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Abstract

A state school system should be expected to reduce income inequality and to make intergenerational mobility easier. It is therefore somewhat surprising to observe that Italy, in comparison to the US, displays less inequality between occupational incomes but a lower degree of intergenerational upward mobility not only between occupations but also between education levels. In this paper we provide evidence on this empirical puzzle and we offer one theoretical explanation building around the idea that even if in Italy *moving* up the social ladder is easier, the incentive to *move* may be lower making mobility less likely.

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1 Introduction

An Empirical Puzzle

The Italian schooling system can be characterised as a prevalently centralised and public system financed by the government through taxation, that provides the same quality of education to everybody. The US system, instead, can be characterised as a prevalently decentralised and private system in the sense that public education is mainly financed at the local level and the share of students going to private school is substantially higher.

Given this characterisation, an Italian family at a low level of income (which can reflect a low level of acquired human capital) should have the same level of education available as a higher income family. A US low income (and low human capital) family, instead should have the additional disadvantage of a low expense in education decided by parents (as a result of a lower direct investment or because of locational choices in communities in which preferences are for lower tax rates and worse schooling institutions).[1] Within this framework it would seem reasonable to predict for Italy a more compressed distribution of human capital investments (and therefore of incomes) matched by a higher likelihood of upward mobility for poor families.

Comparative empirical evidence on Italy and the US, described in Section 2, suggests that this is not the case. While Italy seems characterised by less income inequality, standard measures of intergenerational mobility between occupations and between education levels indicate that poor and non-educated families are less likely to invest in the education of their children and to move up along the occupational ladder. In other words, the Italian centralised public education system can be characterised as an offer of equal opportunities that surprisingly has not been accepted by the Italian poor families. This is the puzzle that we would like to address and explain in our paper.

A Possible Explanation: the Role of Talent and Self Confidence

We propose a theoretical model which can shed some light on this empirical puzzle and, more generally, on the relation between income inequality and intergenerational mobility.[2] Our model builds on existing ones (in particular Glomm and Ravikumar (1992)) but adds an important element: people have talent, which is an essential requirement in the acquisition of human capital. The consideration of talent is what makes the problem of mobility interesting from an economic point of view: without mobility a society may assign high talented people to low education groups, and people with low talent to high

[1] See Benabou (1996a).

[2] This relation has been surprisingly somewhat neglected in the literature. An important exception is represented by the work of Anthony Atkinson (in particular, Atkinson, 1980-81 and Atkinson, 1983 who takes up the challenge posed in Pen (1971) to "build a bridge between the figures on vertical mobility and income distribution". More recently, see also the model proposed by Galor and Tsiddon (1996) in which, inequality and intergenerational mobility are positively correlated and driven by the pace of technological innovations.

education groups; this is an undesirable feature of an immobile society. [3]

Talent is transmitted from father to son with some persistence and cannot be directly observed. [4] The only test for talent is the performance at school. If someone attempts to acquire education, and succeeds, he has a high talent; while, if he fails, he has a low talent. Therefore, school as a sorting mechanism only works for those who chose to invest in human capital. Since talent is imperfectly observable, each person can only try to make some inference about it from the family history.

So the most important decisions, in particular those determining the investment in human capital, are taken on the basis of the belief that each person has on his own talent. The higher this belief, the more likely a person is to invest in education: in fact we shall see that the rational decision is to invest in education if and only if the subjective belief of having the necessary talent is higher than a critical threshold. We refer to this as the self confidence factor, [5] although we have to remember that it is a perfectly rational consideration, since this belief summarises all the information a person has about his own talent.

This belief becomes an important way in which family background affects the decision of a child. A family may be stuck at low levels of education for a sequence of periods because the previous family experiences have given to its members a low confidence. Therefore, a fraction of the population has high talent, but does not use it, *because* of the adverse belief. We say that a society is more mobile if a larger fraction of the people in the low income group makes an effort to increase personal income through an educational investment. The key issue that we analyse in this paper is: which institutional setup for schooling (centralised and public vs. decentralised and private) makes a society more mobile in the above sense, and why. Given this characterisation of mobility, it is desirable to increase it if one wants to reduce the probability that talented individuals remain stuck with low human capital.

In a public school system in which a uniform education quality is offered to everyone, the combination of taxes and educational expenditures transfers revenues from high income families to low income families, and makes a better education available to the latter, at no additional cost. In a private school system a higher income makes the choice of a higher education easier; so income inequality tends to persist. The tranfer of resources induced by the state system and commonly quoted in its support, creates indeed an important incentive for low income families to increase their human capital and tends to raise the degree of mobility induced by public education.

There are however other factors, which go in the opposite direction.

[3] We are here speaking loosely on purpose: the full analysis of the implications of our model for welfare and efficiency is beyond the goals of the present paper. We think, however, that our model provides the necessary structure for an interesting discussion of these issues, so far largely disregarded in the literature on social mobility (particularly in the sociological contributions). We leave such discussion for future research.

[4] Talent should be interpreted as the combination of the genetic and environmental transfers from parents to children; so the assumption of persistence is plausible independently of any belief on genetic transmission. As we will see, without persistence the problem of mobility becomes trivial and our model features perfect mobility independently of the schooling system.

[5] A factor to which, surprisingly, Herrnstein and Murray (1994) devote no time in their book "The Bell Curve".

First, in a private system, a higher parental income directly increases the amount of resources available for the education of the son, while it does not in a public system. If people are altruists, this adds to the attractiveness of a higher education because one knows that if the investment in human capital is successful he will be able to transfer more resources to the next generation; in a public system, the educational transfer to the next generation is centrally determined independently of parental income. Second, a single tax rate may force some parents to a rate of expenditures in education lower than they would desire, thereby making less likely an otherwise attractive investment in education for their sons. Finally, the fact that the tax rate is unique makes useless any information that a person may acquire on his and his son's personal abilities, because he cannot adjust the expense in education for the son according to this information.

Our explanation of the puzzle offered by the comparative evidence on education financing and intergenerational mobility in Italy and in the US hinges on the role of the factors outlined above. In principle, a centralised public system could ensure more mobility than a decentralised private system if the redistribution factor prevails on the others. But the main goal of our model is to show that the opposite outcome is also possible for reasonable values of the relevant parameters. And the comparative evidence on Italy and the US is there to motivate this finding and to prove that it is not just a theoretical possibility with little empirical value.

Of course in a more general model capable, for example, to incorporate the effects highlighted in Benabou (1996a) and (1996b), and in Fernandez and Rogerson (1996)[6] the balance would probably be more favourable to the capacity of a centralised state school system to increase mobility; but the basic trust of our paper would not change: a public and centralised education system introduces distortions in a market economy that societies are usually willing to accept, among other reasons, in order to reduce the probability of leaving talented children stuck in low occupations; our empirical evidence and our model show that this positive outcome *is not a necessary consequence* of a centralised public education system.

Our model draws on the basic structure of Glomm and Ravikumar (1992), but adds to it the consideration of mobility by focusing on the role of talent and self-confidence as determinants of human capital investment decisions. This is an issue that they do not address but that is crucial for an exhaustive comparison of the effects of centralised/public versus decentralised/private education systems. In their model the predicted mobility is necessarily zero, since a dynasty which has an income higher than another in the initial period has a higher income forever. The reason of the difference is clear: in the model of Glomm and Ravikumar there is no talent, persistent or *i.i.d.*.

We, therefore, complement their analysis in a crucial way by showing under what conditions a centralised state system, even if it reduces aggregate human capital accumulation, may be desirable from the point of view of mobility, i.e. from the point of view of reducing the probability that talented individuals remain stuck in low occupations. But we also show that even this desirable property of a centralised public education system is not granted in principle: under plausible conditions, such a system may be inferior to a decentralised private one even from the point of view of mobility.

[6]See also the insightful survey by Bertola and Coen-Pirani (1995).

After the description of the motivating facts concerning mobility and educational institutions in Italy and in the US provided in section 2, in sections 3 and 4 we present the model, the implied equilibria and the steady state distributions. In section 5 we propose some unconventional measures of mobility suggested by the theoretical model. In section 6 we describe and comment the results of numerical computations of the possible equilibria under the two schooling systems. Concluding remarks follow.

2 Evidence on the Puzzle

Occupational Mobility

Social mobility is defined and measured in many different ways in the literature. Among economists, some authors focus on transitions between income classes or between percentiles of the income distribution (Atkinson (1980-81)) while others look at the speed of mean regression of incomes across generations (Becker and Tomes (1986), Solon (1992), Zimmerman (1992)); among sociologist, instead, the attention is concentrated on transitions between occupations ranked according to social prestige (Treiman and Ganzeboom (1990)) or on the transitions between social classes (Erickson and Goldthorpe (1992)). In general while economists tend to study mobility in terms of incomes, sociologists are more likely to focus on occupations.

Our approach can be characterised as a sort of intermediate third way that we adopt partly because of data limitations[7] but also because it offers some advantages from the point of view of achieving a meaningful international comparison and complements in an hopefully interesting way the existing literature. Sociologists have since long argued that because of temporary income fluctuations and measurement error, mobility in terms of yearly income is a misleading upwardly biased indicator of mobility if the goal is to measure transitions between long term economic status. Casting this argument in an econometric framework, Solon (1992) and Zimmerman (1992) propose averages of individual incomes on subsequent years as measures of long term status, but we cannot follow their suggestion because we do not have the necessary information for Italy. We take instead a road more familiar to sociologists and focus on occupations as indicators of economic status; but, we also depart from the sociological literature because we do not rank occupations according to social prestige nor we aggregate them according to subjectively defined social classes.

Given the information contained in our datasets the concept of social mobility that we can measure is represented by mobility between occupations ranked according to the median income paid by each occupation in the generation of children in each country.[8] The reader should therefore keep in mind that in this study, a dynasty is

[7] See the Appendix 8.1

[8] We also performed our analysis using sociological indexes of prestige to rank occupations, but our results concerning the relative performance the two countries in terms of occupational mobility does not change. We present the evidence based on income ranking because it is less conventional from a methodological point of view and because it allows for an analysis of the relation between educational mobility and occupational mobility. Such analysis is impossible if occupations are ranked according to indicators of prestige constructed on the basis of educational achievements.

centralised education system in Italy should have at least partially compensated for the lack of incentives to upward mobility induced by the labour market. On the contrary we observe that also educational mobility (in particular upward mobility) is substantially lower in Italy than in the US.

In the next section we suggest, that some intrinsic features of a public and centralised education system may cause lower intergenerational mobility independently of the labour market. These perverse effects have contributed *together* with the existence of non-competitive labour markets to cause the existence of lower intergenerational mobility in Italy, particularly between education levels. Given the current world-wide debate on the reform of public education we think it is important to highlight the possible role of these undesirable features of centralised and public school systems.

3 The Model

Human Capital and Wages

Population is a continuum, each person lives for two periods and is productive only in the second. His production depends on his human capital, which is described by a real number h. He earns a wage equal to h. There are infinitely many periods; in each period t the distribution of human capital is denoted by G_t; the total human capital is therefore:

$$H_t = \int h dG_t(h) \tag{3.1}$$

The Technology for Human Capital

Each person has a basic working ability, of quality normalised to 1, and a natural talent, which has no direct productive use, but is critical in acquiring additional human capital.

Talent is denoted by $a \in \{L, H\}$; it is transmitted from father to son with some persistency. More precisely, talent follows a first order Markov process:

$$P(a_{t+1} = H \mid a_t = H) = P(a_{t+1} = L \mid a_t = L) = 1 - \alpha$$

with $\alpha \in (0, 1/2)$. Talent is not always known exactly: we denote by ν_t the belief that the talent of the member born at t of the dynasty is H.

A higher human capital can be produced by the combination of a learning effort, the help of an educational system, and the direct or indirect contribution of the human capital of the father. We assume that this is possible only if the talent of the person is of the high type. The technology has (as in Glomm and Ravikumar (1992)) a Cobb Douglas functional form. More precisely,

$$h_{t+1} = \begin{cases} 1 & \text{if } a_{t+1} = L; \\ \theta\,(1-n_t)^{\beta}\, e_t^{\gamma} h_t^{\delta} & \text{if } a_{t+1} = H; \end{cases}$$

where n_t is the leisure enjoyed, e_t is the quality of education, and h_t is the human capital of the father.

Talent cannot be directly observed; the only way to determine it is to put it to the test of the education system. If the person decides to go to school, and fails, then he knows his talent was low; on the contrary if he succeeds he knows that it was high.

Preferences

The utility of each person depends on leisure of the first period, denoted by n_t, consumption of the second period c_{t+1}, and a term which describes the expected utility from the quality of the education which is left to the son. The expectation is taken with respect to the belief ν_{t+1} that the person has on his son's talent, which is not known with certainty. Formally:

$$U(n_t, c_{t+1}, \nu_{t+1}, e_{t+1}) = \log n_t + \log c_{t+1} + \nu_{t+1} \log e_{t+1} \tag{3.2}$$

The budget constraint of each person will depend on the institutional arrangement for the provision of education: so we shall deal with it in the next section.

Two Institutions for Education Financing

As in Glomm and Rawikumar (1992) we consider two different possible institutional arrangements for the provision of education, that is in the context of our model, for the determination of the quantity e_t.

The first is a purely private regime, where e_t is decided by the father, and paid out of his income. The second regime is a pure state school system. The quality of education provided to each child is the same, and is decided as follows. A tax rate $\tau \in [0,1]$ is voted in each period, and chosen according to majority rule. The tax rate applied to the total income gives an amount spent on the collective education:

$$E_t = \tau_t H_t \tag{3.3}$$

We can now state the budget constraint formally. In the case of a private school system, the individual is facing the two constraints:

$$n_t \leq 1; c_{t+1} + e_{t+1} \leq h_{t+1};$$

while in the case of the public school system, with tax rate τ_{t+1}, we have:

$$n_t \leq 1; c_{t+1} \leq h_{t+1}(1 - \tau_{t+1}).$$

The Timing

The life of each person lasts for only two periods. A person born at date t knows the history of attempts to get an education and of successes and failures of former members of his dynasty. In the private school system, he also knows the amount that the father has devoted to his education; while in the state school system he knows the prevailing level of educational quality of the system.

On the basis of the history of his dynasty he now computes his belief on his own talent, denoted by ν_t. [29] He then decides whether to go or not to go to school, a choice which is denoted as the choice between a Y or a N respectively. If he decides Y, he also decides the amount of effort he devotes to the learning activity. He then goes to school, and this is the end of the first period.

At time $t+1$ the talent of the person is revealed and h_{t+1} is determined. In the state school system the tax rate τ_{t+1} is then voted by the old generation. Then the remaining income is consumed and taxes are paid, or, in the private school system, the amount e_{t+1} of funds for the education of the son is provided. Then the son is born and the life of the older generation ends. Note that, to simplify notation, generations do not overlap in this model, but in each calendar period both generations are alive: the oldest in the first part and the youngest in the second part of the period.

To summarise, and to clarify the informational restrictions for the agents: the decision about the education (that is, whether to go to school, and if so how much effort to spend in education) is taken without knowledge of the talent of the person; the vote on taxes, the consumption decision, and the amount for the education of the son, are decided after the additional information on the talent of the person has been obtained. [30]

[29] Note that at the moment of deciding about schooling, each person learns about his talent from his family history, but not from his performance in the early stages of his education. This is clearly an extreme assumption. We have two reasons to defend it. The first is that some of the important decisions about schooling are taken at the very early stages of the education. For instance, the *quality* of the elementary education is important, and has sometimes decisive influence on future choices. The second reason is that we can easily think of a richer model where, say, each agent makes successive choices in education, and receives at each step a signal correlated with his talent from his performance. This model would yield the same qualitative results as ours (provided, of course, that these signals are not too precise). In other words, we want to focus here on the effects of past family experiences on the choice of a person and we claim that our model and its results are robust to the introduction of the possibility of learning from personal experience

[30] For a discussion of the paradox of voting within this framework, see the CEPR WP version of this paper, n. 1466, October 1996.

Learning about Talent

Consider a person with an initial belief ν on his own talent. If he decides to go to school and he is succesful, he will change to 1 the belief on himself while the belief on the talent of his son wil be $1-\alpha$. After a failure in school, instead, these two beliefs will be respectively 0 and α.

If the person decides not to go to school, then he will gather no information about his own talent and will have a belief

$$\hat{\nu} \equiv \alpha + (1-2\alpha)\nu \tag{3.4}$$

on the talent of the son. We shall denote by $\hat{\nu}^i$ the ith iterate of the function defined in 3.4; note that this function is increasing in ν, and its iterates converge to the value $1/2$ independently of the initial value. Since, the belief of the first member that follows a failure in school is $\nu = \alpha$, the belief of the ith member of the dynasty not going to school after a failure is: [31]

$$\hat{\alpha}^i \equiv 0.5(1-(1-2\alpha)^{i+1}). \tag{3.5}$$

The Optimal Policies

We begin with the case of the private school system. The optimal policy is decided by backward induction from the second period, after the decision between Y or N has been taken (and, in the case of a decision Y, the amount of leisure n_t has been chosen). In the second period we have therefore three possible cases: Y and a success, Y and a failure, and N. In each of these cases the problem of the agent is to maximize for a given human capital h_{t+1} and belief ν_{t+1} on the talent of the son:

$$\max_{(c_{t+1},e_{t+1})} \log c_{t+1} + \nu_{t+1} \log e_{t+1}, \text{ subject to } c_{t+1} + e_{t+1} \leq h_{t+1}.$$

which has an optimal e_{t+1} equal to:

$$\frac{\nu_{t+1}}{1+\nu_{t+1}} h_{t+1}.$$

and value:

$$(1+\nu_{t+1}) \log h_{t+1} + L(\nu_{t+1}).$$

where the function L is defined in the appendix 8.3.

[31] A similar learning process is in Piketty (1995) although in that model people learn about a parameter that is social and not dynastic.

So the optimal expense in case of a Y decision and a success is $e_{t+1} = \frac{1-\alpha}{1+(1-\alpha)} h_{t+1}$; in the case of Y and failure we have: $e_{t+1} = \frac{\alpha}{1+\alpha} h_{t+1}$; and finally, if the decision has been N, and the belief on his own talent was ν, then: $e_{t+1} = \frac{\hat{\nu}}{1+\hat{\nu}}$.

In the case of the state system, the important decision in the second period is the one about voting, since consumption is a pure residual from income after payment of taxes. The optimal tax rate τ_{t+1} is

$$\frac{\nu_{t+1}}{1+\nu_{t+1}}.$$

So in the three cases corresponding to the one described above for the private system case we have: $\tau_{t+1} = \frac{1-\alpha}{1+(1-\alpha)}$; $\tau_{t+1} = \frac{\alpha}{1+\alpha}$; and $\tau_{t+1} = \frac{\hat{\nu}}{1+\hat{\nu}}$ respectively.

We can now solve the problem of deciding in the first period the pair (Y, n_t) (go to school, with effort n_t), *versus* N. Leaving the details to the appendix 8.3, in order to understand the optimal policies in the two systems it may be helpful to focus on three generations, each one living for two periods: the *grandfather*, born at $t-1$, the *father*, born at t, who is the agent whose two periods decisions are being modelled, and the *son*, born at $t+1$. [32]

In the private system the optimal choice of expenditure for education of the father is a function of the father's belief on the son's talent, and of the father's realised human capital; we denote this function by $e^P_{t+1}(\nu_{t+1}, h_{t+1})$. Furthermore, the father's optimal choice of Y versus N, and of effort in school, is a function of the human capital of the grandfather and of the avilable quality of education (decided by the grandfather); we denote this function, that will have to be positive for a father to go to school, by $D^P_{t+1}(\nu_t, e_t, h_t)$.

Similarly in the state system, the optimal father's vote on taxes is a function of the father's belief on the son's talent; we denote this function with $\tau^S_{t+1}(\nu_{t+1})$. Furthermore, the fathers's optimal choice of Y versus N, and of effort in school, is a function of the human capital of the grandfather and of the average quality of education available to the father in the state system, e^S_t. We denote this function, that will have to be positive for a *father* to go to school, by $D^S_{t+1}(\nu_t, e^S_t, h_t)$. [33]

Both functions $D^P_{t+1}(\nu_t, e_t, h_t)$ and $D^S_{t+1}(\nu_t, e^S_t, h_t)$ are crucial to determine mobility in the two systems. A detailed discussions of this issue, and of the two functions, is developed in section 5.

The Typical History of a Dynasty

To get some intuition about the way in which the model works we can follow the typical path of a dynasty. After a failure in school of a given member, his son will have a belief

[32] Remember that in each calendar period two generations are alive, but they do not overlap: the oldest lives in the first part and the youngest in the second part of each period.

[33] Note that in general the quality of education available to the father depends on the aggregate human capital and on the median voter preferred tax rate in the generation of grandfathers, but in steady state it will be identical for all generations.

α on his own talent and a human capital equal to 1. Now for a sequence of periods the members of the dynasty will choose not to go to school because their self confidence is too low.

During these periods, however, the belief on talent grows (by the fact that the iterates of the updating rule 3.5 are increasing) until it reaches a critical level at which the corresponding member of the dynasty decides to go to school. For convenience we shall denote this critical level ν_P^* in the private school system and ν_S^* in the state school system case. This critical level, or, equivalently, the length of this initial sequence of periods will depend of course on the institutional arrangement and on the equilibrium; we discuss later how to characterise it, and the various additional factors that influence such critical level in the two systems.

In case of success in school and until a new failure occurs (in which case the cycle we have just described starts all over again) the dynasty goes through a sequence of better and better periods. In each of these periods the members go to school, acquire human capital in an increasing quantity and keep the belief to a high level. In the private school system the members devote an increasing amount of income to the education of their children; while in the state school system they vote for large tax rates in support of education. Eventually, however, a failure occurs and the cycle starts over.

4 Equilibria and Steady State Distributions

In this paper we shall concentrate our attention on the long run property of equilibria; and they can be easily studied by considering the invariant distribution on the relevant variables: human capital, beliefs over talent, investment in education and so on.

¿From our previous discussion of the typical history of a dynasty it should be clear that only certain beliefs over talent are possible in the long run, for a given critical belief. Each dynasty experiences a failure with certainty over an infinite time horizon. After this, the belief of the member of the dynasty in the next generation over his own talent at the moment of deciding about his schooling effort is α (i.e. the probability of being different from his parent). The following members update their beliefs $\hat{\alpha}^k, k = 1, 2, \ldots$ using 3.5 without going to school until the critical level is reached. At that point the corresponding member of the dynasty goes to school, talent is revealed and the belief can only go back to α (in case of failure in school) where the cycle begins again, or to $1 - \alpha$ (in case of success); from this last belief the only transitions possible are either to $1 - \alpha$ again (success) or to α (failure).

If the critical level is above $1/2$ there are countably many beliefs possible; if it is below, then there are only finitely many. In both cases, however, they are a subset of the countable set $\{\alpha, \hat{\alpha}, \hat{\alpha}^2, \ldots, 1 - \alpha\}$. Note that, in turn, this will produce a countable set of possible human capital level, and of possible expenditures in education and of tax rates voted.

In order to examine the structure of the invariant distribution, the first step is the definition of the appropriate state space:

Definition 4.1 *The state space of the process is the product space* $\mathcal{B} \times H = [0,1] \times R^+$ *of beliefs over* $\{H, L\}$ *and of human capital values.*

This state space has to be understood as follows. For the pair (ν, h), ν is the belief of a person on his own talent, at the moment in which he decides the schooling effort n; and h is the human capital that the same person has at the end of the schooling period. [34] The following Lemma describes formally the transition probabilities over this state space: let i be such that the belief $\hat{\alpha}^i$ is the critical belief, ν_P^* or ν_S^*. Then :

Lemma 4.2 *The transition probabilities over* $\mathcal{B} \times H$ *are as follows (wp means: with probability):*

- *from* $(\hat{\alpha}^{k-1}, 1)$ *to* $(\hat{\alpha}^k, 1)$ *for* $k = 0, \ldots, i-1$, *wp* 1;
- *from* $(\hat{\alpha}^{i-1}, 1)$ *to* $(\hat{\alpha}^i, h_0)$ *wp* $\hat{\alpha}^i$, *and to* $(\hat{\alpha}^i, 1)$ *wp* $1 - \hat{\alpha}^i$;
- *from* $(\hat{\alpha}^i, 1)$ *and* $(1-\alpha, 1)$ *to* $(\alpha, 1)$ *wp* 1;
- *from* $(\hat{\alpha}^i, h_0)$ *to* $(1-\alpha, h_1)$ *wp* $1-\alpha$, *and to* $(1-\alpha, 1)$ *wp* α;
- *from* $(1-\alpha, h_j)$ *to* $(1-\alpha, h_{j+1})$ *wp* $1-\alpha$, *and to* $(1-\alpha, 1)$ *wp* α.

The above transition probabilities imply that, after a failure and if it does not go to school, a dynasty moves with certainty across states characterized by a human capital equal to 1 and by subsequent updates of the belief on talent. When the dynasty reaches the critical level of self confidence it goes to school. Since the initial belief after a failure is correct, the updated belief on talent is equal to the true probability of being talented. Therefore, with probability $\hat{\alpha}^i$ the decision to go to school is succesful and h_0 human capital is accumulated; with probability $1 - \hat{\alpha}^i$, instead, the member of the dynasty is untalented and human capital remains equal to 1. If the dynasty keeps being succesful no more updating is needed because each subsequent member knows to be the offspring of a talented parent. Therefore, with probability $1 - \alpha$ the dynasty continues to be succesful and accumulate increasing human capital, while with probability α it fails, human capital falls to 1 and the story starts all over.

The definition and the computation of the invariant distribution for these transition probabilities is reported in the appendix 8.4. We discuss instead, in the next section, how the probabilities in the transition matrix, and therefore intergenerational mobility, depend on the type of school system.

5 Mobility

As we have seen, even on the reduced state space $\mathcal{B} \times H$ the transition matrices are infinite: so we have to find some simple index of the different degrees of mobility in the

[34] See the CEPR WP version of this paper (n. 1466, October 1996), for a proof that this state space is a sufficient description of the process in the sense that the fact that a dynasty is in state $x \in X$ at time 0 provides sufficient information to describe the future conditions of the dynasty.

two educational systems. The simplest is the transition probability among two different classes of human capital.

We divide the total population in two classes: those who have a human capital equal to 1, the minimum value, and those who have a higher value. The first class will be denoted by C_1, the second by C_2. We can then compute the transition matrix between these two classes, say $p_{ij}, i = 1, 2; j = 1, 2$, where p_{ij} is the probability that a dynasty transits from C_i to C_j; we have that:

Lemma 5.1 *The matrix of transition probability across classes is:*

$$\begin{pmatrix} (1 - \frac{\hat{\alpha}^i}{i+1}) & \frac{\hat{\alpha}^i}{i+1} \\ \alpha & (1 - \alpha) \end{pmatrix}$$

The term $\frac{\hat{\alpha}^i}{i+1}$ *is a decreasing function of* i.

The proof is in appendix 8.5. Note that $\frac{\hat{\alpha}^i}{i+1} = \alpha$ when $i = 0$.

The value of $\frac{\hat{\alpha}^i}{i+1}$ can be considered an index of mobility at the steady state equilibrium of the system: the higher this value the more mobile the society is. Note that it is inversely related to the integer i, the number of periods a dynasty remains "discouraged" after a failure. We summarise this as our

Definition of mobility: *a society is more mobile, the shorter the period in which a discouraged dynasty does not attempt to acquire education; that is, the lower the value of the critical* i *(i.e. the lower the level of self-confidence needed to go to school).*

We now turn to a discussion of this critical value and of how it is influenced by the institutional setting for education financing.

Why Mobility Differs in the Two institutional Settings?

The critical value of i is the first time after failure that the expected utility from a Y decision is higher than the expected utility of a N decision. In the private school system, for a father with belief ν on his own talent and available quality of education e, the difference between these two expected utilities is given by the function:[35]

$$D^p(\nu, e) \equiv \nu\beta[1 + (1 - \alpha)]L(\frac{1}{\nu\beta[1 + (1 - \alpha)]}) \tag{5.6}$$
$$+\nu[1 + (1 - \alpha)]\log(\theta e^{\gamma}) + V(\nu) =$$

[35]This is the function that was introduced in the section in which optimal first period policies were described. Here the human capital of the grandfather does not appear as an argument of the function D^p, and analogously for D^s below, because it is equal to 1 for the critical generation.

$$\max_{n\in[0,1]} \left(\log n + \nu[1+(1-\alpha)]\log[\theta e^{\gamma}(1-n)^{\beta}] + V(\nu)\right) \tag{5.7}$$

where the term $V(\nu)$ is equal to:

$$V(\nu) \equiv \nu L(1-\alpha) + (1-\nu)L(\alpha) - L(\hat{\nu}). \tag{5.8}$$

and the function L is defined in the appendix 8.2.

In the public school system, for the father with belief ν on his own talent and available quality of education e, the difference between the expected utilities of the Y and N decisions is given by the function:

$$D^s(\nu, e) \equiv \nu\beta L(\frac{1}{\nu\beta}) + \nu\log(\theta e^{\gamma}) = \tag{5.9}$$

$$\max_{n\in[0,1]} \log n + \nu\log[\theta(\tau H)^{\gamma}(1-n)^{\beta}] \tag{5.10}$$

Mobility under the two systems differs whenever, *coeteris paribus*, the first critical generation i for which D^p becomes positive is different from the first critical generation i for which D^s becomes positive. It is, therefore, crucial to consider how the two functions differ for each given i.

One important difference is that a public school system transfers revenues from high income families to low income families and makes a better education available to the latter at no additional cost. This effect of a state system, that we label *tranfer of resources*, is commonly quoted as the main reason for which public education shoud raise intergenerational mobility.

But other factors, highlighted by our framework, point in the opposite direction making it possible for a private system to induce more mobility. First a father in the private system who decides his effort in the production of his own human capital also keeps into account the fact that in case of success the higher income available to him will also affect positively his son. In the public system instead a higher income will not have this effect, since the expense in education comes from a common fund, and the contribution of each person to it is negligible. *Coeteris paribus*, this makes the value of the Y choice higher in the private system, as reflected by the coefficient $\nu[1+(1-\alpha)]$ rather than ν in front of $\log h_{t+1}$ in the two expressions 5.7 and 5.10; and it increases the effort spent in education in the public system (as it is clear from the equations 8.14 and 8.17 in the appendix). We call this factor *effective altruism.*

Furthermore, for a given i, the median tax rate in the public system is different from the preferred tax rate according to which the critical parent would like to finance education for his son. In general the latter is larger than the former and this factor, that we label *rate of expenditure*, tends to reduce the transfer of resources factor and the capacity of a state system to increse mobility. [36]

[36] To see why, let's call the critical voter the voter in the public system whose son is the first agent to go to school. We can compare his position to the position of the median voter. Observe that the

Finally, the fact that in the public system the tax rate is unique makes useless any information that a person may acquire on his and his son's personal abilities, because he cannot adjust the expense in education for the son according to this information. Formally this effect can be related to the presence of the term $V(\nu)$ in the expression for D^p; this term is instead absent in the expression for D^s because in the public system the tax rates in the three events Y and a success, Y and a failure, and N are the same. The opposite is true for a father in the private system as reflected in the term $V(\nu)$ in the expression for D^p. We may call this term the *value of information*, which is due to the information acquired by going to school *versus* not going. If he goes to school, the father will know if his talent is high or low: hence he will know if the talent of the son is more likely high (with probability $1-\alpha$) or more likely low (with probability α). If he does not go, he will only have the information contained in his updated belief $\hat{\nu}$. But the function L in equation 5.8 is convex; so that we conclude that the value of information is always non negative and therefore increases the desirability of human capital investment in the private system.

We can now summarise our comparison of the two functions D^p and D^s, i.e. of the factors that determine the critical decision to acquire human capital in the two systems. We have seen four factors that affect this critical decision. Three of them, the effective altruism, the rate of expenditure and the value of information, tend to make the private school system more mobile. The first makes a higher income even more attractive for the father in the private system, thanks to the direct positive effect on the son. The second induces lower mobility in the state system by forcing a common lower tax rate, chosen by the median voter, on the critical voter. The third simply adds in the private system an additional reason to go to school: acquiring information on talent.

On the other side there is the transfer of resources factor. This factor captures the fact that taxation in public education systems transfers revenues from higher to lower income dynasties, increasing the quality of education available to the latter.

While the transfer of resources factor is important and is usually quoted as the reason for which public education systems should induce more mobility than private systems, the goal of our model is to show that the other three factors may be relevant as well. In the next section we compute numerical solutions of the model under the two institutional settings and we prove that, for plausible parameters values, a private education system may deliver more mobility than a public system if the technology for the accumulation of human capital is such that the transfer of resources effect is dominated by the other factors. In our simulations we are therefore able to reproduce and explain the puzzle offered by the comparison of education financing and intergenerational mobility in Italy and in the US.

Before looking at these simulations, however, we have to deal with an important special case.

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proportion of unskilled is larger than half when $i \neq 0$. (The proof of this statement is in section 8.5.) Then the median voter is always unskilled if $i \neq 0$; as a result the tax rate for the median voter is always lower than the optimal tax rate for the critical voter.

A Borderline Case

The support of the invariant distribution is a countable set. In the computation of the median voter we begin to add from the lower tax rate, adding at each step discrete quantities corresponding to the different types of voters. It may happen therefore that one of these sums corresponds exactly to half of the voters. This is typically an unlikely event; there is one case however that is particularly important, and requires a detailed discussion.

Suppose that the critical i, *i.e.* the first time after a failure in which a dynasty tries to go to school, is zero. In the invariant distribution there would be exactly half of the population unskilled, with a most preferred tax rate equal to $\frac{\alpha}{1+\alpha}$, and exactly half skilled, with most preferred tax rate equal to $\frac{1-\alpha}{1+(1-\alpha)}$. In this case the equilibrium in voting does not exist.

In the numerical computations, we present however the results for the case in which the critical i is zero, and the tax rate is equal to $\frac{1-\alpha}{1+(1-\alpha)}$. We think the values we present are significant for the following reason.

Consider an economy in which the value of the parameters are such that with $i = 0$ exactly half of the population prefers the tax rate $\frac{1-\alpha}{1+(1-\alpha)}$ to the rate $\frac{\alpha}{1+\alpha}$. This is not, at the corresponding stationary distribution, an equilibrium, because the proportion of population voting for the higher tax rate is not strictly larger than half. Consider however a path where the proportion of the population with human capital higher than 1 is larger than half, say μ_0. Along the path the values of aggregate human capital and the distribution of human capital and belief converge to the values of an economy with tax rate equal to $\frac{1-\alpha}{1+(1-\alpha)}$. The transition is the one described in the previous lemma 5.1; so the fraction of population with belief higher or equal to $1-\alpha$ is equal to $\hat{\mu_0}^n$ in period n, a proportion strictly larger than half.

So along any such path, in every period, the economy is in an equilibrium in which the values of average human capital, its distribution among the population, and so on are close to the values that we report for the case of the critical i equal to 0, and tax rate equal to $\frac{1-\alpha}{1+(1-\alpha)}$.

6 Numerical Computations

The goal of this section is to show that the model described in the previous pages may generate two paradigmatic cases: one in which a private education system induces more mobility than a public education system and one in which the opposite is true: both outcomes are possible depending on parameter values. The set of parameters under which the private system generates more mobility is such that the transfer of resources factor is dominated by the other three factors described in the previous section. This set can be considered as the one more likely to have generated the observed evidence concerning Italy and the US: it is therefore interpreted as our explanation of the puzzle.

In table 13 we present the relevant indicators that describe the performance of

each education system, in the two different paradigmatic cases. In both these cases the parameter α, that measures the persistence in the transmission of talent, has been set equal to 0.1 while the scale parameter θ in the production function of human capital has been set equal to 2.8.[37] The two paradigmatic cases differ instead for the values of the parameters β and γ. These parameters measure, respectively, the elasticity of human capital accumulation with respect to effort $(1 - n_t)$ and with respect to the available quality of education e_t.

Part A of table 13 shows that the main results of Glomm and Ravikumar (1992) hold also in our model. In both Case 1 and Case 2, the state system features a lower degree of inequality but also a lower total human capital (i.e. lower income) and a lower total expenditure in education. The median income in the upper class, that is a measure of inequality because income in the lower class is equal to 1 for everybody, is in fact larger in the private system independently from γ and β. The counterpart of this greater inequality is the larger accumulation of human capital and the larger expenditure in education that the private system can generate, thanks to the fact that fathers are free to spend what they prefer for the education of their sons on the basis of their income and their beliefs on talent. In the state system, instead, where the total quality of education is determined by the common tax rate decided by the median voter and by the aggregate amount of human capital, the total expenditure in education is lower. [38]

However, as we argued in the introduction, the comparison between private and public education systems cannot be limited to these performance indicators, as in Glomm and Ravikumar (1992). A crucial aspect of the comparison is the relative capacity of the two systems to generate mobility and to reduce the mismatch between talents and education. While in the model of Glomm and Ravikumar (1992) this issue cannot be addressed, here we have the elements to compare the performance of the two systems from the point of view of mobility.

A common argument in defence of public schools is that they offer a better quality of education to poor dynasties that, in a private system, would otherwise spend too little for the education of their children. The last column of Part A in table 13 confirms this intuition: the critical expenditure in education e_t, reported in this column, is what the fathers of the first generation going to school spend for the education of their children. Table 13 shows that in both Case 1 and Case 2 the state system offers a better quality of education to this critical generation and this is an implication of the transfer of resources factor that we mentioned in the previous section. The reader will recall that this is indeed the factor that tends to favour mobility in a state system.[39]

[37]Note that $\alpha = 0.5$ implies that the talent of the son is independent of the talent of the father; therefore $\alpha = 0.1$ implies a relatively high inheritability of talent. We will mention later how the results change in relation to the values of α and θ.

[38]It is interesting to observe that the comparison between Italy and the US is perfectly consistent with this latter prediction of the model: in 1992, the expenditure in education per student in the US was equal to 3210 for early childhood education, 5600 for primary education, 6470 for secondary education and 11880 for tertiary education. In Italy the corresponding figures (in ppp dollars) were, respectively, 3280, 4050, 4700 and 5850. These figures show that the expenditure per student in Italy is much lower, particularly at higher levels of education. Also per-capita income is lower in Italy as predicted by our model for a state system.

[39]Note that given that the population is normalised to 1, the total expenditure in education in the state system is equal to the expenditure for each individual including the critical one.

But, the reader will also recall that other factors point in the opposite direction. Part B of table 13 shows indeed that the provision of a better quality of education to poor families does not necessarily make the state system more mobile than the private system: this because the offer of equal educational opportunities to rich and poor dynasties does not generate greater mobility if such an offer is not attractive for poor dynasties.

The paradigmatic case in which the state system fails to generate more mobility even if it offers a better quality of education to poor families, is Case 1 in which $\beta = 0.3$ and $\gamma = 0.1$. Table 13 shows that in this case the probability of upward mobility is higher in the private system (0.09) than in the state system (0.05). A greater level of self confidence (i.e. the critical belief) is needed in the state system in order to go to school (0.42 versus 0.18) and seven generations (instead of one in the private system) wait after a failure without going to school before self confidence becomes sufficiently high to try the human capital investment.

In this case the public offer of equal educational opportunities is not sufficient to ensure more social mobility because the relative weight γ of the quality of education in the production function for human capital is too low. As a result the transfer of resources effect, that tends to increase mobility in a state system, is dominated by the other three factors, mentioned in the previous section, that tend to increase mobility in a private system: effective altruism, the rate of expenditure and the value of information.

On the contrary, in Case 2, when $\beta = 0.1$ and $\gamma = 0.6$, the quality of education is so important for the accumulation of human capital that the public system is capable to induce greater mobility: the reason is that this is precisely the situation in which the public offer of a better education to poor families makes the investment in human capital convenient. In this second paradigmatic case, while the relative performance of the two systems in terms of inequality, total human capital accumulation and expenditure in education is unchanged (see Part A of table 13), no generation waits without going to school in the state system because a belief of 0.1 is enough. In the private system instead the level of self confidence has to grow up to 0.34 and 4 generations wait without going to school. As a result the probability of upward mobility is 0.10 in the state system and 0.07 in the private system.

Increasing the values of the parameters α and θ (that is, making the transmission of talent more random and increasing coeteris paribus the accumulation of human capital in case of success in school) makes mobility more likely in both systems but does not change their qualitative relative performance in relations to the values of β and γ. This is clear from our characterisation of the mobility matrix in section 5: when the talent of the child is independent of the talent of the parent, this matrix has all identical rows, *irrespective* of the values of the parameters and of the schooling system.

To summarise the results of our numerical computations, in order for the transfer of resources factor to prevail, making the state system more mobile, two main conditions have to be met. First redistribution of educational resources from rich to poor dynasties has to be high enough to ensure a sufficiently better quality of education for poor dynasties; and this is the common argument supporting the idea that state systems should generate more upward mobility. But second, the quality of education has to be relatively important, with respect to individual effort, in the accumulation process for human capital. This second requirement is what our paper highlights.

The centralised and uniform provision of education to poor dynasties fails to generate mobility if the quality of education is relatively unimportant for the accumulation of human capital. If this accumulation depends more on individual effort (a large β relative to γ), the offer of equal educational opportunities is of little value for poor families. In this case a private decentralised system in which parents are free to decide how much to spend for the education of their children generates more mobility than a state system in which poor families have access to a better education system but have fewer incentives to do it.

In the light of this model, the lower mobility characterizing the Italian public education system in comparison to the US private system suggests that individual effort is relatively more important than the quality of education in the process of accumulation of human capital that characterizes these countries: the set of parameters described in Case 1 is the set that appears to be most likely given the "two data points" offered by the comparison.

7 Conclusions

If one of the goals of a public education system is to favour equal opportunities of social mobility, the Italian schooling system failed to achieve this goal. The centralised and public structure of education financing in Italy has indeed ensured a substantial uniformity of the quantity and quality of education offered to both rich and poor families; but despite this offer of equal opportunities Italy, in comparison to the US, displays lower intergenerational mobility not only in terms of occupations but also in terms of education levels.

The fact that family background is a more important determinant of individual social fortunes in Italy than in the US is particularly puzzling given that in the US a large fraction of the expenditures for education is financed locally. From the viewpoint of this paper this is the distinctive feature that makes the US education system intrinsically *private*. Indeed, because of local financing (i) the quality of the education which is supplied in the US is significantly different according to the (perhaps implicit) price paid for it; and (ii) the quality of the education provided to the child is decided by the parent on the basis of this cost. In the US the quality of the pre-college education is significantly different in different neighbourhoods and it has an implicit price in the property tax paid by residents and in the higher price of the houses in the best neighbourhoods. The choice of the location of residence is clearly in large part a choice of the education provided to the child. *A fortiori* for college education for which in addition to local financing, US families have access to a large number of private universities. The fact that in such a system family background is less important than in a system in which education is centralised and public is the puzzle that this paper has addressed.

Our explanation of this puzzle starts from the consideration of self confidence as one of the driving forces of upward social mobility. Self confidence has to be greater than a critical value in order for poor dynasties to be willing to make an investment in human capital. Poor dynasties coming from a history of failure or lack of investment in education have lower self confidence and may not invest. As a result, a society may have

in equilibrium talented people with low education.

Public education systems can be thought as being motivated, among other reasons, by the goal of increasing self confidence in poor dynasties so that talented but poor children may reach higher education levels and skilled occupations. The way to achieve this goal is generally to offer a uniform quality of education to all citizens, so that poor families have the same opportunities of rich families to invest in the education of their children. But our analysis shows that an offer of equal educational opportunities may not generate more mobility if the incentive to use education as a way to climb the social ladder is low. Under plausible conditions, even if the quality of education offered to poor dynasties by the state system is higher than the quality offered by a private system, the investment in education may be more attractive for poor dynasties in the private system.

What makes an educational investment attractive in a private system is essentially the possibility to use the outcome of this investments for the benefit of future members of the dynasty. In a private system the information on talent acquired in school can be used to chose optimally the fraction of income to be left to the future generation in the form of education, while in a state system this fraction is decided by the median voter; in addition, in a private system, the higher income that one obtains in school in case of success, benefits directly the next generation because for a given rate of expenditure in education of the father, the actual education quality received by the son is larger. These factors tend to favour mobility in a private system, while in a state system mobility is favoured by the redistribution of resources from rich to poor dynasties .

Therefore, whether a centralised and uniform education system induces more or less mobility than a decentralised and private one depends on effects pointing in opposite directions. Our model shows that a state system generates less mobility when the quality of education is relatively less important than individual effort in the accumulation of human capital. In this case, even if the cost of schooling is low in the state system, the "dynastic" return to schooling is also low and the offer of a better quality of education to poor families has little value to them. This is instead the case in which a private system does a better job in raising the "dynastic" return to schooling, thereby making the investment in human capital attractive even for poor families.

Another way to look at the policy implications of our paper is to observe that primary education is a process of human capital accumulation in which the quality of education (as opposed to individual effort) is relatively important: therefore a public school system may induce more educational investment. On the contrary, tertiary education is a process in which effort is relatively more important and the higher quality of education offered to poor families by a public system does not compensate for the lack of "dynastic" attractiveness of the educational investment. This could be the case of the Italian public university system, whose uniform and low quality does not attract the expected educational investment of poor families because it does not offer a real opportunity for talented children to emerge.

Our data are not rich enough to prove that the public and centralised nature of the education system is the main reason for the low degree of social mobility in Italy in comparison to the US: the existence of a non competitive labour market is certainly an additional crucial factor. But we believe that our explanation is important if one wants to address the policy issues raised in the debate on the reform of public education

systems.

It looks like a paradox, but in a world in which family networks are important for labour market success, a centralised and uniform quality of education, far from helping poor children, takes away from them a fundamental tool to prove their talent, to distinguish themselves and to compete with rich children, whether talented or not.

8 Appendices

8.1 The data

As far as Italy is concerned, our data come from a national survey conducted in 1985 by a group of Italian universities: the *Indagine Nazionale sulla Mobilitá Sociale*). A representative sample of 5016 individuals aged between 18 and 65 was interviewed on their working life, their social attitudes and their family background. From this file, we extracted information concerning the status of the respondent in 1985 and his/her family when he/she was 14. Therefore, while respondents are observed in the same year (1985), their parents are observed in different years, ranging in principle from 1934 to 1981.

¿From the original sample we excluded all individuals not belonging to the labour force or whose occupation was unknown. In addition, for comparability with the US sample (see below), we excluded all women and all individuals younger than 25; this latter restriction is justified by the fact that we want to allow for the possibility of completing university curricula. With these restrictions the original sample reduces to 1666 son-father couples; their age distribution is reported in table 1. The average age of each generation is similar and note that some parents were born during the 19th century.

US data comes, instead, from the Panel Study of Income Dynamics (PSID), that consists of a longitudinal sample of families interviewed for the first time in 1968 and then followed on a yearly basis. The subsample that we use is an extract of the original sample containing information on 1050 father-son couples, whose occupation was known and whose age was greater than 25 at the time of the interview.

An important difference between the two datasets is that US data are based on direct interviews to both sons and fathers, while Italian data on fathers are based on sons' recollections. Information on US sons were collected in 1990, while information on corresponding fathers refer to 1974. Because of the short interval between the two interviews, US sons are on average considerably younger than their fathers as shown in table 1. Although this feature of our data clearly generates a bias we believe that this bias reinforces our conclusions. If Italian children are on average older, they should have had more time to get rid of the effects of an unfavourable family background. Vice-versa, family background should be more important in the US where children are observed earlier in their careers. This because we expect family networking to be more important at the beginning of a career than at the end. Yet, even if the bias in the data increases the likelihood of finding family background more important in the US, we find that it is more important in Italy.

In each country we consider the median income paid by each occupation as the indicator of individual long term economic status. As described in the text, we then group individuals in four classes constructed according to occupational income intervals. We then study mobility tables describing the probability of an intergenerational transition between the four classes.

It should be noted that we have not yet found a single classification of elementary occupations applicable to both countries, nor a conversion table from the national

classifications into a common international one. For Italy our data set is based on the occupation classification developed by DeLillo-Schizzerotto (1985), who grouped 13.000 elementary occupations into 97 basic groups, characterised by a similar degree of social desirability (as measured by the ranking obtained in sample interviews). For the US, we rely on the classification scheme developed by Duncan (1961), who estimated an index of social prestige (based on income and educational achievement) starting from a subgroup of occupations whose social desirability was estimated through direct interviews. In this case the classification scheme include 96 basic groups. Therefore we have a comparable number of occupational groups for the two countries, and these groups were created with similar methodologies, namely on the basis of a homogeneous degree of social desirability. But note that the ranking between occupations in the two countries does not need to be the same.

As far as occupational incomes are concerned, for the US sample we have information about the earnings of both generations. On the contrary, in the Italian sample, we do *not* have any direct information about incomes. We therefore merged occupational income data from another source according to the following procedure.

We started with incomes taken from the 1987 wave of the *Indagine sui Bilanci delle Famiglie Italiane* run by the Bank of Italy. Since this survey reports *net* incomes, we have estimated the corresponding gross incomes on the basis of the relevant fiscal legislation for 1987.[40] We then estimated an earning function using gross incomes. Regressors in the earning function were: age, 6 education dummies, 9 qualification dummies, 11 sector dummies and 5 geographic dummies. We used the estimated parameters to predict incomes for the individuals in our main sample. ¿From these predicted individual incomes we constructed the occupational ranking based on the median income of each occupation. This procedure could of course be used only for the generation of sons. Therefore we were forced to use also for fathers the occupational ranking constructed for sons. In order to allow for a meaningful comparison, we imposed the same restriction on the US dataset as well. But in this data set we have been able to check that the ranking of occupations in terms of median incomes is fairly stable across generations: the correlation between occupational incomes constructed on the distribution of sons and on the distribution of fathers is equal to 0.78.

As far as the educational levels are concerned, we have classified in the high education group all those individuals holding a *college degree* or a *PhD degree* in the US sample, or having obtained a *laurea* or a *dottorato di ricerca* in the Italian sample. This classification corresponds to the UNESCO classification *ISCED 6* and *ISCED 7*, and requires 18 and 16 years of school attendance, respectively in the two countries. People who attended some years of college without obtaining any degree where not considered as *college degree* holders.[41] In the case of Italy we have also used an alternative classification scheme (see table 11): in this case we have included in the high education group all those individuals holding at least a *diploma di maturitá* degree i.e. a secondary school

[40]The Italian system of personal income taxation is step-wise progressive and allows for tax deductions based on household composition. It is therefore possible to reconstruct for each individual his/her gross income starting from his/her net income. Note that preliminary versions of this paper have circulated with evidence based on net incomes.

[41]Because of some missing information on school attendance among fathers, the number of son-father pairs reduces to 1505 observation for Italy and to 1037 for US whenever the education of fathers is considered in the analysis.

degree corresponding to *ISCED 5* classification scheme; in such a case the minimum number of years of school attendance is 15.

8.2 A useful function

The following optimization problem appears repeatedly in our paper:

$$\max_{y\in[0,x]} \log(x-y) + z\log y.$$

Its solution is $y = \frac{z}{1+z}x$, and the value is:

$$(1+z)\log x + L(z), \tag{8.11}$$

where we have denoted:

$$L(z) \equiv z\log z - (1+z)\log(1+z). \tag{8.12}$$

In order to lighten the presentation, we often refer to this function in the paper.

8.3 First period optimal policies

We begin with the private school system. The agent born at t is comparing the maximum between two quantities. The first is the expected maximum utility from the choice (Y, n_t) today, assuming that in the following period the agent will make the optimal choice (of consumption and expenditure on education for the son) conditional on the new information about his own and the son's talent. With belief ν_t on his own talent the first choice gives a success with probability ν_t and failure with probability $1-\nu_t$. If we substitute the values of the second period in the utility function 3.2 and write the maximisation problem for the first period we get:

$$\max_{n_t\in[0,1]} \log n_t + \nu_t\left([1+(1-\alpha)]\log h_{t+1} + L(1-\alpha)\right) + (1-\nu_t)L(\alpha) \tag{8.13}$$

The optimal choice of leisure is

$$\frac{1}{1+\nu\beta[1+(1-\alpha)]} \tag{8.14}$$

and the value is

$$\nu\beta[1+(1-\alpha)]L(\frac{1}{\nu\beta[1+(1-\alpha)]}) \tag{8.15}$$

$$+\nu[1+(1-\alpha)]\log(\theta e^{\gamma})+\nu L(1-\alpha)+(1-\nu)L(\alpha).$$

The second quantity we need to consider is the expected maximum utility from a choice N today. The effort does not affect the human capital, so the optimal choice of leisure is 1; the belief on the son will be $\hat{\nu}_t$, and the corresponding value has the very simple form:

$$L(\nu_{t+1}) = L(\hat{\nu}_t) \tag{8.16}$$

The reasoning in the case of the state school system is similar. The agent solves:

$$\max_{n_t\in[0,1]} \log n_t + \nu_t\left((1-\tau)\log h_{t+1} + (1-\alpha)\log(\tau H)\right)$$

$$+(1-\nu_t)\left(\log(1-\tau)+\alpha\log(\tau H)\right)$$

where the tax rate τ is the prevailing tax rate (and not the tax rate chosen in the second period by the agent). The optimal choice of leisure is

$$\frac{1}{1+\nu\beta} \tag{8.17}$$

and the value is

$$\nu\beta L(\frac{1}{\nu\beta}) \tag{8.18}$$

$$+\nu\log(\theta e^{\gamma})+\log(1-\tau)+[(1-\alpha)\nu+(1-\nu)L(\alpha)]\log(\tau H).$$

8.4 The Invariant Distribution

In this section we provide the values of the invariant distribution over the state space $\mathcal{B}\times H$, for a given value $\hat{\alpha}^i$ of the critical belief.

We denote by Π, respectively Σ, the transition matrix in the private, respectively state, system; $\Pi(x,x')$ is the probability of the transition from x to x'. An equilibrium invariant distribution is a probability F^* that reproduces itself, when each person makes the optimal choice. More formally we say:

Definition 8.1 *A steady state equilibrium distribution for the private school system is a probability measure F_P^* over the product space $\mathcal{B}\times H$ such that*

i. $F_P^* = F_P^* \Pi$,

ii. each member of each dynasty is choosing effort and school expenditure optimally, according to the functions (D^P, e^P) *of section 3.*

Similarly we say:

Definition 8.2 *A steady state equilibrium distribution for the state school system is a triple* (τ^*, e^*, F_S^*) *of a tax rate, an average education quality and a probability measure* F_S^* *over the product space of beliefs and human capital such that* ($F_{S,H}$ *is the marginal of* F_S *over* H*):*

i. $F_S^* = F_S^* \Sigma$;

ii. $\tau^* \int h dF_{S,H}^*(h) = e^*$;

iii. τ^* *is the median voter tax rate for* F_S^*.

iv. each member of the each dynasty is choosing effort and vote on tax rate optimally, according to the functions (D^S, τ^S) *of section 3.*

The integer i is the only factor determining this distribution. Therefore, in an invariant distribution, for each integer $k = 0, 1, \ldots, i-1$ there is a corresponding fraction p_k of the population in state $(\hat{\alpha}^k, 1)$, a fraction $p_{i-1}(1-\hat{\alpha}^i)$ in state $(\hat{\alpha}^i, 1)$, and a fraction $p_i \hat{\alpha}^i$ in state $(\hat{\alpha}^i, h_0)$. It is immediate from the transition matrix that:

$$p_0 = p_1 \ldots = p_{i-1} \equiv p. \tag{8.19}$$

It will be useful now to use the following notational device: the state $(1-\alpha, 1_j)$ is the state of a person with belief $(1-\alpha)$ in the first period of his life, coming after j consecutive successes in his dynasty, and who fails at school. Now denote by q_j and r_j respectively the fraction of the population in state $(1-\alpha, h_j)$ and $(1-\alpha, 1_j)$ we have:

$$q_0 = p_{i-1}\hat{\alpha}^i \equiv p\hat{\alpha}^i; r_0 = p_{i-1}(1-\hat{\alpha}^i) \equiv p(1-\hat{\alpha}^i); \tag{8.20}$$

$$q_{j+1} = (1-\alpha)q_j, r_{j+1} = \alpha q_j, j = 0, 1, 2, \ldots. \tag{8.21}$$

But now observing that:

$$p = \sum_{j=0}^{\infty} r_j$$

we may write:

$$p_0 + \ldots + p_{i-1} + \sum_{j=0}^{\infty} r_j = (i+1)p$$

but also:

$$p_0 + \ldots + p_{i-1} + \sum_{j=0}^{\infty} r_j + \sum_{j=0}^{\infty} q_j = 1$$

and also from 8.21

$$\sum_{j=0}^{\infty} q_j = \frac{q_0}{\alpha}$$

Using the equations above we get:

$$p(1+i) + \frac{1}{\alpha} q_0 = 1,$$

that we can solve to get finally:

$$p = \frac{\alpha}{\alpha(i+1) + \hat{\alpha}^i}; q_0 = \frac{\alpha\hat{\alpha}^i}{\alpha(i+1) + \hat{\alpha}^i}; q = \frac{\hat{\alpha}^i}{\alpha(i+1) + \hat{\alpha}^i}, \tag{8.22}$$

where $q = \sum_0^{\infty}(q_j)$ is the fraction of the population with human capital greater than 1 and $(i+1)p$ is the fraction of the population with human capital equal to 1.

8.5 Proofs

Proof of lemma 5.1. Let F be an invariant distribution for the process described by the matrix Γ. ¿From the ergodic theorem, the measure of the set of dynasty histories with two consecutive values of 1 of human capital is given by:

$$\sum_{\{(\nu,h):h=1\}} F(\nu,h) \left(\sum_{\{(\nu',h'):h'=1\}} \Gamma((\nu,h),(\nu',h')) \right).$$

¿From our computation of the invariant distribution we derive that the above quantity is equal to:

$$p(i+1) - 2p\hat{\alpha}^i + q\alpha;$$

while the total fraction of population with human capital 1 is $p(i+1)$. Taking ratios and using the value for p and q in the appendix 8.4 we get the result. The proof for the other row is obvious.

Recall now that $\hat{\alpha}^i = 0.5[1-(1-2\alpha)^{i+1}]$; calculus applied to the function $(1-(1-2\alpha)^x)x^{-1}$ proves the second claim.

Proof that the proportion of unskilled is larger than half when $i \neq 0$ (see footnote 36).

The statement is equivalent to $(i+1)p > 1/2$ which in turn is equivalent to:

$$\frac{\hat{\alpha}^i}{(i+1)\alpha} < 1$$

But $\hat{\alpha}^i = 1/2[1-(1-2\alpha)^{i+1}]$; so this is equivalent to:

$$(1-2\alpha)^{i+1} > 1-2\alpha(i+1); \tag{8.23}$$

Call $2\alpha = x$ and $i+1 = n$ to simplify; and observe that

$$f(x) \equiv (1-x)^n$$

has derivative at zero equal to $(-n)$, and is strongly convex. Then since $f(x) > f(0) + f'(0)x$ for every strongly convex function, and the above expression is exactly 8.23.

8.6 Numerical Computation

In this appendix we describe the procedure to compute the long run equilibrium. We begin with the private school system. The procedure checks for each integer i if the corresponding belief $\hat{\alpha}^i$ is the critical belief of an equilibrium distribution. Recall that a critical belief is the least belief such that the member of a dynasty with that belief decides to go to school.

In the previous section we have determined the steady state equilibrium proportion of the population for the different beliefs. Note that there are several types of people having the belief $1-\alpha$; namely, those whose dynasty has had a sequence of one, two, and so on successes. These types will have different level of human capital. We now proceed to determine these levels and the corresponding proportions. Let us begin with the first. After the critical level $\hat{\alpha}^i$ is reached, the member of the dynasty goes to school. The father had a human capital equal to 1, a belief on his own talent equal to $\hat{\alpha}^{(i-1)}$, and has invested $e = \frac{\hat{\alpha}^i}{1+\hat{\alpha}^i}$ in the education of the son.

The son invests the optimal amount of effort given these characteristics, and succeeds with probability $\hat{\alpha}^i$. If he does, he has a human capital of

$$h_0 = \theta\left(\frac{\hat{\alpha}^i\beta[1+(1-\alpha)]}{1+\hat{\alpha}^i\beta[1+(1-\alpha)]}\right)^{\beta}\left(\frac{\hat{\alpha}^i}{1+\hat{\alpha}^i}\right)^{\gamma}.$$

Similar arguments give that the dynasties with j consecutive successes in the past have level of human capital that follows the difference equation

$$h_j = \theta\left(\frac{(1-\alpha)\beta[1+(1-\alpha)]}{1+(1-\alpha)\beta[1+(1-\alpha)]}\right)^{\beta}\left(\frac{(1-\alpha)}{1+(1-\alpha)}\right)^{\gamma} h_{j-1}^{(\gamma+\delta)}$$

for $j = 1, \ldots$.

We have conjectured so far that the integer i determines a critical belief $\hat{\alpha}^i$. The last step of the procedure is to verify this conjecture. If it is, we have found a steady state equilibrium; if it is not, we proceed to the next integer. To verify the conjecture we have to check that the belief $\hat{\alpha}^i$ is indeed the least one for which people go to school. But the difference in expected utility between the two choices Y and N for a person with belief ν on his own talent, expenditure e decided by the father and human capital 1 of the father is given by the function D^p. The final step is now obvious: find the least integer i such that

$$D^p\left(\hat{\alpha}^i, \frac{\hat{\alpha}^i}{1+\hat{\alpha}^i}\right) \geq 0.$$

The procedure to determine the steady state equilibrium for the state school system is similar, and we provide here the main lines. In this case too we check if $\hat{\alpha}^i$ is the critical belief of the equilibrium, for every i. Recall now that the preferred level of taxes only depends on the belief of the father at the moment of voting. A simple computation now determines the median voter in this population, and the winning tax rate $\tau(\hat{\alpha}^i)$. Also arguments like the one given above give the human capital for generations with j successes. The equations are now:

$$h_0 = \theta\left(\frac{\hat{\alpha}^i\beta}{1+\hat{\alpha}^i\beta}\right)^\beta e^\gamma;$$

and

$$h_j = \theta\left(\frac{(1-\alpha)\beta}{1+(1-\alpha)\beta}\right)^\beta e^\gamma h_{j-1}^\delta,$$

for $j = 1, \ldots$. The e in the formulas for human capital above is for the moment a parameter to be determined. Keeping into account that the proportion of population with h_0 is $p\hat{\alpha}^i$, and the proportion of population with h_j is $q\alpha(1-\alpha)^j$ for every $j > 0$ we can now determine the aggregate human capital and therefore the aggregate income, *this last as a function of* e (besides i), $H(i,e)$ say. Now solving for e in

$$e = \tau(\hat{\alpha}^i)H(i,e)$$

determines a value of the education quality level in the state school system $e(i)$, say. The final step is, as before, the determination of the integer i for which indeed the belief $\hat{\alpha}^i$ is the critical level. The function giving the difference between the expected utility of the Y and the N decision, for person with father having a human capital equal to 1 is now given by: the function D^s, and as before we conclude by determining the least integer i such that $D^s(\hat{\alpha}^i, e(i)) \geq 0$.

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Table 1: Age distribution for both generations in Italy and in the US

Country	Father/son	Av.age	St.Dev.	Min. age	Max. age
Italy	Father	47	7	31	83
N = 1666	Son	44	11	25	65
United States	Father	47	7	27	74
N = 1050	Son	33	5	25	59

Note: Italian data refer to 1666 father-son pairs; sons were interviewed in 1985, and information regarding their fathers refers to the year in which sons were 14 years old. Source: *Indagine nazionale sulla mobilità sociale.* US data refer to 1050 father-son pairs; information on sons refer to 1990, while information on fathers refer to 1974. Source: *Panel Study of Income Dynamics.*

Table 2: Inequality measures for Italy and the US

Measure	Italy Father	US Father	Italy Son	US Son
90-10 percentile differential	140.6	164.3	131.5	150.3
relative mean deviation	12.2	14.6	13.2	14.3
coefficient of variation	33.8	37.5	34.8	36.0
standard deviation of logs	30.0	35.6	31.3	34.9
Gini coefficient	16.8	20.2	17.9	19.6
Atkinson ($\epsilon = 2$)	8.7	11.8	9.3	11.4
Theil entropy	5.0	6.6	5.5	6.1

Note: All measures are expressed in % terms. Higher values imply greater inequality.

Table 3: Income classes for the United States and for Italy

		US	Italy
Class 1	Minimum	100	100
	Median	130	135
	Maximum	139	144
Class 2	Minimum	148	150
	Median	174	164
	Maximum	215	216
Class 3	Minimum	215	219
	Median	261	234
	Maximum	314	318
Class 4	Minimum	322	331
	Median	337	369
	Maximum	463	474

Note: statistics based on the distribution of sons' incomes; results are similar for the distribution of fathers. Minimum occupational income normalized to 100. Income classes are defined as intervals of equal size of the (log) difference between the highest and the lowest occupational incomes.

Table 4: Italy: interclass transition probabilities

	Son C1	Son C2	Son C3	Son C4	Abs.freq.
Father C1	21.8	50.4	22.3	5.4	367
Father C2	12.0	55.9	25.8	6.3	884
Father C3	5.9	27.0	51.6	15.5	341
Father C4	4.0	16.2	32.4	47.3	74
Abs.freq.	209	783	510	164	1666

Note: each cell contains the row-to-column transition probability. C1-C4 are income classes defined as intervals of equal size of the (log) difference between the highest and the lowest occupational incomes.

Table 5: US: interclass transition probabilities

	Son C1	Son C2	Son C3	Son C4	Abs.freq.
Father C1	25.9	36.4	31.4	6.3	239
Father C2	22.5	37.7	29.7	10.1	337
Father C3	9.3	31.0	41.7	18.0	355
Father C4	4.2	15.1	42.0	38.7	119
Abs.freq.	176	342	373	159	1050

Note: each cell contains the row-to-column transition probability. C1-C4 are income classes defined as intervals of equal size of the (log) difference between the highest and the lowest occupational incomes.

Table 6: Scalar indicators of mobility for interclass transition matrices

	Italy	US	Eq. opp.
$ML = 1 - \lvert\lambda_2\rvert$	0.55	0.65	1
$MT = \frac{k-tr(P)}{k-1}$	0.74	0.85	1
$MD = 1 - \lvert det(P)\rvert^{(1/(k-1))}$	0.79	0.90	1
$MB = \sum_i \sum_j f_{ij} \lvert i - j\rvert$	0.62	0.80	-
$MA = \sum_i \sum_j f_{ij} \lvert W_i - W_j\rvert$	22.44	27.55	-

Note: $|\lambda_2|$ is the modulus of the second greater eigenvalue; $tr(P)$ and $det(p)$ are respectively the trace and the determinant of the interclass transition matrix P; k is the number of classes; f_{ij} is the joint frequency in cell (i, j); the distance $|i - j|$ is the number of class borders crossed in the transition from i to j. $|W_i - W_j|$ is the percentage difference between median incomes of class i and j.

Table 7: Determinants of the probability that a son is in income class 3 or 4

	ITALY			US		
	model 1	model 2	model 3	model 1	model 2	model 3
Father in income class 3 or 4	0.37	0.35		0.22	0.19	
	(.03)	(.03)		(.03)	(.03)	
Father with college degree	0.18	0.02		0.19	0.05	
	(.09)	(.09)		(.04)	(.05)	
Son with college degree		0.31	0.39		0.47	0.50
		(.05)	(.05)		(.03)	(.03)
Father's age	-0.001	-0.001		0.009	0.004	
	(.002)	(.002)		(.002)	(.003)	
Son's age		-0.003	-0.03		0.005	0.007
		(.001)	(.001)		(.004)	(.003)
observed prob.	.427	.427	.427	.508	.508	.508
predicted prob.	.427	.428	.428	.511	.532	.530
Pseudo R2	.08	.10	.04	.07	.19	.16
log-likelihood	-939	-918	-984	-665	-578	-597
sample size	1505	1505	1505	1037	1037	1037

Note: Maximum likelihood estimates of a probit model in which the dependent variable takes value 1 when the son is in income class 3 or 4. The table reports the probability effects, evaluated at the sample averages, due to a discrete change of each dummy independent variable. For the age controls the reported effects are those of an infinitesimal age change.

Table 8: Actual marginal and limiting distributions for education in Italy and US

	Italy	Italy	Italy	Italy	US	US
	E1 = no coll.	E2 = coll.	E1 = no HS	E2 = HS+	E1 = no coll.	E2 = coll.
Father	0.97	0.03	0.92	0.08	0.84	0.16
Son	0.91	0.09	0.71	0.29	0.73	0.27
Limit	0.83	0.17	0.30	0.70	0.65	0.35

Note: marginal and limiting distributions are referred to the matrices of educational transition probabilities. Each limiting distribution is obtained under the assumption that the correspndent matrix describes a Markov process. For Italy: high education = college degree in column 1 and high school degree or more in column 2; for the US: high education = college degree.

Table 9: Italy: transition probabilities from "no college" to "college"

	Son E1	Son E2	Abs.freq.
Father E1	92.9	7.1	1462
Father E2	34.9	65.1	43
Abs.freq.	1374	131	1505

Note: each cell contains the row-to-column transition probability. E1 = no college degree; E2 = completed college degree.

Table 10: US: transition probabilities from "no college" to "college"

	Son E1	Son E2	Abs.freq.
Father E1	79.2	20.8	870
Father E2	38.9	61.1	167
Abs.freq.	754	283	1037

Note: each cell contains the row-to-column transition probability. E1 = no college degree; E2 = completed college degree.

Table 11: Italy: transition probabilities from "less than highschool" to "highschool or +"

	Son E1	Son E2	Abs.freq.
Father E1	75.9	24.1	1389
Father E2	10.3	89.7	116
Abs.freq.	1066	439	1505

Note: each cell contains the row-to-column transition probability. E1 = less than highschool; E2 = completed highschool or more.

Table 12: Scalar indicators of mobility for educational transition matrices

	Italy E2 = coll.	US E2 = coll.	Italy E2 = HS or +	Eq. opp.
$OR = \frac{p_{12}/p_{11}}{p_{22}/p_{21}}$	24.6	6.0	27.3	1
$MT = \frac{k-tr(P)}{k-1}$	0.42	0.60	0.34	1
$MB = \sum_i \sum_j f_{ij}\|i-j\|$	0.12	0.27	0.14	-

Note:OR is the odds ratio; in a 2×2 matrix the indexes MT, MD and ML defined in table 6 are all equal; $tr(P)$ is the trace of the interclass transition matrix P; k is the number of classes; f_{ij} is the joint frequency in cell (i, j); the distance $|i - j|$ is the number of borders crossed in the transition from i to j.

Table 13: Steady state performance indicators of the two systems

Part A								
	β	γ	School System	tax rate	Median income upp. class	Total human capital	Total expenditure in education	critical expenditure in education
CASE 1	0.3	0.1	State	0.28	3.40	1.66	0.47	0.47
			Private		7.30	3.19	1.37	0.15
CASE 2	0.1	0.6	State	0.47	2.52	1.69	0.80	0.80
			Private		8.85	5.22	2.33	0.25
Part B								
	β	γ	School System	tax rate	Proportion of unskilled	Probability of upward mobility	Critical belief	Generations without school after failure
CASE 1	0.3	0.1	State	0.28	0.66	0.05	0.42	7
			Private		0.53	0.09	0.18	1
CASE 2	0.1	0.6	State	0.47	0.50	0.10	0.10	0
			Private		0.60	0.07	0.34	4

Note: All the indicators are computed at the steady state for: $\alpha = 0.1$ and $\theta = 2.8$. The median income of the upper class is a measure of inequality in these economies given that all the individuals in the lower class have an income equal to 1. Total human capital is defined as in equation 3.1. Total expenditure in education is the sum of what each father spends for the education of his son in the private system, while in the state system is given by definition 8.2. The critical expenditure in education is the education available to the generation that goes to school: it is equal to total expenditure in the state system becase of the the normalization of population. The proportion of unskilled is equal to $p(1+i)$ as in section 8.4. The probability of upward mobility is equal to the term $\frac{\hat{\alpha}^i}{i+1}$ in lemma 5.1. The critical beliefs are the beliefs ν_P^* or ν_S^*, respectively for the private and the state system, that dynasties have to reach after a history of no schooling in order to decide to make an investment in education. The first generation in school after a failure is the value of the critical i as characterized, for example, in lemma 4.2.

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