Endogenous mobility, human capital and trade

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Abstract

The paper presents a model that can explain how regional differences emerge in a country as a consequence of foreign trade. The model is based on the widely used increasing returns/transportation costs framework. In addition to the conventional elements, heterogeneous households and imperfect labor mobility are added. The results indicate that for a small economy international trade leads to human capital reallocation, and thus more regional inequality than without labor heterogeneity. Even small migration flows can lead to large inequalities in per capita incomes, if the most skilled workers move. The model also sheds some light on the relative importance of fundamentals and historical factors.

Keywords: Migration, human capital, regional inequalities

JEL Classification: F12, R12, R23.

1 Introduction

Migration is an important mechanism in determining regional incomes. It can act as a force of convergence between regions in neoclassical models, and it can be a force for agglomeration if increasing returns are present. In the age of mass migration wage inequality across the Old and New Worlds decreased substantially because of the movement of labor, as Lindert and Williamson (2001) documents. In models of agglomeration, however, migration of workers to urban centers leads to the emergence of regional inequalities (Krugman 1991).

This paper is concerned with the inequality generating role of migration. In particular, I present a model in which migration acts as a powerful *magnification force* that amplifies existing regional differences. It has been documented by Gallup, Sachs and Mellinger (1998) that areas with good access to transportation (coast lines, navigable rivers etc) are richer than other regions. In a study of Japanese regions, Davis and Weinstein (2001) conclude that locational fundamentals determine basic concentration patterns, but endogenous agglomeration forces might play an important role in amplifying these patterns. This paper is written in the same spirit, where a region with a (potentially) small initial geographical advantage acquires a much bigger lead in income through endogenous migration.

Regions differ in their access to outside markets, which gives the physically closer region a natural advantage. If the economy is closed, this advantage cannot be realized and spatial symmetry is an equilibrium. When, however, the country opens up to international trade, the region closer to the outside market will have a higher real wage and can potentially attract immigrants from the other parts of the country. The crucial contribution of the paper is to endogenize not just the size, but the composition of the migration flow. In particular, since migration costs are assumed to be the same but labor market abilities are not, it will be the skilled workers who are most likely to move. This has two consequences for regional inequalities. First, the market size of the immigrant region will increase by more than the raw number of immigrants, because their income and supply of efficiency units of labor will be above average. In the presence of *scale effects* this leads to a more than proportional increase in the wage rate. Second, average incomes will be higher also because of the *composition effect*. The immigrant region will have a distribution of skills skewed towards the highly skilled, whereas the opposite is true for the other region. Thus the model's prediction is that migration of skilled people reinforces natural advantages by both the scale and composition effects.

The example that motivated this research is the recent experience of Hungary, where large income inequalities emerged in a short period of time between seemingly very similar regions. Up to the end of the 1980s the Hungarian economy was a relatively closed one, at least to trade with the developed world. The reasons were mainly ideological, as the "socialist" countries of Eastern Europe formed an autarchic trade block with the Soviet Union.

Since Hungary's traditional trading partners are in Central and Western Europe, this arrangement (though providing some gains from specialization) was largely artificial, and was only sustained by political means. In 1989, when the Iron Curtain came down, Hungary liberalized its foreign trade in a very short period of time. The old "socialist" trading block collapsed, and in a few years Hungarian trade was redirected from Eastern Europe to the West. It is natural that such a huge shock had a large effect on the country, above and beyond the shock of transforming a command economy into a market economy. What is surprising is how different the response to these shocks was in different parts of the country. Though the initial shock was great in all regions, the northwestern counties rebounded fairly quickly, while the eastern part still seems stuck in a deep recession.

It is interesting to contrast the experience of two counties: Győr-Sopron-Moson in the northwest corner and Borsod- Abaúj-Zemplén in the northeast. Though we do not have regional GDP measurement before 1994 in Hungary, county level data on employment and industrial production are available.[1] In 1989 industry employed about 15% of the population of both counties, and the unemployment rates were practically zero. In the early 1990's both counties went into a deep recession, with many of the big state enterprises struggling with the transition process. Since the middle of the decade, however, the two counties fared quite differently. In Győr-Sopron-Moson indus-

[1] All the data in this paragraph comes from the Hungarian Statistical Yearbook 1989-1996.

trial production reached its 1989 level in 1996, and unemployment remained around 6%. Industrial production stood at 62% of its 1989 level in 1996 in Borsod-Abaúj-Zemplén, and the unemployment rate was close to 20%. In 1997 per capita GDP was 60% higher in Győr-Sopron-Moson than in Borsod-Abaúj-Zemplén. Did the emergence of such huge differences induce emigration from the East to the West? Yes, but at a very modest level. Between 1989 and 1996 Győr-Sopron- Moson saw a migration surplus of around 2% of its 1989 population, and Borsod-Abaúj-Zemplén lost around the same portion of its 1989 population to outmigration. Incentives to migrate were clearly big, but the costs to do so were also fairly large.

The model presented in this paper can clearly explain these facts, because it focuses on the role of skilled people in the migration process. Even if the migration flow is small, the resulting difference in average incomes can be large, due to the scale and composition effects. In fact, the crucial role is played by the latter, because even with small geographical differences it can lead to large regional inequalities. On the other hand, the scale effect is likely to be small when the underlying difference between regions is small, so it is unlikely to explain the Hungarian story alone. In fact, wage rates are not very different for comparable workers in the two regions (*Magyar Statisztikai Évkönyv [Hungarian Statistical Yearbook]* 1989-1996). Evidence from other countries underlines this pattern. In Britain, for example, Duranton and Monastiriotis (2002) documents that regional inequalities arise from differences in skill distribution, and not from differentials in wage rates.

The relevant literature for the paper is the "New Economic Geography", extensively discussed in Fujita, Krugman and Venables (1999). Models in this tradition emphasize the role of endogenous forces (increasing returns and pecuniary externalities) in creating agglomeration, as opposed to locational fundamentals.[2] In Krugman (1991), the seminal article of the literature, agglomeration is a result of labor migration, but the only force creating regional inequalities is the scale effect. Moreover, the model predicts large population imbalances, which is not observed in the Hungarian example and is unlikely to hold for European regions. The role of intermediate inputs in creating industry linkages was emphasized in Krugman and Venables (1995), which generates industrial agglomeration (and wage inequality) without migration. The problem with this approach – at least in the present context – is that inequality results from wage differentials, and the composition effect is absent, which seems empirically questionable. Second, the model predicts complete industrial agglomeration in one region, which does not correspond to the Hungarian experience.

While my specific example is Hungary, the point is much more general. Examples such as the contrast between Northern and Southern Italy or the differential development of the coastal and interior regions in China come readily to mind. In general, it is usual to observe that a depressed region first looses its most skilled workers, which further aggravates the problems.

[2] An exception is Matsuyama (1998), which has various core-periphery patterns emerging as a consequence of geographical differences.

Also, attracting skilled people to a region is a first priority for regional planners. If we think that unemployment is concentrated among the less skilled, the model can also explain why depressed region have much higher unemployment levels (as we saw, this is the case in the Hungarian example). To summarize, though my prime example and motivation is the Hungarian experience, the idea to introduce heterogenous workers into models of economic geography is much more general and the model's predictions can be applied and tested in other countries as well.

The rest of the paper is organized as follows. Section 2 describes the model. Section 2.1 outlines the main assumptions and analyzes household and firm choices. Section 2.2 describes the goods market equilibrium conditions, and Section 2.3 depicts the migration decision. In Section 3 the full equilibrium of the model is described, with Section 3.1 containing results for the autarchy two-region case. In Section 3.2 I introduce foreign trade into the model and look at its effects on the two regions from. Section 3.3 discusses the role of expectations in the agglomeration pattern. Finally, Section 4 concludes.

2 The model

2.1 Basic assumptions

There are two countries, Home and Foreign, and Home has two regions, East and West. The three regions can potentially trade with each other, and goods are subject to transportation costs, which take the well-known "iceberg" form.[3] People can move between the East and West, but not across borders. Migration is subject to a monetary cost of D, which can be payed after moving. This amounts to the existence of perfect credit markets that can finance the cost of relocation.

Consumers in any region consume a variety of goods. There are a continuum of such goods, indexed from 0 to N. I assume that consumers maximize the utility function

$$u = \left[\int_0^N c(i)^{1-1/\sigma} \, di \right]^{\frac{\sigma}{\sigma-1}}, \tag{2.1}$$

where $c(i)$ is consumption of good i, j is the index for households, N is the measure of different products available (it will be determined endogenously) and σ is the constant elasticity of substitution. Goods enter the utility function symmetrically, and consumers have a taste for variety[4]. For the chosen market structure (see below) it is necessary to assume that $\sigma > 1$.

Although they have the same utility function, individuals have different amounts of human capital. Household j has human capital h_j, which it rents out on the labor market. I assume that efficiency units of human capital have a constant price w, thus household j receives an income of wh_j. Then the budget constraint can be written as

$$\int_0^N p(i) c_j(i) di = wh_j, \tag{2.2}$$

with $p(i)$ standing for the price of good i. From (2.1) and (2.2) we can cal-

[3] If $\tau > 1$ units of a good are shipped from region i, only 1 unit arrives in region j.

[4] This can be seen by setting $c(i) = c/N$, and noticing that the resulting expression is increasing in N, the measure of variety.

culate the demand function of person j for good i. As (2.3) below shows, demand is linear in human capital. Aggregation is thus an easy task, and aggregate demand in a region for good i is given by (2.4), where H is aggregate human capital in the region[5]

$$c_j(i) = \left[\frac{p(i)}{P}\right]^{-\sigma} \frac{wh_j}{P} \tag{2.3}$$

$$c(i) = \left[\frac{p(i)}{P}\right]^{-\sigma} \frac{wH}{P}. \tag{2.4}$$

P is the true price index in the region, and it is given by the following expression:

$$P = \left[\int_0^N p(i)^{1-\sigma} di\right]^{\frac{1}{1-\sigma}}. \tag{2.5}$$

Now we can turn to firms. Since they are infinitesimal, they can only set their own price and their decision does not affect the aggregate price index. Production input takes the form of efficiency units of human capital. In order to produce, a firm must pay a variable cost of βw per unit of output and a fixed cost of αw. Thus the cost function has the following form:

$$TC = (\alpha + \beta q)w, \tag{2.6}$$

where q is the quantity produced by the firm[6]. Firms take the regional demands as given in (2.4). In principle they could charge different prices for different regions. In turns out, however, that it is optimal to set the same

[5]For now I omit regional indexes, since the equations so far apply to every region separately. But notice that prices, wages, the range of goods and aggregate human capital are all region specific, and will be treated as such when necessary.

[6]When no confusion arises, I omit the product index i.

price for every region. Assuming that there are no arbitrage possibilities in trade guarantees that if a firm sets a price of $p(i)$ for its export good, it will sell in the destination market for $\tau p(i)$, where τ is the "iceberg" transportation cost. But if we substitute this into the regional demand function, it will have the form of $kp(i)^{-\sigma}$, where k is a constant from the firm's point of view. Since the transportation cost is a part of only k and the profit maximizing price only depends on the constant elasticity of substitution σ, the firm will set the same price of its good for all regions.

Formally, substitute $kp(i)^{-\sigma}$ for $q(i)$ into $pq - TC$, rearrange the first-order condition to get

$$p(i) = \frac{\sigma}{\sigma - 1}\beta w. \tag{2.7}$$

This is the well-known result that firms apply a constant markup over marginal cost that is a decreasing function of the demand elasticity. The optimal price is the same for all regions, and it is also independent of the index i, since goods are completely symmetric. We can count the goods on an arbitrary scale, so I set units in such a way that $\beta\sigma/(\sigma - 1) = 1$, to simplify notation.

There are no barriers to entry by additional firms. Since firms are infinitesimal, entry continues until it drives profits to 0. The zero profit condition pins down firm size:

$$q = \alpha\sigma, \tag{2.8}$$

after using the normalization $\beta = (\sigma - 1)/\sigma$. Finally, factor markets clear in all regions. Using (2.8) and $\sigma/(\sigma-1)\beta = 1$, we have that for region m

$$H_m = N_m(\alpha + \beta q) = N_m \alpha \sigma.$$

Rearranging for N_m we find that the number of firms in region m is given by

$$N_m = \frac{H_m}{\alpha\sigma}. \tag{2.9}$$

2.2 Equilibrium on the goods market

In the full equilibrium of the model both wages and the distribution of human capital are endogenous. To solve the model, I first write down the equilibrium condition on the market for goods with a given distribution of human capital. Then I will use the equilibrium wage rate in the migration decision to close the model.

Since all varieties produced in a country have the same price and demand for them is symmetric, there will be only as many market clearing equations as countries. The supply of a variety is given by (2.8), this must be equal total demand in the regions, each given by (2.4). Notice that we can simplify the price index P_m, since all varieties from country k have the same price, so that

$$P_m^{1-\sigma} = \sum_k N_k w_k^{1-\sigma}.$$

Next, we can use (2.9) that links the number of varieties produced in a region to the aggregate level of human capital there, and substitute it into the price index term. Using the result in the demand functions, the equilibrium condition for a variety produced in region m can be written as

$$\sum_k \frac{\tau_{mk}^{1-\sigma} w_m^{-\sigma} w_k H_k}{\sum_j \tau_{kj} w_j^{1-\sigma} H_j} = 1. \tag{2.10}$$

It must be noted that one of the equations is redundant by Walras' Law, since only relative prices matter. Thus we will normalize one wage rate in what follows, setting $w_w = 1$, $w_e = w$ and $w_f = v$.

2.3 The migration decision

I assume that the initial position is when the East and West are completely symmetric in their size and distribution of human capital endowments. Given the symmetry of the problem, I will only look at the possibility of migration from the East to the West. Person j moves if her utility is greater in the West. Given migration costs, her nominal income is $h_j - D$ in the West and wh_j in the East. With homothetic preferences utility is proportional to the real wage, where the deflator is the price index. Thus the condition for moving is given by

$$\frac{h_j - D}{P_w} > \frac{wh_j}{P_e} \quad \Rightarrow \quad h_j \left(1 - \frac{wP_w}{P_e}\right) > D.$$

Notice that if it is profitable for person j to move, all other workers with human capital greater than j will move as well. This is because the gain from moving is linear in h_j for individuals, since their isolated actions do not influence the wage rate and the migration cost is constant. Also, because the wage rate will be bounded form below, gains from migration are finite. Thus assuming there are people with very low levels of human capital, there will always be someone for whom moving is not profitable. To assure that, I assume that $h_j \in [0, 1]$, with full support.[7]

That means that if there is migration in equilibrium, there must be a marginal person who is indifferent between migrating or not. Let the human capital level of that person be x. Then every worker who has $h_j > x$ will migrate, and all the others will stay. Thus the migration equilibrium of the model can be written as

$$x\left(1 - \frac{wP_w}{P_e}\right) \leq D \quad \text{and} \quad x \leq 1, \tag{2.11}$$

with complementary slackness.

Of course in equilibrium the wage rate and the price index depend on the distribution of human capital, and hence on x. For future reference let us define

$$B(x) \equiv x\left[1 - \frac{wP_w}{P_e}(x)\right],$$

which gives the gains from migration for the *marginal* person who is indifferent between moving and staying. Thus equilibrium is given by $B(x) \leq D$, $x \leq 1$. It is important to understand that $B(x)$ is an aggregate function, and does not correspond to individual gains from moving.

3 The impact of international trade

The full equilibrium of the model is characterized by the wage rates in the regions, and the distribution of human capital between the East and West,

[7] This assumption is not essential, but simplifies the analysis by ruling out full agglomeration.

given that the starting position is full symmetry between these two regions. The wage rates can be calculated from the market clearing conditions (2.10), which also determine the price indexes. Then the distribution of human capital must adjust to satisfy (2.11). Although we are interested in the effect of trade with Foreign, it is instructive to understand how the model works in the closed economy. Let us start with that case.

3.1 Two regions

In this case the market clearing conditions can be written in more simpler forms. Let $\rho = \tau_{ew}^{1-\sigma}$. Using (2.10), we can write the two equations as

$$\frac{H_w}{H_w + \rho w^{1-\sigma} H_e} + \frac{\rho w H_e}{\rho H_w + w^{1-\sigma} H_e} = H_w + H_e$$
$$\frac{\rho w^{-\sigma} H_w}{H_w + \rho w^{1-\sigma} H_e} + \frac{w^{1-\sigma} H_e}{\rho H_w + w^{1-\sigma} H_e} = H_w + H_e.$$

We can further simplify the equilibrium condition (the two equations are not independent) by multiplying the first equation by $\rho w^{-\sigma}$ and substracting it from the second. This yields the following equation:

$$\frac{w^{1-\sigma} - \rho w}{w^{\sigma} - \rho} = \frac{H_w}{H_e}. \tag{3.1}$$

It is easy to check that there is a unique positive solution to the equation, with $w^{\sigma} \in [\rho, 1/\rho]$. The equilibrium relative wage in the East is a decreasing function of H_w/H_e and it increases with the ease of transportation, ρ if and only if $w \leq 1$.

Next, we can use (3.1) to simplify wP_w/P_e. Combining it with the definitions of the price indexes, we get

$$\frac{wP_w}{P_e} = w^{\frac{2\sigma-1}{\sigma-1}}. \tag{3.2}$$

Thus the migration gain function can be written in this case as

$$B(x) = x[1 - w(x)^{\frac{2\sigma-1}{\sigma-1}}]. \tag{3.3}$$

Finally, aggregate human capital levels are characterized by

$$\begin{aligned} H_e &= \int_0^x h\,dG(h) \\ H_w &= \int_0^1 h\,dG(h) + \int_x^1 h\,dG(h). \end{aligned} \tag{3.4}$$

The full equilibrium of the model is given by (3.1), (2.11) together with (3.3) and (3.4).

We can easily check that no migration is an equilibrium. In such a situation $H_w/H_e = 1$, $w = 1$, $B(x) = 0$ and hence $x = 1$. Moreover, it is "tâtonnement" stable, since a small deviation will lead to migration gains smaller than the migration cost D, as long as $D > 0$. The more interesting question is whether there exists another stable equilibrium with positive migration. Proposition 1 shows that the answer is affirmative, as long as the migration cost is not too high.

Proposition 1. *For low enough migration costs there exist a stable equilibrium with positive migration flows.*

Proof. The following properties of $B(x)$ can be shown easily: $B(1) = B(0) = 0$, $B'(0) > 0$ and $B'(1) < 0$. The last two can be seen from the following:

$$B'(x) = 1 - w^{\frac{2\sigma-1}{\sigma-1}} - \frac{2\sigma - 1}{\sigma - 1} w^{\frac{\sigma}{\sigma-1}} w'(x),$$

and from the fact that $w'(x) > 0$. By the continuity of B the derivative properties also extend to neighborhoods of the two endpoints. Stability requires that at the equilibrium point $B' > 0$, and it follows that we can find a small enough D that intersects the B schedule at its increasing part close to $x = 0$. □

There is a presumption that $B(x)$ is quasi-concave, in which case there is a unique stable interior equilibrium (and also an unstable one). The restriction needed is that the p.d.f. $g(h)$ does not decrease too fast at any interior point where $B'(x) = 0$.[8] In the heuristic discussions below I will assume that is the case.

Figure 1 depicts the determination of the equilibrium with $\rho = 3/4$, $\sigma = 2$ and $G(h) = h$.[9] If the moving cost is in the appropriate range we have multiple equilibria. Even if initially the regions are perfectly symmetric, if many people think that moving is profitable inequalities emerge. Thus expectations have an important role in generating regional inequalities in a closed economy. Moreover, as we can see from the picture, moving involves a large shift in population. This result follows from the structure of the

[8] A function $f(y)$is quasi-concave at y_0 iff for any y such that $yf'(y_0) = 0$ we have $y^2 f''(y_0) \leq 0$. This condition is satisfied at any point x where $B'(x) \neq 0$. When $B' = 0$, $B(x)$ needs to be concave, which can be guaranteed by the above condition.

[9] In this case $E(h)$=1/2.

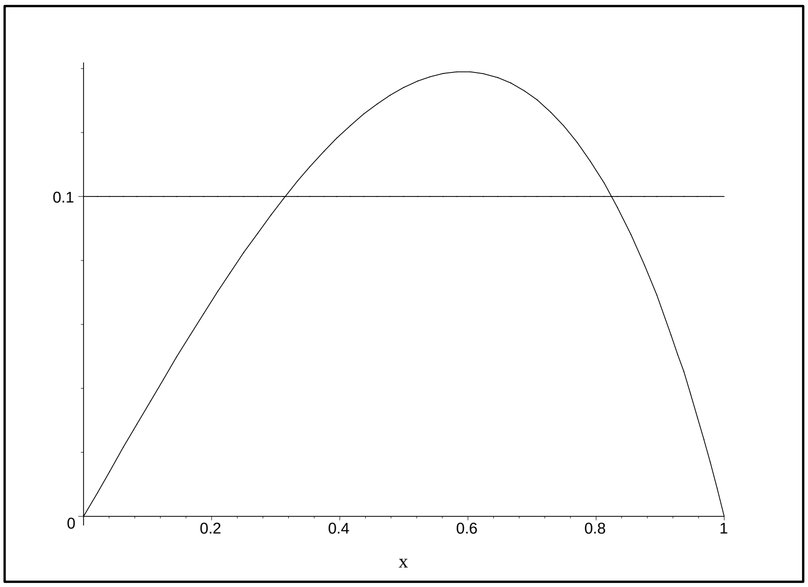
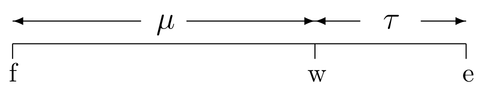


Figure 1: Equilibrium in a closed economy

model, since in order to get sufficient difference in real wages, there must be a large flow of immigration. If the symmetric equilibrium is the initial situation, there must be a dramatic shift in expectations for the asymmetric equilibrium to emerge, even when migration costs are low enough. Thus it seems fair to conclude that although a migration equilibrium is possible, the symmetric one is stable not just locally, but in a neighborhood with positive measure. Thus when introducing foreign trade I start from a position of symmetry.

3.2 Three regions

Now we can turn to the question of how opening the country to foreign trade changes the equilibria. For simplicity I treat the outside region as a homogenous unit, within which trade is costless. I'll label the foreign region with subscript f. To emphasize the difference in the distances from the outside region, I will use the following linear geographic structure shown below:



The picture shows that transport costs are μ between the world and West and τ between East and West. Then a natural assumption is that the transport cost between Foreign and East is $\mu\tau$. This assumption lets us reduce the number of distance parameters to two, and given the nature of the question, a natural one to make.

Let us proceed with the equilibrium conditions on the goods market. The pricing equations and the equilibrium scale of production are still given by (2.7) and (2.8). Similarly, for each region the number of firms will be proportional to the amount of human capital, $\alpha\sigma N_l = H_l$ for region l. Using the additional notation $\theta = \mu^{1-\sigma}$, we can write the price indexes as follows

$$\begin{aligned} \alpha\sigma P_e^{1-\sigma} &= \rho H_w + w^{1-\sigma} H_e + \rho\theta v^{1-\sigma} H_f \\ \alpha\sigma P_w^{1-\sigma} &= H_w + \rho w^{1-\sigma} H_e + \theta v^{1-\sigma} H_f \\ \alpha\sigma P_f^{1-\sigma} &= \theta H_w + \rho\theta H_e + v^{1-\sigma} H_f, \end{aligned} \tag{3.5}$$

where H_f is the (exogenous) size of the foreign country, and v is the wage rate prevailing in the foreign country. Then the equilibrium conditions for a given distribution of human capital are written as

$$\begin{aligned} \alpha\sigma(H_w + H_e + H_f) &= \frac{\rho w^{-\sigma} H_w}{P_w^{1-\sigma}} + \frac{w^{1-\sigma} H_e}{P_e^{1-\sigma}} + \frac{\rho\theta w^{-\sigma} v H_f}{P_f^{1-\sigma}} \\ \alpha\sigma(H_w + H_e + H_f) &= \frac{H_w}{P_w^{1-\sigma}} + \frac{\rho w H_e}{P_e^{1-\sigma}} + \frac{\theta v H_f}{P_f^{1-\sigma}} \\ \alpha\sigma(H_w + H_e + H_f) &= \frac{\theta v^{-\sigma} H_w}{P_w^{1-\sigma}} + \frac{\rho\theta v^{-\sigma} w H_e}{P_e^{1-\sigma}} + \frac{v^{1-\sigma} H_f}{P_f^{1-\sigma}}. \end{aligned} \tag{3.6}$$

These equations (of which only two are independent) do not seem to yield analytical results easily, but it turns out that one can characterize the equilibrium in every important aspect. After some algebraic manipulations[10], we can characterize the solution by the following two equations:

$$\begin{aligned} H_w + \theta v^{1-\sigma} H_f &= \frac{w^{1-\sigma} - \rho w}{w^{\sigma} - \rho} H_e \\ H_w + \rho w^{1-\sigma} H_e &= \frac{v^{1-\sigma} - \theta v}{v^{\sigma} - \theta} H_f. \end{aligned}$$

[10] Substitute the price index definitions from (3.5). Multiply the second equation by $\rho w^{-\sigma}$ and subtract it from the first, this leads to (3.7). Then multiply the second equation by $\theta v^{-\sigma}$ and subtract it from the third, which leads to (3.8).

The equations are scale free, so we can introduce the new variables $h = H_w/(H_e + H_w)$ and $h_f = H_f/(H_e + H_w)$ to get

$$h + \theta v^{1-\sigma} h_f = \frac{w^{1-\sigma} - \rho w}{w^{\sigma} - \rho}(1 - h) \tag{3.7}$$

$$h + \rho w^{1-\sigma}(1 - h) = \frac{v^{1-\sigma} - \theta v}{v^{\sigma} - \theta} h_f. \tag{3.8}$$

The equilibrium wage rates w and v are thus the solutions to (3.7) and (3.8).

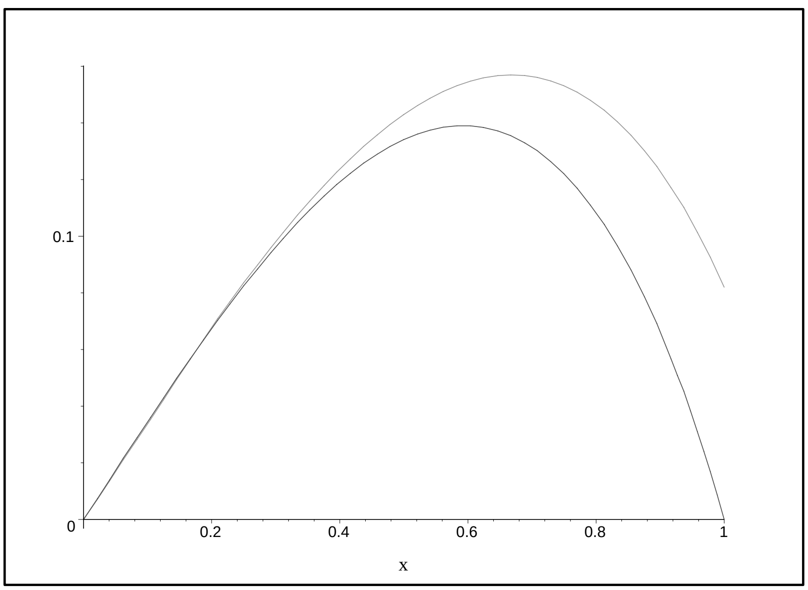


Figure 2: The effect of trade on a large country

Appendix A shows that there is a unique solution to the above system. Moreover, it is possible to show that P_w/P_e takes the same form as in the previous section, thus (3.3) continues to hold.[11] Thus the equilibrium conditions in the three region case are given by (3.7), (3.8), (2.11) together with (3.3) and (3.4). Proposition 2 summarizes the main result of this section.

Proposition 2. *If migration costs are high, the symmetric equilibrium is stable. For low migration costs, symmetry must be broken, and there exists at least one stable interior equilibrium.*

Proof. Appendix A shows that the equilibrium Eastern wage is decreasing in h, the share of the West in Home's human capital. Moreover, from (3.7) it follows that

$$w = 1 \quad \Rightarrow \quad h = \frac{1 - \theta v^{1-\sigma} h_f}{2} < \frac{1}{2}.$$

These together imply that

$$h = \frac{1}{2} \quad \Rightarrow \quad w < 1 \quad \Rightarrow \quad B(1) > 0.$$

Thus for low enough migration costs, symmetry is no longer an equilibrium. Since $B(0) = 0$, if symmetry is broken, there must exist at least one stable interior equilibrium. □

Figure 2 and Figure 3 show what happens with the migration gain function $B(x)$ when a country opens up to international trade. The parameter values $\rho = 3/4$, $\theta = 1/2$, $\sigma = 2$ and $G(h) = h$ are common in both figures, but the first one uses $h_f = 1/2$ and the second uses $h_f = 5$. The pictures confirm that low migration costs lead to symmetry breaking in this model.

[11] Solve (3.7) and (3.8) for h and h_f and substitute these into the price indexes.

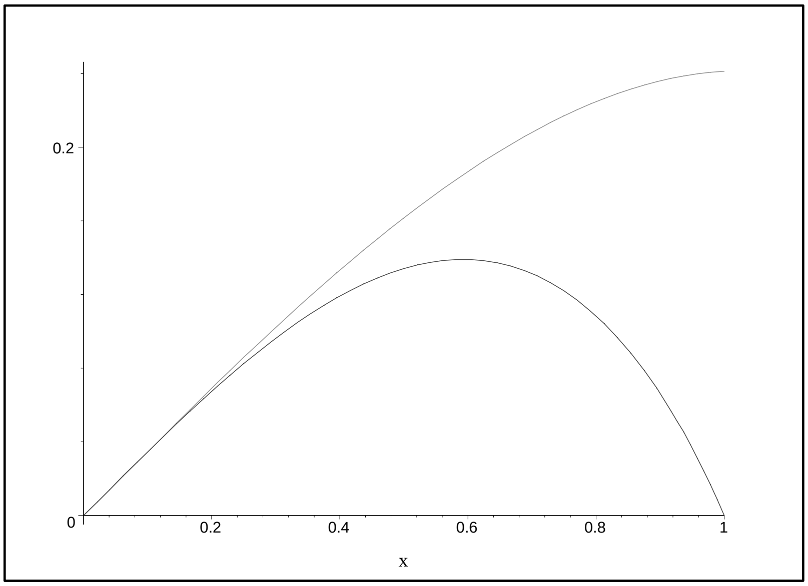


Figure 3: The effect of trade on a small country

More interestingly, as the relative size of the outside region increases, the decreasing portion of the gains function disappears. This is a direct consequence of the comparative statics result proved in Appendix B, that w decreases with h_f. This has two consequences. First, small or undeveloped countries are more likely to experience migration as a consequence of trade. Second, *observed* migration flows are likely to be smaller on average in small countries. In small countries the migration level is a continuous function of migration costs, as Figure 3 shows. In large countries, on the other hand, the migration level jumps from zero to a large fraction when the migration cost falls below $B(1)$ (assuming that in case of multiple stable equilibria the symmetric one is selected). Thus, according to the model, small countries will be more likely to experience trade induced migration, but the resulting asymmetry will be smaller than in large countries with a migration equilibria.

Before finishing this section, it is worth evaluating a quantitative example about the effects of migration on regional incomes. In the introduction I stated that high-skilled migration has a scale effect and a composition effect (in addition to the market access effect that arises purely from geographical differences). The first leads to higher wages in the West per unit of effective labor, and the second leads to higher human capital per capita. To quantify these two effects, let us assume that in equilibrium 5% of the East's population migrates to the West. Assuming $\sigma = 4$, $\rho = 3/4$ ($\tau = 1.1$), $\theta = 1/2$ ($\mu = 1.26$) and $h_f = 5$, without migration the Eastern real wage relative to the Western real wage would be $wP_e/P_w = w^{\frac{2\sigma-1}{\sigma-1}} = 0.9$ (the market access effect). With migration and thus a change in the human capital levels, and assuming $G(h) = h$, $wP_e/P_w = 0.898$ (the scale effect). Thus the scale effect due to skilled migration is quite small. The composition effect, however, is large. Average human capital in the East relative to the West drops to $(1 - h)/h = 0.82$, which leads to a relative average income in the East of 0.736. Thus increasing returns themselves do not magnify significantly the geographycal disadvantage of the East (the real wage difference is essentially the same as the transportation cost between the East and the West), the composition effect adds an additional 17% to regional inequalities.

This calculation was made for a small economy ($h_f = 5$), let us redo it for a large country, assuming $h_f = 1$. Without migration, the real wage ratio would be 0.951. Adding migration decreases the relative Eastern real wage to 0.941. Assuming the same level of migration, the composition effect is the same, $(1-h)/h = 0.82$. The total effect is, then, 0.77. Thus opening up has a smaller effect on a larger country (keeping the level of migration constant), but the scale effect is larger. This follows from the fact that larger countries rely less on international trade, so the internal market is more important. In contrast, outside market access is more crucial for small economies, so the total effect will be larger.

3.3 History vs. expectations

In the previous section I focused on equilibria when migration flows from the East to the West. In principle, however, it is possible that despite the natural advantage of the West, there exists a stable equilibrium with people moving *to the East*. Intuitively, since in autarchy there is a stable equilibrium with such property (as long as migration costs are not very large), if the geographical advantage of the West is small, such an equilibrium might be preserved in free trade. In this section I investigate under what parameter values expectations might lead to this "unhistorical" outcome.

According to (3.3) gains from migration depend only on the equilibrium wage rate in the East for the marginal migrant. Thus in order to have an equilibrium with migration to the East, we need $w > 1$. The previous section showed that this is possible if

$$h > \frac{1 - \theta v^{1-\sigma} h_f}{2},$$

where v is determined by (3.8). Migration to the East is a possible equilibrium if $(w = 1, v > 0)$ solves (3.7) and (3.8) for $0 < h \leq 1/2$.

This suggests that we can calculate a cutoff in the parameter values that separate the states of nature when migration to the East is possible from when it is not. Such a cutoff might be given for h_f, the relative size of Foreign. The reason is that w is decreasing in h_f, as Appendix B shows. To calculate the cutoff, we can solve (3.7) for v at $w = 1, h = 1$ and then solve (3.8) for h_f. Migration to the East is a possible equilibrium if

$$h_f < \frac{1}{\theta} \left[\frac{1 + \rho^2}{\theta(1 + \rho)} \right]^{1-1/\sigma} \equiv \bar{h}_f,$$

where the right-hand side is decreasing in both θ and ρ. For the parameter values used for the previous simulations ($\rho = 3/4$, $\theta = 1/2$ and $\sigma = 2$), the cutoff is $\bar{h}_f = 2.33$. It is easy to see that $\bar{h}_f > 1$, so that for a large country reverse migration is always possible. For small and/or underdeveloped countries, however, the direction of migration is determinate: it has to flow from the East to the West. Thus in these economies expectations have no role in determining the equilibrium outcome.

A related question concerns the effect of international trade on an *asymmetric* situation where the agglomeration is in the East. The above analysis shows that for $h_f > \bar{h}_f$ the equilibrium wage rate in the East is *always* smaller than the wage rate in the West, so that there are incentives to migrate. Even if $h_f < \bar{h}_f$, for $0 << h < 1/2$ the model predicts $w < 1$. Thus when migration costs are low enough, Home is likely to experience a complete reversal of agglomeration patterns. Thus the model can provide an alternative rational to the experience of Mexico - freer trade led to a reallocation of manufacturing from Mexico City to the northern border region - to that found in Krugman and Livas (1996). It is unlikely, of course, that Mexico City will loose its prominence completely, since it has advantages not captured in this model. Nevertheless, I believe that the current model presents a more plausible story about the rise of Mexico's border region. After all, the new agglomeration emerged not just anywhere, as Krugman and Livas (1996) suggests, but next to the US border. Thus geography is clearly important in explaining location patterns, and the model in this paper shows the fruitfulness of exploring the complementarities between location and increasing returns.

4 Conclusion

In this paper I presented a model in which international trade can cause substantial regional differences in a country, even if there were none before trade liberalization. The main driving forces are the possibility of migration, transportation costs, increasing returns and the heterogeneity of the population with respect to human capital. While the first three elements are conventional in models of the "New Economic Geography", heterogeneity (to the best of my knowledge) is a novel feature. Although in general it poses substantial difficulties to solve the model with heterogenous agents, with some simplifying assumptions we were able to get interesting and plausible results.

The main conclusion of the model is that migration is a powerful amplifying force of regional inequalities, if it involves the most skilled. Regional inequalities can emerge within a closed country in some cases as self-fulfilling expectations, and they are inevitable in a small open economy. As a result, average incomes differ sharply, even if migration flows are small, because of the human capital reallocation (composition) effect. Finally, fundamentals matter more than history in a small open economy with a mobile population, as the geographically disadvantaged region cannot maintain its earlier agglomeration advantage.

Admittedly the model presented in this paper is very specific. There is only one sector using one factor, and the assumed distribution of human capital is not very realistic. Nevertheless, I believe the model has general implications. It shows us that incorporating heterogeneity into economic geography models is fruitful and important. With heterogenous workers we can understand why depressed regions can form rapidly and why it is difficult to improve their situation. The model also shows that even small geographic differences can lead to large inequalities, without much agglomeration or concentration. The challenge for future research is to build more general models of economic geography with heterogeneity, introduce dynamics and provide more analytical results. I hope that this paper is a step in this direction.

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Appendix

A The existence of equilibrium with three regions

Let us rewrite the equations that define the equilibrium wage rates from (3.7) and (3.8):

$$A(v,w) \equiv h + \theta v^{1-\sigma} h_f - \frac{w^{1-\sigma} - \rho w}{w^{\sigma} - \rho}(1-h) = 0 \tag{A.1}$$

$$B(v,w) \equiv h + \rho w^{1-\sigma}(1-h) - \frac{v^{1-\sigma} - \theta v}{v^{\sigma} - \theta} h_f = 0. \tag{A.2}$$

The two equations implicitly define two relationships between w and v, and their intersection determine w and v. There is a unique and stable (in the tâtonnemant sense) equilibrium if

$$-\frac{A_v}{A_w} < -\frac{B_v}{B_w} \quad \Leftrightarrow \quad -\frac{A_v}{B_v} < -\frac{A_w}{B_w}.$$

To prove that this holds, it is sufficient to show that $-A_v < B_v$ and $A_w > -B_w$. I will only derive the first of these results, since the second one can be shown completely analogously.

$$\begin{aligned} B_v + A_v &= \frac{[(\sigma-1)v^{-\sigma} + \theta](v^{\sigma} - \theta) + \sigma v^{\sigma-1}(v^{1-\sigma} - \theta v)}{(v^{\sigma} - \theta)^2} h_f - (\sigma - 1)\theta v^{-\sigma} h_f \\ &= \frac{(\sigma-1)[1 - \theta v^{\sigma} + (1 - \theta v^{-\sigma})(1 - \theta v^{\sigma} + \theta^2)] + 1 - \theta^2}{(v^{\sigma} - \theta)^2} h_f \\ &> 0, \end{aligned}$$

since $v^\sigma \in [\theta, 1/\theta]$. Thus the equilibrium wage rates are unique.

B Comparative statics with three regions

Let $\Delta = A_v B_w - B_v A_w$, which was shown to be positive in the previous section. Using this, it is easy to prove some comparative statics results for w:

$$\frac{dw}{dh} = \frac{1}{\Delta}(B_v A_h - A_v B_h) = \frac{1}{\Delta}\left[B_v\left(1 + \frac{w^{1-\sigma} - \rho\sigma}{w^\sigma - \rho}\right) - A_v(1 - \rho w^{1-\sigma})\right] < 0$$

$$\frac{dw}{d\theta} = \frac{1}{\Delta}(B_v A_\theta - A_v B_\theta) = \frac{h_f^2 v^{1-\sigma}}{\Delta(v^\sigma - \theta)^2}[2(1-\sigma)(1-\theta v^{-\sigma}) - (1-\theta^2)] < 0$$

$$\frac{dw}{dh_f} = \frac{1}{\Delta}(B_v A_{h_f} - A_v B_{h_f}) = -\frac{\theta\sigma v^{1-\sigma} h_f (1-\theta^2)}{\Delta(v^\sigma - \theta)^2} < 0$$

The effect of ρ is in general ambiguous.