Grazie, Marco Polo: Return Migrants and the Dispersion of Ideas

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Preliminary and Incomplete

Introduction

Work by Lucas [2008] and Alvarez et al. [2008] has given the the growth literature a new way to think about the transmission of human capital. In this new class of models, human capital is a mixture of a private and public good. In labor models, human capital is often a rival, excludable good which is created through a schooling production function. In a previous generation of growth models, aggregate human capital is a public good [Lucas, 1988]. In the recent growth literature, human capital is somewhere in the middle. The only way to learn something in these models is to come face-to-face with someone who already knows it. Human capital cannot be totally excluded, but a person can only get at it if they are lucky enough to bump into someone with more of it.

If this idea reflects reality, than (return) migrants are an important force for the transfer of knowledge[1]. This paper is a simple theoretical model which captures this idea. Closely following recent work in the growth literature, I will analyze the way immigration policy affects a balanced growth path in which all countries grow at the same rate, as well as the way a change in a developed country's immigration policy affects the growth rate of a developing country.

In these exercises I closely follow work by Perla and Tonetti [2012]. The only difference between their paper and the model I write down below is that Perla and Tonetti consider only a single country. I first focus on a case in which there are a countably infinite number of countries, all with the same immigration policy. This level of abstraction allows me to derive a balanced growth path featuring countries with differing levels of income, and with the balanced growth rate depending upon the strictness of immigration policy. This version of the model does not lend itself to policy analysis, however, since every country would have to decide simultaneously to change immigration policy the same way. In order to take policy more seriously, I develop a second version of the model in which there are only two countries, with one country more developed.

The balanced growth rate depends upon the tightness of immigration policy. The more immigration is allowed, the more quickly all countries grow. This is not surprising, as migrants bring back ideas from abroad. Similarly, a relaxation of a developed country's immigration policy can drastically increase the growth rate of a developing country, and such a relaxation is good for even poor country citizens who do not migrate. Yet to be completed is an analysis of the social planners problem, since in equilibrium there is too little migration.

As I mentioned above, this work would not be possible without the contribution of Perla and Tonetti. Some other recent papers in the new human capital literature include Lucas Jr and Moll [2011] and Perla et al. [2012].[2] There are a number of papers which apply older endogenous growth models to migration

[1] This insight is by no means new–Lucas mentions migration as an possible application of his model in Lucas [2008], and the idea that return migrants bring home knowhow appears in Bowman and Myers [1967].

[2] I will be interested to actually get my hands on the trade paper–it is Chris Tonetti's job market paper this year, and has yet to be made available on any of the authors websites.

[Reichlin and Rustichini, 1998, Larramona and Sanso, 2006]. In this literature Dos Santos and Postel-Vinay [2003] and Dos Santos and Postel-Vinay [2005] deserve special mention, as these papers also emphasize the macroeconomic growth effects return migration.

Immigration Policy and Balanced Growth

There is a countable infinity of countries indexed by $i \in \mathbb{N}$. The countries each contain a continuum of discounted output stream maximizing agents of measure one. There is a single, non-storable good. Each agent is described by a productivity z, and the state of the economy is described by a distribution of productivities F_t^i. Time is discrete.

Each period is divided into three subperiods. In the first subperiod, agents choose to either work or to search. In the second subperiod, those that choose to work are randomly matched up with apprentices from the set of those searching in their country. In the third subperiod, workers produce using the production function $f(z) = z$, and apprentices learn by becoming as productive as their matched worker.

In period two, searchers from i can (and will) try to study in $i+1$. With probability θ a searcher is granted a visa. If his visa is denied, he must study in i. In order to keep the results simple, I assume that if a searcher goes abroad, it takes some time to travel and he only arrives home in the third subperiod of $t+1$, and thus it is not possible for home searchers to immediately learn from him.

Since the cost of searching is only lost wages, it is more expensive for higher productivity agents to search. This means that there will be a cut-off productivity level in each country $\overline{z}_t^i$ such that all agents with productivities lower than $\overline{z}_t^i$ will search, and all agents with higher productivity will work.

The value of searching does not depend upon productivity level, so I define, for home and foreign:

$$V_{s,t,i}^H = \beta \int_{\overline{z}_{i,t}}^{\infty} V_{t+1}(z') dF_t^i(z' | z' \geq \overline{z}_{i,t})$$

$$V_{s,t,i}^F = \beta \int_{\overline{z}_{i+1,t}}^{\infty} \left(z' + \beta V_{t+2}(z')\right) dF_t^{i+1}(z' | z' \geq \overline{z}_{i+1,t})$$

I am only going to consider solutions to the recursive problem, with value function:

(1)
$$V_t^i(z) = \max\{z + \beta V_{t+1}^i(z), \theta V_{s,t,i}^F + (1-\theta) V_{s,t,i}^H\}$$

Assuming that it is desirable to study abroad, the law of motion of F_t^i is:

(2)
$$f_{t+1}^i(z) = \begin{cases} f_t^i(z) + (1-\theta) f_t^i(z | z \geq \overline{z}_t^i) + \theta f_{t-1}^{i+1}(z | z \geq \overline{z}_{t-1}^{i+1}) & \text{if } z \geq \min\{\overline{z}_t^i, \overline{z}_{t-1}^{i+1}\} \\ 0 & \text{otherwise} \end{cases}$$

Equilibrium

Given initial productivity distributions $\{F_0^i\}_i$, an equilibrium is a tuplet $\{F_t^i, V_t^i, \overline{z}_t^i\}_{i,t}$ such that:

1. $\{\overline{z}_t^i\}$ and $\{F_t^i\}$ are consistent with (2).
2. $\{\overline{z}_t^i\}$ and $\{V_t^i\}$ are consistent with (1).

Balanced Growth Path

Next I solve for a balanced growth path equilibrium. A balanced growth path will feature a constant growth rate g for both output and quantiles of the productivity distribution, $F_t^i(z) = F_{t+1}^i(gz)$. I guess that $F_t^{i+1}(z) = F_{t+1}^i(z)$ for all t. This guess simplifies the law of motion (2) as follows [3]:

(3)

$$f_{t+1}^i(z) = \begin{cases} f_t^i(z) + f_t^i(z|z \geq \overline{z}_t^i) & \text{if } z \geq \overline{z}_t^i \\ 0 & \text{otherwise} \end{cases}$$

It can be shown that the only distribution which will satisfy (3) and the BGP quantile requirement is the Pareto distribution $F_t(z) = 1 - \left(\frac{\overline{z}_{i,t}}{z}\right)^\alpha$ [Perla and Tonetti, 2012].

Closely following the solution algorithm in [per], I conjecture that the search cut-offs grow geometrically with time:

$$\overline{z}_t^i = \overline{m}_i g^t,$$

and also that the value of search grows geometrically:

(4)

$$\theta V_{s,t,i}^F + (1-\theta) V_{s,t,i}^H = \overline{W}\overline{m}_i g^t$$

If these conjectures describe a balanced growth path, then neither g nor $\overline{W}$ should depend on time or country (in the balanced growth path, all countries grow at the same rate). To show this is the goal of the next few paragraphs.

At time t, we expect agent $\overline{m}_i g^{t+1}$ to be indifferent between working and searching. Combining (1) and (4), we get the following two equalities:

(5)

$$\overline{W}\overline{m}_i g^t = \overline{m}_i g^{t+1} + \beta \overline{W}\overline{m}_i g^{t+1}$$

(6)

$$\overline{m}_i g^{t+1} \beta \overline{W}\overline{m}_i g^{t+1} = (1-\theta)\,\alpha\beta\left(\overline{m}_i g^{t+1}\right)^\alpha \int_{\overline{m}_i g^{t+1}}^\infty V_{t+1}^i(z') z'^{-\alpha-1} dz' + \theta\alpha\beta\left(\overline{m}_i g^{t+2}\right)^\alpha \int_{\overline{m}_i g^{t+2}}^\infty \left(z' + \beta V_{t+2}^i(z')\right) z'^{-\alpha-1} dz$$

Already we see that the time scripts will drop out of (5). To show the same for (6), we need to iterate forward. Since part of my conjecture is that agents with productivities in the range $[\overline{m}_i g^{t+1}, \overline{m}_i g^{t+2}]$ will search in time $t+1$ and that agents in the range $[\overline{m}_i g^{t+1}, \overline{m}_i g^{t+2}]$ will search in $t+2$, we can write the RHS of (6) above as:

(7)

$$\begin{aligned}
&(1-\theta)\alpha\beta\left(\overline{m}_i g^{t+1}\right)^\alpha \int_{\overline{m}_i g^{t+1}}^\infty V_{t+1}^i(z') z'^{-\alpha-1} dz' + \theta\alpha\beta\left(\overline{m}_i g^{t+2}\right)^\alpha \int_{\overline{m}_i g^{t+2}}^\infty \left(z' + \beta V_{t+2}^i(z')\right) z'^{-\alpha-1} dz' \\
&\quad = (1-\theta)\beta\left(\overline{W}\overline{m}_i g^{t+1}(1-g^{-\alpha}) + \frac{\alpha}{\alpha-1}\overline{m}_i g^{t+2-\alpha} + g^{-\alpha}\alpha\beta\left(\overline{m}_i g^{t+2}\right)^\alpha \int_{\overline{m}_i g^{t+2}}^\infty V_{t+2}^i(z') z'^{-\alpha-1} dz'\right) \\
&\quad + \theta\beta\left(\frac{\alpha}{\alpha-1}\overline{m}_i g^{t+2} + \beta\overline{W}\overline{m}_i g^{t+2}(1-g^{-\alpha}) + g^{-\alpha}\alpha\beta\left(\overline{m}_i g^{t+3}\right)^\alpha \int_{\overline{m}_i g^{t+3}}^\infty \left(z' + \beta V_{t+3}^i(z')\right) z'^{-\alpha-1} dz'\right)
\end{aligned}$$

[3] This is where I use the countable infinity assumption–country $i+1$ was exactly like country i in the previous period.

Consider the one-period-ahead version of (6):

(8)

$$\overline{m}_i g^{t+2} + \beta \overline{W}\,\overline{m}_i g^{t+2} = (1-\theta)\,\alpha\beta\left(\overline{m}_i g^{t+2}\right)^{\alpha}\int_{\overline{m}_i g^{t+2}}^{\infty} V_{t+2}(z')z'^{-\alpha-1}dz' + \theta\alpha\beta\left(\overline{m}_i g^{t+3}\right)^{\alpha}\int_{\overline{m}_i g^{t+3}}^{\infty}\left(z' + \beta V_{t+3}(z')\right)z'^{-\alpha-1}dz'$$

Combining (7) and (8), and simplifying we get the time-subscript free:

(9)

$$\left(1+\beta\overline{W}\right)\beta g = \left(1+\beta\overline{W}\right)g^{\alpha} - \beta\overline{W}\left(g^{\alpha}-1\right) - \beta\frac{\alpha}{\alpha-1} + \theta\beta\left(g^{\alpha}-1\right)(1-\beta g) - \theta\beta\frac{\alpha}{\alpha-1}g\left(g^{\alpha}-1\right)$$

Equation (5) yields the time-subscript free:

(10)

$$\overline{W} = \frac{g}{1-\beta g}$$

Finally, combining (9) and (10) we get an implicit expression for g:

(11)

$$g^{\alpha-1} = \frac{\alpha}{\alpha-1}\beta\left[1+\frac{\theta}{\alpha}\left(g^{\alpha}-1\right)\right]$$

We will need some restrictions on parameters. First we have restrictions on the discount factor β:

$$\frac{\alpha-1}{\alpha} < \beta < \left(\frac{\alpha-1-\theta}{\alpha-\theta}\right)^{-\alpha}$$

The left-hand inequality ensures that people are patient enough for there to be positive growth in equilibrium. On the other hand, if people are too patient, then growth will become infinite. The right-hand inequality guarantees that this does not happen. The restrictions on β imply restrictions on θ, since we need there to be a feasible β. In particular:

$$0 \leq \theta \leq \min\left\{1, \alpha - \left(1-\left(\frac{\alpha-1}{\alpha}\right)^{\alpha}\right)^{-1}\right\}$$

If $\theta = 0$, immigration is not allowed and the unique equilibrium growth rate is exactly the same as that in Perla and Tonetti [2012]. For non-zero values of θ there are either zero, one, or two real positive roots of (11). It is easy to see this from (11): the LHS is an increasing function with zero as its y-intercept, while the RHS is increasing and more convex than the LHS, with a positive y-intercept. However, only one of the roots will ever be allowed as an equilibrium (see Figure 1). We need the value of search (10) to be positive, which requires that $\beta g < 1$. It can be shown that if there is an equlibrium with $\beta g^* < 1$, in any potential second equilibrium $\beta g^* > 1$.

Finally, I show that, for a broad range of α's, the growth rate g is increasing in θ, so that more relaxed immigration policy leads to a higher growth rate. Implicitly differentiating (11), we get:

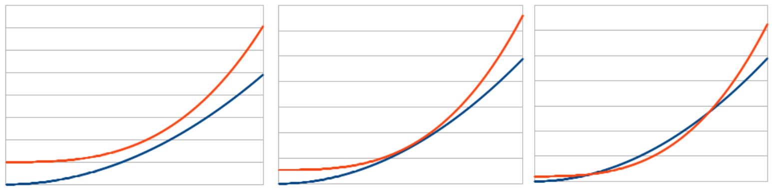

Figure 1: Zero, one, and two equilibria

$$\frac{dg}{d\theta} = \frac{\beta g^2(1 - g^{-\alpha})}{(\alpha-1)^2 - \alpha\beta\theta g}$$

The expression is positive if the denominator is positive. Since we require $\theta \leq 1$ and $\beta g < 1$, as long as $\alpha > \frac{3+\sqrt{5}}{2}$, this is true. I believe that there is a tighter bound, though, as I have yet to generate a numerical experiment in which an admissible growth rate decreases with θ.

Two countries

The last example had a countable infinity of countries, all with the same immigration policy. While this allows me to derive an interesting balanced growth path, it is of little use thinking about actual policy experiments. For this, I consider a world with only two countries–one developed, and one developing. The only balanced growth path in this world will be the poor country completely catching up to the rich country, so I will be interested in looking at the growth on the transition path rather than balanced growth. As you might guess, the developing country growth will depend on immigration policy in the developed country.

While I was able to get algebraic results in the last section, I will need to devise a numerical strategy to solve for transition dynamics in the two country case. This part of the paper is still very much a work in progress, and all results should be considered preliminary. The setup is similar to what I did in the infinite country case. The only major difference is that for now I consider searching abroad completely symetric to searching at home; in the infinite countries case, I assumed that it took some time to return from abroad.

I start with the developed country three times as rich as the developing country. Since the distribution of productivities is better in the developed country, no one wants to go abroad to learn. We can think of the developed country as evolving in isolation, with a Pareto distribution of productivities, and growth rate:

$$g = \left(\frac{\alpha}{\alpha-1}\beta\right)^{\frac{1}{\alpha-1}}$$

The developing country begins with the same distribution, just scaled further down the real line. To be clear, I illustrate this in Figure 2 below:

As before, there is a immigration policy parameter $\theta \in [0, 1]$. Everyone who searches in the poor country wants to apprentice in the developed country. However, only θ of them get a visa. The rest must apprentice at home. This makes the distribution of productivities in the developing country "wavy", as generations migrate abroad and absorb the foreign technology. To illustrate this, in Figure 3 I plot the evolution of the developing country normalized productivity distribution (for simplicity, keeping the mass of searchers at the autarchy level–the endogenous search thresholds found below will simply lead to faster convergence). Normalized here means that only the shape matters–in a BGP the distribution would be the same every period:

If I were to run the simulation in Figure 3 a few more periods, only a single wave at the developed country productivity level would remain. Comparing with Figure 2, we see that the developing country will have become as rich as the developed country.

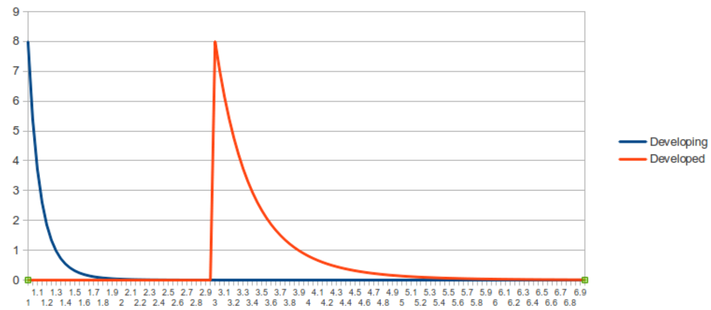

Figure 2: Initial productivity distributions

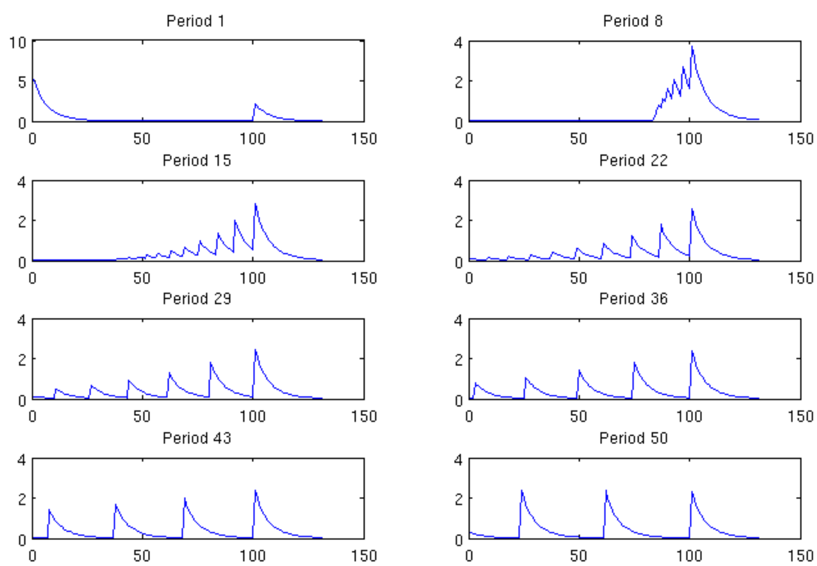

Figure 3: Developing Country (Normalized) Productivity Distributions

period \ θ	0	0.1	0.3
1	1.018	1.1622	1.2789
2	1.018	1.1437	1.1648
3	1.018	1.1566	1.1119
4	1.018	1.1279	1.0622
5	1.018	1.1191	1.0359
6	1.018	1.0888	1.0173
7	1.018	1.0486	1.0109
8	1.018	1.0235	1.0050

Table 1: Growth rates after allowing migration

To get endogenous search cut-offs, I must solve for the transition path to the steady state in which both countries converge to the developed country productivity distribution. While I did not have time to write up all of the details of how my program works, it is similar to the single-country program described in per. The gist of it is as follows:

1. Fix immigration policy as well as the parameters of the initial productivity distributions, get the evolution of the developed country's productivity distribution.
2. Guess a vector of search cut-offs, with one for each period (and a large number of periods).
3. Given the search cut-offs, use the law of motion (2) to get the evolution of the developing country distribution.
4. Given the evolution of the developing country distribution, use backward iteration from the steady state to solve for optimal search cut-offs.
5. Compare the new cut-offs to the old cut-offs. If they are close enough stop, otherwise, use a combination of the new and old cut-offs and go back to 3.

A relaxation in immigration policy on the part of the developed country causes faster growth in the developing country. The important point is that relaxed immigration policy is good for developing country citizens even if they don't go abroad, because those who do go abroad bring back ideas. In Table 1, I show simulated growth rates for various θ levels. The autarchy growth rate is 1.018. As expected, the more relaxed the immigration policy, the faster the growth of the deveoping country. The current simulation results do, however, contain some strange numbers, so these results should be considered very preliminary.

Conclusion

This paper uses a model following the new human capital and growth literature to examine effect of migration on growth. Since in these models human capital is transfered only face-to-face, return migrants are the heros which move ideas from developed to developing countries. Taking cues from Perla and Tonetti [2012], I show that we can get a balanced growth equilibrium in which the rate of growth depends on how easy it is to apprentice abroad. In a numerical example I show that a relaxation of immigration policy by a developed country speeds up the growth of a developing country. Furthermore, developing country citizens who do not study abroad still gain from looser immigration policy as they can learn from return migrants.

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