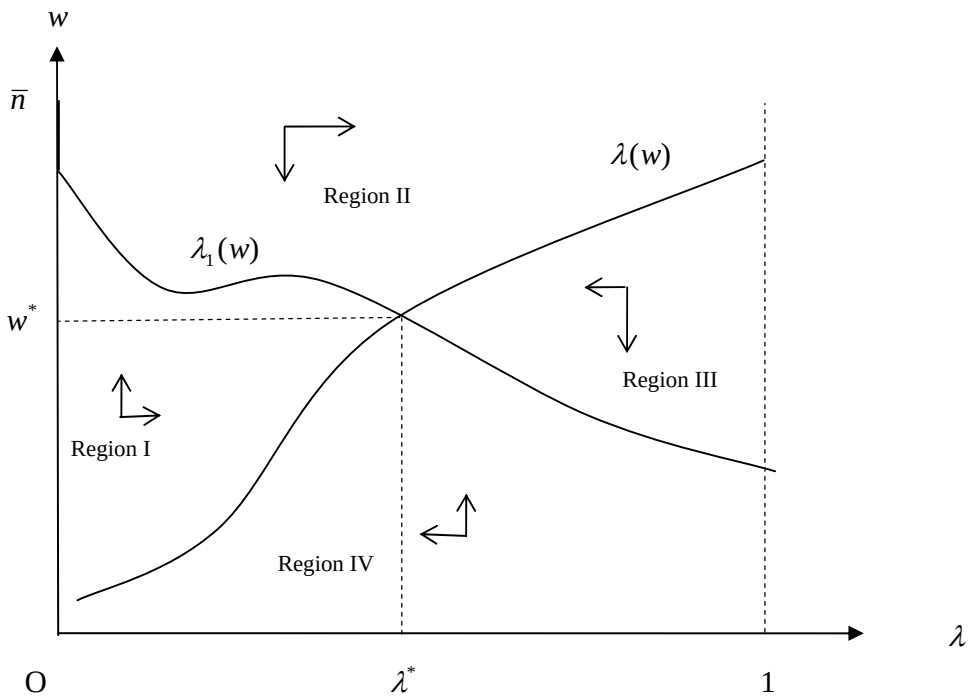

Figure 1: Static Expectations Dynamics

Dynamic paths

- Dynamic paths shaped by the interaction of signaling and wealth constraints. Kutznets paths tend to emerge;
- Region I: skill premium and skill ratio $\uparrow$ together. Additional inflows in the skilled sector of kids from T contribute to $\uparrow$ the average quality;
- Region II: less and less selection in households as the skill ratio increases
- Convergence. Paths may or may not converge to steady state, globally; could flip back to region I again, or overshoot the steady state, in general. We simulate the model;

  (paths with monotone GDP growth are Liapounov, difficult to come up with neat conditions in terms of fundamentals).

Numerical Simulations

- Log utility (U, V), uniform ability distribution on $[0, 1]$
- Education cost $x(n) = 1 - n$
- Figure 3(a): $v = 0.1$; Initial values $\lambda(0) = 0.01, w(0) = 0.8$
- Figures 3(b)-(d): vary $v = 0.2, 0.3, 0.4$, increase wage in T sector lowers initial skill premium, moves economy into second phase at the outset
- Figure 4: lower $w(0)$ to 0.6, make first phase more pronounced

Simulations I

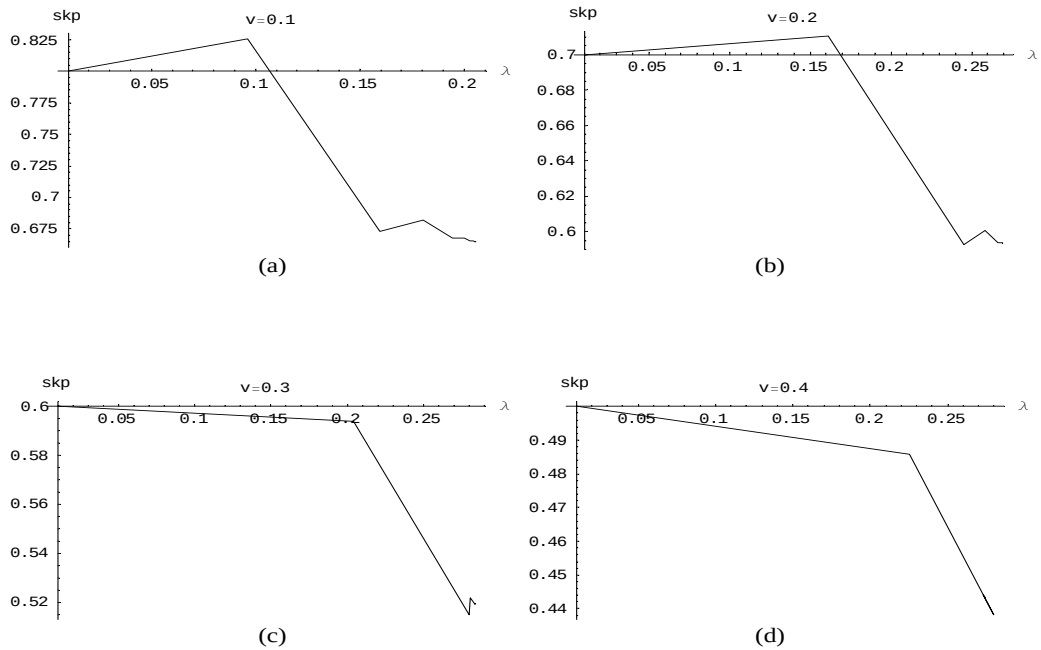

Figure 3.
Uniform distribution on [0,1], log utility, CRS; $w(0) = 0.9$, $\lambda(0) = 0.01$.
(a) v=0.1, (b) v=0.2, (c) v=0.3, (d) v=0.4 .

Simulations II

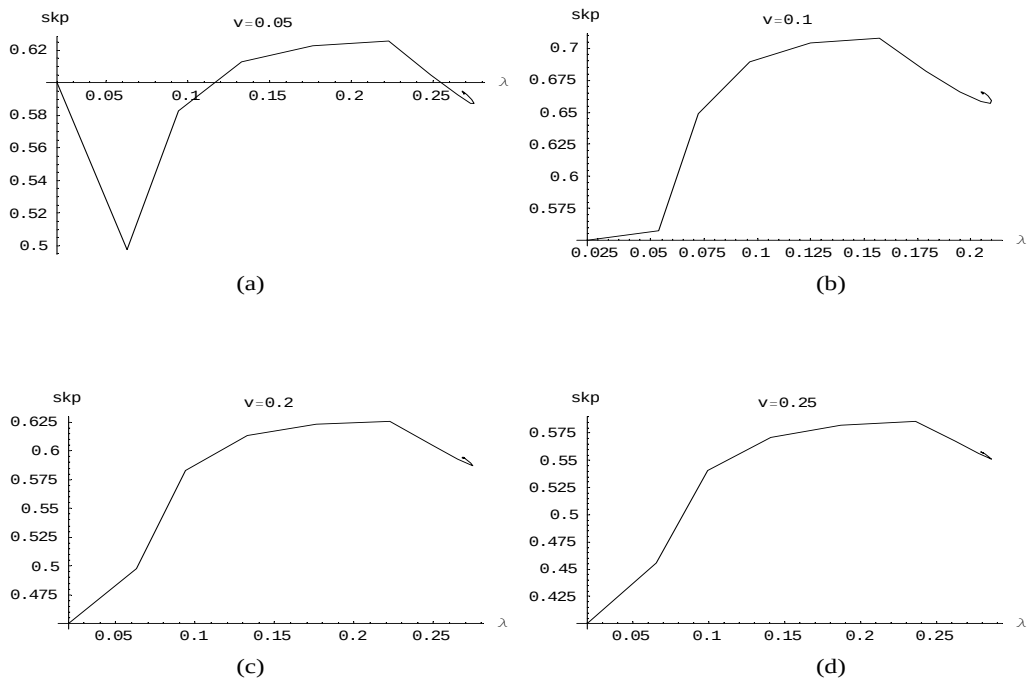

Figure 6.

Slowed down dynamics with 5 periods of working life per cohort, static expectations, Uniform distribution on [0,1], log utility, CRS; $w(0) = ... = w(4) = 0.65$, $\lambda_c(0) = ... = \lambda_c(4) = 0.041$, $\lambda(0) = ... = \lambda(4) = 0.1$.

(a) v=0.05, (b) v=0.1, (c) v=0.2, (d) v=0.25 .

Summary on the dynamics

- So far we have shown that in the presence of *signaling+credit market imperfections* can produce positive comovements between the skill premium and the skill ratio;
- a parsimonious account of up and downs in the skill premium not relying on shocks (SBTC and schooling policies)
- A tendency towards an inverted U;

Dynamics in Benchmark Models

- Suppose employers have perfect information about applicants ability but credit constraints still affect education choice (Appendix E);

  then $w_i = n_i$; so there is a fully fledged wage distribution shaped by wealth constraints.
- the wage distribution dynamics follows a monotone Markov process, there exists a unique wage distribution (memo: v is exogenous)
- the skill ratio λ_t converges monotonically;
- the skill ratio and the average skill premium comove negatively along the transitional dynamics;

  intuition: there exist a fraction of the population unaffected by credit constraints (high enough productivity), any increase in λ can only come from an increase of mass in less productive agents getting education (an expanding middle class).
- there is under-investment (see below) among households in the traditional sector; there may be under or over-investment in the modern sector.

Dynamics in Benchmark Models cont.ed

- Suppose there exists signaling and credit markets are perfect as in Spence,

  then there is no dynamics in the skill ratio (with over-investment), Appendix B
- Suppose employers do not observe ability but can observe a signal of parental background (Appendix D)
- Then a fully fledged income distribution arises, this satisfies a mixing condition for strong convergence.
- By construction, given ability there is negative inter-generational correlation in wage income.

Macro Rates of Returns

- Consider, as a first approximation, GDP growth as an aggregate measure of future returns to education, induced- on average- by an increase in skilled workforce:

$$\frac{y_{t+1} - y_t}{\lambda_{t+1} - \lambda_t} = (w_t - v) + \lambda_{t+1} \frac{w_{t+1} - w_t}{\lambda_{t+1} - \lambda_t} \tag{4}$$

  Evaluate (4) on a *Kuznets path*,

- In the first phase the skill ratio and skill premium both $\uparrow$, hence the social rate of return (GDP Growth) is larger than the market return (skill premium, first term RHS); converse in the second phase;

- Suggested policy implications subsidize education in the first phase when income inequality increases;
- These suggestions are based on aggregates and have limits as a guide for policy which affect individual decisions in a complicated way. What about efficiency at the micro level?

Efficient Investment

- In the presence of financial market imperfections no clear benchmark from alternative investment opportunities, due to heterogeneity households face different rate of returns in this context.
- A notion of Productive Efficiency. Define $\tilde{n}$ by the property that $\delta[\tilde{n} - v] = x(\tilde{n})$. Efficiency involves ability threshold $\tilde{n}$; same for all households as if credit constraints immaterial,
- Hence whether or not there is over or under-investment in M or T depends on how the corresponding threshold in that sector compares with $\tilde{n}$.
- Notice that the benchmark is independent of wage distribution and hence from the distribution of ability, whereas incentives to invest are driven by the average expected wage which depends on the distribution of ability. Do not expect general statement.

Under/Over investment

Proposition

Consider a competitive equilibrium sequence $\{w_t, \lambda_t\}$ *with rational expectations and associated ability thresholds* $n_t^P = n^*(w_{t+1}, v), n_t^R = n^*(w_{t+1}, w_t)$ *used in educational decisions by poor and rich households respectively at date* t*. Suppose that* $V \equiv \delta U$ *for some positive discount factor* δ*.*

(a) There is **under-investment** *among the poor at* $t-1$ **if** *either of the following is satisfied:*

(i) $w_t < \tilde{n}$ *or* $w_t > m(\tilde{n})$

(ii) $\lambda_t < 1 - F(\tilde{n})$

(iii) **The economy is operating in the 'first phase of development' with rising skill premia and ratios**, *i.e.,* $\lambda_t > \lambda_{t-1}, w_{t+1} > w_t > w_{t-1}$.

(b) There is over-investment among the rich if $w_t < m(\tilde{n})$.

Pareto (in)efficiency

- Is there a scope for corrective policy interventions?
- Can an educational loan improve efficiency?
- Notice: signaling effects on the labor market transmitted to the loan market. Consider the government issuing a bond subscribed by parents in M to subsidize parents in T. A rush to the bond by M (with large costs) and a rush to education by T would obtain. Same adverse effects at work as with perfect financial market (if signaling prevails, over-investment). The possibility of balancing the public budget also affected.
- The intervention has to control for such effects and has to sterilize general equilibrium effects on wages in order to support Pareto improvements;
- Suppose government cannot borrow or lend on par with private agents, hence all interventions must balance the government budget period by period.

Pareto (in)efficiency, cont.d

Proposition

Given any competitive equilibrium, the planner can design an intervention involving any pair $t-1, t$ of successive generations with the following properties:

- *in generation $t-1$ it provides public schooling for children of parents in the T sector, funded by a bond purchased by parents in the M sector;*
- *in generation t the recipients of public schooling pay a tax to the government, used to pay children of bondholders;*
- *the government imposes a tax on M sector wages at t to sterilize GE effects;*

and the scheme generates an ex post Pareto improvement, is incentive compatible and runs a government budget surplus at every date.

Contrast this with standard results in the literature on credit market imperfections. The relevance of heterogeneity and the composition effect.

Pareto (in)efficiency, cont.d

- The scheme constructed to take care of IC problems and feasibility constraints; moreover it sterilizes the general equilibrium effect on factor prices.
- Public schooling as a monitoring device designed to attract only kids with ability larger than "average" from the T sector.
- The mechanism encourages the "marginal" household in the M-sector to purchase the bond, by providing random returns: with a certain probability the bond is not repayable to some agents who then will have to educate at their own expenses, this discourages high cost agents in M from joining. (A rationing scheme)
- The composition effect creates the surplus that can be reallocated.

Conclusions

- A model linking educational investment, mobility flows and income inequality dynamics is studied, based on credit market imperfections and educational signaling;
- Results on Steady State and Dynamics of income distribution. Rich dynamics featuring non monotonicty. Kuznets paths tend to emerge when labor force moves from the traditional sector to the modern one;
- Productive Efficiency: On Kuznets paths under-investment in the first phase of human capital accumulation when inequality is increasing;
- Competitive equilibrium is (constrained) Pareto inefficient. Public intervention can improve the composition (rather than the size) of the skilled labor force and enhance equality of education opportunity.

Pareto

V. Pareto on individual heterogeneity, elites and social mobility

In thinking about the long term causes for why the distribution of income was so remarkably stable across nations and time, Pareto focused on fundamental mechanisms of social mobility. About these latter he wrote:

" *In current societies, the inclusion of new elements, necessary for the survival of the elites comes from lower classes and mainly from rural classes*. These are the pot where future elites are shaped, in the shadow. They are like the roots of the plant of which the elite is the flower. This flower passes but it is soon replaced, if the roots are preserved. The causes [behind this process] are not yet well known. *However it seems very likely that rigorous selection in inferior classes, specially of their kids, is among the most important ones. Rich classes have less kids and they save them almost all*."

Pareto V., Introduction to Les systeme socialistes, Lousanne, 1902, now in Oeuvres Completes, V, pp. 2-73.

Friedman

M. Friedman intervening on capital market imperfections in educational investment proposes a financing scheme based on public lending resting on the superior power of the public with respect to the private bank in the enforcement of the loan contract:

“For vocational education, the government, this time however the central government, might likewise deal directly with the individual seeking such education. If it did so, it would make funds available to him to finance his education, not as a subsidy but as "equity" capital. In return, he would obligate himself to pay the state a specified fraction of his earnings above some minimum, the fraction and minimum being determined to make the program self-financing. Such a program would eliminate existing imperfections in the capital market and so widen the opportunity of individuals to make productive investments in themselves while at the same time assuring that the costs are borne by those who benefit most directly rather than by the population at large." (Friedman, 1955)

Card

D. Card on individual heterogeneity and ability bias in regression analysis:

"...there is underlying heterogeneity in the returns to education, and that many of the IV estimates based on supply-side innovations tend to recover returns to education for a subset of individuals with relatively high returns to education. Institutional features like compulsory schooling or the accessibility of schools are most likely to affect the schooling choices of individuals who would otherwise have relatively low schooling. If the main reason that these individuals have low schooling is because of higher-than-average *costs* of schooling, rather than because of lower-than-average *returns* to schooling, then "local average treatment effect" reasoning suggests that IV estimators based on compulsory schooling or school proximity will yield estimated returns to schooling above the average marginal return to schooling in the population, and potentially above the corresponding OLS estimates." (Card, 2001)