Social Interactions and Segregation in Skill Accumulation

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Abstract

This paper studies human capital investment in a spatial setting with interpersonal complementarities. A mixture of local and global social interactions affect the cost of acquiring education, while the return to human capital is determined endogenously in the market. We study how spatially segregated investment equilibria are affected by an increase in the relative importance of global *vis-à-vis* local interactions. Per capita income level, equality and welfare are shown to improve if the skilled constitute a majority to begin with, and if not, these implications are reversed. We also examine the effects of wider local neighborhoods, and lower mobility costs, and study a related two-group model based on social distance.

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1. Introduction

We live in an age of "globalization". While individuals differ in their notions of just what that globalization might be, it is fairly uncontroversial that a decrease in the "local-ness" of social interactions represents one important aspect of it. It is natural to ask what the implications of these changes are for skill accumulation, inequality and per capita income.

We study a simple model of human capital investment incentives in a spatial context, based on Mookherjee, Napel, and Ray (2009) (henceforth MNR). MNR study the interrelationship between local peer effects and economy-wide general equilibrium with endogenous prices. There are two occupations, skilled and unskilled; only the former requires costly investment in training. Neighborhood effects operate through local spillovers. Examples include the formation of aspirations, peer influences in training or locally funded educational facilities. These induce complementarities in investment incentives. The economy-wide price effects arise because the labor market for the economy as a whole is integrated: financial returns to each occupation are decreasing in the fraction of agents in the economy in that occupation. In order to focus on geography dependence rather than history dependence (see, e.g., Banerjee and Newman 1993; Galor and Zeira 1993; Maoz and Moav 1999; Mookherjee and Ray 2003), we assume there are no credit constraints.

This paper extends that model to include global social interactions, and examines the effect of varying the extent of "local-ness" in the neighborhood effects. For instance, transportation costs might decline, causing social interactions to become less local. There may be government-initiated desegregation efforts. Or school financing may shift from a decentralized system (where schools are funded by local taxes) towards a centralized system (where they are funded by national taxes).[1]

A complementary framework, with social groupings replacing geographical peer effects, is studied by Bowles, Loury, and Sethi (2009) (henceforth BLS). In the analysis below, we attempt to bring out both the common and the distinctive features of these two models. With this in mind, we emphasize two special cases of the model, based on notions of distance that are *physical* and *social*, and provide an analysis of each case. The first draws directly on our earlier work, with households assigned to locations on a one-dimensional line. We assume here that local neighborhood effects arise entirely through learning spillovers, and we allow these spillovers to be partly local and partly global: they are a convex combination of average skill in an ε-neighborhood of that location, and in the entire economy. Thus "local-ness" can be represented by two parameters. One is the relative weight on local (as opposed to global) skills. The other is the

[1]We do not explicitly model taxes and subsidies, but can easily do so. Similar results would arise in such an extended context.

width of the local neighborhood.[2] We study geographic segregation in investment decisions, overall skill ratios, and inequality, and examine how these are affected as the various parameters describing local-ness are varied.

The second interpretation, as in BLS, is based on a notion of social distance between two distinct groups (of different ethnicities, religions, or national origins) with different intensities of within-group interaction relative to cross-group interaction. We examine the effect of lowering the relative importance of within-group interaction on equilibria characterized by between-group inequality. We also examine the effects of a rise in the demographic size of one of the two groups (e.g., a rising influx of immigrants in a world where immigrants and natives form distinct groups). While there are broad similarities with the geographical case, we shall see that there are some distinct differences as well.

2. Local and Global Influences on Skill Acquisition

There are two occupations, skilled and unskilled. A global labor market generates wages of $w_s(\lambda), w_u(\lambda)$ for the skilled and unskilled occupations respectively, where λ denotes the global fraction of skilled labor. These wages are the marginal products of a production technology, described by a continuously differentiable, constant-returns-to-scale, strictly quasiconcave, Inada production function T defined on skilled and unskilled labor:

$$w_s(\lambda) = T_1(\lambda, 1-\lambda) \quad \text{and} \quad w_u(\lambda) = T_2(\lambda, 1-\lambda),$$

where subscripts denote appropriate partial derivatives. It follows that $w_s(\lambda)$ and $-w_u(\lambda)$ are continuous and strictly decreasing, that the end-point conditions $\lim_{\lambda \downarrow 0} w_s(\lambda) = \infty$ and $\lim_{\lambda \downarrow 0} w_u(\lambda) = 0$ are satisfied, and that there is some value $\bar{\lambda} \in (0,1)$ with $w_s(\bar{\lambda}) = w_u(\bar{\lambda})$. These assumptions ensure there will always be some skilled and some unskilled agents in the economy.

To each individual attach a "location", indexed by i. Let I be the set of all locations. Several individuals might share the same location; see interpretations below. A location matters because it is assumed to influence the cost of investing in skills. Let x_i be a variable that captures "learning effectiveness" at location i. Effectiveness is determined by a combination of local and global interactions:

$$x_i = \eta\mu_i + (1-\eta)\lambda \tag{1}$$

where $\eta \in (0,1)$ is a parameter that captures the extent to which interactions are local, and μ_i is the fraction of skilled agents that an individual at location i interacts with locally. We assume that the cost of acquiring skill is a decreasing, continuous function $c(x_i)$, defined for all $x_i \geq 0$; at the same time, it is bounded away from zero. A very similar link between peer group quality and costs of human capital accumulation has been considered in the context of statistical discrimination with peer effects by Chaudhuri and Sethi (2008).

[2] In a further extension, we also allow for agent mobility across locations, at some cost.

Investment decisions are not subject to any credit constraints and utility functions are linear in money. Hence an individual at location i invests if

$$w_s(\lambda) - w_u(\lambda) > c(x_i), \tag{2}$$

does not invest if this inequality is reversed, and is indifferent if equality holds. This gives rise to the (informal) definition of an equilibrium as a collection $(\lambda, \{\mu_i\}_{i \in I})$ such that (a) each individual follows the rule described by (2), with x_i given by (1), (b) such individual behavior generates the values μ_i at every location $i \in I$, and (c) individual behavior also generates the aggregate skill ratio λ. It is also easy to write a dynamic version of this model for which (a)–(c) describes a steady state.

This broad setup leaves open the interpretation of what a "location" might be. Once we fill that gap, part (b) of the equilibrium definition above can be made more formal.

One interpretation is that a location is a *geographical* construct; for $\eta = 1$ this yields the model of MNR, with small differences concerning the formalization of local complementarities in investment incentives.[3] Agents have given positions — locations — on an interval of the real line. (Later, we also discuss mobility.) The population distribution over locations is given by a smooth density which is nonconstant almost everywhere. Each individual has a local window — an interval of width 2ε — centered at her location, and μ_i is the proportion of skilled individuals residing within the interval centered at i. A second interpretation is that a location is a *social* construct; this is the model of BLS. An agent belongs to one of two social groups — "locations" — say black and white, with a given population distribution. Then μ_i is just the skill proportion in social group i.

3. Geography

Begin with the geographical interpretation. We can formalize part (b) of the equilibrium definition provided we agree on the spatial patterns of skill acquisition. For instance, if skill proportions are evenly spread over the real line, then $\mu_i = \lambda$ for every i; this is the *unsegregated equilibrium* studied in MNR. There are also *segregated equilibria*, in which the set of all locations is partitioned into alternating intervals of agents that invest and do not invest. We focus on segregated equilibria in this paper: the outcomes of unsegregated equilibria are entirely insensitive to the local-global structure of the model and are of no interest from a comparative static perspective. This does not rule out possibly very significant effects of variations of the interaction structure on the dynamic properties of an unsegregated equilibrium, which BLS focus on. In fact,

[3] These differences are inessential for positive results on aggregate skill investment, per capita income etc. Because MNR assume agents' welfare to be affected by personal income in relation to the neighborhood's income distribution, they matter for normative statements. See Blanchflower and Oswald (2004) for recent empirical evidence on relative income effects.

their main message is that the stability of (two-locations) unsegregated equilibria depends critically on the importance of local relative to global interaction.

For technical reasons, we focus only on those (segregated) equilibria in which each of the intervals has sufficient width relative to an individual's perception window. Specifically, we ask that the width of each interval be at least 2ε; this ensures that for every interval, there are locations which "immerse" an individual fully in her neighborhood: she sees just one kind of investment decision in her local neighborhood. Indeed, to convey the main ideas in a stark way, we sometimes take ε close to zero.

The fact that wages are endogenous allows a simple characterization of segregated equilibria. Within a skilled interval it is optimal to acquire skills; the opposite is true of an unskilled interval. By a simple continuity argument, an agent at a boundary location j between two successive intervals must be indifferent:

$$w_s(\lambda) - w_u(\lambda) = c(\eta\mu_j + (1-\eta)\lambda). \tag{3}$$

Note that all the endogenous variables — λ, boundary points j, μ_j — depend on ε, but this dependence vanishes as ε goes to 0. For as ε becomes vanishingly small, μ_j at a boundary location must converge to $1/2$. Thus for small ε, an equilibrium skill ratio λ is approximately described by a solution to the equation

$$w_s(\lambda) - w_u(\lambda) = c([\eta/2] + (1-\eta)\lambda). \tag{4}$$

Given our assumptions, there exists at least one solution to (4), which is also locally stable in the sense that the wage difference (LHS of (4)) declines faster in λ than the cost (RHS). This solution may be compatible with a number of different equilibrium segregation patterns, varying in the number of intervals they display. But each solution corresponds to one aggregate skill ratio. Of course, if there are multiple solutions to (4) then there are multiple aggregate skill ratios. But if the learning spillovers are not too strong relative to the extent of diminishing returns to any factor in the production process, or if learning is largely local, the wage difference will decline faster in λ than the cost function, and there will be a unique aggregate skill ratio consistent with segregation.

This completes the description of the model. Notice that an equilibrium is associated with particular skill ratios, as well as skilled and unskilled wages and a corresponding amount of economic inequality. These outcomes will be affected as the extent of social interaction is altered. In what follows, we study three notions of "increased global interactions".

3.1. **A Higher Weight on the Global Skill Ratio.** Our first notion equates more global interactions with a lower value of η. To study this, call an equilibrium *majority skilled* if $\lambda > 1/2$, and *minority skilled* if $\lambda < 1/2$. If this is a model of primary or secondary education, most countries will be majority skilled. But if it pertains to university education, most countries will be minority skilled.

We are interested in the effect of varying η, our measure of the local-ness of agents' interactions, on welfare. Fortunately, as long as we identify welfare with the value of any quasiconcave Bergson-Samuelson function defined on individual payoffs, a precise formulation is unnecessary. A rise in the global skill ratio will raise per capita income. It will lower wage inequality between the skilled and unskilled. It will lower the skill acquisition costs for all individuals. Within the class of segregated equilibria, aggregate welfare must move in the same direction as the overall skill ratio. This observation yields:

PROPOSITION **1.** *There is $\bar{\varepsilon} > 0$ such that for any $\varepsilon \in (0, \bar{\varepsilon})$ and for any locally stable segregated equilibrium, an increase in global interactions (measured by a fall in η) improves welfare if the equilibrium is majority skilled, and reduces welfare if the equilibrium is minority skilled.*

The proof follows from the approximation (4). If the skilled form an overall majority, "border agents" encounter a larger fraction of skilled agents globally rather than locally. So an increase in the proportion of global interactions raises the effective variable x_j for border agents j; they would invest with a strict preference and expand the skilled intervals if wages were constant. If the equilibrium is locally stable to begin with, the overall skill ratio must indeed rise. So, for instance, in the case of university education, the theory predicts an adverse impact, while it suggests that the effect on primary and secondary education will be welfare enhancing.

3.2. **Widening Local Neighborhoods.** Next we study the effects of a larger value of ε. For simplicity, assume that the density over locations is symmetric and unimodal. Now any segregated equilibrium can have either two or three intervals. And if there are three, the middle interval *must* contain the mode. Otherwise there must be two interior border points of a particular equilibrium interval on the same side of the mode, with different values of μ. This contradicts the fact that they must both satisfy equation (3).[4]

The interval that contains the mode could be skilled or unskilled. If the former, call the equilibrium *city skilled*; if the latter, call it *city unskilled*. (Think of the area around the mode as the "city".) This definition is a special case of a concept introduced and studied in more detail by MNR. It is relevant here because of the following proposition:

PROPOSITION **2.** *Suppose the population density over locations is symmetric and unimodal. There is $\hat{\varepsilon} > 0$ such that for any $\varepsilon \in (0, \hat{\varepsilon})$ and for any locally stable segregated equilibrium, an increase in global interactions (measured by an increase in ε) improves welfare if the equilibrium is city skilled, and reduces welfare if the equilibrium is city unskilled.*

[4]We use here the assumption that the density is nowhere constant.

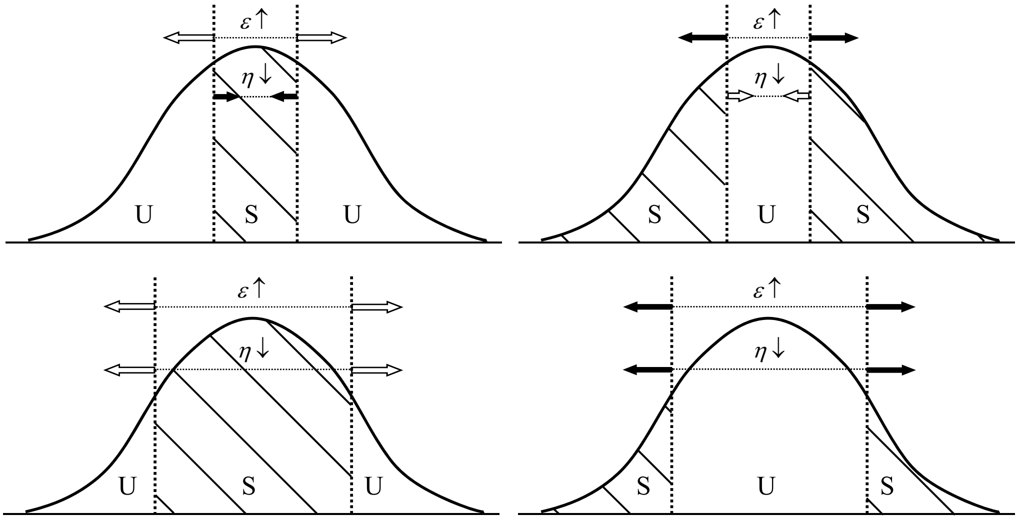

FIGURE 1. Effects of increased "global-ness" on different segregated equilibria

To see how the argument works, note that the value of μ_j for a border agent j is approximately $1/2$ when $\varepsilon \simeq 0$. If the equilibrium is city-skilled, then as ε increases, the corresponding value of μ_j must *exceed* $1/2$, as the border agents see relatively more of others nearer the city. Once again, a stability argument establishes that the overall skill ratio must rise. The opposite argument applies when the equilibrium is city unskilled.

It follows that the effects of increasing globalization depend on the particular notion of "local-ness". The distinct qualitative impacts of changes in ε or η on skilled (S) and unskilled intervals (U) are illustrated in Figure 1. The figures on the left (resp. right) correspond to city-skilled (resp. unskilled) segregated equilibria. The top-left and bottom-right figures depict minority skilled equilibria; the remaining two depict majority skilled equilibria. The welfare effects of a wider local neighborhood may differ from those of lowering the relative importance of a fixed local neighborhood relative to the rest of the society (as in the figures in the top panel). The latter can be thought of as the outcome of mass media or internet-based communication: agents interact more closely with all other agents in society, irrespective of where they happen to be located.[5] In contrast, the former corresponds to changes in transport cost which allows agents to interact with a slightly wider local neighborhood, leaving interactions

[5]MNR look at a formulation of local investment complementarities which involves agents' *aspirations*. These are likely to be even more sensitive to their communication possibilities and media consumption than is their learning effectiveness. See, for example, La Ferrara, Chong, and Duryea (2008) and Chong and La Ferrara (2009) on the effects of increased television coverage on fertility and divorces in Brazil.

with the global society unchanged.

3.3. **Lower Moving Costs.** We briefly outline a third notion of globalization: lower moving costs. Suppose that an agent can move from one location to any other location at a cost of σ.[6] We impose the additional equilibrium condition that no agent must find it worthwhile to move. Note that the agents with the maximal incentives to move are those with the highest learning costs, i.e., those located in the interior of an unskilled neighborhood. They would want to move to the interior of a skilled neighborhood. An equilibrium thus imposes condition (3) *and* the additional no-moving restriction:

$$w_s(\lambda) - w_u(\lambda) - c(\eta + (1-\eta)\lambda) \leq \sigma. \tag{5}$$

Recall that (3), which describes the indifference of border agents, is a necessary condition for a segregated equilibrium. So a segregated equilibrium with moving costs exists if there is at least one skill ratio satisfying (3), which additionally satisfies inequality (5). Put another way, moving costs which are sufficiently low do *not* permit segregated equilibria to exist. On the other hand, an unsegregated equilibrium always exists.

Suppose the fixed moving cost σ is initially large enough to permit a segregated equilibrium to exist, with (5) holding strictly. Then a small reduction in σ leaves that equilibrium unaffected, while a large enough reduction will eliminate it. It is easy to verify that as σ falls, the segregated equilibria with higher wage inequalities must be eliminated first. Ultimately, segregation disappears altogether, and the economy switches to an unsegregated equilibrium. The overall welfare effect of this move will then correspond to a welfare comparison of a segregated equilibrium with an unsegregated equilibrium. This is exactly the same as depicted in Proposition 1: welfare rises if the segregated equilibrium in the comparison is majority-skilled and falls otherwise. The effect of lowering mobility cost is thus qualitatively similar to increasing the frequency of global interactions.

4. Social Groups

BLS study increasingly global interactions for the case of social groups: there are two "locations" or groups, and interaction within each group i is such that μ_i is simply the share of skilled labor in that group. They adopt the first of our three interpretations: increased "globalization" or "desegregation" is just a lowering of η. Their analysis then investigates the effect of the global-ness of interactions on stability of the desegregated (or symmetric) equilibrium if it is unique, and on dynamic selection between different desegregated equilibria in case of multiplicity. Our analysis is different from (and complementing) the one

[6] A richer model would allow endogenous differences in housing costs at different locations, and we can extend the model to include this as well.

that BLS conduct, because we compare the effect of increased global-ness on the static properties of different types of segregated equilibria.

Suppose that there are only two locations $i = 0, 1$. Agents at 0 are "natives," those at 1 are "immigrants". Movement across locations is impossible. The general definition of equilibrium in Section 2 applies here, though there is no such thing as a "border agent". The indifference condition (3) is replaced by the more general rule described in (2) and condition (a).

As in the previous section, there is little of interest to be said about comparative static effects of changes to the local-global structure if the equilibrium is effectively "desegregated", with $\mu_0 = \mu_1$. So we study the case in which $\mu_0 \neq \mu_1$, and without loss of generality we assume that $\mu_0 > \mu_1$. There are two kinds of segregated equilibria satisfying this condition. The first we shall call *immigrant unskilled*: all immigrants are unskilled, and a fraction of natives are skilled. These will tend to exist when the immigrants form a minority. The second kind is one in which all natives are skilled and a proportion of immigrants are skilled; call these *native skilled* equilibria. They tend to arise if immigrants form a majority.

If $\alpha \in (0, 1)$ denotes the proportion of immigrants, then in an immigrant unskilled equilibrium, the proportion of skilled natives is $\lambda/(1-\alpha)$, and natives must be indifferent about investing:

$$w_s(\lambda) - w_s(\lambda) = c\left(\eta \frac{\lambda}{1-\alpha} + [1-\eta]\lambda\right). \tag{6}$$

In a native-skilled equilibrium, the proportion of skilled immigrants is $(\lambda + \alpha - 1)/\alpha$, and immigrants must be indifferent about investing:

$$w_s(\lambda) - w_s(\lambda) = c\left(\eta \frac{\lambda + \alpha - 1}{\alpha} + [1-\eta]\lambda\right). \tag{7}$$

Proposition **3.** *Consider a segregated equilibrium with $\mu_0 > \mu_1$. An increase in global interactions (measured by a fall in η) increases the aggregate skill ratio if the equilibrium is native skilled, and reduces it if the equilibrium is immigrant unskilled.*

In a native skilled equilibrium, the relevant "marginal agent" is an immigrant. An increase in global interactions means that the learning of immigrants is facilitated, since they meet more often with natives who are more skilled on average. This boosts investment incentives. The opposite is true of an immigrant unskilled equilibrium, where the marginal agent is a native. Increased social assimilation of immigrants then dilutes the skill proportion of agents that natives interact with. The logic is not identical (though it is similar) to the case of Proposition 1. What matters here is whether the marginal agent is a native or immigrant, not whether the skilled form a minority or majority. There can be cases where the two models predict different welfare effects, e.g., when the skilled form a minority and the natives form an even smaller minority.

We therefore see that the model makes sharp predictions about the effects of "immigrant assimilation" (or more generally, desegregation) on overall skill ratios. The predicted impact depends crucially on whether the equilibrium is native skilled or immigrant unskilled to begin with.

What about the effects on income inequality between the natives and immigrants — the main criterion considered by BLS? Note that the ratio of per capita incomes of natives to that of immigrants in an immigrant unskilled equilibrium is $\lambda^*[w_s(\lambda^*)/w_u(\lambda^*) - 1]/(1-\alpha) + 1$, which is verified in the case of a Cobb-Douglas aggregate production function to be decreasing in λ^*. Hence, as in the previous section, there may be little ambiguity in linking the overall skill ratio to welfare more generally.

Finally consider the effects of a rise in α, the proportion of immigrants. Since immigrants are less skilled on average than natives, this tends to reduce investments in the "short run", i.e., before any equilibrium adjustment takes place. In contrast, *the new equilibrium must display the opposite effect: the economy-wide skill ratio must rise.* In an immigrant unskilled equilibrium, (6) tells us that a higher fraction of natives are induced to invest following an influx of immigrants, so that the overall skill ratio must rise with α. The same phenomenon occurs in a native skilled equilibrium. Now the immigrants invest more to guarantee a larger fraction of skilled individuals in society (see condition (7)). To be sure, in both cases we presume that the equilibrium in question is locally stable.

5. Conclusion

This paper studies a model of human capital investment with social interactions. The complementarities induced by interpersonal interactions coexist with general equilibrium price effects generated in an integrated labor market. In this framework, we study the implications of a move towards greater global interaction. We consider two variants of the model: one based on continuous variation in physical location (as in MNR), and the other based on two social groups (as in BLS). This broader formulation of what constitutes an agent's neighborhood or peer group has the advantage of permitting us to distinguish between different ways in which the "local-ness" of social interactions may decrease; say, as a consequence of government-initiated desegregation policies, or changes in agents' communication patterns, or greater mobility owing to technological change.

The macroeconomic and welfare effects of these changes depend critically on certain properties of the initial equilibrium. We attempt to describe these in the paper. Among these are whether a majority of population was skilled to begin with, as also whether the initial spatial *concentration* of skilled people is, on average, more or less than the initial concentration of unskilled people. For the case of continuously varying physical locations studied in MNR, much depends on the behavior of "boundary agents", those who are indifferent between acquiring or not acquiring skills. At the same time, there are broad similarities with the discrete case of a small number of social groups studied in BLS.[7]

Similarities notwithstanding, it is useful to distinguish the current exercise from the BLS paper. Their analysis concerns dynamics and is concerned with the effects of global-ness of interactions on the stability of and selection among equal (i.e., unsegregated) steady states.[8] In contrast, our analysis is static, but we study the effects of local-ness on asymmetric (i.e., segregated) equilibria. The main result in BLS argues that the greater global-ness of social interactions can stabilize an unsegregated steady state, i.e., allow states with equality between groups to persist. In this paper, the economy starts (and stays) in a segregated equilibrium (with inequality between groups or neighborhoods), and between-group inequality may rise as a result of increased globalness, depending on the demographic share of different groups and/or distribution of locations in the population. Hence the welfare and inequality effects of increased global-ness are likely to be highly context-dependent, i.e., depend on initial conditions.

A second broad difference is that BLS consider parameter variations that are sufficiently big so as to induce a dynamic regime change: smaller changes have no effect on the unsegregated steady state in their model. In our exercise, small changes in parameters affect the macro properties of the segregated equilibrium in a continuous fashion.[9] Whether results on the basins of attraction of different equilibria can be obtained, not only for the binary group framework of BLS but also the more general topology of segregation introduced in MNR and extended here, is an interesting question for future research.

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[7]Our observations are also related to findings in Chaudhuri and Sethi (2008), who investigate statistical discrimination between two social groups in the labor market.

[8]Apart from incorporating dynamics, their Theorem 1 allows for individual ability shocks, something our model does not consider. In our model, therefore, increased global-ness of interactions has no effect on the unsegregated equilibrium.

[9]An exception is our analysis of moving costs, which only has a discrete effect on the kind of steady states that can exist.

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