DIRECTIONS OF TRADE FLOWS AND LABOR MOVEMENTS BETWEEN HIGH- AND LOW-POPULATION GROWTH COUNTRIES: AN OVERLAPPING GENERATIONS GENERAL EQUILIBRIUM ANALYSIS

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ABSTRACT

This paper considers a two-country world where the population in one country grows faster than the other, and investigates the effects of resulting differences in age composition across countries on international trade flows and migration under alternative simulation scenarios within the framework of an overlapping-generations general equilibrium model. The differing age compositions of populations are shown to give rise to differentials in wage rates and rentals for capital under autarky conditions. This, in turn, causes costs of production and relative prices to differ, creating the grounds for trade. Furthermore, when labor is allowed to be mobile across countries, wage differentials provide incentives for workers from the country with the relatively younger and faster-growing population to migrate to the slowly-growing country that experiences population aging. The paper concludes by discussing the relevance of results from simulation exercises to the likely consequences of economic relations between such young-population countries as Mexico and Turkey and their regional partners within NAFTA and the EU where population aging has long set in.

JEL Classification: F22, F10, J14, J31, D50

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I. Introduction

Due to declining fertility rates and increasing life expectancies, the population share of elderly has been rising steadily in many counties across the world. The process of population aging has been particularly fast in the OECD area and will further be accelerated as baby boom generations born during the late 1940s and the early 1950s mature. In fact, the next few decades are expected to witness a sharp increase in the share of population over the age of 65 in majority of OECD economies as a result of this fertility shock that followed the 2nd World War. United Nations projections for the OECD area indicate that the share of the population over 65 will increase by about 50% and reach 0.22 in 2040 resulting in a rise in the ratio of population outside the working age to the working age population (between the ages of 20 and 64). Also known as the overall dependency rate, this ratio is expected to exceed 70% in the 2040s, corresponding to a more than 10 points increase beyond its value in the 1980s.

Since population aging and the associated increases in dependency ratios have important macro and microeconomic consequences, there emerged a sizable literature investigating various aspects of the problem, including numerous studies that employ overlapping generations (OLG) general equilibrium models developed to analyze the effects of aging within an economywide framework.[1] Despite the rapid growth of general equilibrium OLG literature on the economics of aging, the implications of increasing population shares of the elderly in major OECD economies for other countries maintaining strong economic ties with them have stayed largely unexplored. While the potential role that international flows of factors and commodities could play in transmitting the effects of population aging in one country to the others was recognized in such recent works as Kenc and Sayan (2001), Turner, et. al. (1998) and INGENUE Team (2000), the investigation of the indirect effects of aging populations in large economies of the developed world on other countries remains a critical area where more research is severely needed, as noted by Peterson (1999).

[1] The overwhelming majority of these general equilibrium OLG studies in the existing literature focus on social security and related macroeconomic aspects of aging in one or more of the OECD economies facing higher dependency ratios --see, for example, Miles (1999) for a survey.

The movements of factors and commodities across nations serve as potential channels to transmit the effects of population aging in one country to the others. Kenc and Sayan (2001) explain the role that trade and international capital flows play in transmitting the effects of population aging from one country to the others as follows: Since changes in age composition of population are likely to affect saving and consumption patterns, the resulting changes in composition of demand are expected to affect relative prices between consumption and investment goods. On the supply side, the decline in labor supply and the slow down in capital formation associated with population aging would cause changes in capital-labor ratios.[2] This, in turn, alters relative factor prices and leads to second-round effects on resource allocation. Furthermore, since the changes in the relative capital intensities across traded and non-traded sectors affect real exchange rates and trade patterns, they are expected to create additional effects on partner country economies as well.

Kenc and Sayan (2001) note that these spill over effects could be particularly significant if the countries experiencing population aging are large in the international trade literature sense of the term, whereas their partners are small and have not yet faced a population aging problem themselves. In other words, commodities and capital traded at the terms set by large economies may make these small countries vulnerable to the effects of population aging even if they have relatively young populations. Moreover, the decline in young to old ratios in the populations of developed countries and the resulting increase in wages and living standards is expected to induce labor migration out of the developing countries. While this is already an important issue (for example between the US and Mexico, the EU and surrounding countries, in particular Turkey), the current demographic trend is likely to increase pressures for increased mobility of labor across borders in the future. This implies that the high dependency rates in major OECD economies may soon become a matter of interest even in the countries where increasing share of the elderly is not a pressing domestic issue currently.

The purpose of this paper is to investigate possible general equilibrium effects that population aging in a country might inflict upon the partner country economies using simulation results from an archetype overlapping generations (OLG) general equilibrium model. For this purpose, we consider a world with two countries that are initially identical in every respect except for the differing population growth rates, and look at the effects of differences in age composition across

[2] While the resulting change in capital-labor ratios may be in either direction depending upon the relative magnitudes of the effects on capital formation and labor supply, Auerbach et.al. (1989) predict an increase in economywide capital-labor ratios in the developed economies.

countries arising over time, on international trade flows and labor migration under alternative labor mobility scenarios.

The differences in age composition resulting from differing population growth rates are shown to give rise to differentials in wage rates and rentals for capital under autarky conditions. This, in turn, causes costs of production and relative prices to differ, creating the grounds for trade. Furthermore, when labor is allowed to be mobile across countries, wage differentials provide incentives for workers from the country with the relatively younger and faster-growing population to migrate to the slowly-growing country that experiences population aging. After examining each case through simulation experiments, the paper discusses the relevance of simulation results to the likely consequences of economic relations between such young-population countries as Mexico and Turkey and their regional partners within NAFTA and the EU where population aging has long set in.

The plan of the paper is as follows. The next section describes the model and presents results under autarky conditions. Section III discusses the migration scenarios considered, whereas Section IV takes up trade issues. Section V concludes the paper by discussing the implications of results from simulation experiments.

II. The Model

In this section, we describe the model in reference to baseline scenario which assumes that there are no interactions between countries and concentrate on the behavior of key variables for each country under autarky conditions.

The model used here is a 2-country, infinite horizon overlapping generations (OLG) model with perfect foresight. Since our purpose is to identify the effects of differences in age composition on flows of commodities and labor, the countries we consider (country A and country B) are assumed to be exactly the same in every aspect, including the initial populations, except for the population growth rate, n. Each of the countries is populated by 2-period living individuals who are homogenous not only intergenerationally but also intragenerationally.

At an arbitrary period t in time, two types of individuals are alive in each country: 'Young's that are born in period t and are living the first period of their lives, and 'old's that are born in period *t-1* and are living the last period of their lives. The individuals work only when they are young, each inelastically supplying a fixed amount of labor, and retire in the second period of their lives. Production, exchange and payments are assumed to be made at the end of each period. So, a young born in period t works in the same period, earns a wage of w_t at the end of that period and decides how much to consume and how much to save. In period *t+1*, he makes his savings, A_{t+1}, available to firms and earns $r_{t+1} \cdot A_{t+1}$, where r_{t+1} is the rental rate on capital in period *t+1*. He consumes all of $(1+r_{t+1}) \cdot A_{t+1}$ in period *t+1* since no intergenerational transfers (such as bequests, gifts, etc.) are allowed.

Letting ç$_t$ denote the number of individuals born in period t, and assuming that only the young can bear children, one can write

$$\eta_{t+1} = (1+n) \cdot \eta_t \qquad \textbf{(2.1)}$$

where n denotes the population growth rate as noted before.[3]

For country i $(i \in \{A, B\})$, the production sector and household consumption decisions are characterized as follows.

II.1. Production Sector

There are two goods indexed by j $(j \in \{1,2\})$, both of which are produced according to a constant returns to scale Cobb-Douglas type production function which uses capital (K) and labor (L) as inputs. Good 1, which is used both for consumption purposes and as capital, is taken as numeriare. The price of good 2, which is used only for consumption, at time t is denoted by p_t. Good 1 is the relatively more labor intensive good, while good 2 is relatively more capital intensive.[4] Country *i*'s capital stock in period t is denoted by $\overline{K}^i_t$ and its labor supply is denoted

[3] By this definition, *(1+n)* is the average number of children that each young bears. It is shown in Appendix-A that n is indeed equal to the population growth rate in the usual sense, i.e., the rate of increase in total number of people.

[4] Taking the investment good as the labor intensive good is not common in literature, but not unrealistic. For example, consider wheat, which is used both for consumption and as capital, as good 1 and toothpaste as good 2. Clearly, wheat may well be labor intensive whereas toothpaste more capital intensive, justifying our choice.

by $\overline{L}_t^i$, where $\overline{L}_t^i = \eta_t^i \cdot \bar{l}$,[5] with $\bar{l}$, representing the exogenous level of labor supplied by an individual.

All capital and labor available are divided between the two sectors such that

$$\overline{K}_t = K_{1t} + K_{2t} \qquad \textbf{(2.2)}$$

$$\overline{L}_t = L_{1t} + L_{2t} \qquad \textbf{(2.3)}$$

The production functions are defined as:

$$X_{1t} = (K_{1t})^{\alpha}(L_{1t})^{1-\alpha} \qquad \textbf{(2.4)}$$

$$X_{2t} = (K_{2t})^{\beta}(L_{2t})^{1-\beta} \qquad \textbf{(2.5)}$$

Letting $x_{1t} = \dfrac{X_{1t}}{\eta_t}$ and $x_{2t} = \dfrac{X_{2t}}{\eta_t}$ denote sectoral outputs per worker, $\bar{k}_t = \dfrac{\overline{K}_t}{\eta_t}$ capital per worker, and noting that $\bar{l} = \dfrac{\overline{L}_t}{\eta_t}$, it follows that

$$x_{1t} = (k_{1t})^{\alpha}(l_{1t})^{1-\alpha} \qquad \textbf{(2.6)}$$

$$x_{2t} = (k_{2t})^{\beta}(l_{2t})^{1-\beta} \qquad \textbf{(2.7)}$$

where

$$k_{1t} + k_{2t} = \bar{k}_t \qquad \text{and} \qquad \textbf{(2.8)}$$

$$l_{1t} + l_{2t} = \bar{l} \qquad \textbf{(2.9)}$$

The production sectors are assumed to be competitive so that the representative firm producing good 1 maximizes profits, *ð1t* by solving the problem

$$\max_{k_t, l_t} \quad \pi_{1t} = (k_{1t})^{\alpha}(l_{1t})^{1-\alpha} - r_t k_{1t} - w_t l_{1t} \qquad \text{s.t.} \qquad k_{1t} \geq 0,\ l_{1t} \geq 0 \qquad \textbf{(2.10)}$$

The corresponding problem for the representative firm producing good 2, together with the first order conditions, yields

$$r_t = \alpha \cdot (k_{1t})^{\alpha-1}(l_{1t})^{1-\alpha} = p_t \cdot \beta \cdot (k_{2t})^{\beta-1}(l_{2t})^{1-\beta} \qquad \textbf{(2.11)}$$

[5] The index *i* denoting the country will be dropped in the rest of this section to simplify notation, and all variables will be defined for the same *i* unless noted otherwise.

$$w_t = (1-\alpha)\cdot(k_{1t})^{\alpha}(l_{1t})^{-\alpha} = p_t\cdot(1-\beta)\cdot(k_{2t})^{\beta}(l_{2t})^{-\beta} \quad \textbf{(2.12)}$$

Combining equations (2.8), (2.9), (2.11) and (2.12) we find

$$l_{1t} = \frac{d_t \bar{l}_t - \bar{k}_t}{d_t - e_t} \quad \textbf{(2.13)}$$

$$l_{2t} = \bar{l}_t - l_{1t} = \frac{\bar{k}_t - e_t \bar{l}_t}{d_t - e_t} \quad \textbf{(2.14)}$$

$$k_{1t} = e_t \cdot l_{1t} = e_t \frac{d_t \cdot \bar{l}_t - \bar{k}_t}{d_t - e_t} \quad \textbf{(2.15)}$$

$$k_{2t} = d_t \cdot l_{2t} = d_t \frac{\bar{k}_t - e_t \cdot \bar{l}_t}{d_t - e_t}, \quad \textbf{(2.16)}$$

where

$$e_t = (p_t)^{\frac{1}{\alpha-\beta}}\left(\frac{\beta}{\alpha}\right)^{\frac{\beta}{\alpha-\beta}}\left(\frac{1-\beta}{1-\alpha}\right)^{\frac{1-\beta}{\alpha-\beta}} \quad \textbf{(2.17)}$$

$$d_t = (p_t)^{\frac{1}{\alpha-\beta}}\left(\frac{\beta}{\alpha}\right)^{\frac{\alpha}{\alpha-\beta}}\left(\frac{1-\beta}{1-\alpha}\right)^{\frac{1-\alpha}{\alpha-\beta}} \quad \textbf{(2.18)}$$

II. 2. Household's Problem

An individual born at time *t* has a utility function of the form:

$$U_t = (C_t)^{\mu}\cdot(C_{t+1})^{1-\mu} \quad \textbf{(2.19)}$$

where $C_t = (C_{1yt})^{\theta}\cdot(C_{2yt})^{1-\theta}$ denotes the utility gained from consumption when young and $C_{t+1} = (C_{1ot+1})^{\theta}\cdot(C_{2ot+1})^{1-\theta}$ denotes the utility gained from consumption when old. For $j=1, 2$, C_{jyt} denotes the amount of good j consumed when young and C_{jot+1} denotes the amount of good j consumed when old, all in per capita terms. The representative household solves the problem:

$$\max_{C_{1yt}, C_{2yt}, C_{1ot+1}, C_{2ot+1}} U_t \qquad \text{subject to} \quad \textbf{(2.20)}$$

$$C_{1yt} + p_t \cdot C_{2yt} + \frac{C_{1ot+1} + p_{t+1}\cdot C_{2ot+1}}{1+r_{t+1}} = w_t \cdot \bar{l} \quad \textbf{(2.21)}$$

where r_{t+1} is the rationally anticipated return to capital in period $t+1$ and p_{t+1} is the rationally anticipated price of good 2 in period $t+1$.

The solution to this problem results in the following decisions:

$$C_{1yt} = \mu \cdot \theta \cdot w_t \cdot \bar{l} \quad \textbf{(2.22)}$$

$$C_{2yt} = \frac{\mu \cdot (1-\theta) \cdot w_t \cdot \bar{l}}{p_t} \quad \textbf{(2.23)}$$

$$C_{1ot+1} = (1-\mu) \cdot \theta \cdot w_t \cdot \bar{l} \cdot (1+r_{t+1}) \quad \textbf{(2.24)}$$

$$C_{2ot+1} = \frac{(1-\mu) \cdot (1-\theta) \cdot w_t \cdot \bar{l} \cdot (1+r_{t+1})}{p_{t+1}} \quad \textbf{(2.25)}$$

II.3. Solution of the Model

Since olds consume all their wealth in the current period, only capital transferred to the next period is the savings of the current young,[6] implying:

$$K_{t+1} = A_{t+1} = \left(w_t \cdot \bar{l} - C_{1yt} - p_t \cdot C_{2yt}\right) \cdot \eta_t \quad \textbf{(2.26)}$$

Dynamic equilibrium requires clearance of goods' markets in each period t, i.e.,

$$X_{1t} + K_t = \eta_t \cdot C_{1yt} + \eta_{t-1} \cdot C_{1ot} + K_{t+1} \quad \textbf{(2.27)}$$

$$X_{2t} = \eta_t \cdot C_{2yt} + \eta_{t-1} \cdot C_{2ot} \quad \textbf{(2.28)}$$

Note that equations (2.27) and (2.28) imply each other by Walras' Law. Equation (2.28) results in

$$x_{2t} = C_{2yt} + \frac{C_{2ot}}{1+n} = \frac{\mu \cdot (1-\theta) \cdot w_t \cdot \bar{l}}{p_t} + \frac{(1-\mu) \cdot (1-\theta) \cdot w_{t-1} \cdot \bar{l}}{(1+n) \cdot p_t} \cdot (1+r_t) \quad \textbf{(2.29)}$$

Combining (2.11), (2.12), (2.17), (2.18) and (2.29) enables us to express p_t as a function $p_t = \phi(k_t)$ of capital per worker k_t.

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[6] We assume that the olds who are alive in the first period have some amount of initial endowment and they live only one period.

II.3. The Results

We simulate this economy for a given production technology (i.e., given values of á and â), preferences (i.e., given values of ì and è) and population growth rates; for certain values of initial per capita capital stock ($\bar{k}_1$), labor per worker ($\bar{l}$) and initial per capita wealth of olds in the first period ($\overline{w}$).[7]

We do this by considering the behavior of variables k_t and w_t both on the transition path and at the steady state for two economies that are the same in every aspect except for population growth rates.

Figure 1 and Figure 2 show the time paths of k_t for two countries *A* and *B* with $n_A = 0.05$ and $n_B = 0.2$.

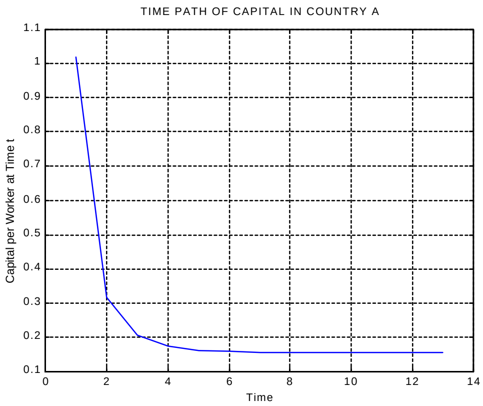

Figure 1

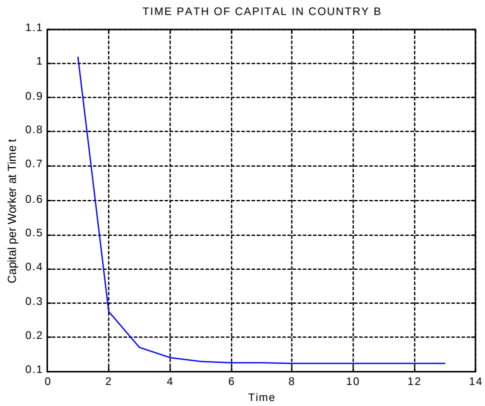

Figure 2

The countries start with the same initial conditions in period 1. Figure 3 shows per capita capital stock in both countries starting from the second period onwards and until steady state is reached. It is clear from the figure that per capita capital stock in country *A* is greater than that in country *B*, at any point in time on the transition path as well as at the steady state.

[7] The results that are reported here are from a simulation with *á* = 0.4, *â* = 0.5, *è* = 0.7, *ì* = 0.4, $\bar{l}$ =1, $\bar{k}_1$= 1.0192, $\overline{w}$ =0.8322.

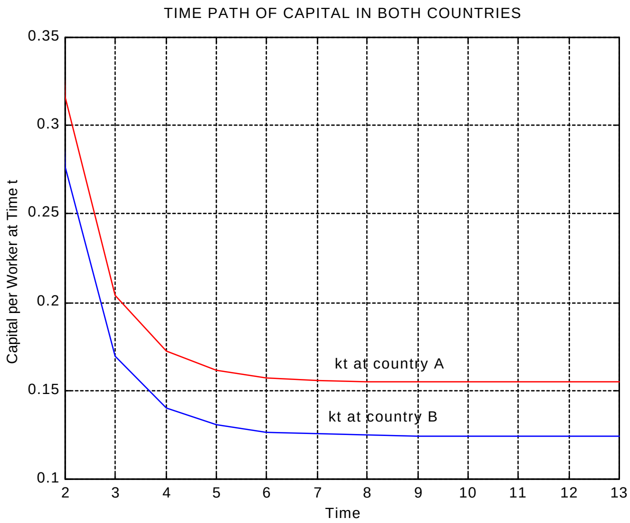

Figure 3

The corresponding graphs for wages in countries *A* and *B* are given in Figures 4 and 5.

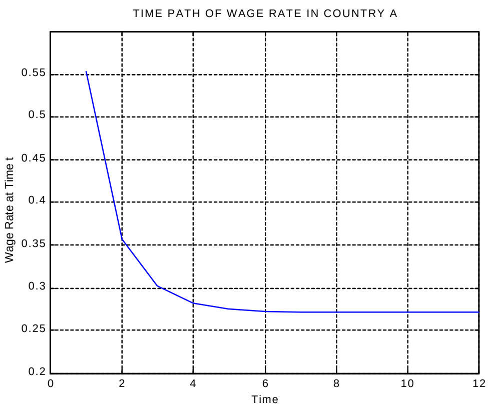

Figure 4

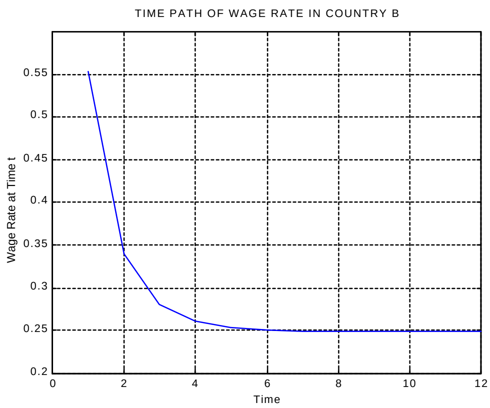

Figure 5

Figure 6 excludes period 1, which is identical in both countries, and compare wage rates in the following periods. Again, we see that wages in the low population growth country (*A*) are always greater than those in the high population growth country at any time.

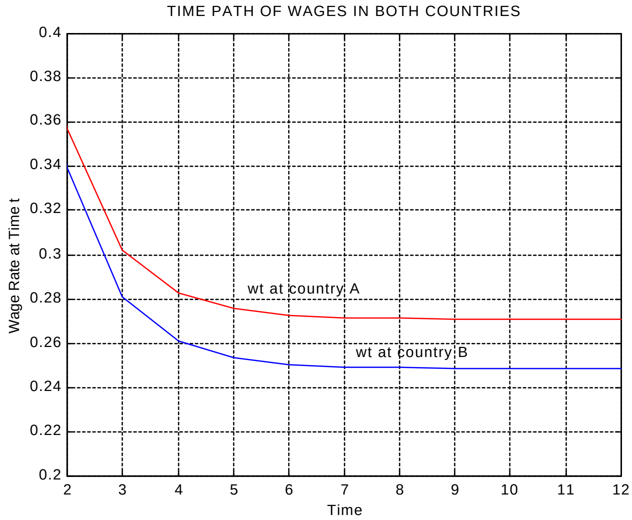

Figure 6

Figures 7, 8 and 9 contain the corresponding graphs for rental rate on capital (r_t) in both countries. As expected, return on capital is lower on the relatively capital abundant country (*A*) in each period, as well as on the steady state.

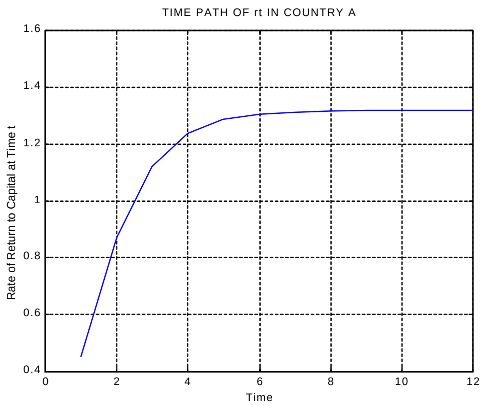

Figure 7

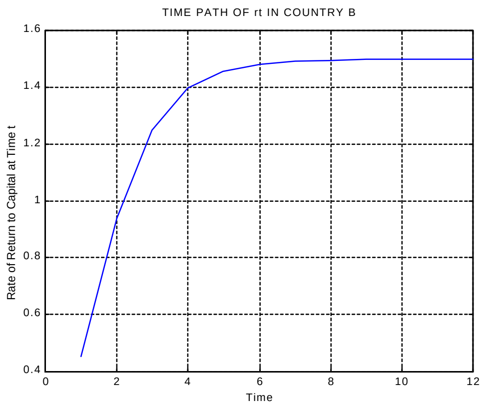

Figure 8

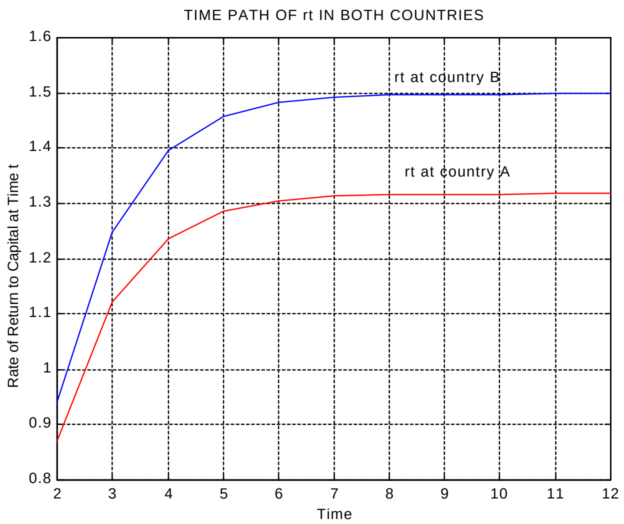

Figure 9

If we concentrate on the steady state values of k_t and w_t corresponding to different values of n, we reach the following result:

Steady state values of k_t and w_t are both decreasing functions of n, for given values of constants á, â, è, ì, $\bar{l}$ and initial conditions $\bar{k}_1, \bar{w}$. Figures 10 and 11 show this relationship between k_t at the steady state and n; and w_t at the steady state and n, respectively.

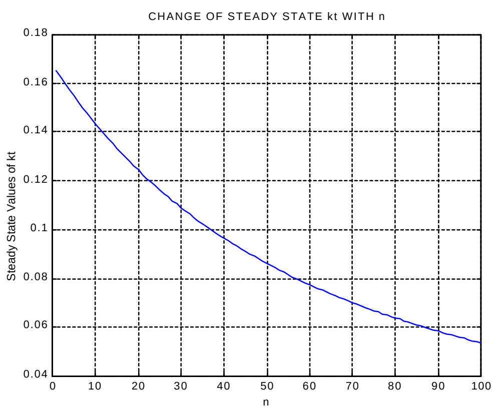

Figure 10

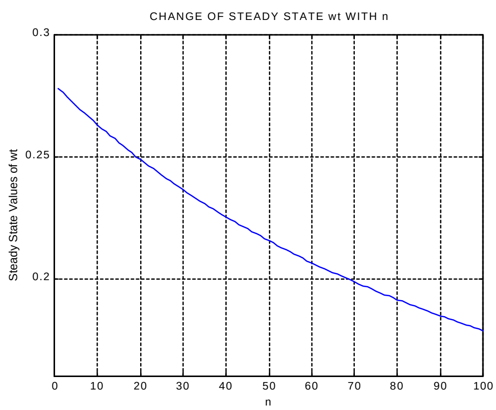

Figure 11

The steady state values of variables in both countries under autarky conditions are presented in Table 1.

Table 1. Steady State Values of Selected Variables under Autarky

Variables	Country A	Country B
k	0.1549	0.1244
w	0.2710	0.2488
r	1.3175	1.4983
u	0.1178	0.1124

Our results show that, if the two countries are exactly the same initially, country *B* (i.e. the one with the higher *n*) ends up with a younger population composition, lower k_t and w_t at the steady state when compared to country *A*. If full labor mobility between the two countries were allowed, one would expect a movement of labor from country *B* to country *A*, since the wage and utility differentials between these countries would provide an incentive for workers in *B* for migration to *A*. This migration and its consequences are discussed in the next section.

III. Migration

In this section, we consider the results of allowing for labor mobility between these countries under two distinct scenarios. In the first scenario, the decision to migrate is based upon the difference between the lifetime utilities obtained in two countries and the migration is assumed to be from country *B* to country *A*. In the second scenario, we allow for two-sided migration (i.e., either from *B* to *A* or from *A* to *B* in any given period) and the decision to migrate depends only on the wage difference. The process of migration works as follows:

At time *t*, there are 2 kinds of new-born workers in the source country: Workers that are able to migrate (which we call mobile workers) and workers that are unable migrate. A mobile worker born at time *t* decides on whether to migrate or not by considering the current state of the economy and the next two periods (in which he will live) under the assumption that none of his fellow countrymen will choose to migrate to the other country during his lifetime. Immediately after birth, a mobile worker evaluates the variables of concern (which are lifetime utilities in scenario 1 and wages in scenario 2) and compare the values that these variables would attain in both countries, had there been no migration. We call these "variables under no migration" and denote them by adding the superscript *NM*. If the migration criteria is satisfied, the mobile workers will migrate from the source country to the receiving country and live both periods of their lives there. The ratio of mobile workers to the whole worker population in period *t* will be denoted by *æ*$_t$. It will be a function of U_t^{ANM}, U_t^{BNM} in the first scenario and w_t^{ANM}, w_t^{BNM} in the second scenario, as explained below.[8]

Since the change in the number of workers due to migration results in a change in the values of all variables in both countries, the values that the workers use to make their decisions are not realized. Here, we relax the perfect foresight assumption by assuming that the value of *æ*$_t$ is not common knowledge, so that a mobile worker is unaware of the other workers' decisions. Simply put, a worker looks at the future of both countries and chooses one of them to live in, by realistically assuming that his choice would have a negligible effect in this future, without knowing and taking into account how many others are making the same decision as himself.

III.1. Migration Scenario 1

The decision rule in this scenario is based on lifetime utilities of workers in both countries that would have been realized if there had been no migration $\left(U_t^{ANM}, U_t^{BNM}\right)$. Unlike Galor (1986) and Karayalcin (1994), where the workers from country *B* migrate if $U^A > U_t$, we

only if the percentage increase in their utility is greater than a certain value. So, the decision rule for a mobile worker in country is:

$$\text{Migrate} \qquad \frac{U_t^{ANM} - U_t^{BNM}}{U_t^{BNM}} > \tau \qquad \textbf{(3.1)}$$

where ô is an exogenously set constant –that is taken as 0.01 in the simulations here.

The share of mobile workers in the generation born at time *t* in country *B* is given by

$$\zeta_t = z \cdot \left(\frac{U_t^{ANM} - U_t^{BNM}}{U_t^{ANM} + U_t^{BNM}} \right)^{\gamma} \qquad \textbf{(3.2)}$$

where *z* and γ are positive constants.

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[8] To avoid a possible confusion, we would like to clarify one point. The phrase "variables under no migration" does not mean that these values are calculated by assuming that there is no migration at all, which would have made them equal to the autarky values. Rather, it suggests that these values are calculated by counterfactually assuming that there will be no migration in the next two periods. Since the mobile worker knows the current state of both economies and uses this information, the effects of actual labor movement up to this period are implicitly taken into account in his decision.

After the migration, worker population in country *A* becomes $\eta_t^A + \left(\zeta_t \cdot \eta_t^B\right)$ and the worker population in country *B* becomes $\left(1-\zeta_t\right)\cdot\eta_t^B$, and the markets in both countries continue to work under autarky conditions.

Before moving on to the results of this scenario, we should note how the values of variables *z* and γ characterize the process of migration. If the workers in country *B* are very reluctant to migrate (i.e., *z* is very small and/or γ is very large), the resulting migration will be very small when compared to the aggregate populations, therefore will not have a big impact. At the other extreme, if the workers in country *B* have a great tendency to migrate (with a very large value for *z* and/or very small value for γ), a small difference in utilities may induce a large wave of migrants, radically change the number of workers in both countries and cause huge jumps in the values of variables, which is not a case that we are willing to consider. We stay away from these extremes and we let *z*=1 and γ=1.5. The resulting steady state values for both countries are given in Table 2.

Table 2. Steady State Values of Selected Variables under Migration Scenario 1

Variables	**Migration Scenario 1**		**Autarky**	
	Country A	Country B	Country A	Country B
k	0.1246	0.1246	0.1549	0.1244
w	0.2489	0.2489	0.2710	0.2488
r	1.4969	1.4969	1.3175	1.4983
u	0.1124	0.1124	0.1178	0.1124
Population Growth Rate	0.1989	0.1989		

One important result we obtain is that migration continues at the steady state with value of ξ converging to a specific value (0.00090 in this simulation) which equalizes population growth rates in both countries. This result is different from the results of the Galor (1986), who, in a different setting, modeled a migration scheme which results in whole population of a country migrating to another country. Time paths of population growth rates in both countries are given in Figures 12 and 13.

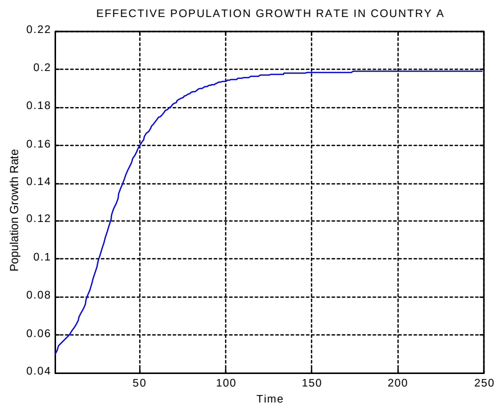

Figure 12

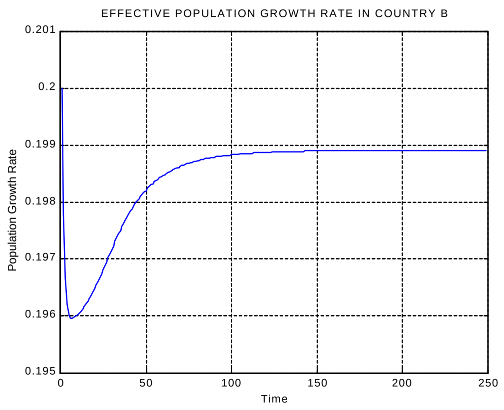

Figure 13

We may interpret the resulting steady state as the case of two countries under autarky conditions, each with a population growth rate of 0.1989. This is very close to $n_B = 0.2$, as expected, since country *B*'s population grows so large when compared to country *A* that only a small portion of its increment is enough to equalize the population growth rates. Still, the effective population growth rate (which is the after migration population growth rate) in country *B* is less than the autarky case and the residents of country *B* are slightly better off[9] with higher utility, wage rate and per capita capital stock at each period. However, the migrants in the early periods benefit a great deal.

Figure 14 shows the graphs of lifetime utility of a migrant to country *A* and the lifetime utility of a worker staying at country *B*. While these converge to the same level at the steady state, the benefit of the migrants in early periods are clearly visible in the figure.

Obviously, residents of country *A* experience an effective population growth rate that is much higher than $n_A = 0.05$ and are made worse off in each period as well as in steady state as a consequence of facing smaller k_t, w_t and U_t values.

[9] In this simulation, the percentage increase in utility of a resident of country B is on the order of 0.01%.

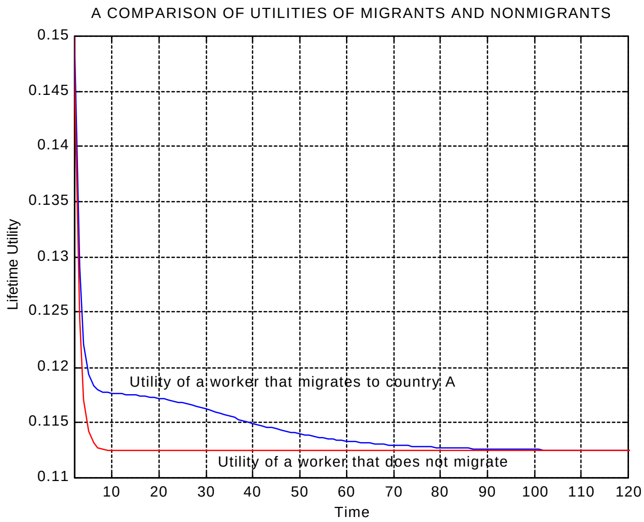

Figure 14

III.2. Migration Scenario 2

In this scenario, we allow for bilateral migration with decision criteria being the "wages under no migration" in both countries. So, the decision rule is:

(I) If $w_t^{ANM} > w_t^{BNM}$ Migration is from *B* to *A* $\zeta_t = z \cdot \left(\frac{w_t^{ANM} - w_t^{BNM}}{w_t^{ANM} + w_t^{BNM}} \right)^{\gamma}$

(3.3)

(II) If $w_t^{BNM} > w_t^{ANM}$ Migration is from *A* to *B* $\zeta_t = z \cdot \left(\frac{w_t^{BNM} - w_t^{ANM}}{w_t^{ANM} + w_t^{BNM}} \right)^{\gamma}$

The results of this scenario is given in Table 3, with æ^A, the rate of migration from *A* to *B*, being 0 at all times and æ^B, the rate of migration from *B* to *A*, converging to 0.00422 at the steady state.

Table 3. Steady State Values of Selected Variables under Migration Scenario 2

Variables	Migration Scenario 2		Autarky	
	Country A	Country B	Country A	Country B
k	0.1252	0.1252	0.1549	0.1244
w	0.2494	0.2494	0.2710	0.2488
r	1.4921	1.4921	1.3175	1.4983
u	0.1126	0.1126	0.1178	0.1124
Population Growth Rate	0.1949	0.1949		

First thing to note is that the qualitative results are same in both migration scenarios. This is due to the fact that we restrict the migration process to be a smooth one, i.e., one that does not cause large jumps in population compositions. As a result, the gap between the wages in both countries decreases gradually and finally disappears. Note that,

$$w_t^A = w_t^B \Rightarrow w_{t+1}^{ANM} > w_t^{BNM}$$

which is the case at the steady state. Therefore, wages in country *B* can never pass the wages in country *A*, causing the migration to be one sided in practice, even though migration in the opposite direction is theoretically possible.

Making a comparison between two migration scenarios is not meaningful, since the relative positions of the countries in steady state under these two different scenarios depend on the initial states. The important point here is that comparing either migration scenario with autarky cases (and the trade scenarios as we will explain in the next section) gives the same results.

IV. Trade

In this section, we examine the results of trade between these two countries under the assumption that both countries are equal in size initially. A second trade scenario where country A is taken to be a large country (in the same sense as used in the trade literature) and country *B* is taken to be a small country is discussed in Appendix B.

A natural result of free trade will be the equalization of prices in both countries in each period so

$$p_t^A = p_t^B, \quad \forall t \qquad \textbf{(4.1)}$$

In the present version of our model, we do not allow for foreign direct investment and factor movements between countries. However, given that good 1 is used for both consumption and investment purposes, capital stock at time *t* comes from good 1 produced at time *t-1*. Therefore, while installed capital itself is immobile between countries, some of good 1 traded in the previous period may be used as capital in the current period.

The capital abundant country (country *A*) specializes in the production of the relatively more capital intensive good (good 2) and exports it, while the labor abundant country (country *B*) specializes in the production of and exports the relatively more labor intensive good (good 1).

Instead of market clearing conditions in each country (as in the autarky case), we require that world-wide demand to both goods is equal to the world-wide supply, meaning that the amount of good 2 (good 1) that country *A* exports (imports) is equal to the amount of good 2 (good 1) that country *B* imports (exports). This requires that the following equations hold.

$$X_{1t}^{A} + K_{t}^{A} - K_{t+1}^{A} - \eta_{t}^{A} \cdot C_{1yt}^{A} - \eta_{t-1}^{A} \cdot C_{1ot}^{A} = \eta_{t}^{B} \cdot C_{1yt}^{B} + \eta_{t-1}^{B} \cdot C_{1ot}^{B} + K_{t+1}^{B} - X_{1t}^{B} - K_{t}^{B} \qquad \textbf{(4.2)}$$

$$X_{2t}^{A} - \eta_{t}^{A} \cdot C_{2yt}^{A} - \eta_{t-1}^{A} \cdot C_{2ot}^{A} = \eta_{t}^{B} \cdot C_{2yt}^{B} + \eta_{t-1}^{B} \cdot C_{2ot}^{B} - X_{2t}^{B} \qquad \textbf{(4.3)}$$

enabling us to determine the world price once k_t^A and k_t^B are known. The resulting steady state values for both countries are reported in Table 4.

Table 4. Steady State Values of Selected Variables under Trade

Variables	**Trade**		**Autarky**	
	Country A	Country B	Country A	Country B
k	0.1422	0.1244	0.1549	0.1244
w	0.2488	0.2488	0.2710	0.2488
r	1.4983	1.4983	1.3175	1.4983
u	0.1124	0.1124	0.1178	0.1124
p	1.2210	1.2210	1.1951	1.2210
Total Exports of Good 1	0	44.1316		
Total Imports of Good 1	44.1316	0		
Total Exports of Good 2	36.1432	0		
Total Imports of Good 2	0	36.1432		

We see that all of the variables in country *B* converge to their steady-state autarky values. Wages, rental rates, prices and utility in country *A* have the same steady state values as country *B*. Capital per worker in *A* is higher than that of *B*, but it is smaller than the value it would have attained under autarky. The results indicate that, in the long run, country *B* behaves as if it were a large country, while country *A* becomes and acts like a small country. This is due to the large population difference that occurs between *A* and *B* over time. Resulting from the high population growth rate in country *B*, this population difference between the two countries grows bigger as time passes. Although country *A* is advantageous in terms of per capita variables, its aggregate production and demand remains very small when compared to aggregate production and demand of country *B*. After a certain time, country *A*'s contribution to the world economy becomes negligible, so the results obtained by solving the model for the world become nearly the same as the results obtained by solving only for country *B*. This means that although we did not require any country to be large in the beginning, the difference in demographics cause country *B* to practically become the large country.

Figure 15 contains a graph comparing the time path of k_t^A under autarky and under the trade scenario. Comparison of time paths of k_t^B in these two cases is given in Figure 16 which plots the difference between k_t^B under the trade scenario and k_t^B under autarky $\left(k_t^{BTrade} - k_t^{BAutarky}\right)$ easy inspection. Similar plots comparing lifetime utilities in both countries are given in Figures 17 and 18.

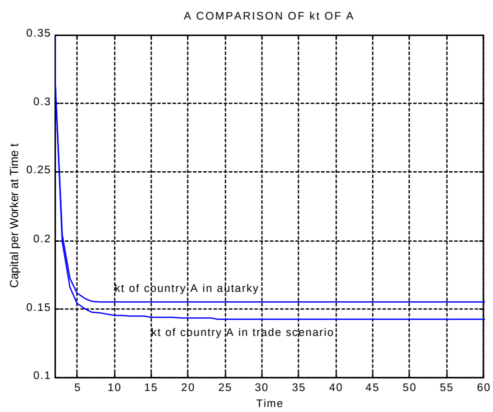

Figure 15

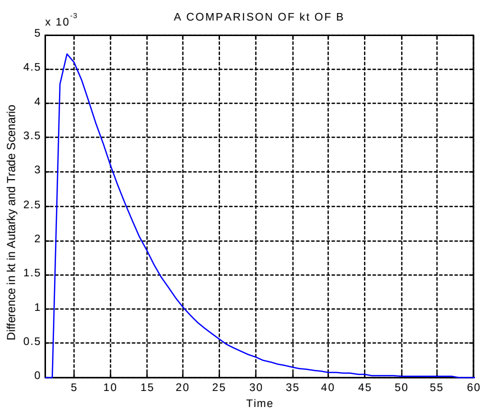

Figure 16

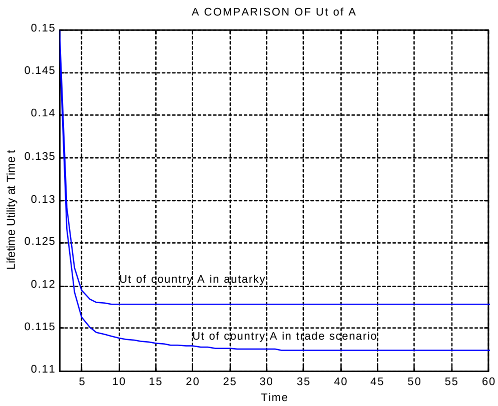

Figure 17

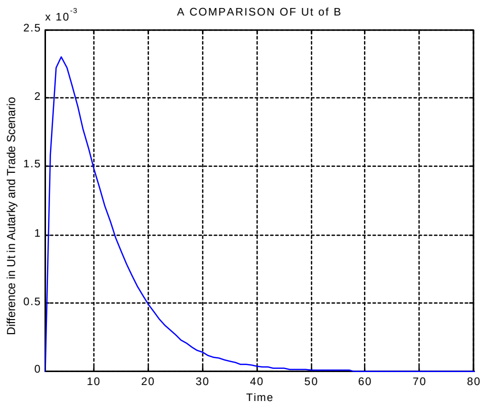

Figure 18

In the initial periods, where the effect of the differences in population growth rates are relatively small, country *B* actually benefits from trade, as in the previous scenario. Trading with country *A*, which has higher k_t and lower p_t, results in lower prices and higher capital per worker for country *B* during the initial stages of transition. However, the effect of the difference between population growth rates induces country *B* to start behaving as a large country after some time and therefore diminishes the benefits of trade for that country. The effect of population growth differences grow stronger as time passes, totally dominating the process eventually and causing the values of all variables in country *B* to converge to their autarky values.

When we compare the current trade scenario with the one presented in Appendix B (i.e., the one where country *A* is the large country), we see that the one in Appendix B is more realistic in two main aspects. First of all, the scenario presented here results in a net welfare loss for country *A*, implying that this country will have no intention to take part in such a trade in the first place. One justification of such a scenario may be a case where country *A* faces a choice between trading with country *B* and accepting migrants from country *B*. If country *A* has no other means of avoiding full labor mobility between these countries (as in the European Union), it may be willing to bear the burden of such a trade if the consequences of migration are more severe for it.

However, when we compare the case of migration with that of trade, we see that the argument in favor of the trade scenario can not be justified immediately. Figure 19 clearly shows that the residents of country *A* are also better off under migration scenario 1 on the transition path as well as at the steady state. However, the difference in steady state values is too small to provide a basis for a clear-cut decision, so that we can consider them as equal and this may lead to a justification of the current trade scenario. The fact is that most of the social factors that are non-existent in our model (such as cultural differences, increasing crime rates, etc.) do not favor accepting migrants. This may motivate country *A* to engage in trade with country *B* to avoid migrants, since the economic outcome for country *A* would be the same in the long run.

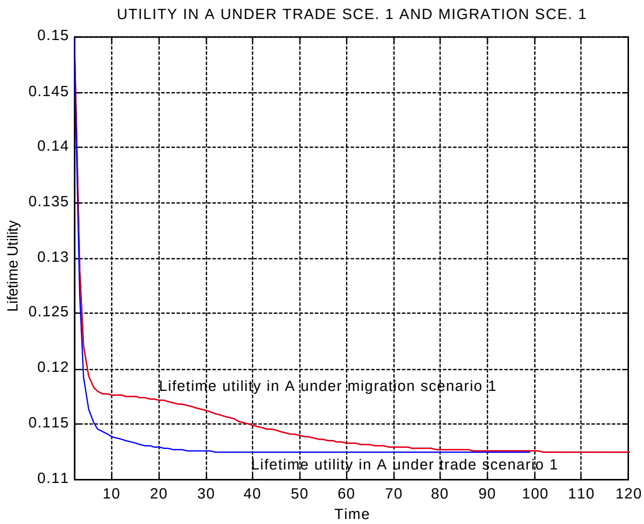

Figure 19

Of course, if country *A* is actually a large country when compared to country *B*, the trade would take place and would not cause a welfare loss for either country (see Appendix B). In such a case, the equalization of prices would eliminate the motive for migration, with country *B* moving up to the level of country *A* rather than country *A* moving down to the level of country *B*, which would happen in the case of migration.

Trade scenario in Appendix B has another advantage over the one in this section in terms of its relevance to real life examples of the issue under consideration. When we consider such examples (such as the EU vs. Turkey, the US vs. Mexico), we see that country that we model as *A* has a much bigger aggregate economy than that of country *B*. Therefore taking country *A* as a large country becomes a much more realistic assumption.

Another realistic modification to the model may be giving country *A* a bigger initial per capita capital stock together with a greater initial population. Even though these modifications have absolutely no effect in the autarky case, they may turn out to be important in a trade scenario, where the relative sizes of populations affect the outcome in a particular period. However, such an effect does not exist in the long run. We observe that the steady state values of the per capita variables are completely unaffected and turn out be equal to the values reported in Table 4.

Clearly, as time passes, the effect caused by differences in population growth rates dominate the effect of initial population differences. As a result, the initial population compositions may weaken (or strengthen if initial population of country *B* is bigger) the effect of *n*'s, alter the time path and change the length of the transition period until the steady state is reached, but have no effect on the level of steady state values of variables.

V. Conclusions

In this paper, we examined the effects of differing population growth rates and resulting age composition differences across countries on the migration and trade patterns. We considered two countries that have the same initial conditions and exactly the same properties except for the population growth rates, and compared the time paths and steady state values of variables like capital per worker, wage rate, rate of return to capital and lifetime utility. We showed that a difference in population growth rates is enough to provide incentives for flow of labor and/or commodities across countries. We modeled international labor migration and examined its effects on both the source and the host country. International trade is also modeled under two different assumptions (with and without allowing for one of the countries to be large) and the consequences of trade are compared with those of migration.

Before moving on to our main results regarding migration and the comparison of trade and migration scenarios, we briefly comment on the autarky cases. Since the countries start with exactly the same initial conditions, the values of variables for both of them are the same at the end of the first period. At the beginning of the second period, while they continue to have the same total capital, population (and hence, labor supply) in country *B* becomes higher than country *A*, causing capital per worker in country *A* to rise above country *B*. As a result, country *B* becomes the labor abundant country with a comparative advantage in producing the relatively more labor intensive good (good 1). Country *A*, on the other hand, turns into the capital abundant country with a comparative advantage in producing the relatively more capital intensive good (good 2), as reflected by the difference between the relative prices in both countries.[10]

The simulation results suggest that the wage rate and capital per worker are lower in country *B* (where labor is abundant), while the return on capital is lower in country *A* (where capital is abundant). Moreover, the representative consumer in country *A* always attains a higher level of lifetime utility than his counterpart in country *B*.

The first result that we obtain from migration scenarios is that the two scenarios are the same in practice. The difference between these scenarios is that migration scenario 1 only allows for one-sided migration (from *B* to *A*) whereas two-sided migration is theoretically possible in migration scenario 2. However, the two scenarios become essentially the same if no incentive to migrate from *B* to *A* arises (i.e., if the wage rate in *B* never exceeds that in *A*), which is exactly what happens in the present simulation. This is due to the restriction that the migration scheme we consider be a smooth one so as not to observe discontinuity in the values of variables, which is a fairly realistic restriction. This migration scheme does not lead to any irregularities such as a large amount of people migrating in one period followed by no migration in the next period, as instantaneous jumps are ruled out. Given that the wages in *A* are initially higher than those in *B*, if the wages in *B* were ever to exceed *A*, they should first become equal (or at least sufficiently close). At first, the large difference between w_t^A and w_t^B (in favor of *A*) provides a big incentive for migration from *B* to *A*. As the system moves closer to steady state, the difference between w_t^A and w_t^B gradually decreases, reducing the incentive to migrate. At the steady state when w_t^A and w_t^B become virtually equal (note that there is still incentive to migrate from *B* to *A* since $w_t^{ANM} > w_t^{BNM}$), the amount of migration is not enough to push w_A lower than w_B. Therefore, no migration from *A* to *B* ever occurs, reducing the effects observed under migration scenario 2 to those observed under migration scenario 1.

[10] A similar argument applies to all periods, meaning that country A should always have comparative advantage in producing more capital intensive good, which is indeed the result of the simulation.

Another important result obtained from the migration scenarios is the convergence of the rate of migrating workers in country *B* to a value that equalizes population growth rates in both countries at the steady state. This result is significantly different than Galor (1986), where the migration does not affect wages causing the incentive to migrate to persist on the adjustment path. This, in turn, results in the migration of the whole population of one country to the other. In our model, migration serves to equalize relative prices and factor prices. The welfare effects are in line with Galor (1986) and Karayalcin (1999) in that the host country gets worse-off while the source country remains at least as well-off (becomes slightly better-off to be exact).

One feature of the adjustment path in migration scenarios is that the length of the transition period is much longer than that of the autarky cases. This causes the resulting common population growth rate (0.1989 in scenario 1 and 0.1949 in scenario 2) to be very close to n_B, which is 0.2. Since the ratio of the youngs born in country *B* to those born in country *A* grows larger and larger over time, the length of the path to steady state makes the movement of only a small portion of youngs in *B* sufficient to equalize population growth rates across countries. As a result, citizens of *A* incur a great welfare loss due to the migration while the welfare of citizens of *B* at the steady state is almost the same under autarky and migration. This, however, does not suggest that the migrants' decisions to migrate are without justification. The time paths of the welfare of the migrants and the non-migrants show that the migrants benefit greatly from migrating, especially in the initial periods.

We also see that we were not mistaken to assume that individuals decide whether to migrate or not by comparing the "under no migration" values of utilities (or wages in migration scenario 2) and ignore the fact that these values would not be realized after migration. While the individuals do ignore some effects by doing so and the improvements in their welfare turn out to be smaller than they anticipated, they are still better-off as compared to the non-migrants, justifying that they were right to decide in favor of migrating in the first place.

Our trade scenarios exhibit the usual characteristics of Heckscher-Ohlin type models with each country specializing in and exporting the good in the production of which it has a comparative advantage and importing the other good. Before moving on to the more interesting case of the comparison of results of trade scenarios with those of migration scenarios, we would like to comment on a few things.

Clearly, results of trade scenario in Section IV imply a Pareto deterioration for country *A* and are contrary to a common result in the trade literature which suggests that none of the parties involved in international trade should face welfare losses. This result might have changed if we had considered compensation schemes or transfer payments between countries. Some studies using OLG models, such as Kemp and Wong (1995) and Roy and Rassouli (1991), argue that the absence of these mechanisms may result in free trade being inferior to autarky. Bohm and Keiding (1985) also present an OLG model with inflation where all agents of one country are made worse off under free trade. However, the real reason behind the welfare loss in our trade scenario is that country *A* is essentially forced to act as a small country in the long run and take the prices realized in country *B* because of the significantly faster population growth in this country. This increases the relative price in country A while the wages fail to compensate the effect of this increase. This result is in line with Galor (1988a, 1988b), who suggest that free trade may cause a Pareto deterioration for a small country in the absence of international transactions in financial assets.

Since migration is also Pareto inferior to autarky, the best solution for country *A* seems to close its borders to both labor and good movements if it is not a large country. A possible reason for not doing so may be country *A*'s inability to prevent legal (which would probably be the case should Turkey be accepted as a full member by the EU) or illegal (which is the case between Mexico and the U.S.) migration of labor. What country *A* may do instead may be to try to eliminate motives for migration by engaging in trade with country *B*. (We would like to remind that one of the arguments raised in the U.S. in defence of NAFTA was that it would slow down labor migration from Mexico to the U.S. by increasing wages in Mexico.)

At a first glance, engaging in trade to avoid migration does not seem to be a rational choice for country *A*, if it does not have the power of imposing its own prices as a large country, as in the scenario in Section IV. While migration, which pushes country *A* close to the welfare level of country *B* under autarky and causes a net welfare loss, is bad for this country, trade is worse in this case, pushing country *A* even more (towards what is almost exactly the autarky welfare level of country *B*) and causing a larger welfare loss.

However, it should be noted that the values of variables at steady state under the two scenarios are fairly close to each other, with the utility under trade scenario of Section IV being only 0.01% less than that of migration scenario. Therefore, claiming that the economic analysis clearly favors migration over trade is not possible, considering the infinitesimal difference. If political and social factors heavily favor trade over migration (and they almost always do), a government may be willing to bear this small burden instead of dealing with the potential problems of migration, such as hostility against migrants due to a number of social and cultural differences, opposition of labor unions to the inflow of cheap labor, etc. Moreover, the economic factors that we do not take into account in our model may be increasing the cost of accepting migrants. Wellisch and Walz (1998) and Razin and Sadka (1992) emphasize the importance of redistribution policies and claim that accepting migrants who often work in low-wage jobs increases the burden of social protection policies. Data in Wellisch and Walz (1998), for example, suggest that social protection expenditures correspond to one-third to one-half of government expenditures in the U.S., Germany and the EU as a whole. In such a case, country *A* may actually be better-off by preferring trade over migration if the extra burden of trade on the population is less than the extra burden of immigrants on the government budget. Of course, this issue requires further inspection, probably using a model like that in Wellisch and Walz (1998). However, we can safely say that arguments supporting trade over migration are at least as good as the opposing arguments, if not better, even when the actual trade scenario is the one in Section IV.

If the relevant trade scenario is the one in Appendix B, i.e., if country *A* is actually a large country whereas country *B* is small, the choice between trade and migration is much easier. In this case, trade Pareto dominates migration by improving the welfare of country *B* to the autarky level in country *B* without causing any decrease in the welfare level of country *A*. Not only country *A* gets better off than it would have been under migration scenario, but country *B* also gets better off than it would have been under autarky or the migration scenarios.

We can say that while both migration and trade equalizes factor prices and relative prices in both countries, they are by no means substitutes (especially when one of the countries is large) and the low-population-growth country prefers trading with the other country rather than accepting migrants from it.

Further study on the issue may consist of inclusion of a government to study the effects of migration on government policies, such as tax rates, tax revenue, social redistribution expenditures, etc. (for such a study, see Storesletten, 2000). The case of temporary migration seems quite straight-forward and not expected to provide greater insight. Even though endogenizing the length of stay of migrant workers in the foreign country (which would require a model with more cohorts) or introducing a probability of return to home country could make the model more realistic, the main results presented here are not expected to change.

REFERENCES

Auerbach, A., L.J. Kotlikoff, R. P. Hagemann and G. Nicoletti. 1989. "The Economics of an Ageing Population : the Case of Four OECD Countries," *OECD Economic Studies* 12: 97-130.

Auerbach, Alan J. and Laurence J. Kotlikoff. 1987. *Dynamic Fiscal Policy.* Cambridge: Cambridge University Press.

Bohm, Volke and Hans Keiding. 1985. "Inflation and Welfare in International Trade," *Universite Catholique de Louvain Centre for Operations Research and Econometrics Discussion Paper: 8601.*

Broer, D.P., E.W. Westerhaut and A.L. Bovenberg. 1994. "Taxation, Pensions and Savings in a Small Open Economy," *Scandinavian Journal of Economics* 96: 403-424.

Calvo, Guillermo, A. 1978. "On the Indeterminacy of Interest Rates and Wages with Perfect Foresight," *Journal of Economic Theory* 19(2): 321-337.

Chiswick Barry R. 1986a. "Human capital and the Labor Market Adjustment of Immigrants: Testing Alternative Hypotheses." In Oded Stark, ed., *Human Capital, Migration and Development.* Greenwich: JAI Press, 1-26.

-----.1986b. "Is the New Immigration Less Skilled than the Old?," *Journal of Labor Economics* 4: 168-192.

Djajic, Slobodan and Ross Milbourne. 1988. "A General Equilibrium Model of Guest Worker Migration," *Journal of International Economics* 25: 335-351.

Djajic, Slobodan. 1989. "Migrants in a Guest Worker System: A Utility Maximization Approach," *Journal of Development Economics* 31: 327-339.

Ethier, Wilfred J. 1985. "International Trade and Labor Migration," *American Economic Review* 75(4): 691-707.

Farmer, Karl. 1997. "Heterogenous Capital in a Two-Sector Overlapping-Generations Model" *Metroeconomica* 48(1): 36-54.

Galor, Oded and Oded Stark. 1990. "Migrants' Savings, the Probability of Return Migration and Migrants' Performance," *International Economic Review* 31: 463-468.

-----.1991. "The Probability of Return Migration, Migrants' Work Effort, and Migrants' Performance," *Journal of Development Economics* 35: 399-405.

Galor, Oded. 1986. "Time Preference and International Labor Migration," *Journal of Economic Theory* 38: 1-20.

-----.1988a. "Trade Growth and Welfare in a Small Overlapping Generation Economy," *Brown University Department of Economics Working Paper: 88-4.*

-----.1988b. “Is Free Trade Indeed Optimal for a Small Economy? A Dynamic General Equilibrium Analysis,”*Brown University Department of Economics Working Paper:88-8.*

-----.1992. “A Two-Sector Overlapping Generations Model: A Global Characterization of the Dynamical System,” *Econometrica* 60(6): 1351-1386.

Geide-Stevenson, Doris. 1998. “Social Security and international Labor and Capital Mobility,” *Review of International Economics* 6(3): 407-416.

Guillo, Maria Dolares. 1999. “On Terms of Trade and Capital Accumulation,” *Review of International Economics* 7(2): 228-244.

Hagemann, Robert P. and Giuseppe Nicoletti. 1989. “Population Ageing: Economic Effects and Some Policy Implications for Financing Public Pensions,” *OECD Economic Studies* 12: 51-96.

Heckscher, Eli F. 1919. “The Effect of Foreign Trade on the Distribution of National Income,” *Economisk Tidskrift* 21.

INGENUE Team. 2000. “INGENUE, A Multi-regional Computable General Equilibrium, Overlapping Generations Model,” Paper presented at the Sixth International Conference on Computing in Economics and Finance organized by the Society for Computational Economics, Barcelona, Spain, July 6-8.

Karayalcýn, Cem. 1994. “Temporary and Permanent Migration With and Without an Immobile Factor” *Journal of Development Economics* 43: 197-215.

Kemp, Murray C. and Kar Yiu Wong. 1995. “Gains from Trade with Overlapping Generations,” *Economic Theory* 6(2): 283-303.

Kenc, Turalay and Serdar Sayan. 2001. “Demographic Shock Transmission from Large to Small Countries: An Overlapping Generations CGE Analysis,” forthcoming in *Journal of Policy Modeling.*

Kochhar, Rakesh. 1992. “International Labor Migration and Domestic Labor Supply,” *Journal of Population Economics* 5(2): 113-134.

Lerner, A. P. 1952. “Factor Prices and International Trade,” *Economica* 19: 1-16.

Markusen, James. R. 1983. “Factor Movements and Commodity Trade as Complements,” *Journal of International Economics.* 14(3-4): 341-356.

Meade, J. E. 1951. *The Balance of Payments.* London: Oxford University Press.

Miles, D. 1999. “Modelling the Impact of Demographic Change upon the Economy,” *Economic Journal* 109: 1-36.

Ohlin, Bertil. 1929. “The German Transfer Problem : A Discussion,” *Economic Journal* 39: 172-173.

Perraudin, William R.M and Thierry Pujol. 1991. “European Fiscal Harmonization and the French Economy,” *IMF Staff Papers* 38: 399-440.

Razin, Assaf and Efraim Sadka. 1995. “Resisting Migration: Wage Rigidity and Income Distribution,” *American Economic Review* 85: 312-316.

-----.1997. “International Migration and International Trade.” In Mark R. Rosenzweig and Oded Stark, eds., *Handbook of Population and Family Economics, vol 14.* Amsterdam, New York and Oxford: Elsevier Science, North-Holland, 851-887.

Reichlin, Pietro. 1986. “Endegenous Fluctuations in a Two-Sector Overlapping Generations Economy” Dip. Di Scienze Economiche, Universita degli Studi di Roma.

Rivera-Batiz, Francisco L. 1983. “The Economics of the ‘to and fro’ Migrant: Some Welfare Theoretical Considerations,” *Scandinavian Journal of Economics* 85(3): 403-413.

Roy, Raj and Ali Rassouli. 1991. “A Note on International Capital Movements in an Overlapping Generations Model,” *Rivista Internazionale di Scienze Economiche e Commerciali* 38(10-11): 969-978.

Ruffin, Roy J. 1984. “International Factor Movements,” in Ronald W. Jones and Peter B. Kenen, eds., *Handbook of International Economics Volume 1*. Amsterdam, New York, Oxford and Tokyo: North Holland, 237-288.

Samuelson, Paul A. 1949. “International Factor Price Equalization Once Again,” *Economic Journal* 62: 278-304.

Storesletten, Kjetil. 2000. “Sustaining Fiscal Policy through Immigration,” *Journal of Political Economy* 108(2): 300-323.

Turner, D., C. Giorno, A. de Serres, A. Vourch and P. Richardson. 1998. The Macroeconomic Implications of Ageing in a Global Context. OECD Economics Department Working Paper No. 193, Paris.

Wellisch, Dietmar and Uwe Walz. 1997. “Why Do Rich Countries Prefer Free Trade Over Free Migration? The Role of the Modern Welfare State,” *European Economic Review* 42: 1595-1612.

Wong, Kar Yiu. 1995. *International Trade in Goods and Factor Mobility*. Cambridge: Cambridge University Press.

APPENDIX-A

Population Growth Rate, Age Composition and *n*

Assume that at an arbitrary period *t*, there are $\overline{\eta}_{OLD}$ number of olds in country *j*. By definition, there are $(1+n)\cdot\overline{\eta}_{OLD}$ youngs at that period. In period *t+1*, there are $(1+n)\cdot\overline{\eta}_{OLD}$ olds and $(1+n)^2\cdot\overline{\eta}_{OLD}$ youngs. So the population growth rate is

$$\text{Population Growth Rate} = \frac{\left((1+n)\cdot\overline{\eta}_{OLD} + (1+n)^2\cdot\overline{\eta}_{OLD}\right) - \left(\overline{\eta}_{OLD} + (1+n)\cdot\overline{\eta}_{OLD}\right)}{\overline{\eta}_{OLD} + (1+n)\cdot\overline{\eta}_{OLD}}$$

$$= \frac{(1+n)^2 - 1}{(1+n)+1} = \frac{(2+n)\cdot n}{2+n} = n \qquad \textbf{(A.1)}$$

Also at an arbitrary period *t*, ratio of youngs in the population would be

$$\text{Ratio of Youngs in Population} = \frac{(1+n)\cdot\overline{\eta}_{OLD}}{(1+n)\cdot\overline{\eta}_{OLD} + \overline{\eta}_{OLD}} = \frac{1+n}{(1+n)+1} = \frac{1}{1+\frac{1}{1+n}} \qquad \textbf{(A.2)}$$

Clearly, this ratio is increasing in *n*, meaning that of the 2 countries with the same initial conditions, the one with the greater *n* will have a younger population each period.

APPENDIX-B

Trade Scenario 2

When country *A* is taken to be 'large' and country *B* 'small', relative prices observed in country *A* will directly be transmitted to country *B*. Since the effects of trade on the values of variables in country *A* will be negligible in such a case, period *t* prices in *A* will be

$$p_t^A = \phi\left(k_t^A\right) \quad \textbf{(B.1)}$$

where k_t^A is the capital per worker in country *A*. As prices in country *B* will also move to make $p_t^B = p_t^A = \phi\left(k_t^A\right)$, other variables in both countries will be determined according to this common relative price.

However, it is not possible to simulate such a case with the values that we use in the previous parts. To highlight the effects of the difference between n_A and n_B, we had chosen two countries with a large difference between the population growth rates. While such a difference is not unrealistically large, it is still large enough to cause the aggregate economy in country *B* to grow extremely large when compared to that of country *A*. So, even if we start from a situation where country *A* is the large country, the difference in population growth rates would soon offset this effect, making it impossible to analyze a case where country *A* remains a large country for a reasonable period of time. To study such a case, we consider two countries with distinct but relatively close population growth rates, with $n_A = 0.05$ and $n_B = 0.08$. By this way, country *A* will remain to be a large country, once it starts as one, enabling us to compare the results with that of autarky. Note that country *A* again exports good 2 and imports good 1 and the relative prices in *A* do increase. However, since *A* is the large country, its per capita exports and imports are so small that they become negligible, causing the increase in p_A to be negligible as well.

Table B reports the steady state values of all variables for both countries. Country *B*'s taking of the prices in country *A* results in the same level of wages, rental rates and utilities at the steady state in both countries, which are equal to those of autarky case in country *A*. Country *B* ends up with lower rental rates and prices and higher wages and utility as compared to the autarky case.

Table B. Steady State Values of Selected Variables under Trade

Variables	Trade		Autarky	
	Country A	Country B	Country A	Country B
k	0.1549	0.1355	0.1549	0.1244
w	0.2710	0.2710	0.2710	0.2488
r	1.3175	1.3175	1.3175	1.4983
u	0.1178	0.1178	0.1178	0.1124
p	1.1952	1.1952	1.1951	1.2210
Total Exports of Good 1	0	44.1316		
Total Imports of Good 1	44.1316	0		
Total Exports of Good 2	36.1432	0		
Total Imports of Good 2	0	36.1432		

A graph of capital per worker in country *A* and country *B* in autarky and country *B* under trade scenario 2 are given in Figure B. We see that while trade is enough to equalize other variables of concern, k_t in country *B* remains lower than that of country *A*. However, there is still an improvement in country *B* when compared to its autarky case. Clearly, this scenario induces a Pareto improvement over the autarky case by clearly improving the welfare of country *B* without causing a deterioration in the welfare of country *A*.

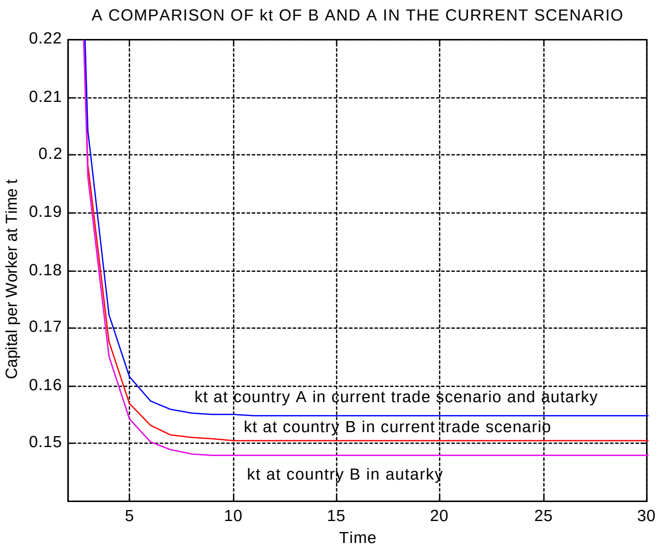

Figure B