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INTERGENERATIONAL MOBILITY and SOCIAL STATUS in A MODEL with HUMAN CAPITAL INVESTMENTS and TRAIT INHERITANCE

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# Intergenerational mobility and social status in a model with human capital investments and trait inheritance

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**proposed running head:** Intergenerational mobility and social status

## **Abstract**

We study a model in which parents care about the economic and social status of their offsprings. Chances of an individual of achieving social status depend on innate traits, i.e. IQ, ability, social and cultural environment and other price insensitive endowments, passed on by their parents, on human capital investments and on chance events. Parents can, through human capital investments, increase the offspring's probability of climbing the social ladder, although they cannot borrow against the children's perspective earning. Consequently, income and trait heterogeneity are the determinants of unequal opportunities and of intergenerational mobility<sup>1</sup>.

**Keywords:** Intergenerational mobility; Status competition; Inequality; Human capital; Innate traits

**JEL:** J62, O40

# 1 Introduction

Economic status and intergenerational mobility are strongly interrelated. Both can be defined and measured along dimensions such as the social prestige of occupations and/or differences in earnings. If people care about economic and social status then there will be a competition for achieving it. Status competition for high social prestige occupations or high earning jobs will lead to an inefficient allocation of resources since social status is by definition a relative position.

We consider a model in which intergenerational mobility and thus the achievement of high status positions in the economy depend on price insensitive as well as on price sensitive endowments.<sup>2</sup> Parents transmit to their offsprings innate traits, such as IQ, ability, work ethic, and so on. These inheritable endowments, compounding also the social and cultural environment, are insensitive to market prices<sup>3</sup>. The achievement of high social status positions depends also on individuals' endowment of human capital. Parents, while transmitting those traits, also invest in their offsprings' human capital. Investment in human capital is price sensitive since it depends on the relative cost of human capital investments as well as on the gain in social prestige from being on top of others. We assume that parents cannot borrow against the children's perspective earning. Thus, rich families can invest more in human capital than poor ones can and thus inequality shapes opportunity (Corak, 2013). Our paper is closest in spirit with Fershtman, Murphy and Weiss (1996) where it is argued that, because of competition for social status, high income but low ability individuals may crowd out low income but high ability individuals. Compared with Fershtman, Murphy and Weiss (1996) we assume that price insensitive traits can be transmitted from parents to offsprings. In our paper acquired human capital interacts with the quality of inherited traits, and thus parental status can be a strong predictor of the likely economic status of the next generation. Individuals are heterogenous in their endowment of innate traits and human capital. Thus, income and trait heterogeneity are the determinants of unequal opportunities and of intergenerational mobility. Our paper is closely related to that of Becker and Tomes (1979, 1986) and Solon (2004). In these papers parents face borrowing constraints, and transmit ability to their offsprings. Parents can increase their offsprings' human capital by investing in education. Couch and Morand (2005) build a model aimed at investigating how the interaction between the persistence of ability across successive generations and the accumulation of human capital determines the distribution of income across a population. The authors show that the introduction of an exogenous ability is unlikely to produce a systematic relationship between mobility and inequality. In these papers, mobility does not affect the return on education. Maoz and Moav (1999) and Owen and Weil (1998) examine how incentives for and constraints on human capital investments affect intergenerational mobility and further assess the relationship between inequality, mobility and economic growth. In Owen and Weil (1998) multiple steady state equilibria are possible where higher level of output correspond to lower inequality, higher mobility and more efficient distribution of education. Maoz and Moav (1999) find a unique dynamic growth path, where increased mobility stems from a decreased wage inequality. In both papers the distribution of offsprings innate traits (ability) is independent of parental traits. Hassler and Mora

(2000) distinguish between genetic heritage, consisting of intellectual ability, and social heritage, consisting of social advantages due to a particular upbringing and determined by parents' social position. In a low growth regime the social background is key to economic and social success while in a high growth regime intelligence is more important. The joint dynamics of intergenerational mobility and technological growth are investigated. The authors do not investigate parent's decision to invest in their offspring's human capital and do not look into the issue of status competition. Building on Becker and Tomes (1979, 1986), Retuccia and Urrutia (2004) and more recently Seshadri and Yoon (2016) construct quantitative models of intergenerational transmission of human capital that features transmission of innate abilities and investment in education. In these papers, parents care about their offsprings' utility and the models are solved numerically and calibrated using US data with the aim to investigate education policies. In contrast, we focus on status competition, where parents care about their offsprings' social position, proxied by relative income. Moreover, we investigate analytically situations where only poverty trap equilibria exist and situations where poverty trap equilibria coexist with an equilibrium that features social mobility and how these equilibria are affected by the degree of status competition and the inheritability of innate traits.

Our paper is also related to the literature on intergenerational cultural transmission. In this literature, altruistic parents try through costly actions to instill preferences in their offsprings (Bisin and Verdier, 2001). Doepke and Zilibotti (2008) study a dynamic dynastic model where parents invest in their offsprings' patience and work ethic, which are treated as human-capital-like state variables. The authors show that the endogenous accumulation of "patience capital" can lead to endogenous inequality, even if all individuals are initially identical and that technological change can trigger drastic changes in the income distribution. In a similar vein, Doepke and Zilibotti (2014) consider a model where entrepreneurs try to instill patience and risk-tolerance in their offsprings. A self-reinforcing mechanism can lead to multiple equilibria: in a highly entrepreneurial society one observes strong investments in high human capital investment and risky innovation, leading to a high growth rate and high investments in entrepreneurial preferences. Chakraborty and Thompson (2016) study occupation-specific cultural bias in a model where paternalistic parents prefer their offsprings to follow in their footsteps. The authors show that the feedback effect can eventually lead to a stagnating economy. Varvarigos (2017), in a model where parents try to instill their willingness to devote more time and effort towards the formation of their human capital, show how the dynamic interplay between accumulation of physical and human capital and the process of intergenerational cultural transmission can lead to the emergence of multiple, path dependent equilibria with persistent long-term differences in economic performance.

We follow Galor and Zeira (1993) in assuming that human capital investments are non-convex. It is a well established result in the literature that credit constraints together with non-convexities in the (human capital) investment technology can lead to poverty traps (see Ghatak, 2015, and Matsuyama 2010 for a discussion). Galor and Zeira (1993) consider a model of investment in human capital in the presence of imperfect credit markets, where individuals either invest in human capital or else supply unskilled labor. Distribution of wealth determines

the aggregate levels of investment in human capital, of skilled and unskilled labor and of output. The authors show that credit constraints and non-convexities imply that initial conditions on wealth distribution affect the economy in the short and long run. Banerjee and Newman (1993) study, in a model with credit constraints and investment indivisibilities, economic development focusing on the interplay between agents' occupational decision and the distribution of wealth. Economic development depends on initial conditions. If initially there are many poor agents then labor supply is large and consequently equilibrium wages are low. Consequently, workers are trapped in poverty. If there are sufficiently few poor agents, then labor supply is sufficiently low and equilibrium wages are sufficiently large such that sooner or later individuals are able to invest and become entrepreneurs. Wealth in this case trickles down from the rich to the poor.<sup>4</sup> In all these models trait inheritance as well as status considerations play no role.

In our model individuals become either entrepreneurs, or workers. We assume that being an entrepreneur is a socially superior position than being a worker and that the value of this social status is increasing in the income differential. Entrepreneurs use a freely available technology, which uses labour as the only input to produce a homogeneous output. Workers supply inelastically one unit of labor in a competitive labor market. Income is endogenously determined through a labor market clearing condition. The probability of becoming an entrepreneur depends positively on human capital endowments and on inherited traits. We assume that parents care about the economic status of their offsprings, defined as the income differential between entrepreneurs and workers, and invest in their offsprings' human capital.

We investigate the importance of status competition, inherited traits and human capital investments on inter-generational mobility. We assume that human capital investments are effective only if they are sufficiently large. Put differently, we assume that below a critical level, human capital investments are unsuccessful in raising the probability of becoming a successful entrepreneur. As a consequence, for a given parameter configuration of the model, we obtain a threshold for this critical level above which only poverty trap equilibria exist. Thus, if this critical level is too large, then only the rich invest in human capital while the poor don't and thus offsprings inherit their parents' social status. Below this threshold, thus if the critical human capital investment level is sufficiently low, an equilibrium with intergenerational mobility coexists with poverty trap equilibria. This threshold level is the larger the stronger individuals compete for social status and the more likely it is that good and bad traits are passed on to offsprings. The intuition is the following. Stronger status competition leads more individuals to invest in education. This increases the number of entrepreneurs, reducing the profit rate and increasing the wage rate, and, as a consequence, increases the threshold above which workers can't afford to invest in their offsprings' human capital. The more likely it is that good and bad traits are passed on to offsprings, the more likely it is that offsprings of individuals with good traits become entrepreneurs. This increases the number of entrepreneurs and thus labor demand, thereby increasing workers' income, and increasing thus the threshold above which workers can't afford to invest in their offsprings' human capital.



We find that the probability of passing on good and bad traits has an ambiguous effect on intergenerational mobility, depending on the effectiveness of human capital investments. Two countervailing effects are at work. On the one side, the larger is this probability, the larger, because of the above reasoning, the workers' income and thus the larger the threshold for human capital investments below which an intergenerational mobility equilibrium exist. On the other side, increasing the trait inheritance probability increases the likelihood of inheriting also their social status. If the critical human capital investment level is very low, then the latter effect prevails and increasing the trait inheritance probability reduces intergenerational mobility; if it is very large, then the former effect prevails and increasing the trait inheritance probability increases intergenerational mobility. For some parameter values, for intermediate values of the critical human capital investment level there exists an inverted-U shaped relationship between trait inheritance probability and intergenerational mobility. Moreover we find that the more parents care about their offsprings' social status, the greater is intergenerational mobility. The intuition for this result is that the more parents care about their offsprings' social status, the more they invest in their offsprings' human capital. This reduces the number of workers per entrepreneur, thereby increasing labor demand and thus increasing (reducing) workers' (entrepreneurs') income. As a consequence, offsprings of workers (entrepreneurs) with good (bad) traits have a greater (lower) probability of becoming entrepreneurs and thus intergenerational mobility is greater.

The remaining part of the paper is organized as follows. In Section 2 the model is outlined. In Section 3 the steady states of the model are characterized. In Section 4 intergenerational mobility is investigated. Section 5 concludes the paper. Proofs are in the Appendix.

## 2 The model

We consider an overlapping-generation model. In each period of time a unit mass of individuals that live for two periods is born. In the first period human capital is acquired; in the second period they either become entrepreneurs ( $E$ ) or workers ( $W$ ). Entrepreneurs employ workers to produce a homogeneous product. Markets are competitive. Each individual has one offspring. Time is discrete.

Parents transmit to their offsprings price insensitive traits, such as IQ, ability, work ethic, social network and so on, and invest in their offsprings' human capital. We consider two possible types of traits  $a_t^i \in \{g, b\}$ , where index  $i$  indicates lineage  $i$  and  $t$  is a time index;  $g$  indicates good traits, for example, high ability or IQ or favorable social and cultural environment;  $b$  indicates bad traits. Good traits increase the probability of becoming an entrepreneur. Trait inheritance dynamics is described by a two state Markov process with  $\Pr(a_{t+1}^i = g | a_t^i = g) = \Pr(a_{t+1}^i = b | a_t^i = b) = p$ , which is the trait inheritance probability, constant over time<sup>5</sup>. Consistent with the evidence from Bruce J. Sacerdote (2002) and Erik Plug and Wim Vijverberg (2003), we assume that the innate ability of a child is positively correlated with the innate ability of the parent, i.e.  $p \geq \frac{1}{2}$ . Note that in this case, since the transition matrix is symmetric and therefore the probability of changing state is the same for both types,

in the steady state, half of the population has good while half has bad traits.<sup>6</sup>

Human capital investments increase the offsprings' chances of becoming entrepreneurs. Let  $e$  denote the investment in human capital. We assume that, when taking the education investment decision, parents already know their offsprings' traits quality.

Becoming an entrepreneur depends on an individual's acquired human capital, on inherited traits as well as on chance events. Let  $q_a(e)$  be the probability of becoming an entrepreneur, given the investment in education  $e$  made by a parent with offspring's trait quality  $a \in \{g, b\}$ . We assume that  $q_a(e) = \max\{\min\{\kappa(a)e - \tau, 1\}, 0\}$ , where  $\kappa(g) > \kappa(b) > 0$  while  $\tau$  is the threshold below which education is ineffective because of insufficient human capital accumulation. Thus, implicitly we are assuming that investments in higher ability individuals are more productive.<sup>7</sup>

An entrepreneur produces a homogeneous good employing  $x$  units of labor and using the available technology  $f(x) = x^\alpha$ , with  $\frac{1}{2} \leq \alpha < 1$ . Let  $\mu_t$  be the number of entrepreneurs at time  $t$ ,  $1 - \mu_t$  the number of workers and  $x_t = \frac{1-\mu_t}{\mu_t}$  the number of workers per entrepreneur. Markets are competitive. The wage function is  $w(x) = \alpha x^{\alpha-1}$ , where  $w'(x) < 0$ , and the profit function is  $\pi(x) = (1 - \alpha)x^\alpha$ , where  $\pi'(x) > 0$ . We define the income differential  $\Delta(x) = \pi(x) - w(x) = (1 - \alpha)x^\alpha - \alpha x^{\alpha-1}$ , where  $\Delta'(x) = (1 - \alpha)\alpha(1 + x)x^{\alpha-2} > 0$ . Note that there exists a unique  $\hat{x} = \frac{\alpha}{1-\alpha}$  such that  $\Delta(\hat{x}) = 0$  and  $\Delta(x) > 0$  for each  $x > \hat{x}$ .

Parents care about their offsprings' social status, which, we assume, they proxy by today's income differential. Individuals choose their consumption level<sup>8</sup> and their offsprings' education investment solving the following maximization problem

$$\begin{aligned} \max_{e,c} \quad & q_a(e) \Delta(x) + \beta \log(c) \\ \text{s.t.} \quad & c + e \leq r_s(x) \\ & e \geq 0 \end{aligned}$$

for  $a \in \{b, g\}$ ,  $s \in \{W, E\}$ ,  $r_E(x) = \pi(x)$  and  $r_W(x) = w(x)$ . The larger (lower) is  $\beta$ , the less (more) important is social status.

The first order condition for the optimal educational investment  $e^*$  yields

$$e^*(x, s, a) = \begin{cases} 0 & \text{if } r_s(x) - \frac{\beta}{k(a)\Delta(x)} < \frac{\tau}{k(a)} \\ r_s(x) - \frac{\beta}{k(a)\Delta(x)} & \text{if } \frac{\tau}{k(a)} < r_s(x) - \frac{\beta}{k(a)\Delta(x)} < \frac{\tau+1}{k(a)} \\ \frac{\tau+1}{k(a)} & \text{if } r_s(x) - \frac{\beta}{k(a)\Delta(x)} > \frac{\tau+1}{k(a)} \end{cases} \quad (1)$$

for  $a \in \{g, b\}$  and  $r_s(x) \in \{\pi(x), w(x)\}$  since  $s \in \{E, W\}$ . Using (1) we obtain the probability that an individual with traits  $a \in \{g, b\}$  and parent of type  $s \in \{E, W\}$  becomes an entrepreneur

$$q_{s,a}(x) = \max\{\min\{\kappa(a)e^*(x, s, a) - \tau, 1\}, 0\}$$

$s \in \{E, W\}$  and  $a \in \{g, b\}$ . Note that, for a given  $x$ ,  $q_{s,a}(x)$  is increasing in  $a$ , decreasing in  $\tau$  and decreasing in  $\beta$ .

$q_{s,a}(x)$  also depends on  $\tau$  and  $\beta$ . In order to simplify notation, we omit reference to these parameters.

**Remark 1** *The credit constraints assumption together with the traits-human capital investment complementarity assumption lead to the inequality*

$$q_{W,b} \leq \min \{q_{W,g}, q_{E,b}\} \leq \max \{q_{W,g}, q_{E,b}\} \leq q_{E,g}$$

Innate trait and human capital investment complementarity implies that the probability of becoming an entrepreneur is lowest if a child is endowed with bad traits and born to workers; the probability is largest if a child is endowed with good traits and born to entrepreneurs. Children endowed with bad (good) traits and born to entrepreneurs (workers) have a probability of becoming entrepreneurs that lies in between these two values.

Transition probabilities are determined by the joint dynamics of the inheritance of traits and the education investment choices made by parents:

$$\Pr(s_{t+1}, a_{t+1} | s_t, a_t) = \Pr(s_{t+1} | a_{t+1}, s_t, a_t) \Pr(a_{t+1} | a_t, s_t) \quad (2)$$

where  $\Pr(s_{t+1} | a_{t+1}, s_t, a_t) = q_{s,a}(x)$ , for  $s \in \{E, W\}$  and  $a \in \{g, b\}$ .

Optimal parental investment depends on the offspring's inherited traits  $a$ , on parent's status  $s$ , and on the number of workers employed by each entrepreneur  $x$ . The influence of  $x$  on the human capital investment decision and thus on the probability of becoming entrepreneurs is twofold. Firstly,  $x$  changes the parents' disposable income. The higher is the number of workers per entrepreneurs  $x$ , the lower (higher) the wage (profit) rate and the more (less) binding is the budget constraint for workers (entrepreneurs). Secondly,  $x$  affects the value of the social status of becoming a entrepreneur. The larger is the number of workers per entrepreneurs  $x$ , the larger the profit and the lower the wage rate, and thus the larger is the income differential. Consequently, the higher is the social value of becoming an entrepreneur and the stronger the incentive to invest in the offspring's human capital. For an entrepreneur these two effects work in the same direction and thus  $q_{E,a}(x)$ , for  $a \in \{g, b\}$ , is increasing in  $x$ . For a worker these two effects act in the opposite direction: for sufficiently low values of  $x$  the incentive to invest in the offspring's education is negligible small, while for  $x$  sufficiently large the parent's income is too low to invest in the offspring's education. Consequently,  $q_{W,a}(x)$  is increasing for low values of  $x$  and decreasing for large values of  $x$ . Putting these results together, there exist thresholds for  $x$  such that for values larger than these thresholds the probability of inheriting the parent's status is 1

$$\bar{x}_a = \min \{\bar{x}'_a : q_{E,a}(x) = 1 \text{ for each } x \geq \bar{x}'_a\}$$

and

$$\underline{x}_a = \min \{\underline{x}'_a : q_{W,a}(x) = 0 \text{ for each } x \geq \underline{x}'_a\}$$

for each  $a \in \{g, b\}$ . Note that  $\bar{x}_a$  is decreasing in  $a$  and increasing in  $\tau$  while  $\underline{x}_a$  is increasing in  $a$  and decreasing in  $\tau$ . Thus, the values of  $k(g)$ ,  $k(b)$  and  $\tau$  crucially matter for intergenerational mobility.

The following assumption allows us to significantly simplify the exposition.

**Assumption 1** *We assume that  $k(b)$  and  $\beta$  are such that*

$$\max_x \left\{ k(b) w(x) - \frac{\beta}{\Delta(x)} \right\} < 0$$

Assumption 1 implies that  $\underline{x}_b = 0$ . We further assume that parameters and initial conditions are such that  $x > \bar{x}_g$  and thus restrict our attention to the functions  $q_{E,b}(x)$  and  $q_{W,g}(x)$  as the driving forces of intergenerational mobility.<sup>9</sup> In the subsequent analysis a primary role is played by the threshold levels  $\bar{x}_b \equiv \bar{x}$ , where  $q_{E,b}(x) = 1$  for each  $x \geq \bar{x}$  (i.e. income of entrepreneurs and incentives to invest in offspring's education are so large that the offspring inherits the parent's entrepreneurial status, even though endowed with bad innate traits), and  $\underline{x}_g \equiv \underline{x}$  where  $q_{W,g}(x) = 0$  for each  $x \geq \underline{x}$  (i.e. income of workers is too low and thus parents cannot afford to invest in the offsprings education, even though incentives to do so are very strong, and thus the offspring inherits the parent's social status).

### 3 Steady states and stability

Let us define the set of values of  $x$ :  $\xi = \{x \in \mathbb{R}^+ : x \geq \max\{\underline{x}, \bar{x}\}\}$ . For each  $x \in \xi$  we have that  $q_{E,b}(x) = 1$  and  $q_{W,g}(x) = 0$  and hence offsprings inherit their parents' social status with certainty. It follows that each  $x \in \xi$  is a steady state equilibrium. In order to find other possible equilibria in addition to the set  $\xi$  we have to solve the two dimensional dynamical system describing the time evolution of the number of entrepreneurs with bad traits  $n_{E,b}$  and the number of workers with good traits  $n_{W,g}$ . In the Appendix we show that in a long run equilibrium of the two-dimensional dynamical system (8) for which  $q_{W,g}(x) \neq 0$ , the number of workers per entrepreneurs  $x$  satisfies the fixed point problem

$$x = F(x) \tag{3}$$

where

$$F(x) = \frac{1 - q_{E,b}(x)}{q_{W,g}(x)} \frac{1 + (1 - 2p)[1 - q_{W,g}(x)]}{1 + (1 - 2p)q_{E,b}(x)} \tag{4}$$

where  $F(x)$  is decreasing in  $p$  and, since  $q_{s,a}(x)$  is decreasing in  $\tau$  and  $\beta$ , increasing in  $\tau$  and  $\beta$ .

Conversely, for every fixed point (3) there exists a unique equilibrium of the two-dimensional system (8). Moreover, it is easy to verify that for all reasonable values of the parameters all these equilibria are largely above the threshold  $\bar{x}_g$ , which fully justifies the simplification of having set  $q_{E,g}(x) \equiv 1$ .

The following Proposition characterizes the steady states.

**Proposition 1** *There exists a  $\hat{\tau}$  where for  $\tau > \hat{\tau}$  the only equilibria are given by set  $\xi$ , while for  $\tau < \hat{\tau}$  in addition to the set  $\xi$  at least one equilibrium with social mobility exists.  $\hat{\tau}$  is increasing in  $p$  and decreasing in  $\beta$ .*

The critical value  $\hat{\tau}$  separates the situation where only poverty trap equilibria exists from those situations where poverty trap equilibria coexist with social mobility equilibria. If  $\tau$  is sufficiently large, only entrepreneurs invest in their offsprings human capital and thus offsprings inherit their parents' social status; if  $\tau$  is sufficiently low, there exists at least one equilibrium where also workers invest in their offsprings' human capital and thus offsprings stand a chance of climbing the social ladder. The critical value  $\hat{\tau}$  is decreasing in  $\beta$ . The lower  $\beta$ , the more important is social status, the higher the incentive to invest in the offsprings' human capital. More entrepreneurs with low ability offsprings will invest in their education. As a consequence, more offsprings become entrepreneurs which increases labor demand and hence the wage rate, making human capital investments for workers more affordable. This increases  $\hat{\tau}$ .  $\hat{\tau}$  is increasing in  $p$ . The more likely it is that good and bad traits are passed on to offsprings, the more likely it is that offsprings of individuals with good traits become entrepreneurs. This increases the number of entrepreneurs and thus labor demand, thereby increasing workers' income, and increasing thus the threshold above which workers can't afford to invest in their offsprings' human capital.

In the following proposition we further characterize the steady states.

**Proposition 2** *Consider an initial state of the economy where  $\tau > \hat{\tau}$ . In this case the only steady states are given by set  $\xi$ , where  $\min\xi$  is locally stable. Decreasing  $\tau$  decreases  $\min\xi$ . Once  $\tau$  is below the critical value  $\hat{\tau}$ ,  $\min\xi$  becomes locally unstable and an equilibrium with social mobility emerges. This equilibrium is decreasing in  $p$  and increasing in  $\tau$  and  $\beta$ .*

An economy with a large  $\tau$  can be viewed of as an economy where the public education system is absent or very poor and human capital investments become effective only by resorting to costly private education. A reduction in  $\tau$  occurs therefore if, for example through public investments, the education system becomes more efficient and its quality increases. A reduction in  $\tau$  reduces  $\min\xi$ : as the education system becomes more efficient more offsprings of entrepreneurs are able to become entrepreneurs, thereby increasing labor demand. Once  $\tau$  is below the critical value  $\hat{\tau}$ , labor demand and hence the wage rate is sufficiently high such that also workers are able to invest in their offsprings human capital. Note that the lower is  $\beta$  or the larger is  $p$ , the larger the threshold  $\hat{\tau}$  above which only poverty trap equilibria exist. Put differently, the stronger the competition for status or the larger the trait inheritance probability, the lower the quality and quantity of education necessary for offsprings to stand a chance to climb the social ladder. Further reductions in  $\tau$ , lead to a further reduction in the steady state workers per entrepreneur. In a similar vein, an increase in  $p$  or a decrease in  $\beta$  reduces the equilibrium number of workers per entrepreneurs.

In the following we provide some numerical simulations that exemplify these results. In the simulations we have set  $\alpha = 0.5$ ,  $\kappa(g) = 2.36$  and  $\kappa(b) = 0.168$ . As for  $p$  we have considered values ranging from  $p = 0.5$  to  $p = 0.9$ ;

for  $p = 0.5$  there is no correlation between fathers' and sons' traits, while for  $p = 0.9$  the correlation coefficient is 0.8.<sup>10</sup> Since the simulations aim at an immediate and visual illustration of the analytical results, we have chosen parameters for which numerical results are more readable, while a calibration of the model is beyond the scope of this paper.<sup>11</sup>

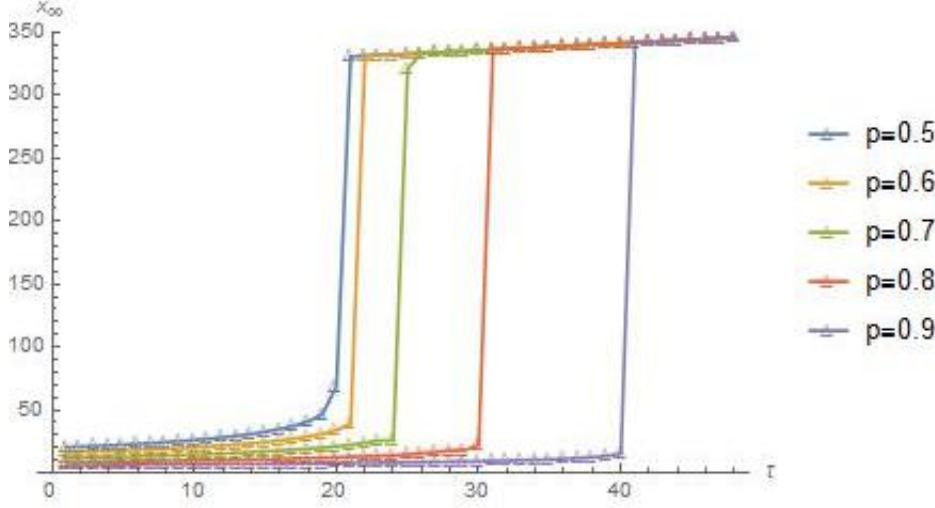


Figure 1: Steady state values of  $x$  as a function of  $\tau$  for values of  $p \in \{0.5, 0.6, 0.7, 0.8, 0.9\}$ ;  $\beta = 0.45$  and  $\alpha = 0.5$ .

From the numerical simulations in Figure 1 and 2 we observe that for values of  $\tau > \hat{\tau}$ , the systems converges to  $\min \xi$ . Workers' income is too low to invest in their offsprings' human capital, while entrepreneurs continue to invest. Offsprings inherit the social status of their parents with certainty.

For  $\tau < \hat{\tau}$  the economy converges to the fixed point  $x^*$  solving (3). The number of workers per entrepreneur is relatively small and as a consequence the wage rate is sufficiently large to allow workers to invest in human capital of offsprings with good traits. Also entrepreneurs whose offsprings have bad traits invest in their human capital but the probability that these become entrepreneurs is lower than one. Hence, offsprings do not inherit the social status of their parents with certainty. Reducing  $\tau$  increases the probability of becoming entrepreneurs and thus reduces  $x^*$ ; this increases workers' income, decreases entrepreneurs' income and reduces the income differential, and hence the value of social status.

From Figure 1 we observe that the larger is the trait inheritance probability  $p$ , the lower the steady state number of workers per entrepreneur ( $x$ ) and the larger the critical value of  $\tau$  above which the fixed point  $x^*$  solving (3) disappears. The intuition is the following. Since, in the steady state, half of the population has good and half has bad traits, the more likely it is that traits are passed on to offsprings, the more likely it is that offsprings of individuals with good traits become entrepreneurs. Consequently, the number of workers per entrepreneur is the lower the larger is  $p$ , increasing thereby workers' income and reducing the value of social status. Hence, the threshold for  $\tau$  above which workers can't afford to invest in their offsprings' human capital has to increase.

From Figure 2 we observe that the more parents care about their offsprings' social status, i.e. the lower is  $\beta$ , the

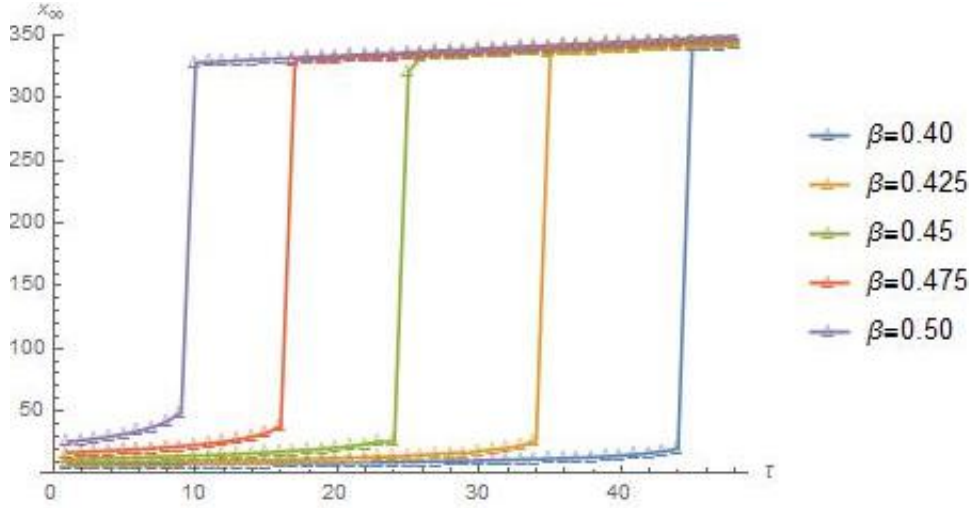


Figure 2: Steady state values of  $x$  as a function of  $\tau$  for values of  $\beta \in \{0.4, 0.425, 0.45, 0.475, 0.5\}$ ;  $p = 0.7$  and  $\alpha = 0.5$ .

more parents invest in their offsprings' human capital and thus lower is the number of workers per entrepreneur. As a consequence, the wage rate is higher and thus the larger the threshold for  $\tau$  above which workers can't afford to invest in their offsprings' human capital.

## 4 Intergenerational mobility

In this section we focus on intergenerational mobility, which is the change in social status between different generations within the same family. Two types of mobility measures are used in the literature. Becker and Tomes (1979, 1986), Solon (1992, 2004) and Zimmerman (1992) use intergenerational income elasticities. In these models the return on human capital is independent of mobility, and thus changes in income across generations capture changes in occupational status. In Maoz and Moav (1999) mobility feeds back into wages and thus wage changes between generations can either be due to mobility of individuals belonging to other families as well as due to mobility of offsprings. In order to disentangle these two effects, Maoz and Moav (1999) characterize intergenerational mobility by the number of individuals who experienced upward and downward mobility. Also in the present paper mobility feeds back into wages and profits, and thus we follow Maoz and Moav (1999) in characterizing mobility.

Let us define  $\Pr(s^i = E | s_{-1}^i = E) \equiv p_{EE}$ , being the probability that an entrepreneur's offspring becomes an entrepreneur. This probability can be rewritten as

$$p_{EE} = \Pr(s_{t+1}^i = E | a_{t+1}^i = g, s_t^i = E) \Pr(a_{t+1}^i = g | s_t^i = E) \\ + \Pr(s_{t+1}^i = E | a_{t+1}^i = b, s_t^i = E) \Pr(a_{t+1}^i = b | s_t^i = E)$$

where  $\Pr(a_{t+1}^i = g | s_t^i = E) = \frac{\Pr(a_{t+1}^i = g, s_t^i = E)}{\Pr(s_t^i = E)} = \frac{n_{E,g}}{\mu}$  and  $\Pr(a_{t+1}^i = b | s_t^i = E) = \frac{\Pr(a_{t+1}^i = b, s_t^i = E)}{\Pr(s_t^i = E)} = \frac{n_{E,b}}{\mu}$ . In the

steady state, the measure of class-persistence is

$$p_{EE} = \frac{n_{E,g}}{\mu} q_{Eg} + \frac{n_{E,b}}{\mu} q_{Eb}$$

and

$$p_{WW} = \frac{n_{W,g}}{1-\mu} (1 - q_{Wg}) + \frac{n_{W,b}}{1-\mu} (1 - q_{Wb})$$

We define the upward (downward) mobility index  $I_{up}$  ( $I_{down}$ ) as the share of individuals, that, being born to workers (entrepreneurs), is expected to become entrepreneurs (workers). Using the notation introduced above we may write

$$\begin{aligned} I_{up} &= (1 - \mu) (1 - p_{WW}) \\ I_{down} &= \mu (1 - p_{EE}) \end{aligned} \tag{5}$$

Combining those two indexes we obtain a compound index of mobility  $I_{igm} = I_{up} + I_{down}$

$$I_{igm} \equiv 1 - (1 - \mu) (1 - p_{WW}) - \mu (1 - p_{EE}) \tag{6}$$

which can be rewritten as

$$I_{igm} = n_{E,b} (1 - q_{E,b}) + n_{W,g} q_{W,g}$$

Using (9) and (10) we obtain

$$I_{igm} = \frac{1}{2} (1 - p) \frac{(1 - q_{E.,b}) q_{W,g} (1 + q_{E,b} - q_{W,g})}{\det(I - A)}$$

where  $A$  is the transition matrix defined in the Appendix.

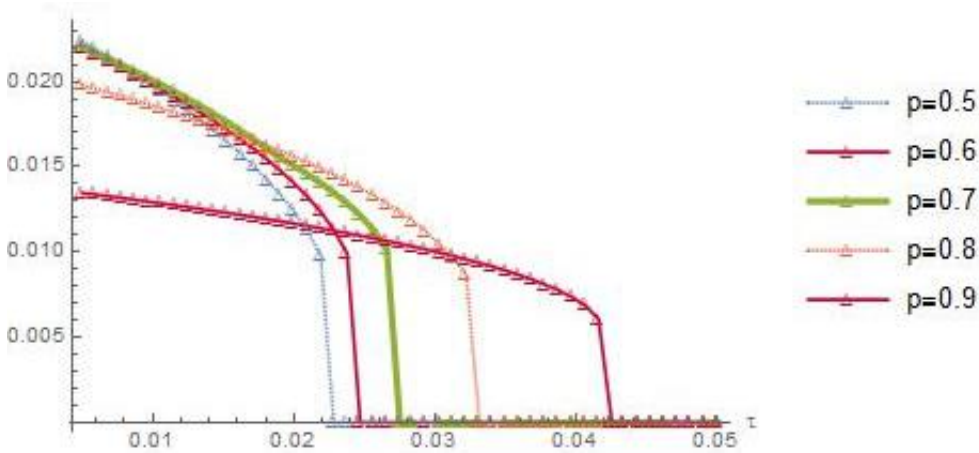


Figure 3: Intergenerational mobility index as a function of  $\tau$  for values of  $p \in \{0.5, 0.6, 0.7, 0.8, 0.9\}$ ;  $\beta = 0.45$  and  $\alpha = 0.5$ .

From Figure 3 and 4 we observe that an increase in  $\tau$  reduces intergenerational mobility. The larger  $\tau$ , the lower



the probability that individuals become entrepreneurs because of investments in human capital and thus the lower intergenerational mobility.

$p$  has two countervailing effects on intergenerational mobility. On the one side a larger  $p$ , by reducing  $x^*$  increases the income of workers, and thus increases the threshold for  $\tau$  below which an equilibrium with intergenerational mobility exists. On the other side, a larger  $p$ , by increasing the likelihood of inheriting the parents' traits, increases the likelihood of inheriting also their social status. Which of these two effects prevails depends on the value of  $\tau$ . For low values of  $\tau$  the latter effect dominates and intergenerational mobility is decreasing in  $p$ . In this case the probability of becoming entrepreneurs is large and hence  $x^*$  is low. As a consequence, income of workers (entrepreneurs) is large (low) and thus workers whose offsprings have good traits will invest more in human capital while entrepreneurs whose offsprings have bad traits will invest less. Thus, the larger  $p$ , the more likely it is that entrepreneurs (workers) have good (bad) traits and thus the more likely it is that offsprings of entrepreneurs (workers) become entrepreneurs (workers). In other words, intergenerational mobility will be lower the larger is  $p$ . For large values of  $\tau$  the former effect prevails and intergenerational mobility is increasing in  $p$ . In this case, a larger  $p$ , by reducing  $x^*$  and increasing the workers' income, increases the threshold for  $\tau$  below which an equilibrium with intergenerational mobility exists. As a consequence, intergenerational mobility will be larger the larger is  $p$ . For intermediate values of  $\tau$  intergenerational mobility is inverted-U related with  $p$ . These results can be discerned from Figure 3.<sup>12</sup>

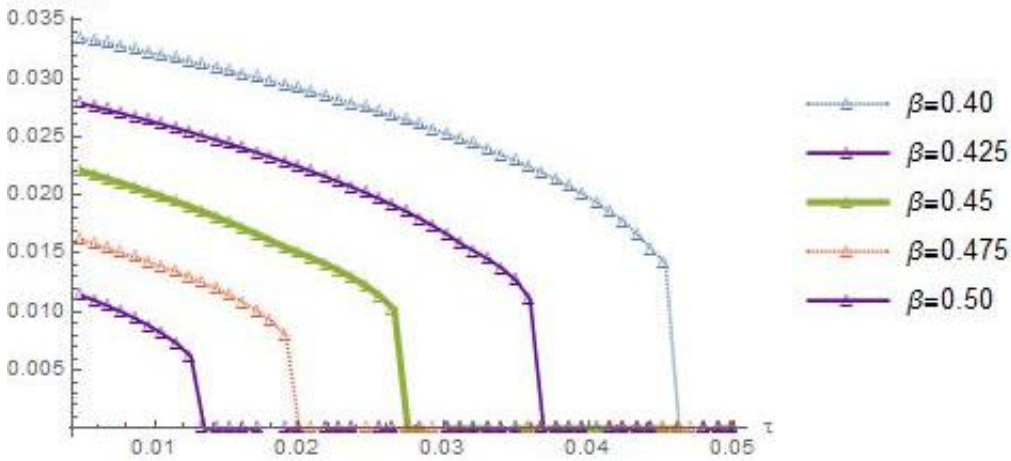


Figure 4: Intergenerational mobility index as a function of  $\tau$  for values of  $\beta \in \{0.4, 0.425, 0.45, 0.475, 0.5\}$ ;  $p = 0.7$  and  $\alpha = 0.5$ .

From Figure 4 we observe that the more parents care about their offsprings' social status, i.e. the lower is  $\beta$ , the greater is intergenerational mobility. The reason for this result is that the lower is  $\beta$ , the more parents invest in their offsprings' human capital. This reduces the number of workers per entrepreneur, thereby increasing (reducing) workers' (entrepreneurs') income. As a consequence, offsprings of workers (entrepreneurs) with good (bad) traits have a greater (lower) probability of becoming entrepreneurs and thus intergenerational mobility is greater.

## 5 Conclusion

We studied how the transmission of traits and human capital investments affect intergenerational mobility in a model where parents care about the social status of their offsprings. Traits are inheritable endowments such as IQ, ability, work ethic and so on, compounding also the social and cultural environment, and are insensitive to market prices. Human capital investments are price sensitive since they depend on the relative cost of human capital investments as well as on the gain in social prestige from being on top of others. We assumed that human capital investments increase the chances of climbing the social ladder if they are sufficiently large, while if low, they are ineffective.

We found threshold levels for human capital investments above which only poverty trap equilibria with no intergenerational mobility exist. Below this threshold an equilibrium with intergenerational mobility coexists with poverty trap equilibria. We have shown that if human capital investment are effective only at very large levels, then offsprings inherit their parents' social status. For instance, this is the case where the public education system is absent or very poor, and human capital investments are effective only by resorting to costly private education. In this case, public investments in the education system reduce this threshold and, as a consequence, more offsprings of entrepreneurs become entrepreneurs. This increases labor demand and hence income of workers. Once the education system becomes sufficiently efficient (i.e. its quality is sufficiently high), labor demand and the wage rate become sufficiently high such that workers will be able to invest in their offsprings' human capital. In other words, a new, asymptotically stable, equilibrium with social mobility emerges. We have also shown that the stronger the competition for status or the larger the trait inheritance probability, the lower the quality and quantity of education necessary for offsprings to stand a chance to climb the social ladder.

We argued that the probability of passing on good and bad traits has an ambiguous effect on intergenerational mobility, depending on the effectiveness of human capital investments. Increasing the trait inheritance probability on the one side increases the threshold below which intergenerational mobility equilibrium exists, and thus positively affects intergenerational mobility; on the other side it increases the likelihood of inheriting the parents' social status, which negatively affects intergenerational mobility. If human capital investments are effective already at very low levels, then the latter effect prevails and increasing the trait inheritance probability leads to lower intergenerational mobility; if human capital investments are effective only for very large levels, then the former effect prevails and increasing the trait inheritance probability increases intergenerational mobility. For intermediate levels there exists an inverted-U shaped relationship between trait inheritance probability and intergenerational mobility. Moreover we found that the more parents care about their offsprings' social status, the greater is intergenerational mobility. Parents invest more in their offsprings' human capital, thereby increasing their chances of climbing the social ladder, thus increasing intergenerational mobility.

A limitation of our model is that we assume only one threshold for the effectiveness of education investments. The model would be more realistic and yield much richer dynamics if there was more than one threshold. Multiple

thresholds could represent different years of completed schooling, with increasing effectiveness as the individual accumulates human capital. A further shortcoming of the paper is that innate trait and human capital heterogeneity only affects the probability of becoming entrepreneurs, but not their productivity. Heterogeneous productivity would lead to an additional positive feedback channel and most likely acerbate inequality of opportunities. All these questions are left for future research.

## 6 Appendix

**The steady state.** In this Appendix we omit the dependence of  $q_{s,a}(x)$  on  $x$ . Let  $n_{s,a,t}$  be the number of individuals with social status  $s \in \{E, W\}$  and offsprings' traits  $a \in \{g, b\}$  at time  $t$ . Let us define  $\vec{n}_t = \begin{bmatrix} n_{E,g,t} & n_{E,b,t} & n_{W,g,t} & n_{W,b,t} \end{bmatrix}^T$  and the transition matrix

$$\tilde{A} = \begin{bmatrix} p & 1-p & pq_{W,g} & (1-p)q_{W,g} \\ (1-p)q_{E,b} & pq_{E,b} & 0 & 0 \\ 0 & 0 & p(1-q_{W,g}) & (1-p)(1-q_{W,g}) \\ (1-p)(1-q_{E,b}) & p(1-q_{E,b}) & 1-p & p \end{bmatrix}$$

The dynamical system is

$$\vec{n}_{t+1} = \tilde{A}\vec{n}_t \quad (7)$$

It follows that  $n_{E,g,t} + n_{W,g,t} = n_g = \frac{1}{2}$ ,  $n_{E,b,t} + n_{W,b,t} = n_b = \frac{1}{2}$  and  $n_{E,g,t} + n_{E,b,t} = \mu_t$ ,  $n_{W,g,t} + n_{W,b,t} = 1 - \mu_t$ . Using the assumption that  $q_{E,g} = 1$  and  $q_{W,b} = 0$ , the population dynamics is as follows

$$\vec{n}_{t+1} = A\vec{n}_t + B \quad (8)$$

where  $\vec{n}_t = \begin{bmatrix} n_{E,b,t} & n_{W,g,t} \end{bmatrix}^T$  and

$$A = \begin{bmatrix} pq_{E,b} & -(1-p)q_{E,b} \\ -(1-p)(1-q_{W,g}) & p(1-q_{W,g}) \end{bmatrix}$$

and

$$B = \begin{bmatrix} (1-p)q_{E,b}n_g \\ (1-p)(1-q_{W,g})n_b \end{bmatrix}$$

The long run stationary state can be described by the following system

$$n_{E,b,\infty} = \frac{1}{2}(1-p) \frac{q_{E,b}q_{W,g}}{\det(I-A)} \quad (9)$$

$$n_{W,g,\infty} = \frac{1}{2}(1-p) \frac{(1-q_{E,b})(1-q_{W,g})}{\det(I-A)} \quad (10)$$

Note that  $\mu_t = n_g - n_{W,g,t} + n_{E,b,t}$  and  $1 - \mu_t = n_b - n_{E,b,t} + n_{W,g,t}$ . Thus, using (9), (10) and the definition of  $x$  we have that in equilibrium

$$x = F(x)$$

where  $F(x)$  is given by (4). ■

**Proof of Proposition 1.** In the following we are going to study the fixed points of (3) for different values of  $\tau$ . Let us first define  $\underline{x}$  as

$$\underline{x} = \max \{ \underline{x}' : q_{W,g}(x) = 0 \text{ for each } x \leq \underline{x}' \}$$

where there are very few workers per entrepreneur (very low values of  $x$ ) and, because the income differential ( $\Delta$ ) is very small, parents do not invest in education.

Note that  $\underline{x}$  is decreasing in  $\tau$  while  $\bar{x}$  is increasing in  $\tau$ . Moreover, since for sufficiently large values of  $\tau$ ,  $\underline{x} = 0$  while  $\bar{x} > 0$  and for  $\tau \rightarrow 0$ ,  $\underline{x} \rightarrow \infty$ , while  $\bar{x} < \infty$ , there exists a unique  $\tau'$  such that  $\underline{x} = \bar{x}$ . This proves that there exists a unique  $\tau'$  such that  $\underline{x} = \bar{x}$  and where, for each,  $\tau > \tau'$ ,  $\bar{x} > \underline{x}$ , while, for each  $\tau < \tau'$ ,  $\bar{x} < \underline{x}$ .

For  $\tau < \tau'$ ,  $\bar{x} < \underline{x}$  and thus  $F(x)$  has only one singularity at  $\underline{x}$  while for large values of  $x$ ,  $F(x) = 0$ . As a consequence, there exists one fixed point solving  $F(x) = x$ .

For  $\tau > \tau'$ ,  $\bar{x} > \underline{x}$  and thus  $F(x)$  has two vertical asymptotes at  $\underline{x}$  and  $\bar{x}$ . In this case, since  $F(x)$  is increasing in  $\tau$ , for low values of  $\tau$  there are two equilibria  $x_1^*$ ,  $x_2^*$  with  $x_1^* < x_2^*$ . Increasing the value of  $\tau$  increases, because of the implicit function theorem,  $x_1^*$  and decreases  $x_2^*$ . For large values of  $\tau$  both fixed points disappear. This proves the existence of  $\hat{\tau}$  and the properties of the fixed points. The comparative statics of  $\hat{\tau}$  follow from the implicit function theorem and the results that  $F(x)$  is decreasing in  $p$ , increasing in  $\tau$  and  $\beta$ .

Concerning the issue of stability we first consider the set of equilibria  $\xi$  and in particular the stability of  $\min \xi$ . Two situations may arise, according to the value of  $\tau$ . For  $\tau > \tau'$ ,  $\bar{x} > \underline{x}$ . For each  $x \in [\underline{x}, \bar{x}]$  we have  $q_{W,g} = 0$  while  $q_{E,b} < 1$  and consequently offsprings of workers remain workers, while offsprings with bad traits of some entrepreneurs become workers. Hence, the number of workers per entrepreneur ( $x$ ) increases. Thus, the set of steady states  $\xi$  is locally asymptotically stable and its basin of attraction includes the interval  $[\underline{x}, \bar{x}]$ . For  $\tau < \tau'$ ,  $\bar{x} < \underline{x}$ . For each  $x \in [\bar{x}, \underline{x}]$  we have  $q_{W,g} > 0$  while  $q_{E,b} = 1$  and consequently offsprings of entrepreneurs remain entrepreneurs while offsprings with good traits of some workers become entrepreneurs. Hence, the number of workers per entrepreneur ( $x$ ) declines. Thus, set of steady states  $\xi$  has no basin of attraction. ■

**Proof of Proposition 2.** The Proposition is a direct consequence of Proposition 1 and the results obtained in its proof. ■

# Notes

<sup>1</sup>The authors would like to thank three anonymous referees and all the participants of NED 2017 for their comments and remarks.

<sup>2</sup>For a comprehensive survey on human capital formation see Heckman and Mosso (2014).

<sup>3</sup>Roemer (2004) evidences three types of inheritable endowments that are important drivers of intergenerational mobility: social connections, genetically transmitted characteristics and family values. Durlauf, Kourtellos and Tan (2017) find that parental cognitive and noncognitive skills play an important role in shaping the prospects of children. See also Bowles and Gintis (2002) for a discussion of the importance of price insensitive factors for intergenerational mobility.

<sup>4</sup>See also Aghion and Bolton (1997), Piketty (1997) and Matsuyama (2000). In Mookherjee and Ray (2003) occupational diversity as opposed to indivisibilities leads to long run inequality. The authors consider a model where different occupations, each requiring different training costs, have to be filled. At the equilibrium, different occupations have to pay different wages, leading to endogenous inequality.

<sup>5</sup>Assuming that the probability of inheriting good and bad traits is the same is a simplifying assumption. The main qualitative results hold also in the more general framework where the two probabilities differ.

<sup>6</sup>In a more general setting it is possible to assume that  $p_j$  be the probability to remain in the state  $j$ ; then the transition matrix is  $A = \begin{bmatrix} p_1 & 1 - p_2 \\ 1 - p_1 & p_2 \end{bmatrix}$  and the steady state is the solution  $v$  of the equation  $Av = v$ . Whence  $v_2 = \frac{1-p_1}{1-p_2}v_1$ . All the qualitative results hold also under this assumption, but calculations as well as exposition become far more cumbersome. Clearly  $p_2 = p_1$  yields  $v_2 = v_1$ .

<sup>7</sup>See Heckman and Mosso (2014), p.697, for a discussion.

<sup>8</sup>For simplicity's sake, consumption comprises both parents' and offspring's consumption.

<sup>9</sup>This assumption is supported by empirical evidence discussed in Heckman and Mosso (2014), p. 715.

<sup>10</sup>The empirical data found by Restuccia and Urrutia (2004) suggest that in the US the correlation coefficient is between 0.2 and 0.4 which in our model approximately means  $0.6 < p < 0.7$ .

<sup>11</sup>For instance, for values of  $\alpha$  larger than 0.5 we obtain very similar results but with  $\beta$  and  $\tau$  larger than in the case  $\alpha = 0.5$ .

<sup>12</sup>Simply looking at Fig. 3 one can observe that, for example, for  $\tau = 0.015$ , intergenerational mobility increases when  $p$  passes from 0.5 to 0.6 and from 0.6 to 0.7 but decreases from 0.7 to 0.8 and from 0.8 to 0.9. A similar result holds also for larger values of  $\tau$ , at least up to  $\tau = 0.025$ .

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