Optimal Intergenerational Mobility of Income and the Allocation of Talent *

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Abstract

While much progress has been made on *measuring* intergenerational income mobility, less progress has been made on *understanding* what optimal mobility might be. Most existing empirical work implicitly assumes that a weaker correlation of income across generations is more desirable than a stronger correlation, since the former seems to imply a fairer allocation than the latter. We show that this is not necessarily the case because intergenerational mobility depends not just on nature and nurture, but also on redistributive institutions that emerge endogenously from collective decisions of a society. Since these institutions are, by their own nature, distortive of individuals' incentives, there are costs to intergenerational mobility, and there is no reason to expect that the socially optimal intergenerational correlation of incomes should be zero. Our analysis suggests that the widely studied coefficient of intergenerational income correlation has a useful economic interpretation only under very restrictive assumptions. Therefore, empirical studies that compare estimates of this coefficient across countries or within country over time, offer us little guidance in evaluating the welfare of the corresponding societies.

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1 Introduction

Starting with pioneering work by Solon (1992) and Zimmerman (1992), the economic literature has made enormous advances on the question of how to *measure* the intergenerational correlation of income. In a recent article, Solon (1999) provides a comprehensive and influential survey of this literature. While much progress has been made on the *positive* aspects of intergenerational mobility, less progress has been made on (1) its economic interpretation; and (2) on its *normative* aspects.

First, we still have only a partial idea of what the intergenerational correlation of income really means economically and what it tell us about equity and efficiency. Important but still preliminary inroads in this direction have been made by Becker and Tomes (1979), who have showed how the intergenerational correlation of income reflects both “nature and nurture”. In their model, individuals are given a certain talent by nature, and parents can add to that talent by investing in their children. The intergenerational transmission of income is therefore a combination of exogenous biological factors and endogenous optimizing behavior of parents.

However, these models have generally ignored the role of redistributive institutions. For example, the quality and fairness of the public education system can significantly affect economic opportunities of individuals who come from disadvantaged socioeconomic backgrounds. More in general, most redistributive policies—including affirmative action, welfare programs, subsidies that target children or poor parents—potentially affect the intergenerational correlation of income.[1] These institutions may generate efficiency costs for the society.

Second, we know even less about what the socially optimal intergenerational income correlation should be, what trade-offs it involves and how this socially optimal correlation may depend on alternative intertemporal welfare criteria. Intergenerational mobility of income is generally considered one of the best summary measures of the degree to which a society gives equal opportunity of success to all its members, irrespective of their family background. As a consequence, it is typically taken for granted that more mobility—i.e. lower intergenerational correlation of incomes—is unambiguously better.

Solon (1999) makes this point quite effectively by comparing two societies with the same

[1] See, for example, Glomm and Ravikumar (1992) and Checchi, Ichino and Rustichini (1999).

amount of cross-sectional inequality but with different correlation of income across generations. In the first society there is complete income persistence across generations, while in the second society there is no persistence. One is strongly tempted to consider the latter society more desirable than the former. More specifically, this comparison seems meant to suggest that, "under the veil of ignorance" everybody should ex ante prefer to live in the mobile society because it minimizes the risk of an unlucky genetic or economic draw. This point is made even more explicitly by Mulligan (1997), who writes (page 25): "The perfect mobility case is often referred to as perfect 'equality of opportunity' because the income of a child is unrelated to the income of his or her parents. The degree of intergenerational mobility is therefore an index of the degree of 'equality of opportunity'. Equality of opportunity is often seen as desirable."

In this paper we show that this is not necessarily the case. We argue that in the real world, intergenerational mobility depends not just on nature and nurture, but also on redistributive institutions that emerge endogenously from collective decisions of a society. Since these institutions are, by their own nature, distortive of individuals' incentives, there are costs to intergenerational mobility. Therefore, more mobility is not always desirable. There is such a thing as "too much mobility".

To formalize this intuition, we propose a parsimonious model that focuses on the interaction between the private and the collective decisions of dynasties on how to transfer endowments between generations. In the model, heterogeneous dynasties privately decide how much to invest in the talent of children given the exogenous transmission of genetic ability, as in Becker and Tomes (1979). But unlike the previous literature, dynasties can also collectively choose redistributive institutions to insure against the risk of low genetic ability.

Our main theoretical result is that there is no reason to expect that the socially optimal intergenerational correlation of incomes should in general be zero. This turns out to be true even in a "Rawlsian society" were dynasties seek to maximize the welfare of their most unlucky members. As in Becker and Tomes (1979), parents react to the level of genetic ability exogenously assigned to their children by giving up some of their consumption to endow their children with the privately optimal amount of talent. But while this investment offsets some of the genetic risk, it can not offset all of the risk. Therefore, "under the veil of ignorance" parents may collectively decide to put in place institutions that provide insurance against the risk of low genetic ability. We model these institutions as a redistributive scheme that takes away income from the better endowed children and gives it to the least endowed children. Since redistribution distorts parental investment in children talent, the well known trade-off between insurance and incentives emerges. As a consequence, society will in general not choose the maximum amount of mobility, i.e. a zero intergenerational correlation of incomes.

A contribution of the model is that it clarifies how to interpret economically the widely studied coefficient of intergenerational correlation of income. The typical regression estimated in the literature is

$$y_s = \alpha + \beta y_f + u_s \tag{1}$$

where y_s denotes son's income and y_f father's income. In the existing literature, empirical estimates of β are often compared across countries or across time periods within a country. For example, see Bjorklund and Jantti (1997) and Solon (1999, 2002) for comparisons across countries; and Mazumder (2005, 2007), Lee and Solon (2006), and Aaronson and Mazumder (2008) for comparisons over time for the US.

However, we argue that this reduced form relationship is difficult to interpret and not easily compared across countries or time periods, even when measurement issues have been resolved. As in the previous literature, our model clarifies that the parameter β is a function of the structural parameters that characterize the transmission of genetic ability and talent.[2] But, unlike previous studies, it also highlights the role of institutions. We show that given two countries A and B, $\beta_A < \beta_B$ does not imply that country A has higher social welfare. Moreover, even if society would like to minimize the variability of dynastic utility, observation of $\beta_A < \beta_B$ also does not identify the society that is closer to this social optimum.

We conclude the paper with an empirical application. Our model suggests that the structural parameters that form β are generally not identified in the datasets that are typically used in the empirical literature. We use a unique dataset for Norway in which we observe both income and measures of intellectual and physical talent for two consecutive generations.[3] We argue that institutions in Norway for two successive periods can be identified as departures from the steady state using the within generation variation of our data. If

[2] See, for instance, Goldberger (1989) and Solon (2004).

[3] We are searching for equivalent data in the NLSY in order to perform this comparison between US and Norway.

dynasties are ex ante heterogeneous or culture and genes are persistent, such an identification is not possible using the intergenerational variation in the data. Using our proposed identification scheme, we find that Norway evolved to more progressive steady state between the late 1920s and the late 1950s of the past century. It is, however, possible that this shift of preferences for more redistribution in Norway occured at some efficiency costs.

The paper is organized as follows. Section 2 presents our model. In Section 3 we show the pitfalls associated with the interpretation of the results from the standard intergenerational regression and in Section 4 we present our results for Norway. Section 5 concludes.

2 Private Vices and Public Virtues in the Intergenerational Transmission of Income and Talent

The main objective of our model is to derive the structural parameters underlying the coefficient of intergenerational transmission of income. This coefficient—β in equation (1)—has been the main focus of the existing empirical literature. Therefore, our framework intentionally remains close in spirit to the original Becker and Tomes (1979) model, as further explored by Goldberger (1989), Mulligan (1997) and Solon (2004), which allows us to highlight our point of departure from this literature.

We show that social mobility depends both on genetic transmission of talent, on parental investment in children talent and on redistributive policies. We model redistributive policies as optimal or politico-economic equilibrium outcomes. Our model relates to the equilibrium models of Alesina and Rodrik (1994), and Persson and Tabellini (1994). These papers show how cross sectional inequality causes growth, through endogenous public policies. Benabou (1996) further develops this strand of literature and endogenizes the relationship between inequality, social mobility, redistribution and growth as a function of the incompleteness of the financial market. While our model abstracts from non human capital accumulation, it emphasizes the endogenous production of talent with the purpose to link the theoretical results to our empirical application.

Piketty's (1995) model explains the emergence of persistent differences in the equilibrium attitudes for the costs of redistribution. Benabou and Ok (2001) show how rational beliefs about one's relative position in the income ladder affect the equilibrium level of redistribution. These papers derive the implications of social mobility for redistributive policies, while we focus on the reverse channel and analyze how endogenously chosen public policies affect intergenerational mobility. By endogenizing public policy, the well-known trade-off between incentives and insurance emerges naturally into the intergenerational mobility model. Piketty (2000) highlights this point. Farhi and Werning (2008) also examine the insurance-incentives trade-off, and prove the progressivity (and negativity) of the general non linear estate tax.

The contribution of our model is to illustrate how taking into account distortions in parental investment induced by mobility-enhancing public policies, clarifies the interpretation of the intergenerational correlation coefficient. In particular, and contrary to existing research, we argue that the reduced form regression of son income on father income that has received so much attention in the literature is not informative on the truly interesting question, i.e. how to compare welfare levels between different countries or different cohorts.

2.1 Setup of the Model

We consider an infinite horizon overlapping generations economy populated by a measure one of dynasties, $i \in [0,1]$. In each period $t = 0, 1, 2, ...$ two generations are alive, the fathers and the sons. In each generation, the production function is $Y_{i,t} = f(\mu_t, \Theta_{i,t}, U_{i,t})$. μ_t is the redistributive system, $\Theta_{i,t}$ is father's talent, and $U_{i,t}$ denotes a random and inelastic production factor which represents market luck.

Specifically, we assume that the production function is given by

$$Y_{i,t} = \mu_t^{\alpha} \left(U_{i,t}\Theta_{i,t}\right)^{\mu_t} \tag{2}$$

where $\mu_t \in (0,1]$ and $\alpha \geq 0$. In Figure 1 we depict the production function.

Redistribution and its effects are characterized by two parameters, μ_t and α. The parameter μ_t allows for a trade-off between equity and efficiency when thinking about intergenerational mobility of earnings and talent. A lower μ_t parameterizes a more progressive social policy. For example, μ_t can be thought as public education, a process that increases output for low talented subjects but may distort output for the most talented ones, as in the left panel of Figure 1. Alternatively, μ_t may represent a non-linear tax instrument, in which case $Y_{i,t}$ would be net earnings from labor supply. However, as we show later, μ_t has various implications for the intergenerational transmission of income and talent, and therefore it captures more general features in the public provision of insurance and redistribution than a simple income tax scheme. We prefer therefore to call μ_t the redistributive system or social insurance, with the understanding that these terms are broadly defined. In Section 2.4 we describe how fathers choose the redistributive scheme. For now we just note that this choice is made under the veil of ignorance, i.e. before random ability $V_{i,t+1}$ and the inelastic factor $U_{i,t+1}$ realize.

The term α in the output production function parameterizes the distortions associated with the redistributive system. As α increases for given μ_t, an increasingly smaller fraction of talents $\Theta_{i,t}$ gain from the redistributive system μ_t because the system creates disincentives for high talented agents. That is, in the right panel of our Figure 1, the area to the left of the intersection of the production function with the 45 degree line (which measures the gains from redistribution) becomes smaller relative to the area to the right of the intersection of the production function with the diagonal (which measures the costs of redistribution).[4]

In each period t the following events take place:

1. Fathers produce output $Y_{i,t}$.

2. Fathers choose the redistributive policy for their sons, μ_{t+1}, according to the institution or political process P.

3. Sons are born with random endowment or ability $V_{i,t+1}$. The random factor of production $U_{i,t+1}$ is realized.

4. Fathers observe $V_{i,t+1}$ and $U_{i,t+1}$ and choose investment $I_{i,t}$ to maximize the dynastic utility. Investment produces son's talent according to the production function $\Theta_{i,t+1} = g(I_t, V_{i,t+1})$.

5. Fathers die, sons become fathers and the process repeats ad infinitum.

Son i is born with random endowment or ability $V_{i,t+1}$. Following Becker and Tomes (1979) and many others, we assume that the logarithm of ability is a "Galtonian" AR(1) process

$$v_{i,t+1} = (1 - \rho_1)\rho_0 + \rho_1 v_{i,t} + \epsilon_{i,t+1} \tag{3}$$

[4] We do not restrict $\Theta_{i,t}$ to be smaller than unity. If, nevertheless, talent turns out to lie in the unit interval for all families in some period, then a public policy with $\alpha = 0$ can be thought as a reform that relaxes a credit constraint and promotes efficiently educational goals. The positive spillover effects of the policy would benefit every family, but the lowest talented families who face the binding constraint gain relatively more.

where $v = \ln V$ (small caps denote logs of corresponding variables throughout the paper). For every dynasty i, $\epsilon_{i,t+1}$ is a white noise process with $\mathbf{E}(\epsilon_{i,t}) = 0$, $\mathbf{Var}(\epsilon_{i,t}) = \sigma_v^2$ and zero autocorrelations. We assume that $0 \leq \rho_1 < 1$ and therefore the logarithm of ability regresses towards the mean, $\mathbf{E}(v_{i,t}) = \rho_0$, and has stationary variance equal to $\mathbf{Var}(v_{i,t}) = \sigma_v^2/(1-\rho_1^2)$. Note that the stationary moments are not indexed by i. ρ_1 parameterizes the cultural or genetic inheritage of traits related to talent and income, and is assumed identical across families i.

A second random component is represented by market luck, $U_{i,t}$. We assume that its logarithm is a white noise process, has variance σ_u^2, and is independent to $\epsilon_{i,t}$. The insurance scheme μ_{t+1} also offsets adverse effects of market luck in the production process. The difference between $U_{i,t}$ and $\Theta_{i,t}$ is that the latter is an elastic factor and therefore remains subject to the distortions of the insurance scheme.

Fathers observe $V_{i,t+1}$ and $U_{i,t+1}$ and choose how to allocate their income $Y_{i,t}$ into consumption $C_{i,t}$ and investment $I_{i,t}$ in order to maximize the dynastic utility. Parental investment $I_{i,t}$ can be thought as an intra-familiar or private educational input that increases children's talent. Sons' talent is produced according to

$$\Theta_{i,t+1} = (h_i V_{i,t+1}) I_{i,t} \tag{4}$$

where h_i is a family-specific time-invariant ability effect. If $h_i = h$, then all families are ex ante identical, and the stochastic process for ability $h_i V_{i,t+1}$ is common to all families. More in general, h is distributed in some bounded interval $\mathbf{H} \subset R_{++}$ according to some density function Φ_h, and dynasties are allowed to be ex ante heterogeneous. A higher h_i implies that family i has a higher long run ability level. We assume that h_i is orthogonal to the disturbances $\epsilon_{i,t+1}$ and $u_{i,t+1}$.

Parents allocate resources $Y_{i,t}$ among their consumption and investment in their son's talent so as to maximize dynastic utility:

$$\ln C_{i,t} + \frac{1}{\gamma} \ln Y_{i,t+1} \tag{5}$$

subject to the budget constraint

$$C_{i,t} + I_{i,t} = Y_{i,t} \tag{6}$$

where $Y_{i,t+1}$ is children's income.[5] $\gamma > 0$ parameterizes the degree of parental selfishness,

[5] We assume that fathers cannot borrow against their son's future income. See Becker and Tomes (1986)

with higher values denoting smaller altruism.

2.2 Income and Talent Transmission Equations

Solving the problem in (5)-(6), using the production functions (2) and (4) and taking logs, we arrive at the following equation for the intergenerational transmission of log income:

$$y_{i,t+1} = \delta_{0,i} + \delta_1 y_{i,t} + \delta_2 v_{i,t+1} + \delta_3 u_{i,t+1} \tag{7}$$

where

$$\delta_{0,i} = \delta_0 + \delta_i \tag{8}$$

$$\delta_0 = \mu_{t+1} \ln\left(\frac{\mu_{t+1}}{\mu_{t+1} + \gamma}\right) + \alpha \ln \mu_{t+1} \tag{9}$$

$$\delta_i = \mu_{t+1} \ln h_i \tag{10}$$

$$\delta_1 = \mu_{t+1} \tag{11}$$

$$\delta_2 = \mu_{t+1} \tag{12}$$

$$\delta_3 = \mu_{t+1} \tag{13}$$

This and all the subsequent derivations are presented in Appendix 1. In the income transmission equation, (7), income appears to be an AR(1) process, but with a first-order serially correlated error $\delta_2 v_{i,t+1}$, income follows an AR(2) process.[6] The intercept $\delta_{0,i}$ can be decomposed into two parts. δ_0 is a common effect across all dynasties i. δ_i denotes the dynasty-specific time-invariant effect, and shows that higher h_i-families have higher lifetime income.

Our δ_1 coefficient is different from the one in Becker and Tomes (1979) because we assume a multiplicative (in levels) production structure for output and talent. In our Cobb-Douglas environment, the result is that parental altruism γ does not affect the intergenerational transmission directly, i.e. for given policy μ_{t+1}.[7] Second, the exponent of investment in the talent production function (4), i.e. the rate of return to parental investment, is normalized to unity. We comment below for our functional form assumptions.

and Mulligan (1997), for elaborate analysis of the relationship between social mobility and borrowing constraints. Benabou (1996, 2000) is the seminal contribution in the literature of redistribution, inequality and growth under incomplete asset markets.

[6]From now on we refer to the logarithms of income and talent as simply income and talent respectively.

[7]Solon (2004) uses a "double semi-log" specification to derive the log-linear intergenerational income regression and parental altruism also does not enter into the corresponding elasticity.

In (7), the slope δ_1 equals the redistributive system that fathers set in place for their sons, μ_{t+1}. In our model, social redistribution distorts the incentive of parents to invest in their children's human capital and weakens the intergenerational correlation of net earnings.[8] This clear association between redistribution and intergenerational transmission of income highlights our difference with the rest of the literature that emerged after Becker and Tomes (1979). In our model, the slope of the regression δ_1 is collectively decided by the fathers of each dynasty. We can show that talent obeys the following stochastic difference equation:

$$\theta_{i,t+1} = \lambda_{0,i} + \lambda_1 \theta_{i,t} + \lambda_2 v_{i,t+1} + \lambda_3 u_{i,t} \tag{14}$$

where

$$\lambda_{0,i} = \lambda_0 + \lambda_i \tag{15}$$

$$\lambda_0 = \ln\left(\frac{\mu_{t+1}}{\mu_{t+1} + \gamma}\right) + \alpha \ln \mu_t \tag{16}$$

$$\lambda_i = \ln h_i \tag{17}$$

$$\lambda_1 = \mu_t \tag{18}$$

$$\lambda_2 = 1 \tag{19}$$

$$\lambda_3 = \mu_t \tag{20}$$

The first notable difference between the talent and the income transmission equations is that the slope coefficient in the former equals μ_t, the redistributive scheme that the grandfathers have chosen for the fathers, while in the latter it is the redistributive system μ_{t+1} that the fathers choose for their sons. This difference stems from the fact that the talent production process takes place before the new insurance scheme μ_{t+1} is placed *in operation*, while the production of income occurs subsequently and is subject to the chosen scheme. The same intuition applies when we compare the intercept coefficients. The term inside the logarithm in the intercepts in (9) and (16) denotes the parental marginal propensity to invest. Since parental investment takes place after fathers have chosen μ_{t+1}, this term is common to the two transmission equations.

[8] Note that δ_1 is not indexed by i because h_i enters multiplicatively and not exponentially in the production function for talent (4). This convenient assumption does not affect our theoretical claims. Farhi and Werning (2008) also show how the progressivity of the estate tax relates with consumption's regression towards the mean, within a fully general non linear taxation framework.

A second important difference lies between the coefficients δ_2 and λ_2. These coefficients measure the output and talent elasticity of cultural or genetic ability respectively. The latter is not affected by the redistributive system, because talent is a "private" production process. On the other hand, talent is an intermediate input in the production of income and therefore, the elasticity effect of cultural ability on market income is endogenous to public policy. We analyze below the important implications of this property.

As we show in Section 2.4, our choice of functional forms is tractable because it implies that, given structural parameters $s = (\alpha, \gamma, \rho_0, \rho_1, \sigma_v^2, \sigma_u^2)$, distribution Φ_h of dynasty specific ability, and institutions P that do not depend on calendar time, the process for the redistributive system μ_{t+1} is always in steady state. Therefore, the coefficients in the income and talent processes do not depend on calendar time, and every family's income and talent fluctuate around the stationary steady state. This implies that permanent shocks in the politico-economic environment $\{s, P, \Phi_h\}$ will change the income and the talent processes for every family as the economy evolves to another stationary steady state. As a result, our model identifies a possible difference between the coefficients of the income and the talent equations as a departure from the initial "grandfather's steady state" with policy μ_t.

2.3 The Trade-Off Between Equity and Efficiency

2.3.1 Expectations

In our model, a more progressive and mobile system entails both costs and benefits for the society. To see this, consider the stationary expectation or long run value of income for household i:

$$\mathbf{E}(y_{i,t+1}|h_i) = \frac{\mu_{t+1}\left[\rho_0 + \ln\left(h_i \frac{\mu_{t+1}}{\mu_{t+1}+\gamma}\right)\right] + \alpha \ln \mu_{t+1}}{1-\mu_{t+1}} \tag{21}$$

for all t.[9] In (21), the expectation is conditioned on h_i to denote family dependency. There are four ways through which the redistributive system μ_{t+1} affects expected output.

1. *Distortions in Private Investment*: This is captured by the $\ln\left(\frac{\mu_{t+1}}{\mu_{t+1}+\gamma}\right)$ term. In more progressive systems (lower μ_{t+1}), the marginal propensity to invest $\frac{\mu_{t+1}}{\mu_{t+1}+\gamma}$ is lower, and

[9] For given politico-economic environment, μ_{t+1} is always in steady state, and therefore income and talent for every dynasty i are well-defined stationary AR(2) processes. Even though μ_{t+1} is independent of calendar time, we keep the time subscript to emphasize the difference between the income and the talent transmission process which is relevant for our empirical results.

as a result the long run level of income tends to decline. This effect is identical for every dynasty i.

2. *Distortions in Output or "Labor Supply Distortion"*: This effect is shown in the $\alpha \ln \mu_{t+1}$ term, and is associated with the shifter μ^{α} in the production function for income (2). The effects of redistribution on output are more adverse when the deadweight loss parameter α increases.

3. *Social Insurance or Benefits of Public Education*: The μ_{t+1} term that multiplies the bracket in the numerator of (21) captures the exponent of Θ^{μ} in the production function (2). For low ability h_i dynasties, a more progressive social insurance or public education scheme increases expected lifetime income. The opposite happens for sufficiently able families, as shown in Figure 1.

4. *Intertemporal Insurance or Social Mobility*: This effect is given by the denominator $1-\mu_{t+1}$. For sufficiently high h_i-dynasties, the numerator is positive and more mobility decreases expected income. On the other hand, low ability dynasties gain from the prospect of upwards mobility and progressivity increases their lifetime income.

This analysis shows that (i) there is a trade-off between equity and efficiency; and (ii) if families are heterogeneous, then the net beneficiaries of social mobility are the low h_i ability dynasties.[10] As a result, our framework implies the existence of *political conflict* over the optimal or equilibrium level of social mobility. In Section 2.4 we describe how this level is chosen by the society.

2.3.2 Variances

The stationary variability that a given dynasty h_i faces in its income process is:

$$\mathbf{Var}(y_{i,t+1}|h_i) = \frac{\mu_{t+1}^2}{1-\mu_{t+1}^2}\frac{1+\rho_1\mu_{t+1}}{1-\rho_1\mu_{t+1}}\frac{\sigma_v^2}{1-\rho_1^2} + \frac{\mu_{t+1}^2}{1-\mu_{t+1}^2}\sigma_u^2 \tag{22}$$

[10]Note that the trade-off concerns solely the first moment of the income distribution. As we show in Section 2.4, there exists also a trade-off between the first and the second moment of the income distribution. Becker and Tomes (1979) consider a simple linear tax system and redistribution in their model only decreases long run income, as for our high h_i households in the fourth effect that we derive. In this extension of their model, they assume however that households are identical, so there is no political conflict over the optimal social mobility.

which occurs because the disturbances $\epsilon_{i,t+1}$ and $u_{i,t+1}$ have different realizations across time for a given family i. From inspection of (22), we see that a more progressive redistributive system lowers the fraction of variability that is attributed to endowment luck $v_{i,t+1}$ and reduces overall variability. Similarly, a weaker cultural or genetic transmission ρ_1 reduces variability in the income process. We comment below for the dynastic variance in the talent process.

The variance that every family faces in (22) would coincide with the stationary ex post inequality in the cross section of families, that is the inequality that we observe in the data, if all families were identical. With heterogeneous families, we can use the well known result for the decomposition of the variance, and write the *ex post* or cross-sectional variance of income as [11]

$$\mathbf{Var}(y_{i,t+1}) = \mathbf{Var}(y_{i,t+1}|h_i) + \mathbf{Var}(\mathbf{E}(y_{i,t+1}|h_i)) \tag{23}$$

where the last term represents the variance "under the veil of ignorance", which from (21) is equal to:

$$\mathbf{Var}(\mathbf{E}(y_{i,t+1}|h_i)) = \frac{\mu_{t+1}^2 \mathbf{Var}(\ln h_i)}{(1-\mu_{t+1})^2} \tag{24}$$

In (23), the stationary total inequality in the cross section of families is decomposed into the dynastic variability in the process for income—common to all families i—and the inequality that arises because heterogeneous families have different levels of long run expected income. It is immediate to see that a more progressive redistributive system reduces all inequalities. The two variances that decompose the cross-sectional inequality differ in the role of cultural or genetic persistence ρ_1. Because all families are assumed to transmit identically their talents to their offsprings, ρ_1 does not matter for ex ante inequality, to the extent that the redistributive scheme is in place.[12]

2.3.3 Covariances

Finally, consider the intergenerational correlation in incomes and talent. This summary statistic is what the literature calls social mobility, inequality across generations or "equality

[11]Note that in (22) the expression is not indexed by i and hence its expectation equals the expression itself. The dynastic variance is common across families i because we have assumed that h_i enters multiplicative and not exponentially into the production of talent. The decomposition assumes the cross-sectional orthogonality of h_i to the disturbances $\epsilon_{i,t+1}$ and $u_{i,t+1}$.

[12]In our model, the choice of μ_{t+1} will not be a function of ρ_1 and therefore culture or genetics have neither direct nor indirect effects on ex ante inequality. This result depends heavily on the assumed AR(1) specification for $v_{i,t}$ in (3), and can be relaxed.

of opportunity". Consider the time path of earnings and talent in some family i with time-invariant ability level h_i, and suppose we are in the steady state with $\mu_{t+1} = \mu_t = \mu$ and stationary dynastic variance for every family i. Conditioning on h_i, we distinguish between the intergenerational correlation of earnings within family, $\mathbf{Corr}(y_{i,t+1}, y_{i,t}|h_i)$, and the correlation we may observe in the data when families are heterogeneous, $\mathbf{Corr}(y_{i,t+1}, y_{i,t})$, and which is discussed later. Given that we are in a stationary state with $\mathbf{Var}(y_{i,t+1}|h_i) = \mathbf{Var}(y_{i,t}|h_i)$, we can derive the dynastic intergenerational correlation of income,

$$\mathbf{Corr}(y_{i,t+1}, y_{i,t}|h_i) = \frac{\mathbf{Cov}(y_{i,t+1}, y_{i,t}|h_i)}{\mathbf{Var}(y_{i,t}|h_i)} = \frac{(\mu_{t+1} + \rho_1)\sigma_v^2 + \mu_{t+1}(1 - \rho_1\mu_{t+1})(1 - \rho_1^2)\sigma_u^2}{(1 + \rho_1\mu_{t+1})\sigma_v^2 + (1 - \rho_1\mu_{t+1})(1 - \rho_1^2)\sigma_u^2} \tag{25}$$

and that of talent, $\mathbf{Corr}(\theta_{i,t+1}, \theta_{i,t}|h_i)$, which is given in Appendix 1.

We summarize all the above findings in the following Proposition.

Proposition 1. Effects of Progressivity on Second Moments: *In any stationary steady state,* $0 < \mu_{t+1} = \mu_t = \mu \leq 1$*:*

1. *The dynastic variance of income* $\mathbf{Var}(y_{i,t+1}|h_i)$ *and that of talent* $\mathbf{Var}(\theta_{i,t+1}|h_i)$ *are strictly increasing in* μ*.*

2. *The ratio* $\mathbf{Var}(y_{i,t+1}|h_i)/\mathbf{Var}(\theta_{i,t+1}|h_i) \leq 1$*, with strict inequality if* $\mu < 1$*, and is strictly increasing in* μ*.*

3. *The dynastic intergenerational correlation of income* $\mathbf{Corr}(y_{i,t+1}, y_{i,t}|h_i)$ *is strictly increasing in* μ*.*

4. *The ratio* $\mathbf{Corr}(y_{i,t+1}, y_{i,t}|h_i)/\mathbf{Corr}(\theta_{i,t+1}, \theta_{i,t}|h_i) \leq 1$*, with strict inequality if* $\mu < 1$*, and is strictly increasing in* μ*.*

Proposition 1 shows that a more progressive public policy decreases the dynastic variance in the production of income and talent, and by equations (23) and (24) it also decreases the cross sectional inequality. Second, in economies with more progressive redistributive schemes the within-dynasty intergenerational correlation of incomes is lower.[13] In the competitive

[13] Therefore, our model is consistent with the general equilibrium effects of educational subsidies derived in Hassler, Rodriguez Mora and Zeira (2007). For talent, the intergenerational correlation has an ambiguous comparative static with respect to μ. A more progressive policy decreases both the covariance and the variance of income and talent. For income, the rate of decrease in the variance is smaller than that of the covariance and the comparative static is unambiguous. For talent, however, the covariance of income $y_{i,t}$ with ability $v_{i,t+1}$ is not sufficiently falling because talent is privately produced. The intergenerational correlation in talent is increasing in μ, if σ_u^2 is not too large relative to σ_v^2.

limit, the ratio of intergenerational correlations of income versus talent and the ratio of the variances equal unity, but they decrease as public policy becomes more progressive. This is intuitive because talent is an intermediate input and its intergenerational correlation weakens only because of the adverse effects of redistribution on parental investment. On the other hand, progressive public policy affects the intergenerational elasticity of income through two channels: Directly through decreased parental investment, but also indirectly by weakening the cultural or genetic transmission process that affects the production of income.[14] The lesson for public policy is that redistribution may not be efficient in affecting directly the parental transmission of culture and genes (i.e. when sons' IQ is produced), but it may still neutralize it indirectly because talent is an input in the production of income. Of course, fathers will internalize efficiency costs associated with such an egalitarian policy, a topic which we now analyze.

2.4 The Political Economy of Social Mobility

Intergenerational mobility is not randomly allocated into different societies, but emerges from the combined effect of "nature", "nurture" *and* public policies that fathers place for their offsprings. While the previous literature has derived social mobility as a function of the optimizing behavior of utility-maximizing families, in this paper we go one step further and endogenize and structurally identify the political process that aggregates conflicting preferences for intergenerational mobility. Our simple intuition that social mobility entails costs and benefits implies that perfect social mobility cannot always be optimal. This is a point highlighted by Piketty (2000), but neglected by the empirical literature.

Every father i in period t has rational expectations about the realization of his offspring's endowment $V_{i,t+1}$ and market luck $U_{i,t+1}$. Under the veil of ignorance, the parental induced preference over the public policy μ_{t+1} is given by:

$$W(\mu_{t+1}, h_i; s) = \ln C_{i,t} + \frac{1}{\gamma}\mathbf{E}(y_{i,t+1}|h_i) \tag{26}$$

where s is the vector of structural parameters, $\mathbf{E}(y_{i,t+1}|h_i)$ is given by (21) and the expectation is formed between the first and the second stage of the game. Note the very important implications of our log-log specification of preferences and multiplicative production func-

[14] Looking at the two production functions (2) and (4), note that $V_{i,t}$ is not affected by $\mu_{i,t}$ at the talent production stage, but is affected by policy at the output stage. Alternatively, compare λ_2 to δ_2.

tions. First, preferences over the redistributive scheme μ_{t+1}, depend on current consumption, the expected level of income, but not on other long run moments. Second, since consumption is a constant fraction of output,

$$C_{i,t} = \frac{\gamma}{\mu_{t+1} + \gamma} Y_{i,t} \tag{27}$$

and calendar time enters only through μ_{t+1} into the long run level of income, it follows that the current state of the system, $Y_{i,t}$, enters log-separably into (26). Therefore, any policy μ_{t+1} that maximizes induced preferences is independent of calendar time and in any stochastic dynamic politico-economic equilibrium, redistribution is always in steady state. We summarize this discussion in the following proposition.

Proposition 2. Stationary Most Preferred Public Policy *Given the structural parameters $s = (\alpha, \gamma, \rho_0, \rho_1, \sigma_v^2, \sigma_u^2)$ and the level of ability h_i, the most preferred public policy for any father of family i*

$$\mu_{t+1}(h_i; s) \in \arg\max_{\mu} W(\mu, h_i; s)$$

is independent of t. Therefore, income and talent are stationary processes and expectations, variances and covariances do not depend on calendar time.

From (26), it follows that the most preferred redistributive scheme for every father trades off costs and benefits in two levels. First, the four channels operating through the life long value of income analyzed in Section 2.3.1 apply. Second, redistribution allocates resources intertemporally. The stationary consumption-investment ratio for every father is γ/μ_{t+1}, which implies that fathers may choose a less progressive system in order to consume less, invest more and increase the size of the pie for the future generation. On the other hand, a more progressive system (lower μ_{t+1}) redistributes consumption in favor of the old generation.[15]

Before sons' ability $V_{i,t+1}$ and market luck $U_{i,t+1}$ realize, fathers choose the redistributive scheme according to a predetermined institution P. We define the institution in terms of the equilibrium outcome that it implies.

Definition 1. Institution P: *An institution P results in the redistributive scheme μ_{t+1}^p mostly preferred by the dynasty in the 100pth percentile of the ability distribution Φ_h, i.e. the family with a level of ability such that $p = \Phi_h(h_p)$.*

[15] This role of μ_{t+1} may capture a more generous pay-as-you-go pension system.

Our definition is quite general and encompasses all commonly used institutions, both in the optimal and in the political economy of taxation literature. Let the average dynasty-specific level of ability be $\bar{h} = \int_{\mathbf{H}} z d\Phi(z)$. Then if $p = \Phi(\bar{h})$, one obtains the utilitarian social rule that maximizes the welfare of the average father:

$$\max_{\mu} \int_{\mathbf{H}} W(\mu, h, s) d\Phi_h(h) \tag{28}$$

This is also the welfare function in a representative-dynasty economy, when a representative father chooses the redistributive scheme under the veil of ignorance for the realization of h. Another popular choice is the pure majority voting institution. In Appendix 1 we can show that induced preferences over policies $W(\mu, h_i; s)$ satisfy the single crossing condition of Gans and Smart (1996) and therefore the median father is the decisive voter. Since the median father's vote is decisive, it follows that $p = 1/2$ is the unique equilibrium outcome of the pure majority rule game.[16] This is also the unique equilibrium outcome when two Downsian parties compete for the votes of the fathers. More in general, we can allow for $p > 1/2$, capturing campaign contributions of the rich fathers or ideologically diverse preferences for parties of the poor fathers. If $p < 1/2$, then social preferences are averse to inequality and can be thought to internalize the ex ante variance given in (24). From a political economy point of view, a lower p may capture the bargaining power of socialist parties or labor organizations in unionized economies. In the limit, $p = 0$ leads to the "Rawlsian institution" that maximizes the welfare of the least well-off dynasty. Henceforth, we parameterize the institution by p.

Given this definition, the properties of the optimal (in a optimal taxation sense) or equilibrium (in a political economy sense) level of social mobility μ_{t+1}^e are given in the following Proposition.

Proposition 3. Optimal Social Mobility: *μ_{t+1}^e is increasing both in α and in p. It increases in ρ_0 and does not depend on ρ_1, σ_v^2 and σ_u^2. The effects of γ are ambiguous.*

This simple proposition shows that the redistributive system becomes less progressive (higher μ_{t+1}) when output costs α increase, but more progressive as the position p of the

[16] That is, this is the Condorcet winner of the game. Given the form of $W(.)$ conditions for single peakedness are too complicated to establish. In our numerical simulations, preferences appear to be single peaked for $\rho_0 < 0$, but not necessarily for $\rho_0 > 0$. Single crossing on the other hand is obvious in our setup, regardless of parameter values.

decisive dynasty in the ability distribution decreases. Our result shows that, as long as optimally chosen redistributive public policies affect intergenerational mobility, there is no reason to expect that a collective action of fathers transmits a perfectly mobile society to their sons.[17] In our model, the standard intuition, that the Rawlsian outcome entails a broader scope for government redistribution than the majority voting equilibrium, and that majority voting implies more progressivity than the utilitarian optimum applies. That both α and p decrease redistribution shows clearly the efficiency-equity trade-off (if for instance, μ_{t+1} denotes income taxation) or the incentives-insurance tradeoff (if for example, μ_{t+1} is public education).

Note that for the refusal of this proposal, one would need to show *both* the costs associated with redistribution to be negligible *and* institutions to favor low ability families. This is an important point to keep in mind, because empirically it may difficult to find evidence for the magnitude of α or in reality some public reforms may entail small costs. On the other hand, there is strong evidence that rich families have a larger "say" on the politico-economic outcome and the political system is wealth-biased (Benabou, 1996).

The scope for beneficial reforms, and hence for social mobility, increases in societies with lower long run income (lower ρ_0). At a first glance, this may appear counterfactual, since the conjecture is that in less developed economies, social mobility is lower.[18] However, note that this is a ceteris-paribus proposition, and if in reality less developed economies are also less mobile, this is because of their poor technology in collecting taxes (high α) and the limited expansion of the voting rights (high p).

The effects of altruism $1/\gamma$ are ambiguous, which exemplifies our difference with the Becker and Tomes (1979) model and the subsequent literature. In their model, altruistic parents invest more in the human capital of their children which strengthens the intergenerational mechanism. This effect is absent from our model because of the Cobb-Douglas structure. But our model highlights a second, novel, channel through which altruism affects the intergenerational transmission. On the one hand, altruistic fathers tend to insure their sons and μ_{t+1} tends to decrease, weakening the intergenerational mechanism. But on the other, altruistic parents want to maximize the size of the pie and commit to a high level

[17] That is, even if $\rho_1 = 0$, the intergenerational correlation of earnings in (25) need not be zero. In fact, even with no cultural or genetic transmission, fathers may choose a random walk process for income if α is sufficiently high.

[18] See for instance Solon (2002) and the references listed therein.

of investment by minimizing efficiency losses, which tends to strengthen the intergenerational transmission. This simple example shows that in a more parameterized version of our model, deep parameters that the previous literature has shown to affect directly the intergenerational mechanism, will now also operate *indirectly* on social mobility, through the endogenously chosen public policy. These indirect effects may even offset the previously known direct effects.

Let us briefly comment on our functional form assumptions. As we have shown, the log-log utility specification and the double Cobb-Douglas production structure permits us to solve closed-form for the stochastic dynamic politico-economic equilibrium. Furthermore, it delivers the structural log-linear intergenerational mobility model that the literature estimates, and therefore our assumptions represent a natural benchmark.[19] The importance of the ex ante variance in (24) is captured implicitly through our parameter p. An increase in the cross sectional variability of h_i would lower p and lead — "under the veil of ignorance" — to a more progressive and mobile economy. On the other hand, σ_v^2 and σ_u^2 do not affect the optimal redistributive scheme because only the expectation of long run income matters for the dynastic induced preferences, and not the family specific variance given in (22). Obviously, without log separability, the scope of insurance would be higher when endowment and market luck become more variable, and in a more general formulation these parameters would also matter for the optimal level of progressivity μ_{t+1}.[20]

Despite our assumptions, our intuition for the role of institutions, redistribution and social mobility should survive any generalization as long as our two very basic premises can be seen to hold: Social mobility is endogenously chosen and it entails both costs and benefits for the society.

[19] See Solon (1992), Zimmerman (1992), Bjorklund and Jantti (1997), Mulligan (1997), Solon (1999), and many others.

[20] Cultural or genetic persistence ρ_1 does not appear as an argument of the optimal redistributive scheme because of the normalization in the intercept of (3). Relaxing this parameterization, would produce an effect of ρ_1 on μ_{t+1}, which arbitrarily depends on the sign ρ_0.

3 What the Intergenerational Correlation of Income Really Means: Interpretation of the Galton-Becker-Solon Regression

The literature has typically focused on variants of the Galton-Becker-Solon (GBS) regression:

$$y_{i,t+1} = \beta_0 + \beta_1 y_{i,t} + \varepsilon_i \tag{29}$$

where y_{t+1} and y_t denote son's and father's life long income in the population.

The existing literature has attributed to the reduced-form coefficient β_1 a specific meaning. Becker and Tomes (1979; abstract and page 1182) argue that "[...] Intergenerational mobility measures the effect of a family on the *well-being* of its children.[...]".[21] Another influential contribution is that of Mulligan (1997, page 25), who in defining social mobility notes that "[...] The perfect mobility case - $\beta_1 = 0$ - is often referred to as perfect 'equality of opportunity' because the income of a child is unrelated to the income of his or her parents. The degree of intergenerational mobility is therefore an index of the degree of 'equality of opportunity'. Equality of opportunity is often seen as *desirable* because, with little correlation between the incomes of parents and children, children from rich families do not enjoy much of a "head start" on children from poor families.[...]".

The same presumption may be implied by the analysis of Solon (1999), when he compares two countries and argues that A and B may have the same level of cross sectional inequality, but nevertheless their inequality be of very different character, because country A is perfectly mobile while B is perfectly immobile.

Our model clarifies that the coefficient β_1 is a specific function of underlying structural parameters. Previous models have recognized that β_1 is a function of genetic and cultural inheritage, altruism and technological parameters, such as the net return to parental investment. However, we show that this coefficient also depends on institutions that a generation puts in place to insure the following generation from adverse shocks.

Proposition 4. Decomposition of Population Slope *Consider a stationary state with* $\mu_{t+1} = \mu_t = \mu$ *and* $\mathbf{Var}(y_{i,t+1}) = \mathbf{Var}(y_{i,t})$. *Then, the coefficient* β_1*—the slope in the*

[21] Emphasis added.

population regression of son's on father's income—is

$$\beta_1 = \mathbf{Corr}(y_{i,t+1}, y_{i,t}) = \mu \left(1 + \frac{\frac{\rho_1 \mu \sigma_v^2}{(1-\rho_1^2)(1-\rho_1\mu)} + \frac{\mu}{1-\mu}\mathbf{Var}(\ln h_i)}{\mathbf{Var}(y_{i,t})} \right)$$

where the variance refers to the cross sectional variance in (23).

What do learn from observing the population slope β_1? In general, not much. Suppose that we have two populations, the first residing in country A and the second in country B. We can only make interesting normative comparisons between the two countries under two extremely restrictive assumptions:

1. β_1 *uniquely identifies* μ: In our model this holds, and in fact $\beta_1 = \mu$, only when

   - dynasties are ex ante identical and therefore $\mathbf{Var}(\ln h_i) = 0$.
   - there is no cultural or genetic persistence, $\rho_1 = 0$.

   If dynasties are identical, then the cross sectional variance given by (23) in the denominator of the decomposition, is identical for every family and given by (22). In addition, with $\rho_1 = 0$, the expression inside the parenthesis equals unity and μ is identified.

2. *The institution P implies social preferences that are strictly monotone in μ*: If this is the case, then β_1^A and β_1^B can be ordered in terms of welfare level.[22]

In general, these two restrictions might not be true. Therefore, contrary to the claims in the existing literature, cross country comparisons are not very informative, unless we learn more about the optimal or equilibrium level of social mobility. Only under very restrictive assumptions, intergenerational mobility identifies the degree of progressivity of the redistributive scheme. And even if it identifies it, more progressivity is not always welfare enhancing. Therefore, in the case of the two countries described by Solon (1999) above, we cannot conclude that the children of country A are living in a better or worse society relative to those of B — in reality this is the important normative comparison that underlies the literature on intergenerational mobility.

[22] β_1 is strictly increasing in μ.

4 An Empirical Illustration: Intergenerational Mobility in Norway

4.1 Identification

The previous Section has two important implications. First, it shows how to interpret the parameter β_1 in the standard reduced form GBS equation (29). The parameter β_1 is a function of the underlying structural parameters that characterize the role of redistributive institutions and the transmission of genetic ability and talent. Second, and strictly related to the first point, the previous Section highlights that even when it is possible to estimate consistently the parameter β_1 in the standard reduced form GBS equation (29), the underlying structural parameters are in general not identified.[23] This implies that even if in countries A and B, social welfare takes as sole argument the variability of income, observation of the population coefficient β_1 cannot identify which country is closer to satisfying its social goals.[24]

Our data offer a unique opportunity to go behind the standard reduced form coefficient β_1. Specifically, while we can not estimate all the structural parameters in β_1, our data allow us to estimate the parameter μ_{t+1}, which represents the degree of progressivity in the society. Even though μ_{t+1} is an "intermediate parameter" and, as we show, depends on deeper structural parameters, it is still a useful summary statistic for many purposes. In itself, it does not have normative implications. In this sense, our empirical exercise is simply an application of our model that may shed some light on the degree of progressivity in Norway. However, we also note that, for the special case where "under the veil of ignorance", everybody agrees that a lower ex ante variance is always a desirable goal (this is the second condition in Section 3 for firm cross-country comparison), a lower μ denotes higher welfare.

[23] The are two sets of reasons. First, since it is possible that special interests—such as business interests or labor unions—affect the redistributive system, one cannot expect the families to be ex ante identical, leading to the utilitarian outcome. This effect is parameterized by p in our model, which will vary from country to country. But when families are ex ante heterogeneous, the covariance of the fixed effect with income $\mathbf{Cov}(\ln h_i, y_{i,t})$ may generate cross country differences in β_1. See Han and Mulligan (2001) for an argument on the ability specific effect. Second, two countries may differ in other dimensions. One example is differences in cultural and political attitudes. See Alesina and Giuliano (2007) for recent evidence on cross country cultural differences. Goldberger (1989) is the first to point out the under-identification of the Becker and Tomes (1979) model.

[24] An example of a paper that avoids this pitfall is Solon (2004). He correctly points out that the intergenerational correlation of income depends on various structural parameters such as the level of progressivity and the inheritage of parental endowment, without attaching any normative judgment to these parameters.

We use data from two generations in Norway that aggregate information from military records and other public registers. They consists of fathers born in 1932 and 1933 and who enrolled for conscription in 1952 and 1953, and their sons born between 1950 and 1985 and tested form 1968 to 2005. A great advantage of our data set over many others in the literature is that we have the population of men and can link adult children in 2005 to characteristics of their parents, even in cases where the children do not live with their parents. We describe our data in detail in Appendix 2 and report summary statistics in Table 1.

Unlike the data typically used by the previous literature, our data are unique in that they allow us to estimate the production function (2) for two separate cohorts: the cohort of the fathers (i.e. those individuals born in 1932-1933)—which we call cohort f—and the cohort of the sons (i.e. those individuals born between 1950 and 1985)—which we call cohort s. We estimate the following four equations:

$$y_s = \beta_{0,y} + \beta_{1,y} y_f + \varepsilon_y \tag{30}$$

$$\theta_s = \beta_{0,\theta} + \beta_{1,\theta} \theta_f + \varepsilon_\theta \tag{31}$$

$$y_f = \beta_{0,f} + \beta_f \theta_f + \varepsilon_f \tag{32}$$

$$y_s = \beta_{0,s} + \beta_s \theta_s + \varepsilon_s \tag{33}$$

Equations (30) and (31) are the standard GBS regressions. They are similar to the estimates of GBS equation for successive cohorts of US males presented in Aaronson and Mazumder (2008) and Mazumder (2007). Our model in the previous Section has clarified that the estimation of the coefficients from the intergenerational GBS regressions, would not shed light on Norway's social policy because these identify a combination of genetics, culture, institutions, market and endowment variability, family specific heterogeneity; the net return to parental investment could also be included in this list. But in contrast to the previous literature, our data allow us to estimate two additional equations, namely the production functions in equation (32) and (33). These two equations are important because they identify the progressivity of the redistributive system that the fathers and sons are exposed to, respectively. In other words, these two production functions can identify changes in redistribution.

It is important to realize that while in the model we focus on the case where the redistributive institutions are in steady state, in practice societies may move between steady states when we look at two different cohorts observed in two different moment in time. To see this, let the slope of the log linear regression of income on talent for the first and the second cohort be μ_0 and μ_1, respectively. We model unexpected permanent shocks in the economy by assuming the following timing: (i) the economy is initially in steady state. This original steady states holds for the fathers cohort; (ii) a permanent unexpected shock hits the economy before the sons cohorts is born; (iii) fathers observe the permanent shock, and collectively agree on a new optimal redistributive institution;[25] (iv) talent is "predetermined" and responds to the permanent shock with a lag of one period.[26] (v) the next stages of the game are realized and the economy then stays forever in the new steady state.

Note that to identify such a change with the typical GBS framework, one would need data for the great-grandchildren of the fathers that chose μ_t in the late 1920s. These data are rarely available. Our estimation of the two production functions offers a credible alternative. More precisely, if the deadweight loss from redistribution α or the position of the decisive voter p decrease permanently and all other structural parameters remain constant, then

1. $\mu_0 = \beta_f$ and $\mu_1 = \beta_s$ are uniquely identified from the population slopes in (32) and (33). Furthermore, by Proposition 3 we must have $\mu_0 > \mu_1$.

2. If $\beta_{1,y} > \mu_1$ and $\beta_{1,\theta} > \mu_0$, then either $\mathbf{Var}(\ln h_i) > 0$ or $\rho_1 > 0$ or both. If $\beta_{1,y} = \mu_1$ or $\beta_{1,\theta} = \mu_0$, then $\mathbf{Var}(\ln h_i) = 0$ and $\rho_1 = 0$.

The estimation of the degree of redistribution based on equations (32) and (33) hinges upon the assumption that the production functions are well specified. Yet, identifying μ from the within generation variation seems more credible than estimating the typical GBS regression, for several reasons. First, estimation of the production function is less likely to be contaminated by the presence of the unobserved heterogeneity in h_i.[27] Second, it is

[25] Specifically, at period t, after $Y_{i,t}$ is produced and before fathers vote for μ_{t+1}, a shock in a member of the structural parameter vector $\{s, \Phi_h, p\}$ takes place. Fathers observe the permanent shock, and collectively agree on μ_{t+1}. Solon (2004) presents a similar though experiment, aimed to rationalize within country trends in intergenerational mobility.

[26] Specifically, at period t, before $V_{i,t+1}$ and $U_{i,t+1}$ are realized, the variance of talent $\mathbf{Var}(\theta_{i,t+1})$ depends on the public policy that grandfathers have chosen for the fathers, μ_t. Therefore, $\mathbf{Var}(\theta_{i,t+1}) = \mathbf{Var}(\theta_{i,t})$. The variance of talent jumps to its new long run value due to endogenous policy only in period $t + 2$.

[27] As an example, it is possible that income is measured after-tax, and talent is proportional to gross earnings, then the production functions that we estimate are not sensitive to the family specific effect, h_i, but only to the redistributive scheme which transforms pre tax to after tax earnings, and which is common to all families.

likely that the persistence ρ_1 of the family's endowment process, does not enter *directly* as an exponent in the technology that transforms pre tax to after tax income.[28] In other words, our method seems to be free from at least one of the structural parameters that causes the under-identification of the GBS regression. More in general, any parameter that is common to all the families and enters multiplicatively or additive into our production functions ends up into the intercept and therefore should not affect our estimates of β_f and β_s. Finally, endowment variability is not a deeper parameter, and market variability enters only through the error term and not through the population coefficient as in the GBS regression.

4.2 Empirical Estimates

Table 2 reports estimates of the four equations that we can identify: equations (30) to (33). The first column of Table 2 reports the standard Galton-Becker-Solon regression for our Norwegian dataset. A ten percent increase of the income of fathers is associated with a 2.1 percent increase in the income of sons. This estimate is consistent with existing estimates of intergenerational mobility in Scandinavian countries and is about half of the estimates from similar regressions based on US data (Solon, 1999). Our estimate is precisely estimated. To account for the fact that several siblings may be present in the data, throughout the paper standard errors are clustered by family.

Column 2 reports estimates of the relationship between sons's talent and father talent. The regression coefficient is 0.37, indicating a positive and rather large intergenerational transmission of talent. Columns 3 and 4 are estimates of the production functions for the father generation and the sons generation. These estimates indicate that the relationship between income and talent is weaker for the sons cohort. The coefficient for sons is 15 percent smaller than the corresponding coefficient for fathers. Based on our model, this implies an increase in redistribution between the fathers cohort and the sons cohort.

One concern arises from one important limitation of our data. In our data, the IQ variable has been standardized using the Stanine method which transforms raw scores into a nine point scale with a normal distribution, a mean of 5, and a standard deviation of 2. As shown in Table 1 this IQ measure has the same mean and variance for fathers and sons. This may pose a problem for estimation, as it implies that the production function in the

[28] In our model, ρ_1 also does not enter the production function indirectly, i.e. through μ, but as we explained this depends crucially on the assumed AR(1) process in (3).

model is not consistent with the one that can be estimated in the data. (Recall that in the production function output is a function of absolute talent, not standardized talent.) Practically, this data limitation implies that the production function coefficients may not be directly compared across cohorts, since father income may have (and indeed has) a different variance than sons' income, while talent has by construction the same variance in both generations.

To account for this data limitation, in Table 3 we present estimates where all variables (including IQ) have been standardized to have zero mean and variance equal to 1. Table 3 shows that our qualitative results are robust to this data transformation. Indeed, the decline in the relationship between income and talent is now more pronounced. The coefficient for sons is less than half the corresponding coefficient for fathers.

We interpret our findings in Tables 2 and 3 as evidence that the collective preferences for redistribution in the generation of the grand fathers are different from the collective preferences for redistribution in the generation of fathers. Specifically, the collective preferences in Norway have shifted towards greater redistribution. This in itself would imply a lowering of the correlation of income between fathers and sons. Such a change may have generated efficiency costs, and as a result the change in Norway's social welfare cannot be identified.

In terms of the model, this result indicates that $\mu_0 > \mu_1$, so that Norway jumped from one steady state to another between the late 1920s and late 1950s. The comparison of the two production functions rejects the null hypothesis that the structural environment did not change between these two periods.[29]

This is a key limitation of the reduced form approach implicit in the GBS regression. The existing literature estimates β_1, implicitly assuming that the economy is in the same steady state throughout the period of observation. Our data allows us to test and ultimately reject this assumption.

As far as estimation is concerned, two additional points are worth making. First, our results are robust to alternative definitions of the relevant talent in the production function. For example, assume that output is a function of physical strength, instead of IQ. Assume

[29]We note however that an alternative mechanism, that could rationalize the same observation is that μ_{t+1} is a stochastic process itself and varies around a stationary steady state. While the intuition that this paper develops would still be the same, the technical arguments leading to our conclusion would have to modified.

also that an individual height is a measure of physical strength.[30] Tables 4 and 5 show that our qualitative results do not vary when talent is proxied by height.

Second, we point out that one could estimate equations (30)-(33) by pairwise Seemingly Unrelated Regression (SUR), instead of OLS. While SUR generates more efficient estimates, both SUR and OLS are consistent estimators. In practice, the estimation methodology does not affect our results. Allowing for the residuals of the four equations in the system to be pair-wise correlated yield estimates and standard errors very similar to the ones presented.

5 Conclusion

In this paper we argue that the truly interesting question – how intergenerational mobility affects welfare – cannot be answered with the reduced form estimation of the Galton-Becker-Solon regression. We propose a framework which is a first step in clarifying why this is the case. We show that intergenerational mobility is endogenous to economic policy. Therefore, societies characterized by different structural parameters may optimally chose different levels of mobility. These cross country differences do not imply that some societies are better off than others, but only that they optimize under a different set of structural parameters.

Our analysis suggests that the widely studied coefficient of intergenerational income correlation has a useful economic interpretation only under very restrictive assumptions. Therefore, empirical studies that compare estimates of this coefficient across countries or within country over time, offer us little guidance in evaluating the welfare of the corresponding societies.

We present an empirical application with the purpose of showing that cross sectional evidence on earnings and measures of talent may offer a reliable alternative in identifying some interesting deeper parameters of the relationship between intergenerational mobility and welfare. In the light of our model and of the data, Norway appears to have evolved to a more progressive steady state in the transition between the late 20's and the late 50's of the past century. It is, however, possible that the shift of preferences for more redistribution in Norway occured at some efficiency costs.

[30] For evidence on the strong relationship between height and income see, among others, Judge and Cable (2004), Persico, Postlewaite, and Silverman (2004) and Case and Paxson (2006).

References

Aaronson, Daniel and Bhashkar Mazumder. 2008. "Intergenerational Economic Mobility in the US: 1940 to 2000." *Journal of Human Resources,* 43(1): 139–172.

Alesina, Alberto, and Paola Giuliano. 2007. "The power of the family." NBER Working Paper, No. 13051.

Alesina, Alberto, and Dani Rodrik. 1994. "Distributive Politics and Economic Growth." *Quarterly Journal of Economics,* 109: 465–490.

Becker, Gary, and Nigel Tomes. 1979. "An equilibrium theory of the distribution of income and intergenerational mobility." *Journal of Political Economy,* 87: 1153–1189.

Becker, Gary, and Nigel Tomes. 1986. "Human capital and the rise and fall of families." *Journal of Labor Economics,* 4: S1–S39.

Benabou, Roland. 1996. "Inequality and Growth." In *NBER Macroeconomics Annual.* ed. Ben Bernanke and Julio Rotemberg, 11–73. Cambridge, MIT Press.

Benabou, Roland. 2000. "Unequal Societies: Income Distribution and the Social Contract." *American Economic Review,* 90: 96–129.

Benabou, Roland, and Efe Ok. 2001. "Social Mobility and the Demand for Redistribution: The POUM Hypothesis." *Quarterly Journal of Economics,* 116(2): 447–487.

Bjorklund, Anders, and Markus Jantti. 1997. "Intergenerational Income Mobility in Sweden Compared to the United States." *American Economic Review,* 87: 1009-1018.

Black, Sandra, Paul Devereux, and Kjell Salvanes. 2007. "Like Father, Like Son? IQ and the Intergenerational Transmission of Income." Mimeo, The Norwegian School of Economics and Business Administration.

Case, Anne, and Christina Paxson. 2006. "Stature and Status: Height, Ability, and Labor Market Outcomes." NBER Working Paper, No. 12466.

Checchi, Daniele, Andrea Ichino, and Aldo Rustichini. 1999. "More Equal But Less Mobile? Education Financing and Intergenerational Mobility in Italy and the US." *Journal of Public Economics,* 74: 351–393.

Farhi, Emmanuel, and Ivan Werning. 2008. "Progressive Estate Taxation." Mimeo, Harvard.

Gans, Joshua, and Michael Smart. 1996. "Majority Voting with Single-Crossing Preferences." *Journal of Public Economics,* 59: 219–237.

Glomm, Gerhard, and Balasubrahmanian Ravikumar. 1992. "Public vs. Private Investment in Human Capital: Endogenous Growth and Income Inequality." *Journal of Political Economy,* 100: 818–834.

Goldberger, Arthur. 1989. "Economic and Mechanical Models of Intergenerational Transmission." *American Economic Review,* 79(3): 504–513.

Judge, Timothy, and Daniel Cable. 2004. "The Effect of Physical Height on Workplace Success and Income: Preliminary Test of a Theoretical Model." *Journal of Applied Psychology,* 89(1): 428-441.

Han, Song, and Casey Mulligan. 2001. "Human Capital, Heterogeneity and Estimated Degrees of Intergenerational Mobility." *Economic Journal,* 111(470): 207–243.

Hassler, John, Jose Vicente Rodriguez Mora, and Joseph Zeira. 2007. "Inequality and Mobility." *Journal of Economic Growth,* 12: 235–259.

Lee, Chul-In, and Gary Solon. 2006. "Trends in Intergenerational Income Mobility." NBER Working Paper, No. 12007.

Mazumder, Bhashkar. 2005. "Fortunate Sons: New Estimates of Intergenerational Mobility in the U.S. Using Social Security Earnings Data." *Review of Economics and Statistics,* 87(2): 235–255.

Mazumder, Bhashkar. 2007. "Trends in Intergenerational Mobility." *Industrial Relations,* 46(1): 1–6.

Mulligan, Casey. 1997. *Parental Priorities and Economic Inequality.* The University of Chicago Press.

Persson, Torsten, and Guido Tabellini. 1994. "Is Inequality Harmful for Growth?" *American Economic Review,* 84(3): 600–621.

Persico, Nicola, Andrew Postlewaite, and Dan Silverman. 2004. "The Effect of Adolescent Experience on Labor Market Outcomes: The Case of Height." *Journal of Political Economy,* 112(5): 1019–1053.

Piketty, Thomas. 1995. "Social Mobility and Redistributive Politics." *Quarterly Journal of Economics,* 110(3): 551–584.

Piketty, Thomas. 2000. "Theories of Persistent Inequality and Intergenerational Mobility." In *Handbook of Income Distribution.* ed. Antony B. Atkinson and Francois Bourguignon, Volume 1: 429-476. North-Holland.

Romer, Thomas. 1977. "Majority Voting on Tax Schedules: Some Further Results." *Journal of Public Economics,* 7: 127-133.

Solon, Gary. 1992. "Intergenerational Income Mobility in the United States." *American Economic Review,* 82: 393–408.

Solon, Gary. 1999. "Intergenerational mobility in the Labor Market." In *Handbook of Labor Economics.* ed. Orley C. Ashenfelter and David Card, Volume 3B: 1762–1796. New York, NY: Elsevier Science Press.

Solon, Gary. 2002. "Cross-Country Differences in Intergenerational Earnings Mobility." *Journal of Economic Perspectives,* 16(3): 59–66.

Solon, Gary. 2004. "A Model of Intergenerational Mobility Variation over Time and Place." In *Generational Income mobility in North America and Europe.* ed. Miles Corak, 38–47. Cambridge University Press.

Sundet, Jon, Dag Barlaug, and Tore Torjussen. 2004. "The End of the Flynn Effect? A Study of Secular Trends in Mean Intelligence Test Scores of Norwegian Conscripts During Half a Century." *Intelligence,* 32: 349–362.

Sundet, Jon, Kristian Tambs, Jennifer Harris, Per Magnus, and Tore Torjussen. 2005. "Resolving the Genetic and Environmental Sources of the Correlation Between Height and Intelligence: A Study of Nearly 2600 Norwegian Male Twin Pairs." *Twin Research and Human Genetics,* 7: 1–5.

Tambs, Kristian, Jon Sundet, and Per Magnus. 1988. ”Genetic and Environmental Effects on the Covariance Structure of the Norwegian Army Ability Tests.” *Person. Individ. Diff.,* 9(4): 791–799.

Zimmerman, David. 1992. ”Regression Toward Mediocrity in Economic Stature.” *American Economic Review,* 82: 409–429.

Appendix 1

Derivation of Income (7) and Talent (14) Transmission Equations

Solving the talent production function (4) for investment and then substituting into the resulting expression $\Theta_{i,t+1}$ from output's production function (2) for period $t+1$, we take:

$$I_{i,t} = (h_i V_{i,t+1})^{-1} \left[(Y_{i,t+1})^{\frac{1}{\mu_{t+1}}} (U_{i,t+1})^{-1} (\mu_{t+1})^{-\frac{\alpha}{\mu_{t+1}}} \right] \tag{A.1}$$

If we insert this equation into the budget constraint, $C_{i,t} = Y_{i,t} - I_{i,t}$, we see that the budget is concave for $\mu_{t+1} \leq 1$, strictly when $\mu_{t+1} < 1$. It then follows from our log-log specification of preferences in (5), that the solution is unique, interior and fully characterized by the first order condition:

$$\frac{C_{i,t}}{\gamma Y_{i,t+1}} = \frac{1}{\mu_{t+1}(h_i V_{i,t+1}) U_{i,t+1}} (\mu_{t+1})^{-\frac{\alpha}{\mu_{t+1}}} (Y_{i,t+1})^{\frac{1}{\mu_{t+1}}-1} \tag{A.2}$$

Solving for $C_{i,t}$ and substituting back to the budget constraint we derive the solution for children's income:

$$Y_{i,t+1} = \left(\frac{\mu_{t+1}}{\mu_{t+1} + \gamma} \right)^{\mu_{t+1}} (h_i V_{i,t+1} U_{i,t+1})^{\mu_{t+1}} (\mu_{t+1})^{\alpha} (Y_{i,t})^{\mu_{t+1}} \tag{A.3}$$

which when taking logs yields the income transition equation (7) for the coefficients defined in (8)-(13). From (A.1) we get the solution for investment,

$$I_{i,t} = \left(\frac{\mu_{t+1}}{\mu_{t+1} + \gamma} \right) Y_{i,t} \tag{A.4}$$

which shows that investment equals a constant fraction of the endowment. Similarly, consumption is given by:

$$C_{i,t} = \left(\frac{\gamma}{\mu_{t+1} + \gamma} \right) Y_{i,t} \tag{A.5}$$

Finally, substituting the production function (2) into the solution (A.3), we derive the relationship between sons' income and talent of fathers:

$$Y_{i,t+1} = \left(\frac{\mu_{t+1}}{\mu_{t+1} + \gamma} \right)^{\mu_{t+1}} (h_i V_{i,t+1} U_{i,t+1})^{\mu_{t+1}} (\mu_{t+1})^{\alpha} \left[\mu_t^{\alpha} \Theta_{i,t}^{\mu_t} U_{i,t}^{\mu_t} \right]^{\mu_{t+1}} \tag{A.6}$$

Forwarding the output production function (2) one period and solving for talent, yields $\Theta_{i,t+1} = (\mu_{t+1})^{-\frac{\alpha}{\mu_{t+1}}} (U_{i,t+1})^{-1} (Y_{i,t+1})^{\frac{1}{\mu_{t+1}}}$. Substituting (A.6) into the latter and canceling terms we obtain the solution for talent:

$$\Theta_{i,t+1} = \left(\frac{\mu_{t+1}}{\mu_{t+1} + \gamma} \right) (h_i V_{i,t+1}) (\mu_t)^{\alpha} U_{i,t}^{\mu_t} \Theta_{i,t}^{\mu_t} \tag{A.7}$$

Taking logs gives the transmission equation for talent (14)-(20).

Stationarity of the Income and Talent Processes given Stationary Policy μ_{t+1}

As we show in Section 2.4, for given structural parameters $s = (\alpha, \gamma, \rho_0, \rho_1, \sigma_v^2, \sigma_u^2)$, distribution Φ_h of dynasty specific ability, and institutions P that do not depend on calendar time, the process for the redistributive system μ_{t+1} is always in steady state. Therefore, for what follows, μ_{t+1} is treated as a parameter, independent of calendar time. Subtracting $\rho_1 y_{i,t}$ from both sides of the income transmission equation (7), using the definition for $v_{i,t+1}$ in (3), and substituting in the resulting expression the fact that $\rho_1 (\delta_2 v_{i,t} - y_{i,t}) = -\rho_1 (\delta_{0,i} + \delta_1 y_{i,t-1} + \delta_3 u_{i,t})$, we express the AR(1) process for income in (7) as an AR(2) process:

$$y_{i,t+1} = (1-\rho_1)(\delta_{0,i} + \delta_2\rho_0) + (\delta_1 + \rho_1) y_{i,t} + (-\delta_1\rho_1) y_{i,t-1} + \delta_2\epsilon_{i,t+1} + \delta_3 u_{i,t+1} - \delta_3\rho_1 u_{i,t} \quad \text{(A.8)}$$

where $\delta_2\epsilon_{i,t+1}$, $\delta_3 u_{i,t+1}$ and $-\rho_1\delta_3 u_{i,t}$ are three independent white noise processes. The AR(2) process is stationary if the roots of the characteristic equation

$$1 - (\delta_1 + \rho_1)x - (-\delta_1\rho_1)x^2 = 0 \quad \text{(A.9)}$$

lie outside the unit circle. The two roots are given by $\phi_1 = -\frac{1}{\rho_1}$ and $\phi_2 = -\frac{1}{\delta_1} = -\frac{1}{\mu_{t+1}}$. Therefore, the log income process is stationary for every family i, if $\rho < 1$ and $\mu_{t+1} < 1$. Similarly, the talent process can be expressed as a stationary AR(2) as in (A.8), and with the appropriate change of notation the same conditions apply.

Expected Income and Talent given Stationary Policy μ_{t+1}

The expectation of log income for family i is easily computed by setting $\mathbf{E}(y_{i,t+1}) = \mathbf{E}(y_{i,t}) = \mathbf{E}(y_{i,t-1})$ in (A.8) or (7), and the resulting manipulations yield equation (21) in the text. All comparative statics for the expectation analyzed in the text follow from inspection. A similar reasoning applied at the talent transmission equation (14) yields

$$\mathbf{E}(\theta_{i,t}|h_i) = \frac{\rho_0 + \ln\left(h_i \frac{\mu_{t+1}}{\mu_{t+1}+\gamma}\right) + \alpha \ln \mu_t}{1 - \mu_t} \quad \text{(A.10)}$$

for all t.

Variance of Income and Talent given Stationary Policy μ_{t+1}

To derive the stationary variance $\mathbf{Var}(y_{i,t+1}|h_i)$ for dynasty i, we impose stationarity in the AR(1) specification of log income in (7) and recall that $u_{i,t+1}$ is independent from $v_{i,t+1}$ and $y_{i,t}$:

$$(1-\mu_{t+1}^2)\mathbf{Var}(y_{i,t+1}|h_i) = \mu_{t+1}^2\mathbf{Var}(v_{i,t+1})+2\mu_{t+1}^2\mathbf{Cov}(y_{i,t}, v_{i,t+1}|h_i)+\mu_{t+1}^2\mathbf{Var}(u_{i,t+1}) \quad \text{(A.11)}$$

For the covariance term, using the stationarity of the process and the properties of $\epsilon_{i,t+1}$ and that of the covariance we take:

$$\mathbf{Cov}(y_{i,t}, v_{i,t+1}|h_i) = \frac{\rho_1\mu_{t+1}\sigma_v^2}{(1-\rho_1\mu_{t+1})(1-\rho_1^2)} \quad \text{(A.12)}$$

Substituting (A.12) into (A.11), using the definitions of the variances for $v_{i,t+1}$ and $u_{i,t+1}$ and rearranging we obtain the expression given in the text, (22). We can follow the same reasoning and with minor modifications, the conditional variance of talent is given by

$$\mathbf{Var}(\theta_{i,t+1}|h_i) = \frac{1}{1-\mu_t^2}\frac{1+\rho_1\mu_t}{1-\rho_1\mu_t}\frac{\sigma_v^2}{1-\rho_1^2} + \frac{\mu_t^2}{1-\mu_t^2}\sigma_u^2 \quad \text{(A.13)}$$

which is also increasing in μ_t. Taking the ratio of income's over talent's variance and imposing the steady state condition $\mu_{t+1} = \mu_t = \mu$ (see Section 2.4) we obtain

$$\frac{\mathbf{Var}(y_{i,t}|h_i)}{\mathbf{Var}(\theta_{i,t}|h_i)} = \frac{\kappa + \sigma_u^2}{\frac{\kappa}{\mu^2} + \sigma_u^2} \quad \text{(A.14)}$$

for $\kappa = \frac{1+\rho_1\mu}{1-\rho_1\mu}$. If $\mu < 1$ and $\sigma_v^2 > 0$, then the denominator exceeds the numerator in (A.14), and the ratio is smaller than unity as claimed in Proposition 1.

To prove the claim in Proposition 1 that the ratio is increasing in μ, we can show that the derivative of the ratio with respect to μ is proportional to

$$\sigma_u^2\left[\kappa'(1-\frac{1}{\mu^2}) + 2\frac{\kappa}{\mu^3}\right] + 2\frac{\kappa^2}{\mu^3} \quad \text{(A.15)}$$

Sufficient for the argument is that the first term is positive, or after some algebra that:

$$g(\mu,\rho_1) = \mu(\mu^2 - 1 - \mu\rho_1^2) > -1 \quad \text{(A.16)}$$

which proves the claim because the function g has minimum at -1, for $\rho_1 = 1$ and $\mu = 1$.

Intergenerational Correlation Coefficient of Income and Talent given Stationary Policy μ_{t+1}

In this part we consider the intergenerational correlation within one dynasty i and treat h_i as a time invariant fixed effect. By the stationarity of the variance, the steady state intergenerational correlation in income is

$$\mathbf{Corr}(y_{i,t+1}, y_{i,t}|h_i) = \frac{\mathbf{Cov}(y_{i,t+1}, y_{i,t}|h_i)}{\mathbf{Var}(y_{i,t}|h_i)} = \mu_{t+1} + \mu_{t+1}\frac{\mathbf{Cov}(y_{i,t}, v_{i,t+1}|h_i)}{\mathbf{Var}(y_{i,t}|h_i)} \tag{A.17}$$

where we have used (7) and the properties of $u_{i,t+1}$. Inserting the expression for the variance from (22) and the formula for the covariance in (A.12), and manipulating the resulting expression yields (25) as claimed. One can differentiate (25) and after some manipulations show that $\partial\mathbf{Corr}(y_{i,t+1}, y_{i,t}|h_i)/\partial\mu_{t+1}$ is proportional to the sum of three positive terms: $\sigma_v^4(1-\rho_1^2) \geq 0$, $\sigma_u^4(1-\rho_1^2)^2(1-\rho_1\mu_{t+1})^2 \geq 0$ and $\sigma_v^2\sigma_u^2(1-\rho_1^2)(2(1-\rho_1\mu_{t+1})+\rho_1(1-\mu_{t+1}^2)) \geq 0$. Hence, this proves the claim in Proposition 1.

A similar reasoning applies for the intergenerational correlation in talent, for which the stationary intergenerational correlation can be shown to be:

$$\mathbf{Corr}(\theta_{i,t+1}, \theta_{i,t}|h_i) = \frac{(\mu_t + \rho_1)\sigma_v^2 + \mu_t^3(1-\rho_1\mu_t)(1-\rho_1^2)\sigma_u^2}{(1+\rho_1\mu_t)\sigma_v^2 + \mu_t^2(1-\rho_1\mu_t)(1-\rho_1^2)\sigma_u^2} \tag{A.18}$$

which in general has ambiguous comparative static in μ_t, but is increasing in μ_t provided that σ_u is not too large relative to σ_v^2.

To prove the claim in Proposition 1, we take ratio of intergenerational correlations by dividing (25) with (A.18), and assuming we are in steady state $\mu_{t+1} = \mu_t = \mu$ (see Section 2.4). After some rearrangement we can show that this is:

$$\mathbf{Corr}(y_{i,t+1}, y_{i,t}|h_i)/\mathbf{Corr}(\theta_{i,t+1}, \theta_{i,t}|h_i) =$$

$$\frac{(\mu+\rho_1)(1+\rho_1\mu)\sigma_v^4 + \mu^3(1-\rho_1\mu)^2(1-\rho_1^2)^2\sigma_u^4 + \sigma_v^2\sigma_u^2(1-\rho_1\mu)(1-\rho_1^2)(\mu^2(\mu+\rho_1)+\mu+\mu^2\rho_1)}{(\mu+\rho_1)(1+\rho_1\mu)\sigma_v^4 + \mu^3(1-\rho_1\mu)^2(1-\rho_1^2)^2\sigma_u^4 + \sigma_v^2\sigma_u^2(1-\rho_1\mu)(1-\rho_1^2)(\mu^3(1+\rho_1\mu)+\mu+\rho_1)} \tag{A.19}$$

The difference between the last term in the denominator and the numerator is $\sigma_v^2\sigma_u^2(1-\rho_1^2)(1-\rho_1\mu)\rho_1(\mu-1)^2$, which if $\sigma_v^2 > 0$, $\sigma_u^2 > 0$ and $\rho_1 < 1$, is positive. As a result, the expression in (A.19) is smaller than unity, strictly when $\mu < 1$, as claimed in Proposition 1.

Furthermore, the ratio is increasing in μ. To see this, rewrite the ratio as:

$\mathbf{Corr}(y_{i,t+1}, y_{i,t}|h_i)/\mathbf{Corr}(\theta_{i,t+1}, \theta_{i,t}|h_i) =$

$$\frac{(\mu+\rho_1)\frac{1+\rho_1\mu}{(1-\rho_1\mu)^2}\sigma_v^4 + \mu^3(1-\rho_1^2)^2\sigma_u^4 + \sigma_v^2\sigma_u^2\frac{1-\rho_1^2}{1-\rho_1\mu}(\mu^2(\mu+\rho_1)+\mu+\mu^2\rho_1)}{(\mu+\rho_1)\frac{1+\rho_1\mu}{(1-\rho_1\mu)^2}\sigma_v^4 + \mu^3(1-\rho_1^2)^2\sigma_u^4 + \sigma_v^2\sigma_u^2\frac{1-\rho_1^2}{1-\rho_1\mu}(\mu^3(1+\rho_1\mu)+\mu+\rho_1)} \tag{A.20}$$

Denote by N the numerator and D the denominator. Then the ratio of correlations increases in μ if and only if the derivate $N'D - D'N$ is positive. Since the denominator exceeds the numerator, $D > N$, it suffices to show that $N' > D' > 0$. From (A.20) it is evident that both terms increase in μ. The difference $N - D$ equals $-\sigma_v^2\sigma_u^2\frac{1-\rho_1^2}{1-\rho_1\mu}\rho_1(\mu-1)^2$, and therefore $N' - D' = -\sigma_v^2\sigma_u^2(1-\rho_1^2)\rho_1\frac{(\mu-1)(2-\rho\mu-\rho)}{(1-\rho_1\mu)^2} > 0$, which proves the claim in Proposition 1.

Proof that Preferences Satisfy Single Crossing

Let h_A and h_B be two ability types and μ_1 and μ_2 two policies with $\mu_1 > \mu_2$. Suppose that dynasty h_A prefers μ_1 to μ_2, i.e.

$$W(\mu_1; h_A) > W(\mu_2; h_A) \tag{A.21}$$

where the value functions are given in (26) after substituting the formula for consumption in (27) and expected income in (21). It suffices to show that, if $h_B > h_A$, then $W(\mu_1, h_B) = \ln(Y_B\gamma) + \ln\left(\frac{1}{\mu_1+\gamma}\right) + \frac{1}{\gamma}\frac{\bar{\delta}_0(1)}{1-\mu_1} + \frac{\mu_1}{\gamma(1-\mu_1)}\ln h_B$ exceeds $W(\mu_2, h_B) = \ln(Y_B\gamma) + \ln\left(\frac{1}{\mu_2+\gamma}\right) + \frac{1}{\gamma}\frac{\bar{\delta}_0(2)}{1-\mu_2} + \frac{\mu_2}{\gamma(1-\mu_2)}\ln h_B$, where $\bar{\delta}_0(1) = \mu_1\left(\rho_0 + \ln\left(\frac{\mu_1}{\mu_1+\gamma}\right)\right) + \alpha\ln\mu_1$ and $\bar{\delta}_0(2) = \mu_2\left(\rho_0 + \ln\left(\frac{\mu_2}{\mu_2+\gamma}\right)\right) + \alpha\ln\mu_2$. That is, if the low type h_A prefers the high policy μ_1, then the high type h_B also prefers the high policy. Adding to $W(\mu_1, h_B)$ the term $\ln(Y_A\gamma) + \frac{\mu_1}{\gamma(1-\mu_1)}\ln h_A - \frac{\mu_1}{\gamma(1-\mu_1)}\ln h_A$, and to $W(\mu_2, h_A)$ the term $\ln(Y_A\gamma) + \frac{\mu_2}{\gamma(1-\mu_2)}\ln h_A - \frac{\mu_2}{\gamma(1-\mu_2)}\ln h_A$, the requirement is simply:

$$W(\mu_1; h_A) + (\ln h_B - \ln h_A)\frac{\mu_1}{\gamma(1-\mu_1)} > W(\mu_2; h_A) + (\ln h_B - \ln h_A)\frac{\mu_2}{\gamma(1-\mu_2)} \tag{A.22}$$

Since $W(\mu_1; h_A) > W(\mu_2; h_A)$ by (A.21), $\ln h_B - \ln h_A > 0$ and $\mu_1 > \mu_2$ by assumption, the single crossing condition of Gans and Smart (1996) is verified.

Comparative Statics of μ_{t+1} in Proposition 3

If $0 < \mu_{t+1}(h_i) < 1$ is a most preferred tax system for a dynasty with parameter h_i, then it necessarily satisfies the necessary first and second order conditions: $\partial W/\partial\mu_{t+1} = 0$, and $\partial^2 W/\partial(\mu_{t+1})^2 \leq 0$. Some comments: (1) The most preferred policy $\mu_{t+1}(h_i)$ need not be interior (< 1). (2) The first and second order necessary conditions need not identify unique maxima. If for some parameters, the value function W happens to be non single peaked, we conduct "local" comparative statics as in Romer (1977). Therefore we need to assume that the local optimum is regular and that at this point $\partial^2 W/\partial(\mu_{t+1})^2 < 0$.

The first order condition for the most preferred redistributive scheme of dynasty h_i reads as

$$\frac{\partial W}{\partial \mu_{t+1}} = W_1 + \frac{1}{\gamma}\left[W_2 + W_3 + W_4 + H + W_5 + W_6\right] = 0 \tag{A.23}$$

where $W_1 = -\frac{1}{\mu_{t+1}+\gamma} < 0$ captures the intertemporal trade-off, $W_2 = \frac{1}{1-\mu_{t+1}} \ln\left(\frac{\mu_{t+1}}{\mu_{t+1}+\gamma}\right) < 0$ measures the beneficial insurance effects of public policy, $W_3 = \frac{1}{1-\mu_{t+1}}\frac{\gamma}{\mu_{t+1}+\gamma} > 0$ is the term associated with the distortions in investment, $W_4 = \frac{1}{1-\mu_{t+1}}\frac{\alpha}{\mu_{t+1}} > 0$ is the direct output cost (labor supply), $H = \frac{1}{1-\mu_{t+1}} \ln h_i$ captures that the insurance effect is more profound for low ability h_i households, and $W_5 = \frac{1}{(1-\mu_{t+1})^2}\left[\mu_{t+1}\ln\left(\frac{\mu_{t+1}}{\mu_{t+1}+\gamma}\right) + \alpha \ln \mu_{t+1} + \mu_{t+1}\ln h_i + \mu_{t+1}\rho_0\right]$ is negative for low h_i and positive for sufficient high ability dynasties. Finally, $W_6 = \frac{1}{1-\mu_{t+1}}\rho_0 > 0$ is positive which captures that insurance is more beneficial when the long run level of income is lower.

In the interior, all expressions are differentiable and hence the Implicit Function Theorem applies. Given the local strict concavity, for any parameter z, the comparative static $\partial\mu_{t+1}(h_i)/\partial z$ has the same sign as the cross partial $\partial^2 W(\mu_{t+1}(h_i))/\partial(\mu_{t+1})\partial z$. We can see that:

$$\frac{\partial^2 W(\mu_{t+1}(h_i))}{\partial\mu_{t+1}\partial\alpha} = \frac{1}{\gamma}\left(\frac{\partial W_4}{\partial\alpha} + \frac{\partial W_5}{\partial\alpha}\right) = \frac{1}{\gamma}\left(\frac{1}{(1-\mu_{t+1})\mu_{t+1}} + \frac{\ln\mu_{t+1}}{(1-\mu_{t+1})^2}\right) > 0 \tag{A.24}$$

To see this define the function $K(\mu) = \frac{1}{\mu} - 1 + \ln\mu$. We have $K(1) = 0$ and $K'(\mu) < 0$ for all $0 < \mu < 1$, which means that $K > 0$ in the interior. Hence $\ln\mu/(1-\mu) \geq -1/\mu$, with strict inequality for all interior μ, and the expression in (A.24) is positive. It is easy to see that:

$$\frac{\partial^2 W(\mu_t + 1(h_i))}{\partial\mu_{t+1}\partial h} = \frac{1}{\gamma}\left(\frac{\partial H}{\partial h} + \frac{\partial W_5}{\partial h}\right) = \frac{1}{\gamma}\left(\frac{1}{(1-\mu_{t+1})}\frac{1}{h} + \frac{(\mu_{t+1})}{(1-\mu_{t+1})^2}\frac{1}{h}\right) > 0 \tag{A.25}$$

which is another way of stating the single crossing property. Since the most preferred system μ_{t+1} of low h_i families is lower, it follows that when the position of the decisive agent p decreases, μ_{t+1} also decreases. Finally, since W_6 increases in ρ_0, μ_{t+1} also increases in this parameter.

Decomposition of Population Slope in (29) and Proof of Claims in Section 4.1

The population coefficient vector is defined as the argument that minimizes the least squares problem in the population

$$(\beta_0, \beta_1) = \arg\min_{\beta} \mathbf{E}\left[(y_{i,t+1} - \beta_0 - \beta_1 y_{i,t})^2\right] \tag{A.26}$$

from which the well known formula for the population slope is given by

$$\beta_1 = \frac{\mathbf{Cov}(y_{i,t+1}, y_{i,t})}{\mathbf{Var}(y_{i,t})} = \frac{\mathbf{Cov}(\delta_0 + \mu_{t+1}(\ln h_i + y_{i,t} + v_{i,t+1} + u_{i,t+1}), y_{i,t})}{\mathbf{Var}(y_{i,t})} \tag{A.27}$$

which, from the imposed stationarity $\mathbf{Var}(y_{i,t+1}) = \mathbf{Var}(y_{i,t})$, also equals the cross sectional intergenerational correlation, $\mathbf{Corr}(y_{i,t+1}, y_{i,t})$. Recalling the properties of $u_{i,t+1}$ and $\epsilon_{i,t+1}$, we have:

$$\beta_1 = \mu_{t+1}\left(1 + \frac{\mathbf{Cov}(v_{i,t+1}, y_{i,t}) + \mathbf{Cov}(\ln h_i, y_{i,t})}{\mathbf{Var}(y_{i,t})}\right) \tag{A.28}$$

The first covariance is still given by (A.12), because the fixed effect h_i is orthogonal to the $v_{i,t+1}$ process. The stationary covariance between the fixed effect and income is given by $\mathbf{Cov}(\ln h_i, y_{i,t}) = \frac{\mu_{t+1}}{1-\mu_{t+1}}\mathbf{Var}(\ln h_i)$. Putting all the pieces together, yields the expression in Proposition 4. After tedious algebra, once can show that β_1 increases in μ.

For the two claims in Section 4.1, we have that the population slope for the talent equation (31) is given by

$$\beta_{1,\theta} = \frac{\mathbf{Cov}(\theta_{i,t+1}, \theta_{i,t})}{\mathbf{Var}(\theta_{i,t})} = \mu_0\left(1 + \frac{\frac{\rho_1\sigma_v^2}{(1-\rho_1^2)(1-\rho_1\mu_0)} + \frac{\mu_0}{1-\mu_0}\mathbf{Var}(\ln h_i)}{\mu_0\mathbf{Var}(\theta_{i,t};\mu_0)}\right) \tag{A.29}$$

where $\mathbf{Var}(\theta_{i,t};\mu_0)$ is the cross sectional variance of talent evaluated at policy μ_0, given by $\mathbf{Var}(\theta_{i,t+1}|h_i)$ in (A.13) plus the term $\frac{1}{(1-\mu_0)^2}\mathbf{Var}(\ln h_i)$ with is the ex ante variance in talent. In deriving this condition we use the old policy μ_0, since in the transmission process for talent (14), μ_t is the relevant coefficient. For the income equation (30) we have

$$\beta_{1,y} = \mu_1\left(1 + \frac{\frac{\rho_1\mu_0\sigma_v^2}{(1-\rho_1^2)(1-\rho_1\mu_0)} + \frac{\mu_0}{1-\mu_0}\mathbf{Var}(\ln h_i)}{\mathbf{Var}(y_{i,t};\mu_0)}\right) \tag{A.30}$$

where we have used the new steady state coefficient in the AR(1) process for income in (7), and $\mathbf{Var}(y_{i,t})$ is given by (23) in the text. From the properties of $u_{i,t+1}$ and the two production functions we have that $\beta_\theta = \mu_0$ and $\beta_y = \mu_1$. Combining these two conditions with (A.29) and (A.30), implies directly our two claims in Section 4.1.

Data Appendix

Our dataset is based on administrative records from Statistics Norway and contains information and all the Norwegian men born in 1932-1933 and on their sons (16462 dynasties). The main source is military records which contain information on the medical and psychological suitability for service in the army of all the young Norwegians, because military service is compulsory in Norway. Thanks to a unique personal identifier this military information has been merged with demographic and economic information from other public registers. Descriptive statistics for our sample are given in Table 1.

Individual incomes are constructed from information on total pension-qualifying earnings reported in the tax registry for all individuals aged at least 16 years old. These are not top-coded and include labor earnings, taxable sick benefits, unemployment benefits, parental leave payments, and pensions. We deflate earnings using the Consumer Price Index for Norway. For fathers we use average incomes earned between the age of 35 and 40, including zero incomes. For sons we use average incomes earned between the age of 30 and 32, again including zero incomes.

We measure talent in two ways. First as the IQ measure contained in the military records. This IQ measure is a composite score from three IQ tests – arithmetic, word similarities, and figures (see Sundet et al. (2005) for details). There is no information available as to how these tests corresponds with other IQ tests although the tests certainly were made based on the standard tests. For a subsample of twins, however, there exist subtest scores for a general Wechsler Adult Intelligence Scale (WAIS) IQ test. Although the data set is relatively small, Tambs et al. (1988) conclude that there is a close relationship between the standard WAIS IQ test and the one used here. Note that our composite IQ score is reported in stanine (Standard Nine) units, a method of standardizing raw scores into a nine point scale with a normal distribution, a mean of 5, and a standard deviation of 2.

While IQ is meant to capture intellectual talent, height is the measure that we use to proxy a more physical dimension of talent. Physical height has been found to be strongly correlated with income by several authors, like Judge and Cable (2004), Persico, Postlewaite, and Silverman (2004) and Case and Paxson (2006). The height of both fathers and sons comes again from military records.

For further information on this dataset see Black, Devereux and Salvanes (2007).

Figure 1: The Production Function (2)

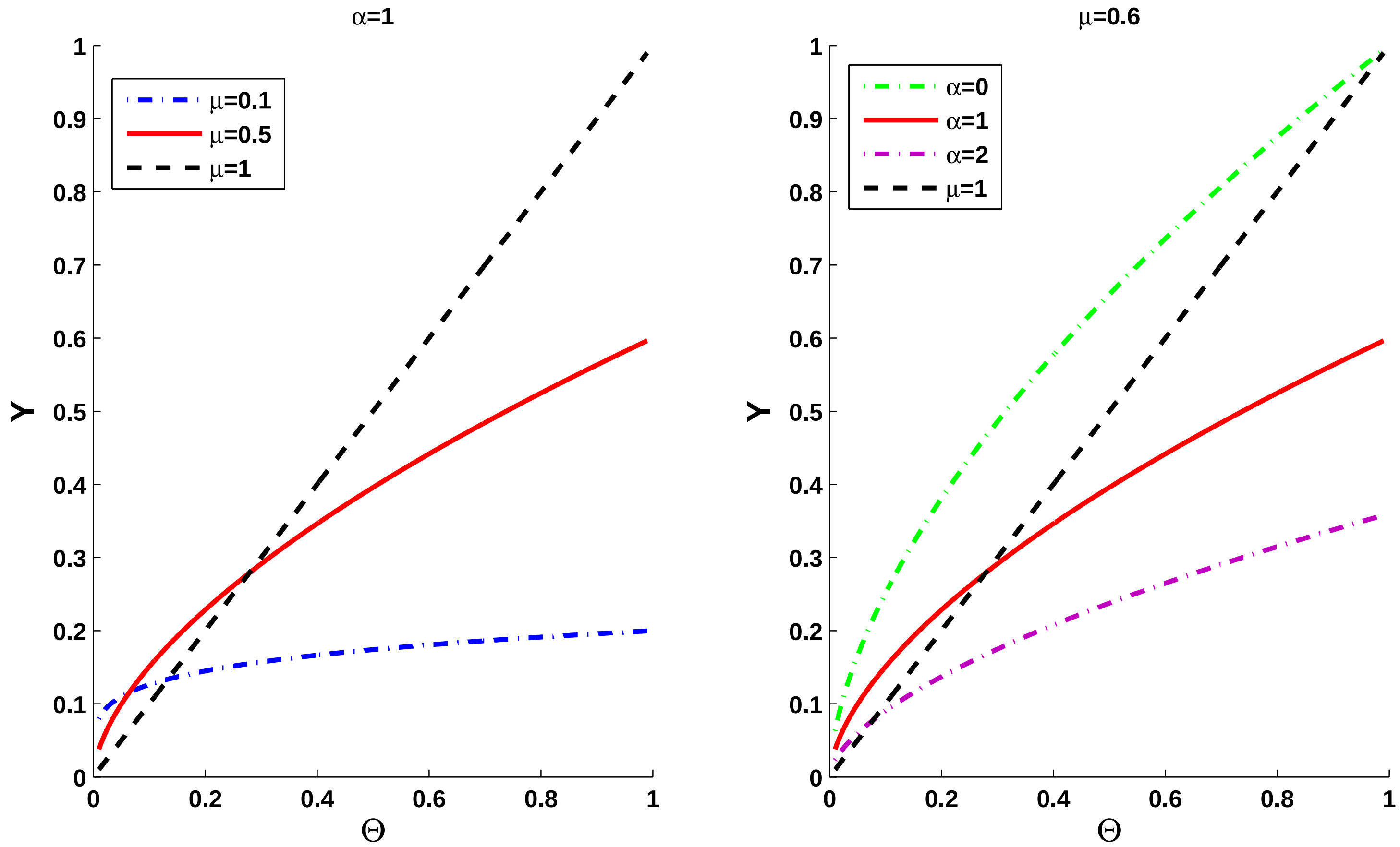

Table 1: Summary statistics

	Fathers	Sons
Year of birth	1932	1962
	(0.5)	(4.2)
IQ	5.2	5.4
	(1.9)	(1.8)
Height	176.6	179.6
	(6.1)	(6.3)
Years of education	10.1	12.3
	(3.0)	2.3)
Log(income)	12.2	12.3
	(0.4)	(0.7)
Number of observations	25150	
Number dynasties	16462	
Number first born	15299	
Number sons per father	1.5	
	(0.7)	

Notes: Fathers' income is computed as the average of the incomes earned between age of 35 and age of 40, including zero incomes. Sons' income is computed as the average of the incomes earned between age of 30 and age of 32, including zero incomes.

Table 2: Intergenerational mobility in income and talent defined as IQ

Model :	1	2	3	4
N. obs:	25150	25150	16462	25150
Depvar:	Sons' Income	Sons' Talent: IQ	Fathers' income	Sons' Income
Fathers' income	0.21			
	(0.01)			
Fathers' talent: IQ		0.37	0.08	
		(0.01)	(0.00)	
Sons' talent: IQ				0.07
				(0.00)
Intercept	9.71	3.48	11.75	11.91
	(0.16)	(0.03)	(0.01)	(0.02)
R-sq	0.015	0.149	0.168	0.037

Notes: Standard errors (in parentheses) are clustered by family.

Table 3: Intergenerational mobility in income and talent defined as IQ: standardized variables

Model :	1	2	3	4
N. obs:	25150	25150	16462	25150
Depvar:	Sons' Income	Sons' Talent: IQ	Fathers' income	Sons' Income
Fathers' income	0.12			
	(0.01)			
Fathers' talent: IQ		0.39	0.41	
		(0.01)	(0.01)	
Sons' talent: IQ				0.19
				(0.01)
Intercept	0.00	0.00	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.01)
R-sq	0.015	0.149	0.168	0.037

Notes: All variables are standardized by subtracting the mean and dividing by the standard deviation, so that for all variables the mean is zero and the variance is 1. This transformation has been implemented also for talent, which, in the original data is standardized with a mean of 5 and a standard deviation of 2. This further standardization explains why the estimates of column 2 in this table differ from those of column 2 in Table 2. Standard errors (in parentheses) are clustered by family.

Table 4: Intergenerational mobility in income and talent defined as height

Model :	1	2	3	4
N. obs:	25150	25150	16462	25150
Depvar:	Sons' Income	Sons' Talent: Height	Fathers' income	Sons' Income
Fathers' income	0.212			
	(0.013)			
Fathers' talent: height		0.491	0.008	
		(0.011)	(0.000)	
Sons' talent: height				0.007
				(0.001)
intercept	9.713	92.928	10.791	11.124
	(0.163)	(1.986)	(0.087)	(0.131)
R-sq	0.015	0.223	0.016	0.004

Notes: Standard errors (in parentheses) are clustered by family.

Table 5: Intergenerational mobility in income and talent defined as Height: standardized variables

Model :	1	2	3	4
N. obs:	25150	25150	16462	25150
Depvar:	Sons' Income	Sons' Talent: Height	Fathers' income	Sons' Income
Fathers' income	0.12			
	(0.01)			
Fathers' talent: Height		0.47	0.12	
		(0.01)	(0.01)	
Sons' talent: Height				0.06
				(0.01)
Intercept	0.00	0.00	0.02*	0.00
	(0.01)	(0.01)	(0.01)	(0.01)
R-sq	0.015	0.223	0.016	0.004

Notes: All variables are standardized by subtracting the mean and dividing by the standard deviation, so that for all variables the mean is zero and the variance is 1. Standard errors (in parentheses) are clustered by family.