Is Equal Opportunity Enough?
A Theory of Persistent Group Inequality*

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Abstract

For a society in transition from group-based hierarchical organization to a regime of equal opportunity one may ask whether group inequality engendered by past discrimination will eventually disappear. The answer is not obvious when ongoing social segregation leads different groups to benefit unequally from human capital spillovers. We identify conditions under which group differences in economic success persist across generations in the absence of either discrimination or group differences in ability, provided that social segregation is sufficient. Moreover, the relationship between long run group inequality and social segregation is characterized by an important discontinuity: there is a threshold level of integration above which group inequality cannot be sustained.

Keywords: segregation, networks, group inequality, human capital

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1 Introduction

Many societies have sustained long periods of hierarchical organization characterized by distinctly unequal economic opportunity for members of different social groups. In the United States during slavery and the Jim Crow period, and in South Africa during Apartheid, group membership based on a system of racial classification was a critical determinant of economic opportunity. In the Indian subcontinent formal caste-based hierarchies have been in place for centuries. In these and many other societies there has been a transition from an explicitly hierarchical mode of organization towards one that is at least notionally egalitarian in the sense of allowing for equal economic opportunity for all social groups. This paper is concerned with the consequences of such a transition. Specifically, we address the following question: given a history of discrimination which has left one group economically disadvantaged relative to another, will a transition to equal opportunity result in eventual convergence in group outcomes?

We show that the answer to this question depends critically on the extent to which social networks continue to remain segregated in the equal opportunity regime. While the vigorous enforcement of anti-discrimination statutes can eradicate discrimination in market interactions, there are many important non-market interactions which lie outside the scope of such laws. For instance, the judicial system cannot regulate discrimination in an individual's own choice of a date, a spouse, an adopted child, a role model, a friend, membership in a voluntary association, or residence in a neighborhood. Since so much of early childhood learning takes place in families and peer-groups, racial segregation in the formation of social networks can have important implications for the perpetuation of group inequality across generations. Voluntary discrimination in *contact* can give rise to persistent group inequality even in the absence of discrimination in *contract*.

The link between social segregation and the dynamics of inequality arises because of interpersonal spillovers in the accumulation of human capital. Human development always and everywhere takes place within a social context, and can be greatly facilitated by access to a social network that is rich in human capital. As noted by Lucas (1988), "human capital accumulation is a *social* activity, involving groups of people in a way that has no counterpart in the accumulation of physical capital." Brock and Durlauf (2001) discuss a number of channels through which such effects may operate, including the possibility that an individual's cost of investing effort in education is decreasing in the investments of his social affiliates. Under these conditions, two individuals with identical ability but belonging to different social groups may make different investment decisions, and group bias in social ties can cause historical group disparities to become locked-in. This can happen even when human capital is perfectly observable (so there is no basis for statistical discrimination), and when investments are not limited by credit constraints.

We explore these interactions in a model of overlapping generations in which all individuals belong to one of two social groups and parents invest in the human capital of their children. There are two occupational categories, one of which requires a higher level of costly human capital investment than the other. Investment costs depend both on an individual's ability and on the level of human capital in one's peer-group. Wages in each period are determined under competitive conditions by the overall distribution of human capital in the economy, and human capital investment decisions are based on anticipated wages. There is no discrimination in the labor market, so wages depend only on one's investment and not on one's group identity, and ability is identically distributed across groups. Nevertheless, if the initial state is one of inequality, members of different groups will invest at different rates when there is some degree of segregation in social networks and peer effects exist. The central question of interest pertains to the limiting properties of equilibrium paths. We show that under certain conditions, there exists a critical level of segregation such that convergence to group equality occurs if and only if segregation lies below this threshold. If segregation lies above the threshold, convergence over time to group equality is impossible from almost any initial state. Hence the relationship between group equality and social segregation is characterized by a discontinuity: a small increase in integration, if it takes the economy across the threshold, can have large effects on long run group inequality, while a large increase in integration that does not cross the threshold could have no persistent effect.

We also examine a special case of the model with inelastic wages and multiple symmetric steady states with varying levels of human capital. Again we find that group inequality can be sustained if and only if segregation is sufficiently high, so integration can be equalizing if it proceeds beyond a threshold. However, since there are multiple steady states with group equality, this raises the question of which one is selected when equalization occurs. Here we find that the population share of the initially disadvantaged group plays a critical role. If this share is sufficiently small, integration can result not only in the equalization of income distributions across groups, but also in an increase in the levels of human capital in *both* groups. Under these conditions integration might be expected to have widespread popular support. On the other hand, if the population share of the initially disadvantaged group is sufficiently large, integration can give rise to a decline in human capital in both groups and, if this result is anticipated, may face widespread popular resistance.

The idea that social segregation is central to understanding the transmission of group inequality across generations dates back to Loury (1977). It has also been explored in some detail by Lundberg and Startz (1998), in the context of a model where community human capital affects both current output and the returns to investment in the human capital of the next generation. They model social groups as essentially distinct economies, except for the possibility that the human capital of the majority group has a spillover effect on the production of human capital in the minority group. The size of this spillover effect is interpreted as the level of segregation. Their model gives rise to equality across groups in the steady state growth rate of income and human capital, although convergence to the steady state may be very slow when segregation is high. Moreover, unless segregation is complete (in which case the two groups function as truly separate economies) there is eventual equalization not just in growth rates but also in income levels. In contrast, we identify conditions under which group equality cannot be sustained no matter how narrow the initial inequality between groups may be. Attempts at equalization in this case will either be futile, or will lead to a reversal of roles and an inversion of the initial hierarchy. In fact, our model shows not only how group inequality can persist, but also how it could emerge from initially group-egalitarian structures.

Our work is also related to the extensive theoretical literature on the intergenerational dynamics of income inequality (Becker and Tomes 1979, Loury 1981, Banerjee and Newman 1993, Galor and Zeira 1993, Mookherjee and Ray 2003). This line of research is concerned with the evolution of the income distribution in a population that consists of a single social group. Individuals differ with respect to their endowments and preferences, but not with respect to their group identities. Moreover, in these models, credit constraints play a critical role in sustaining inequality across generations. We abstract here from credit constraints, with the result that inequality *within* groups arises simply due to within group differences in endowed ability. Introducing credit constraints into our model would constitute an interesting extension, and might yield insights into the interplay between within-group and between-group inequality.

In order to better focus on the consequences of equal opportunity, we abstract here from all forms of discrimination in contractual relations, whether motivated by hostility as in Becker (1957), or by incomplete information about individual productivity as in the theory of statistical discrimination (Arrow, 1973, Phelps, 1972, Aigner and Cain, 1977). Our point is that even in the complete absence of such discriminatory practices, group inequality can persist indefinitely as long as social segregation endures. This finding is relevant to the debate over the appropriate policy response to a history of overt discrimination. Procedural or rule-oriented approaches emphasize the vigorous enforcement of anti-discrimination statutes and the establishment of equal opportunity. Substantive or results-oriented approaches advocate group-redistributive remedies such as affirmative action or reparations. Our results suggest that there are conditions under which group inequality will persist indefinitely even in the face of equal economic opportunity. While this does not imply that group-redistributive policies should be adopted, it does mean that a failure to adopt them can result in persistent divergence across groups in economic outcomes. If group equality is a policy goal, equal opportunity may not be enough to secure it.

2 The Model

Consider a society that exists over an infinite sequence of generations and at any date $t = 0, 1, ...$ consists of a continuum of workers of unit measure. The workers live for two periods acquiring human capital in the first period of life and working for wages in the second. The generations overlap, so that each young worker (i.e. the child) is attached to an older worker (the parent). For convenience, we assume that each worker has only one child. There are two occupations, of which one requires skilled workers while the other may be performed by unskilled workers. Total output in period t is given by the production function $f(h_t, l_t)$, where h_t is the proportion of workers assigned to high-skill jobs, and $l_t = 1 - h_t$. Only workers who have invested in human capital can be assigned to high skill jobs, so $h_t \leq s_t$, where s_t is the proportion of the population that is qualified to perform skilled jobs at date t. The production function satisfies constant returns to scale, diminishing marginal returns to each factor, and the conditions $\lim_{s \to 0} f_1 = \lim_{s \to 1} f_2 = \infty$. Given these assumptions the marginal product of high (low) skill workers is strictly decreasing (increasing) in h_t. The $\tilde{h}$ denote the value of h at which the two marginal products are equal. Since qualified workers can be assigned to either occupation, we must have $h_t = \min\{s_t, \tilde{h}\}$. Wages earned by high and low skill workers are equal to their respective marginal products, and are denoted $w_h(s_t)$ and $w_l(s_t)$ respectively. The wage differential $\delta(s_t) = w_h(s_t) - w_l(s_t)$ is positive and decreasing in s_t provided that $s_t < \tilde{h}$, and satisfies $\lim_{s \to 0} \delta(s) = \infty$. Furthermore, $\delta(s) = 0$ for all $s \geq \tilde{h}$. Since investment in human capital is costly, $s_t \geq \tilde{h}$ will never occur along an equilibrium path.

The population of workers consists of two disjoint groups, labelled 1 and 2, having population shares β and $1 - \beta$ respectively. Let s_t^1 and s_t^2 denote the two within-group (high) skill shares at date t. The mean skill share in the overall population is then

$$s_t = \beta s_t^1 + (1-\beta)\, s_t^2. \tag{1}$$

The costs of skill acquisition are subject to human capital spillovers and depend on the skill level among one's set of social affiliates. These costs may therefore differ across groups if the within-group skill shares differ, and if there is some degree of segregation in social contact. In a perfectly integrated society, the mean level of human capital in one's social network would simply equal s_t on average, regardless of one's own group membership. When networks are characterized by some degree of assortation, however, the mean level of human capital in the social network of an individual belonging to group i will lie somewhere between one's own-group skill share and that of the population at large. Suppose that for each individual, a proportion η of social affiliates is drawn from the group to which he belongs, while the remaining $(1-\eta)$ are randomly drawn from the overall population. We assume that η is the same for both groups. Then a proportion $\eta + (1-\eta)\,\beta$ of a group 1 individual's social affiliates will also be in group 1, while a proportion $\eta + (1-\eta)\,(1-\beta)$ of a group 2 individual's affiliates will be in group 2. These proportions are referred to as isolation indexes in the empirical segregation literature.

The parameter η is sometimes refereed to as the *correlation ratio* (Denton and Massey, 1988). In the Texas schools studied by Hanushek, Kain, and Rivkin (2002), for example, 39 percent of black third grade students' classmates were black, while 81 percent of white students classmates were white, which yields an estimate of $\eta = 0.2$. The relevant social network depends on the question under study: for the acquisition of human capital, parents and (to a lesser extent) siblings and other relatives are among the strongest influences. Because family members are most often of the same group, the social networks relevant to our model may be very highly segregated.

Let σ_t^i denote the mean level of human capital in the social network of an individual belonging to group $i \in \{1, 2\}$ at time t. This depends on the levels of human capital in each of the two groups, as well as the extent of segregation η as follows:

$$\sigma_t^i = \eta s_t^i + (1-\eta)\, s_t. \tag{2}$$

Except in the case of perfect integration ($\eta = 0$), σ_t^1 and σ_t^2 will differ as long as s_t^1 and s_t^2 differ.

The costs of acquiring skills depend on one's ability, as well as the mean human capital within one's social network. By 'ability' we do not mean simply learning capacity, or cognitive measures such as IQ, but rather any personal characteristic of the individual affecting the costs of acquiring human capital, including such things as the tolerance for classroom discipline or the anxiety one may experience in school. The distribution of ability is assumed to be the same in the two groups, consistent with Loury's (2002) axiom of anti-essentialism. Hence any differences across groups in economic behavior or outcomes arise endogenously in the model, and cannot be traced back to any differences in fundamentals. The (common) distribution of ability is given by the distribution function $G(a)$, with support $[0, \infty)$. Let $c(a, \sigma)$ denote the costs of acquiring human capital, where c is non-negative and bounded, strictly decreasing in both arguments, and satisfies $\lim_{a \to \infty} c(a, \sigma) = 0$ for all $\sigma \in [0, 1]$.

The benefit of human capital accumulation is simply the wage differential $\delta(s_t)$, which is identical across groups. That is, there is no unequal treatment of groups in the labor market. Individuals acquire human capital if the cost of doing so is less than the wage differential. (Note that the costs are incurred by parents while the benefits accrue at a later date to their children. Hence we are assuming that parents fully internalize the preferences of their children.) Thus the skill shares s_t^i in period t are determined by the investment choices made in the previous period, which in turn depend on the social network human capital σ_{t-1}^i in the two groups, as well as the anticipated future wage differential $\delta(s_t)$. Specifically, for each group i in period $t-1$, there is some threshold ability level $\tilde{a}(\delta(s_t), \sigma_{t-1}^i)$ such that those with ability above this threshold accumulate human capital and those below do not. This threshold is defined implicitly as the value of $\tilde{a}$ that satisfies

$$c(\tilde{a}, \sigma_{t-1}^i) = \delta(s_t) \tag{3}$$

Note that $\tilde{a}(\delta(s_t), \sigma_{t-1}^i)$ is decreasing in both arguments. Individuals acquire skills at lower ability thresholds if the expect a greater wage differential, or if their social networks are richer in human capital. The share of each group i that is skilled in period t is simply the fraction of the group that has ability greater than $\tilde{a}(\delta(s_t), \sigma_{t-1}^i)$. Thus we obtain the following dynamics:

$$s_t^i = 1 - G(\tilde{a}(\delta(s_t), \sigma_{t-1}^i), \tag{4}$$

for each $i \in \{1, 2\}$. Given an initial state (s_0^1, s_0^2), a *competitive equilibrium path* is a sequence of skill shares $\left\{(s_t^1, s_t^2)\right\}_{t=1}^{\infty}$ that satisfies (1–4).

The following result rules out the possibility that there may be multiple equilibrium paths originating at a given initial state (all proofs are collected in the appendix).

Proposition 1. *Given any initial state* $(s_0^1, s_0^2) \in [0, 1]^2$, *there a unique competitive equilibrium path* $\left\{(s_t^1, s_t^2)\right\}_{t=1}^{\infty}$. *Furthermore, if* $s_0^1 \leq s_0^2$, *then* $s_t^1 \leq s_t^2$ *for all* t *along the equilibrium path.*

Proposition 1 ensures that the group with initially lower skill share, which may assume without loss of generality to be group 1, cannot "leapfrog" the other group along an equilibrium path. A key question of interest here is whether or not, given an initial state of group inequality ($s_0^1 < s_0^2$), the two skill shares will converge asymptotically ($\lim_{t\to\infty} s_t^1 = \lim_{t\to\infty} s_t^2$).

3 Steady States and Stability

A competitive equilibrium path is a *steady state* if $(s_t^1, s_t^2) = (s_0^1, s_0^2)$ for all periods t. Of particular interest are *symmetric* steady states, which satisfy the additional condition $s_t^1 = s_t^2$. At any symmetric steady state, the common skill share s_t must be a solution to

$$s = 1 - G(\tilde{a}(\delta(s), s)).$$

Since costs are bounded and $\lim_{s\to 0} \delta(s) = \infty$, we have $\lim_{s\to 0} \tilde{a}(\delta(s), s) = 0$. And since $\delta(1) = 0$, $\lim_{s\to 1} \tilde{a}(\delta(s), s) = \infty$. Hence there must exist at least one symmetric steady state. There will be exactly one such steady state if $\tilde{a}(\delta(s), s)$ is strictly increasing in s, which will be the case if peer effects are not so strong as to overwhelm the general equilibrium impacts of higher skill shares on relative wages. A necessary and sufficient condition for uniqueness is that the following is satisfied at each steady state:

$$\tilde{a}_1\delta' + \tilde{a}_2 > 0, \tag{5}$$

where $\tilde{a}_1$ and $\tilde{a}_2$ denote the partial derivatives of $\tilde{a}$ with respect to its two arguments. Condition (5) precludes situations in which the improved peer effects of an increase in the high skill share reduce the costs of human capital investment by enough to offset the reduced incentive entailed by the associated reduction in wage differentials. Note that this need not be the case globally: as long as (5) is satisfied at each symmetric steady state, there can be only one such state. We shall assume for the moment that this is indeed the case, and consider the multiplicity of symmetric steady states in the section to follow.

As a benchmark, consider the case in which the population consists of a single group rather than two. Then the dynamics (4) simplify to the one-dimensional system

$$s_t = 1 - G(\tilde{a}(\delta(s_t), s_{t-1}). \tag{6}$$

In this case, condition (5) implies not just the uniqueness of the steady state, but also its local asymptotic stability:

Proposition 2. *Suppose (5) is satisfied and the population consists of a single group. Then there is a unique and locally asymptotically stable steady state.*

An immediate corollary of this is that in the two group model, if the human capital shares in the two groups are initially identical and sufficiently close to the unique symmetric steady state, the economy will converge to that state. This need not be the case, however, if the initial state is one with group inequality, as the following example illustrates.

Example 1. Suppose $\beta = 0.25$, $f(h, l) = h^{0.7}l^{0.3}$, $G(a) = 1 - e^{-0.1a}$, and $c(a, \sigma) = 1 - \sigma + 1/a$. Then there is a unique symmetric steady state $(s^1, s^2) = (0.26, 0.26)$. There exists $\hat{\eta} \approx 0.21$ such that if $\eta < \hat{\eta}$ the symmetric steady state is locally asymptotically stable, and if $\eta > \hat{\eta}$ the symmetric steady state is locally unstable. (Figure 1 shows the paths of investment shares for $\eta = 0.10$ and $\eta = 0.30$ respectively.)

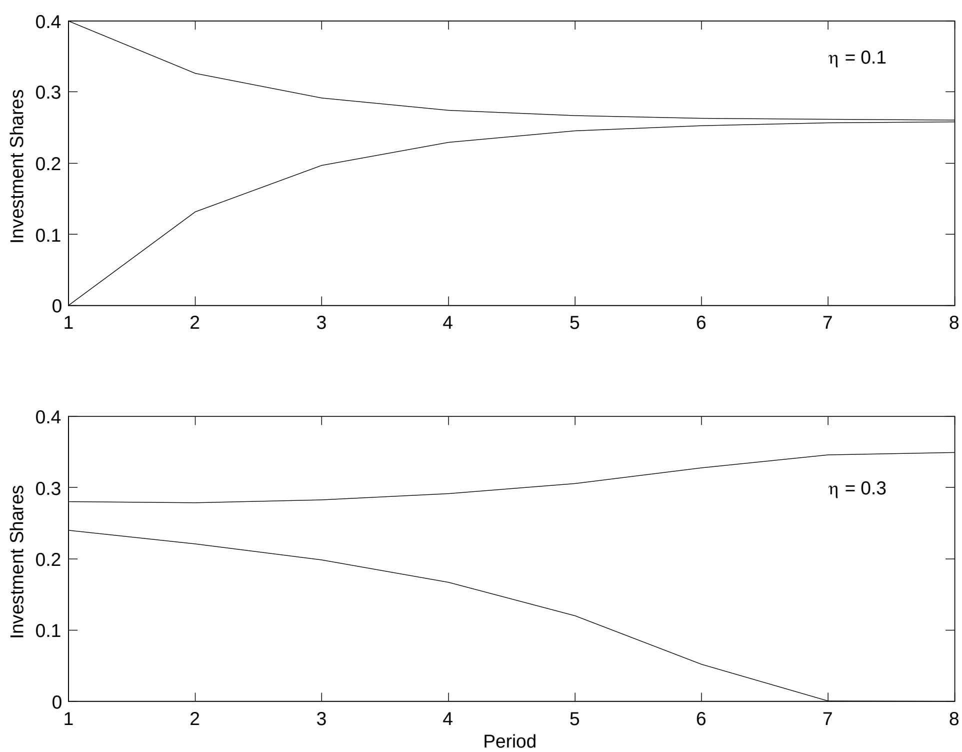

Figure 1. Dynamics of investment shares for two different segregation levels.

Example 1 illustrates that, starting from a state in which the two groups are unequal with respect to human capital investment, group inequality can persist indefinitely if the level of segregation is sufficiently high. In this example, a small increase in integration can destabilize an asymmetric steady state and result in a transition to equality. This lowers skill levels among the initially advantaged group but raises them among the initially disadvantaged. The effect on the overall skill share and wages is ambiguous in general. There is a loss in welfare for those in group 2 who invest in the asymmetric steady state (regardless of whether or not they continue to invest in the symmetric steady state). This is because their costs of investment rise. Similarly, there is a gain in welfare for those in group 1 who invest in the symmetric steady state (regardless of whether or not they invested in the asymmetric steady state).

This example illustrates a robust phenomenon that holds under quite general conditions. Since there exists a unique competitive equilibrium path from any initial state (s_0^1, s_0^2), we may write (4) as a recursive system:

$$s_t^i = f^i(s_{t-1}^1, s_{t-1}^2), \tag{7}$$

where

$$f^i = 1 - G(\tilde{a}(\delta(\beta f^1 + (1-\beta) f^2), \eta s_{t-1}^i + (1-\eta)(\beta s_{t-1}^1 + (1-\beta) s_{t-1}^2)). \tag{8}$$

Note that condition (5), which ensures uniqueness of the symmetric steady state, implies that $G' \tilde{a}_1 \delta' > G' |\tilde{a}_2|$. In addition to this, we assume

$$G' |\tilde{a}_2| > 1. \tag{9}$$

This assumption states that, at the symmetric steady state, the effect of an increase in the level of human capital in one's peer-group on the proportion who choose to invest is not too small. This could be because the ability threshold is sufficiently responsive to changes in peer-group quality and/or because the distribution function is steep at this state. Unless (9) holds, the symmetric steady state will be locally asymptotically stable at all levels of segregation. Our main result is the following.

Theorem 1. *There exists a level of segregation* $\hat{\eta} \in (0,1)$ *such that the unique symmetric steady state is locally asymptotically stable if* $\eta < \hat{\eta}$, *and unstable if* $\eta > \hat{\eta}$.

Theorem 1 implies that when segregation is sufficiently great, group equality cannot be attained even asymptotically, no matter what the initial conditions may be. Initial disparities will persist even under a regime of fully enforced equal opportunity. Moreover, even group-redistributive policies can only maintain group equality as long as they are permanently in place. Any temporary policy of redistribution will either be futile in the long run, or result in a reversal of roles in the social hierarchy. On the other hand, a policy of social integration can stabilize the symmetric steady state and give rise over time to a convergence of incomes across groups, provided that the policy is effective in raising the level of integration beyond the required threshold. We discuss the feasibility of such a policy below, but first examine the possibility of multiple symmetric steady states.

4 Multiplicity and Coordination

We have assumed to this point that there is a unique symmetric steady state. But if condition (5) fails to hold, there may be multiple symmetric steady states, which raises the question of which one is selected when integration results in equality of group outcomes. It turns out that the population share of the initially disadvantaged group plays a critical role in this regard.

In order to allow for multiplicity of symmetric steady states, (5) must be violated. This happens trivially if relative wages are completely inelastic: $\delta(s_t) = \overline{\delta}$ for all periods t. In this case the dynamics of skill shares satisfy

$$s_t^i = 1 - G(\tilde{a}(\overline{\delta}, \sigma_{t-1}^i).$$

Consider the case of complete segregation, corresponding to $\eta = 1$. In this case $\sigma_t^i = s_t^i$ for each group i and so

$$s_t^i = 1 - G(\tilde{a}(\overline{\delta}, s_{t-1}^i)). \tag{10}$$

In any steady state, we must have

$$s_t^i = 1 - G(\tilde{a}(\overline{\delta}, s_t^i)), \tag{11}$$

for all t, so group inequality can persist if and only if (11) admits multiple solutions. In general the existence of multiple solutions will depend on details of the distribution and cost functions which we will explore presently. But to clarify the logic of the argument, we begin with a simple case in which all individuals have the same ability.

Suppose that all individuals have the same ability $\bar{a}$, so the cost function is $c(\bar{a}, \sigma)$. In this case the only stable steady states involve homogeneous skill levels within groups. (There may exist equilibria in which members of a group are all indifferent between acquiring human capital and not doing so, and make heterogeneous choices in the exact proportions that maintain this indifference, but such equilibria are dynamically unstable.) Suppose that

$$c(\bar{a}, 1) < \overline{\delta} < c(\bar{a}, 0), \tag{12}$$

which ensures that both $\left(s^1, s^2\right) = (0,0)$ and $\left(s^1, s^2\right) = (1,1)$ are stable steady states at all levels of segregation η. Condition (12) also implies that under complete segregation ($\eta = 1$), the skill distribution $\left(s^1, s^2\right) = (0,1)$ is a stable steady state. Define $\tilde{\beta}$ as the group 1 population share at which $c(\bar{a}, 1-\tilde{\beta}) = \bar{\delta}$. This is the value of β for which, under complete integration, the costs of acquiring human capital are $\bar{\delta}$ for both groups. (This is because, if $\eta = 0$ and $\left(s^1, s^2\right) = (0,1)$, then $\sigma^i = 1 - \beta$ for both groups.) There is a unique $\tilde{\beta} \in (0,1)$ satisfying this condition since $c\left(\bar{a}, \sigma\right)$ is decreasing in σ and satisfies (12). We then have

Proposition 3. *Given any* $\beta \in (0,1)$, *there exists a unique* $\hat{\eta}(\beta)$ *such that the stable asymmetric equilibrium* $\left(s^1, s^2\right) = (0,1)$ *exists if and only if* $\eta > \hat{\eta}(\beta)$. *The function* $\hat{\eta}(\beta)$ *is positive and decreasing for all* $\beta < \tilde{\beta}$, *positive and increasing for all* $\beta > \tilde{\beta}$, *and satisfies* $\hat{\eta}(\tilde{\beta}) = 0$.

Hence group inequality can persist if segregation is sufficiently high, where the threshold level of segregation itself depends systematically on the population share β of the disadvantaged group. If segregation declines to a point below this threshold, group inequality can no longer be sustained. In this case convergence to a symmetric steady state must occur. However, there are two of these in the model, since both $\left(s^1, s^2\right) = (0,0)$ and $\left(s^1, s^2\right) = (1,1)$ are stable steady states at all levels of segregation η. Convergence to the former implies that equality is attained through declines in the human capital of the initially advantaged group. Convergence to the latter, in contrast, occurs through increases in the human capital of the initially disadvantaged group. The following result establishes that convergence to the high human capital state occurs if and only if the population share of the initially disadvantaged group is sufficiently low.

Proposition 4. *Suppose that the economy initially has segregation* $\eta > \hat{\eta}(\beta)$ *and is at the stable steady state* $\left(s^1, s^2\right) = (0,1)$. *If segregation declines to some level* $\eta < \hat{\eta}(\beta)$, *then the economy converges to* $\left(s^1, s^2\right) = (1,1)$ *if* $\beta < \tilde{\beta}$, *and to* $\left(s^1, s^2\right) = (0,0)$ *if* $\beta > \tilde{\beta}$.

Propositions 3-4 are summarized in Figure 2, which identifies three regimes in the space of parameters β and η. For any value of β (other than $\tilde{\beta}$), there is a segregation level $\hat{\eta}(\beta) \in (0,1)$ such that group inequality can persist only if segregation lies above this threshold. If segregation drops below the threshold, the result is a sharp adjustment in human capital and convergence to equality. This convergence can result from a decline in the human capital of the initially advantaged group if the population share of the initially disadvantaged group is large enough (i.e. $\beta > \tilde{\beta}$). Alternatively, it can result from a rise in the human capital of the disadvantaged group if it's population share is sufficiently small. The threshold segregation level itself varies with β non-monotonically. When β is small, $\hat{\eta}(\beta)$ is the locus of pairs of η and β such that $c(\bar{a}, \sigma^1) = \bar{\delta}$ at the state $(s^1, s^2) = (0, 1)$. Increasing β lowers σ^1 and hence raises $c(\bar{a}, \sigma^1)$, which implies that $c(\bar{a}, \sigma^1) = \bar{\delta}$ holds at a lower level of η. Hence $\hat{\eta}(\beta)$ is decreasing in this range, implying that higher values β require higher levels of integration before the transition to equality is triggered. When β is larger than $\tilde{\beta}$, however, $\hat{\eta}(\beta)$ is the locus of pairs of η and β such that $c(\bar{a}, \sigma^2) = \bar{\delta}$ at the state $(s^1, s^2) = (0, 1)$. Increasing β lowers σ^2 and hence raises $c(\bar{a}, \sigma^2)$, which implies that $c(\bar{a}, \sigma^2) = \bar{\delta}$ holds at a higher level of η. Hence $\hat{\eta}(\beta)$ is increasing in this range, and higher values of β require lower levels of integration in order to induce the shift to equality.

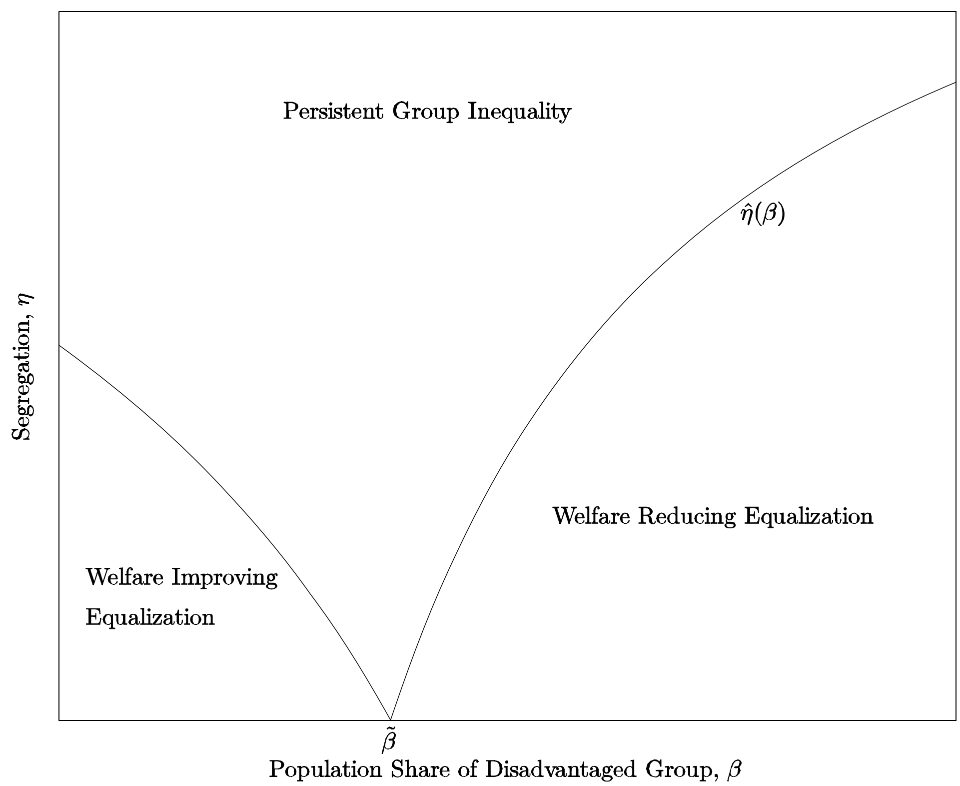

Figure 2. Effects of segregation and population shares on persistent inequality

Greater integration within the regime of persistent inequality raises the costs to the advantaged group and lowers costs to the disadvantaged group. Hence one might expect integration to be resisted by the former and supported by the latter. Note, however, that this is no longer the case if a transition to a different regime occurs. In this case, when β is small, both groups end up investing in human capital as a consequence of integration. But when β is large, integration policies that reduce η below $\hat{\eta}(\beta)$ will result in higher steady state costs of human capital accumulation for both groups, with the consequence that no human capital investment is undertaken. Hence *both* groups have an incentive to support integrationist policies if β is small, and both might resist such policies if β is large. (This effect arises also in Chaudhuri and Sethi, 2003, which deals with the consequences of integration in the presence of statistical discrimination.)

The simple model with homogeneous ability delivers a number of insights, but also has several shortcomings. There is no behavioral heterogeneity within groups, and all steady states are at the boundaries of the state space. Changes in segregation only affect human capital decisions if they result in a transition from one regime to another; within a given regime changes in social network quality affect costs but do not induce any behavioral response. Furthermore, even when transitions to another regime occur, human capital decisions are affected in only one of the two groups. Finally, convergence to a steady state occurs in a single period. These shortcomings do not arise when the model is generalized to allow for heterogeneous ability within groups, which we consider next.

When ability is heterogenous within groups (though distributed identically across groups), steady states will typically involve heterogeneous choices within each of the groups. As noted above, multiple steady states will exist under complete segregation if and only if there are multiple solutions to equation (11). Given our assumptions on the cost function, $G(\tilde{a}(\bar{\delta}, 0)) < 1$ and $G(\tilde{a}(\bar{\delta}, 1)) < 0$. This implies that (11) must have an odd number of solutions for generic parameter values, so if there are multiple solutions there must be at least three. We shall assume that there are precisely three, and let s^l and s^h respectively denote the smallest and largest solutions. Then there are two stable symmetric steady states (s^h, s^h) and (s^h, s^h) at all levels of segregation η, and the pair (s^l, s^h) is an asymmetric stable steady state when $\eta = 1$. There will also be *unstable* symmetric steady state at (s^m, s^m), where $s^m \in (s^l, s^h)$ is the intermediate solution to (11). Now consider the effects of increasing integration, starting from this state. For any given population composition β, we shall say that integration is *equalizing* and *welfare-improving* if there exists some segregation level $\hat{\eta}(\beta)$ such that for all $\eta < \hat{\eta}(\beta)$ there is no stable asymmetric steady state, and the initial state (s^l, s^h) is in the basin of attraction of the high-investment symmetric steady state (s^h, s^h). Similarly, we shall say that integration is *equalizing* and *welfare-reducing* if there exists some segregation level $\hat{\eta}(\beta)$ such that for all $\eta < \hat{\eta}(\beta)$ there is no stable asymmetric steady state, and (s^l, s^h) is in the basin of attraction of the low-investment symmetric steady state (s^l, s^l). We then have the following result.

Theorem 2. *There exist* $\beta_l > 0$ *and* $\beta_h < 1$ *such that (i) integration is equalizing and welfare-*

improving if $\beta < \beta_l$ *and (ii) integration is equalizing and welfare-reducing if* $\beta > \beta_h$.

When local complementarities in the accumulation of human capital are strong enough to allow for multiple stable steady states under complete segregation, integration can have dramatic effects on steady state levels of human capital. Once a threshold level of integration is crossed, asymmetric steady states may fail to exist, resulting in a transition to equality. As in the case of homogeneous ability, this can happen in one of two ways: through a sharp decline in the human capital of the previously advantaged group, or through a sharp increase in the human capital of the previously disadvantaged group. If the population share of the initially less affluent group is small enough, integration can result in group parity (meaning that equally able individuals acquire similar levels of human capital) and higher average incomes for both groups. Under these conditions, one should expect broad popular support for integrationist policies. On the other hand, if the initially disadvantaged group constitutes a large proportion of the total population, parity may be still attained through integration but at the cost of income, as costs are higher and human capital levels in both groups decline.

Thus integration may benefit the disadvantaged group without harming the advantaged group, as is suggested by the empirical analysis by Cutler and Glaeser (1997) of the relationship between segregation and high school graduation rates. But integration may also harm both groups. Thus the challenges facing policy makers in an urban area such as Baltimore are quite different from those in Bangor or Burlington. Similarly the challenges of assuring group-equal opportunity are quite different in New Zealand, where 15 percent of the population are Maori and South Africa where the disadvantaged African population constitutes 78 percent of the total.

5 Discussion

The theoretical arguments developed here apply quite generally to any society in transition from a regime of overt discrimination to one of equal opportunity. In particular, they apply to the case of racial division in the United States. In *Brown v. Board of Education* the U.S. Supreme Court (1954) struck down laws enforcing racial segregation of public schools on the grounds that 'separate educational facilities are inherently unequal'. Many hoped that the demise of legally enforced segregation and discrimination against African Americans during the 1950s and 1960s, coupled with the apparent reduction in racial prejudice among whites would provide an environment in which significant social and economic racial disparities would not persist. But while substantial racial convergence in earnings and incomes did occur from the 50s to the mid-70s, little progress has since been made. For example, the strong convergence in median annual income of full time year round male and female African American workers relative to their white counterparts that occurred between the 1940s and the 1970s was greatly attenuated or even reversed since the late 70s (President's Council of Economic Advisors, 1991 and 2006). Conditional on the income of their parents, African-Americans receive incomes substantially (about a third) below those of whites, and this intergenerational race gap has not diminished appreciably over the past two decades (Hertz, 2005). Similarly, the racial convergence in years of schooling attained and cognitive scores at given levels of schooling that occurred prior to 1980 appears not to have continued subsequently (Neal, 2005). Significant racial differences in mortality, wealth, subjective well being, and other indicators also persist (Deaton and Lubotsky, 2003, Wolff, 1998, Blanchflower and Oswald, 2004).

Enduring discriminatory practices in markets are no doubt part of the explanation (Bobo et al., 1997, Greenwald et al., 1998, Antonovics 2002, Bertrand and Mullainathan, 2004, Quillian, 2006). Even in the absence of any form of market discrimination, however, there are mechanisms through which group inequality may be sustained indefinitely. Racial segregation of friendship networks, mentoring relationships, neighborhoods, workplaces and schools places the less affluent group at a disadvantage in acquiring the things – contacts, information, cognitive skills, behavioral attributes – that contribute to economic success. We know from Schelling (1971) and the subsequent literature that equilibrium racial sorting does not require overt discrimination and may occur even with pro-integrationist preferences (Young 1998, Sethi and Somanathan 2004). Preferentially associating with members of one's own kind (known as homophily) is a common human trait (Tajfel, Billig, Bundy, and Flament, 1971) and is well documented for race and ethnic identification, religion, and other characteristics. A survey of recent empirical work reported that:

> We find strong homophily on race and ethnicity in a wide range of relationships, ranging from the most intimate bonds of marriage and confiding, to the more limited ties of schoolmate friendship and work relations, to the limited networks of discussion about a particular topic, to the mere fact of appearing in public or 'knowing about' someone else... Homophily limits peoples' social worlds in a way that has powerful implications for the information they receive, the attitudes they form, and the interactions they experience (McPherson, Smith-Lovin, and Cook, 2001, pp. 415, 420).

In a nationally representative sample of 130 schools (and 90,118 students) same-race friendships were almost twice as likely as cross-race friendships, controlling for school racial composition (Moody, 2001). In this sample, by comparison to the friends of white students, the friends of African American students had significantly lower grades, attachment to school, and parental socioeconomic status. There is also evidence that peer effects such as penalties for 'acting white' among African American students can provide disincentives for academic achievement (Fryer and Torelli, 2005).

While there are many channels through which the racial assortation of social networks might disadvantage members of the less well of group, statistical identification of these effects often is an insurmountable challenge. The reason is that networks are selected by individuals and as a result plausible identification strategies for the estimation of the causal effect of exogenous variation in the composition of an individual's networks are difficult to devise. Hoxby (2000) and Hanushek, Kain, and Rivkin (2002) use the year-to-year cohort variation in racial composition within grade and school to identify racial network effects, finding large negative effects of racial assortation on the academic achievement of black students. Studies using randomized assignment of college roommates have also found some important behavioral and academic peer effects (Kremer and Levy, 2003, Sacerdote, 2001, Zimmerman and Williams, 2003). A study of annual work hours using longitudinal data and individual fixed effects found strong neighborhood effects especially for the least well educated individuals and the poorest neighborhoods (Weinberg et al., 2004). An experimental study documents strong peer effects in a production task, particularly for those with low productivity in the absence of peers (Falk and Ichino, 2004).

The combined effect of interpersonal spillovers in human capital accumulation and own-group bias in the formation of social networks is the persistence across generations of group inequality. We have shown that under certain conditions there is a unique and locally unstable symmetric steady state which implies that equal opportunity alone cannot ensure the convergence of group outcomes even in the long run. In fact, when there is no stable state with group equality, even group-redistributive policies cannot result in long run equalization unless they are sustained indefinitely. The only viable solution in this case appears to be a commitment to integration.

But how much greater integration be accomplished in practice? In other words, are there non-paternalistic ways in which a policy maker could legitimately alter patterns of sorting in the formation of social connections? We think that there are. First, under quite general conditions equilibrium sorting produces levels of segregation that are Pareto-inefficient in the sense that an arbitrary reduction in segregation could enhance the well being of members of both groups (Schelling, 1978). In this case policies to reduce, say, neighborhood segregation do not override individual preferences over aggregate outcomes, but rather allow for their greater satisfaction. Second, segregated networks may be the unintended result of current policies. For example the degree of racial segregation of friendship networks in schools appears to be affected by the extent of tracking, the degree of cross grade mixing, and the extent of racial mixing in extracurricular activities, all of which are subject to alteration by school policies (Moody, 2001). However, the most important social affiliates for the formation of human capital are parents and siblings, and these kin networks remain highly segregated. As long as assortative matching continues to prevail in marriage and child rearing, there may be quite stringent limits to the degree to which segregation of the relevant networks can be reduced.

Appendix

Proof of Proposition 1. Suppose $(s_0^1, s_0^2) \in [0,1]^2$ is given. Then, using (1) and (2), $s_0 \in [0,1]$ and $(\sigma_0^1, \sigma_0^1) \in [0,1]^2$ are uniquely defined. Define the function $\varphi(s)$ as follows:

$$\varphi(s) = \beta(1 - G(\tilde{a}(\delta(s), \sigma_{t-1}^1))) + (1-\beta)(1 - G(\tilde{a}(\delta(s), \sigma_{t-1}^2))).$$

Note that $\varphi(0) = 1$, $\varphi(1) = 0$ and $\varphi(s)$ is strictly decreasing. Hence, given (σ_0^1, σ_0^2), there exists a unique value of s such that $s = \varphi(s)$. Note from (1) and (4) that in equilibrium, s_1 must satisfy $s_1 = \varphi(s_1)$, so s_1 is uniquely determined. The pair (s_1^1, s_1^2) is then also uniquely determined from (4). The second claim follows from (4) and (2), since $\tilde{a}$ is decreasing in its second argument. ■

Proof of Proposition 2. If (5) is satisfied, then there is a unique steady state in the single group case. From Proposition 1, there exists a unique competitive equilibrium path for any initial condition s_0, which we may write as $s_t = f(s_{t-1})$. A necessary and sufficient condition for stability of the steady state is that $|f'| < 1$ at this state. Write (6) as follows:

$$f(s_{t-1}) = 1 - G(\tilde{a}(\delta(f(s_{t-1})), s_{t-1}).$$

Hence $f' = -G'(\tilde{a}_1 \delta' f' + \tilde{a}_2)$. Using this, together with (5), we get

$$|f'| = \frac{G' |\tilde{a}_2|}{1 + G' \tilde{a}_1 \delta'} < \frac{G' |\tilde{a}_2|}{1 + G' |\tilde{a}_2|} < 1$$

at the unique steady state. Hence the steady state is locally stable. ■

Proof of Theorem 1. The stability of the (unique) symmetric steady state under the dynamics (7) depends on the properties of the Jacobean

$$J = \begin{bmatrix} f_1^1 & f_2^1 \\ f_1^2 & f_2^2 \end{bmatrix}$$

evaluated at the steady state. Specifically the state is stable if all eigenvalues of J lie within the unit circle, and unstable if at least one eigenvalue lies outside it. From (8), we get

$$f_1^1 = -G' \left(\tilde{a}_1 \delta' \left(\beta f_1^1 + (1-\beta) f_1^2 \right) + \tilde{a}_2 \left(\eta + (1-\eta) \beta \right) \right) \quad (13)$$

$$f_2^1 = -G' \left(\tilde{a}_1 \delta' \left(\beta f_2^1 + (1-\beta) f_2^2 \right) + \tilde{a}_2 (1-\eta)(1-\beta) \right) \quad (14)$$

$$f_1^2 = -G' \left(\tilde{a}_1 \delta' \left(\beta f_1^1 + (1-\beta) f_1^2 \right) + \tilde{a}_2 (1-\eta) \beta \right) \quad (15)$$

$$f_2^2 = -G' \left(\tilde{a}_1 \delta' \left(\beta f_2^1 + (1-\beta) f_2^2 \right) + \tilde{a}_2 \left(\eta + (1-\eta)(1-\beta) \right) \right) \quad (16)$$

For $i \in \{1,2\}$, define

$$\omega_i = \left(\beta f_i^1 + (1-\beta) f_i^2\right),$$

Then

$$\begin{aligned} \beta f_1^1 &= -\beta G' \left(\tilde{a}_1 \delta' \omega_1 + \tilde{a}_2 (\eta + (1-\eta)\beta)\right) \\ (1-\beta) f_1^2 &= -(1-\beta) G' \left(\tilde{a}_1 \delta' \omega_1 + \tilde{a}_2 (1-\eta)\beta\right) \end{aligned}$$

Adding these two equations, we get

$$\begin{aligned} \omega_1 &= -G' \left(\tilde{a}_1 \delta' \omega_1 + \tilde{a}_2 (1-\eta)\beta + \beta \tilde{a}_2 \eta\right) \\ &= -G' \left(\tilde{a}_1 \delta' \omega_1 + \beta \tilde{a}_2\right) \end{aligned}$$

so

$$\omega_1 = \frac{-\beta G' \tilde{a}_2}{1 + G' \tilde{a}_1 \delta'}. \tag{17}$$

Define $\gamma \in (0,1)$ as follows

$$\gamma = \frac{G' \tilde{a}_1 \delta'}{1 + G' \tilde{a}_1 \delta'}. \tag{18}$$

Hence, from (13) and (15),

$$\begin{aligned} f_1^1 &= -G' \tilde{a}_2 (\eta + \beta (1-\eta-\gamma)), \\ f_1^2 &= -G' \tilde{a}_2 \beta (1-\eta-\gamma). \end{aligned}$$

Now consider

$$\begin{aligned} \beta f_2^1 &= -\beta G' \left(\tilde{a}_1 \delta' \omega_2 + \tilde{a}_2 (1-\eta)(1-\beta)\right) \\ (1-\beta) f_2^2 &= -(1-\beta) G' \left(\tilde{a}_1 \delta' \omega_2 + \tilde{a}_2 (\eta + (1-\eta)(1-\beta))\right) \end{aligned}$$

Adding these two equations, we get

$$\begin{aligned} \omega_2 &= -G' \tilde{a}_1 \delta' \omega_2 - G' \tilde{a}_2 (1-\eta)(1-\beta) - (1-\beta) G' \tilde{a}_2 \eta, \\ &= -G' \tilde{a}_1 \delta' \omega_2 - G' \tilde{a}_2 (1-\beta), \end{aligned}$$

so

$$\omega_2 = -\frac{(1-\beta) G' \tilde{a}_2}{1 + G' \tilde{a}_1 \delta'}.$$

Hence, from (14) and (16),

$$\begin{aligned} f_2^1 &= -G' \tilde{a}_2 (1-\beta)(1-\eta-\gamma), \\ f_2^2 &= -G' \tilde{a}_2 (1-\gamma-\beta(1-\eta-\gamma)). \end{aligned}$$

The Jacobean J is therefore

$$J = -G'\tilde{a}_2 \begin{bmatrix} \eta + \beta(1-\eta-\gamma) & (1-\beta)(1-\eta-\gamma) \\ \beta(1-\eta-\gamma) & 1-\gamma-\beta(1-\eta-\gamma) \end{bmatrix}.$$

It can be verified that the eigenvalues of J are

$$\begin{aligned} \lambda_1 &= -G'\tilde{a}_2\eta, \\ \lambda_2 &= -G'\tilde{a}_2(1-\gamma), \end{aligned}$$

both of which are positive. Note from (18) that

$$G'\tilde{a}_1\delta' = \frac{\gamma}{1-\gamma}.$$

Hence, using (5), we get

$$\lambda_2 = -G'\tilde{a}_2(1-\gamma) < G'\tilde{a}_1\delta'(1-\gamma) = \gamma < 1$$

Since $\lambda_2 < 1$ for all parameter values, and both eigenvalues are positive, the steady state is locally asymptotically stable if $\lambda_1 < 1$ and unstable if $\lambda_1 > 1$. Applying assumption (9) immediately yields the result. ■

Proof of Proposition 3. At the state $(s^1, s^2) = (0,1)$, the mean skill share is $s = 1-\beta$ from (1). Hence, using (2), we get

$$\begin{aligned} \sigma^1 &= (1-\eta)(1-\beta), \\ \sigma^2 &= \eta + (1-\eta)(1-\beta). \end{aligned}$$

Since c is decreasing in its second argument, $c(\bar{a}, \sigma^1)$ is increasing in η and $c(\bar{a}, \sigma^2)$ is decreasing in η. Under complete integration ($\eta = 0$) we have $\sigma^1 = \sigma^2 = 1-\beta$, and the costs of human capital accumulation are therefore $c(\bar{a}, 1-\beta)$ for both groups. Under complete segregation, $\eta = 1$ and hence $\sigma^1 = 0$ and $\sigma^2 = 1$. Hence under complete segregation, the costs of human capital accumulation are $c(\bar{a}, 0)$ and $c(\bar{a}, 1)$ for the two groups respectively, where $c(\bar{a}, 1) < \bar{\delta} < c(\bar{a}, 0)$ by assumption.

First consider the case $\beta < \tilde{\beta}$, which implies $c(\bar{a}, 1-\beta) < \bar{\delta}$. Since $c(\bar{a}, \sigma^2)$ is decreasing in η and satisfies $c(\bar{a}, \sigma^2) < \bar{\delta}$ when $\eta = 0$, it satisfies $c(\bar{a}, \sigma^2) < \bar{\delta}$ for all η. Since $c(\bar{a}, \sigma^1)$ is increasing in η and satisfies $c(\bar{a}, \sigma^1) < \bar{\delta}$ at $\eta = 0$ and $c(\bar{a}, \sigma^1) > \bar{\delta}$ at $\eta = 1$, there exists a unique $\hat{\eta}(\beta)$ such that $c(\bar{a}, \sigma^1) = \bar{\delta}$. For all $\eta > \hat{\eta}(\beta)$, we have $c(\bar{a}, \sigma^2) < \bar{\delta} < c(\bar{a}, \sigma^1)$, which implies that $(s^1, s^2) = (0,1)$

is a stable steady state. For all $\eta < \hat{\eta}(\beta)$, we have $c\left(\bar{a}, \sigma^2\right) < c(\bar{a}, \sigma^1) < \bar{\delta}$, which implies that $\left(s^1, s^2\right) = (0,1)$ cannot be a steady state. Note that any increase in β within the range $\beta < \tilde{\beta}$ raises $c(\bar{a}, \sigma^1)$. Since $c(\bar{a}, \sigma^1)$ is increasing in η, this lowers the value of $\hat{\eta}(\beta)$, defined as the segregation level at which $c(\bar{a}, \sigma^1) = \bar{\delta}$.

Next consider the case $\beta > \tilde{\beta}$, which implies $c\left(\bar{a}, 1-\beta\right) > 0$. Since $c(\bar{a}, \sigma^1)$ is increasing in η and satisfies $c(\bar{a}, \sigma^1) > \bar{\delta}$ at $\eta = 0$, it satisfies $c(\bar{a}, \sigma^1) > \bar{\delta}$ for all η. Since $c\left(\bar{a}, \sigma^2\right)$ is decreasing in η and satisfies $c(\bar{a}, \sigma^2) > \bar{\delta}$ at $\eta = 0$ and $c(\bar{a}, \sigma^2) < \bar{\delta}$ at $\eta = 1$, there exists a unique $\hat{\eta}(\beta)$ such that $c\left(\bar{a}, \sigma^2\right) = \bar{\delta}$. For all $\eta > \hat{\eta}(\beta)$, we have $c\left(\bar{a}, \sigma^2\right) < \bar{\delta} < c(\bar{a}, \sigma^1)$, which implies that $\left(s^1, s^2\right) = (0,1)$ is a stable steady state. For all $\eta < \hat{\eta}(\beta)$, we have $\bar{\delta} < c\left(\bar{a}, \sigma^2\right) < c(\bar{a}, \sigma^1)$, which implies that $\left(s^1, s^2\right) = (0,1)$ cannot be a steady state. Note that any increase in β within the range $\beta > \tilde{\beta}$ raises $c\left(\bar{a}, \sigma^2\right)$. Since $c\left(\bar{a}, \sigma^2\right)$ is decreasing in η, this raises the value of $\hat{\eta}(\beta)$, defined as the segregation level at which $c\left(\bar{a}, \sigma^2\right) = \bar{\delta}$.

Proof of Proposition 4. First consider the case $\beta < \tilde{\beta}$. Recall from the proof of Proposition 3 that if the economy is initially at $\left(s^1, s^2\right) = (0,1)$, then for all $\eta < \hat{\eta}(\beta)$, we have $c\left(\bar{a}, \sigma^2\right) < c(\bar{a}, \sigma^1) < \bar{\delta}$. Hence all individuals in each of the two groups will find it optimal to invest in human capital, resulting in a transition to $\left(s^1, s^2\right) = (1,1)$. This lowers both $c\left(\bar{a}, \sigma^2\right)$ and $c(\bar{a}, \sigma^1)$, and hence maintains the condition $c\left(\bar{a}, \sigma^2\right) < c(\bar{a}, \sigma^1) < \bar{\delta}$. Hence the economy remains at $\left(s^1, s^2\right) = (1,1)$ thereafter.

Next consider the case $\beta > \tilde{\beta}$. Recall from the proof of Proposition 3 that if the economy is initially at $\left(s^1, s^2\right) = (0,1)$, then for all $\eta < \hat{\eta}(\beta)$, we have $\bar{\delta} < c\left(\bar{a}, \sigma^2\right) < c(\bar{a}, \sigma^1)$. Hence all individuals in each of the two groups will find it optimal to remain unskilled, resulting in a transition to $\left(s^1, s^2\right) = (0,0)$. This raises both $c\left(\bar{a}, \sigma^2\right)$ and $c(\bar{a}, \sigma^1)$, and hence maintains the condition $\bar{\delta} < c\left(\bar{a}, \sigma^2\right) < c(\bar{a}, \sigma^1)$. Hence the economy remains at $\left(s^1, s^2\right) = (0,0)$ thereafter. ■

Proof of Theorem 2. Using (1–4), we may write the dynamics of investment levels s^1 and s^2 as follows

$$\begin{aligned} s_t^1 &= 1 - G(\tilde{a}(\bar{\delta}, \eta s_{t-1}^1 + (1-\eta)\left(\beta s_{t-1}^1 + (1-\beta)\, s_{t-1}^2\right)) \\ s_t^2 &= 1 - G(\tilde{a}(\bar{\delta}, \eta s_{t-1}^2 + (1-\eta)\left(\beta s_{t-1}^1 + (1-\beta)\, s_{t-1}^2\right)) \end{aligned}$$

For each s^2, define $h_b(s^2)$ as the set of all s^1 satisfying

$$s^1 = 1 - G(\tilde{a}(\bar{\delta}, \eta s^1 + (1-\eta)\left(\beta s^1 + (1-\beta)\, s^2\right)).$$

This corresponds to the set of isoclines for group 1, namely the set of points at which $\Delta s^1 \equiv s_t^1 - s_{t-1}^1 = 0$ for any given s^2. Similarly, for each s^1, define $h_w(s^1)$ as the set of all s^2 satisfying

$$s^2 = 1 - G(\tilde{a}(\bar{\delta}, \eta s^2 + (1-\eta)(\beta s^1 + (1-\beta) s^2)).$$

This is the set of points at which $\Delta s^2 = 0$ for any given s^1.Any state (s^1, s^2) at which $s^1 \in h_b(s^2)$ and $s^2 \in h_w(s^1)$ is a steady state. Now consider the extreme case $\eta = 0$, and examine the limiting isoclines as $\beta \to 0$. In this case $h_b(s^2)$ is the set of all s^1 satisfying

$$s^1 = 1 - G(\tilde{a}(\bar{\delta}, s^2))$$

and $h_w(s^1)$ is the set of all s^2 satisfying

$$s^2 = 1 - G(\tilde{a}(\bar{\delta}, s^2)).$$

There are exactly three solutions, s^l, s^m, and s^h to the latter equation. Hence there are three horizontal isoclines at which $\Delta s^2 = 0$, as shown in the left panel of Figure 3. The former equation generates a single isocline $s^1 = h_b(s^2)$ which is strictly increasing, and satisfies $h_b(0) \in (0, s^l)$, $h_b(1) \in (s^h, 1)$, and $h_b(s) = s$ for each $s \in \{s^l, s^m, s^h\}$, also depicted in the left panel of Figure 3. As is clear from the figure, only three steady states exist, all of which are symmetric. Only two of these, (s^l, s^l) and (s^h, s^h) are stable. The initial state (s^l, s^h) is in the basin of attraction of of the high investment steady state (s^h, s^h). Since the isoclines are all continuous in η and β at $\eta = \beta = 0$, it follows that for β sufficiently small, integration is equalizing and welfare-improving.

Next consider the limiting isoclines as $\beta \to 1$ (maintaining the assumption that $\eta = 0$). In this case $h_b(s^2)$ is the set of all s^1 satisfying

$$s^1 = 1 - G(\tilde{a}(\bar{\delta}, s^1))$$

and $h_w(s^1)$ is the set of all s^2 satisfying

$$s^2 = 1 - G(\tilde{a}(\bar{\delta}, s^1)).$$

There are exactly three solutions, s^l, s^m, and s^h to the former equation. Hence there are three vertical isoclines at which $\Delta s^1 = 0$, as shown in the right panel of Figure 3. The latter equation generates a single isocline $s^2 = h_w(s^1)$ which is strictly increasing, and satisfies $h_w(0) \in (0, s^l)$, $h_w(1) \in (s^h, 1)$, and $h_w(s) = s$ for each $s \in \{s^l, s^m, s^h\}$, also depicted in the right panel of Figure 3. As in the case of $\beta = 0$, only three steady states exist, all of which are symmetric and two of which,

(s^l, s^l) and (s^h, s^h), are stable. The initial state (s^l, s^h) is in the basin of attraction of of the low investment steady state (s^l, s^l). Since the isoclines are all continuous in η and β at $\eta = 1 - \beta = 0$, it follows that for β sufficiently large, integration is equalizing and welfare-reducing. ■

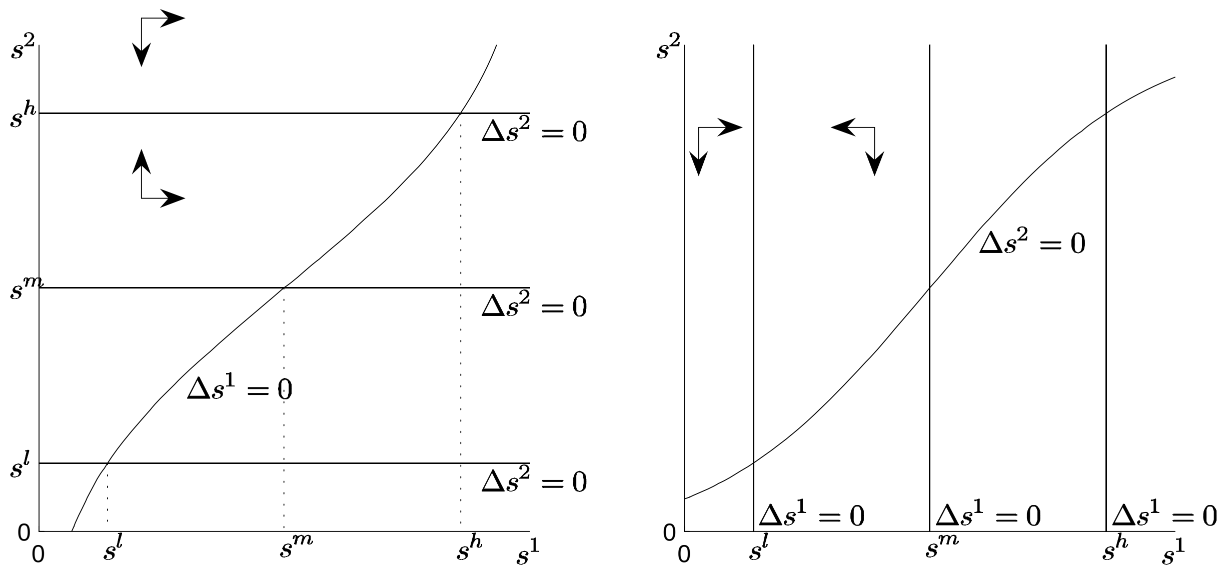

Figure 3. Limiting Isoclines for $\eta = 0$, with $\beta \to 0$ (left) and $\beta \to 1$ (right).

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