ISSN 1791-3144

DEPARTMENT OF ECONOMICS

DISCUSSION PAPER SERIES

Welfare effects of illegal immigration

Theodore Palivos

WP 2007 - 01

Department of Economics
University of Macedonia
156 Egnatia str
540 06 Thessaloniki
Greece
Fax: + 30 (0) 2310 891292
http://econlab.uom.gr/econdep/

Welfare Effects of Illegal Immigration*

Theodore Palivos†

Department of Economics, University of Macedonia,
156 Egnatia Street, GR- 540 06, Salonica, Greece.

November 15, 2007

Abstract

This paper analyzes the welfare effect of illegal immigration on the host country within a dynamic general equilibrium framework and shows that it is positive for two reasons. First, immigrants are paid less than their marginal product and second, following an increase in immigration, domestic households find it optimal to increase their holdings of capital. It is also shown that dynamic inefficiency may arise, despite the fact that the model is of the Ramsey type. Nevertheless, the introduction of a minimum wage, which leads to job competition between domestic unskilled workers and immigrants reverses all of the above results.

JEL Classification: F2; O4.

Key Words: Economic Growth, Illegal Immigration.

*I would like to thank Hung-Ju Chen, Bharat Hazari, Chong Yip, seminar participants at the Chinese University of Hong Kong, the Kyung Hee University and the University of Cyprus, and especially two anonymous referees for valuable comments and suggestions on an earlier version of the paper. I would also like to thank the Research Committee of the University of Macedonia for financial support.

†E-mail address: tpalivos@uom.gr

1. Introduction

The phenomenon of illegal immigration is present in almost every developed as well in several developing countries, e.g., Canada, the European Union, India, Japan, the U.S., etc. According to the UN Population Division, the total number of undocumented immigrants is estimated around 30-40 million, which corresponds to 15-20% of the world's population of legal immigrants (United Nations 2004). In other words, approximately one in every six immigrants has "either entered a country without proper authorization or stayed beyond the legal time period." (United Nations 2004, p.82)

The existing literature has offered insightful results on the effects of illegal immigration (for an up to date survey see Moy and Yip, 2006). Nevertheless, most of this literature studies the issue within a static framework in which the (domestic) supply of capital is inelastic. Furthermore, the emphasis is usually on the effects of border control policies (see, for example, the seminal work of Ethier, 1986, and the recent paper of Woodland and Yoshida 2006). This paper seeks to supplement the literature by analyzing the issue within a dynamic framework in which there is endogenous capital accumulation. Two important contributions along the same lines are those of Hazari and Sgro (2003) and Moy and Yip (2006).[1] They analyze the issue of illegal immigration within a dynamic general equilibrium framework, where it is assumed that a certain number of immigrants always find a way to enter the host country illegally. Furthermore, the perspective from which both papers perform the analysis is that of a social planner in which externalities are internalized. They find that the entry of illegal immigrants has an ambiguous effect on the long-run level of per capita domestic consumption.

Indubitably, the analysis of the problem faced by a social planner constitutes a useful benchmark, especially when one is interested in public policy within a first-best environment. Nevertheless, from a practical point of view, it is also interesting to evaluate the effects of illegal immigration in competitive economies. Accordingly, in this paper I first analyze the issue of illegal immigration from the perspective of an economy with essentially the same fundamentals as the one analyzed in Hazari and Sgro (2003) and Moy and Yip (2006), in which all markets are competitive. Within such a framework, it is shown that illegal immigration unambiguously raises the welfare of domestic citizens.[2]

[1] Of course, there is also an extensive literature that analyzes various aspects of *legal* immigration within a dynamic growth setting. Recent contributions include Meier and Wenig (1997), Kemnitz and Wigger (2000) and Chen (2006).

[2] Throughout the paper, I am interested in the effects of illegal immigration on the host country. For an analysis of the effects of *legal* immigration on economic growth of the *source* country see Chen (2006).

To examine the robustness of this result, I next extend the model in two ways. First, I allow for heterogeneous labor; that is, I analyze the case where there are two types of domestic labor, skilled and unskilled. Second, I introduce a minimum wage, which leads to job competition between domestic unskilled workers and immigrants and consequently to unemployment in the labor force. I show that the main result mentioned above survives in the first, but not in the second case.

The paper is also related to the work of Meier and Wenig (1997), who analyze the effects of legal immigration within a dynamic growth model of the Solow type.[3] They also find that an increase in immigration raises both the per capita income and the per capita wealth of the natives. The main differences between the two papers are outlined below.[4]

The remainder of the paper is organized as follows. Section 2 presents the model and analyzes the competitive equilibrium for the case where domestic and foreign labor are perfect substitutes. Section 3 studies the effect of illegal immigration on the welfare of domestic citizens. Section 4 comments on the case where the two types of labor are imperfect substitutes. Section 5 revisits the issue using an extended framework in which there is unemployment in the labor force. Section 6 concludes.

2. The Model

2.1. Basic Structure

Output (Y) is produced with two factors, capital (K) and labor (N) according to a linearly homogeneous production function $Y = F(K, N)$, which in intensive form is written as $y = f(k)$, $y \equiv Y/N$ and $k \equiv K/N$. Furthermore, there are two types of labor, domestic (L) and foreign (M). In the simplest case, where these two types are perfect substitutes, we have $N = L + M$.

All foreign labor is assumed to be illegal. In fact, the following two assumptions are meant to distinguish legal from illegal immigration. First, illegal workers are paid a wage (w_m) that is lower than the wage rate (w) paid to domestic labor; in particular, it is assumed that $w_m = \beta w$, $\beta \in [0, 1]$. Second, illegal workers do not save in terms of assets located in the host country. Instead, they channel all their savings abroad.

Regarding the first assumption, Rivera-Batiz (1999) found that the average hourly wage rate of male (female) Mexican legal immigrants in the U.S. was 41.8% (40.8%)

[3] I am grateful to a referee for calling my attention to the work of Meier and Wenig (1997).

[4] They also analyze the effects on income and wealth of immigrants as well as on the average income and wealth among both natives and immigrants.

higher than that of the undocumented workers. Assuming that legal immigrants are paid as much as domestic workers, this suggests a value for $\beta = 0.71$. Moreover, Appendix A provides some micro-foundations regarding this assumption. Specifically, it is shown that the equation $w_m = \beta w$, $\beta \in [0, 1]$ can emerge as an outcome in an environment where the government imposes a fine on a firm if caught employing an illegal immigrant, as it is the case in most countries (for details see, for example, Martin and Miller, 2000, and United States Accountability Office, 2005). Alternatively, the same equation arises in a framework in which the wage rate paid to immigrants is determined through a Nash bargaining process.

Obviously, it is difficult to find reliable data regarding illegal immigration. Nevertheless, some existing indirect evidence suggests that the second assumption is a sound one, at least as a first approximation of actual behavior. For example, Amuedo-Dorantes and Pozo (2006) found that undocumented Mexican immigrants in the US remit 49% of their earnings home (their documented counterparts remit 44%). Similar results were found in Amuedo-Dorantes et al. (2005) also for Mexican workers and in Markova and Reilly (2007) for Bulgarian workers. Moreover, as Appendix B shows the results remain the same if immigrants do not save but consume all their income domestically (the latter is the assumption made in Hazari and Sgro, 2003, and Moy and Yip, 2006).

2.2. Households and Firms

Households maximize their lifetime utility

$$\int_0^\infty \frac{c_t^{1-\theta} - 1}{1-\theta} e^{-\rho t} dt, \qquad \theta > 0, \tag{2.1}$$

where $c \equiv C/L$ and C denote, respectively, the individual and the aggregate consumption of the domestic household at time t and ρ is the discount rate. Without loss of generality, I assume that the utility function takes the constant elasticity of intertemporal substitution form.

All members of the domestic household work and receive a wage w. They also save and accumulate wealth in terms of capital, which earns an interest rate r. Finally, they receive dividends Π from the firm shares that they own. Thus, the budget constraint of the household is $\dot{K}_t + C_t = w_t L_t + r_t K_t + \Pi_t$, where $\dot{K}_t$ is household's total investment.

Upon dividing by N, the budget constraint can be written in per capita terms as[5]

$$\dot{k} + \alpha c = \alpha w + rk + \pi - nk, \tag{2.2}$$

where $\alpha \equiv L/N$ is the ratio of domestic to total labor, $\pi \equiv \Pi/N$ is dividend per worker and n denotes the population growth rate.

The first-order conditions for the maximization of (2.1) subject to (2.2) are

$$U'(c) = \mu\alpha, \tag{2.3}$$

$$\dot{\mu} = \mu(\rho - r + n), \tag{2.4}$$

(2.2) and a typical transversality condition, where μ denotes the co-state variable.

A representative competitive firm maximizes its profit

$$\Pi = F(K, N) - rK - wL - w_m M, \tag{2.5}$$

taking all prices as given. The first-order conditions with respect to K and L are $F_K = r$ and $F_L = w$.

2.3. Equilibrium

Combining (2.3), (2.4) and $F_K = f' = r$ yields

$$\frac{\dot{c}}{c} = \frac{f'(k) - (n + \rho)}{\theta}. \tag{2.6}$$

Next notice that in equilibrium firms make a profit. To see this recall that $F(\cdot)$ is linearly homogeneous in K and N, $N = L + M$ and $F_L = F_M$ (domestic and foreign labor are perfect substitutes). Thus, $F(K, N) = F_k K + F_L L + F_L M$. Substituting this in (2.5) yields $\Pi = (1 - \beta)wM$ or, since $\pi = \Pi/N$,

$$\pi = (1 - \beta)(1 - \alpha)w. \tag{2.7}$$

Substituting (2.7) and $f(k) = f'(k)k + w$ into (2.2), we have

$$\dot{k} = f(k) - \alpha c - \beta(1 - \alpha)w(k) - nk. \tag{2.8}$$

The linearized system of (2.6) and (2.8) around the steady state (k^*, c^*) exhibits saddle-path stability, while the values of k^* and c^* are given by the intersection of

$$\dot{c} = 0 \text{ locus:} \qquad f'(k^*) = n + \rho, \tag{2.9}$$

$$\dot{k} = 0 \text{ locus:} \qquad f(k^*) = \alpha c^* + \beta(1 - \alpha)w(k^*) + nk^*. \tag{2.10}$$

[5] Note that the division by N is simply a transformation and it does not mean that immigrants receive dividends. Section 4 below explains the advantage of dividing all variables by N instead of L.

3. The Effects of Illegal Immigration

3.1. The Possibility of Dynamic Inefficiency

The steady-state equilibrium value of the capital stock, k^*, is determined solely by equation (2.9): $f'(k^*) = n+\rho$. This is not, however, the optimal value, $\overline{k}$. The latter, which can be found by solving the social planner's problem, is given by $f'(\overline{k}) = n+\rho-\beta(1-\alpha)\overline{k}f''(\overline{k})$; the difference between the two expressions is the increase in the payment of immigrants caused by an increase in the capital stock. In other words, in a competitive economy when each (small) household makes an investment decision, it ignores the impact of that decision on the market wage rate and thus on the wage paid to immigrants (recall that $w_m = \beta w$). Since $f'(\overline{k}) = n+\rho-\beta(1-\alpha)\overline{k}f''(\overline{k}) > n+\rho = f'(k^*)$ and $f''(k) < 0$, there will be over-accumulation of capital, $k^* > \overline{k}$.

Next, let $\widehat{k}$ denote the value of k that corresponds to the maximum of the $\dot{k} = 0$ locus. Notice that when α is close to 1, $\widehat{k}$ is given by $f'(\widehat{k}) = n < n+\rho = f'(k^*)$; thus, the steady-state equilibrium k^* occurs on the upward sloping part of the $\dot{k} = 0$ locus (e.g., point A in Figure 1). For values of $\alpha < 1$, however, $\widehat{k}$ is given by $f'(\widehat{k}) = n - \beta(1-\alpha)\widehat{k}f''(\widehat{k})$. Thus, if $\rho < -\beta(1-\alpha)\widehat{k}f''(\widehat{k})$, then the steady-state equilibrium value of the capital stock k^* occurs on the downward sloping part of the $\dot{k} = 0$ locus (e.g., point B in Figure 1, where $\dot{k}_0 = 0$ denotes the original locus and $\dot{k} = 0$ that resulting from a decrease in α). We conclude that there will be over-accumulation of capital, which may in fact lead to *dynamic inefficiency* ($k^* > \widehat{k}$). This means that for any given value of m, a decrease in capital accumulation can increase consumption and welfare (note that each locus $\dot{k} = 0$ in Figure 1 corresponds to a particular value of m).[6]

3.2. The Effects on Consumption and Welfare

Suppose now that, starting from a steady-state equilibrium, immigration increases (α decreases). This leaves the $\dot{c} = 0$ locus unchanged and rotates the $\dot{k} = 0$ locus in the way that is shown in Figure 1 (a subscript "0" denotes the initial loci). The system will jump immediately from the old to the new steady state (from point A to point B). Hence, consumption and welfare increase. Since there are no transitional dynamics, the impact

[6] As noted in the Introduction, Meier and Wenig (1997) analyze legal immigration within a Solow growth model. It is well known that in the Solow model the equilibrium capital stock can be on either side of the golden rule path of capital accumulation. Meier and Wenig (1997) show that immigration policy may be used to implement the golden rule. In a similar flavor, in this framework immigration affects not only the capital stock but also the side relative to the golden rule on which the economy finds itself.

on consumption can also be found by simple differentiation of the steady-state equation. More specifically, differentiating (2.10) and using the fact that $f(k) = kf'(k) + w$ we find

$$\frac{dc^*}{d\alpha} = -\frac{1}{\alpha^2}\left[f(k^*) - \beta k^* - nk^*\right] = -\frac{1}{\alpha^2}\left\{\left[f'(k^*) - n\right]k^* + (1-\beta)w(k^*)\right\} < 0, \qquad (3.1)$$

since $f'(k^*) - n = \rho > 0$. Thus, an increase in the number of illegal immigrants raises unambiguously the consumption and hence the welfare of the domestic citizens. There are two reasons for this. First, even though the value of capital per worker k $(= K/N)$ remains the same, the capital owned by each domestic resident (K/L) goes up. To see this notice that $K/N = \alpha(K/L)$; thus, for K/N to remain the same when α goes down, K/L must go up. This effect generates additional income for the domestic citizens and is captured by the first term inside the braces. Second, when immigration goes up, the domestic households receive a higher dividend, which emanates from the "exploitation" of more immigrants, that is, the fact that more people are paid less than their marginal product. This effect is captured by the second term inside the braces in (3.1). Next, notice that the effect of illegal immigration remains positive even if $\beta = 1$, that is, even if domestic citizens do not receive any dividend (if $\beta = 1$, then $w = w_m$; immigrants cease to be exploited). The reason for this is that, while the second effect disappears when $\beta = 1$, the first effect is still present.[7]

Numerical calculations, based on a Cobb-Douglas production function and standard parameter values, show that a decrease in α by 0.01 (or an increase in the immigration ratio $m \equiv M/L = (1-\alpha)/\alpha$ by 0.01) raises consumption each period by 0.4% and the domestic lifetime utility by approximately 0.84%. Details are available upon request.

4. Imperfect Substitutes

Next I analyze the case where domestic and foreign labor are imperfect substitutes. Accordingly, suppose that there are two types of labor in the host country, skilled and unskilled. Each household has a constant proportion of its members possessing one type of labor and the rest possessing the other type. To be more specific, let L_1 and L_2 be the two types of labor, where $\phi \equiv L_2/L_1$. Let also foreign labor be a perfect substitute for L_2 but not for L_1. In this case the production function can be written as $Y = F(K, L_1, L_2 + M)$.

[7] The case where $\beta = 1$ corresponds to the case where immigration is legal and immigrants do not save within the country. Hence, if set $\beta = 1$ in this section of the paper and the saving rate of the immigrants equal to zero in the Meier and Wenig (1997) paper, then the only difference that remains is that the former uses a Ramsey type and the latter a Solow type growth model. Nevertheless, both papers find the same result.

I continue to assume that $F(\cdot)$ is linearly homogeneous with respect to all inputs; hence, $y = f(k, \phi + m)$, where variables are redefined as follows: $y \equiv Y/L_1$, $k \equiv K/L_1$ and $m \equiv M/L_1$.

The household's utility function depends again on the average consumption among its members, $C/(L_1 + L_2) = c/(1 + \phi)$, where c is redefined as C/L_1. The household then maximizes (2.1), with $c/(1 + \phi)$ replacing c, subject to the budget constraint $\dot{K} + C = w_1 L_1 + w_2 L_2 + rK + \Pi$, where w_1 and w_2 denote the wage rate for L_1 and L_2, respectively. Furthermore, $w_m = \beta w_2$. Upon dividing by L_1 and defining $\pi \equiv \Pi/L_1$, the budget constraint can be written as $\dot{k} + c = w_1 + \phi w_2 + rk + \pi - nk$.

In equilibrium $\pi = (1 - \beta) w_2 m$ and the $\dot{c} = 0$ and $\dot{k} = 0$ loci become

$$\dot{c} = 0 \text{ locus:} \qquad f_k(k^*, \phi + m) = n + \rho, \tag{4.1}$$

$$\dot{k} = 0 \text{ locus:} \qquad f(k^*, \phi + m) = c^* + \beta f_m(k^*, \phi + m)m + nk^*. \tag{4.2}$$

Using (4.1) and (4.2), it is straightforward to show that if capital and immigrant labor are again Edgeworth complements, i.e., $F_{KM} > 0$ or, equivalently, $f_{km} > 0$, then all the results of the previous case still hold. In particular, domestic households gain from illegal immigration (an increase in m).

To see the similarity between this case and that of perfect substitutes, note that even in the latter case one could have contacted the analysis in terms of K/L and M/L, instead of K/N and L/N. I did not do so, because in that case the analysis would be more complicated, since m would enter both the $\dot{c} = 0$ and the $\dot{k} = 0$ equations; hence, in Figure 1 a change in m would shift both loci, instead of just one. Indeed, upon dividing by L, $\dot{c} = 0$ and $\dot{k} = 0$ (equations (2.9) and (2.10)) become $F_k(k^*, 1 + m) = n + \rho$ and $F(k^*, 1 + m) = c^* + \beta F_m(k^*, 1 + m)m + nk^*$, respectively. By comparing these with equations (4.1) and (4.2), it becomes immediately apparent that the results do not change when domestic and foreign labor are imperfect substitutes, since basically in the latter case ϕ replaces 1.

5. Illegal Immigration and Unemployment

The previous sections analyze some of the effects of illegal immigration in an environment where there is full employment. Nevertheless, one of the arguments against immigration in general and especially illegal immigration is that it increases the unemployment of the native workers. Indeed, the introduction of unemployment in the labor force is a serious factor that ought to be taken into account when examining issues of immigration. Accordingly, in this section I make an attempt to analyze the issue of illegal immigration in an extended optimal growth model with unemployment. Admittedly the model is rather simplistic and it should be viewed as a first attempt with the intention to show that the existence of unemployment can have a significant impact on agents' welfare.

Consider a model similar to the one in the previous section with two types of labor, skilled and unskilled. The only additional element is that now I introduce a minimum wage ($\widetilde{w}$), which applies only to unskilled workers and is assumed to be binding. The domestic labor force is now divided into employed and unemployed, that is, $L_2 = U + E$. Consequently, the production function is written as $Y = F(K, L_1, E + M)$ or, if we define again $y \equiv Y/L_1$, $k \equiv K/L_1$, $m \equiv M/L_1$ and $e \equiv E/L_1$, then $y = f(k, e + m)$.[8]

The budget constraint of the household is $\dot{K} + C = w_1 L_1 + \widetilde{w}E + rK + \Pi$. Furthermore, $w_m = \beta\widetilde{w}$. Upon dividing by L_1 and defining $\pi \equiv \Pi/L_1$, the budget constraint can be written as

$$\dot{k} + c = w_1 + \widetilde{w}e + rk + \pi - nk. \tag{5.1}$$

The household then maximizes (2.1), with $c/(1 + \phi)$ replacing c, subject to the budget constraint (5.1).

In equilibrium $\pi = (1 - \beta)\widetilde{w}m$ and the $\dot{c} = 0$ and $\dot{k} = 0$ loci become

$$\dot{c} = 0 \text{ locus:} \qquad f_k(k^*, e^* + m) = n + \rho, \tag{5.2}$$

$$\dot{k} = 0 \text{ locus:} \qquad f(k^*, e^* + m) = c^* + \beta\widetilde{w}m + nk^*. \tag{5.3}$$

The long-run equilibrium is then described by equations (5.2), (5.3) and the equation for the minimum wage

$$f_e(k^*, e^* + m) = \widetilde{w}. \tag{5.4}$$

Notice that, according to equations (5.2) and (5.4), the marginal products of capital and unskilled labor are constant. Furthermore, domestic unskilled labor and immigration are perfect substitutes. Consequently, an increase in the immigration ratio m will have a negative effect on the employment ratio e^*, which is one-to-one, but will leave the capital stock unchanged. Indeed, differentiating (5.2) and (5.4) yields $dk^*/dm = 0$ and $de^*/dm = -1$. Using these two equations together with (5.3) yields $dc^*/dm = -\beta\widetilde{w} < 0$. This result is intuitive. Recall from the previous sections that immigration had a positive

[8] It is assumed that illegal immigrants do not stay in the host country if they do not have a job. Alternatively, if they stay in the host country without a job, then they do not qualify for unemployment benefits.

effect on consumption for two reasons. First, there was an increase in the capital stock, which in this case disappears, that is, $dk^*/dm = 0$. Second the representative household was receiving, in terms of higher dividends, $(1-\beta)w$ for each immigrant worker. In the present case it continues to receive the same amount, $(1-\beta)\widetilde{w}$, but at the same time it loses $\widetilde{w}$, because each additional immigrant replaces a native unskilled worker. Hence, the net effect is $-\beta\widetilde{w} < 0$.

In addition, the existence of over-accumulation of capital and the possibility of dynamic inefficiency do not exist anymore. Once again, the reason is simple. The over-accumulation of capital, in the previous section, occurred because in a competitive economy when each (small) household makes an investment decision, it ignores the impact of that decision on the market wage rate and thus on the wage paid to immigrants (recall that $w_m = \beta w$). In the case I examine in this section, however, the wage rate paid to immigrants is fixed $w_m = \beta\widetilde{w}$ and in particular it is not affected by investment decisions.

In sum, the introduction of a minimum wage rate that leads to job competition among domestic unskilled workers and immigrants reverses all of the results derived in the previous sections. Namely, immigration increases unemployment, leaves the capital stock unchanged and decreases consumption and welfare.

6. Conclusions

This paper has analyzed the effect of illegal immigration on the welfare of the host country, within a competitive dynamic general equilibrium framework. It has shown that illegal immigration leads to over-accumulation of capital and perhaps to dynamic inefficiency, despite the fact that the model is of the Ramsey type, in which there exists a representative household with infinite horizon. Moreover, in such a framework, illegal immigration raises unambiguously domestic consumption and welfare. Finally, it was shown that if expanded, in a rather simple way, to allow for unemployment in the labor force, the model yields exactly the opposite results; namely, consumption and welfare decrease.

The framework used here is amenable to various extensions. First of all, as mentioned above, the reason that unemployment arises in this model may be inadequate to explain all aspects of such a complex phenomenon. Thus, one may consider more elaborate models of unemployment and immigration (see, for example, Ortega 2000). Moreover, one can incorporate remittances in the model and examine the effect of immigration on the source country as well. Also, it will be interesting to investigate the impact of illegal immigration on pensions since illegal immigrants do not pay taxes. Finally, it is often the case that illegal immigrants are employed in certain "informal" sectors, which are intensive in low-skilled labor and also cannot be monitored easily by the authorities. To analyze issues pertaining to labor reallocation and output composition one must utilize a multi-sector growth model. I intend to pursue some of these topics in future research.

Appendix A

The wage rate paid to immigrants

In this Appendix I offer two alternative justifications for the relative wage rate paid to immigrants; namely, the equation

$$w_m = \beta w, \quad \beta \in [0, 1]. \tag{A1}$$

a) First, suppose that there is a cost associated with the employment of an undocumented immigrant (a similar approach is followed in Epstein and Heizler, 2007). If caught employing an illegal immigrant, which occurs with probability p, an employer must pay a fine γ to the government. Then maximizing again the representative competitive firm's profit (equation 2.5) with respect to all inputs K, L **and** M

$$\Pi = F(K, N) - rK - wL - w_m M - p\gamma M,$$

taking all prices as given, yields, besides $F_K = r$ and $F_L = w$, $F_M = w_m + p\gamma$. Since, $F_L = F_M$,it follows that $w - w_m = p\gamma > 0$; that is, as assumed in the main text, illegal immigrants are paid a wage (w_m) that is lower than the wage rate (w) paid to domestic labor. In particular, since $w_m = \beta w$ and $w - w_m = p\gamma$, it follows that

$$\beta = \frac{w - p\gamma}{w}. \tag{A2}$$

Hence, β is determined in equilibrium. Moreover, if either the fine or the probability of being caught is zero, that is, if the expected fine is equal to zero, then the immigrants will be paid as much as the natives. With this formulation, firms will not have any profit and thus there will be no dividend. Hence, we have to examine if the results that are derived in the main text change. Instead of the firms, the revenue from the "exploitation" of the immigrants goes to the government. Indeed, the government raises total revenue equal to

$$\Pi = p\gamma M.$$

If we assume that this revenue is distributed to domestic households in a lump-sum manner then

$$\pi \equiv \frac{\Pi}{N} = p\gamma(1 - \alpha). \tag{A3}$$

Substituting (A3) in the private budget constraint (2.2), we get

$$\dot{k} = f(k) - \alpha c - (1-\alpha)[w(k) - p\gamma] - nk. \tag{A4}$$

The equilibrium path is then determined by equations (2.6) and (A4). If we make the additional assumption that the fine γ imposed by the government is a multiple of the current wage rate, for example $\gamma = \theta w$, then (A4) becomes

$$\dot{k} = f(k) - \alpha c - (1-\alpha)(1-p\theta)w(k) - nk. \tag{A5}$$

In this case, the analysis is identical to the one in the main text, since upon setting $1 - p\theta \equiv \beta$, (A5) and (2.8) become identical. Nevertheless, even if one does not accept the simplification $\gamma = \theta w$, all the results still hold. The only difference is that the term $w(k) - p\gamma$ replaces now the term $\beta w(k)$.

b) Suppose instead that the wage rate of the immigrant workers is determined via a bargaining process. Specifically, suppose that each period a representative firm bargains with a representative immigrant for the wage rate w_m. All negotiations are instantaneous and conducted according to a Nash bargaining rule, in which immigrants receive a share β and firms a share $1-\beta$ in the surplus from a match. If the firm employs an immigrant worker it gains $\Pi = F(K, N+M) - rK - wL - w_m$. Instead of the immigrant, the firm can employ a domestic worker in which case it gains $\Pi' = F(K, N+M) - rK - wL - w$. Hence, the gain to a firm employing an illegal immigrant is $w - w_m$. On the other hand, an immigrant can work for the firm and receive w_m or return to her country and receive w_f. Thus, the gain to an illegal immigrant from accepting to work for a firm in the host country is $w_m - w_f$. The wage rate w_m derived from the Nash bargaining solution is such that it maximizes $(w - w_m)^{1-\beta}(w_m - w_f)^{\beta}$, $\beta \in [0,1]$. Performing the suggested differentiation leads to $w_m = \beta w + (1-\beta)w_f$. This equation coincides with (A1) if $w_f = 0$. This can be justified with the additional assumption that the cost for the immigrant of returning to her country is high relative to the benefit. Thus, her outside option is not w_f but zero.

Appendix B
Immigrants' saving behavior

In this Appendix I show that making the alternative assumption, as in Hazari and Sgro (2003) and Moy and Yip (2006), according to which immigrants do not save, instead of sending all their savings abroad, does not change our results. Let us start by specifying the resource constraint in aggregate terms for the economy:

$$\dot{K} + C + C_M + S_M = F(K, N), \tag{B1}$$

where C_M and S_M denote, respectively, the consumption and savings of the immigrants. Consider the following two alternatives: a) immigrants do not save and hence their consumption is equal to their income, that is,

$$S_M = 0 \quad \text{and} \quad C_M = \beta M w, \tag{B2a}$$

or b) immigrants save but they channel all their savings abroad, that is,

$$S_M > 0 \quad \text{and} \quad C_M + S_M = \beta M w. \tag{B2b}$$

Substituting either of the two equations (B2a) and (B2b) in (B1) leads to

$$\dot{K} + C = F(K, N) - \beta M w,$$

or if we divide both sides by N

$$\dot{k} + ac = f(k) - b(1 - \alpha)w - nk,$$

which is the resource constraint (2.8) considered in the main text. Therefore, both alternatives lead to the same resource constraint. Of course, equation (2.6), which determines the consumption rule of the natives, also does not change if either assumption is made; thus, the equilibrium remains the same under either assumption. The reason is simply that this is a growth model with full employment. As long as capital accumulation is not affected, whether part of immigrants' income is spent within the country or abroad does not alter the equilibrium.

References

[1] Amuedo-Dorantes C, Pozo S (2006) Remittances as Insurance: Evidence from Mexican Immigrants. *Journal of Population Economics* 19(2): 227-254.

[2] Amuedo-Dorantes C, Bansak C, Pozo S (2005) On the Remitting Patterns of Immigrants: Evidence from Mexican Survey Data. *Economic Review*, Federal Reserve of Atlanta 90(1): 37-58.

[3] Chen HJ (2006) International Migration and Economic Growth: A Source Country Perspective. *Journal of Population Economics* 19(4): 725-748.

[4] Epstein GS, Heizler (Cohen) O (2007) Illegal Immigration, Enforcement and Minimum Wage. IZA Discussion Paper, No. 2830.

[5] Ethier WJ (1986) Illegal Immigration. *American Economic Review* 76(2): 258-262.

[6] Hazari BR, Sgro PM (2003) The Simple Analytics of Optimal Growth with Illegal Migrants. *Journal of Economic Dynamics and Control* 28(1): 141-151.

[7] Kemnitz A, Wigger BU (2000) Growth and Social Security: The Role of Human Capital. *European Journal of Political Economy* 16(4): 673-683.

[8] Markova E, Reilly B (2007) Bulgarian Migrant Remittances and Legal Status: Some Micro-Level Evidence from Madrid. *South-Eastern Europe Journal of Economics* 5(1): 55-69.

[9] Martin P, Miller M (2000) Employer Sanctions: French, German and US Experiences. International Migration Papers, No. 36.

[10] Meier V, Wenig A (1997) Welfare Implications of International Labor Migration. *Zeitschrift für Wirtschafts- und Sozialwissenschaften* 117(4): 505-524.

[11] Moy HM, Yip CK (2006) The Simple Analytics of Optimal Growth with Illegal Migrants: A Clarification. *Journal of Economic Dynamics and Control* 30(12): 2469-2475.

[12] Ortega J (2000) Pareto-Improving Immigration in an Economy with Equilibrium Unemployment. *Economic Journal* 110(460): 92-112.

[13] Rivera-Batiz FL (1999) Undocumented Workers in the Labor Market: An Analysis of the Earnings of Legal and Illegal Mexican Immigrants in the United States. *Journal of Population Economics* 12(1): 91-116.

[14] United Nations (2004) World Economic and Social Survey 2004. United Nations Department of Economic and Social Affairs, E/2004/75/Rev.1/Add.1.

[15] United States Accountability Office (2005) Immigration Enforcement: Preliminary Observations on Employment Verification and Worksite Enforcement Efforts, June.

[16] Woodland AD, Yoshida C (2006) Risk Preferences, Immigration Policy and Illegal Immigration. *Journal of Development Economics* 81(2): 500-513.

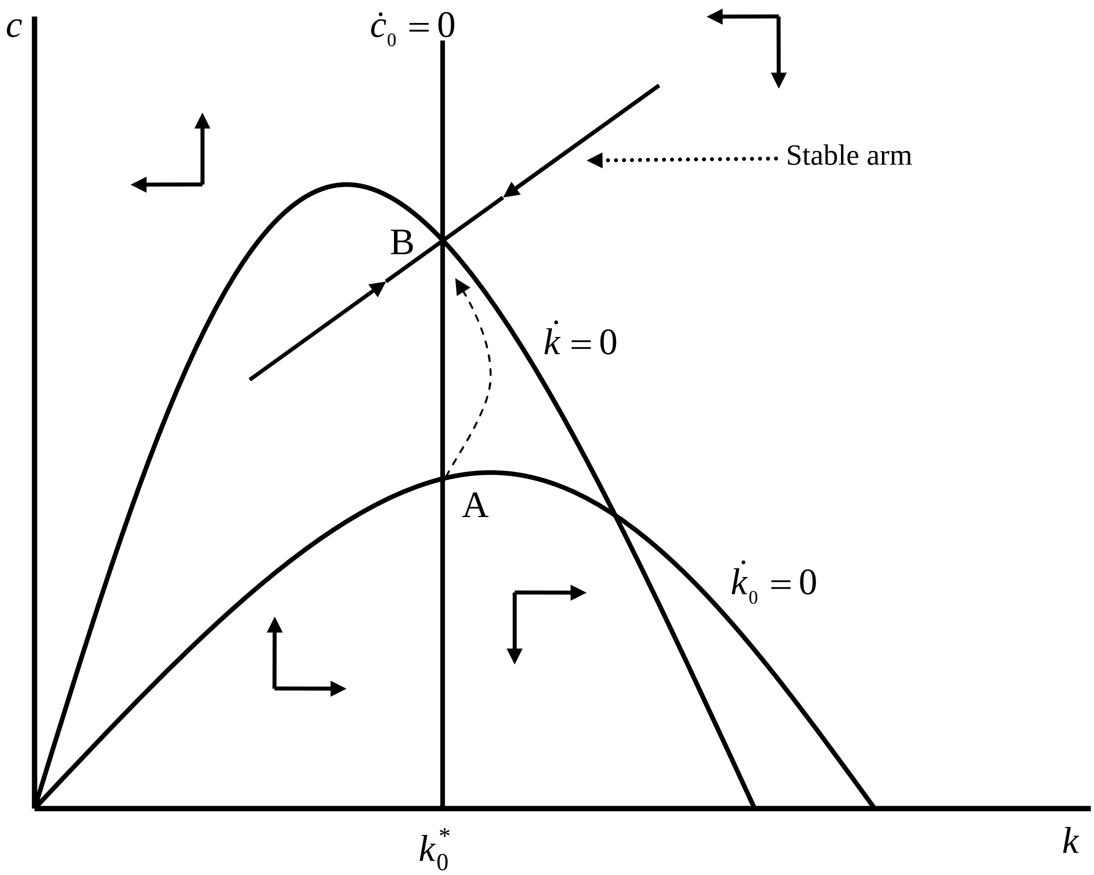

Figure 1. Competitive Equilibrium