Crossing the Rio Grande: Migrations, Business Cycles and the Welfare State *

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Abstract

In this paper we study the macroeconomic effects of an inflow of low-skilled workers into an economy where there is capital accumulation and two types of agents. We find that there are substantial dynamic effects following unexpected migrations with adjustments that resemble those triggered by a sudden disruption of the capital stock. We look at the interrelations between these dynamic effects and three different fiscal systems for the redistribution of income and find that these schemes can change the dynamics and lead to prolonged periods of adjustments. The aggregate welfare implications are sensitive to the welfare system: while there are welfare gains without redistribution, these gains may be turned into costs when the state engages in redistribution.

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1 Introduction

Migration flows from underdeveloped areas to OECD countries have been substantial in the past and even over the last decade they have continued to play an important role in the demographics of many industrialized countries. For example, in the 16 EU-member countries, net immigration has been about 0.5% of the native population in every of the last ten years and this factor has been by far the most important source of aggregate population growth. There have also been recent episodes of large and temporarily concentrated migration flows, e.g. Albanians to Italy and Greece or Eastern Europeans to Central Europe at the beginning of the 90s, and one could think of German unification as a mass migration from an underdeveloped country towards a large and developed one.

Both policy circles and the popular press seem to be particularly concerned with migrations and there have been international actions to prevent mass migrations toward industrialized nations: political pressure has led to regulate the flow and qualifications of migrants (e.g. in Australia and Canada), and to restrict the type of labor activities migrants can undertake and the welfare benefits they enjoy. The latest example of this type is the US Illegal Immigration Reform and Immigration Responsibility Act passed in 1996 which exclude legal migrants from certain welfare benefits (Supplementary Security Income, Food stamps and, in some cases, Medicaid) enjoyed by natives and naturalized citizens, disregarding the fact that these migrants might have payed social security taxes in the past. It has been estimated (see Super and Daskal (1997)) that such a change could affect 450.000-700.000 legal migrants in the US, little less than 0.5% of the population, with budget savings for the welfare state of about 1.5 billion dollars.

In this paper we attempt to shed some light on why public perception toward migrations in OECD countries has changed in the last 15-20 years by answering the following questions: (i) What are the dynamic effects of an inflow of agents in the economy? (ii) Are these effects dependent on the skill composition of the migrants relative to the native population? (iii) Do migration flows affect sectors of native population differently? Which group is more affected? (iv) Do macroeconomic effects depend on the presence of a welfare state? (v) How do restrictions on migrants' access to the labor market and the welfare state alter the macroeconomic effects of labor flows across countries?

We consider a model of a single economy and neglect both the economic consequences on the sending country and the international repercussions. This seems a sensible modelling strategy once it is taken into account that the focus of our analysis is a large and developed receiving country, which one may think of as Europe or the US, and that migrations take place primarily because of political reasons. Furthermore, since (at least until very recently) most migrants are low-skilled relative to the average native our model has heterogeneous agents differing in their productivity: the native population is initially made up of two types of agents, and the highly-skilled type is more productive than the low-skilled type. In modelling this feature we highlight the fact that the degree of substitutability between the two types of labor is an important factor determining both the aggregate repercussions and the distributional effects on natives of migration flows.

Within this set-up we model migrations as a temporary increase in the growth rate of the unskilled portion of the population and examine the consequences of such an inflow under different redistribution schemes. Initially, we assume that there is no redistribution and study whether migrations with different features produce different dynamics responses of aggregate and sectorial variables. This may be thought of as a model for the US or for Europe before the establishment of the various components of the welfare state. Afterwards we consider a constant income tax rate system with tax receipts redistributed to low-skilled workers. The third case we look at is related to the system currently in place, e.g., in Canada or the Scandinavian countries where redistributions are guided by egalitarian considerations. Finally, we look at a case where the tax system is used to insure low-skilled consumption. This system bears resemblance to the insurance scheme in place after German unification (see Schrettl (1992)) and it is foreseen in analyses of the future common fiscal unit of the European Union.

We find that the presence of a welfare state is important for evaluating how migrations affect the economy and that it may be one of the factors explaining the change in the public perception towards migrations. Without redistributive policies, an inflow of low-skilled labor triggers an adjustment process that resembles the effects which would take place if the capital stock was suddenly disrupted: since the population growth rate temporarily increases, there is initially less capital per-capita and agents work harder to rebuild the capital stock. This process leads initially to a downward pressure on wages and an increase in interest rates. Indeed, if all workers were identical and no redistribution was in place, this would be the only adjustment and there would be no long-run effects. However, with heterogeneous agents, there is a second effect since the composition of the population changes permanently. This compositional effect causes both more substantial short-run dynamics and permanent long-run effects. In particular, if migrants have lower productivities than the average native worker and the two types of labor are sufficiently substitutable in production, steady-state output, capital, hours in efficiency units and high-skilled hours will be permanently lower in the new steady-state.

It is worth noting that our set-up, which allows for capital accumulation, leads to dynamics which are different than those typically encountered in models with a fixed capital stock (see e.g. Benhabib (1996)). In such models an inflow of labor typically leads to a once-and-for-all change in the capital-labor ratio: if migrants carry less capital than the average native the capital-labor ratio decreases, thereby making capital owners better off and workers worse off and vice versa if the migrants carry more capital than the average native. These modifications correspond roughly to the short-run effects we find in our set-up. However, because of capital accumulation, long-run effects will be different in our model. In the long-run, the capital-labor ratio is determined by preferences, technology and taxes via a modified golden rule. Thus, if taxes are unaltered and the two types of workers perfect substitutes, a migration flow does not affect wages and interest rates in the long-run and simply leads to an increase in the wealth of capital owners who end up holding more capital per-capita. Obviously, if taxes change or the two types of workers are imperfect substitutes, these long-run effects will be altered.

An inflow of low-skilled labor produces important redistributive effects from wage to capital income along the adjustment path since the wage rate is depressed while the return to capital increases. In addition, if the two types of workers are imperfect substitutes in production, such an inflow produces a further redistribution from low-skilled to high-skilled agents. Given these effects we find that, if we take skill differences between natives and migrants as exogenous, transient migrants may be preferred to permanent ones if the objective is to minimize long-run changes and that high-skilled migrations may be beneficial for the economy both over the business cycle and in the long-run.

All these effects, however, depend on the fiscal system. For example, high-skilled/capitalists may be heavily penalized by the welfare state under certain policies because they have to support a larger number of low-income agents. Essentially, redistribution schemes can shift the costs of migrations from low-skilled to high-skilled/capitalists providing additional depressive effects on capital accumulation both over the business cycle and in the long-run. We show that these effects may be partially avoided if the admittance of migrants to the welfare state provisions is limited but it is hard to believe that this policy will be politically sustainable in the medium-long-run.

As a corollary to our analysis, we consider the effects of an inflow of illegal migrants and of restrictions on the labor market activities of migrants. In our set-up the distinguishing feature of illegal migrants is that these agents do not receive transfers and do not pay income taxes. When the state is egalitarian we find, maybe surprisingly, that both types of agents would encourage illegal immigration! The reason for this is that low-skilled agents are net-receivers of transfers from the welfare state. Thus, excluding these migrants from the welfare state means that taxes need to be increased less after an inflow of low-skilled agents, which is a policy favored by the high-skilled agents, and that the tax revenues are redistributed to the native low-skilled agents only. Another surprising result is that, with a welfare state, low-skilled natives favor the admittance of migrants to the labor market while skilled agents will oppose it. The reason is that when the migrants are allowed to work the welfare state will be more prone to redistribute, which harms high-skilled agents and improve the welfare of low-skilled agents.

Finally, we attempt to quantify the social welfare costs of migrations. We compute the percentage change in consumption, evaluated from one steady-state to another, which keeps utility unchanged before and after the flow of low-skilled agents takes place. Two measures are investigated: the first measures the welfare changes if capital owners were to bear the entire costs or benefits of migrations, while the second measure weights the utility of the two types of native agents. When the economy does not engage in redistribution, we find that there are aggregate welfare gains from migrations. For example, the economy would be willing to give up 0.25-0.6% of annual consumption to encourage low-skilled migrations which change the composition of population by 1%. This result is well-known in models with fixed capital stocks, reappears here and it is due to the fact that capital owners are better off. With a welfare system in place, however, these gains are turned into substantial costs (up to 0.5% of annual consumption). The quantitative features of the results depend on the size of migration flows, the skill composition of native population and the elasticity of substitution of the two types of labor in production.

The remainder of the paper is organized as follows: section 2 discusses relevant facts about recent migration flows to the OECD countries; section 3 outlines our model; section 4 analyzes the quantitative effects of migrations; section 5 repeats the analysis under various welfare systems; section 6 computes the social welfare costs of migrations and section 7 concludes.

2 Some Facts about Recent Migrations in OECD Countries

We begin by providing some facts about migration flows in recent years. Far from being complete, our description outlines primarily the facts which are useful to build a sufficiently articulated dynamic model where migrations generate interesting effects. For a thorough description of recent trends we invite the reader to consult "Trends in International Migration", published annually by the OECD since 1992, where we have taken most of the information.

Migration flows toward the US and Europe levelled off in the 90's after a large increase in the trend in the last part the 1980's due to the breakdown of the communist bloc and to worsening economic conditions in the Central and South America and the Southern part of the Mediterranean basin. Over the last decade Germany has been the European country with the largest net immigration flow. In 1992 and 1993 the net flow of legal migrants (excluding foreigners of German background) was about 575,000 and 280,000 which correspond to 0.9% and 0.4% of the existing population. For France and Switzerland there were net immigrations of approximately 100,000 persons each year while for the U.K., Belgium and the Netherlands the net number of legal immigrants was about 50,000 each year. Sweden occupies a special place having allowed an inflow of 50,000 Bosnians each year since the beginning of the war in ex-Yugoslavia. In percentage, net migration flows have accounted on average for about 0.5% of the EU population over the last 10 years. In 1993, new inflows as percentage of population were 0.5% in Switzerland, 0.6% in the Netherlands, 0.3% in Norway and Denmark and 0.2% in the UK and France.

On average, 30% of the migrants are workers, most of which are males 14-49 years of age. The rest is composed of accompanying family members, migrants for purpose of family reunification and refugees or asylum seekers. Switzerland, Germany and France are the countries where the percentage of workers among migrants is largest. In particular, in Switzerland in 1993, 43% of the migrants were workers. In the US and Canada, the percentage of workers is low (about 10%) and family reunification accounts for the largest percentage of net inflows.

Migrants to Europe come from a variety of continents and countries and over the last decade there has been an increase in the range of nationalities. North African immigration is strong in Spain, France, Italy and Germany; migrants from the ex-Yugoslavia primarily go to Germany, Sweden, Italy and Switzerland; migrants from the old eastern block settle primarily in Germany, Finland, France and Italy; Turks and Middle Easterns prefer Germany, Belgium, France and the Netherlands and finally, East Asians settle primarily in Southern Europe, and in particular, Italy, where most of the east Asian migrants are females. Migrants to the US and Canada are primarily from Asia and Central America.

A large percentage of the migrants toward Central Europe (Germany, Switzerland and Austria) are temporary or seasonal workers who remain in the country for six months or less. For example, in 1993, 200,000 migrants to Germany and 72,000 to Switzerland were seasonal. Also, while at the beginning of the 90's migration flows from Eastern to Central Europe had permanent characteristics, since 1993 there has been a shift from permanent to temporary, seasonal or contract-based migrations. A similar pattern seems to occur in the US, Canada and Australia. Most of the migrants are low-skilled but the percentage of migrants with little qualification has being declining over the last decade. Movements of highly qualified labor are still very small but increase at a sufficiently rapid rate.

For the countries in the EU, net migration is by far the predominant component of the growth of population over the last 10 years. For example, in 1992-93, 68% of the growth in the European population was due to migrations (59% in the Nordic countries). Over the 1987-93 period local growth rates of population were around 0.2% while the migrant population growth rate was approximately 0.5%. Italy is the most extreme case in this respect, followed by Germany: the growth rate of the local population was 0.05% and the one due to migration was 0.3%. For the US and Canada the share of population growth due to migrations is smaller but still substantial (on average 35%).

Migration flows to EU (and OECD) countries over the 80's and 90's appears to be unrelated to business cycle conditions and, instead, linked to political and economic changes. The share of foreigners in the labor force has dramatically increased in the 1990-93 period as a result of migrations, changes in the participation rate of nationals and demographics. In EU countries migrants have unemployment rates which are similar to those of nationals while in the US and Canada foreign-born workers have higher and more variable unemployment rates than nationals and are more vulnerable to unemployment spells. The increase in the number of arrivals in the 90's contributes to the swelling of unemployed foreigners, particularly for low-skilled workers. Over the period 1983-92 foreign employment has increased faster than native employment in half of the OECD countries and the increase was divided between all sectors (including tertiary and services).

In Europe foreign (male) labor is concentrated in sectors which are very cyclical and are either declining or undergoing restructuring. In Germany, for example, foreign workers are most represented in manufacturing, where they account for 15% of total employment; in France they account for about 18% of employment in construction; in Belgium and the Netherlands they account for 15% and 8% of employment in extraction. In the US foreigners account for about 25% of the employed in precision engineering and other high-tech industries. Also, laid-off foreign workers are typically 50+ years old and have held manual and unskilled occupations for a number of years, a characteristic which gives them little chance of being re-employed in the upturn of the business cycle.

3 The Basic Model

The choice of a model, which we use to analyze how an inflow of labor affects an economy, is guided by a number of considerations. First, we want to concentrate on the consequences for the receiving country and we ignore both international repercussions and the effects on the sending country. Hence, we will be concerned with a single and large economic unit such as Europe or the US. Second, we wish to examine the dynamic adjustment of macro variables following labor migrations of different types and with different persistence characteristics. Thus, we will employ a model that is well-suited for analyzing business cycle properties. For this aim we use a version of the neo-classical growth model with capital accumulation. Third, we want to consider a native heterogeneous labor force since we are particularly interested in modelling an inflow of workers whose skill composition differs from the one of natives. Hence, we will work with an economy with two types of agents that differ in their productivity levels (as in Kydland

(1984, 1995) and Rios-Rull (1993)) and we follow Kydland in modelling productivity differences.

We assume that low-skilled agents are unable to save for future occurrences. The fact that low-income households are restricted from accessing financial markets is well documented in the literature. For example, Campbell and Mankiw (1989) and Mankiw and Zeldes (1991) have estimated that approximately 50% of US households are liquidity constrained. A large proportion of migrants who move to Europe or the States owns little or no capital and are de-facto restricted from engaging in borrowing activities so they may be thought of as liquidity constrained. However, in this paper, we go a step further and assume that low-skilled agents are unable to intertemporally smooth consumption. This assumption is partly made for computational ease but we believe that it is reasonable for at least two reasons. First, in the US about 25% of the households hold either negative or no wealth and the head of the household is typically low-skilled. In European countries this number varies from 5 to 20% but it is still true that, typically, the head of households with no wealth has low skills. Secondly, first generation low-skilled migrants transfer a large portion of their income back to their home country at regular periods and tend to live close to the subsistence level. Moreover, because they are less wealthy than the average native, they are typically unable to purchase insurance contracts or assets which would allow them to smooth their consumption stream.

It is instructive to present the economy first and then discuss the modelling of migration. We let the index $i = u, s$, denote the two group of agents (s denotes high-skilled and u denotes low-skilled). The number (measure) of agents of type i at time t is given by N_t^i and we define $\gamma_t \in [0;1]$ as the time t population share of high-skilled agents.

We assume that there is a large number of identical competitive firms renting factors of production from the households. Production takes place using labor in efficiency units (H^e) and capital (K) and we assume that the production function is Cobb-Douglas with constant returns to scale to these two factors. Hours in efficiency units is modelled as a CES-aggregate of the two types of labor with an elasticity of substitution of $1/\rho > 0$. We also assume that high-skilled hours are more productive than low-skilled hours and we let $\omega \geq 1$ denote productivity differences. When these two factors are perfect substitutes $H^e = H^u + \omega H^s$, where H^i denotes total number of hours of workers of type i.

The maximization problem of the representative firm is given by:

$$\max_{\{H_t^s, H_t^u, K_t\}} z_t \left[\omega (H_t^s)^{1-\rho} + (H_t^u)^{1-\rho}\right]^{\frac{\alpha}{1-\rho}} K_t^{1-\alpha} - w_t^s H_t^s - w_t^u H_t^u - r_t K_t \tag{1}$$

where $H_t^i \equiv N_t^i \cdot h_t^i$, h_t^i is the number of hours of a worker of skill i, and z_t is a productivity disturbance. Converting (1) in per-capita terms using our definition of γ_t, we obtain:

$$\max_{\{h_t^s, h_t^u, k_t\}} z_t \left[\omega(\gamma_t h_t^s)^{1-\rho} + ((1-\gamma_t)h_t^u)^{1-\rho}\right]^{\frac{\alpha}{1-\rho}} (\frac{k_t}{g_t^p})^{1-\alpha}$$
$$-\gamma_t w_t^s h_t^s - (1-\gamma_t) w_t^u h_t^u - r_t(\frac{k_t}{g_t^p}) \tag{2}$$

where all lower case letters denote per-capita variables and g_t^p the growth rate of the population[1]. It follows immediately from the assumptions of competition that all factors are paid their marginal products so that:

$$w_t^s = \omega w_t^u \left(\frac{\gamma_t h_t^s}{(1-\gamma_t)\, h_t^u}\right)^{-\rho}$$

The two groups of agents face different optimization problems because low-skilled workers own no capital or other assets and because it is assumed that they are restricted from purchasing insurance contracts. These agents solve the following problem:

$$\max_{\{c_t^u, l_t^u\}} E_0 \sum_{t=0}^{\infty} \beta^t U\left(c_t^u, l_t^u\right) \tag{3}$$

subject to a sequence of budget constraints:

$$c_t^u \leq w_t^u h_t^u (1-\tau_t^u) \tag{4}$$

and time constraints:

$$l_t^u + h_t^u \leq 1 \tag{5}$$

where c^u denotes consumption of goods, l^u is leisure, h^u is hours worked, τ^u is the net marginal income tax rate (including transfers), β is the subjective discount factor and where we have normalized the time endowment to one each period. Assuming that the utility function is of the CRRA type, $U(c_t^u, l_t^u) = \frac{1}{1-\sigma^u}\left(\left[\left(c_t^u\right)^{\theta^u}\left(l_t^u\right)^{1-\theta^u}\right]^{1-\sigma^u} - 1\right)$, the solution to the problem is:

$$h_t^u = \theta^u, \quad y_t^u = \theta^u \cdot w_t^u, \quad c_t^u = (1-\tau_t^u)\cdot y_t^u$$

High-skilled workers are more productive than low skilled workers and can accumulate capital which allows them to smooth consumption over time. Their problem is:

$$\max_{\{c_t^s, h_t^s, k_t\}} E_0 \sum_{t=0}^{\infty} \beta^t U(c_t^s, l_t^s) \tag{6}$$

[1] With the exception of k_t all lower case letters are defined by $x_t = X_t/N_t$. k_t is defined as K_t/N_t in order to simplify calculations.

subject to a sequence of budget constraints:

$$c_t^s + x_t/\gamma_t \leq (w_t^s h_t^s + r_t k_t/\gamma_{t-1})(1-\tau_t^s) \tag{7}$$

time constraints:

$$l_t^s + h_t^s \leq 1 \tag{8}$$

and the capital accumulation equation:

$$k_{t+1} = (1-\delta)\frac{k_t}{g_t^p} + x_t \tag{9}$$

where x_t denotes investments, τ^s the tax rate on skilled agents and δ is the depreciation rate [2]. Assuming that the utility function is of CRRA type (as for the low-skilled agents), the intertemporal and intratemporal optimality conditions are :

$$\frac{1-\theta^s}{\theta^s}\frac{c_t^s}{1-h_t^s} = w_t^s(1-\tau_t^s)$$

$$\lambda_t = \beta E_t \lambda_{t+1}\left((1-\delta)/g_{t+1}^s + (1-\tau_{t+1}^s)r_{t+1}\right)$$

where λ is the multiplier on the budget constraint (7), g_{t+1}^s is the growth rate of the high-skilled population, and θ^s is the share parameter that enters as the power of consumption in the utility function. The first of these conditions equates the marginal rate of substitution between consumption and leisure to the relative price, while the second condition gives rise to a standard Euler equation.

We assume that there is a government whose aim is to redistribute income across classes of agents via taxes and transfers and it is forced to do this by balancing its budget on a period-by-period basis. We assume that $\tau_t^u = \tau_t^s - \mu_t$, so that μ_t can be thought of as a tax rebate on low-skilled workers, that τ_t^s is either a parameter or is endogenously chosen to target a certain redistributive policy, while μ_t is endogenously determined to satisfy the government budget constraint:

$$\tau_t^s \gamma_t y_t^s = (\mu_t - \tau_t^s)(1-\gamma_t)y_t^u \tag{10}$$

where y_t^s and y_t^u are the taxable incomes of the two types of agents.

In the aggregate the following income composition and resource constraints must hold:

[2]Equation (9) can be derived using $k_t^s N_{t-1}^s = K_t$, $k_t = \frac{K_t}{N_{t-1}} = k_t^s \gamma_{t-1}$ and $\frac{\gamma_{t+1}}{\gamma_t} = \frac{g_{t+1}^s}{g_{t+1}^p}$

$$y_t = \gamma_t y_t^s + (1-\gamma_t) y_t^u \tag{11}$$

$$y_t = \gamma_t c_t^s + (1-\gamma_t) c_t^u + x_t \tag{12}$$

Finally, we assume that z_t is a first-order autoregressive process,

$$z_t = (1-\psi_z)\overline{z} + \psi_z z_{t-1} + \varepsilon_t \tag{13}$$

where $\psi \in (0,1)$ and $\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$.

4 The Dynamic Effects of Labor Migration

We begin by considering the case of migrations of low-skilled agents with no government and, therefore, set all tax parameters to zero. This step is useful in order to understand how migration disturbances affect the business cycle properties of an economy in isolation from issues of redistribution and welfare. Since most of the migrations in the 1950's and the 1960's occurred in a situation where the welfare state was small or non-existent, our comparative analysis may highlight why public perception toward migrations has changed dramatically over the last 10-15 years and why countries engaged in active policies designed to curb or select the type of migrants allowed in the country.

We model low-skilled migrations as an exogenous temporary increase in the growth rate of low-skilled workers, N_t^u. While it is easy to endogenize migrations as a function of business cycle conditions, we neglect this possibility since it appears to be of minor importance, at least for OECD countries. The temporary increase in number of low-skilled workers has two demographic effects. First, the aggregate population growth rate rises directly. This effect alone produces only short-run dynamics since the long-run capital-output ratio is determined by the parameters of technology and preferences and none of the other steady-state conditions is affected. Second, there is a permanent effect on the composition of the population which alters long-run conditions.

These two effects can be worked out as follows. Assume (without loss of generality) that the growth rate of the high-skilled population, g_t^s, is constant over time and equal to g^s and that the growth rate of the low-skilled population is $g_t^u = (1+e_t)\, g^s$, where e_t is possibly an autocorrelated process. Define the following recursive variable:

$$\Pi_t \equiv \prod_{i=1}^{t} (1+e_i) = (1+e_t)\,\Pi_{t-1}, \qquad \Pi_0 = 1. \tag{14}$$

It then follows that:

$$g^p_{t+1} = \frac{(1-\gamma_0)\,\Pi_{t+1}+\gamma_0}{(1-\gamma_0)\,\Pi_t+\gamma_0} g^s \tag{15}$$

$$\gamma_{t+1} = \frac{\gamma_0}{(1-\gamma_0)\Pi_t+\gamma_0} \tag{16}$$

Hence, the growth rate of population is stationary as long as e_t is stationary, while there is a permanent effect on the composition of the population regardless of the assumed process for e_t. This implies that migration flows create short-term and long-run changes in the economy with the latters due to the fact that (low-skilled) migrants can not invest to improve their productivities since skill differences are exogenous in the model.

Before examining the short-run dynamics it is useful to consider long-run effects. As mentioned, a temporary inflow of low-skilled workers permanently decreases the share of high-skilled workers in the population which in turn alters hours in efficiency units and may affect the capital-output ratio (or, alternatively, on the capital-labor ratio). In Appendix A we describe in details how these two variables change as a function of various parameters. Here we summarize the main features of the results. The steady-states levels of output, efficiency hours and the capital-output ratio are given by:

$$y = z^{1/\alpha}\left(\frac{k}{y}\right)^{(1-\alpha)/\alpha}(h^e)^{1/(1-\rho)}$$

$$h^e = \omega\,(\gamma h^s)^{1-\rho} + ((1-\gamma)\,\theta)^{1-\rho}$$

$$\frac{k}{y} = \frac{\beta g^p\,(1-\alpha)\,(1-\tau^s)}{1-\beta\,(1-\delta)}$$

where variables without time subscripts denote steady-state levels.

Note that the capital-output ratio is determined by preferences, technology and by the tax-rate levied on high-skilled agents. Thus, the capital-output ratio is affected only if the tax rate on high-skilled agents change with an inflow of low-skilled workers. If taxes are held constant, changes in aggregate activity are exclusively determined by the changes in efficiency hours. When the two types of labor are perfect substitutes, hours in efficiency units are *increasing* in γ as long as $\omega > 1$. Thus, an inflow of low-skilled agents (a decrease in γ) lowers per-capita output, investment and consumption in the long-run. This effect on efficiency hours is solely determined by the effect on high-skilled hours which decrease because of a positive wealth effect. Native low-skilled agents are unaffected by migrations in the long-run because the wage rate is constant

When the two types of labor are imperfect substitutes these results crucially depend on the value of ρ, γ and ω. In the Appendix we show the following results. First, independently of ω and the initial share of skilled workers, *skilled hours* are increasing in γ for $\rho < 1$ and decreasing in γ for $\rho > 1$. Thus, whether or not skilled hours increase or decrease depends solely on whether the elasticity of substitution exceeds 1 or not. Second, for a sufficiently high initial share of skilled workers, *hours in efficiency units* is decreasing in γ for all $\rho \geq 0$. If, on the other hand, the initial share of skilled workers is moderately low, *hours in efficiency units* may be decreasing in γ and this is more likely the lower is the elasticity of substitution between the two types of labor. For such cases, an inflow of low-skilled workers can increase activity because skilled workers increase their labor supply.

In the standard case (i.e. for sufficiently high elasticities of substitution and/or high initial shares of skilled workers) the steady-state capital stock and output per capita decrease following an immigration of low-skilled workers; high-skilled workers work fewer hours, invest less but have higher income and consumption (because capital income is higher), while low-skilled workers earn lower income and consume less in the long-run because their relative wage declines.

If taxes are varied in response to migrations, the steady-state capital-output ratio is altered since marginal taxes distort the accumulation of capital. Since an inflow of low-skilled workers is likely to be associated with an increase in the size of the welfare state and thus in τ^s, this creates an additional source of negative long-run effects in addition to those coming through changes in hours in efficiency units.

4.1 Calibration

We calibrate the model to match annual data and try to use standard parameter values whenever it is possible. The depreciation rate is set equal to 10% and the real interest rate to 4%. The parameter α (the labor share of income) is set to 64%. We also assume that the population growth is stationary in the steady-state. For moderate values of the income tax parameter these values imply a capital-output ratio close to 2.5. We assume that the two types of agents have identical utility functions. We set the intertemporal elasticity of substitution to 0.5, and we also assume that θ is equal to 0.3. This implies that low-skilled workers use 30% of their non-sleeping time on market activities. In general, high-skilled workers will not use 30% of their time on market activities because they are more productive, own the capital stock and face a different tax rate.

The productivity differential ω is a parameter for which we have less information. Kydland (1984) and Rios-Rull (1993) suggest a value of 2. Here we use $\omega = 1.3$ in order not to exaggerate the difference between the two types of workers since low-skilled agents hold no capital. We assume that the share of low-skilled agents is 25%. This is consistent with our estimates of low-skilled agents holding negative or zero wealth from the PSID and informal calculations performed on some European countries.

Finally, we need to calibrate the elasticity of substitution between high and low-skilled workers, $1/\rho$. There are many estimates of this parameter in the literature depending on how workers are divided. The closer classification is probably the one of Bean and Pissarides (1991) who divide workers into manual and non-manual in UK manufacturing industries. Their point estimates of the elasticity of substitution vary between 0.2 and 2 with large standard errors, so that one can not reject the hypothesis that it is equal either to zero or to one. Because of this large range we examine two cases: one where the two types of workers are perfect substitutes ($\rho = 0$) and another where there is a moderate degree of substitutability between the two types of labor ($\rho = 0.25$).

As a preliminary exercise we have studied how the economy adjusts following an unexpected 1% increase in productivity. Since the aggregate dynamics are very similar to those obtained with a representative agent business cycle model and because there are no surprises at disaggregated level either, we confine the discussion to Appendix B.

In what follows, we examine the dynamic adjustment following a temporary but persistent migration shock which changes the composition of the population in the steady-state from 75% to 73%. We model the e_t as an autoregressive process $e_t = \psi_e e_{t-1} + \upsilon_t$ where υ_t is i.i.d. $N(0, \sigma_\upsilon^2)$. We set ψ_e, which measures the persistence of the migration process, to 0.6 so that current inflows signal future inflows of the same sign. Figure 1 presents the dynamics with perfectly substitutable labor and Figure 2 the dynamics with imperfectly substitutable labor. Baseline parameters values are summarized in the table 1.

Table 1: Baseline Parameters

α	ρ	δ	θ	σ	β	τ^s	μ	g^p	γ	ψ_e	ω
0.64	0	0.1	0.3	2	0.96	0	0	1	0.75	0.6	1.3

4.2 Dynamics with perfect substitutability

The response of aggregate variables is similar, in some respects, to the adjustments brought about by a sudden disruption of the capital stock. On impact an inflow of labor decreases the capital-labor ratio (measured in efficiency units) and this causes the interest rate to increase and the wage rate to decrease. Since the return to capital is high, investments and the aggregate capital stock increase, aggregate consumption decreases and high-skilled agents work more and lower their consumption in order to rebuild the capital stock. Output (per-capita) decreases on impact because the rise in skilled hours is not sufficient to counteract the decrease in the capital-labor ratio.

Over the adjustment path, the wage per efficiency unit decreases (because of the initial drop in the capital-labor ratio) and then returns to its original steady-state value and the interest rate increases and then returns to the initial level in the long-run from above. The process is relatively slow with significant adjustments still taking place ten years after the shock. The differential behavior of the rental rates of the two factors of production induces a substantial redistribution of income across classes of agents over the adjustment path. In fact, since the wage rate of an efficiency unit of labor drops, low-skilled workers' income and consumption decline. Also, because the economy attempts to reconstruct the (per-capita) capital stock, consumption of high-skilled drops more than that of low-skilled agents and rises above the pre-migration level after 16 years.

Overall, there are two highly intertwined effects following a migration of low-skilled workers. First, there is redistribution over the business cycle with holders of capital benefitting and workers being worse off as competition from the migrants decreases the wage rate. Second, there is a strong wealth effect in the long-run since high-skilled workers, which are now a smaller fraction of the population, permanently own more capital per head. This makes their income and consumption permanently higher and their hours permanently lower since the relative abundance of low-skilled labor, combined with their willingness to work more, results in substitution from high-skilled to low-skilled labor in production. Hence, unambiguously, migrations of low-skilled agents will be encouraged by those sectors of the economy which own capital and/or are highly productive.

The model of Ambler and Paquet (1994) with stochastic capital depreciation also generates responses which are qualitatively similar to our's over the business cycle. Two differences, however, can be noted. First, a temporary disturbance to the depreciation rate of capital does not change the steady-state of the economy so none of the long-run effects we describe are present in their paper. Second, our model in the perfectly substitutable case can also be interpreted as one with stochastic depreciation with the main difference being that now there is a stochastic adjustment cost to investment as well. Because such adjustment cost is stochastic and countercyclical, the responses of investment and output following a migration shock are smaller in magnitude and less persistent than those presented by Ambler and Paquet.

4.3 Basic Dynamics with imperfect substitutability

The dynamics of aggregate variables when labor is imperfect substitutable in production are not substantially altered. Quantitatively, only investment shows a sizable change with the impact increase now being smaller. As mentioned, with sufficiently low substitutability between the two types of labor, the relationship between hours in efficiency units and γ_t can change sign and this indeed happens here; long-run output, investments and the capital stock now ends up being slightly higher than in the original steady state.

The major difference between perfect and imperfect substitutable labor is that now there is a wedge between high and low-skilled wages. The reason for this is clear: unless high-skilled agents increase their labor supply substantially, an inflow of low-skilled agents must increase the relative wage of high-skilled agents. Whether this also leads to an absolute increase in high-skilled wages depends on the exact value of, among other parameters, the elasticity of substitution between the two types of labor. In the case of Figure 2, the absolute wage of high-skilled wages still decrease on impact (but increase in the long-run). For lower elasticities high-skilled wages may increase on impact.

Over the business cycle, the wage gap between high and low-skilled agents increases and this produces an extra source of income transfers. The redistribution from low to high-skilled agents is substantial because it occurs in conjunction with the redistribution from labor to capital we have previously discussed, making low-skilled agents much worse off. Furthermore, such redistribution now takes place not only in the short-run but also in the long-run since low-skilled (high-skilled) wages will be permanently below (above) their initial level. Thus, low-skilled consumption decreases more than in the previous case while high-skilled consumption rises above the initial level much faster and increases more in the long-run.

In conclusion, while in the case of perfect substitution there is a redistribution of income between wage earners and capital owners, as the real rate increases while the wage rate declines, here there will also be redistribution between low and high-skilled wage earners. Notice that because wage effects dominate in magnitude relative changes in the price of capital and labor both over the business cycle and in the long-run, migrations of low-skilled agents will be strongly encouraged by high-skilled agents.

4.4 Migrations with low persistence

So far we have considered persistent migration flows, i.e. a positive inflow this year signals positive inflows next year. Next, we consider the case of migrations with low persistence ($\psi_e = 0.1$), which lead to a 2% long-run change in the composition of the population (as in the previous cases). Because of the way we have designed the experiment, long-run effects are identical to the previous cases and only the cyclical properties of the model will be affected. Also, comparing the outcomes of this experiment with the previous ones may suggest a rationale for choosing gradual vs. once and-for-all migration schemes. The results for this experiment are presented in Figure 3 for both the case $\rho = 0$ and $\rho = 0.25$.

In general, when persistence is low, the reaction of the economy will be reduced, since the informational content of the shock is smaller. In particular, in the case of perfect substitutable labor investment per-capita and hours in efficiency units will increase less so that output per-capita will decline more. In the case of imperfect substitutable labor, the wage gap between the two types of labor will be smaller both on impact and over the business cycle so that the effects we have described in the previous subsections will be attenuated. One interesting feature of the responses is that the investment increases more in the case of imperfect substitutes than in the case of perfect substitutes, while with more persistent shocks the opposite was true.

In essence, the business cycle/redistribution consequences are magnified when migration flows are gradual since, in deciding the optimal response in the current period, agents take into account future migration developments.

4.5 Transient migration

We next consider transient migrations, in the sense that after the initial shock there will be a shock of similar or smaller magnitude in the opposite direction. Because of our modelling strategy, we can not consider the more interesting case of a purely temporary change in the composition of the population (so that the initial and the final steady state shares of high-skilled agents are the same). However, the chosen experiment represents the closest approximation we can construct using a linear AR representation for the shocks. We now model the migration process as:

$$e_t = \psi_e^1 e_{t-1} + \psi_e^2 e_{t-2} + \xi_t$$

and assume that $\psi_e^1 = -0.3$, $\psi_e^2 = 0.25$. Furthermore, the initial shock is assumed to be of the same size as in the baseline case. With the above process this reduces the long-run share of high-skilled agents from 75% to 74.24%.

Impulse responses for this experiment are presented in Figure 4. As expected, given that the compositional effect is smaller, long-run changes are smaller both in the perfect and the imperfect substitutable cases. Over the business cycle the magnitude of the responses of aggregate and sectorial variables is smaller relative to the two baseline cases. This is to be expected as changes in the population (and in the share of skilled agents in the economy) this year are known to be followed by changes next year in the opposite direction.

Hence, when migrations are transient, they will induce less cyclical behavior in per-capita aggregates and reduced long-run consequences on the receiving country.

4.6 Migrations of high-skilled workers

Finally, we turn attention to the case of migrants which are more skilled than the average native. This experiment is interesting because some countries (e.g. Australia or Canada) have adopted immigrations policies where the educational level of potential migrants is used as screening device to limit the flow of newcomers. Moreover, such an exercise may provide indications on whether this policy, which is clearly beneficial in the long-run, has also important positive effects over the business cycle.

To model high-skilled migrations we assume that the growth rate of low-skilled agents is now constant and let $g_t^s = (1 + e_t)g^u$. This is not necessarily the symmetric equivalent of a drop in the low-skilled portion of the population since high-skilled migrants carry capital with them. To make the analysis tractable we assume (i) e_t is a iid shock and (ii) the per-capita capital stock migrants carry is the same as the per-capita capital stock of native high-skilled workers. Had we not made these assumptions, we would end up having an unbound number of types of agents in the economy (distinguished by their asset holdings at each point in time) and we would not be able to analyze this case within the context of the model we are considering[3]. Once these assumptions are made, the impulse responses are qualitatively the same as those we presented in figures 1 and 2 except that now there is a sign change in all the responses[4].

Hence, an inflow of high-skilled agents increases (decrease) activity in the long-run when the two types of labor are perfect substitutes (imperfect substitutes for low enough substitutability) substitutes.In the short-run such a migration will decrease investments and interest rates and increase the wage rate. Thus, low-skilled native will favor limiting migrate type to high-skilled agents who carry large amounts of capital with them.

5 Migrations and the Welfare State

In the previous section we have seen that a temporary inflow of low-skilled agents produces a redistribution of income from low-skilled natives to high-skilled/capital holders, making them substantially better off over the business cycle. It is therefore conceivable to think of transfer rules which attempt to limit the

[3] It is well-known that the analysis of heterogeneous agents economies can be computationally very difficult. The problem often encountered is that without further assumptions (on the determination of relative prices) the analysis of such models requires one to find the competitive equilibrium by finding fixed points in the space of functions that maps sets of measures into itself, see e.g. the discussion in Rios-Rull, 1995. In our case the biggest problem is that a migration of skilled workers can give rise to an unbounded set of different types of agents.

[4] The most appropriate case to look at is the one with low migration persistence. The reason is that we assume the migrants, *at every point in time*, hold the same amount of capital as the native high-skilled agents. Thus, in principle, migrants are indexed by the state vector of the economy.

damages to low-skilled agents, while maintaining some of the gains for the high-skilled/capital holders. Here we consider the effects of migration disturbances when there is government which either passively or actively pursues redistributive policies. In all cases we assume that the policy is exogenous. This assumption is made in order to simplify the analysis but it would be feasible to endogenize it, for example through voting on redistribution policies. For our purposes, however, it seems natural to consider exogenous policies since we consider marginal changes in the population composition.

We consider three different schemes:

- *a passive rule* (**PR**) in which the income tax rate is taken parametrically;
- *an egalitarian rule* (**ER**), where the income tax rate on high-skilled workers is chosen so as to keep the ratio of income of high to low-skilled agents constant;
- *an insurance rule* (**IR**) where the government insures the consumption of low-skilled agents from any type of fluctuations.

Under **PR**, the government sets $\tau_t^s = \tau^s, \ \forall t$, and varies μ_t period-by-period so as to satisfy the government budget constraint, (10). In the **ER**-system, it chooses the income tax rate on high-skilled agents (τ_t^s) and the transfer rate (μ_t) to satisfy its budget constraint and to target a given relative income difference between the two groups of agents, i.e.:

$$(1-\tau_t^s)\, y_t^s = \eta \left(1-(\tau_t^s-\mu_t)\right) y_t^u \tag{17}$$

where η is the wedge between the after-tax income of the two types of agents.

Under **IR**, taxes and transfers are chosen to satisfy the government budget constraint and to make:

$$\left(1-(\tau_t^s-\mu_t)\right) y_t^u = \overline{y}^u \tag{18}$$

where $\bar{y}^u$ is a constant.

The reason for studying these rules is simple. The first is chosen as benchmark: we would like to know how the responses of endogenous variables differ from those previously described when a government, without an explicit objective function, is present in the economy. The second rule is common both in theoretical studies examining the static effects of migration (see Razin and Sadka (1995)) and in the real world (e.g. in Canada or the Scandinavian countries). Egalitarian rules also turn out to be sufficiently popular as redistributive tools in standard models of public finance (see e.g. Auerbach and Kotlikoff (1987)) to grant them a particular status in our study. The third rule has been designed keeping in mind both the structure of the model, where low-skilled agents are unable to insure income fluctuations, and some concerns of European policy makers, who foresee the provision of public insurance over the business cycle as a future task for a European fiscal unit (see e.g. Padoa-Schioppa (1987)). Note that the second rule allows for fluctuations in low-skilled workers' income over the business cycle as long as they are proportional to high-skilled income, while this is not permitted with the **IR** rule.

We assume that before the experiments take place the income tax rate on skilled agents is 5%, a number close to those observed in many countries once it is taken into account that the tax rate in our model relates only to the parts of the government budget associated with redistribution. To save space we concentrate on the case $\rho = 0$. Since when $\rho > 0$ the redistributive effects of a migration disturbance against low-skilled agents are exasperated, the qualitative features of the dynamics will be similar to those described here, but the quantitative changes would be more dramatic.

5.1 Parametric Tax Rule

The impulse responses obtained under the PR rule are presented in Figure 5.

Overall, there are no major qualitative changes in the responses of aggregate variables relative to the baseline case. The reason is that when τ_t^s is constant over the cycle high-skilled agents behave as in the case where the tax rate is zero (except for the change in the elasticities brought about by the associated change in the capital-output ratio). Hence, their decisions are unchanged relative to the baseline model.

The major difference relative to the impulse responses of Figure 1 is present in the consequences for the low-skilled agents. Because the tax rate on high-skilled workers is constant and the number of low-skilled workers increases, it follows that the transfers to the low-skilled workers decrease. This is clear from the dynamics of μ_t which not only declines, but it is negative, implying higher taxation for low-skilled. Hence low-skilled consumption declines over the business cycle making them worse off than in the baseline case.

Thus, this tax scheme is not able to insure low-skilled agents from the consequences of a migration of low-skilled workers. On the contrary, when a passive tax rule is in place, low-skilled workers are penalized in two ways by the existence of migrations. First, competition in the labor market causes a decline in their wage, income and consumption. Second, because the amount that high-skilled workers contribute to the welfare system shrinks and the share of low-skilled workers increases, low-skilled agents are taxed more heavily to make up for the loss of government revenue and the larger number of agents which are potentially recipients of the transfers.

5.2 Egalitarian Tax Rule

In this exercise we treat η as a parameter and the benchmark value corresponds to the value implied by a 5% income tax rate on high-skilled agents. Given other parameters, this implies that the low-killed after-tax income is 31% of the after tax income of the high-skilled before any shock takes place[5]. The impulse responses following a migration disturbance appear in Figure 6.

The most important change in per-capita variables relative to the baseline case occurs because the marginal tax rate on high-skilled agents increases substantially as their before-tax income increases. Higher income taxes discourage investments both on impact and over the business cycle and this leads to a more pronounced negative long-run effect on output, investment and the capital stock.

At the sectorial level, the changes relative to the two previous cases are substantial. Because an inflow of low-skilled migrants permanently alters the income distribution in favor of capital holders, the government will tax high-skilled workers/capital owners more heavily. This implies that their consumption decreases on impact and will be persistently lower over the business cycle. The higher tax rate on high-skilled agents also implies that the pool of revenues available for redistribution increases and this has beneficial effects on low-skilled consumption on impact. However, this favorable occurrence is partly due to the increase in high-skilled labor supply and over the business cycle low-skilled consumption decreases but by much less than in the previous case. Furthermore, the increase in taxes adversely affect high-skilled income and this limits the amount of redistribution that the welfare state can engage in. Low-skilled agents will therefore also bear higher tax rates during the adjustment to the new steady state and this combined with a lower wage implies that their consumption will be lower than in the two previous cases. Because the composition of the population has permanently changed, tax rates on both types of agents will permanently increase in the long-run.

In sum, this redistribution scheme has important side effects in the presence of migrations. With inflow of low-skilled agents, the "size" of the welfare state increases and skilled agents, which are a smaller fraction of the population, contribute a larger percentage of total government revenues. Because they are taxed more heavily they contract investments and this in turn generates a reduction of per-capita income that exceeds that observed in the two previous cases. Notice that this occurs despite the fact that the after tax real rate of interest is positive over the business cycle. Thus, this tax system effectively shifts the costs from low-skilled to high-skilled agents.

[5]We have also experimented with a set-up where η is a deterministic function of γ_t. This might be relevant in terms of political economy based determination of redistribution. The dynamics generated in this set-up are qualitatively similar to those obtained with parametric tax rules but the effects are magnified, particularly in the case of a migration shock. We do not report this case because such effects are likely to take place over longer horizons than those that we are mainly concerned with.

5.3 Insurance Tax Rule

The impulse responses of the variables following a migration disturbance are presented in Figure 7. In general, the aggregate dynamics following a low-skilled migration shock are similar to those obtained with an egalitarian tax rule.

The responses of sectorial variables are more dramatic because of the associated tax effects: an inflow of low-skilled agents leads to higher marginal tax rates on high-skilled agents and this effect is now stronger than before. Hence, investments will be discouraged and the negative effect on the long-run capital stock is large. This process is somewhat self-enforcing: tax rates must increase along the business cycle because of the negative effect that such an increase has on capital accumulation, and this leads to magnified effects both over the business cycle and in the long-run.

By eliminating short-run fluctuations in low-skilled consumption, this rule heavily penalizes high-skilled workers in the presence of unexpected migrations since low-skilled income declines while at the same time there is a larger number of people that needs to be insured. Compared with an egalitarian rule, the burden of the short-run adjustment is more heavily tilted towards high-skilled agents which now bear up to an 18% increase in their marginal tax rate over the business cycle.

To summarize, when unexpected migrations of low-skilled agents occur, the size of the welfare state increases. When high-skilled agents' taxation is fixed over the business cycle, redistribution policies turn against low-skilled agents which are now worse off because there is a smaller pool of resources to be redistributed to a larger number of agents. When high-skilled workers contribute with varying amounts to the welfare state over the adjustment path, the cyclical consequences may be more dramatic as tax disincentives depress capital accumulation and per-capita income. With egalitarian taxes both classes of agents are penalized over the business cycle relative to the case of no redistribution. With insurance taxes, the full burden of the increase in the welfare state falls on high-skilled agents and the depressing effects are significantly larger.

5.4 Illegal migrations

Although the evidence of section 2 concerns legal migration, it is well known that the magnitude of illegal migrants flows to some OECD regions is probably as large as the one of legal migrants. It is therefore interesting to consider what illegal migrations do in the context of our model when there is an active welfare state.

Given the simplicity of the economy, we capture only one aspect of the very complex problem of illegal migration, namely that illegal migrants enter the labor market, but are not entitled to the welfare benefits that the government provides to native low-skilled agents. In our setup, illegal migrants do not pay taxes either but we could easily amend this and have them pay payroll taxes without receiving any transfers. This experiment is interesting to policymakers since with the recent IIRIRA ACT of 1996, even *legal* migrants in the US will no longer be entitled to the welfare benefits enjoyed by natives.

Relative to the baseline case, the main change in the model[6] is now that the government budget constraint reads:

$$\tau_t^s \gamma_0 y_t^s = (\mu_t - \tau_t^s)(1-\gamma_0) y_t^u \tag{19}$$

where γ_0 and $1-\gamma_0$ denote the pre-migration shares of the two types of native agents.

We present the impulse responses of this experiment in Figure 8 when there is an egalitarian welfare state. The qualitative behavior of per-capita variables is unchanged and even quantitative differences are small relative to the case considered in Figure 6. However, at the disaggregate level, changes are important. Since the pool of potential users of the welfare state decreases relative to the case where low-skilled natives and migrants enjoy an egalitarian redistribution, high-skilled agents will be taxed at a lower rate and this allows them to increase their consumption along the business cycle (although, quantitatively, the change is small). On the other hand, since tax-revenues increase following the increase in high-skilled income, the welfare state redistributes more to native low-skilled agents, which now experience an increase in their after-tax incomes. Finally, migrant income, which is the same as native low-skilled income before redistribution, declines on impact and stays below zero over the business cycle.

Hence, one way to reduce the negative effects on both capital accumulation and low-skilled consumption due the presence of an egalitarian government is to reduce (or eliminate) the benefits for the newcomers. Native low-skilled will favor this proposal and prefer illegal to legal migrants when there is an egalitarian state because they can reap larger per-capita benefits per unit of consumption subtracted to high-skilled agents. Native high-skilled will be better off because they pay lower income taxes. These gains, however, are entirely at the cost of the migrants who are excluded from the welfare state.

5.5 Restricting the labor market participation of migrants

We finally consider the case where migrants are not allowed to enter the labor market of the receiving country, but are compensated enjoying the same level redistribution of native low-skilled agents. This could have represented the situation of migrants who reached the US for family unification or with a refugee status prior to August 1996.

[6] This case also requires one to change the goods marget clearing condition because local low-skilled agents and the migrants have different after-tax incomes.

Since the migrants effectively have a consumption rate of 1, the experiment we consider is equivalent to a permanent increase in government spending financed through distortionary taxes (apart from the fact that migrants also increase the size of the population). We assume that transfers to the migrants are a fixed fraction of the native low-skilled agents' initial income $c_t^{IM} = \varphi y_0^u$ where y_0^u denotes low-skilled agents' pre-migration income and φ determines the level of the transfers to the migrants. We assume that $\varphi = 25\%$ and that the government engages in egalitarian redistribution.

Figure 9 illustrates the dynamic effects in this case. At the aggregate level all variables now decline on impact and over the business cycle: particularly strong is the effect on investment which now declines by 1.5% while in figure 6 was increasing by about 1.5%. The reason is that the government needs to increase taxes on high-skilled to finance transfer payments to migrants and this occurs in a situation where the high-skilled/capitalists do not experience a higher income since wages and interest rates, in contrast to the previous cases, are unchanged.

The most significant effects are apparent at the disaggregated level. Since total resources decrease slightly and the government transfers income to migrants, consumption of both types of natives decrease. The percentage decreases are of approximately the same size because they are driven by tax effects and they become substantial over the adjustment path, as the percentage decreases in consumption of both types reaches 0.5%. For high-skilled agents this decrease is smaller than that observed in figure 6 while the opposite is the case for low-skilled agents. Thus with an egalitarian welfare state, high-skilled agents would oppose admitting migrants to the labor market while low-skilled agents would prefer migrants to enter into the labor market.

This outcome might seem counterintuitive: restricting labor market participation of migrants avoids the competition that harms native low-skilled agents. The explanation can be found in the specification of the welfare state. Under the egalitarian system the government keeps the wedge between high-skilled and low-skilled after-tax incomes fixed. Thus, when migrants *are* admitted to the labor market the welfare state engages in "more" redistribution because high-skilled agents' income rises as the return on capital increases. Therefore, this redistribution makes local low-skilled agents better off relative to the case considered here.

It is worth considering whether this result crucially depends on the level of transfers that the immigrants receive and the details of the welfare transfers. First, whether high-skilled agents would prefer not to admit immigrants to the labor market clearly depends on the tax burden. If φ is increased to 50% we find that even high-skilled agents would favor admitting migrants to the labor market. Second, if the welfare state operates under the **IR** system native low-skilled agents are equally well off whether immigrants are admitted to the labor market or not. Thus, in this case the question is whether the high-skilled agents are better off with or without admitting the migrants to the labor market. Again, this depends on the transfers parameter, φ: for values above 30%, high-skilled agents would prefer that the migrants enter the labor market.

In summary, whether natives prefer to have migrants in the labor market or not depends on the level of transfers and on the type of natives we consider. In general, for low transfers high-skilled agents would prefer to keep migrants out of the labor market while low-skilled agents would favor their labor market participation.

Finally it is worth mentioning that, as far as the welfare of natives is concerned, this experiment resembles a foreign-aid program in which the government transfers funds to a foreign country raising taxes on natives. Clearly, such a program would not affect the per-capita variables in the same way (since the size of the domestic population is unchanged in the case of foreign-aid) but the qualitative effects on natives would be quite similar.

6 Welfare Gains and Losses From Migrations

The analysis so far has demonstrated that migrations of low-skilled agents may have very different implications for the receiving country depending on the type of redistributive policy pursued by the government. Without taxes, skilled agents/capital holders benefit from migrations and this may explain why there was not much public outcry against migrations in the 50's and the 60's. However, with redistributive taxes, the burden of migration costs is shifted in part or completely onto high skilled workers and capital owners.

In this section, we ask: how much are residents willing to pay in terms of consumption in order to keep migrants out of the country? In other words, we ask how much a country (or sectors of a country) is willing to devote to programs which would restrict the flow of migrants in exchange of foreign aids programs to nations with a potential pool of migrants. This question is not purely academic. Several countries, e.g., Italy in the case of Albanians, have engaged in active foreign aid policies to curb massive inflows of migrants responding to political and economic changes occurring in their countries. Others, e.g. the Scandinavian countries, where well developed welfare states are in place, might find themselves burdened by the potential costs of admitting migrants into the country. The US, on the other hand, has diverted funds from welfare provisions of migrants to programs controlling borders easily penetrable by migrants.

We compute long-run welfare measures along the lines of Lucas (1987). In particular, we compute the percentage change in consumption such that the utility of the native population is the same before and after the migration of low-skilled workers. It is possible also to evaluate the welfare effects taking the dynamic adjustment path into account, but we choose to abstract from this in order to get a welfare metric that is more easily interpretable. Because native population is a heterogeneous group, we compute two such measures. The first imputes all the costs or gains to skilled workers/capitalists. The other measure assumes that the two different groups of native households share the costs or gains and weights the two groups by their initial share of the population in the social welfare function . This gives us the following two welfare measures:

$$\lambda_1 = 1 - \frac{c_1^s}{c_0^s}\left(\frac{1-h_1^s}{1-h_0^s}\right)^{(1-\theta)/\theta} \tag{20}$$

$$\lambda_2 = 1 - \left(\frac{W_0}{W_1}\right)^{1/\theta(1-\sigma)} \tag{21}$$

where $c_0^s(c_1^s)$ denotes high-skilled consumption prior to (after) the inflow of low-skilled workers, $h_0^s(h_1^s)$ are hours worked prior to (after) the inflow and

$$W_0 \equiv \gamma_0\left(c_0^s\right)^{\theta(1-\sigma)}\left(1-h_0^s\right)^{(1-\theta)(1-\sigma)} + (1-\gamma_0)\left(c_0^u\right)^{\theta(1-\sigma)}\left(1-h_0^s\right)^{(1-\theta)(1-\sigma)} \tag{22}$$

$$W_1 \equiv \gamma_0\left(c_1^s\right)^{\theta(1-\sigma)}\left(1-h_1^s\right)^{(1-\theta)(1-\sigma)} + (1-\gamma_0)\left(c_1^u\right)^{\theta(1-\sigma)}\left(1-h_1^u\right)^{(1-\theta)(1-\sigma)} \tag{23}$$

We compute these two measures for: (i) zero taxes, (ii) a constant income tax rate equal to 5 percent, (iii) an egalitarian tax-system, and (iv) an insurance tax-system. In all cases we assume that $\gamma_0 = 0.75$ and then compute λ's for 1 to 5 percentage point changes in the composition of the population. For each of these cases we look at the welfare effects for three different relative productivities of the two groups of households. In one case we let both groups have exactly the same productivities so that the only difference is due to the ownership of the capital stock. In the second case we set $\omega = 1.3$, and the final case corresponds to the parameterization of Kydland (1984), i.e. $\omega = 2.0$. As ω increases, the productivity difference between the average natives and the migrants increases. Also, we examine two different values of the elasticity of substitution parameter, $\rho = 0.0$ and $\rho = 0.25$.

Before discussing the results, it is worth stressing that our calculations may be affected by several mechanisms which we have not modelled in the paper. In particular, we have assumed that the skill differences are exogenous. It has been observed in many studies that second generation immigrants do not differ significantly from natives in terms of skills. However, it is also true (see Felderer (1994)) that human capital accumulation of migrants is very slow. While we believe that skill acquisition is an important issue one needs to model before taking a firm view of the welfare effects of migrations, we also believe that, as a first approximation, it may be interesting to compute welfare costs disregarding this issue (Storesletten (1995) considers a model with these effects).

Table 2 reports welfare measures for $\rho = 0$ while table 3 welfare measures for $\rho = 0.25$ Part A of Table 2 examines the case where there is no redistribution. It is quite clear that in this case migrations lead to an increase in both welfare measures. Furthermore, the welfare gain is increasing in the size of the migration flow and decreasing in the productivity differential. The intuition is straightforward: an inflow of labor unambiguously leads to a welfare gain for the capitalists. To realize this, one can simply consider the welfare effects if the capital stock was kept constant. In that case the capitalists would enjoy a higher income due to the higher return on capital because the capital-labor ratio decreases. This is the case investigated by Berry and Soligo (1969), Borjas (1994a,b) in a model with homogenous natives, and Benhabib (1996) in a model with heterogeneous agents. However, in our set-up there is an incentive to accumulate capital and the economy ends up with an unchanged capital-output ratio (but the capitalists hold per-household more capital in the new steady-state), while interest rates and wages are unchanged. Hence, capital-owners will unambiguously be better off while the utility of low-skilled agents is unchanged. When the productivity difference increases, the corresponding change in the initial effective capital-labor ratio is smaller and less new capital will be accumulated. Clearly, welfare gains are smaller when the two groups share the benefits.

Panel B of table 2 corresponds to a 5 percent income tax which we hold constant while the effective redistribution to the low-skilled agents is varied so that the government budget constraint is satisfied. When high-skilled agents bear the costs, welfare costs are exactly the same as in the previous case since the only distortion associated with the income tax is to lower output through its' effect on the capital-output ratio. Hours worked - and hence the labor input in efficiency units - are unaffected because of the preference specification we use. Hence, in percentage terms, the welfare gains for high-skilled are exactly the same as with a zero tax rate. The effects on the low-skilled workers, however, change. With a constant income tax rate, an inflow of low-skilled workers implies that there are fewer resources available for redistribution. Hence high-skilled workers cannot compensate low-skilled agents for this loss and aggregate welfare declines. Note again, that welfare losses are increasing in ω.

Part C of Table 2 reports the results when an egalitarian rule is in place. The results differ from the previous two cases because the marginal income tax rate changes. It is important to recall that in this case the ratio of the after tax income levels of the two groups is kept constant and equal to η. The inflow of low-skilled labor increases the before tax income of high-skilled agents and taxes are increased to keep η constant. This implies that steady-state capital-output ratio declines, that there is a welfare loss for high-skilled workers, which again is increasing in ω and, in contrast to above, that the welfare cost is decreasing in ω since the tax effect is smaller the more productive high-skilled workers are. Note that because low-skilled agents benefit from this program, the economy wide losses are smaller than those suffered by high-skilled agents for each ω.

With an insurance system (Part D), the welfare effects of migrations are very similar. With an inflow of migrants taxes need to be increased in order to maintain the after tax income that the welfare state promised to the low-skilled. When the productivity differences are sufficiently small, the costs for the capital owners are small, but they increase with ω. Note also that in this latter case costs are significant for high-skilled workers since tax rates are slightly higher than those experienced with an egalitarian rule while low-skilled agents welfare is unchanged.

When $\rho = 0.25$ the qualitative the effects are similar to those presented in table 2. The only significant difference is in the case $\omega = 2.0$ for the case of no taxes since now there are welfare losses while before there were gains. This is due to the fact that when the productivity difference is high, the differential effect on wages becomes large and this leads to a larger loss for the low-skilled agents. Two other facts need to be noticed. First, tax rates with ER and IR rules are much larger than in the previous case. The reason is that the before tax income differential between the two types of agents is much larger here. Second, the magnitude of the gains and losses in the four different schemes is magnified. For example, high-skilled agents would be willing to give up 1.7% of annual consumption to admit a flow of low-skilled migrants which change the composition of population by 1% with no taxes but they are willing to pay up to 0.5% of their consumption when there are insurance taxes to keep the same amount of migrants away. Once again this magnification is due to the presence of two redistributive margins and that taxes on high-skilled are very high.

To sum up, the quantitative effects of low-skilled labor migration crucially depend on the size of the immigration flow, the relative productivity difference between migrants and natives and on the redistribution system in place in the receiving country. When the receiving country does not engage in redistribution, migrations are unambiguously welfare improving for high-skilled agents and the receiving country, notwithstanding the possible short-run costs associated with adjustments of the capital stock, should encourage migration of this type of agents. However, if the receiving country does engage in redistribution, as is common in most OECD countries, welfare gains may turn into large costs, which may permanently affect the long-run prospects of the economy.

7 Summary and Conclusions

In this paper we analyzed the quantitative effects of low-skilled migrations in a dynamic model with capital accumulation. Migrations to OECD countries have been substantial over a prolonged period of time and it seems natural to investigate the macroeconomic consequences of such flows over the business cycle. One characteristic emphasized in the demographic literature is that migrants to OECD countries are less skilled than the average native worker and this aspect was included in our analysis.

We find that an inflow of low-skilled workers induces adjustments which resemble those taking place if the capital stock was suddenly disrupted. Such a change leads to higher investments over the business cycle, and if all agents were identical, this would be the only macroeconomic adjustment taking place. However, with an heterogeneous workforce, an inflow of low-skilled workers has also a composition effect which leads both to long-run changes and to differential impact on high and low-skilled agents. In the long-run migrations lead to a decrease in per-capita capital, output and investment if the two types of workers are perfect substitutes in production. Skilled agents are better off when there is a migration of low-skilled agents because they own the capital stock: in the short-run, i.e. for a fixed capital stock, the return on capital increases, while in the long-run they have higher capital income because they each hold more capital per-capita. Low-skilled agents are worse off in the short-run because wages fall following a migration flow but are unaffected in the long-run as wages return to the original steady state. When the two types of agents are imperfect substitute a differential wage effect is added which sharpens the income gap between high and low-skilled agents both over the business cycle and in the long-run.

We have analyzed the sensitivity of the results to alterations of the persistence of the shocks, the size of the long-run compositional effects and the relative skill differential of migrants and natives and found some rationale for policies preferring transient to permanent migrations and high-skilled to low-skilled migrations over the business cycle.

Our conclusions are altered when there is redistribution among classes of agents. First, we consider a case where the marginal income tax rate is kept constant across classes of agents while government revenues are redistributed to low-skilled agents. With this scheme low-skilled agents are worse off in the long-run because there are more agents to share the pool of government revenues. Second, we consider an egalitarian scheme in which the government keeps the ratio of high to low-skilled agents after tax income constant. In this case, there is a negative effect on the capital stock since a flow of low-skilled agents forces high-skilled agents to finance a larger welfare state. The final case we considered was one in which the government insures low-skilled consumption over the business cycle and adjusts the tax rate accordingly. Here, an inflow of low-skilled workers leads to a prolonged period of adjustment and to an overall decline in welfare for both types of agents.

As a corollary to our analysis, we consider the effects of an inflow of illegal migrants and of restrictions on the labor market activities of migrants. In our set-up the distinguishing feature of illegal migrations is that these agents do not receive transfers and do not pay income taxes. When the state is egalitarian we find, maybe surprisingly, that both types of agents encourage illegal immigration! The reason for this is that low-skilled agents are net-receivers of transfers from the welfare state. Thus, excluding these migrants from the welfare state means that taxes increase less after an inflow of low-skilled agents, taxes needs to be increased less, which is favored by the high-skilled agents, and that the tax revenues are redistributed to the native low-skilled agents only. Another surprising result is that, when these is a welfare state in place, low-skilled natives favor the admittance of migrants to the labor market while skilled agents will oppose it. The reason is that when the migrants are allowed to work the welfare state will be more prone to redistribute income, which harms high-skilled agents and improve the welfare of low-skilled agents.

It is important to stress that our analysis constitutes only a first look at the problem and it would probably be important to endogenize skill formation before we can give a definite answer to the questions we have posed in the introduction. Empirical evidence suggests that initial skill differences between natives and migrants disappear over time, although at a very slow rate, and this may modify the results of our welfare calculations. Another issue that one may wish to address is whether international repercussions are important and whether or not international aid schemes lead to improved conditions in international settings. These issues will be taken up in future research.

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Appendix A: Steady-State Effects

In this appendix we discuss the steady-state effects of changes in the share of skilled agents. To start with, we collect various steady-state conditions and we will then analyze the steady-state changes in steps of increasing generality. The model delivers the following steady-state conditions (below all variables are evaluated at the non-stochastic steady-state):

$$\frac{1-\theta}{\theta}\frac{c^s}{1-h^s} = (1-\tau^s)\, w^s \tag{24}$$

$$c^u = (1-\tau^u)\,\theta w^u \tag{25}$$

$$w^s = \alpha\left(\frac{y}{h^e}\right)\omega\,(\gamma h^s)^{-\rho} \tag{26}$$

$$w^u = \alpha\left(\frac{y}{h^e}\right)((1-\gamma)\,\theta)^{-\rho} \tag{27}$$

$$y = \gamma c^s + (1-\gamma)\,c^u + x \tag{28}$$

$$y = z^{1/\alpha}\left(\frac{k}{y}\right)^{(1-\alpha)/\alpha}(h^e)^{1/(1-\rho)} \tag{29}$$

$$\frac{k}{y} = \frac{g^p\,(1-\alpha)}{r} \tag{30}$$

$$r = \frac{1-\beta\,(1-\delta)}{\beta\,(1-\tau^s)} \tag{31}$$

$$s_x = \frac{x}{y} = (1-(1-\delta)/g^p)\,\frac{k}{y} \tag{32}$$

$$\gamma\tau^s y^s = -\,(1-\gamma)\,\tau^u y^u \tag{33}$$

$$h^e \equiv \omega\,(\gamma h^s)^{1-\rho} + ((1-\gamma)\,\theta)^{1-\rho} \tag{34}$$

These equations will together with a tax-rule determine the steady-state of the economy. In order to analyze the issues of interest it is convenient to start by setting all taxes to zero.

A.1 No Taxes

In this case it follows from (30) and (31) that the capital-output ratio depends only on preferences and technology:

$$\frac{k}{y} = \frac{\beta g^p\,(1-\alpha)}{1-\beta\,(1-\delta)} \tag{35}$$

Thus, changes in the share of the two types of agents will not affect the capital-output ratio. Notice also that the output share of investment is independent of γ. From equation (29) it follows that the effects on aggregate activity are solely determined by the effect on h^e, which, in turn, is depends on skilled hours, the productivity parameter ω, and the shares of the two types of agents. Because skilled hours is the only endogenous variable, we concentrate initially on the determination of h^s.

Combining (24) with (26) and (25) with (27) gives us:

$$\frac{1-\theta}{\theta}\frac{c^s}{1-h^s} = \alpha\left(\frac{y}{h^e}\right)\omega\left(\gamma h^s\right)^{-\rho} \tag{36}$$

$$c^u = \alpha\left(\frac{y}{h^e}\right)\left(\left(1-\gamma\right)\theta\right)^{-\rho} \tag{37}$$

Inserting into (28) and rearranging gives us:

$$\left(1-s_x-\alpha\right)\left(1+\frac{1}{\omega}\left(\frac{\left(1-\gamma\right)\theta}{\gamma h^s}\right)^{1-\rho}\right) = \alpha\frac{\theta-h^s}{\left(1-\theta\right)h^s} \tag{38}$$

This relationship defines h^s as an implicit function of γ. Note that since $s_x+\alpha<1$, we have that $h^s<\theta=h^u$. There are two special cases where we can explicitly solve (38) for h^s.

A.1.1 Perfect Substitutes

When the two types of labor are perfect substitutes, i.e. when $\rho=0$, (38) and (34) can easily be solved for h^s and h^e:

$$h^s = \frac{\alpha\theta-\left(1-s_x-\alpha\right)\frac{1}{\omega}\frac{1-\gamma}{\gamma}\theta\left(1-\theta\right)}{\alpha+\left(1-s_x-\alpha\right)\left(1-\theta\right)} \tag{39}$$

$$h^e = \frac{\alpha\theta\left(\left(1-\gamma\right)+\omega\gamma\right)}{\alpha+\left(1-\theta\right)\left(1-s_x-\alpha\right)} \tag{40}$$

It follows immediately that:

$$\frac{\partial h^s}{\partial\gamma} = \frac{\left(1-s_x-\alpha\right)\frac{\theta}{\omega}\frac{1}{\gamma^2}}{\alpha+\left(1-s_x-\alpha\right)\left(1-\theta\right)}$$

and that

$$\frac{\partial h^e}{\partial\gamma} = \frac{\alpha\theta}{\alpha+\left(1-\theta\right)\left(1-s_x-\alpha\right)}\left[\omega-1\right]$$

Thus, an inflow of low-skilled labor decreases skilled hours and “effective” hours for $\omega>1$.

A.1.2 Unitary Elasticity of Substitution

The second special case where one can easily solve for h^s is when $\rho=1$. In this case (38) reduces to:

$$h^s = \frac{\alpha\theta\frac{\omega}{\omega+1}}{\left(1-s_x-\alpha\right)\left(1-\theta\right)+\alpha} \tag{41}$$

The important thing to notice is that h^s is independent of γ. Thus, in this case, the effects of changes in the skill composition on aggregate activity is determined completely by the composition effect on $\left(h^e\right)^{1-\rho}$, see (29) and (34). It follows immediately that:

$$sign\left(\frac{\partial\left(h^e\right)^{1-\rho}}{\partial\gamma}\right) = sign\left(\frac{\omega}{1+\omega}-\gamma\right)$$

Thus, for large enough skill differences, or big enough shares of low-skilled agents, an inflow of low-skilled agents will increase aggregate activity and vice versa for low skill differences and high share of high-skilled agents.

A.1.3 The General Case

In the general case we cannot derive closed form solutions. We can, however, analyze the properties of skilled hours viewing (38) as a function implicitly defining h^s as a function of γ. The right hand side of (38) does not involve γ and therefore defines a function $f(h^s)$. f is a decreasing function of h^s. Notice also that $f(\theta) = 0$ and that $\lim_{h^s \to 0_+} f(h^s) = \infty$. The left hand side of (38) involves γ and we let this function be denoted by $g(h^s, \gamma)$. The derivative of this function with respect to h^s is given by:

$$\frac{\partial g(h^s, \gamma)}{\partial h^s} = (\rho - 1)(1 - s_x - \alpha)\frac{1}{\omega}\left(\frac{(1-\gamma)\theta}{\gamma}\right)^{1-\rho}(h^s)^{\rho}$$

Thus, the left hand side of (38) is an increasing function of h^s for $\rho < 1$ and a decreasing function of h^s for $\rho > 1$. Notice also that the slope tends to zero for h^s tending to 0 for any $\rho \geq 0$, that $\lim_{h^s \to 0_+} g(h^s, \gamma) = l < \infty$, and that $g(\theta, \gamma) > 0$ for any $\gamma > 0$.

Thus, f and g will have a unique intersection for $h^s \in]0, \theta[$ and at this equilibrium g will cut f from below. This implies that the response of skilled hours to changes in the skill composition can be determined from the changes in $g(h^s, \gamma)$ due to γ. The partial derivative of g with respect to γ is given by:

$$\frac{\partial g(h^s, \gamma)}{\partial \gamma} = (\rho - 1)(1 - s_x - \alpha)\frac{1}{\omega}\left(\frac{1-\gamma}{\gamma}\right)^{-\rho}\left(\frac{\theta}{h^s}\right)^{1-\rho}\frac{1}{\gamma^2}$$

This implies that h^s is an increasing function of γ for $\rho < 1$ and a decreasing function of γ for $\rho > 1$. An inflow of low-skilled agents will decrease skilled hours in the new steady state if the two types of labor are relatively good substitutes (i.e. if $\rho < 1$) and increase skilled labor supply if high-skilled and low-skilled labor are relatively poor substitutes.

Thus, the properties of h^s depend on whether the elasticity of substitution is greater or smaller than one. The effect on h^s does not translate directly into what happens with aggregate activity since this is determined by the effect on hours in efficiency units. The derivative of $(h^e)^{1-\rho}$ is given as:

$$\frac{\partial (h^e)^{1-\rho}}{\partial \gamma} = (h^e)^{-\rho}\left[\omega (h^s)^{-\rho}\gamma^{-\rho}\left(h^s + \gamma\frac{\partial h^s}{\partial \gamma}\right) - \theta^{1-\rho}(1-\gamma)^{-\rho}\right] \tag{42}$$

In general, this expression cannot be signed. We can, however, say the following. First, regardless of the elasticity of substitution, when γ is sufficiently high, the derivative will be negative since the last term in the square bracket will dominate for $\forall \rho > 0$. This effect is stronger the smaller is the elasticity of substitution. Thus, a high-share of high-skilled agents together with a low elasticity of substitution between the two types of labor means that an inflow of low-skilled agents leads to an increase in aggregate activity through the effect on hours in efficiency units. Note that this effect is somewhat mechanical since it comes because the marginal product of low-skilled labor is high when the share of these agents is low.

When γ is sufficiently low that the above effect does not dominate, the steady-state results crucially depend on the elasticity of substitution. If the elasticity is high, we know from above that $\partial h^s/\partial\gamma > 0$. Thus, it is especially likely in this case that an inflow of unskilled agents will lead to a decrease in activity and the likelihood of this event is higher the bigger is ω. If the elasticity of substitution is low, the effect on activity of a decrease in γ is more likely to be positive but the sign depends critically on other parameters.

A.2 Taxes

The addition of taxes creates additional problems in signing the derivatives and do not allow us to deliver many straight insights. We can, however, note the following two principles:

(a) The aggregate distortion created by the welfare state is caused solely by changes in the capital income tax rate, (b) hours worked are not distorted by marginal taxes.

To see this, it is convenient to start with the second principle which follows because of homothetic preferences. It is particularly easy to show this property for low-skilled agents.

At the optimum the marginal rate of substitution (between consumption and leisure) is equalized to the relative price, i.e.:

$$\frac{1-\theta}{\theta}\frac{c_t^u}{T-h_t^u} = \left(1-\tau_t^u\right) w_t^u$$

Inserting the budget constraint then gives that:

$$\frac{h_t^u}{T-h_t^u} = \frac{\theta}{1-\theta}$$

The reason for this result is that, because of homothetic preferences, the income and substitution effects of changes in the wage rate or in marginal taxes cancel out. This result holds at any point in time so that labor supply is not even adjusted to temporary changes in taxes or wages.

A similar result to above can be derived for high-skilled agents but in this case it only holds at the steady-state since intertemporal substitution triggers off adjustments over time in consumption and labor supply for dynamic changes in wages and marginal tax rates. With taxes, the equations equivalent to (35)-(37) reads:

$$\frac{k}{y} = \left(1-\tau^s\right)\frac{\beta g^p\left(1-\alpha\right)}{1-\beta\left(1-\delta\right)} \tag{43}$$

$$\frac{1-\theta}{\theta}\frac{c^s}{1-h^s} = \left(1-\tau^s\right)\alpha\left(\frac{y}{h^e}\right)\omega\left(\gamma h^s\right)^{-\rho} \tag{44}$$

$$c^u = (1-\tau^s)\,\alpha\left(\frac{y}{h^e}\right)((1-\gamma)\,\theta)^{-\rho} + \frac{\tau^s}{1-\gamma} \tag{45}$$

Inserting into (28) and rearranging gives us:

$$(1-\tau^s) - (1-\tau^s)\,\frac{\beta g^p\,(1-\alpha)}{1-\beta\,(1-\delta)}\,(1-(1-\delta)\,/g^p) \tag{46}$$

$$= \quad \alpha\frac{\theta - h^s}{(1-\theta)\,h^s}\frac{\omega\,(\gamma h^s)^{1-\rho}}{h^e}\,(1-\tau^s) + \alpha\,(1-\tau^s) \tag{47}$$

This relationship is independent of $(1-\tau^s)$ and involves h^s as the only endogenous variable. Hence, high-skilled hours in the steady-state does not depend on the marginal income tax rate and this establishes the result.

Thus, we have established that steady state hours worked of both types of labor is neutral with respect to changes in the marginal tax rate. By inspecting equation (29) one can see that any extra steady-state effect associated with the presence of taxes is caused by changes in the capital-output ratio. From equation (43) we see that the capital-output ratio is determined by preferences, technology, and the marginal income tax rate levied on the skilled agents.

This implies that when τ^s is held constant over the adjustment path, the presence of a welfare state will not induce changes in the steady-state effects identified in the previous section. Under the two alternative redistribution schemes where τ^s is adjusted following a migration, any changes in this tax rate will be associated with further steady-state effects because of the distortionary effect on capital accumulation.

Appendix B

In Figure B.1 we illustrate how the economy adjusts following an unexpected 1% increase in productivity. We have assumed that the persistence of the productivity shock is 0.81, a value consistent with a quarterly value of 0.95, that the income tax rate is 0 and that $\rho = 0$. The figure reports the percentage deviation of each variable from its original steady-state and the notation should be self-explanatory. The presence of two types of workers does not modify the well-known dynamic pattern of adjustment of per-capita aggregate variables that these types of models generate in response to technological disturbances. On impact, investment increases to approximately 3.5% above its steady-state value. Output, hours and consumption also increase but with considerably smaller elasticities. Furthermore, since agents are risk averse, the consumption path is smoother than that of other variables. The capital stock also increases and peaks with a lag of 6-7 years. The aggregate marginal product of labor increases on impact by almost exactly the size of the disturbance while the interest rate initially increases and then declines below the steady-state.

At disaggregated level, income of high-skilled agents grows more than that of low-skilled at impact because they are more productive and own the capital stock. Given the structure of the model, the consumption path of high-skilled agents is smoother than the one of low skilled agents as we have forced the latter agents to consume their income on a period-by-period basis. Also, the increase in total hours we observe is entirely due to high-skilled agents working harder since the labor supply of low-skilled agents is fixed. Since there are only γ% of high skilled agents in the population, the increase in their hours worked exceeds the increase in per-capita hours in the economy.

To summarize, when a favorable technology disturbance hits the economy, high-skilled workers provide the additional hours necessary to take advantage of the improved technological conditions and smooth over time the benefits of the disturbance by varying the level of investments. Low-skilled workers benefit from the improved technological conditions because their wages increase over the adjustment path. Note that, because low-skilled workers work a fix number of hours, we can think of this class of agents as being hoarded by the firms which vary the number of hours of high-skilled workers to meet their production requirements over the cycle. In this way, our economy resembles the one analyzed by Burnside, Eichenbaum and Rebelo (1993).

Table 2. Welfare Consequences of Migrations ($\rho = 0.0$)

A. Model Without Taxes

	$\omega = 1.0$		$\omega = 1.3$		$\omega = 2.0$	
γ	λ_0	λ_1	λ_0	λ_1	λ_0	λ_1
0.74	-0.25	-0.16	-0.19	-0.13	-0.12	-0.08
0.73	-0.50	-0.34	-0.39	-0.26	-0.25	-0.16
0.72	-0.76	-0.52	-0.59	-0.39	-0.38	-0.25
0.71	-1.03	-0.71	-0.79	-0.53	-0.52	-0.33
0.70	-1.31	-0.90	-1.01	-0.68	-0.66	-0.42

B. Model With Fixed Income Tax

	$\omega = 1.0$		$\omega = 1.3$		$\omega = 2.0$	
γ	λ_0	λ_1	λ_0	λ_1	λ_0	λ_1
0.74	-0.25	0.09	-0.19	0.21	-0.12	0.41
0.73	-0.50	0.15	-0.39	0.39	-0.25	0.79
0.72	-0.76	0.20	-0.59	0.54	-0.38	1.15
0.71	-1.03	0.23	-0.79	0.68	-0.52	1.47
0.70	-1.31	0.24	-1.01	0.80	-0.66	1.77

C. Model With Egalitarian Tax-System

	$\omega = 1.0$			$\omega = 1.3$			$\omega = 2.0$		
γ	τ	λ_0	λ_1	τ	λ_0	λ_1	τ	λ_0	λ_1
0.74	5.3	0.23	0.17	5.3	0.26	0.20	5.3	0.29	0.25
0.73	5.6	0.48	0.34	5.6	0.52	0.41	5.5	0.59	0.51
0.72	5.9	0.73	0.53	5.8	0.79	0.62	5.8	0.90	0.77
0.71	6.2	0.99	0.72	6.1	1.07	0.84	6.1	1.21	1.04
0.70	6.6	1.26	0.92	6.4	1.35	1.06	6.3	1.53	1.32

D. Model with Insurance Tax-System

	$\omega = 1.0$			$\omega = 1.3$			$\omega = 2.0$		
γ	τ	λ_0	λ_1	τ	λ_0	λ_1	τ	λ_0	λ_1
0.74	5.3	0.24	0.17	5.3	0.29	0.20	5.3	0.35	0.23
0.73	5.6	0.49	0.35	5.6	0.59	0.41	5.6	0.71	0.48
0.72	5.9	0.75	0.53	5.9	0.90	0.63	5.9	1.09	0.73
0.71	6.3	1.03	0.73	6.2	1.23	0.86	6.2	1.47	0.99
0.70	6.6	1.33	0.94	6.6	1.58	1.10	6.5	1.88	1.27

Notes: A negative sign indicate gains and a positive sign losses.

Table 3. Welfare Consequences of Migration ($\rho = 0.25$)

A. Model Without Taxes

	$\omega = 1.0$		$\omega = 1.3$		$\omega = 2.0$	
γ	λ_0	λ_1	λ_0	λ_1	λ_0	λ_1
0.74	-0.69	-0.21	-0.55	-0.07	-0.38	0.11
0.73	-1.38	-0.43	-1.12	-0.16	-0.77	0.22
0.72	-2.09	-0.67	-1.68	-0.25	-1.16	0.31
0.71	-2.81	-0.91	-2.26	-0.36	-1.56	0.39
0.70	-3.54	-1.17	-2.85	-0.48	-1.97	0.45

B. Model With Fixed Income Tax

	$\omega = 1.0$		$\omega = 1.3$		$\omega = 2.0$	
γ	λ_0	λ_1	λ_0	λ_1	λ_0	λ_1
0.74	-0.69	-0.08	-0.55	0.10	-0.38	0.38
0.73	-1.38	-0.17	-1.12	0.18	-0.77	0.74
0.72	-2.09	-0.29	-1.68	0.24	-1.16	1.07
0.71	-2.81	-0.42	-2.26	0.29	-1.56	1.37
0.70	-3.54	-0.57	-2.85	0.31	-1.97	1.66

C. Egalitarian Tax-System

	$\omega = 1.0$			$\omega = 1.3$			$\omega = 2.0$		
γ	τ	λ_0	λ_1	τ	λ_0	λ_1	τ	λ_0	λ_1
0.74	5.6	0.25	0.20	5.5	0.27	0.22	5.4	0.30	0.27
0.73	6.2	0.54	0.43	6.0	0.57	0.47	5.8	0.62	0.55
0.72	6.8	0.85	0.68	6.5	0.88	0.74	6.3	0.96	0.85
0.71	7.4	1.18	0.96	7.1	1.22	1.03	6.7	1.32	1.17
0.70	8.0	1.54	1.26	7.6	1.58	1.34	7.2	1.69	1.51

D. Insurance Tax-System

	$\omega = 1.0$			$\omega = 1.3$			$\omega = 2.0$		
γ	τ	λ_0	λ_1	τ	λ_0	λ_1	τ	λ_0	λ_1
0.74	5.6	0.29	0.21	5.5	0.33	0.23	5.5	0.37	0.26
0.73	6.2	0.64	0.46	6.1	0.70	0.50	5.9	0.78	0.53
0.72	6.9	1.04	0.75	6.7	1.12	0.79	6.4	1.22	0.84
0.71	7.6	1.50	1.08	7.3	1.59	1.12	7.0	1.70	1.17
0.70	8.3	2.02	1.45	8.0	2.11	1.49	7.5	2.22	1.52

Notes: A negative sign indicate gains and a positive one losses.