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On the mechanics of migration decisions: skill complementarities and endogenous price differentials

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Abstract

Why are highly skilled workers more responsive than other workers to productivity differentials when taking migration decisions? Why do low-skilled workers abandon rich regions? This paper aims to answer these questions using skill complementarities and endogenous price differentials between rich and poor regions. If the skill premium is increasing in the average level of human capital of a location, the more skilled the workers are, the stronger the economic incentives to migrate to the rich regions become. In contrast, the low-skilled workers have an incentive to migrate to the poor regions to minimize their living costs.

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1. Introduction

The empirical evidence on within-country migration and regional development often puzzles the economics profession. While highly skilled workers appear to be responsive to economic incentives and to move to the wealthiest regions, low-skilled workers not only have lower mobility rates, but also seem to abandon the high-growth regions, where wages are higher and the rate of unemployment is lower. This tends to perpetuate regional disparities and hampers convergence. The experience of Silicon Valley and in general of

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the US, as well as of several European countries suggests that the observed migration flows may be due to the inflation in the cost of living that accompanies economic growth.[1]

This paper addresses these issues by formalizing the links among the self-selection of migrants, regional disparities and cost-of-living differentials. It shows that their common origin may be the skill complementarities among the workers employed in a location. In fact, if the skill premium is increasing in the average level of human capital of a location, the more skilled the workers are, the stronger the economic incentives to migrate to the rich regions (where the concentration of highly skilled workers is higher) will be. In particular, if migration costs are high or if there are huge differences in the relative price of facilities, especially housing, only individuals who expect large increases in their wages will move to the most productive regions. Otherwise, the wage gain from migrating is offset by the higher costs of facilities in the rich regions, and for low-skilled workers it may even be advantageous to move to relatively poorer and low-cost locations, where the skill premium is also lower. This assertion is compatible with Borjas et al. (1992), who find that in the US interstate differences in the return to skill are a major determinant of both the size and the skill composition of internal migration flows. In particular, he finds that highly skilled workers tend to choose states where the return to skill proxied by wage dispersion is highest. The contrary is true for low-skilled workers.

Not only can skill complementarities account for skilled (unskilled) workers' migration flows to the high (low) skill premia regions, but they can also explain why interregional skill premia and cost-of-living differentials arise. Skill premia differentials arise because the average skill level of workers in a region affects that region's total factor productivity and therefore wages. In this context, if the self-selection of migrants affects total factor productivity in the traded goods sector, differences in the price of nontraded goods arise endogenously, as pointed out by Balassa (1964) and Samuelson (1964), and originate cost-of-living differentials.

I also show that convergence in per capita GDP may discourage migration to the rich regions, even if it is incomplete and leaves large regional disparities. This happens if the process of capital accumulation cause faster convergence in wages than in living costs and is compatible with the experience of many European countries, such as Italy and the UK.

Migration choices are modeled using a two-location overlapping generations model, as in Galor (1986). However, the context is very different. Galor studies international labor migration between two countries with different rates of time preference. In contrast, I assume that the two locations are identical ex ante, with the exception of the initial level of capital intensity, and introduce a further element of heterogeneity among workers. Workers born in a location differ in their skill levels and, therefore, also in their labor productivity. This creates different incentives to migrate, even for workers born in the same location at the same time.[2]

The skill complementarities allow steady-state equilibria with asymmetric distribution of skills even if the locations are ex ante identical. In this respect, this paper is close to

[1] More empirical evidence will be presented in the next section.

[2] The origin of the self-selection of migrants is also very different from Katz and Stark (1987), where only skilled workers for whom it is easier to overcome asymmetric information problems have an incentive to migrate.

those studies that point out the existence of skill complementarities and local externalities, due to the concentration of human capital, to explain the persistence of productivity differentials among countries or regions and the lack of convergence in per capita income. Lucas (1988) seminal paper, for instance, uses differences in the average level of human capital to explain growth differentials. The microeconomic foundation of this external effect of human capital is the sharing of knowledge and skills among workers that occurs through both formal and informal interaction. Random meetings which take place with higher probability within a limited geographic area favor the "cross-fertilization" of ideas that is the engine of growth in Lucas' framework. A related point is made by Kremer (1993). In order to explain productivity differentials, he assumes a production function in which the productivity of each worker depends on other workers' skills. As a consequence, total factor productivity and, therefore, wages and output are a steeply increasing function of skills.

My contribution is to show that skill complementarities and local externalities arising from the concentration of human capital may also account for the skill contents of migrant flows to the rich and the poor regions, and for interregional wage and price differentials.

The model also has important implications for the effects of migration on regional convergence. The productivity differentials that arise endogenously because of the self-selection of migrants may interrupt the process of regional convergence and permit poverty traps to arise, as in Azariadis and Drazen (1990). Therefore, in my model migration hampers convergence as in Faini (1996). However, the explanation is very different. In Faini's paper, migration provokes regional divergence because it does not allow the marginal productivity of capital to decrease in the initially wealthier location and the issue of self-selection of migrants is not addressed. In the model presented here, the convergence process is arrested because the self-selection of migrants causes differences in total factor productivity.

This paper is organized as follows. Section 2 describes a number of unexplained features of internal migration. Sections 3 and 4 describe the long-run equilibria and the transitional dynamics of the model, respectively. Conclusions follow in Section 5.

2. Stylized facts

This section summarizes a number of unexplained features of internal migration, which suggest the importance of skill complementarities and living-cost differentials in explaining this phenomenon.

2.1. Skilled workers are attracted mostly by the rich and booming regions; in contrast, low-skilled workers often abandon the rich regions and move to the relatively poor ones

A well-known and thoroughly studied empirical fact about migration is that highly skilled workers are far more mobile than the average worker.[3]

[3] For empirical evidence on this point, see Antolin and Bover (1997), Borjas et al. (1992), Hunt (2000) and Giannetti (2001), who provide empirical evidence for Spain, the US, Germany, and Italy, respectively.

The fact that workers do not migrate exclusively from low-income to high-income regions, and that indeed there are two-way migration flows, has been much less studied. In this respect, the empirical evidence suggests that skilled workers migrate mostly to the rich regions, where the concentration of skilled workers is higher. In contrast, the migration decisions of unskilled workers are apparently less responsive to economic incentives. Borjas et al. (1992), for instance, notice that in the US the highly skilled workers move to the states where wage dispersion and skill remuneration are greatest (which are generally the richest ones), while the contrary is true for low-skilled workers. These authors also present evidence that the skill endowments of different locations have an important influence on the direction of internal migration flows and that skilled workers migrate to regions where the concentration of human capital is highest.

Silicon Valley represents the most striking example of a high-growth region losing its unskilled workers. In a recent issue, Economist (2000a) points out that "the exodus of working-class residents is creating both commercial problems and political strife. (...) A quarter of the positions in the Los Altos police are empty because officers, unable to live near the town, have resigned and the force expects to be down to half-strength by the autumn".

Even more surprisingly, in countries where regional imbalances are far larger than in the US, like Italy and Spain, rich and low unemployment regions have failed to attract workers from other regions since the early 1980s.[4] In Italy, for instance, only highly skilled and young workers move to the rich northern regions (Economist, 1997). Recent empirical evidence (Giannetti, 2001) shows that the determinants of the migration flows of the highly skilled workers are different and that a high concentration of skilled workers in a region is a significant pull factor for skilled workers alone. Analogously, in Spain the poor and high-unemployment regions have become net immigration regions, and the better-off regions have become net outmigration ones (Bover and Velilla, 1999). Moreover, Antolin and Bover (1997) find that unemployed workers who live in high unemployment regions are less likely to abandon the region of origin, while most of the flows are due to public sector workers who move with a job. However, also for Spain there is evidence that skill matters: Bover and Velilla (1999) report that higher education not only directly increases the probability of migration, but individuals with higher education tend to be sensitive to their region unemployment. Moreover, Mauro and Spilimbergo (1999) show that in Spain workers of different skill levels respond differently to regional shocks. Highly skilled workers migrate promptly in response to a decline in regional labor demand, while low-skilled workers drop out of the labor force or stay unemployed.

2.2. Costs of living differentials are important in explaining migration decisions

Cost of living differentials are probably the only factor that can explain migration flows both within the US and the European countries, as the existence of safety nets, which

[4] Hunt (2000) provides further evidence on this point for Germany, where migration from the East to the West has fallen from high levels in the immediate aftermath of the reunification to close to zero, and pertains essentially to young and skilled individuals, as in Italy.

reduces the responsiveness to economic incentives, may be seriously advocated only for the latter ones.

To go back to the experience of Silicon Valley, Economist (2000a) notes that the tremendous growth in wealth has been accompanied by steep inflation in the cost of living: "the median house price in San Francisco's Bay Area is $370,000, compared with $135,000 for the country at large".

Even if the existence of safety nets may contribute to explain the low mobility of European workers notwithstanding the large regional disparities, these are of little help in explaining why low-skilled workers should bear migration costs to move to the relatively poorer regions, since welfare programs, such as unemployment subsidies, are generally equal across the regions of a country. Moreover, interregional cost of living differentials, as measured by house prices, are showed to be important for migration decisions in several empirical studies. In an empirical study on Spain, Antolin and Bover (1997) find that individuals are more likely to migrate if they live in a region with above-average house prices. Moreover, the high cost of living in the north of Italy "where the cheapest job barely pays the rent" is considered by Economist (2000b) as the most important reason for the low mobility rate of Italy's southerners. More evidence on the impact of cost of living differentials on migration decisions are provided by Cameron and Muellbauer (1998) for the UK, where the dramatic increase in housing prices in the southeast coincided with a drop in the mobility rate during the 1980s.

In the next section, I show that a model with skill complementarities may jointly explain the observed migration flows, regional disparities and cost of living differentials.

3. A model of migration decisions and productivity differentials

This section studies migration decisions under the assumption that the equilibrium skill premium increases in the average level of human capital of a location because of skill complementarities in production.

The empirical relevance of skill complementarities and the positive externalities deriving from the concentration of human capital on aggregate productivity have been documented in a number of empirical studies, such as Rauch (1991) and Cooper and Haltiwanger (1996), but their consequences in terms of migration flows have been neglected.

When one considers skill complementarities, it becomes straightforward to account for the higher-than-average migration flows of the most skilled workers to the rich regions. In fact, if there are fixed migration costs, only individuals who benefit most from high skill premia find it optimal to migrate to regions where the average level of human capital is higher. But what can explain two-way migration flows? The model shows that the general equilibrium effects of differences in total factor productivity originating from differences in the average level of human capital can explain the flows of the least skilled migrants to the poorest regions as well. In fact, if the total factor productivity in the traded goods sector is an increasing function of the average skill level of a region, the price of nontraded goods is higher in regions where the most skilled workers reside.[5] In this context, low-skilled individuals, who benefit less from the skill complementarities in high-productivity and high-cost regions, may have an incentive to move to the relatively poorer regions in order to minimize their living costs. In this way, one can explain two of the most important features of internal migration without positing any embedded preference to remain in the region of origin or having depopulation of the poorer regions, as in most of the existing literature (see, for instance, Bertola, 1993; Faini, 1996).

The model studies internal migration within a small open economy with two regions, the North (N) and the South (S). The economy is open to capital flows and both workers and firms can borrow and lend any amount at the world interest rate, ρ.

In what follows, first I describe the two locations and their inhabitants and then the production technology and moving decisions.

3.1. Workers

I rely on an overlapping generation framework with infinite periods. The demography is described as follows. During each period, a two-period lived generation of workers is born. Each generation consists of a continuum of workers. The mass of the population of each region is 1. Workers are heterogeneous, since they differ in their skill level and in their region of origin. Each worker is endowed with one unit of time that she offers inelastically. However, skill differentiates workers' endowments of efficiency units of labor services. This means that a worker with skills, s_i, is endowed with s_i units of labor services. Skills are drawn from a fixed distribution, equal in both regions,[6] with c.d.f. F and support $[s_{\min}, s_{\max}]$ with $s_{\min}>0$. Hence, the average skill level of workers is equal across regions before migration decisions are taken.

The use of a continuum of workers is a simplifying assumption to study aggregate implications of skill complementarities without worrying about the strategic interaction among migrants, and ensures that the entire distribution F is fully represented.

The agents of this economy decide where to live when they are born, work in the first period of their life and can consume in both periods. Their type j is defined by the region of origin and their skill level. The preferences of an individual of type j, who is young at time t, are represented by the following utility function, which is linear in the consumption of traded goods:

$$U(C^t_{y,t,j}, C^t_{y,t+1,j}) = C^t_{y,t,j} + \frac{C^t_{y,t+1,j}}{1+\beta} \quad \text{if} \quad C^t_{x,t,j} \geq \bar{C}_x. \tag{1}$$

[5] This general equilibrium effect was first pointed out by Balassa (1964) and Samuelson (1964). The so-called Balassa–Samuelson effect refers to a tendency of countries with higher productivity in tradables compared with nontradables to have higher price levels.

[6] The implications of relaxing this assumption will be examined at the end of this section.

The utility of an individual of type j born at time t is increasing and linear in the consumption of the traded good (Y) at time t and $t+1$, $C^t_{y,t,j}$ and $C^t_{y,t+1,j}$ respectively; β is the intertemporal discount rate, which is equal to the international interest rate, $\rho - 1$. Utility is defined for values of consumption of nontraded good X above the basic living expenditures, $\bar{C}_x$, and consumers derive positive utility only from income net of living costs, which differs according to the region of residence.[7] This assumption reflects the fact that there are some basic expenditures, such as housing,[8] that constitute a bigger share of expenditure for individuals with lower income. For simplicity's sake, I consider only consumption of nontraded goods at time t, $C^t_{x,t,j}$, but all the results remain unchanged if consumption of nontraded goods over the two periods of life is used to define basic living expenditures or if consumption of nontraded goods above the basic living expenditures enters in the utility function.[9]

Agents differ in their budget constraint. Young individuals work in the formal sectors of production and earn a wage, which, as is shown later, depends both on their skills and location in equilibrium. I define $w^r_{t,i}$ the wage rate for a worker with skills s_i in region r at date t. Moreover, all young individuals earn a basic income T, which guarantees that every individual can afford her basic living expenditures: $T > \max\{p^S_{xt}\bar{C}_x, p^N_{xt}\bar{C}_x\}$. This sort of minimum wage T can be seen as a part of the worker income that is produced with a home production technology available to all workers (or in the public sector) and that does not benefit from skill complementarities.[10] Alternatively, one may think that individuals receive lump sum transfers from the government, T, funded with the interest earned on some government assets.[11] For simplicity's sake in what follows, I assume that T is an endowment with which all the individuals are born.

As is shown below, these assumptions on basic income and basic living expenditures have important implications for migration decisions. As a consequence of the non-homotheticity of preferences, low-skilled workers have a smaller portion of their budget left over after satisfying basic living expenditures to save and consume at their discretion and may choose to live in low-cost, low-productivity regions in order to minimize their living costs.

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[7] This utility function may be seen as a specialized version of the non-homothetic utility function estimated by Atkenson and Ogaki (1996).

[8] The basic living expenditures whose cost differs across regions may also include goods, such as food. Although this is commonly considered a traded good, its price differs across locations because it also includes the services necessary for distribution (see Kravis and Lipsey, 1982 on this point). The income net of these basic living expenditures may be used for true traded goods, such as travel or the accumulation of financial wealth.

[9] In the case where consumption of nontraded goods above the basic living expenditures enters in the utility function, the income net of living costs must be deflated using the regional price index. Results do not change because it is easy to show that the real income is higher in the region with higher nominal wages.

[10] Results would be unaffected if I allowed for substitution between home-production activity and formal production, as in Greenwood et al. (1995). In this model, only low-skilled individuals would use the home-production technology.

[11] Indeed, there are subsidies especially for poorer and less skilled individuals, which are homogeneous within a country and do not take into account regional price differentials. Nothing would change in the model if only individuals with lowest income got the subsidies. However, if, as happens sometimes (for instance in Spain), these subsidies are higher in less developed regions, their existence reinforces the incentive to migrate to poorer regions. In what follows, I show that even without distorting subsidies, there may be economic incentives to migrate to poorer and low-productivity locations.

The intertemporal budget constraint of an individual with skills, s_i, who is born at time t in region r and does not migrate, is:

$$C^t_{y,t,i} + \frac{C^t_{y,t+1,i}}{\rho} = w^r_{t,i} + T - p^r_{x,t}\bar{C}_x + \Omega \tag{2}$$

where $p^r_{x,t}$ is the price of nontraded goods in region r at date t, the price of traded goods has been normalized to 1, and Ω represents the firm profit distributed to young individuals in the economy.

To differentiate the natives of region r from the immigrants, I assume that any worker who migrates from region r' to region r incurs a fixed migration cost Δ.[12] Hence, the intertemporal budget constraint of an individual with skill, s_i, born at time t in region r' and migrating to region r is:

$$C^t_{y,t,i} + \frac{C^t_{y,t+1,i}}{\rho} = w^r_{t,i} + T - p^r_{x,t}\bar{C}_x - \Delta + \Omega. \tag{3}$$

It is easy to show that utility is maximized if workers locate in the region where they can enjoy higher consumption of traded goods. Therefore, agents will choose the location that guarantees higher income net of any moving costs and nontraded good expenditures.

Formally, a worker with skills s_i migrates from region r to region r' if the following inequality is satisfied:

$$(w^r_{t,i} - w^{r'}_{t,i}) > (p^r_{x,t} - p^{r'}_{x,t})\bar{C}_x + \Delta.^{13} \tag{4}$$

Inequality (Eq. (4)) implies that a worker migrates from region r' to region r, only if what she gains (loses) from the wage differential is sufficient to compensate for what she loses (gains) in terms of living costs.

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[12] One may think of Δ as a quantity of traded good that is lost due to migration.

[13] It is interesting to note that the incentive to migrate does not change and therefore the results of the model are not affected if there is demand of nontraded goods above the basic living expenditures (i.e. if consumption of nontraded goods above the basic living expenditures enters in the utility function), although the algebra becomes more tedious. Let us consider the following utility function:

$$U^t_{t,j} = (C^t_{y,t,j})^{\gamma}(C^t_{x,t,j} - \bar{C}_x)^{1-\gamma} + \frac{(C^t_{y,t+1,j})^{\gamma}(C^t_{x,t+1,j} - \bar{C}_x)^{1-\gamma}}{1+\beta}.$$

In this case, the intertemporal utility function is linear in aggregate consumption

$$\chi^t_{s,j} = (C^t_{y,s,j})^{\gamma}(C^t_{x,s,j} - \bar{C}_x)^{1-\gamma}.$$

Therefore, if the price of nontraded goods is not decreasing over time, the utility is maximized if workers consume only in the first period. A worker migrates from region r' to region r, only if her indirect utility from migrating is larger. Inequality (Eq. (4)) in this case is:

$$\frac{w^r_{t,i}}{(p^r_{x,t})^{1-\gamma}} - \frac{w^{r'}_{t,i}}{(p^{r'}_{x,t})^{1-\gamma}} > \frac{T - p^{r'}_{x,t}\bar{C}_x}{(p^{r'}_{x,t})^{1-\gamma}} - \frac{T - p^{\,r}_{x,t}\bar{C}_x - \Delta}{(p^{\,r}_{x,t})^{1-\gamma}}.$$

Also in this case, individuals compare what they earn from moving in terms of higher wages (left-hand side of the inequality) with what they lose in terms of living (right-hand side). It is interesting to note that in this extension the results hold even if $\bar{C}_x = 0$, as long as $T > 0$. The interpretation would change slightly because the fraction of a worker's income that benefits from the skill premium would matter for her migration decision (and not the magnitude of basic living expenditures relative to the total income). However, what is important is that in both cases the results depend on the difference in living costs relative to the wage differential.

3.2. Production

There are two sectors producing traded and nontraded goods. Both sectors employ capital, K, and labor services, L, and the factors of production can move freely across sectors. The output depends on the efficiency units of labor services, which in turn depend on workers' skill levels, and not on the mass of workers that are employed (i.e. $L=\int s_i \mathrm{d}F(s_i)$ and not $\int \mathrm{d}F(s_i)$).

Sectoral outputs are represented by Cobb–Douglas production functions:

$$Y_t^r = \bar{s}_t^r (K_{y,t}^r)^{\alpha} (L_{y,t}^r)^{1-\alpha} \quad 0 < \alpha < 1$$

$$X_t^r = A_x (K_{x,t}^r)^{v} (L_{x,t}^r)^{1-v} \quad 0 < v < 1, \tag{5}$$

where Y_t^r and X_t^r are the output levels of the traded and nontraded good sectors, respectively, in region r, where $r \in \{N,S\}$, at time t, and α, v and A_x are technological parameters. The total factor productivity in the traded good sector depends positively on the average skill level of workers employed in the region, $\bar{s}_t^r$.[14] Purely for notational simplicity, I assume that the average skill level enters log-linearly in the production function.

Firms maximize profits taking factor and output prices as given and choose the amount of labor services and capital to employ. The profit maximizing factor demands in the traded and nontrade sectors are, respectively:

$$w_t^r = (1-\alpha)\bar{s}_t^r (k_{y,t}^r)^{\alpha}$$

$$\rho = \alpha \bar{s}_t^r (k_{y,t}^r)^{-\alpha}$$

$$w_t^r = (1-v) p_{x,t}^r A_x (k_{x,t}^r)^{v}$$

$$\rho = v p_{x,t}^r A_x (k_{x,t}^r)^{-v},$$

where $k_{y,t}^r \equiv K_{y,t}^r / L_{y,t}^r$, $k_{x,t}^r \equiv K_{x,t}^r / L_{x,t}^r$. It is important to note that capital is expressed per efficiency units of labor services, rather than per worker, because labor services, and not the mass of workers, are the relevant input. Moreover, w_t^r is the remuneration per unit of

[14] The production function of the traded goods sector may be regarded as a version of the "o-ring" production function introduced by Kremer (1993).

labor services, while the actual remuneration of a worker endowed with s_i efficiency units of labor services in region r is:

$$w_{t,i}^{r} = s_i w_t^{r}. \tag{6}$$

The remuneration of a worker with skills s_i in region r is an increasing function of her own skills, s_i, and of the average skill level of the region where she works, $\bar{s}^{r}$ which depends on migrants' skills. Strategic complementarities arise from the interaction of individual and regional average skill level because the cross derivative, $(\partial w_{t,i}^{r})/(\partial s_i \partial \bar{s}^{r})$, is positive. This implies that highly skilled individuals benefit more from productivity improvements due to an increase in the average skill level. In fact, a higher wage rate per unit of labor services implies a higher skill premium, because highly skilled workers have a larger endowment of labor services.[15]

There is a firm for each sector in each region and firms' profits are distributed equally among all the young individuals in the economy. The aggregate per capita profits of this two-region economy are: $\Omega \equiv \pi_y^{\mathrm{N}} + \pi_y^{\mathrm{S}} + \pi_x^{\mathrm{N}} + \pi_x^{\mathrm{S}}$, where π_j^{r} are the profits of the firm in sector j in region r. As is always the case with constant returns to scale production functions, profits will be equal to zero in equilibrium.

3.3. Steady-state equilibrium

In equilibrium, labor is fully employed in both regions. The output of the traded good sector can either be used as a consumption good or transformed into a capital good, while the output of the nontraded sector can only be used as a consumption good.

Under the assumptions (which will be relaxed in the next section) that the economy is open to capital flows and there are no adjustment costs, the economy is always in steady state and there are no transitional dynamics. In what follows, I refer to steady-state variables by omitting time subscripts.

The steady-state levels of capital per unit of efficiency of labor services in the traded and nontraded good sectors are easily determined from the first order conditions and are, respectively:

$$k_y^{r} = \left(\frac{\bar{s}^{r}\alpha}{\rho}\right)^{\frac{1}{1-\alpha}}$$

$$k_x^{r} = \left(\frac{p_{x,t}^{r} A_x v}{\rho}\right)^{\frac{1}{1-v}}. \tag{7}$$

[15] Therefore, the model endogenizes the skill premia differentials, identified by Borjas et al. (1992) as the main determinant of migration flows.

Hence, the steady-state equilibrium wage rate per efficiency unit of labor is:

$$w^r = (1-\alpha)\left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}}(\bar{s}^r)^{\frac{1}{1-\alpha}}. \tag{8}$$

Since labor is perfectly mobile across sectors, the price of nontraded goods in region r is obtained by equating the wage rate in the two sectors within region r:

$$p^r = B(\bar{s}^r)^{\frac{1-v}{1-\alpha}} \tag{9}$$

where

$$B \equiv \frac{(1-\alpha)^{1-v}\left(\frac{\alpha}{\rho}\right)^{\frac{\alpha(1-v)}{1-\alpha}}}{A_x(1-v)^{1-v}\left(\frac{v}{\rho}\right)^{v}}.$$

From Eqs. (8) and (9), it is evident that both the remuneration per unit of labor services and the price of nontraded goods are increasing in the regional average skill level. Whether or not it is convenient to locate in a high productivity (i.e. high average skill level) region depends on the worker's skills (i.e. her endowment of labor services). If these are low, it may be convenient for the worker to move to a low-productivity region, because living expenditures are lower.

Since all variables depend on the average skill level of the population, it is necessary to establish how this is determined in order to describe fully the steady-state equilibrium.

A symmetric steady-state equilibrium, in which no skilled worker migrates from the region of origin, always exists. No one migrates if she expects that the average skill levels of the workers active in each region are equal, that is if $\bar{s}^{\mathrm{N}} = \bar{s}^{\mathrm{S}}$. In this case, the total factor productivity in the nontraded sector remains equal in the two regions, and neither wage nor price differentials emerge. Inequality (Eq. (4)) is never satisfied so that no one actually finds it optimal to migrate.

However, since skills are strategic complements, this does not need to be the unique steady-state equilibrium (Cooper and John, 1988). If a worker expects the most skilled workers born in region r' to migrate to region r, she may find it optimal to move to region r as well, because her own productivity is increasing in the average skill level of the workers producing in the same location. If all workers share the same expectations in equilibrium, skills may be asymmetrically distributed between the two regions, even if these are symmetric ex ante.

Let us assume without loss of generality that, if an asymmetric equilibrium emerges, the most skilled workers migrate to the North. Proposition 1 describes the conditions that must be satisfied in an equilibrium with asymmetric distribution of skills.

Proposition 1. (Equilibria with asymmetric distribution of skills). *In an asymmetric equilibrium, in which the average skill level (and therefore productivity in the traded good sector) is higher in the North than in the South, the following conditions are satisfied:*

(i) *All workers with skills $s_i \geq \bar{\bar{s}}$ migrate from the South to the North, where $\bar{\bar{s}}$ is the least s_i such that: $s_i(w^N - w^S) > (p_x^N - p_x^S)\bar{C}_x + \Delta$.*

(ii) *All workers with skills $s_i \leq \underline{\underline{s}}$ migrate from the North to the South, where $\underline{\underline{s}}$ is defined as the highest value of s_i which satisfies the following inequality: $s_i(w^S - w^N) > (p_x^S - p_x^N)\bar{C}_x + \Delta$.*

(iii) *The average skill levels in the North and the South are, respectively:*

$$\bar{s}^{\mathrm{N}} = \frac{\int_{\{s_i \in R^+ : s_i \geq \underline{\underline{s}}\}} \mathrm{d}F(s_i)}{\int_{\{s_i \in R^+ : s_i \geq \underline{\underline{s}}\}} \mathrm{d}F(s_i) + \int_{\{s_i \in R^+ : s_i \geq \bar{\bar{s}}\}} \mathrm{d}F(s_i)} \int_{\{s_i \in R^+ : s_i \geq \underline{\underline{s}}\}} s_i \mathrm{d}F(s_i) + \frac{\int_{\{s_i \in R^+ : s_i \geq \bar{\bar{s}}\}} \mathrm{d}F(s_i)}{\int_{\{s_i \in R^+ : s_i \geq \underline{\underline{s}}\}} \mathrm{d}F(s_i) + \int_{\{s_i \in R^+ : s_i \geq \bar{\bar{s}}\}} \mathrm{d}F(s_i)} \int_{\{s_i \in R^+ : s_i \geq \bar{\bar{s}}\}} s_i \mathrm{d}F(s_i) \quad (10)$$

$$\bar{s}^{s} = \frac{\int_{\{s_i \in R^+ : s_i \leq \bar{\bar{s}}\}} \mathrm{d}F(s_i)}{\int_{\{s_i \in R^+ : s_i \leq \underline{\underline{s}}\}} \mathrm{d}F(s_i) + \int_{\{s_i \in R^+ : s_i \leq \bar{\bar{s}}\}} \mathrm{d}F(s_i)} \int_{\{s_i \in R^+ : s_i \leq \bar{\bar{s}}\}} s_i \mathrm{d}F(s_i) + \frac{\int_{\{s_i \in R^+ : s_i \leq \underline{\underline{s}}\}} \mathrm{d}F(s_i)}{\int_{\{s_i \in R^+ : s_i \leq \underline{\underline{s}}\}} \mathrm{d}F(s_i) + \int_{\{s_i \in R^+ : s_i \leq \bar{\bar{s}}\}} \mathrm{d}F(s_i)} \int_{\{s_i \in R^+ : s_i \leq \underline{\underline{s}}\}} s_i \mathrm{d}F(s_i). \quad (11)$$

(iv) *Firms in both sectors maximize profits given w_t^r, ρ, $p_{x,t}^N$, and $p_{x,t}^S$.*

(v) *Good markets and labor markets clear in the North as well as in the South.*

The model has an equilibrium with asymmetric distribution of skills, if either (i) or (ii) or both are satisfied when the average skill level in the two regions is determined according to (iii). This is an equilibrium only if workers' beliefs about the average skill level in both regions and, ultimately, about wages and prices are satisfied in equilibrium. In Eqs. (10) and (11), the equilibrium average skill level in both regions is determined. In both equations, this is equal to the weighted average of the skills of the residents who do not move (first term) and of the newcomers (second term) with weights equal to their relative mass in the regional population.

In an asymmetric equilibrium, the highly skilled workers, who benefit more from high skill premia, move to the North, while the low-skilled workers move to the South because the higher wage is not sufficient to compensate for the higher cost of nontraded goods, since they can benefit only to a limited extent of the higher skill premium in the North. Workers with intermediate levels of skills prefer not to move from the region of origin in order not to spend the fixed migration cost, since the difference in skill remuneration between the two regions just about compensates the difference in living costs.

The existence of an asymmetric equilibrium with the characteristics of the one described in Proposition 1 is not warranted and depends on the parameter's values. The difference between the extremes of the support of the distribution of skills, $s_{\max} - s_{\min}$, must be large enough in order to observe two-way migration flows, because there must be workers with sufficiently different incentives. Moreover, for migration of low-skilled workers to the South to occur, the basic living expenditures must be a sufficiently large part of a worker's income. In particular, the larger the impact of average skill level on total factor productivity is (as happens if total factor productivity is a convex function of the average skill level, rather than a linear function), the higher the basic living expenditures must be relative to the total income.[16]

If an asymmetric equilibrium exists, the self-selection of migrants has clear implications for regional disparities. Per capita GDP in the North is higher, not only because the most productive workers, who receive higher wages, are in the North, but also because the self-selection of migrants increases total factor productivity in the traded goods sector in the North and decreases it in the South. Therefore, technologies differ only ex post as a consequence of migrant flows. I show in the next section, using a slightly more complicated model that has transitional dynamics that an economy can indeed converge to such an asymmetric steady state.

The observed migration flows depend on the distribution of skills in the population. For instance, the fact that the mobility rate is lower in Spain than in Italy and there are larger flows to the poorest regions in Spain may be explained by differences in the composition of population. In fact, while Italian residents with at least a high school diploma accounted for 11% of the overall population in 1980 (20% in 1992), in Spain the percentage of workers who completed high school was only 5% in 1980 (8% in 1992).[17] Therefore, since there are relatively more skilled workers in Italy, the observed migration flows to the richest regions are also larger. Analogously, the model is compatible with the higher mobility rate that characterizes the US with respect to Europe. In fact, this could be explained by a more polarized distribution of skills in the US or by technological differences that favor more wage inequality.

The model can also account for the remarkably higher mobility rate of skilled workers relative to the average mobility rate of the population observed in the studies on internal migration. This is true in the model as far as $F(\underline{s}) < 1 - F(\overline{s})$, i.e. if the mass of highly skilled individuals migrating from the South to the North is larger than the mass of low-skilled individuals migrating from the North to the South.

The results have been derived under the simplifying assumption that the next generation size is not affected by migration flows. However, the results of the model are completely unchanged if migration affects the size of the new generation without

[16] In particular, if the average skill level has a large impact on productivity and the basic living expenditures are a small fraction of a worker's income it may be convenient also for low-skilled workers to migrate to the North.

[17] See Giannetti (1999, 2001) for details.

modifying the distribution of skills.[18] By contrast, if newborns inherited the skill level from their parents, the distribution of skills in the new generation would depend on the characteristics of individuals working in the region during the previous period. In this case, it could happen that the new generation born in the region losing its more skilled workers is less skilled and migration flows decrease because of this endogenous change in the distribution of skills, which accentuates regional disparities. However, if one thinks that skills depend not only on education but also on innate ability, the assumption does not appear too restrictive and allows us to focus on the consequences of self-selection of migrants for uneven development.

4. The dynamics of migration and convergence

The previous section shows that a steady state in which only the most skilled workers are responsive to productivity differentials, while low-skilled workers move to low-cost low-productivity regions, is perfectly consistent with economic rationality. This section shows that such a steady state can indeed be the long run equilibrium of a dynamic model.

Moreover, I also show that a model based on skill complementarities and endogenous price differentials can explain why several European countries, such as Italy, Spain, and the UK have experienced a dramatic drop in mobility rates since the late 1970s (Bentolila, 1997; Bover and Velilla, 1999; Cameron and Muellbauer, 1998; Faini et al., 1997; Giannetti, 2001).[19] The empirical evidence reported in these studies shows that despite the fact that the process of regional convergence was not completed, and in fact came to a halt in those years, the average mobility rate of the overall population dropped significantly in comparison to the 1960s. Even Germany, notwithstanding the pronounced disparities between the East and the West, registered a similar drop in internal mobility from the 1991, only 2 years after the reunification (Hunt, 2000).

A closer look at the above mentioned empirical studies makes clear that highly skilled workers continue to have a high propensity to move to the most productive regions. Moreover, in a few cases, low-skilled workers contextually began to migrate to the poorest regions (Bover and Velilla, 1999).

This section studies the dynamics of migration flows and its interaction with the process of capital accumulation, and shows that a dynamic version of the model is compatible with the empirical evidence.

[18] In fact, in this model the size of the labor force does not influence the marginal productivity of capital, because capital is assumed to be perfectly mobile and its cost is always equal to the international interest rate (as is common in small open economy models). However, if there were increasing returns to capital, like in Faini (1996), population growth due to the immigrant flows would make convergence less likely (see Gillen and Guccione, 2000; Faini, 2000).

[19] There are alternative explanations of this phenomenon in the existing literature. Pissarides and Wadsworth (1989) and Bentolila (1997) attribute this trend to the increase in the national rate of unemployment, which decreases the probability of finding a job in another region and reduces the benefits of migration. This argument, though, does not provide any explanation for the high mobility of the most skilled workers and the self-selection of migrants. The argument of Faini and Venturini (1994), who suggest that the relationship between migration and income is nonlinear and, therefore, an increase in the standard of living may reduce mobility, suffers from the same problem.

In order to introduce dynamics into the model, I add adjustment costs, which are a quadratic function of the change in capital per efficiency unit of labor: $\phi((k_{t+1}-k_t)^2/2k_t)$.[20] This implies that it is costly for firms to change the capital intensity of the technique of production.

Moreover, to avoid indeterminacy problems due to the interdependence of investment and migration decisions, I assume that total factor productivity in the traded good sector at time t depends on the average skill level of workers employed in that region at $t-1$. In this way, when firms invest, total factor productivity in the traded sector is given. Migration decisions at time t are taken after investment decisions are observed.[21]

To reduce the dimension of the dynamic system that describes the two-region economy, I assume that the ratio of capital intensities in the two sectors of region r at $t=0$ is equal to the steady-state ratio of capital intensities. This implies that the process of capital deepening proceeds at the same rate in both sectors of a region during the transition to the steady state. Therefore, to study the dynamics, I can focus on the capital per efficiency units of labor services of the traded good sector in region r. For notational simplicity, in what follows the subscript y is omitted.

In this context, I study migration flows as the economy converges to an asymmetric steady state.

In this dynamic version of the model, firms maximize profits net of adjustment costs and the cost of capital, ρ, by choosing the capital intensity of the technique of production. The objective function for a firm in the traded goods sector is:

$$\sum_{t=0}^{\infty}\frac{\pi_{t+1}^r}{(\rho)^t}=\sum_{t=0}^{\infty}\frac{y_{t+1}^r-\rho k_{t+1}^r-\phi\frac{(k_{t+1}^r-k_t^r)^2}{2k_t^r}}{(\rho)^t}.$$

The growth rate of capital per efficiency units of labor services in the economy is determined according to the first order conditions for profit maximization. These are:

$$\frac{k_{t+1}^r-k_t^r}{k_t^r}-\frac{k_{t+2}^r-k_{t+1}^r}{\rho k_{t+1}^r}-\frac{1}{2}\left(\frac{k_{t+2}^r-k_{t+1}^r}{\rho k_{t+1}^r}\right)^2=\frac{1}{\phi}[\alpha\bar{s}_t^r(k_{t+1}^r)^{\alpha-1}-\rho]. \tag{12}$$

The equilibrium of this two-region economy is described by the capital intensity sequences which satisfy the second-order difference equation (Eq. (12)) in both regions.

Moreover, in Eq. (12), $\bar{s}_t^r$ is determined according to part (iii) of Proposition 1, and, therefore, depends on capital intensity in both regions. In fact, $\bar{s}_t^r$ is a function of migration decisions at t, that is, of $\bar{\bar{s}}_t$ and $\underline{\underline{s}}_t$. Migration decisions, in turn, depend on the remuneration of labor services and the price of nontraded goods. The remuneration of labor services and the price of nontraded goods depend on capital intensity at time t and on the level of total factor productivity in the traded goods sector in region r, which is equal to the average skill level in this region at $t-1$. Therefore, the following difference equation must hold: $\bar{s}_t^r=g^r(k_t^N,k_t^S,\bar{s}_{t-1}^N,\bar{s}_{t-1}^S)$, where g^r is the function that maps capital intensities and past average skill levels in the current average skill level of region r.

[20] Without adjustment costs, the model has no transitional dynamics and jumps immediately to the steady state, because capital can flow freely into the economy.

[21] Cooper and Haltiwanger (1996) provide empirical evidence for the existence of dynamic complementarities.

To summarize, the dynamics of the model are described by a system of four difference equations with initial conditions $\bar{s}_0^{\rm N}$, $\bar{s}_0^{\rm S}$, $k_0^{\rm N}$ and $k_0^{\rm S}$. Since I analyze convergence to an asymmetric steady state in which the highly skilled workers move to the North, the initial conditions must be such that: $\bar{s}_0^{\rm N}>\bar{s}_0^{\rm S}$ and $k_0^{\rm N}>k_0^{\rm S}$.

The steady states of this dynamic system are the same as the equilibria of the economy without transitional dynamics described in the previous section. To establish under which conditions the economy converges to an asymmetric steady state of the type described in Proposition 1, the system is linearized around the steady state (see Appendix A). Proposition 2 gives a sufficient condition for local convergence of the dynamic system.

Proposition 2. (Sufficient condition for local convergence to an asymmetric steady state). *A sufficient condition for local convergence to an asymmetric steady state is that the value of the density function, f(s), associated with the c.d.f. F is sufficiently close to zero at* $\underline{\underline{s}}$ *and* $\bar{\bar{s}}$.[22]

Proof. See Appendix A. □

Under the condition stated in Proposition 2, the regional average skill level is not significantly affected by migrants' skills in the neighborhood of the steady state.

In what follows, I assume that the sufficient condition stated in Proposition 2 is satisfied and examine the evolution of migration flows, while the system converges to an asymmetric steady state, starting from the neighborhood of the steady state.

I am interested to know under what conditions regional convergence brings a change in the pattern of migration flows as the one observed within European countries. I analyze this question under the extreme assumption that only the less productive region is growing, while the richest region is already in steady state (where the growth rate is normalized to zero), because conclusions depend on the direction from where the system approaches the steady state. This in turn is related to the relative speed of capital accumulation in the two regions. Since I want to get insights on the dynamics of migration flows while a convergence process is in act, as in Europe in the 1960s and early 1970s, I study a situation in which the South is growing faster. For simplicity's sake, I assume that at $t=0$, while the South is catching up and accumulating capital, the North has already reached the steady state.[23]

Proposition 3 describes the conditions under which migration flows to the North decrease during the transition to the steady state.

Proposition 3. (Migration flows to the North). *If capital accumulation has a limited effect on the price of nontraded goods (α − ν sufficiently small), or if fixed migration costs are relatively high, migration flows from the South to the North decrease over time.*

Proof. Migration to the North decreases as $\bar{\bar{s}}_t$ rises, where from Proposition 1:

$$\bar{\bar{s}}_t \equiv \frac{(p_{x,t}^{\rm N}) - p_{x,t}^{\rm S}\bar{C}_x + \Delta}{w_t^N - w_t^S}.$$

[22] I continue to refer to steady state values by omitting the time subscript.

[23] For the result to hold, it is sufficient that the South is growing faster than the North. This is true if the capital level in the North is closer to the steady state at $t=0$.

By log-linearizing $\bar{\bar{s}}_t$ in a neighborhood of the steady state, it turns out that $\bar{\bar{s}}_t$ increases to its steady-state value during the process of capital accumulation as long as difference in factor intensities in the two sectors is not too pronounced, that is, if $\alpha - v$ is sufficiently small. In this case, regional convergence in the price of nontraded goods (where the nontraded good price differential can be written as: $\ln(p_t^N) - \ln(p_t^S) = \ln(\bar{s}_{t-1}^N) - \ln(\bar{s}_{t-1}^S) + (\alpha - v)(\ln(k_t^N) - \ln(k_t^S))$ proceeds at a sufficiently slower pace than convergence in wages (where the wage differential is $\ln(w_t^{\mathrm{N}}) - \ln(w_t^{\mathrm{S}}) = \ln(\bar{s}_{t-1}^{\mathrm{N}}) - \ln(\bar{s}_{t-1}^{\mathrm{S}}) + \alpha[\ln(k_t^{\mathrm{N}}) - \ln(k_t^{\mathrm{S}})]$).

Alternatively, if Δ is relatively high the effect of the increase in the ratio of migration costs to the wage differential prevails with respect to the convergence in the cost of living across the two regions. Therefore, the migration flow to the North decreases in this case as well. □

The difference in factor intensities between the two sectors, $\alpha - v$, plays an important role in determining the effects of convergence on migration flows, because it measures the degree to which an increase in capital intensity in region r is reflected in an increase in the price of nontraded goods. If this difference were large, the regional differential in the price of nontraded goods would decrease relatively fast. In contrast, if the capital accumulation has a larger effect on interregional wage differentials than on nontraded good price differentials, convergence in capital intensities may discourage migration to the North.

It is possible to show that, under the conditions of Proposition 3, also migration flows from the North to the South increase ($\underline{\underline{s}}_t$ increases). This is compatible with the empirical evidence showing that the decrease in migration flows to the rich regions is accompanied by positive migration flows to the relatively less productive regions.

Analogously, it can be shown that, if the North is growing, while the South is stagnating, there may be large outflows of low-skilled workers from the growing location ($\bar{\bar{s}}_t$ is increasing), if the inflation in the cost of living proceeds at a high rate (i.e. if $\alpha - v$ is large). This could explain, for instance, the experience of booming regions, such as Silicon Valley.

Such a mechanism based on faster (slower) convergence of wages is definitively at work in many countries, even if it is often due to institutional reasons, such as centralized bargaining, besides of the technological mechanism underlined in this paper.

The model also has interesting implications for long-run convergence in regional per capita GDP. The self-selection of migrants generates differences in total factor productivity, which yield an equilibrium with an asymmetric distribution of income. An initial economic disadvantage (lower capital intensity in the model) has long-run effects because the self-selection of migrants perpetuates the uneven distribution of skills and gives rise to a "poverty trap". This may explain the changing dynamics of migration and convergence within the European Union where, as has been noticed (Giannetti, 2001, 2002), not only did internal migration drop in the 1980s, but the process of regional convergence also appears to have come to a halt.

From a normative point of view, whether the concentration of skilled workers and the consequent regional disparities maximize social welfare or not depends on the shape of the distribution of skills within the population. There are two contrasting effects at work. On the one hand, the self-selection of migrants increases total factor productivity in the North and this in turn increases the output of workers employed in the North. On the other hand, the opposite is true in the South. The net effect on total output depends on whether the increase in output in the North is larger or smaller than the decrease in the South. This depends on the shape of the distribution of skills in the population. In particular, if the mass of workers remaining in the South is very large with respect to the mass of migrants, the self-selection of migrants reduces aggregate GDP and, therefore, a social planner would seek to limit migration flows. In addition, if one considered endogenous skill acquisition, the departure of the most talented workers would depress accumulation of human capital in the South and would further deepen regional disparities.

5. Conclusions

This paper shows how heterogeneity in migrants' skill levels and living-cost differentials can explain some of the puzzles surrounding internal migration and regional development. The shortage of unskilled workers in booming regions like Silicon Valley is easily explained by the existence of skill complementarities that increases not only aggregate productivity but also the price of nontraded goods and, consequently, create incentives to leave for workers who benefit less from high skill premia.

The model also shows how the self-selection of migrants may generate poverty traps for regions that start from less favorable conditions, because it leads to differences in total factor productivity in the traded goods sector. However, there is no danger of depopulation for the poorer regions, as models that merely consider wage differentials would forecast, because forces are at work leading unskilled workers to migrate to these regions.

Finally, the mechanisms proposed in the model can explain the changing dynamics of migration and convergence within the European Union where, as has been widely noted, not only did internal migration drop during the 1980s, but the process of regional convergence also appears to have stopped.

The conclusions of the model have also interesting policy implications for the integration of Eastern European economies into the European Union. Allowing free mobility of labor between Eastern and Western Europe might create a poverty trap for transition economies, since the most educated and skilled individuals would be the ones with strongest incentives to migrate, especially if living standards (and what is considered basic living expenditures) converged quickly to Western European standards.

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Appendix A. Proof of Proposition 2

Local convergence to the asymmetric steady state

The dynamics of the economy are described by two difference equations of second order and two difference equations of first order:

$$\frac{k_{t+1}^r - k_t^r}{k_t^r} - \frac{k_{t+2}^r - k_{t+1}^r}{\rho k_{t+1}^r} - \frac{1}{2}\left(\frac{k_{t+2}^r - k_{t+1}^r}{\rho k_{t+1}^r}\right)^2 = \frac{1}{\phi}\left[\alpha \bar{s}_t^r (k_{t+1}^r)^{\alpha-1} - \rho\right]$$

$$\bar{s}_t^r = g^r(k_t^{\mathrm{N}}, k_t^{\mathrm{S}}, \bar{s}_{t-1}^{\mathrm{N}}, \bar{s}_{t-1}^{\mathrm{S}})$$

with $r \in \{\mathrm{N,S}\}$.

As usual, the system can be transformed into a system of six difference equations of first order with initial conditions $\bar{s}_0^{\mathrm{N}}$, $\bar{s}_0^{\mathrm{S}}$, k_0^{N}, k_0^{S}. The matrix of coefficients of the system linearized in a neighborhood of the asymmetric steady state is the following:

$$\begin{bmatrix} a_{11} & a_{12} & 0 & 0 & a_{15} & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & a_{33} & a_{34} & 0 & a_{36} \\ 0 & 0 & 0 & 1 & 0 & 0 \\ a_{51} & 0 & a_{53} & 0 & a_{55} & a_{56} \\ a_{61} & 0 & a_{63} & 0 & a_{65} & a_{66} \end{bmatrix}$$

where

$$a_{11} = a_{33} = \frac{\rho(1-\alpha) + \left(1 + \frac{1}{\rho}\right)\phi}{\frac{\phi}{\rho}},$$

$a_{12} = a_{34} = -1$, $a_{15} = \rho^2/\bar{s}^{\mathrm{N}}$ and $a_{36} = \rho^2/\bar{s}^{\mathrm{S}}$. All the terms in the last two rows may be written as $A_{ij} f(\bar{\bar{s}}) + \Gamma_{ij} f(\underline{\underline{s}})$, where A_{ij} and Γ_{ij} depend on the parameters of the model and the steady-state values of the variables.

If $f(\underline{\underline{s}})$ and $f(\bar{\bar{s}})$ are sufficiently close to zero in the asymmetric steady state, the previous matrix can be approximated by one in which the last two rows are zeros and it is straightforward to calculate the eigenvalues.

It turns out that the dynamics of the system can be approximated by the dynamics of two independent second-order difference equations with initial conditions k_0^{N} and k_0^{S}. Moreover, since both difference equations have an eigenvalue larger and one smaller than one for all the parameter values, there is saddlepath convergence to the steady state. □

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