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The Evolution of Wealth Distribution in a Model of Educational Investment with Heterogenous Agents

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Abstract

The implications of individual heterogeneity for the evolution of wealth distribution are studied in a standard model of occupational choice with financial market imperfections and local non convexities in education investment technology. We consider heterogeneity in the cost of educational investment, interpreted as genetic variation at the level of lineage. Ergodicity of the wealth distribution is obtained whenever the (exogenous) distribution of education costs entails the presence of ability types for which the educational investment is inefficient vis a vis financial investment, regardless of how "large" the support is. Conversely, poverty traps can emerge only if investment is efficient for every single agent in the economy. We show that under quite general conditions, the accumulation of wealth at the lineage level does not eliminate financial market imperfections over the long run, motivating our exploration of policy implications. In particular heterogeneity requires more persitent policies to achieve similar results as in the standard case. On the other hand policies can be effective in environments where they would fail under the assumption of homogeneous costs.

JEL classification: D31, D91, I21, J24, O15

Keywords : Intergenerational Mobility, Inequality Dynamics, Occupational Choice, Educational Investment, Borrowing Constraints

Introduction

Poverty traps arising from many sorts of market failures represent one of the influential analytical frameworks to understand persistence of large differences in the performance of households in the labor market and economies on the development path. Such persistence is considered as inconsistent with the outcome of more standard models in which perfect markets efficiently govern temporary reversal of fortunes of households or countries, although the empirical relevance of the theoretical construct is debated (Azariadis and Stachursky, 2006, Ravallion, 2006). The analysis of the microstructure of a poverty trap and its aggregate consequences has also been an influential framework for policy design (see Barret et al., 2008 and references therein) since it is deemed to establish the relevance and to clarify scope and power of temporary policies to achieve permanent objectives. Subject to a proper scale dictated by fiscal budget constraints and provided that individual state (usually wealth) is observed by the policy maker, policy interventions are easy to enforce featuring a very nice property: once broken the jaws of the trap, policy and the enforcing public institutions become irrelevant and can disappear.

Whether indivisibility and threshold effects induced by financial market imperfections are relevant features of actual economies and how the answer to this question changes in time and space, what is the role of individual heterogeneity and family altruism in making the assessment pending towards ergodicity or not of the actual dynamics of wealth distribution is a difficult empirical question (Azariadis and Stachursky, 2006, Ravallion, 2006). Our starting point is simply that financial market imperfections are particularly relevant for educational investment where also indivisibilities can matter, both ingredients are typical sources of poverty traps and have been widely analyzed. Our aim is to investigate in some detail the role of heterogeneity for the evolution of wealth and for policy design in a standard model (with no interaction between wealth distribution and factor prices) of educational investment with indivisibilities and financial market imperfections. We consider heterogeneity in the cost of education investment, interpreted as genetic variation at the level of a lineage. In this context we explore the role of heterogeneity addressing three issues: i. the implications for the evolution of wealth distribution; ii. if and under which conditions financial market imperfections are overcome by the accumulation of wealth at the lineage level; iii. what, if any, is the role for policy in this context.

Clearly individual characteristics, in the context of educational investment and occupational choice, can induce further occupational mobility than that usually obtained in standard models of poverty traps (Gal Or and Zeira, 1993), producing similar dynamics as in models of mobility traps (Piketty, 1997 and Aghion and Bolton, 1997) and in models of short term persistence of wealth distributions (Becker and Tomes, 1979, and Loury

1981). With heterogeneity the specific outcome in terms of long run wealth distribution depend, via financial market imperfections, on the possibility for agents at the bottom of wealth distribution to finance upward occupational mobility, turning on the engine of wealth accumulation in a family lineage. The emergence of poverty traps will, therefore, depend on whether or not the race between individual ability and financial market imperfections allow lineages, sooner or later in their history, to cope with the indivisibility in investment.

It may seem that if wealth constraints are not binding for a positive fraction of agents, regardless of their wealth background, the mismatch between ability (the exogenously random element in the rate of return to educational investment) and the distribution of wealth (as a source of finance in a world of financial market imperfections) is transitory. As a result, as time goes by, an ergodic distribution of wealth is shaped, financial imperfections are overcome by wealth accumulation. The scope for policy, if any, is to tackle financial problems at the bottom range of the wealth distribution to trigger or accelerate the process of occupational mobility.

However, even if the presence of a gifted agent in a poor lineage can always trigger upward occupational and wealth mobility, it does not necessarily imply, as it happens instead in the case of homogeneous agents once the threshold level of wealth is reached, that financial market imperfections become irrelevant in any history. In that case the race between random elements of luck and indivisibilities would be won by the former in the long run making financial market imperfections a transitory problem in the development process.

The point is that heterogeneity, possibly entailing the presence of low ability types, may trigger downward occupational and therefore downward wealth mobility in skilled households, setting the conditions for the continuous bite of financial market imperfections on investment choice and, possibly, a scope for policy.[1]

Whether or under which conditions ergodicity of the wealth distribution is related to the progressive elimination of financial market imperfection is, therefore, less clear and deserves some attention on its own right.

Our analysis is conducted in a simple economic environment: a small open economy is considered where the size of indivisibilities, financial market imperfections and returns to factors are set exogenously in the competitive equilibrium (i.e. we study a non interactive model of wealth distribution).

[1]Financial market imperfections are doomed to persist in the long run whenever non insurable shocks (not considered in this paper) hit the returns to investment. See for example Loury (1981), Banerjee and Newman (1991), Aghion and Bolton (1997), Piketty (1997). The interaction of wealth accumulation at the lineage level can serve both as a source of finance in the presence of credit market imperfections and as insurance device, whenever moral hazard aspects in production prevent complete insurance of idiosyncratic shocks. Our focus is on the former.

Of course the bite of financial market imperfections evolve with the accumulation of wealth at the lineage level, not with the state of the aggregate economy. The model is, therefore, an ideal setting for a simple but detailed accounting of occupational and wealth mobility flows and their implications for aggregate investment and growth. In this context, the dynamics are shown to be quite different depending on whether ability distribution entails or not an inefficient type for whom the financial bequest is preferable as an alternative to educational investment. In particular, we show that poverty traps disappear whenever the distribution of education costs entails the presence of ability types for which the educational investment is inefficient vis a vis an alternative financial investment available in the economy. The result holds regardless of how ”large” the support of the distribution of abilities is. Moreover, and more importantly for the motivation of our exploration of policy issues, the disappearance of poverty trap does not necessarily imply the irrelevance of wealth constraints on investment in a steady state with occupational mobility. It is still possible that financial market imperfections bind investment decisions over the long run. Actually, we show that in our economy, if at a single point in time a single lineage is constrained, financial market imperfections cannot disappear in the long run at any steady state with occupational mobility. Relatedly, it holds that whenever the observed frequency of investment in skilled households correlates, at any point in time, with wealth background, then financial market imperfections can not disappear, even in the long run.

Conversely, a poverty trap can emerge only if investment is efficient for every single agent in the economy, that is when fixed costs are ”small” (i.e. when a given rate of return on educational investment are large compared to education costs). Traps will emerge (of course) provided that wealth accumulation in the traditional sector converges below the minimum threshold required for investment and the middle class is not constrained by wealth in its investment choices. Whether financial market imperfections are operative for households in the skilled sector, is crucial for the long run equilibrium: when both households in the unskilled sectors are trapped and middle class (less wealthy agents in the skilled sector) are constrained for some of their ability types the economy declines towards stagnation in the traditional sector. In this case it also holds that occupational mobility at steady state imply the persistence of financial market imperfections over the long run.

The possibility that, with heterogeneity, wealth accumulation does not eliminate financial market imperfection over the long run is one of the motivations for our investigation of policy design in this environment, when a more direct intervention on financial market imperfections is not available as a policy instrument.

It is well known that local indivisibilities and the failure of financial markets form an economic environment where the initial distribution can matter.

Equivalently, temporary (both structural and policy) shocks can have permanent effects in this environment. Then redistributive policies can have permanent effects on investment, equality of opportunity and per capita income. An example of the effectiveness of policies arises in the case of homogeneous agents: if average wealth in the economy (or the scale of outside intervention through external resources) is large enough "one shot redistribution policies can have permanent effects", both for the elimination of the poverty trap and for the role of policy response to transitory adverse shocks. This view about the role of transitory policies in environments exhibiting poverty traps has been challenged in models where long run intervention is required by the emergence of so called mobility traps (see Piketty, 2000, for a survey), similar conclusions are suggested by Mookherjee and Napel (2007) in a model with heterogeneity and endogenous factor prices. With this debate in mind, we address the implications of heterogeneity for the design of effective policies aimed at increasing educational investment, per capita output and social mobility in a standard environment with indivisibilities.

In particular we show that, in a well defined sense, models with heterogeneity call for more persistent policies, arising, essentially from the impossibility for the policy maker to observe agents' ability type and targeting the transfer scheme accordingly. More importantly we also show that redistributive policies can be effective in environments where they would not be under the assumption of homogeneous costs. In particular, we characterize a set of conditions on the distribution of abilities such that a permanent policy is effective even when economic fundamentals would dictate a declining path: intuitively heterogeneity in ability provides additional opportunities for redistributing resources when financial market fail.

The role of heterogeneity is briefly discussed in Gal Or and Zeira (1993) on which we heavily draw for the modeling of the economic environment. There it is stated that provided that the variability of the individual (ex-post) non insurable shock (wages) is not too large poverty traps are still obtained. Our analysis spells out all the emerging equilibrium configurations, and investigates some policy implications in greater detail for the slightly different case of ex-ante heterogeneity.

The work by Mookherjee and Napel (2007) analyzes the role of heterogeneity in shaping intergenerational mobility in the context of a model where pecuniary externalities to educational investment arise due to the presence of standard decreasing returns to scale technology in both the modern and the traditional sector. They provide results and open important questions, some of which motivated our analysis here. Their analysis is conducted on the assumption that investment costs always ensure downward occupational mobility in skilled households. This latter assumption, coupled with the assumption of positive occupational mobility at the bottom of the wealth distribution, entails the shrinking of the set of steady state from a continuum to a finite number, in a model with no financial bequest motive. Our analysis, conducted in a simpler model with exogenous returns to factor, can be seen as an exploration, without restricting the cost distribution a priori, of similar issues for the evolution of wealth distribution, which is important for establishing whether the accumulation of wealth process at the level of a lineage can, and to what extent, eliminate, wealth constraints on households investment choice. They also briefly discuss policy implications arguing for the role of persistent policies, due to multiple equilibria. We arrive at a similar conclusions, but the argument is different and it holds under ergodicity.

The relationship of our analysis to models generating ”low mobility traps” (as in Piketty, 1997, see, Piketty 2000, for a survey) is weak since the main impact of initial distribution of wealth in these models works via the endogenous accumulation of aggregate capital and the determination of the interest rate, which is instead fixed in our model. The policy implications of heterogeneity, however, remind some of the conclusions drawn in these models.

The rest of the paper is organized as follows: in section 2 we lay out the model, specializing the main features in Gal-Or and Zeira to the case of no financial markets for human capital investment, moreover we analyze the benchmark case of homogeneous investment costs and discuss some implications for policy design with a focus on the two points discussed in this section, in section 3 we discuss the results about the dynamics of wealth distributions and occupational mobility in the case of heterogeneous investment costs, in section 4 we discuss the implications of heterogeneity for policy design. Section 5 discusses some extensions and section 6 concludes. All the proofs are reported in the Appendix.

1 The model

Our model economy is very similar to that considered in Gal-Or and Zeira (1993) except for two features: there is no financial market whatsoever for educational investment and, more importantly, there is heterogeneity in the investment cost. The first feature is just a simplification and it does not affect the results (see Piketty 2000, pp.459 and ss.), the second represents the specific focus of our investigation.

Specifically, we consider a small open economy where a single good can be produced with two technologies, using skilled labor and physical capital in one case and unskilled labor in the other case. In the sector where skilled labor is employed output is given by:

$$Y_t^s = F(K_t, L_t^s) \tag{1}$$

where Y_t^s is output, K_t is the amount of physical capital, L_t^s is the amount of skilled labor employed in production, $F(.)$ is a homogeneous function of degree one.

Production in the sector employing unskilled labor is given by:

$$Y_t^n = vL_t^n \tag{2}$$

i.e. returns to unskilled labor (v) are assumed to be constant. The hypothesis of small open economy and homogeneity of degree one of F imply that returns to capital (r) and skilled labor (w) are constant as well. Firms do not face financial market imperfection.

The economy is populated by agents whose measure is normalized to 1 in every period t. Agents derive utility from their own consumption and bequest to their offspring according to:

$$U_t = \alpha \log c_t + (1-\alpha)\log b_t \quad \text{con } \alpha \in (0,1) \tag{3}$$

where c_t denotes consumption and b_t denotes the bequest, $\alpha \in (0,1)$ is a (inverse) measure of altruism within lineages.

Each agent, given the inherited bequest, has to decide whether to invest in human capital or not and how much to bequeath to her own offspring; the budget constraint is given by

$$c_t + b_t = (1+r)(b_{t-1} - e \cdot x) + y_e \tag{4}$$

where $e \in \{0,1\}$ summarizes the indivisibility in human capital investment, capturing non convexities in the investment technology that vary at the individual level. If $e = 0$ agents do not invest in human capital and $y_0 = v$. If $e = 1$ the agent bear the cost of investment x and she works as skilled yielding a wage $y_1 = w$.

We model financial market imperfection simply as non existence of credit market (Loury, 1981, Mookherjee and Ray, 2003) for human capital investment, i.e. investment choices are subject to wealth constraints as follows:

Assumption 1. *(Financial Market Imperfection)* $b_{t-1} \geq e \cdot x$.

The investment cost is heterogeneous across individuals in a given generation, so that it holds:

Assumption 2. *(Heterogeneity in Investment Costs) x, a measure of ability, is a random variable distributed according to $G(x)$ on the support $\Delta x = [\underline{x}, \overline{x}]$, with $\underline{x} \geq 0$ and average $x_e = \int_{\underline{x}}^{\overline{x}} x dG(x)$.*

Assumption 2 captures the presence of indivisibilities in education investment (local non convexity) but adds heterogeneity as in Mookherjee and Napel (2007). Notice that heterogeneity in investment costs is such that each agent makes investment decisions based on an individual specific cost that does not depend on the inherited wealth (and therefore is independent on her ancestors' ability). Of course ancestor's ability affect their offspring's investment through bequeathed wealth.

For stability we require that:

Assumption 3. *(Stability)* $\rho := (1+r)(1-\alpha) < 1$.

Simple algebra shows that lifetime resources is allocated between consumption and bequest as follows:

$$c_t(e) = \alpha[(1+r)(b_{t-1} - e \cdot x) + y_e] \tag{5}$$
$$b_t(e) = (1-\alpha)[(1+r)(b_{t-1} - e \cdot x) + y_e] \tag{6}$$

with $b_{t-1} \geq e \cdot x$.

By substituting (5) and (6) into (3) we get the indirect utility as a function of e, given b_{t-1} and x_t

$$U_t(e) = \log((1+r)(b_{t-1} - e \cdot x) + y_e) + \epsilon$$

where $\epsilon := \alpha \log \alpha + (1-\alpha)\log(1-\alpha)$.

Due to indivisibility agents choose investment by solving:

$$\underset{e}{Max}\, \{U_t(e=0), U_t(e=1)\} \tag{7}$$
$$s.to\ b_{t-1} \geq e \cdot x$$

where:

$$U_t(e=0) = \log((1+r)b_{t-1} + v) + \epsilon \tag{8}$$
$$U_t(e=1) = \log((1+r)(b_{t-1} - x) + w) + \epsilon \tag{9}$$

It is easy to see that the solution to (7) entails a cut off level for x; moreover, such level depends on whether the wealth constraint is binding or not. In households where wealth constraints are not binding, equate (8) and (9) and get the value of x such that:

$$U_t(e=0) = U_t(e=1) \Rightarrow \tilde{x} = \frac{w-v}{1+r} \tag{10}$$

In households where wealth constraints are binding investment occurs whenever $x \leq b_{t-1}$.

Summarizing the solution to the human capital investment problem in each lineage we state:

Remark 1. *Educational investment occurs ($e = 1$) if and only if*

$$x \leq \min\{\tilde{x}, b_{t-1}\} \qquad (11)$$

Intuitively, Remark 1 states that both the individual cost of investment and inherited wealth affect, in general, the choice of investment. Unconstrained agents $(b > x)$ will invest whenever the rate of returns on human capital investment is larger than the rate of returns of financial market; i.e. $e = 1$ for $x < \tilde{x}$. Constrained agents' investment is, instead, limited by financial market imperfection[2]. Also intuitively, for given distributions of x and b the demand for investment in human capital increases when the rate of return on education increases (the skill premium $w - v$ is larger) and when the return on financial wealth decrease ($1 + r$ is lower).

Notice that, from (6) it is easy to see that the Markov system of family decisions defines a "non interactive dynamics" of the evolution of wealth distribution: the history of each lineage does not depend neither on the measure of that lineage nor on the measure of any other lineage in the economy. This allows us to study separately the dynamics of bequest in each lineage and the induced measure of given wealth interval. Given these features, the competitive equilibrium is simply obtained by aggregating individual choices. Therefore the competitive equilibrium of our model is an evolution of measures on the admissible set of bequests (as for example in Loury, 1981, Becker and Tomes, 1979, Piketty and Aghion and Bolton) induced by an initial distribution and the equilibrium investment decisions made as above.

In particular, individual decisions are such that the optimal allocation of lifetime income between consumption and bequests as described by (5) and (6) and the optimal investment choice as described in (7) by each agent. Agents will differ depending on x and b_{t-1}. The structure of family decisions making defined by (5), (6), (7) (since they are all functions of the state b_{t-1}) allows us to study the evolution of the economy as a Markov process[3]. Therefore the object of analysis is the evolution of a random variable $\mu_t(b)$ describing the distribution of bequests at each period t induced by $\mu_{t-1}(b)$, the past distribution at $t - 1$ given exogenous prices in factor markets and other parameters of the model. The set of all exogenous parameters is denoted as $\Gamma = \{\alpha, r, w, v, G(x)\}$.

The aim of the analysis is to establish whether and under which conditions on Γ the evolution of wealth distributions $\mu(b)$ exhibits or not ergodicity with respect to $\mu_0(.)$ and derive some policy implications.

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[2]Notice that constrained agents have strictly larger rate of return than the unconstrained in the human capital investment.

[3]See the appendix for a formal proof that the evolution of our economy follows a Markov process. The result is easily obtained by suitably adapting arguments in Loury (1981).

Before studying the model with heterogeneity it is convenient to review some results on the model in the absence of heterogeneity as a useful benchmark. This will both help the intuition of our main results in the analysis of the evolution of the economy with heterogenous agents and in the analysis of the role of redistributive policies.

1.1 The benchmark case of homogeneous costs of investment

As it is well known, in the case of homogenous agents a few configurations emerge for the long run equilibrium depending on the forces that allow households to eliminate financial market imperfections through asset accumulation (returns on financial wealth, altruism, labor income and investment costs). The analysis of the dynamic evolution emerging for homogeneous costs will be important for describing the dynamics of different households in the case of heterogeneity and constitute a useful benchmark.

Our benchmark is constructed, without loss of generality and for a reason that will be clear in the discussion of policies, so that the homogenous cost of investment is equal to the average cost x_e.

In this case, by Remark 1 the solution to (7) is $e = 1$ for $x_e \leq b$ and $e = 0$ otherwise. Notice first that for $x_e > \widetilde{x}$ the investment technology is *inefficient*[4], $e = 0$ and $\phi(b; x_e) = (1-\alpha)v + \rho b$, this case is trivial and disregarded.

For $x_e \leq \widetilde{x}$ investment is *efficient* i.e. every agent would invest if feasible. The outcome depends on how family altruism and the storing technology $(1+r)$ allow households to circumvent financial market imperfections sooner or later and in their history along the wealth accumulation path, for the given value of x. By remark 1 it is straightforward to conclude that with homogenous costs the dynamics of wealth are governed by the map $\phi : b_{t-1} \rightarrow b_t$ defined as follows:

$$\phi(b; x_e) = \begin{cases} \phi_u(b; x_e) := (1-\alpha)v + \rho b & x_e > b \\ \phi_s(b; x_e) := (1-\alpha)w + \rho(b - x_e) & x_e \leq b \end{cases} \tag{12}$$

where the time subscript is eliminated for the subsequent exposition, to simplify the notation. Notice that the mapping $\phi(b; x_e)$ is stepwise linear increasing, with slope ρ and it exhibits a discontinuity at $b = x_e$, the wealth threshold. Also notice that occupational and bequest choice are two aspects of the same phenomenon, i.e. whenever wealth is above a threshold x_e the household member is employed in the skilled sector forever on and the accumulation equation is governed by ϕ_s. Occupational mobility flows exactly mirror mobility flows in the wealth distribution. This is implied by the fact that in a world of homogeneous costs either the investment is efficient

[4]The cost of investment is larger than the discounted present value of the return on investment.

or it is not for every single agent in the economy. Then mobility flows are regulated by inherited wealth (in the form of a threshold $b = x_e$) rather than by credit markets, ability does not play any role in the long run. [5]

In particular, three possible equilibrium configurations emerge from the analysis of the homogeneous cost case, summarized in the following:

Lemma 1. *Fix x_e so that $x_e < \widetilde{x}$, define FP as the set of fixed points of ϕ, denote $b_s = (1-\alpha)w$, $\underline{b} = \frac{(1-\alpha)v}{1-\rho}$. Then FP is characterized as follows:*

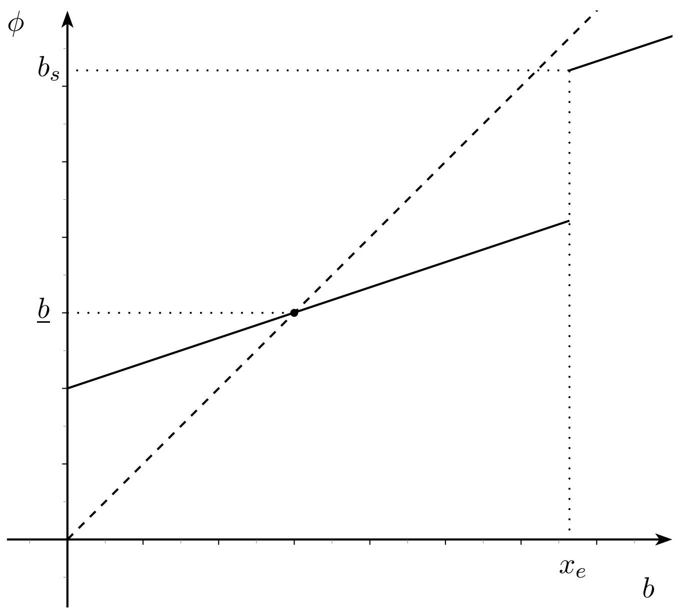
i) (Decline) If $x_e > b_s$, then $FP = \{\underline{b}\}$;

ii) (Self sustaining growth) If $x_e < \underline{b}$, then $FP = \left\{\frac{(1-\alpha)w-\rho x_e}{1-\rho}\right\}$

iii) (Poverty trap) If $x_e \in [\underline{b}, b_s]$, then $FP = \left\{\underline{b}, \frac{(1-\alpha)w-\rho x_e}{1-\rho}\right\}$.

Case 1. and 2. are ergodic, in case 3. the measure of skilled agent converging to either of the two steady state wealth levels depends on the initial distribution of wealth.

This result is well known (e. g. Gal-Or and Zeira, 1993) but some comments will be helpful for the discussion of the dynamics with heterogeneous agents.



[5]This aspect of the model with homogeneous investment cost will be lost in general in the case of heterogeneity: in the latter case the transition from one occupation to the other (both upward and downward) is not necessarily regulated permanently by the threshold x_e in wealth. With heterogeneity in investment costs the law governing the evolution of wealth within family will be regulated by both the position in the wealth distribution and by the random draw of ability by members of the lineage in each generation, both in the form of thresholds, due to indivisibilities of investment.

Figure 1 (decline). Type $B_0 := x_e > b_s$

Case 1. (*Decline*). Consider b_s the minimum level of wealth that can be bequeathed by a member of the skilled sector, if $b_s < x_e$, b_s must be reached in finite time by any lineage in that sector and then a straightforward implication of (7) is $e = 0$ in the next and every subsequent generation. Every lineage is doomed to pass through state b_s then the economy converges to a unique steady state, $\underline{b}$, regardless of the initial distribution of wealth. Financial market imperfections in this case are not countervailed by family altruism and have such a severe impact that they will end up to constrain investment in every lineage in the economy in the long run (a scenario we label decline). Both downward and upward wealth mobility flows can be observed in the transition, depending on the initial distribution, although, after a finite number of periods the unskilled becomes the only operating sector in the economy.

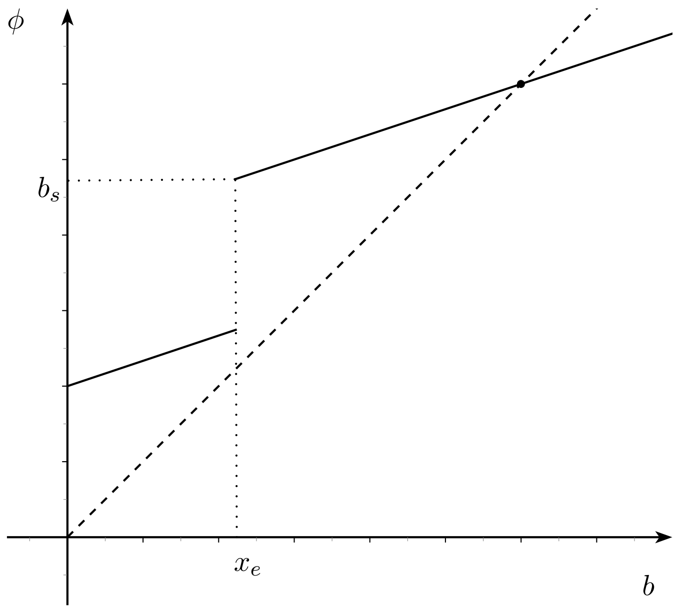


Figure 2: (Self-sustaining growth). Type $B_2 := x_e < \underline{b}$

Case 2 (*Self sustaining growth*). If $x_e < \underline{b}$ then lineages in the unskilled sector will be unconstrained in finite time, thereafter upward occupational mobility is observed, along with both upward and downward mobility in wealth.

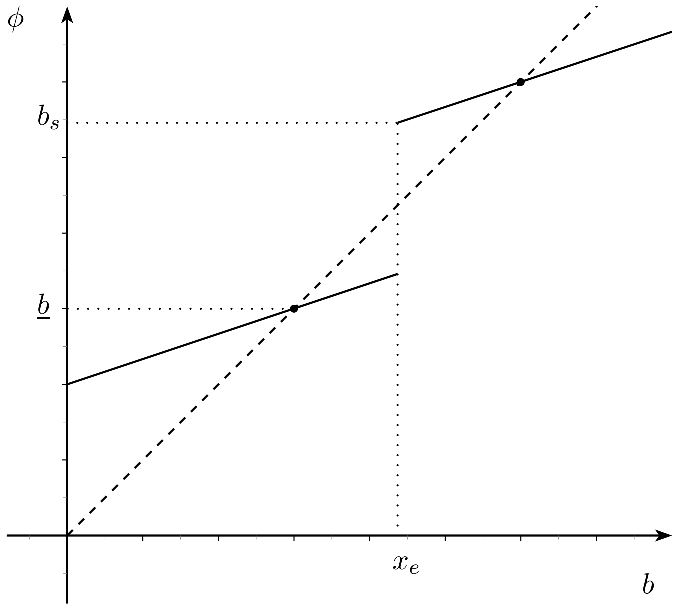


Figure 3 (Poverty traps). Type $B_1 := \underline{b} \leq x_e \leq b_s$ [6].

Case 3 (*Poverty trap*) For $\underline{b} \leq x_e \leq b_s$ a straightforward implication of (7) is $e = 1$ for $b \geq x_e$ in a given period, then the same will hold in the next and any subsequent generation in such lineage, downward occupational mobility will never occur: households in the skilled sector are unconstrained ($x_e \leq b_s$), households in the traditional sector are constrained in the long run ($\underline{b} \leq x_e$). No occupational mobility can occur in the transition, some upward and downward mobility in wealth can be observed in the transition. Multiple steady states (the measure of agents in each sector) arise depending on the initial distribution of wealth.

2 The evolution of wealth distribution in the presence of heterogeneity

In this section we analyze the dynamics of the model under Assumption 2. With heterogeneity, the implicit rate of return on investment is spread across individuals in a given generation according to the distribution function of x which, provided that wealth constraints are not binding, will be the source for upward and downward occupational mobility within lineages and for the induced mobility in wealth.

Equilibrium bequest and investment policies, for any given individual state (b, x), are defined by the map Φ as follows:

[6] Observe that: $\frac{(1-\alpha)w-\rho x}{1-\rho} \geq b_s$ whenever $x_e \leq b_s$

Definition 1. *For a given x, define $\Phi(b;\,x) := \underset{b,e}{ArgMax}\,\{U_t(e=0), U_t(e=1)\}$, where $U_t(e=0)$ and $U_t(e=1)$ are defined as in (8) and (9).*

The dynamics of wealth accumulation can therefore be defined in the following way:

$$\Phi(b;\,x) = \begin{cases} \Phi_u := (1-\alpha)v + \rho b & x > \min\{\tilde{x}, b\}, \quad e=0 \\ \Phi_s := (1-\alpha)w + \rho(b-x) & x \leq \min\{\tilde{x}, b\}, \quad e=1 \end{cases} \tag{13}$$

Observe that Φ is a correspondence $b \to \Phi(b)$, where $\Phi(b)$ is the set of equilibrium bequest achievable by agents who received b, for different values of x.

By studying $\Phi(b;\,x)$ a first characterization of the limit support of wealth distribution, denoted by S_∞, is obtained. Define $B := [\underline{b}, \overline{b}]$, where $\underline{b} = \frac{(1-\alpha)v}{1-\rho}$ and $\overline{b} = \frac{(1-\alpha)w-\rho\underline{x}}{1-\rho}$. Notice that B is the smaller convex set containing the set of fixed point of Φ. It holds the following:

Lemma 2. *Suppose the support of the initial distribution of wealth, S_0, is bounded then the sequence $\{S_n\}$ converges to a unique limit set $S_\infty \subset B$.*

The result establishes that there exists a compact set such that the support of the limit distribution takes values in it. This set has not necessarily full measure on the borel sets with respect to B. Which subsets of B will feature positive measure it will depend on the evolution of wealth distribution as shaped by the parameters of the model which we now study. To this aim it is immediate to see that, again, three possibilities can emerge, depending on the rate of returns on human capital investment in the population as dictated by the support Δx of the distribution $G(x)$, i.e. depending on whether $\tilde{x} < \Delta x$, $\tilde{x} \in \Delta x$, $\tilde{x} > \Delta x$. If $\tilde{x} < \Delta x$ human capital technology is inefficient, the economy trivially converges to $\underline{b}$.

1. For $\tilde{x} \in \Delta x$ the rate of return of educational investment belongs to set of admissible investment costs. Individual variation of ability, regardless of inherited wealth, is such that in every lineage at any point in time there may exist both efficient and inefficient types. Occupational mobility flows, in this case, are regulated by both the (endogenous) process for the evolution of wealth and the exogenous process generating abilities. Economies satisfying this condition will always feature inefficient agents and efficient agents that are constrained in their investment choice due to financial market imperfections. With financial market imperfections occupational mobility flows interact with wealth mobility. We denote this as a case of *intermediate fixed costs.*

2. For $\tilde{x} > \Delta x$ the rate of return of educational investment is greater than all investment costs, the modern sector is efficient for any possible x. Then every agent faces an efficient investment technology,

occupational mobility flows are regulated by wealth constraints alone. In this case the fundamental features of the ability process are similar to the case generating poverty traps in the homogeneous cost case. We denote this as a case of *low fixed costs*.

Case 1 and 2 above are studied separately in the following two subsections.

2.1 The evolution of wealth distribution in the case of intermediate fixed costs ($\tilde{x} \in \Delta x$)

In this case the set of admissible x includes both efficient and inefficient agents. The task of the market economy is to allocate individual talent x to an occupation in one of the two sectors. Recall that from equation (7) inefficient agents $x > \tilde{x}$ will not invest $(e = 0)$ whereas efficient agents will invest provided that $x \leq b$.

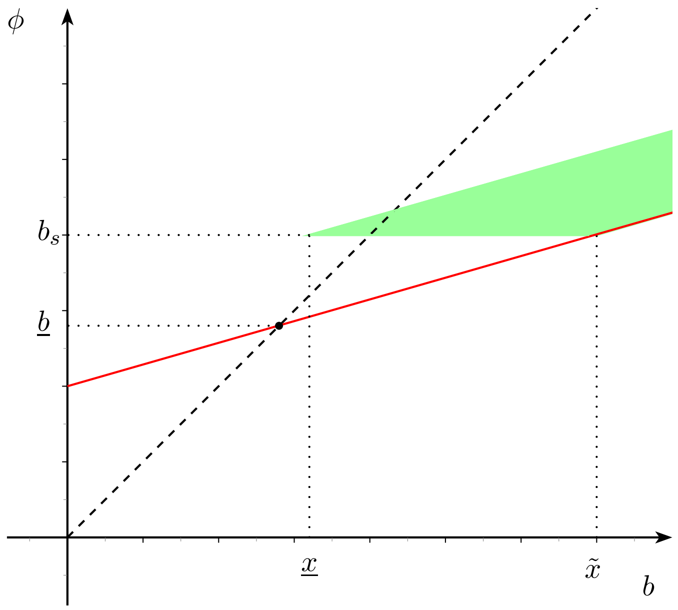


Figure 4. Image set of b under Φ in the case of Intermediate Costs (Decline)

In figure 4 we report $\Phi(b; x)$ in the case of intermediate costs. The green area represents the set of bequeathed wealth by agents employed in the skilled sector. The red line represents the set of bequeathed wealth by agents in the unskilled sector. One important topological property is that the two sets are connected for $b \geq \tilde{x}$. [7] The economic counterpart of

[7]Notice that $\tilde{x}$ is, by definition, the value of x such that the agent is indifferent between investing and not investing regardless of wealth. Therefore at $x = \tilde{x}$ the equilibrium bequest

this property is that any lineage starting from $b \geq \tilde{x}$ does not face wealth constraints regardless of her immediate ancestor's occupation. Conversely for $b < \tilde{x}$ any lineage has a non zero probability to face a wealth constraint (for efficient agents) regardless of occupation. [8]

The evolution of wealth distribution in the case of *intermediate fixed costs* is characterized in the following

Proposition 1. *For $\tilde{x} \in \Delta x$ the dynamic of the evolution of wealth distributions is ergodic (with respect to μ_0). Moreover only two wealth distributions emerge, depending on Γ:*

- *i) (Decline) if $\underline{b} \leq \underline{x}$, then the dynamics of the wealth distributions converge to $\underline{b}$ with full measure;*
- *ii) (Self Sustaining Growth with Social and Occupational Mobility) if $\underline{x} < \underline{b}$, then the system converges to $[\underline{b}, \overline{b}]$ with a unique measure μ^*.*

In words, the proposition states that if the exogenous process determining individual variation in x regulates occupational mobility flows and financial market imperfections only constrain investment choice at the bottom of wealth distribution then poverty traps disappear, the system is ergodic. A more worrisome scenario of decline can be part of the equilibrium configuration.

Sooner or later, in finite time, every household in the upper segments of the wealth distribution is doomed to end up below the wealth threshold that allows to invest. The destiny of wealthy households is only transitorily separated from that of the poor.

The intuition is straightforward: if there always exists an inefficient type independently of the level of parental wealth, there will always exist downward *occupational* mobility flows in any range of the wealth distribution. Consequently any lineage can always experience a large enough number of bad draws, after which their wealth converges to a neighborhood of $\underline{b}$. To achieve a stable limit distribution with mobility (and to avoid decline) these downward mobility flows must be mirrored by equivalent upward mobility flows. Whether upward mobility is possible only depends on how much

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policy must be the same regardless of the sector of occupation. This is a necessary feature for this case of intermediate cost the property induced on the structure of the image set of the mapping Φ allows, in principle, the extensions of the results in this section to more general individual transition functions generated by a more general structure of the fundamental economy (utility functional forms, bequest motive, endogenous wages).

[8] It is easy to see that the existence of a path connecting the red line with the green area will imply the ergodicity of the system in this configuration.

wealth the unskilled manage to accumulate in the long run vis a vis the minimum investment cost. If wages in the unskilled sector are large enough, $\underline{x} < \underline{b}$ then upward wealth mobility flows are able to balance the downward wealth mobility (implied by necessary downward occupational mobility flows) and the economy can sustain investment in the long run featuring wealth and occupational mobility; if $\underline{b} \leq \underline{x}$ the only possible limit distribution settles on $\underline{b}$ with full measure. In such a configuration, it is not possible for poverty traps to arise, even with indivisibilities and financial market imperfections [9].

It is worth noticing that, *the result holds regardless of how large the support measuring genetic variation* Δx *is*. Even a small amount of heterogeneity induces ergodicity as long as there always exist the possibility of investment being inefficient in wealthy lineages. Relatedly, the result holds regardless of whether financial market imperfections constrain investment choices in segments other than at the bottom of the wealth distribution. On the other hand, even in the case of self sustaining growth with occupational mobility financial market do not necessarily disappear over the long run because of wealth accumulation within lineages. In particular it holds the following result:

Lemma 3. *The offspring of an unskilled household is wealth constrained* ($b \leq \tilde{x}$) *at* $\underline{b}$ *if and only if the offspring of the less wealthy household in the skilled sector (an agent receiving wealth in a neighborhood of* b_s*) is wealth constrained too.*

This implies that, contrary to what happens in the case of homogeneous costs (where, once a lineage's wealth is above a threshold that allows investment than the lineage is not wealth constrained forever on), financial market imperfections can not necessarily disappear over the long run if lineages in the traditional sector are constrained.

The model predicts that, at any given point in time along the dynamic path and at steady state, the impact of financial market imperfections at the bottom of the wealth distribution is necessarily the same as in lineages in intermediate segments of the wealth distribution employed in the skilled sector: if a positive measure of agents is constrained in the unskilled sector so will be a (lower) positive measure of households in the skilled sector. The immediate empirical implication is that whenever it is observed that educational investment varies across wealth groups within household with parents in the skilled sector, then financial market imperfections must be binding for both the lower and the middle class, even in the limit. Therefore, if one lineage at a given point in time faces the consequences of financial

[9] This result can easily be generalized to the extent that the economy generates an image set under Φ with topological properties similar to those illustrated in figure 2. More precisely it is easy to see that, the existence of $\widetilde{x} \in \Delta x$ is equivalent to the existence of a path in Φ connecting the image of the bequest function in both occupational sectors.

market imperfection it must be true that every lineage will face the consequences of financial market imperfections[10]. This fact motivates our interest in the exploration of redistributive policies.

2.2 The evolution of wealth distribution in the case of low fixed costs ($\tilde{x} > \Delta x$)

In the case of low fixed costs educational investment is profitable to every agent in all lineages. There is no finite history of bad draws in the genetic lottery within wealthy lineages that can trigger downward occupational mobility and the associated downward wealth mobility. The role of financial market imperfections is clearly the only constraint faced by agents in their investment choice. Since financial market imperfections are all that matters in driving education investment choice and they are the only force that shape wealth mobility, the role of genetic variation is less important (but not null, of course). Therefore, initial wealth is crucial and we can expect that non ergodicity emerges in the form of poverty traps.

The mapping for the evolution of wealth is reported in figure 5.[11]

[10]This property does not hinge on the assumption of constant return to factor and can be generalized. This is provided in a separate paper. To get the intuition notice that with decreasing returns to scale in both sectors the skill premium is monotonically decreasing. Suppose that, at a given point in time, for w and v such that $\widetilde{x} \in \Delta x$, Lemma 3 must hold. Then in any subsequent period with $w' < w$ and $v' > v$ skilled agents are still constrained.

[11]By looking at Figure 5 notice that the (topological) properties of function Φ in the case of low costs suggest that we should expect that the limit distribution will actually depend on the initial distribution of wealth. Since there is no level of x such that the any agent in any range of the wealth distribution is indifferent across occupations, for each b we have that $(1-\alpha)v + \rho b < (1-\alpha)w + \rho(b-x)$ for all $x \in \Delta x$, so that the red line describing the bequest policy for agents in the unskilled sector has no contact point with the green area describing the bequest policy for agents in the skilled sector.

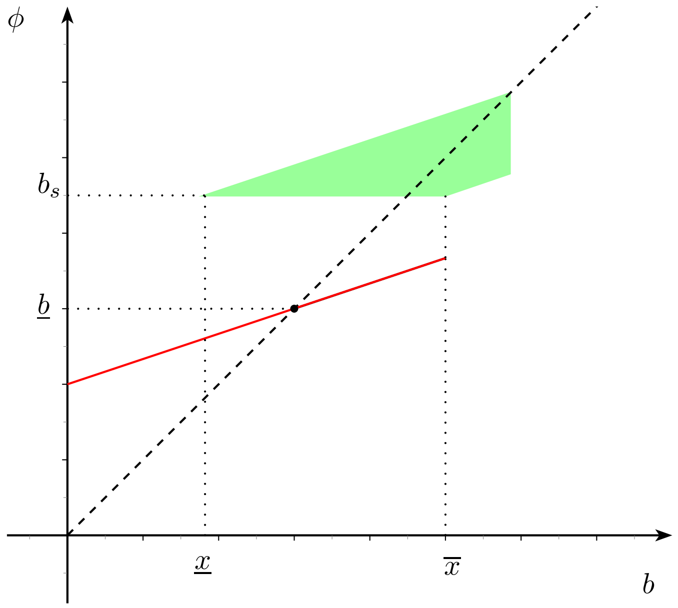

Figure 5. Image set of b under Φ in the case of Low Investment Costs (Self Sustaining Growth)

The evolution of wealth distribution is characterized in the following

Proposition 2. *For $\tilde{x} > \Delta x$ the following results hold:*

i) *(Decline) if $\underline{b} \leq \underline{x}$ and $b_s < \overline{x}$ then the system is ergodic and the dynamics of the wealth distributions converge to $\underline{b}$ with full measure;*

ii) *(Self Sustaining Growth with Social Mobility) if $\underline{x} < \underline{b}$ then the system is ergodic and it converges to $[\underline{b}, \overline{b}]$ with a unique measure μ^*. In particular if $\overline{x} \leq b_s$ the system converges to $[b_s, \overline{b}]$, in this case every agent will be employed in the skilled sector over the long run;*

iii) *(Poverty Trap) if $\underline{b} \leq \underline{x} \leq \overline{x} < b_s$ then the system is not ergodic and the dynamics of wealth distribution converges to $\{\underline{b}\} \cup \left[b_s \, \overline{b}\right]$ with a measure that depends on μ_0.*

Notice, again, that ergodicity- when obtained- holds with respect to μ_0. Which limit distribution will prevail depends on the set of parameters Γ. Notice also that, provided the relevant conditions in Proposition 2 are satisfied, the amount of genetic variation in the ability process $G(x)$ does not matter.

Both case i) and case ii) in Proposition 2 also emerged in the regime of intermediate fixed costs. The reason for their emergence in the case currently under analysis is, however, completely different. In the case where $\tilde{x} \in \Delta x$ ergodicity was driven by the fact that each agent in all lineages and regardless of wealth distribution, could be hit by a sufficiently long sequence of bad shocks in the process generating x (downward occupational mobility flows were always in operation on efficiency grounds). In the present context of small fixed costs, instead, every agent in the economy is efficient and the main role in the shaping of the dynamics is played by financial market imperfections, which are the only mechanism regulating whether upward occupational and wealth mobility channel are operative.

In particular, whereas in the case analyzed in the previous section the properties of the long run distribution depend only the impact of financial market imperfections in the lower segments of the wealth distribution (at a neighborhood of $\{\underline{b}\}$) here things are different. What matters for the long run now is how financial constraints operate both at the low and at the intermediate range of the wealth distribution i.e. how severely credit market imperfections affect choices at $\{\underline{b}\}$ and $\{b_s\}$ at any time.

In case i) $\underline{x} \geq \underline{b}$ implies, as usual, that once a lineage gravitates in a neighborhood of $\underline{b}$ the occupational destiny is doomed and there is no way to escape that position in the wealth distribution; whereas $b_s < \overline{x}$ implies that the poorest among the skilled households can be wealth constrained for a large enough value of x, i.e. the measure of credit constrained agents holding b_s is positive and these households have to disregard profitable human capital investment opportunities. Again when financial market imperfections affect the middle class (in the wealth scale), decline is the resulting outcome.

The emergence of poverty traps (case iii)) is, instead, specific for the configuration of parameters under consideration. Again it arises from the specific mode of operation of financial market imperfections. With small fixed costs, financial market imperfections affect differently the choices of agents in the neighborhood $\{\underline{b}\}$ who cannot invest and agents in the neighborhood of $\{b_s\}$ who will always invest since $b_s \geq \overline{x}$, inducing polarization effects on the wealth distribution in the long run (as in Gal-Or and Zeira, 1993). Notice that, whenever poverty traps emerge, financial market imperfections for households in the intermediate range of the wealth distribution are, as time goes by, overcome by family bequest driven by altruism and disappear for a the fraction of population not in the trap.

Finally notice that even in this case ergodicity with self sustaining growth it is not necessarily the case that financial market imperfection are eliminated over the long run. Part *ii)* of Proposition 2 specifies that the elimination of the financial market imperfections over the long run depends on whether it holds $b_s > \overline{x}$, which only happens when the first best level of investment is achieved, every agent ends up to be employed in the skilled sector. Once again, similarly to the previous section, whenever $b_s \leq \overline{x}$ both the middle class and agents in the unskilled sector will be wealth constrained, even in the long run: steady state with occupational mobility require that financial market imperfection is not eliminated by wealth accumulation.

Taken together Propositions 1 and 2 have clear cut predictions linking the observation of occupational mobility to the evolution of wealth distribution and the economic perspectives of the aggregate economy. One example for all: if at any point in time the economy features no upward *occupational* mobility flows and a positive (arbitrarily small) amount of downward *occupational* mobility flows, then the wealth accumulation process of the economy is set on a declining path, therefore both future aggregate (and per capita) income and wealth must be expected to decline. On the other hand, if different investment frequencies are observed in different wealth groups (even in the subset of skilled households) then financial market imperfection do not disappear over the long run, and each lineage is doomed to face wealth constraints in her history. This motivates our exploration in the next section.

3 Implications for redistributive policies

It is well known that local indivisibilities and the failure of financial markets form an economic environment where the initial distribution can matter. Equivalently, temporary (both structural and policy) shocks can have permanent effect in this environment. If financial market failure cannot be corrected redistributive policies can have permanent effects on investment, equality of opportunity and per capita income. An example of the effectiveness of policies arises in the case of homogeneous agents: if average wealth in the economy (or the scale of outside intervention through external resources) is large enough "one shot redistribution policies can have permanent effects", both for the elimination of the poverty trap and for the role of policy response to transitory adverse shocks. This view about the role of transitory policies in environments exhibiting poverty traps has been challenged in models where long run intervention is required by the emergence of so called mobility traps (Piketty, 1997, 2000, Aghion and Bolton, 1997), similar conclusions are suggested by Mookherjee and Napel (2007) in a model with heterogeneity and endogenous factor prices[12]. With this debate in mind, in this section, we investigate the following question: what are the implications of heterogeneity for the design of effective policies aimed at increasing educational investment, per capita output and social mobility in a standard environment with indivisibilities?

We will argue that heterogeneity introduces additional constraints on policy design, calling for longer time span of intervention. In some cases

[12] The role of large scale temporary policies has been important for the policy debate in developing countries where any form of initial accumulation of asset is prevented by fundamental conditions for a large fraction of the population (see for example, Sachs, 2005).

persistent policies are required as in models of mobility traps. On the other hand we show that heterogeneity in abilities makes redistributive policies somewhat more powerful: they not only can dismantle poverty traps when they arise (as in the case of homogeneous agents), but there exist conditions under which policies are effective in scenarios of decline (induced by financial market imperfections) where they would be ineffective under homogeneity.[13]

Both points are quite intuitive in principle: heterogeneity in abilities introduces additional constraints on redistributive policies that are essentially informational in nature.

Whenever ability is not observed there are two additional problems: on the one hand low wealth does not necessarily imply that the agent is efficient and therefore investment should be financed; on the other hand a tax on agents in high segments of the wealth distribution is limited since, in order not to exploit wealth preventing efficient investment by wealth households agents should not be taxed so that net wealth is below their investment costs. In the absence of observability, would have incentive to report high ability cost. Therefore, if there is no way to guarantee incentive compatibility properly, a tax transfer scheme is limited upward by $b-T \geq \min\{\widetilde{x}, \overline{x}\}$ to guarantee efficient investment, therefore a tax transfer scheme cannot raise the same revenues as in the case of homogeneous agents, for a given wealth distribution.

It is also intuitive that heterogeneity in ability among lineages (which is transitory, since by assumption the process for genetic variation is i.i.d.) generates heterogeneity in wealth (which is more persistent since it can get transmitted[14]) introducing more scope for redistribution. With perfect financial markets, the transitory mismatch between ability (a technology in the educational investment process) and the distribution of wealth (as a source of finance) would be cleared intertemporally by debt/credit positions across lineages[15]. These same forces that would make the credit market thicker

[13]Our discussion will not deal with shocks. However it is clear that whether ergodicity is present or not hinges on the possibility that transitory shocks have permanent effects. The same argument provided to establish effectiveness of policy interventions can be used to characterize the effectiveness of policies to counteract the permanent effects of temporary shocks. An instance of such policies can be easily constructed in the context of the present model: consider the case (as it happens for a poverty trap scenario) of temporary exogenous shocks driving wealth down to the level where investment is no longer feasible, our results imply that there exist conditions under which temporary redistributive policies avoid the decline.

[14]Even if "ability" would be partially endogenous so that wealth family can reduce x by suitable investment as in Becker and Tomes (1979) the same point would hold as long as wealth can be transmitted at a lower cost than ability. This would be true whenever ability, although partially transmittable, includes some i.i.d. component. In other words the presence of i.i.d. components in a model with endogenous talent only relocates the problem of financial market imperfections on layer up in the education process.

[15]A temporarily inefficient wealthy lineage would finance investment in a temporarily effi-

due to heterogeneity, we argue, increase the scope for (redistributive) policy intervention in the absence of credit markets[16].

More specifically we will show, firstly, that, compared to homogeneous costs, in the presence of heterogeneity, the required horizon for effective redistributive policies must be, in a well defined sense, longer. This is important since, when policies are transitory, considerations about the bequest motive and associated distortions (e.g. crowding out effects on private savings) due to redistribution are less important, in the light of the transitory nature of the intervention. If heterogeneity is an important aspect, then the required time horizon for effective redistribution policies is longer, anticipation of tax and associated distortions in bequest are relevant and therefore the preservation of the tax base in the future can be an important concern even in models with indivisibilities.[17]

Secondly we will show that, with heterogeneity, there is a larger scope for policies than in the homogenous cost case: in a well defined sense genetic variation can be exploited for the design of effective redistributive policies in cases where policy is ineffective under homogeneity. [18]

Before providing the details a few remarks are in order to clarify the limits of our analysis. Firstly, we stick to our modeling choice where the bequest motive is given by "joy of giving" motive [19] disregarding the crowding out effect of redistribution on savings.

Secondly, our focus is on feasibility constraints (i.e. policies are required to be budget balanced period by period), no optimality criterion is cast on the class of tax transfer policies considered here. We will simply define a policy as "effective" to the extent that it is able to support a larger measure of investment (and output) than otherwise.

Finally, as already noticed, in the presence of heterogeneity, the tax transfer scheme is, in principle, informationally more demanding because

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cient poor lineage to the point where the rate of return to educational investment is larger than the financial investment. With enough wealth in the economy every $x \geq \widetilde{x}$ would be financed.

[16]As long as tax distortions do not destroy incentive to transmit wealth. See below.

[17]It is clear that the requirement of proper scale in policies aimed at dismantling the poverty trap is related to the same point. If the scale of intervention cannot dismantle the trap in one period, the are of course other ways to eliminate poverty traps in the presence of non convexities (decentralized as Roscas, or different forms of public intervention designed in the form of "triage") where the required scale of redistribution can be reduced at the cost of prolonging the time horizon of the policy with similar consequence on the relevance of distortionary effects.

[18]One implication being that, policies can prevent the long run effects of temporary adverse shocks. As it is well known one important aspect of redistributive policies in models where poverty traps can arise is the possibility for transitory policies to have permanent effects. An important related question is what is the scope for policy in the case of an adverse transitory shock hitting the economy (see Gal-Or and Zeira, 1993).

[19]See e.g. Aghion and Bolton (1997) for a motivation of policy analysis under similar assumptions; see also Cremer and Pestieau (2003) for a survey.

of two relevant dimensions, wealth and ability. Both aspects are potentially important in the design of the redistributive scheme. In the following analysis we will assume that wealth is observable, whereas ability is not; i.e. we construct redistributive policies conditioned on wealth, but not on the ability of the agent and will always make sure that investment by high cost agents is, if efficient, never prevented by taxation[20].

3.1 Some implications for policy in the case of homogeneous costs

We preliminarily review some implications for redistributive policies in the model with homogeneous costs. Again, as in section 2, some or all of these results are well known and discussed sparsely in many of the contributions already mentioned. A brief review is useful as a benchmark for the subsequent assessment of the implications of heterogeneity for policy design.

We start by constructing a simple example and consider a policy tackling the poverty trap. We assume that the initial wealth is large enough to obtain feasibility of a large enough one shot intervention.

Definition 2. *Let $\widetilde{\mu}_0$ be the initial distribution of wealth such that $\int_0^\infty b d\widetilde{\mu}_0 = x_e$.*

The economy is rich in wealth *just enough* to allow a one shot transfers so that all lineages overcome the wealth threshold that, in the absence of credit markets, makes investment viable,

Definition 3. *Let $T = \{\sigma, \tau\}$ be a tax transfer scheme such that $b - \tau \geq x_e$ (i.e. T preserves investment by taxed agents);*

The above definition restrict the class of transfer schemes within which the analysis is provided.

Definition 4. *Let $n^*(\widetilde{\mu}_0)$ the minimum number of periods such that the transfer system T is in place and $\mu_{n^*+1}(x_e) = 0$,*

It defines the minimum number of periods after which every agent in the economy faces no wealth constraints and can therefore invest, if efficient.

The following proposition summarizes conditions under which transitory policy has permanent effect in the case of no heterogeneity.

[20]This will insure that incentive compatibility constraints are always satisfied in a weak sense (i.e. in any direct mechanism on x, under the proposed tax scheme, the agent is indifferent between truthtelling and misreporting x).

We concentrate on redistribution of wealth across lineages.This is equivalent to the case where tax revenues are used as a source of finance for public investment that reduce indivisibilities (transportation infrastructure or location of schools in remote villages).

Lemma 4. *Fix $\widetilde{\mu}_0$ as in Definition 2 and $n^*(\widetilde{\mu}_0)$ as in Definition 4, then there exist a transfer system T satisfying Definition 3 such that the following holds true:*

i) if $x_e < b_s$ (poverty trap and self sustaining growth) then $n^*(\widetilde{\mu}_0) = 1$;

ii) if $x_e > b_s$ (decline) then there exist no T which is feasible after a finite $n^d(\widetilde{\mu}_0)$ and such that $1 - \mu_{n^d+1}(b) > 0$ for $b > x_e$.

In words i) states the well known results that there exist a family of initial distributions (all those that stochastically dominate $\widetilde{\mu}_0(b)$) of wealth such that, for any initial distribution belonging to this family, a one shot redistributive policy dismantles the poverty trap.

Result ii) states that the action of the policy maker, under homogeneous costs, is much more limited when the economy is declining. In this case there is no feasible redistributive policy T that can prevent the decline. The intuition is easy: in a collapsing economy the fundamentals are such that family altruism is not large enough in each lineage to accumulate enough wealth to sustain investment in the long run. There is no way for policy to shut off the leakage driving wealth de-cumulation in order to prevent downward occupational mobility in middle class households. Redistributing resources from the upper segments of the wealth distribution to middle class is not feasible since the dynamics of the economy destroy, sooner or later, the tax base. *This result will be different when heterogeneity comes into play.*

Of course the scope for policy in the economic environment under analysis is larger than the simple scheme analyzed: when the economy operates in a regime with a poverty trap and wealth distribution is stochastically dominated by $\widetilde{\mu}_0$ it is still possible to limit the measure of recipients of the program to a subset of the poor. If distortionary effects of taxation are small enough this policy will eliminate the poverty trap in the long run.[21] A transitory transfer policy is feasible in a standard poverty trap environment with homogenous agents, in other words it is always feasible to empty the pool of financially constrained agents if $x_e < b_s$ even with a "small" safety net operating for a sufficiently long horizon.

Remember that results on non-ergodicity in models with indivisibilities and financial market imperfections can be immediately be re-interpreted in terms of resiliency of the economy to transitory shocks. It is easy to show that if the economy satisfies conditions for self sustaining growth (case i) then there is no shock that can destroy conditions for ergodicity: after the

[21] As in triage policies. Compared to a lottery where recipients are randomly chosen (as in Roscas), by targeting suitable segments of the wealth distribution (triage) it is possible to minimize the tax requirements to achieve this target.

shock disappears the economy returns to its converging dynamics. Ergodicity is equivalent to resiliency of the economy to prolonged (albeit transitory) shocks and redistributive policies have no long run effects. (This can be considered just an equivalent definition for ergodicity). If, on the other hand, the economy operates in a regime of poverty trap then there always exist a large enough temporary shock such that the measure of skilled agents is reduced to zero and there exist no way to design redistribution, from households in the upper segments of the wealth distribution to households in the intermediate segments, that prevent downward occupational mobility and the ensuing downward wealth mobility, destroying the financial basis of future investment in all lineages. [22]

To summarize, provided that the economy is rich enough, a poverty trap can always be dismantled by a one time intervention, whereas decline cannot be arrested. These conclusions will be different in the presence of heterogeneity as we show next.

3.2 Some implications for policy in the presence heterogeneity

Remember that one of the consequences of the introduction of heterogeneity in previous sections was that a sufficient condition for ergodicity to hold is the presence of inefficient agents in the population (as in the case denoted intermediate fixed costs). On the other hand, we showed that whenever wages in the unskilled occupation are close enough to subsistence, and educational investment is efficient for all agents in the economy, a poverty trap arises (as in the case denoted intermediate costs). In both cases, financial market imperfections survive at steady state with occupational mobility, motivating this analysis.

We will show that heterogeneity of investment costs has two implications on policy design: 1. it requires more persistent policies in order for redistribution to be effective and 2. it enlarges the scope for policy effectiveness, in declining economies.

In order to study the implications of heterogeneity for the time horizon required by redistributive policies to be effective we consider a comparison performed under the same structural parameters and initial wealth distribution as in the homogeneous cost case, i.e. $\widetilde{\mu}_0(b)$ satisfy Definition 2. The equivalent definition for the minimum number of periods after which policy can be dismantled in the case of heterogeneity is the following

Definition 5. *Let $n^*(\widetilde{\mu}_0)$ the minimum number of periods such that the transfer system T is in place and $\mu_{n^*+1}(\overline{x}) = 0$.*

It holds:

[22] It is immediate to notice that if the economy operating in the regime of decline is hit by an adverse shock the convergence to $\underline{b}$ is accelerated, and, a fortiori, there cannot exist an effective policy.

Proposition 3. *Suppose x is observable by the policy-maker. Fix $\widetilde{\mu}_0$ as in Definition 2, T as in Definition 3 and $n^*(\widetilde{\mu}_0)$ as in Definition 5. If $\overline{x} \leq b_s$ and $\underline{x} > \underline{b}$ (poverty trap), then $n^*(\widetilde{\mu}_0) = 1$*

From the above proposition it is clear that with no additional informational constraint induced by heterogeneity, policy effectiveness can be achieved under the same conditions as in the case of homogeneous costs.

Definition 6. *Let $T = \{\sigma, \tau\}$ be a tax transfer scheme such that $b - \tau \geq \min\{\overline{x}, \widetilde{x}\}$, and $\sigma - b \leq \min\{\overline{x}, \widetilde{x}\}$*

The above definition restricts the class of transfer schemes within which the analysis is provided, Notice that T preserves (efficient) investment by taxed agents if efficient and does not provide subsidies above the (efficient) investment cost. The following result holds:

Proposition 4. *Suppose x is not observable. Fix $\widetilde{\mu}_0$ as in Definition 2, T as in Definition 6 and $n^*(\widetilde{\mu}_0)$ as in Definition 5. If $\overline{x} \leq b_s$ and $\underline{x} > \underline{b}$ (poverty trap), then for any $G(x)$ satisfying Assumption 2 it must be $n^*(\mu_0) > 1$.*

In words, under the same aggregate conditions under which a one shot intervention has permanent effects under homogeneous costs, heterogeneity does require more persistent intervention to dismantle the poverty trap, unless investment transfer and tax can be conditioned upon both b and x. The intuitive reason for this result is that when x is not observable, in order to preserve incentives to invest to wealthy people the planner cannot tax wealth below $\overline{x}$. On the same ground, in order to allow investment in lineages with low wealth the minimum amount of wealth to be transferred is, again, $\overline{x}$. I.e. *heterogeneity makes feasibility constraints more binding for the policymaker*. The lack of information by the policy maker makes redistributive policies more persistent than in the absence of heterogeneity in order to achieve similar results (all efficient agents manage to invest).[23]

A less immediate result holds for the case in which the economy is on a declining path:

Proposition 5. *Suppose x is not observable by the policymaker. Fix $\widetilde{\mu}_0$ as in Definition 2, T as in Definition 6 and $n^*(\widetilde{\mu}_0)$ as in Definition 5. If $b_s < \overline{x}$ and $\underline{x} > \underline{b}$ (decline). Then for any $G(x)$ satisfying Assumption 2 it holds:*

i) (Low investment costs) If

$$b_s \geq (1 - \rho)\overline{x} + \rho x_e$$

then T permanently in place is such that $e = 1$ for a strictly positive measure of agents in each period and therefore $\mu_t(\underline{b}) < 1$

[23] Although the exact implications of incentive compatibility is left for future work we conjecture that the effect of explicitly considering incentive compatibility constraints in the design of the transfer policy will increase the persistence of the policy required to be effective.

ii) (Intermediate investment costs) If

$$b_s \geq (1 - \rho \cdot G(\tilde{x}))\,\tilde{x} + \rho \cdot G(\tilde{x}) \cdot E[G \mid x \leq \tilde{x}]$$

then T permanently in place such that $e = 1$ for a strictly positive measure of agents in each period and therefore $\mu_t(\underline{b}) < 1$.

In other words the proposition above states that in a scenario of decline policy is effective as long as the minimum wealth inherited by the offspring of a household in the skilled sector is large enough.

Therefore, contrary to the case of homogeneity, it is possible to use redistributive policies (from higher segments of the wealth distribution to lower segments)[24] that allow the economy to sustain investment for a subset of agents provided some conditions on Γ hold. The intuition is the following: suppose that, given the initial distribution of wealth, it is feasible for the policymaker to tax households in the top segments of wealth distribution (there exist a positive measure of $b > \overline{x}$) and finance investment in lower segments. If the condition $(1 - \rho)\overline{x} + \rho x_e \leq b_s$ holds[25], then this policy can be replicated for an arbitrarily large number of periods to avoid decline. The condition under which the policy can be replicated require that the investment cost is low enough for a sufficiently large measure of agents, or the minimum level of wealth accumulated by agents in the skilled sector is large enough (so that the scale of intervention satisfies the fiscal budget constraint). Under such condition T supports the same measure of investment next period and so on.

We conclude therefore that, in the presence of heterogeneity- even if x is not observable- decline can be prevented by a system of transfer policies. The same transfer system would fail for the same aggregate economy in the absence of heterogeneity.

One immediate but important implication of the Proposition 5 is that redistributive policies in the environment considered can be extremely powerful in avoiding long term persistence of temporary shocks: consider an economy working under in the steady state configuration considered in Proposition 2 point iii) (i.e. poverty trap); consider, for example, the effect of a (perfectly forecasted) temporary negative shock on wealth: this will have the effect of permanently reducing the investment level in the economy even (when hitting for a sufficiently long time horizon) forcing investment to zero. A redistributive policy (albeit temporary) of the kind devised in Proposition

[24] As noticed in the case homogeneous costs, reverse redistribution can also sustain investment in a scenario of decline, by transferring resources from households in the unskilled occupations to households in skilled occupations, whose wealth, in the dynamics, is doomed to fall below x in finite time.

[25] Trivial algebra shows that the condition $(1 - \rho)\overline{x} + \rho x_e \leq b_s$ is consistent with $b_s < \overline{x}$ since $0 < \rho < 1$.

5 would allow the economy to avoid such effect by preserving investment opportunities for the same measure of agents as before the negative shock. In such a scenario a temporary policy is able to design a safety net for a subset of household avoiding the decline.

Finally, it also holds:

Corollary 1. *If the sufficient conditions in Proposition 5 hold with strictly inequality, then a permanent policy makes it feasible for all lineages to invest in the long run, whenever it is efficient.*

Summarizing, we have shown that heterogeneity has two important implications for the design of feasible redistributive policies in the presence of indivisibilities. Since they require more information to target tax and subsidies to wealth segments of the population than the homogeneous case, redistributive policies are subject to additional constraints that induce *larger policy persistence* in order to remove wealth constraints to investment. At the same time, policies can be more effective in the presence of heterogeneity. To show this we constructed an example where under similar fundamental conditions under which a one shot intervention has permanent effect in the homogeneous cost case, a more prolonged time span for policy is required in the presence of heterogeneity. Another example showed that in conditions of decline where redistributive policies are completely ineffective in the hypothesis of homogeneous costs, the policymaker, through suitable transfers, can exploit genetic variation to dynamically reconstruct the tax base and preventing the economy from decline. Equivalently, under heterogeneity redistribution increases the resiliency of the economy to transitory (albeit prolonged) shocks that would otherwise set the economy on a path of decline.

4 Extensions

Most of our results in section 3 can be extended to less restrictive hypothesis on the main structure of the model.

Considering a different bequest motive would not change the results on the dynamic equilibrium of the model (see Piketty, 2000) provided that the main qualitative features of the bequest function Φ defining the evolution of wealth within lineages would be preserved under quite general assumptions [26].

[26] More precisely, the main results of section 3 would be maintained to the extent the fundamentals are such that the topological properties of the inverse image set of the Φ function are maintained. The presence of a discontinuity in the bequest function is maintained since it is induced by the presence of fixed cost and the absence of financial market requiring

We assumed that individual characteristics only matter in the skilled sector on the presumption that the unskilled sector represents the traditional sector where productive capabilities can be transferred within families and the standard technology does not require individual talents and financial investment to be learned and applied to production. In a more general interpretation (market luck), individual characteristics can be a feature of individual performance in both sectors. In such a model the result on the ergodicity in Proposition 1 would not be changed (if any, ergodicity would obtained a fortiori). Results in Proposition 2 still hold with suitable qualifications. In particular poverty traps obtain to the extent that market luck in the unskilled sector would not be large enough to overcome financial market imperfections in the households there employed[27].

In the course of the paper we considered an i.i.d. process for the transmission of abilities within lineages, a positive correlation of genetic endowment (to include, for example, the effect of nurturing, as in Becker and Tomes, 1979) would increase persistence of wealth distribution without affecting the main results.

Finally, the analysis of the model with endogenous returns to factor could be easily extended as in Gal-Or and Zeira ([9] 1993), where agents are homogeneous with respect to the investment costs. With endogenous labor productivity, in particular it is easy to see that a continuum of steady state (limit distributions) would arise whenever the initial condition factor allocation is such that the induced factor prices are consistent with the conditions for the poverty trap characterized in section 2 and 3. For example in the case where the initial allocation is concentrated in the traditional sector and the skill premium $w - v$ is large, the economy is likely to exhibit non ergodicity as in the case of low fixed costs analyzed above. If the initial distribution allows some upward occupational mobility wealthy agents in the traditional sector, on the other hand, ergodicity is more likely to emerge along the lines and under the conditions studied in Mookherjee and Napel ([12] 2007), where heterogeneity is present but there is no wealth accumulation within lineages.

As for the implications of heterogeneity on policy design, the argument for extension is more delicate, as already argued in section 4. Indeed the more prolonged time horizon required in order for policies to be effective can induce a deadweight losses due to expected taxation under alternative assumptions on the bequest motive. Such modifications would generate a model where the trade off between efficiency and redistribution is relevant

a threshold level of wealth beyond which financial market imperfections become irrelevant. The location of this discontinuity with respect to the boundary of the support of the fixed cost would dictate the properties of the model in terms of ergodicity. See Bernheim and Ray (1987) for the monotonicity almost everywhere of the bequest strategy in the case of dynastic preferences.

[27] Here the discussion in Gal Or and Zeira (1993) p.43 applies along similar lines.

for policy design. Notice however, that the presence of distortionary effects would restrict the tax base and make the feasibility constraint even tighter, increasing the time required time horizon compared to the one shot redistribution in the homogenous cost case. The results on the larger scope allowed by heterogeneity would also be influenced restricting the sufficient conditions in Propositions (4) and (5).

5 Conclusions

We studied the implications of individual heterogeneity for the evolution of wealth distribution in a standard model with financial market imperfections and local non convexities in education investment technology. We considered heterogeneity in the cost of education investment, interpreted as genetic variation at the level of lineage.

Ergodicity obtains whenever the distribution of education costs entails the presence of ability types for which the educational investment is inefficient vis a vis financial investment, regardless of how ”large” the support of the distribution of abilities is. Conversely, a poverty trap can emerge only if investment is efficient for every single agent in the economy.

Does ergodicity of the wealth distribution imply the ability of lineages to overcome financial market imperfections in the long run? The answer is a qualified no. If the distribution of education costs includes both efficient and inefficient types, the implication is that financial market imperfection can disappear. However, it is established that whenever households in the traditional sectors are wealth constrained so are agents in the skilled sector with low wealth (middle class), in every long run equilibrium with occupational mobility. In this latter case, due to ergodicity, every lineage will face wealth constraint in any history and in the steady state.

If the distribution of education costs is such that educational investment is efficient for every agent in the economy, financial market imperfection cannot disappear in the long run. In the case of poverty traps (no occupational mobility) financial market imperfection will not disappear by definition, for the subset of trapped lineages, as in the case of homogeneous costs. In the case of ergodic distribution financial market imperfections cannot disappear whenever the steady state entails occupational mobility. Once again, every lineage will meet wealth constraint in any history *and* in the steady state.

The persistence of financial market imperfection in cases when ergodicity is induced by heterogeneity and a more general interest about the role of the latter in policy design motivated our exploration of policy issues.

In particular we show that, in a well defined sense, models with heterogeneity call for more persistent policies. We also show that redistributive policies can be more effective in environments with heterogeneous agents, specially when transitory shocks may set the economy on a declining path, as well as in economies featuring poverty traps. The results suggest that indeed temporary policies are less effective in altering educational investment, per capita income and inequality in the presence of heterogeneity. If the failure of financial markets in the process of education investment and its persistence in the development path is an important feature and financing has to rely on a system of public transfer then, heterogeneity, per se, defines conditions for policies that call for the establishment of long run institutions for their design.

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Appendix A.

Here we introduce notation, a list of definitions used in the paper and in the remaining of the Appendix and we report a few preliminary results on the Markov process for the evolution of wealth distribution.
Let b be a real number and S an element of the system of Borel sets on Z, a bounded set of $\mathbb{R}_+$.

Definition 7. *A transition probability on Z is a function $Q : Z \times \mathcal{Z} \rightarrow [0,1]$ such that 1. $Q(b,.)$ is a probability measure and 2. $Q(.,S)$ is a $\mathcal{Z}-$measurable function on $\mathbb{R}_+$. Where $\mathcal{Z}$ is the collection of Borel sets on Z.*

Φ defines a transition probability in our model. For any $b \in Z$ and $S \in \mathcal{Z}$, $Q(b;\, S)$ is defined as follows

$$Q(b,\, S) = \int_{\Phi^{-1}(S;\, b)} dG(x) \tag{14}$$

where $\Phi^{-1}(S;\, b) := \{x \in [\underline{x}, \overline{x}] \mid \Phi(b;\, x) \in S\}$.
Using 14 it is immediate to prove that Q satisfies Definition 7.

The definition of the above transition probability allows us to define the object of our analysis, the evolution of wealth distribution, in the standard way (see Stokey and Lucas, 1989) as stated in the next two definitions.

Definition 8. *An equilibrium distribution of bequest at time t is a probability measure satisfying $\mu_t = T^*\mu_{t-1}$; where $T^*\mu_{t-1} = \int_Z Q(b,S)(d\mu_{t-1})$, i.e. T^* is the self adjoint operator on Q.*

Definition 9. *A steady state (invariant) distribution of bequest is a measure μ satisfying $\mu^* = T^*\mu^*$.*

Limit Support

Proof of Lemma 1 (homogeneous costs).
Part i) If $x_e > b_s$, then there exists no fixed point for $\phi_s(b;\, x_e) < b$. Indeed if $b > \underline{b}$ then we have that $\phi_s(b;\, x_e) < b$.

Part ii) If $x_e < \underline{b}$, then there exists no fixed point for ϕ_u and the credit market imperfection vanishes in the long run, indeed $b_s \leq \underline{b}$.

Part iii) If $\underline{b} \leq x_e \leq b_s$, then there exist a unique fixed point for ϕ_s, i.e. $((1-\alpha)w - \rho x_e)(1-\rho)^{-1}$ and a unique fixed point for ϕ_u. This means that FP is disconnected. More precisely $FP = \{\underline{b}, ((1-\alpha)w - \rho x_e)(1-\rho)^{-1}\}$.
□

Proof of Lemma 2. (heterogeneous costs). First of all notice that wealth bequeathed by the poorest unskilled is always below the wealth bequeathed by the richest investing agent defined as the agents with lowest costs $\underline{x}$ and wealth $b_{\max}$ in the initial set $S_0 = [b_{\min}, b_{\max}]$, therefore it holds

$$\Phi(b_{\min}; \overline{x}) \leq \Phi(b; x) \leq \Phi(b_{\max}; \underline{x})$$

equivalently $S_1 = [\Phi(b_{\min}; \overline{x}), \Phi(b_{\max}; \underline{x})]$.
By induction, set $S_n = [\Phi^n(b_{\min}; \overline{x})\Phi^n(b_{\max}; \underline{x})]$ where:

$$\begin{aligned}\Phi^n(b_{\min}; \overline{x}) &= \Phi(\Phi^{n-1}(b_{\min}; \overline{x}); \overline{x}) \\ \Phi^n(b_{\max}; \underline{x}) &= \Phi(\Phi^{n-1}(b_{\max}; \underline{x}); \underline{x})\end{aligned}$$

by trivial algebra and using the definition of Φ we get

$$\Phi^n(b_{\min}; \overline{x}) = \rho^n b_{\min} + \left(\sum_0^{n-1} \rho^n\right)((1-\alpha)v)$$

$$\Phi^n(b_{\max}; \underline{x}) = \rho^n b_{\max} + \left(\sum_0^{n-1} \rho^n\right)((1-\alpha)w - \rho\underline{x})$$

Since $\rho < 1$, take $n \to \infty$, then $\Phi^n \to B := \left[\underline{b}, \overline{b}\right]$. □
An important result for the characterization for the evolution of measure μ is the following

Remark 2. *$\underline{b} < b_s$ if and only if $b_s < \tilde{x}$. Indeed $\underline{b} = \frac{(1-\alpha)w-\rho\tilde{x}}{1-\rho} = \underline{b}$ and $b_s = (1-\alpha)w$, then*

$$\frac{(1-\alpha)w - \rho\tilde{x}}{1-\rho} < (1-\alpha)w \Leftrightarrow \tilde{x} > (1-\alpha)w.$$

In the following section we prove the result of dynamic of the wealth distribution.

Limit Distribution

Proof of Proposition 1.
Part i) The set of possible histories of any lineage can be partitioned in two possible subsets, H_n such that a member of the lineage did not invested ever and H_s such that at least a member of the lineage invested. Histories in H_n will, in finite time, converge to a neighborhood of $\underline{b}$ since $\underline{b} \leq \underline{x}$, therefore upward occupational mobility is zero for such lineages.
Consider now lineages in H_s. They face a positive probability to disinvest, since $\tilde{x} \in \Delta x$, generating downward occupational mobility with positive

measure. Therefore for any initial wealth, b, there exists N_b such that after $n > N_b$ generations with low ability offspring the lineage will end up with wealth below $\underline{x}$.

Part ii) Following Stokey and Lucas (1989) if Condition M holds then T^* is a contraction, and if T^* is a contraction then the Markov process is ergodic.
We will show that Condition M holds in our model, i.e. there exists $\epsilon > 0$ and an integer $N \geq 1$ such that for any $S \in \mathcal{B}$ either $Q^N(b, S) \geq \epsilon$, all $b \in B$, or $Q^N(b, S^c) \geq \epsilon$, all $b \in B$.
We proceed in two steps:
Step 1: We prove that if $\underline{x} < \underline{b}$, then $\lim_{N\to\infty} \Phi^N(b) = S_\infty$, all $b \in B$.

For any $b \in B$ we put: $\Phi(b) = \{\Phi(b; x) \mid x \in \Delta x\}$ and $\Phi^N(b) = \cup_{b'^{N-1}(b)} \Phi(b')$, for $N > 1$.
$Q^N(b, S)$ is the probability that a lineage starting from b, after N generations arrives to a wealth level in $S \cap \Phi^N(b)$.

In words, since $\underline{x} < \underline{b}$ there is upward mobility, a household can reach $\overline{b}$. On the other hand, there always exist a sequence of arbitrary lenght such that a lineage experiencing $x > \widetilde{x}$ has positive measure, due to $\widetilde{x} \in \Delta x$ inducing downward occupational mobility which, in turn, makes wealth state $\underline{b}$ reachable starting from any initial wealth in B

Step 2: Suppose that Condition M is not satisfied, then there must exist a borell set $S \cap S_\infty \neq \emptyset$, such that for any N we have:

$$b_N \in B : \quad \Phi^N(b_N) \cap S = \emptyset$$

Using Step 1, for all b_N we have that $\lim_{n\to\infty} \Phi^n(b_N) = S_\infty$, then the sequence $\{\Phi^N(b_N)\}_N$ converges to S_∞. We arrive to a contradiction

$$\emptyset = \lim_{N\to\infty} (S \cap \Phi^N(b_N)) = S \cap \lim_{N\to\infty} \Phi^N(b_N) = S \cap S_\infty \neq \emptyset.$$

Therefore Condition M holds in our model for the case of intermediate investment costs. $\square$

Proof of Lemma 3.
Suppose $\underline{b} < \tilde{x}$, then the inequality $b_s \geq \tilde{x}$ yields a contradiction by Remark 2.
Suppose $\underline{b} > \tilde{x}$, then the inequality $b_s \leq \tilde{x}$ yields a contradiction by Remark 2. $\square$

Proof of Proposition 2.
Part i) If $\underline{b} < \underline{x}$ and $b_s < \overline{x}$ then the equilibrium wealth is $\underline{b}$, with full measure.

The proof is the same as for point $i)$ of Proposition 1.

Part ii) If $\underline{x} < \underline{b}$ and $b_s < \overline{x}$ then **Condition M** holds. The proof is the same as for point $ii)$ in Proposition 1.

Moreover if $\overline{x} < b_s$ the offspring in skilled households will always invest, $\forall x \in \Delta x$, i.e. there is no downward occupational mobility . Since $\underline{x} < \underline{b}$ every lineage will be able to invest, so that $b > b_s$ for every agent in the economy.

Part iii) If $\underline{b} \leq \underline{x}$ and $\overline{x} < b_s$ then the limit distribution depends on the initial distribution μ_0. This is easy to show by considering two extreme cases. Consider μ_0 that has full measure on $[\underline{b}, \underline{x}]$, in this case no lineage can switch to skilled occupations and every lineage converges to $\underline{b}$.

On the other extreme consider μ_0 concentrated on $[b_s, \overline{b}]$, any agent can cover investment cost and there exists no downward occupational mobility flows. The equilibrium distribution has support in $[b_s, \overline{b}]$. □

Appendix B: Proofs of results in Section 3

Proof of Lemma 4.
Part i) (Poverty Trap) Since μ_0 just satisfies feasibility for T, a one shot redistribution such that $b_j = x_e$ for any lineage j is feasible, $e = 1$ for all agents in the economy. Moreover, since $x_e < \phi(x_e; x_e) = b_s$, each agent will leave a bequest larger than x, investment is feasible in all lineages thereafter; therefore $n^*(\mu_0) = 1$.

Part ii) (Decline) Since $x = E[b \mid \widetilde{\mu}_0]$, a one shot redistribution takes every agent at $b_j = x$. However it holds $\phi(x_e; x_e) < x_e$. Therefore average wealth next period must be lower than x_e, implying that all agents will disinvest.

The result can be trivially extended to a more general case $E[b \mid \widetilde{\mu}_0] > x_e$, when, a fortiori, there exists a redistributive policy under which investment is feasible for all agents in the economy. To see this denote μ_0' the distribution of wealth induced by the redistributive scheme, i.e. $E[b \mid \widetilde{\mu}_0] = E[b \mid \widetilde{\mu}_0']$.
Observe that $\phi(b; x_e) < b$, so μ_0' stochastically dominates (first order stochastic dominance) by μ_1. Then the average wealth in the economy decreases, i.e. $E[b \mid \widetilde{\mu}_0] > E[b \mid \widetilde{\mu}_1]$.
If $x_e > E[b \mid \widetilde{\mu}_1]$ then feasibility is violated; If $x_e < E[b \mid \widetilde{\mu}_1]$ redistribution is feasible for the next period but the above argument can be replicated. By induction there must exist N such that $E[b \mid \widetilde{\mu}_n] < x_e$, for $n > N$. □

Proof of Proposition 3 (poverty trap).
Suppose x is observable, then it is feasible for the policymaker to set $T = \{\sigma, \tau\}$ such that:

$$\text{if } b \geq x \quad \tau(b,\, x) = b - x\,; \quad \text{if } b < x \quad \sigma(b,\, x) = x - b$$

since $E[b \mid \widetilde{\mu}_0] = x_e$. Moreover ex hypothesis $b_s > \overline{x}$ then investment is self-sustaining in all lineages, i.e. $n^*(\mu_0) = 1$, policy can be removed in one period. □

Proof of Proposition 4 (poverty trap).
Suppose x is not observable. Fix $\widetilde{\mu}_0$ such that $x_e = E[b \mid \widetilde{\mu}_0]$. $\forall \widetilde{\mu}_0$, there always exist $\epsilon > 0$ such that $\Delta x = [x_e - \epsilon, x_e + \epsilon]$ and $\int_{x_e+\epsilon}^{\infty} d\tilde{\mu}_0 > 0$. Then it is possible for the policymaker to set $T = \{\sigma, \tau\}$ such that:

$$\text{if } b \geq \overline{x} \quad \tau(b) = b - \overline{x}\,; \quad \text{if } b < \overline{x} \quad \sigma(b) = \overline{x} - b.$$

Since $1 - \mu_0(\overline{x}) > 0$ then there exists $y < \overline{x}$ such that it is feasible for the policymaker for a measure of lineage given by $\int_0^y d\mu_0 > 0$. Since $y < \overline{x}$, then it is immediate to conclude that $n^*(\mu_0) > 1$.

Notice that $\Phi(\overline{x};\, x) \geq b_s > \overline{x}$, imply there are no downward mobility thereafter. The transfer scheme can be replicated to make the measure of investing lineages increasing over time reaching 1 in finite time. $\square$

Proof of Proposition 5 (decline).
Remember that decline can occur both in the case of low and intermediate investment costs. We prove the result for the case of low costs and intermediate costs separately. For both configurations we construct redistributive schemes such that permanent intervention prevents the economy to decline, i.e. the measure of non investing agent induced by the policy is $\mu_n(\underline{b}) < 1$. Suppose x is not observable, whereas individual wealth is observable. Fix $\widetilde{\mu}_0$ such that $x_e = E[b \mid \widetilde{\mu}_0]$. $\forall \widetilde{\mu}_0$, there exists $\epsilon > 0$ such that $\Delta x = [x_e - \epsilon, x_e + \epsilon]$ and $\int_{x_e+\epsilon}^{\infty} d\widetilde{\mu}_0 > 0$.

Without loss of generality define M_1 the measure of investing agents after redistribution. Then $M_1 = \int_{x_e+\epsilon}^{\infty} d\widetilde{\mu}_0 + \int_0^y d\widetilde{\mu}_0$.

Low cost of investment ($\tilde{x} > \Delta x$). Consider the following redistributive scheme $T = \{\sigma, \tau\}$ such that:

$$\text{if } b \geq \overline{x} \quad \tau(b) = b - \overline{x}\,; \quad \text{if } b < \overline{x} \quad \sigma(b) = \overline{x} - b$$

Define:

$$y_{\overline{x}} := \frac{b_s - (1-\rho)\overline{x}}{\rho}$$

under parameter configurations such that the economy is in decline it holds: $b_s \in \Delta x$, therefore simple algebra shows (use the definition of Φ) that there exists $y_{\overline{x}} \in\ \Delta x$. Such that:

$$\Phi(\overline{x};\, x) = \begin{cases} > \overline{x} & x < y_{\overline{x}} \\ < \overline{x} & x > y_{\overline{x}} \end{cases} \tag{15}$$

Which implies that the distribution of investment costs is such that there exists a positive measure of lineages who bequeth a larger amount of wealth than the (net of taxation) they received. This implies that it is feasible for the policymaker to replicate the tax scheme and to sustain a positive measure of investment thereafter.
The measure of investing agents will be given by $M_1 \cdot G(y_{\overline{x}})$. Therefore the tax revenues from the next generation will be given by

$$E(M_1) := M_1 \cdot G(y_{\overline{x}}) \cdot E[\Phi(\overline{x};\, x) - \overline{x} \mid x \leq y_{\overline{x}}]$$

where $G(y_{\overline{x}})$ measures the probability that an agent features investment cost below $y_{\overline{x}}$, $E[\Phi(\overline{x};\, x) - \overline{x} \mid x \leq y_{\overline{x}}]$ is the (conditional) average tax. Subsidies for the subset of M_1 who did not invest, whose measure is given by $M_1(1 - G(y_{\overline{x}}))$ will be defined by the following

$$U(M_1) := M_1 \cdot (1 - G(y_{\overline{x}})) \cdot E[\overline{x} - \Phi(\overline{x};\, x) \mid x > y_{\overline{x}}]$$

where $E[\overline{x} - \Phi(\overline{x};\, x) \mid x > y_{\overline{x}}]$ is the conditional average subsidy.

The transfer scheme is self sustainable for a measure M_1 if the following feasibility constraint holds:

$$G(y_{\overline{x}}) \cdot E[\Phi(\overline{x};\, x) - \overline{x} \mid x \leq y_{\overline{x}}] \geq (1 - G(y_{\overline{x}})) \cdot E[\overline{x} - \Phi(\overline{x};\, x) \mid x > y_{\overline{x}}] \quad (16)$$

First notice that (16) does not depend neither upon M_1, nor upon $\widetilde{\mu}_0$. Use the definition of average tax

$$E[\Phi(\overline{x};\, x) - \overline{x} \mid x \leq y_{\overline{x}}] = \frac{\int_{\underline{x}}^{y_{\overline{x}}} [\Phi(\overline{x};\, x) - \overline{x}] dG}{G(y_{\overline{x}})} \quad (17)$$

and the definition of average subsidy:

$$E[\overline{x} - \Phi(\overline{x};\, x) \mid x > y_{\overline{x}}] = \frac{\int_{y_{\overline{x}}}^{\overline{x}} [\overline{x} - \Phi(\overline{x};\, x)] dG}{1 - G(y_{\overline{x}})} \quad (18)$$

Replace the last two equations into (16), simple algebra shows that feasibility holds if

$$b_s \geq (1 - \rho)\overline{x} + \rho x_e$$

i.e. the transfer scheme is self-sustaining for a measure M_1 of lineages depending on $G(x)$.

Intermediate cost of investment. If $\tilde{x} \in \Delta x$ notice that agents with $x > \tilde{x}$ will not invest, therefore the policymaker can devise a tax transfer scheme such that wealth is taxed above $\tilde{x}$ and subsidy is below $\tilde{x}$ and still preserve investment opportunities in wealthy lineages (those with $b > \tilde{x}$). Replicating the same argument as in the previous proof we conclude that a permanent tax transfer scheme satisfying feasibility constraints in each period exists if

$$G(y_{\tilde{x}}) \cdot E[\Phi(\tilde{x};\, x) - \tilde{x} \mid x \leq y_{\tilde{x}}] \geq (1 - G(y_{\tilde{x}})) \cdot E[\tilde{x} - \Phi(\tilde{x};\, x) \mid x > y_{\tilde{x}}] \quad (19)$$

once again the condition does not depend upon M_1; Using the definition of average tax and subsidy get

$$E[\Phi(\tilde{x};\, x) - \tilde{x} \mid x \leq y_{\tilde{x}}] = \frac{\int_{\underline{x}}^{y_{\tilde{x}}} [\Phi(\tilde{x};\, x) - \tilde{x}] dG}{G(y_{\tilde{x}})} \quad (20)$$

and

$$E[\tilde{x} - \Phi(\tilde{x};\, x) \mid x > y_{\tilde{x}}] = \frac{\left[\int_{y_{\tilde{x}}}^{\tilde{x}} [\tilde{x} - \Phi(\tilde{x};\, x)] dG + \int_{\tilde{x}}^{\overline{x}} [\tilde{x} - b_s] dG\right]}{1 - G(y_{\tilde{x}})} \quad (21)$$

Then replacing (20) e (21) into (19) we get the sufficient condition:

$$b_s \geq (1 - \rho \cdot G(\tilde{x}))\, \tilde{x} + \rho \cdot G(\tilde{x}) \cdot E[G \mid x \leq \tilde{x}]$$

for a permanent tax transfer scheme to be feasible avoiding decline for a subset of agents with positive measure. □

Proof of Corollary 1.

Observe now that when the sufficient condition for self sustainable redistributive schemes holds with strictly inequality in either of the two cases above, the policymaker can use the surplus of tax revenues to subsidez a fraction of $(1-M_1)$ agents in the second round. For the new mass of investing agents the sufficient condition also holds with strictly inequality, then the policymaker can further extend the measure of subsidized lineages and so on. □

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