On the welfare impacts of an immigration amnesty

J. Machado

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Joël Machado †

Abstract

This paper aims to assess the effects of an immigration amnesty on agents' welfare by using a simple two-period overlapping generations model. Given that illegal immigrants play a role in the economy even before being regularized, an amnesty differs from new immigration. In the presence of labor market discrimination, capital holders are harmed as the acquisition of legal status increases the wage bill that they pay. The net fiscal effect strongly depends on the discrimination that illegal workers face ex ante. A calibration of the model on Germany and the United Kingdom highlights overall limited economic consequences of amnesty which can be contrasted to the effects of deportation and new legal immigration. In particular, when public welfare expenditures are low, amnesty and new immigration can increase native's welfare in the long run while deportation might harm less-educated agents.

Keywords: illegal immigration, amnesty, regularization, discrimination
JEL Classification: F29, J61, J79

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†IRES - Place Montesquieu, 3, B-1348 Louvain-la-Neuve, Belgium
E-Mail: joel.machado@uclouvain.be

1 Introduction

In recent years, illegal immigration[1] has been an issue for numerous countries all over the world (OECD, 2006). Table 1 provides estimates of the illegal population in the EU15 in 2002. The authorities and the public opinion regularly debate on how to tackle this problem and shape the immigration policy.

The policies defined by national authorities often focus on a selective choice of immigrants allowed to enter the country (e.g. the points systems in Australia and Canada[2]) or on the means to be used in order to control the borders and the inflow of foreigners on the national soil. However, several governments have conducted, under certain specific circumstances, a regularization (also referred to as legalization or amnesty) of the illegal population present in their country. An amnesty for illegal immigrants can be defined as a governmental pardon for violating regulations related to immigration, which might include forgiving individuals for using false documentation such as social security numbers or identification cards, in order to remain in the country and/or gain employment. This procedure confers permanent residency in the host country to those illegal immigrants who respect the criteria for application.

[Insert Table 1 here]

In general, an amnesty is a "one-off" political decision without fixed institutional framework, although some countries have permanent programs such as France and the United Kingdom (see Levinson, 2005). Several political or social reasons may justify the organization of a regularization. Without being exhaustive, these can include: the improvement of illegal workers' life conditions, the increase in labor market transparency or the strengthening of knowledge and control over illegal immigration (see Levinson, 2005). In the same article, the author also mentions various application criteria recurrent in these procedures: the attribution of legal status might be based on duration of residence, on participation in the labor market or on socio-political reasons[3].

In opposition to new immigrants, unauthorized residents already play a role in the society and the economy: they might work (in the shadow economy), perceive different sorts of subsidies, pay the value added tax on

[1] An illegal immigrant can be defined as a foreigner who has either entered the country illegally or violated the terms of legal admission (e.g. by overstaying the duration of a tourist visa).

[2] In these systems, applicants receive points for different characteristics like education, work experience, language skills and job prospects (a guaranteed employment contract). To be eligible for a visa, a certain number of points must be obtained CIC, 2011.

[3] One of the possible criteria for legalization in the Belgian procedure of 2009 was indeed the excessive time that the responsible administrations took to treat applications for asylum (SPF Intérieur, 2009)

consumption and their children are educated in the national education system. Therefore, an amnesty has a different impact on the economy than the admission of new immigrants. Several countries have provided amnesties, among which the largest, in terms of applicants, was the Immigration Reform and Control Act (IRCA) of 1986 in the U.S. (OECD, 2008).

The literature on amnesties is quite limited and a huge majority of the papers studies the IRCA and its consequences, due to the lack of data on other regularization cases. Some studies focus on the European countries (Pastore, 2004; Levinson, 2005; Marx *et al.*, 2008; Papantoniou-Frangouli and Leventi, 2000, Baldwin-Edwards and Kraler, 2009 for the EU27 and Reyneri, 2001 for the Mediterranean countries,).

The theory of amnesty has been treated in different ways by the authors who addressed this question. Generally, it has been viewed as part of a larger immigration control strategy, including border control and internal inspections (Chau, 2001, 2003). Karlson and Katz (2003) argued that an amnesty also provides incentives for potential immigrants needed as labor force in the host country. In Epstein and Weiss (2001) an amnesty is considered as a means to reduce the burden on the government of illegal immigrants, who could not be prevented from establishing in the country. The optimal timing of the amnesties has also received some attention (Epstein and Weiss, 2001, 2011).

Part of the literature focuses on the effects of an amnesty on migrants' welfare and the dynamics of immigration (Gang and Yun, 2006; Epstein and Weiss, 2001). The consequences of an amnesty (mainly the IRCA) for the legalized immigrants or the labor market in general have been empirically assessed in several papers (Borjas and Tienda, 1993; Kaushal, 2006; Amuedo-Dorantes *et al.*, 2007; Barcellos, 2010; Amuedo-Dorantes and Bansak, 2011). However, the findings of this literature vary considerably and depend largely on the estimation methods and samples used (Borjas and Tienda, 1993).

The main objective of this paper is to assess the economic impact of an amnesty on different categories of agents. It is important to stress out that illegal agents already play a role in the economy through their labor market participation and net impact on the public budget. Thus, their presence is not neutral prior to the amnesty, which is rarely underlined in the existing literature. Using a simple overlapping generations (OLG) model as framework allows to separate the effects on high- and less-educated workers and capital owners (retired individuals). To our knowledge, this type of model has not yet been used to analyze the regularization of illegal immigrants. An amnesty yields contradicting effects for agents belonging to different generations. In the short run, at constant capital stock and workforce, profits are reduced and the interest rate falls. Hence, the old generation embodying the capital owners suffers a welfare loss. Simultaneously, the effects on the government budget are uncertain and depend on the number of illegals and country characteristics (e.g. skill structure of the labor market and fiscal

policy). A decrease in the income tax rate can benefit the whole workforce in the economy. In the long run, capital accumulation might undo the negative short run effects on the interest rate. The consequences on native low-educated individuals remain limited. When a shock on the population size and structure is considered (either by allowing deportation or considering new immigration inflows), several additional ambiguities arise.
A parameterization of the model on two different countries (Germany and United Kingdom) allows to quantify these changes and particularly to highlight the differences between an amnesty and new immigration. The former generally implies weaker effects than the latter due to the role already played by illegals in the economy.

The remainder of this paper is organized as follows. The next section presents the two-period OLG model, used to investigate the consequences of a regularization in section 3. Furthermore, the latter analyses the cases of deportation and new legal immigration. Section 4 briefly reviews the effects of an amnesty in a small open economy framework. Section 5 provides a parameterization of the model to reproduce two different economies and compares the effects of an amnesty with the two alternative policies. Some sensitivity analysis to different parameters' values are also provided. Section 6 concludes.

2 Theoretical Framework

In the closed economy considered, one good is produced and there are four different types of perfectly foresighted workers ($j = h, n, m, i$) differentiated by skill and origin. A high-educated (college graduated) worker[4] is denoted by subscript h while a low-educated worker is either a native (n), a legal (m) or illegal (i) immigrant. High- and low- educated workers are imperfect substitutes. Legal and illegal immigrants are perfect substitutes[5] but imperfectly substitutable with natives[6]. An immigrant's productivity is assumed to be status independent. However, illegal immigrants might be discriminated on the labor market and only receive a fraction of the (legal) immigrant's wage and of the public transfers. On the other hand, they are not subject to labor income taxation.

[4]In order to simplify the analyses, high-educated workers are assumed to be perfect substitutes. A policy shock will therefore have the same effects on high-educated natives than it does on high-educated immigrants.

[5]It is assumed that only the status differentiates legal and illegal low-educated immigrants while foreign citizens might concentrate on different segments of the labor market than natives.

[6]Orrenius and Zavodny (2004) argue that, although granting legal status might increase the competition between legalized and native workers, the latter keep a certain protection due to their language skills, their higher level of education and their better knowledge of the labor market institutions.

2.1 Utility maximization

When young, each agent supplies one unit of labor inelastically. Her income is either consumed or saved. The savings are used to consume when she becomes old and no bequests are left. The lifetime utility of an agent born at time t is given by[7]:

$$U_j^t = ln(c_{j,t}) + \beta ln(d_{j,t+1}) - S_j \qquad \text{where } j\text{=}h,m,n,i \tag{1}$$

β is the type-independent discount factor while $c_{j,t}$ and $d_{j,t+1}$ represent, for an agent of type j, the consumption of the single good at time t and $t+1$. S_j is a fixed cost that the illegal status imposes on immigrants without proper documentation. Thus, $S_i > 0$ while $S_j = 0$ for $j = n, m, h$. This cost might represent a variety of aspects ranging from the discomfort due to the irregular situation, the fear to be caught or limitations in the daily life that the absence of legal status imposes (e.g. impossibility to have a driving license). Given that she lives for two time periods, the lifetime budget constraint of a j-type agent can be written:

$$\psi_{j,t} = c_{j,t}(1+v) + \frac{d_{j,t+1}(1+v)}{R_{t+1}}. \tag{2}$$

where v is a constant value added tax (VAT) rate on consumption and R_{t+1} is the return on savings. The disposable income of a j-type agent is given by $\psi_{j,t}$ with:

$$\psi_{j,t} = w_{j,t}(1-\tau_t) + g \qquad for\ j\text{=}h,m,n \tag{3}$$

$$\psi_{i,t} = \gamma w_{m,t} + \Theta g \tag{4}$$

where $w_{j,t}$ is the j-type worker's wage, τ_t the income tax rate and g the constant public transfer provided by the government. The fractions of the low-education wage and transfers that an undocumented individual receives are respectively denoted by γ and Θ. In the literature, several reasons are provided to explain the lower wages of illegal workers. Among the most common are a lower productivity of the illegal immigrants (Chiswick, 1988), the risk of employer sanctions passed on to workers (Chau, 2001) or discrimination due to the status (Rivera-Batiz, 1999). The latter argument is the one used in this model. Furthermore, even though the illegal workers do not pay taxes, they might be able to apply for specific public assistance programs and their children might integrate the public education system. Therefore, they impose a cost on the public budget.

Maximizing (1) subject to (2) yields per capita consumption and savings, which given the logarithmic utility function, are a constant fraction of the

[7]A useful reference guide for OLG models can be found in de la Croix and Michel (2002).

disposable income:

$$c_{j,t} = \frac{\psi_{j,t}}{(1+v)(1+\beta)}$$
$$s_{j,t} = \psi_{j,t} - c_{j,t}(1+v) = \frac{\beta}{1+\beta}\psi_{j,t}$$
$$d_{j,t+1} = \frac{\beta}{1+\beta}\psi_{j,t}\frac{R_{t+1}}{1+v}.$$

By means of the aggregate disposable income $\Psi_t = \sum_{j=h,n,m,i} \psi_{j,t}$, the corresponding aggregates of these variables become:

$$C_t = \frac{\Psi_t}{(1+v)(1+\beta)}, \quad S_t = \frac{\beta\Psi_t}{1+\beta}, \quad D_t = \frac{R_t S_{t-1}}{1+v}.$$

2.2 Labor market structure

At each period t, the constant workforce (expressed in efficient labor units) consists of two types of agents, who live for two periods: high-educated workers $Q_{h,t}$ and low-educated workers $Q_{l,t}$ whereby high education is considered to be any tertiary degree (or assimilated)[8]. As in a recent strain of the immigration literature (see Ottaviano and Peri, 2008, 2012; Docquier *et al.*, 2010) the low-educated labor force is represented by a nested CES function. This allows to take into account imperfect substitution between immigrants and native workers. Low-educated labor, $Q_{l,t}$, is thus:

$$Q_{l,t} = \left[\theta_n N_t^{\frac{\sigma_N - 1}{\sigma_N}} + (1-\theta_n)\,(M_t + I_t)^{\frac{\sigma_N - 1}{\sigma_N}}\right]^{\frac{\sigma_N}{\sigma_N - 1}}$$

In order to remain consistent, high-educated workers are also expressed in efficient labor units. It is assumed that highly-educated natives ($N_{h,t}$) and immigrants ($M_{h,t}$) are perfect substitutes with:

$$Q_{h,t} = [\theta_e N_{h,t} + (1-\theta_e)\,(M_{h,t})]$$

In order to simplify the analyses, both types of agents have the same productivity and are therefore paid the same wage rate. It is thus assumed that the relative labor productivity level θ_e=0.5. The total number of high-educated workers is henceforth noted as $H_t = N_{h,t} + M_{h,t}$.
A low-educated j-type agent is distinguished through her origin, where N_t is the number of native workers, M_t and I_t the number of legal and illegal immigrants present in the labor market. The low-educated immigrants are all

[8] Given the structure of the OLG models and the constant population assumption, the number of retired agents living in the economy at each period t equals the number of working-age agents.

perfect substitutes, the only difference being the illegal status for a fraction of them[9]. The parameter θ_n represents the relative labor productivity level of native workers and σ_N is the elasticity of substitution between the native and immigration workforce. Following Docquier *et al.* (2010), total labor is expressed in efficiency units as a nested CES function of the high-($Q_{h,t}$) and low-educated workers ($Q_{l,t}$):

$$Q_t = \left[\theta_h Q_{h,t}^{\frac{\sigma_H - 1}{\sigma_H}} + (1-\theta_h) Q_{l,t}^{\frac{\sigma_H - 1}{\sigma_H}}\right]^{\frac{\sigma_H}{\sigma_H - 1}}$$

with θ_h being the relative productivity of high-educated workers and σ_H the elasticity of substitution between the two education groups (which are imperfect substitutes).

2.3 Profit maximization

The production is represented by a Cobb-Douglas function, using capital K_t and the labor quantity expressed in efficient units Q_t[10]. Capital is given by the total savings of the previous period such that $K_t = S_{t-1}$[11] and full depreciation is assumed.

$$Y_t = AK_t^{\alpha} Q_t^{1-\alpha}$$

The typical firm maximizes profits, which are then distributed to the capital owners in order to remunerate their savings.

$$\max_{N_h, M_h, N, M, I} \pi = AK_t^{\alpha} Q_t^{1-\alpha} - w_{h,t} H_t - w_{n,t} N_t - w_{m,t}(M_t + \gamma I_t)$$

Legal workers are assumed to be completely mobile such that the respective segments of the labor market are perfectly competitive. On the other hand,

[9]The evidence in the literature relating to the substitutability between legal and illegal immigrants is quite scarce. To our knowledge, no estimates for elasticity of substitution have so far been obtained. We thus assume that legal and illegal agents are only differentiated by their status. Assuming imperfect substitution would reduce the negative effects of an amnesty on the legal immigrants.

[10]Ottaviano and Peri (2008) argue that the implication of the Cobb-Douglas functional form leading to the same degree of substitutability between capital and each type of workers can be defended. They find that the results of Krusell *et al.* (2000) (who state that physical capital complements highly educated and substitutes lower educated workers) would imply the income share of capital to increase over time following “the large increase in supply and income share of highly educated” in the U.S. (Ottaviano and Peri, 2008). This, they say, has however not been observed.

[11]The capital market is assumed to be perfect in the sense that the savings of illegal agents serve the capital accumulation. In other words, it is assumed that illegal agents can place their savings at an interest factor R_t. This rather strong assumption does not influence the intuition of the results. In the short term capital, is fixed and thus assuming imperfect access to capital markets only implies a level effect. In the long run, the capital stock does, in that case, not only change due to the variations in disposable income but also due to the additional capital belonging to the regularized. An amnesty therefore has one additional positive effect in the presence of imperfect capital market access.

illegal workers might be restrained on their mobility[12] due to the lack of proper documentation, lower information about employment possibilities or networks concentrated in certain sectors (Massey, 1987). Thus, the market for illegal immigrants might not be perfectly competitive and the latter can be paid a fraction $\gamma \leq 1$ of the legal immigrant's wage rate. Hence, when $\gamma < 1$, the illegal worker receives a remuneration below her marginal productivity such that her employer extracts a marginal profit on her. This allows to take into account the assumption that illegal immigrants can be exploited by their employer and receive a lower wage due to their illegal status (Rivera-Batiz, 1999)[13]. The wage rates[14] are given by the following first order conditions:

$$\begin{aligned}
w_{h,t} &= 0.5\,(1-\alpha)\,\theta_h \frac{Y_t}{Q_t}\left(\frac{Q_t}{Q_{h,t}}\right)^{\frac{1}{\sigma_H}} \\
w_{n,t} &= (1-\alpha)\,(1-\theta_h)\,\theta_n \frac{Y_t}{Q_t}\left(\frac{Q_t}{Q_{l,t}}\right)^{\frac{1}{\sigma_H}}\left(\frac{Q_{l,t}}{N_t}\right)^{\frac{1}{\sigma_N}} \\
w_{m,t} &= (1-\alpha)\,(1-\theta_h)\,(1-\theta_n)\,\frac{Y_t}{Q_t}\left(\frac{Q_t}{Q_{l,t}}\right)^{\frac{1}{\sigma_H}}\left(\frac{Q_{l,t}}{M_t+I_t}\right)^{\frac{1}{\sigma_N}} \\
w_{i,t} &= \gamma w_{m,t}
\end{aligned} \tag{5}$$

Profit is redistributed to the capital owners such that the interest factor can be defined as:

$$R_t = \frac{Y_t}{K_t}\left(\alpha + (1-\alpha)\,(1-\gamma)\,(1-\theta_h)\left(\frac{Q_{l,t}}{Q_t}\right)^{\frac{\sigma_H-1}{\sigma_H}}(1-\theta_n)\left(\frac{M_t+I_t}{Q_{l,t}}\right)^{\frac{-1}{\sigma_N}}\frac{I_t}{Q_{l,t}}\right) \tag{6}$$

Given that firms might pay illegal immigrants below their marginal productivity, the interest factor (which can be written as $R_t = \frac{\alpha Y_t + (1-\gamma) I_t w_{m,t}}{K_t}$) has a premium over the factor that would prevail with a perfectly competitive labor market (with $\gamma = 1$) $R_t = \alpha \frac{Y_t}{K_t}$.

2.4 The public budget

Income taxation and the value added tax on consumption, collected at the respective rates of τ_t and υ, constitute the public resources. The VAT rate

[12]In fact, Kossoudji and Cobb-Clark (2002) state that the IRCA's amnesty provisions impacted on the wages of legalized workers mainly by improving their labor mobility, allowing them to access better-paid jobs.

[13]As mentioned previously, the discrimination of the illegal workers is operated through two parameters: lower wage earned given by the fraction γ and constrained access to public funding Θ. Furthermore, they are not subjected to labor income taxation.

[14]Note that high-educated workers receive the same wage rate with no distinction of origin such that $w_{h,t} = \frac{\delta \Pi_t}{\delta N_{h,t}} = \frac{\delta \Pi_t}{\delta M_{h,t}}$.

is assumed to be constant over time whereas the income tax rate is adjusted in order to maintain a budget balance at every period t. Public expenditures consist of constant structural spendings G and per capita transfers g. Thus, rearranging the constraint yields the income tax rate that balances the budget:

$$\tau_t = \frac{g\left(H_t + N_t + M_t + \Theta I_t\right) + G - v\left(C_t + D_t\right)}{H_t w_{h,t} + N_t w_{n,t} + M_t w_{m,t}}. \tag{7}$$

The presence of illegal workers in the economy is not neutral to the public budget. In fact, although these agents do not pay income taxation, they contribute through the value added tax levied on consumption. On the other hand, they perceive some public transfers, even though they are only entitled to a fraction (Θ) of the legal agents' transfers.

3 The effects of an amnesty, immigration and deportation

This section focuses on the consequences of an amnesty, which allows illegal immigrants, who already play a role in the economy (through effects on the labor market and the public budget) to apply for a regularization of their illegal situation[15]. In order to extend the analysis to the immigration and deportation cases, a general notation for the change in the foreign workforce is used. Starting with a (constant) immigrant population of $M_{T-1} + I_{T-1}$, a policy shock occurs at the beginning of period T[16]:

$$M_T = M_{T-1} + \epsilon M_{T-1} + \eta I_{T-1} \quad \text{and} \quad I_T = I_{T-1}\left(1 - \eta - \delta\right) \tag{8}$$

and thus,

$$M_T + I_T = M_{T-1}(1+\epsilon) + I_{T-1}\left(1 - \delta\right) \tag{9}$$

In general terms, η is the fraction of legalized illegals, δ is the fraction of deported illegals and ϵ is used to express an increase in legal migration (as a fraction of the stock present at the steady state). The benchmark amnesty model is recovered when $\delta = \epsilon = 0$ and an exogenous fraction $0 < \eta \leq 1$

[15] In order to simplify the analysis, it is assumed that the illegal status causes a disutility which is so high that an illegal agent always prefers to be legalized (see equation (1))

[16] Given the structure of the two-period OLG model, the immigrant population affected by the shock in period T is not the same as the one present at $T-1$. However, if the economy is supposed to be at the steady state in $T-1$, considering an amnesty at period T allows to highlight the different effects that this measure causes. Stated differently, two alternative outcomes are compared for the generations living in T: the outcome with amnesty can be contrasted to the steady state, in which the agents born in T would live, had the amnesty not occurred.

of the applications end in legalization[17]. Thus, the size of the workforce remains intact. In case of success, the legalized worker earns a higher gross wage (if she was being paid below the marginal productivity) and receives more transfers although at the same time she becomes subject to income taxation.
A possible extension is to consider that a fraction of unsuccessful applicants are deported. With $\epsilon = 0$ and $\delta \geq 0$[18], deportation occurs and labor in efficient units decreases (see Appendix A). Furthermore, a third scenario of a migratory shock implying a rise in the total labor force is explored by setting $\eta = \delta = 0$ and $\epsilon > 0$.

3.1 Short run effects with constant population[19]

In the benchmark scenario, where $\eta > \delta = \epsilon = 0$, the amnesty is implemented in period T and no deportation occurs. Furthermore, in order to extract the effects of an amnesty, the economy is assumed to start at the steady sate in period $T-1$ [20]. In the short term, the capital stock K_T is predetermined, as it was constituted by the agents' savings of the previous period. Hence, there is no effect on the population size, on the production or on the wage rates (given the assumption of perfect substitutability). However, the fraction η of immigrants, whose situation is regularized, now receives the same wage and transfers as the legal immigrants (instead of just the fraction γ they would perceive as illegal workers) which leads to a change in the interest factor (through relation (6)):

$$\Delta R_T = \frac{-\eta(1-\gamma)I_{T-1}w_{m,T}}{K_T} \tag{10}$$

The numerator in (10) expresses the change in the profit caused by an amnesty, which is exclusively due to the suppression of wage discrimination against the legalized immigrants. In the presence of status discrimination on the labor market (with $\gamma < 1$), the interest factor is certain to decrease. In the case of perfectly competitive markets (with $\gamma = 1$), no effect occurs on profits thereby leaving the interest factor unchanged. Thus, the discrimination that illegal workers face on the labor market plays an important

[17] As individuals are homogeneous, it follows that if one illegal agent applies for amnesty, so do all the others. However, only an exogenous fraction η is successful. Without loss of generality, it can be assumed that individuals are chosen randomly until the fraction of legalization is met.

[18] η might take any value in this case, such that the extreme scenario of pure deportation with $\eta = 0$, where no illegal immigrant is regularized, can be studied.

[19] The detail for the subsequent results can be found in Appendix B.

[20] All the following analysis compare the amnesty scenario (in T) to the starting steady state in period $T-1$. Thus, the impact of an amnesty on any variable x is measured by the difference between its value with and without amnesty $\Delta x_T = x_T - x_{T-1}$.

role: the less discriminative is the labor market against legal status, the less profit is affected by the amnesty. Moreover, the higher is the number of regularized illegals ηI_t, the stronger is the impact on the return factor.
A second short run effect of the amnesty concerns the public budget. The taxable income base increases unambiguously by the exact amount of the regularized workers' wage. Secondly, taxation on consumption is affected. However, the direction of this change is a priori undefined, as the old generation's consumption might be reduced (compared to the steady state), while the variation in the working agents' consumption depends on the evolution of the taxation rate. The change in total consumption ($\Delta C_T + \Delta D_T$) is thus related to the evolution in the aggregate disposable income ($\Delta \Psi_T$) and the interest factor (ΔR_T):

$$\Delta C_T + \Delta D_T = \frac{\Delta \Psi_T}{(1+\beta)(1+v)} + \frac{\Delta R_T S_{T-1}}{1+v} \tag{11}$$

In the short term, given the constant population, the disposable income of a legal j-type agent changes only due to the variation in income taxation (since $w_{j,T} = w_{j,T-1}$):

$$\Delta \psi_{j,T} = -\Delta \tau_T w_{j,T}$$

The impact of the amnesty on the taxation rate is given by the net cost of the legalized individuals and the policy's impact on revenues from the value added tax on consumption:

$$\Delta \tau_T = \frac{\eta I_{T-1}(g(1-\Theta) - \tau_T w_{m,T}) - v(\Delta C_T + \Delta D_T)}{W_{T-1}}, \tag{12}$$

with $W_{T-1} = H_{T-1} w_{h,T-1} + N_{T-1} w_{n,T-1} + M_{T-1} w_{m,T-1}$ being the taxable income base (which is constant). The importance of discrimination must be stressed out. The higher is pre-amnesty discrimination (the lower is Θ), the higher is the regularization's effect on the income tax rate. Discrimination in wage rates enters this equation through its impact on total consumption due to the change in aggregate disposable income. Furthermore, the number of regularized illegals is also determinant. Using (10) and (11) in (12) it is possible to rewrite the taxation rate as:

$$\Delta \tau_T = \frac{\eta I_{T-1}}{W_{T-1}} \left(\Delta \psi^{\ell}_{i,T} - \frac{w_{m,T}\,(1-\gamma)\,(1+\beta)}{1+\beta+\beta v} \right) \tag{13}$$

with $\Delta \psi^{\ell}_{i,T} = w_{m,T}(1-\gamma-\tau_T) + g(1-\Theta)$. Equation (13) implies that an amnesty reduces the income tax rate (and thereby increases the disposable income of the legal workers) if the income gains for the legalized agents do not exceed a certain threshold. If this condition does not hold (and $\Delta \tau_T$ is positive), all the legal workers in the economy are likely to suffer a welfare loss given that a lower disposable income is added to a potentially reduced post-amnesty interest factor. The change in aggregate disposable income depends on the improvement of illegal immigrants' revenues and its impact on income taxation:

$$\begin{aligned}\Delta\Psi_T =& \eta I_{T-1}\left[\left(1-\tau_T-\gamma\right)w_{m,T}+g(1-\Theta)\right]-\Delta\tau_T(W_{T-1}) \\ =& \frac{\eta I_{T-1}w_{m,T}(1-\gamma)(1+\beta)}{(1+\beta+\beta v)}\end{aligned} \tag{14}$$

From equation (14) it can be noted that the aggregate disposable income is certain not to decrease even under the circumstance of a higher taxation rate. A potential decrease in the (formerly) legal workforce's aggregate disposable income (due to higher income taxation) is thus more than compensated by the rise in legalized workers' income. Given that savings are a constant fraction of the disposable income, capital accumulates if the aggregate disposable income increases.

3.1.1 Perfect competition ($\gamma = 1$)

The case of perfect competition on the labor market yields straightforward conclusions. As there is no discrimination ($\gamma = 1$), all the production factors are paid at their competitive rates such that there is no effect on the interest factor (equation (10)) and on the wages. Thus, the only consequences of an amnesty in the particular framework of this model would be on the public budget. With constant disposable income and interest factor, an amnesty has no effects on the value added tax income in period T and the change in the income tax rate is given by rewriting equation (13):

$$\Delta\tau_T = \frac{\eta I_{T-1}}{W_{T-1}}\left(g(1-\Theta)-\tau_T w_{m,T}\right)$$

Hence, the income tax rate increases if the net cost of a regularized agent is positive.

3.1.2 Imperfect competition ($\gamma < 1$)

If $\gamma < 1$, the legalized workers are more expensive than if they had remained discriminated illegals. Thus, profit decreases and the interest factor is reduced (see equation (10)). Therefore, the old generation living at the time of amnesty (the capital owners) suffers a welfare reduction compared to the no-amnesty scenario, as their savings yield a lower return.

The impact on the legal workers is due to the change in the income tax rate, which depends on the net fiscal cost of the legalized agents and the effect on value added tax revenues[21] (see equation (13)). When $\gamma < 1$, an

[21] Total consumption varies with the interest factor (which decreases) and with the disposable aggregate income.

income redistribution occurs from the old generation to the young through the higher wages paid to the legalized workers in exchange of a lower profit perceived by capital owners. Thus, even if the income tax rate increases, the aggregate disposable income in the economy is certain to increase and capital accumulates (see equation (14)). Summarizing, the retired agents suffer from a decrease in the interest factor and workers are affected by a change in the income tax rate. However, capital is certain to increase which triggers new dynamics in the model (see section 3.3).

3.2 Short run effects with a shock on the population

The capital stock remains constant in the short run but a shock on the population size and structure leads to a change in the wages represented by $\Delta w_{j,T} = w_{j,T} - w_{j,T-1}$ (effect which was absent in the benchmark scenario with constant population). Two scenarios are considered with changing population size: deportation, when a fraction $\delta > \epsilon = 0$ of the rejected applicants is expelled and (low-educated) immigration, where $\epsilon > \delta = \eta = 0$. In order to contrast these scenarios with the benchmark case, it is necessary to reconsider the results of the previous section. More specifically, wages are no longer constant when population size varies and the change in the regularized agents' disposable income is given by:

$$\Delta\psi_{i,T}^{\ell} = (1-\tau_T)w_{m,T} - \gamma w_{m,T-1} + (1-\Theta)g$$

whereas all the remaining j-type agents (for $j \neq i^{\ell}$) are faced with

$$\Delta\psi_{j,T} = (1-\tau_T)\Delta w_{j,T} - \Delta\tau_T w_{j,T}.$$

For the legalized workers, the effects of a policy shock are reflected by the change in the wage and the net transfers perceived while the legal workers need to additionally take into account the impact on the income tax rate. The return factor is affected by additional ambiguous effects as the agents' wages are influenced by the shock on the population structure:

$$\Delta R_T = \frac{\Pi_T - \Pi_{T-1}}{K_T} = \frac{\alpha(Y_T - Y_{T-1}) + (1-\gamma)I_{T-1}[\Delta w_{m,T} - (\eta+\delta)w_{m,T}]}{K_T} \tag{15}$$

Compared to equation (10), the first term in the numerator takes into account the effects caused by the change in the number of workers on total production. The second term contrasts the variation in benefits made with the illegal workforce with the loss due to the exit of certain workers from the illegal workforce (either regularized or deported). Rearranging, the following relations can be extracted:

$$\text{If} \quad \frac{w_{m,T}}{w_{m,T-1}} > \frac{1}{1-\eta-\delta} \quad \text{, the second term is positive} \tag{16}$$

$$\text{If} \quad \frac{w_{m,T}}{w_{m,T-1}} < \frac{1}{1-\eta-\delta} \quad \text{, the second term is negative} \tag{17}$$

The benchmark expression is recovered when the population structure is unaffected (with $\eta > \delta$=0, constant production and wages).
In the presence of a population size effect, the income tax rate changes with:

$$\Delta\tau = \frac{g(\epsilon M + \eta I - (\delta+\eta)\Theta I) - \tau_T \Delta W_T - v(\Delta C + \Delta D)}{H w_{h,T-1} + N w_{n,T-1} + M w_{m,T-1}} \tag{18}$$

In contrast to equation (12), the change in the taxable income base is accounted for by ΔW_T (with $\Delta W_T = H_{T-1}\Delta w_{h,T} + N_{T-1}\Delta w_{n,T} + M_{T-1}\Delta w_{m,T} + (\epsilon M_{T-1} + \eta I_{T-1}) w_{m,T}$). Moreover, the first term in the numerator has to be readjusted to consider the change in the composition of the population entitled to transfers. Further conclusions depend particularly on the evolution of efficient labor units Q_T and thereby on the scenario considered. However, a larger taxable income base (with ΔW_T >0) reduces the income tax rate. The presence of discrimination against the illegal workers on the labor market (with $\gamma < 1$) is again not neutral in this framework. Note that the change in a legalized agent's wage depends on two factors: the impact on the marginal productivity, which is common to all workers and the suppression of wage discrimination (if $\gamma < 1$). Therefore, if deportation is possible, the firms might lose workers which are being paid below their marginal productivity such that deportation can be particularly harmful for capital owners (see equation (15)). When markets are perfectly competitive, no extra profits are made due to exploitation such that the effect on the interest factor is exclusively due to the change in the population size and structure.

3.2.1 The case of deportation

The risk of deportation[22] for a fraction δ of the applicants is introduced. If labor in efficient units Q_T decreases due to deportation, a reduction in the educated workers' wage ($\Delta w_{h,T} < 0$) and a rise in the low-educated workers' wage rates ($\Delta w_{n,T} > 0$ and $\Delta w_{m,T} > 0$) are to be expected (see Appendix A). The lower efficient labor Q_T is compensated by higher marginal productivity due to the reduction in the number of close substitutes. The variation of a j-type agent's disposable income also depends on the effect of deportation on the taxation rate. The latter is affected by a potentially lower additional burden on the public funds than in the benchmark case (illustrated by the first term in the numerator of equation (18)). In particular, this is true if it is assumed that no illegal immigrants are regularized but some are deported (e.g. $\eta = 0$ and $\delta > 0$). Considering the change of the interest factor, the first term in the numerator of equation (15) is negative, as production increases in Q_T. The second term depends on the relation in equation (17), which can be shown to hold in the case of full deportation

[22]Note that no cost is incurred to expel illegal immigrants and, in that case, the latter keep a utility $\bar{U}$ (which is lower than the utility of remaining in the country). Without loss of generality, $\bar{U}$ can be set to 0.

(δ=1). Thus, if all the illegal workers are expelled, profits would be reduced and even more so than in the case of an amnesty due to the negative effect on production. A priori, nothing allows to discuss the variation in taxable income (ΔW_T) and total consumption reflected in the third term of equation (18). Thus, further conclusions are impossible and numerical examples are provided in section 5 to allow for clearer insights.

3.2.2 The case of new legal immigration

The case of new immigration with $\epsilon > \eta$=δ=0 implies a positive shock on the size of the legal foreign low-educated workforce (while the number of illegal workers remains unchanged). Under this scenario, Q_T increases and opposite effects to the deportation case are observed such that $\Delta w_{h,T}$ is positive whereas $\Delta w_{n,T}$ and $\Delta w_{m,T}$ are negative (see Appendix A).
The interest factor in this scenario increases if the rise in production dominates the decrease in the wage rate of migrant workers $w_{m,T}$ (relation 17 holds). In any case, the shock on the interest factor is expected to be less negative than under an amnesty, such that the old generation living in the period of the shock is better off in the case of new immigration than with an amnesty.
The effect on the income tax rate is again ambiguous due to the new immigrants' access to complete transfers but simultaneous contribution through taxation. The additional burden on public funds is higher than in the benchmark, given that the formerly illegal workers were already perceiving part of the transfers. The effect on total consumption is ambiguous and it is not clear whether the taxable base increases more than in the case of an amnesty which strongly depends on the skill repartition of the population.

3.3 Long run effects

Any of the shocks considered in the previous subsections is by assumption a one-time shock ("one-shot" policy) and no further changes in the population occur after the shock[23]. Thus, the long run effects in any of the three scenarios depend solely on the capital dynamics caused by the policy. The difference in utility for two subsequent generations is therefore exclusively due to the different capital levels and its implications (on income and taxation).
In the post-shock periods the disposable income of a j-type agent adjusts compared to the previous generation:

$$\Delta\psi_{j,T+p} = (1-\tau_{T+p})\Delta w_{j,T+p} - \Delta\tau_{T+p} w_{j,T+p-1} \quad \textit{with } p \geq 2 \tag{19}$$

[23]Given the constant population structure, the value of γ does not influence the results after period T.

The change in the wage rate (the interest factor) is positively (negatively) correlated to the evolution of the capital level, given the constant population assumption. In the benchmark amnesty scenario, capital was shown to increase due to equation (14), leading to a higher gross wage and a lower interest factor for the following generations. The effect on the taxation rate however remains ambiguous. Indeed, even if gross wages increase, the old generation faces a lower interest factor such that the evolution of their consumption remains uncertain:

$$\Delta D_{T+p} = \frac{\Delta R_{T+p} S_{T+p-1} + R_{T+p-1} \Delta S_{T+p}}{1+v}$$

Consequently, the change in income taxation remains ambiguous (see Appendix B.5):

$$\Delta \tau_{T+p} = -\frac{v(\Delta C_{T+p} + \Delta D_{T+p}) + \tau_{T+p-1} \Delta W_{T+p}}{W_{T+p}} \tag{20}$$

The income tax rate decreases if the taxable income base increases and the rise in the young generation's consumption outweighs the potential decrease in the old generation's consumption. However, the conclusion on the taxation rate remains ambiguous and prevents a clear statement on the evolution of a j-type agent's disposable income (given by equation (19)).

On the one hand, if aggregate disposable income decreases, as it can possibly be the case under the deportation scenario, lower capital accumulation implies a decreasing trend on the wage rates and an increasing trend on the interest factor. On the other hand, the opposite occurs if aggregate disposable income increases, as it may happen under new immigration inflow. In any case, further conclusions are not possible and therefore numerical simulations must be considered.

4 The small open economy

In a small open economy (with no labor mobility between countries), the interest rate is dictated by the international capital markets such that the interest factor $\bar{R}$ is fixed. This implies that the capital labor ratio is given by:

$$\frac{K_t}{Q_t} = \left[\frac{A}{\bar{R}} \left(\alpha + Z_1 (1-\gamma) \left(\frac{Q_{l,t}}{Q_t} \right)^{\frac{\sigma_H - 1}{\sigma_H}} \left(\frac{M_t + I_t}{Q_{l,t}} \right)^{\frac{-1}{\sigma_N}} \frac{I_t}{Q_{l,t}} \right) \right]^{\frac{1}{1-\alpha}} \tag{21}$$

with $Z_1 = (1-\alpha)(1-\theta_h)(1-\theta_n)$.

In this framework, capital flows into or out of the country until the interest rate equalizes the one prevailing on the international capital markets.

Thus, the capital stock in a certain period is no longer predetermined by the savings of the previous generation. Instead, capital movements must be taken into account until:

$$\bar{K}_t = S_{t-1} + B_t \tag{22}$$

where B_t is the net capital inflow. In a small open economy, an amnesty does not change the interest factor such that the old generation living in period T is not hit by the shock. However, the capital stock is adapted in order to reflect the change in the population structure.

$$\left(\frac{K_T}{Q_T}\right)^{1-\alpha} - \left(\frac{K_{T-1}}{Q_{T-1}}\right)^{1-\alpha} = Z_1(1-\gamma)I_{T-1}(\Delta J_T - \delta J_T) \tag{23}$$

with $J_T = Q_T^{\frac{1}{\sigma_H}-1} Q_{l,T}^{\frac{1}{\sigma_N}-\frac{1}{\sigma_H}} (M_T + I_T)^{\frac{-1}{\sigma_N}}$ and $\Delta J_T = J_T - J_{T-1}$.

In the absence of positive profits (with γ=1), the capital stock adjusts in order to maintain a constant capital labor ratio (in efficient units), whatever the values of η and δ. The gross wages nevertheless change depending on the considered scenario's effect on the efficient labor structure (see equation (5)). The change in the income tax rate introduces a dynamic in the disposable income (which is similar to the one presented for the closed economy). Therefore, the repartition of the capital used in the economy between residents and foreigners, through capital inflow, changes. The process continues until a new equilibrium is reached.

On the other hand, when $\gamma < 1$, the capital labor ratio changes in period T due to the reduction in extra profits thereby affecting the wage rates. From equation (23) it can be inferred that the capital labor ratio decreases in the case of an amnesty (with ΔJ_T=0 and $\delta > 0$). An amnesty in a small open economy with a constant labor force expressed in efficient units leads to a lower capital labor ratio and thus a lower capital stock. This in turn reduces gross wages which leads to higher income tax rates. Immigration inflow (with $\Delta J_T < 0$ and $\delta = 0$) reduces the capital labor ratio but the magnitude is lower than in the case of an amnesty. Labor in efficient units is certain to increase while the change in capital stock is undetermined and depends on the structure of the population.

In the case of deportation, a lower capital labor ratio is obtained when $\Delta J_T < \delta J_T$, which is to be expected[24]. Given that in this case labor in efficient units is below the steady state level, the capital stock must be lower too.

The consequences of these different policies under the open economy framework depend on the structure of the population (through the policies' effects

[24]In fact, in equation (23) ΔJ_T is marginal and thus the second term (and the value of δ) should be determinant for the sign and magnitude of the change in the capital labor ratio.

on wages perceived) and are thus not defined a priori. In the long run, the capital labor ratio remains constant but the balance of payments adjusts due to the change in income taxation until the new equilibrium is reached. Thus, the temporal dynamic is lead by the income tax rate (see equation (12)).

5 Simulations

This section provides a series of numerical simulations in order to illustrate the theoretical results. One period is assumed to last 30 years. The discount factor is $\beta = 0.3$, which amounts to a quarterly discount factor of 0.99 and the capital's share of output, α, is set to 0.3 as it is common in the literature. The data used was gathered from OECD datasets and the reference year is 2002 due to restrictions on data availability (in particular for relative wages and the distribution of immigrant's educational attainments). The workforce size is estimated by OECD's labor force data (OECD, 2010a) which distinguishes agents by origin and educational attainment[25]. The estimates for the illegal workers are taken from the report of Kovacheva and Vogel (2009b). A value between the extrema shown in Table 1 is taken for the UK while in the case of Germany, a recent downward correction suggests that the number of illegals is well below the maximum reported in Table 1 (Kovacheva and Vogel, 2009a). The number of illegals is varied in section 5.3 in order to highlight its impact.
The elasticities of substitution used are those provided by the literature. The estimates for σ_H range from 1.3 (Borjas, 2003) and 1.5 (Katz and Murphy, 1992) to 2 (Angrist, 1995). Similarly, the substituability between native and foreign agents belonging to the same group is largely debated in the literature. Depending on the assumptions and data used, values ranging from 6 (Manacorda *et al.*, 2008) over 20 (Ottaviano and Peri, 2012; Card, 2009 for the US and D'Amuri *et al.*, 2010 for Germany[26] to infinity (Borjas *et al.*, 2008) are found. Our benchmark estimation is done with the intermediary values for the elasticities with respectively $\sigma_H = 1.5$ and $\sigma_N = 20$, as a high but imperfect substituability seems to better fit the European (and particularly the German) labor market. The relative productivity parameters for highly educated agents (θ_h) and native low-educated (θ_n) are calibrated in

[25]The educated agents are those classified as LIS5/6 in OECD datasets, which represents tertiary education. Workers for which the education level is known but not the citizenship are counted as immigrants. Given the structure of the OLG-model, the population size at period t is equal to the sum of the workforce and the old generation, born one period earlier. The total population is thus assumed to have the same skill-structure as the workforce.

[26]For workers without tertiary education in Germany, Brücker and Jahn (2011) estimate the elasticity of substitution between 3 and 18 depending on the education level considered while Felbermayr *et al.* (2008) find values ranging from 7 to 28.

order to replicate the tertiary education wage premia of male workers (of 46.3 % in Germany and 62.9 % in the UK) provided by Strauss and de la Maisonneuve (2007). Simultaneously, we consider the existence of a small wage premium for citizenship in order to take into account easier labor market access due to language proficiency and better adaptation to the labor market conditions. The resulting values for Germany (θ_h^D=0.41; θ_n^D=0.53) result in a citizenship premia of 6 % while the parameters ($\theta_h^{UK} = 0.439$; $\theta_n^{UK} = 0.54$) yield a premia of 4.8 % in the UK. Economic data for the year 2002, like the gross domestic product, is obtained from OECD (2011). Total tax revenue provided by OECD (2010d) is used as proxy for the governmental expenditures. Public funds are either distributed under the form of transfers or used for structural spending, which does not directly affect the agents' income and utility. A generous transfer system implies a lower structural expenditure (in percentage terms). The constant per capita transfer is assessed by using data from OECD (2010b) on the total social spending as percentage of GDP (ϕ) and is thus written:

$$g = \frac{\phi Y}{H + M + N + \Theta I} \tag{24}$$

The value added tax rate is calculated in order to proxy tax income on goods and services (in % of gdp) provided by OECD (2010c). The value added tax rates obtained are 13.6 % and 16.2 % respectively for Germany and the UK. Finally, the income taxation rate is set to maintain the budget equilibrium. It is therefore expected to exceed the rates observed in reality given that the model abstracts from capital taxation and does not include public debt. As shown in Table 2, the resulting values are 36.79 % for Germany and 33.76 % for the United Kingdom.

Two further important parameters are the wage discrimination and the illegal agents' access to public transfers. The first is set to $\gamma = 0.7$[27]. In order to reflect the idea that illegal immigrants impose a cost on the budget, $\Theta = 0.3$ is used.

As discussed in the theoretical section, the extent of status discrimination, and in particular the proportion of transfers to which an illegal agent qualifies for, are of crucial importance. The latter is hardly quantifiable as, by definition, illegal immigrants are in general not entitled to public support. Nevertheless, in many western countries several exceptions exist like very urgent medical care provision or children's school enrollment. However, some

[27] In the literature, which often focuses on the United States, the estimation of wage functions for legalized and legal foreign-born population permits to extract the role of the legal status in the wage formation. Kossoudji and Cobb-Clark (2002) estimate, from panel data on legalized immigrants, a wage penalty of 14 % to 24 % for undocumented workers due to their status. Taking into account national origins, Borjas and Tienda (1993) find that the legal workers earn up to 30 % higher wages in similar positions while this figure rises to 41.8 % in Rivera-Batiz (1999).

countries like Germany impose their public workers to report any information about illegal immigrants that would occur to them, whereas this is not the case in Belgium or France (PICUM, 2011). This kind of regulation is very likely to discourage illegal immigrants from applying for public support. In order to highlight its impact, we will vary the extent of support availability in a later section[28].

In the benchmark case it is assumed that all the countries regularize 100 % of their illegal workers (η=1; δ=ϵ=0). Even though a hundred percent legalization rate is never observed in reality (Levinson, 2005), this scenario allows to highlight the potential upperbound effects of an amnesty. Table 2 summarizes the countries' characteristics and the model's prediction.

[Insert Table 2 here]

5.1 The effects of an amnesty on the native population

In the following section, the elasticities of substitution considered are $\sigma_H = 1.5$ and $\sigma_N = 20$. In section 5.3 the sensitivity of the results to these parameters is assessed. Figure 1 shows the evolution of the utility, normalized to a constant lifetime consumption. More specifically, utility is monetarized by computing the constant amount of consumption z_t that generates the lifetime utility level U^t for each agent of type j born in period t:

$$U^t = ln(z) + \beta ln(z)$$
$$z = exp^{\frac{U^t}{1+\beta}}$$

and is normalized to an index 100 for the steady state value of the generation born in $T-2$.

[Insert Figure 1 here]

In general, an amnesty has limited effects on the native population, with the variation of lifetime consumption remaining between -0.3 % and +0.1 % and -0.5 % and 0 % for the UK and Germany respectively. Independently of the country considered and the agent's education level, the old generation living at the period of the shock (which is the generation born in $T-1$) suffers a welfare reduction due to the lower interest factor (as shown in the theoretical analysis). However, a difference is observed for the agents born in period T. In the UK, their utility is slightly higher than the previous generation's because the positive contribution of the regularized agents to the public budget partially compensates the lower wage and interest factor that the amnesty causes. In Germany, this does not occur and the utility

[28] Further details and country specific analysis of illegal immigrants' basic rights are provided on the web page of the Platform For International Cooperation On Undocumented Migrants (PICUM, 2011).

of the agents born in period T is lower than their predecessors'. At the new equilibrium, native agents are better off in the UK while German natives have a welfare level around 0.1 % to 0.2 % below the inital steady state.
It can be seen that an amnesty decreases the income tax rate in both countries by close to 0.3 percentage points (pp.) (see Figure 2). Thus, the regularized agents would reduce the tax burden of the native agents in the given examples. Nevertheless, this positive effect on the taxation rate is not enough to compensate for the lower wages in Germany such that native agents still suffer from a slightly lower utility (as shown in Figure 1). The conclusions for the high-and low-educated agents are quite similar, although the effects on the former are more pronounced. A possible explanation is that the high-educated agents perceive higher wages and thus benefit from a stronger disposable income increase when the (agent-type independent) income tax rate falls.

[Insert Figure 2 here]

5.2 Amnesty versus new immigration and deportation

The effects of a regularization are contrasted with the cases of new (legal) immigration and deportation of low-educated workers. To highlight the differences of these policies, the cases of the UK and Germany are considered in Figure 3. The change in the number of workers at time T constitutes the difference between the benchmark model and these two extensions. The shocks considered are of the same magnitude, in order to improve comparability. In the deportation case, it is assumed that the whole illegal population is expelled (with η=ϵ=0 and δ=1). In the immigration case, the illegal group remains untouched and the legal immigrant workforce is increased by the size of the illegal workforce such that δ=η=0 and $\epsilon=\frac{I}{M}$.

In both countries, the three different policies generate similar trends in the short run. Introducing deportation decreases the size of the workforce which increases the wages paid to low-educated workers and simultaneously reduces the wages of the high-educated agents. Further, the profit decreases even more than in the benchmark case, such that the shock on the interest factor is stronger than with amnesty. The reduction in production forces outweighs any potential positive effect on the low-education wages and income taxation in both countries. Thus, the low-educated agents are worse off at the new steady state.
In contrast, an immigration inflow pushes up the profit and the interest factor, thus benefiting the agents born in $T-1$. However, the wages paid to the low-educated workers decrease due to the additional competition on the labor market such that the generation born in T is harmed. In the long run, new immigrants lead to a higher steady-state for natives in the UK while in Germany the welfare is below the starting point. Overall, the three shocks have effects of low magnitude.

[Insert Figure 3 here]

5.3 Sensitivity analysis

Figure 4 depicts how changing various key parameters or characteristics of the model affects the results for German low-educated natives. This allows to underline the role played by each parameter in the results. Panel 4a shows the importance of (pre-amnesty) social transfer access for illegal immigrants. As mentioned previously, the higher is availability of public support prior to legal status, the lower will be the effects of regularization given that the additional burden on the budget is reduced but collected taxes increase. If illegal immigrants were to receive only 1 % of the transfers prior to regularization, the low-educated natives would lose at most 1.6 % of their welfare with regularization. The role of wage discrimination is shown on panel 4b. In the absence of wage discrimination (with $\gamma = 1$), amnesty would have a pure fiscal effect by reducing the labor income tax rate and hardly change the natives' welfare. On the other hand, a high discrimination will lead to a strong profit reduction (and thus a higher shock on the interest factor) followed by a subsequently stronger capital accumulation. It can be noted that even in the presence of high discrimination, the native's utility is reduced by less than 0.5 % at the new steady state.
Panel 4c highlights the effects of amnesty for different values of transfers (as % of gdp). The 0 % line shows the case where no public funds would be used as transfers while 35.4 % would mean that all the collected money is redistributed to the agents. In this case, the new steady state utility would only be around 0.5 % below the inital value. On the other hand, if all the money is spent for public consumption (and thus not entering the utility function), the natives would benefit from the amnesty as each regularized immigrant would pay a postive contribution to the budget (given that structural expenses are constant). Panel 4d indicates that a higher value added tax rate leads to slightly worse effect on the native's utility. The reason therefore is that illegal immigrants pay the value added tax on their consumption. The higher is the rate, the lower will be their additional marginal contribution after regularization. Panel 4e shows how the results change if the number of illegals present in the economy varies. As could be expected, a low number of illegals (100.000 in our example) reduces the effects. On the other hand, if the number of illegals is doubled up to 2.000.000 individuals, the welfare loss would amount at most to 0.3 % at the new steady state. Nevertheless, the old generation living at the time of amnesty would suffer a welfare reduction close to 0.8 % of the initial steady state.
The last panel 4f uses different values for the elasticities of substitution found in the literature (see Table 2 in Docquier *et al.* (2010)). The benchmark choice ($\sigma_H = 1.5$, $\sigma_N = 6$) is contrasted to a high complementary case ($\sigma_H = 2$, $\sigma_N = 6$) and a high substitutability case ($\sigma_H = 1.3$, $\sigma_N = +\infty$).

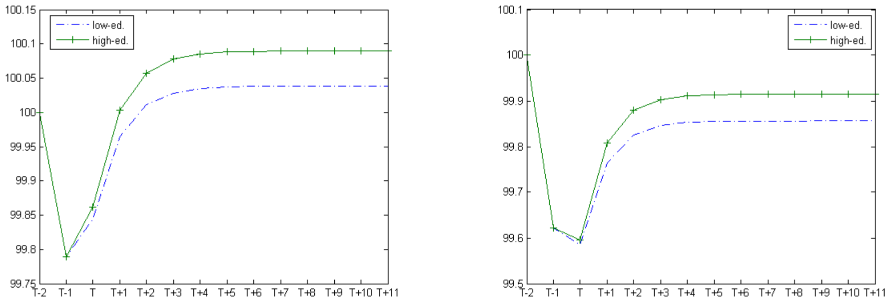
The substitutability between national and foreign workers (σ_N) is of particular importance. High- and low-educated workers remain highly complementary (with $\sigma_H \in [1.3, 2]$), whereas the substitutability among low-educated groups is considered more dispersedly (with $\sigma_N \in [6, +\infty]$). It is thus not surprising that the change in σ_N accounts for most part of the variability observed in Figure 4f. In the examples provided, the immigrants' wage rate decreases with native-foreign substitutability (see Appendix C for detailed results). The intuition behind this suggests that with a higher substitutability, a change in the workforce has a stronger short run impact on the wages.

[Insert Figure 4 here]

6 Conclusion

Discarding from displacement effects on the labor market and assuming that illegal immigrants bear a certain cost on the government's budget (without contributing through income taxation), an amnesty leads to a slight decrease in capital owners' welfare through a reduction in the return to investment. The effect on the public budget depends on the net contribution of legalized agents. The crucial question is whether a potentially positive effect is strong enough to compensate the decrease in the interest rate. Furthermore, the model predicts that, in general, consequences remain quite limited. In particular, comparing the amnesty to an inflow of legal immigrants allows to show that legalization has quantitatively lower effects than immigration. Additionally, under the studied framework, the loss in productive powers due to the deportation of workers is likely to harm native individuals. Moreover, the more native and foreign workers are complementary, the more likely an amnesty can benefit the former. Concluding, the model highlights the trade-off between harming capital-owners in the short run and potentially increasing native agents' welfare in the long run. The outcome depends particularly on the structure of the population, the economic role of the government and discrimination level that illegal immigrants face prior to the regularization.

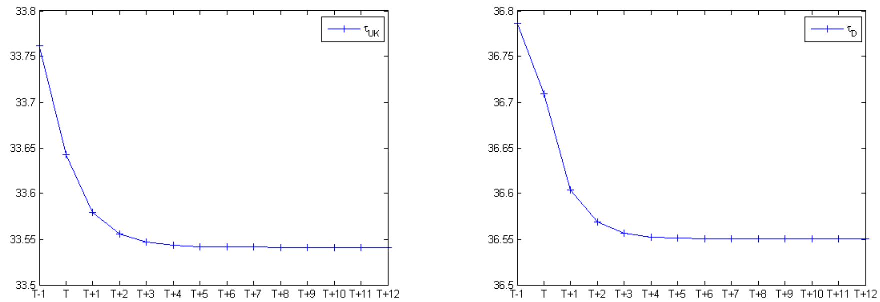
Figure 1: Effect of an amnesty on the normalized constant lifetime consumption of a low-and high-educated native agent born in period t in the United Kingdom (a) respectively Germany (b). The amnesty occurs at time T and the reference steady state utility belongs to the generation born in period $T-2$.



(a) Results for the United Kingdom

(b) Results for Germany

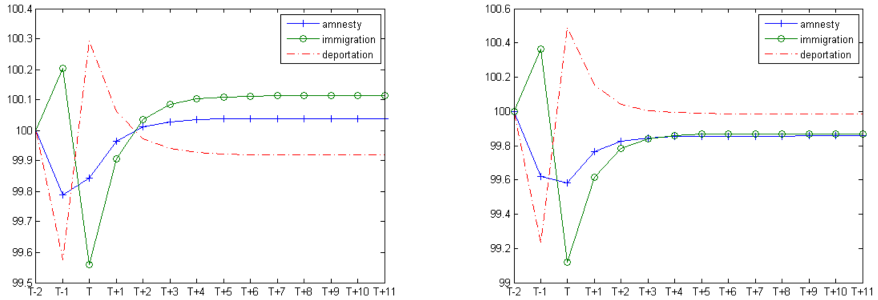
Figure 2: Evolution of the income tax rate (τ), with amnesty occurring in T



(a) Results for the United Kingdom

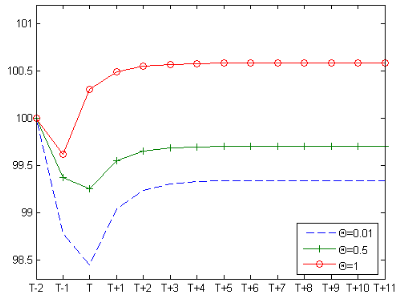
(b) Results for Germany

Figure 3: Comparison of an amnesty with new immigration and deportation on the normalized constant lifetime consumption of a low-educated native agent born in period t (amnesty occurs at time T).

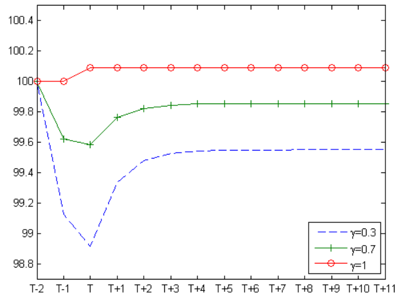


(a) Results for the United Kingdom (b) Results for Germany

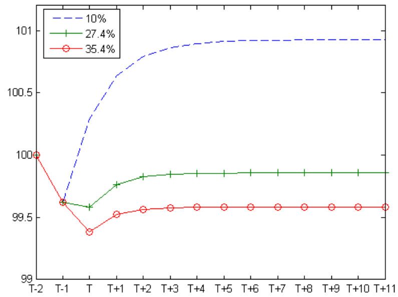
Figure 4: Sensitivity of a German low-educated native's (born in period t) welfare to a change in different parameters with amnesty occuring at time T



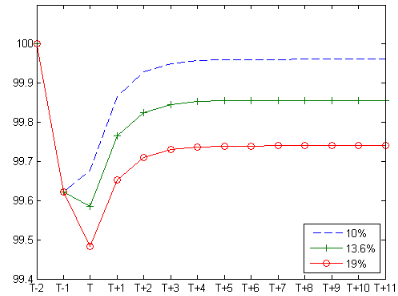
(a) Change in Θ



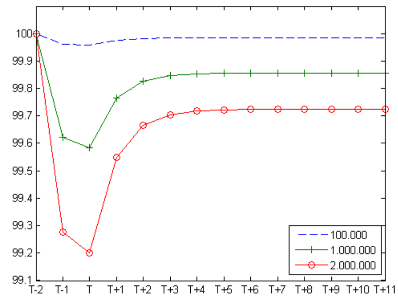
(b) Change in γ



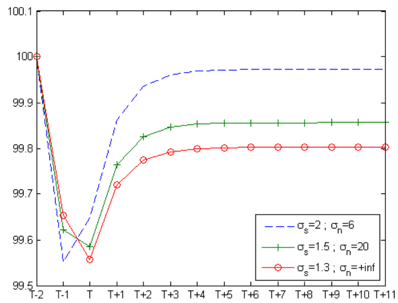
(c) Change in social transerfs (as % of gdp)



(d) Change in VAT rate



(e) Change in number of illegals



(f) Change in σ

Table 1: Illegal immigration (estimates for the year 2002) in EU15 countries (% of total immigrants)

Country	minimum estimates	maximum estimates
EU15	3059095 (14.5)	5310889 (25.2)
Austria	29660 (4)	86964 (11.9)
Belgium	90000 (10.6)	150000 (17.7)
Denmark	1000 (0.4)	5000 (1.9)
Finland	8000 (8.1)	12000 (12.2)
France	300000 (9.2)	500000 (15.3)
Germany	1000000 (13.7)	1500000 (20.5)
Greece	320000 (42)	480000 (63)
Ireland	20416 (10.9)	37538 (20)
Italy	702156 (52.6)	1000000 (74.9)
Luxembourg	2143 (1.3)	4959 (2.9)
Netherlands	77721 (11.3)	179876 (26)
Portugal	40000 (17.8)	200000 (88.9)
Spain	150000 (7.6)	572551 (29)
Sweden	8000 (1.7)	12000 (2.5)
United Kingdom	310000 (11.2)	570000 (20.7)

Source: Kovacheva and Vogel (2009b)

Table 2: Data used in the model

Country	Germany	U.K.
GDP (billion $)	2275.4	1713.7
High-educated Workers	8708855	6629768
Low-educated Natives	21300623	18583598
Low-educated Immigrants	5133470	1477352
Illegal immigrants	1000000	430000
Size of the government tax revenue (% of GDP)	35.4	34.6
Social spending (% of GDP)	27.4	19.4
Value added tax income [OECD](% of GDP)	10.26 [10.3]	11.28 [11.3]
Wage premia [Strauss et al. 2007] (in %)	46.24 [46.3[a]]	62.86 [62.9]
Income tax rate (in %)	36.79	33.76

[a]Values for 2001

Appendix

A Effect of a population shock on the wage rates

In order to analyze the consequences of the change in the number of foreign workers on the wage rates consider first the following results:

$$\frac{\partial Q_l}{\partial(M+I)} = (1-\theta_n) Q_l^{\frac{1}{\sigma_N}} (M_t + I_t)^{\frac{-1}{\sigma_N}} \tag{25}$$

$$\frac{\partial Q}{\partial(M+I)} = (1-\theta_h) Q^{\frac{1}{\sigma_H}} Q_l^{\frac{-1}{\sigma_H}} \frac{\partial Q_l}{\partial(M+I)} \tag{26}$$

These results allow to conclude the following impact on the wage rates:

$$\frac{\partial w_h}{\partial(M+I)} = (1-\alpha)\left(\frac{1}{\sigma_H} - \alpha\right) \theta_h A K^\alpha Q_h^{\frac{-1}{\sigma_H}} Q^{\frac{1}{\sigma_H}-\alpha-1} \frac{\partial Q}{\partial(M+I)}$$

and thus *sign* $\left(\frac{\partial w_h}{\partial(M+I)}\right)$=*sign*$\left(\frac{\partial Q}{\partial(M+I)}\right)$. The population shock changes the wage of a national low-educated agent as follows:

$$\begin{aligned}
\frac{\partial w_n}{\partial(M+I)} =& Z_1 \left[\left(\frac{1}{\sigma_H} - \alpha\right) Q_l \frac{\partial Q}{\partial(M+I)} + Q\left(\frac{1}{\sigma_N} - \frac{1}{\sigma_H}\right) \frac{\partial Q_l}{\partial(M+I)}\right] \\
=& Z_1 Q^{\frac{1}{\sigma_H}} \frac{\partial Q_l}{\partial(M+I)} \left[\left(\frac{1}{\sigma_H} - \alpha\right)(1-\theta_h) Q_l^{\frac{\sigma_H - 1}{\sigma_H}} + Q^{\frac{\sigma_H-1}{\sigma_H}} \left(\frac{1}{\sigma_N} - \frac{1}{\sigma_H}\right)\right]
\end{aligned}$$

obtained using (26) and with $Z_1 = (1-\alpha)(1-\theta_h)\theta_n A K^\alpha N^{\frac{-1}{\sigma_N}} Q^{\frac{1}{\sigma_H}-\alpha-1} Q_l^{\frac{1}{\sigma_N}-\frac{1}{\sigma_H}-1}$. Substituting for $Q^{\frac{\sigma_H-1}{\sigma_H}}$ and using $Z_2 = Q^{\frac{1}{\sigma_H}} Z_1$:

$$\begin{aligned}
\frac{\partial w_n}{\partial(M+I)} =& Z_2 \frac{\partial Q_l}{\partial(M+I)} \\
& \left[(1-\theta_h) Q_l^{\frac{\sigma_H-1}{\sigma_H}} \left(\frac{1}{\sigma_H} - \alpha + \frac{1}{\sigma_N} - \frac{1}{\sigma_H}\right) + \theta_h Q_h^{\frac{\sigma_H-1}{\sigma_H}} \left(\frac{1}{\sigma_N} - \frac{1}{\sigma_H}\right)\right] \\
=& Z_2 \frac{\partial Q_l}{\partial(M+I)} \left[(1-\theta_h) Q_l^{\frac{\sigma_H-1}{\sigma_H}} \left(\frac{1}{\sigma_N} - \alpha\right) + \theta_h Q_h^{\frac{\sigma_H-1}{\sigma_H}} \left(\frac{1}{\sigma_N} - \frac{1}{\sigma_H}\right)\right]
\end{aligned}$$

where $Z_2 > 0$ and the second multiplier is negative given that the possible parameterizations in this paper always lead to $\frac{1}{\sigma_N} < \alpha$ and $\frac{1}{\sigma_N} < \frac{1}{\sigma_H}$. Therefore, *sign*$\left(\frac{\partial w_n}{\partial(M+I)}\right)$ = -*sign*$\left(\frac{\partial Q_l}{\partial(M+I)}\right)$. Similarly, for a legal immigrant worker:

$$
\begin{aligned}
\frac{\partial w_m}{\partial(M+I)} =& Z_3 \frac{\partial Q_l}{\partial(M+I)} \left[\left(\frac{1}{\sigma_H} - \alpha \right) (1-\theta_h) Q_l^{\frac{\sigma_H - 1}{\sigma_H}} + Q^{\frac{\sigma_H - 1}{\sigma_H}} \left(\frac{1}{\sigma_N} - \frac{1}{\sigma_H} \right) \right] \\
& - Z_3 \frac{1}{\sigma_N} Q^{\frac{\sigma_H - 1}{\sigma_H}} \frac{Q_l}{M+I} \\
=& Z_3 \frac{\partial Q_l}{\partial(M+I)} \left[(1-\theta_h) Q_l^{\frac{\sigma_H - 1}{\sigma_H}} \left(\frac{1}{\sigma_N} - \alpha \right) + \theta_h Q_h^{\frac{\sigma_H - 1}{\sigma_H}} \left(\frac{1}{\sigma_N} - \frac{1}{\sigma_H} \right) \right] \\
& - Z_3 \frac{1}{\sigma_N} Q^{\frac{\sigma_H - 1}{\sigma_H}} \frac{Q_l}{M+I}
\end{aligned}
$$

with $Z_3 = (1-\alpha)(1-\theta_h)(1-\theta_n) A K^{\alpha} Q^{\frac{2}{\sigma_H} - \alpha - 1} Q_l^{\frac{1}{\sigma_N} - \frac{1}{\sigma_H} - 1} (M+I)^{\frac{-1}{\sigma_N}} > 0$. Then using (25), it is possible to obtain:

$$
\begin{aligned}
\frac{\partial w_m}{\partial(M+I)} =& Z_3 \left(\frac{Q_l}{M+I} \right)^{\frac{-1}{\sigma_N}} \Bigg\{ -\frac{1}{\sigma_N} Q^{\frac{\sigma_H - 1}{\sigma_H}} \left(\frac{Q_l}{M+I} \right)^{\frac{\sigma_N + 1}{\sigma_N}} \\
& + (1-\theta_n) \left[(1-\theta_h) Q_l^{\frac{\sigma_H - 1}{\sigma_H}} \left(\frac{1}{\sigma_N} - \alpha \right) + \theta_h \, Q_h^{\frac{\sigma_H - 1}{\sigma_H}} \left(\frac{1}{\sigma_N} - \frac{1}{\sigma_H} \right) \right] \Bigg\}
\end{aligned}
$$

Given the chosen parameter range, the multiplier in brackets is always negative such that $\frac{\partial w_m}{\partial(M+I)} < 0$. If the number of immigrant workers increases, the wage rate paid to the foreign workforce thus decreases while the inverse holds in the case of deportation.

B Effects of a policy shock

In this section the calculations of a policy's different consequences are provided. Suppose the amnesty occurs in period T while the steady state is in $T-1$.

B.1 Impact on the interest factor

In the short run capital stock is fixed at K_t. Thus:

$$
\begin{aligned}
R_T - R_{T-1} =& \frac{\Pi_T - \Pi_{T-1}}{K_{T-1}} \\
=& \frac{\alpha(Y_T - Y_{T-1}) + (1-\gamma)(1-\delta-\eta) I_{T-1} w_{m,T} - (1-\gamma) I_{T-1} w_{m,T-1}}{K_{T-1}} \\
=& \frac{\alpha(Y_T - Y_{T-1}) + (1-\gamma) I_{T-1} (\Delta w_m - (\eta+\delta) w_{m,T})}{K_{T-1}}
\end{aligned}
$$

which in the benchmark case with $\eta > \delta = 0$ and no shock on the population size becomes:

$$\Delta R_T = \frac{-(1-\gamma)\eta I_T w_{m,T}}{K_T} \tag{27}$$

B.2 Variation in disposable income

Aggregate disposable income before and after a shock writes:

$$\begin{aligned}
&\Psi_{T-1} = (1-\tau_{T-1})(H_{T-1}w_{h,T-1} + N_{T-1}w_{n,T-1} + M_{T-1}w_{m,T-1}) + I_{T-1}\gamma w_{m,T-1} \\
&+ g(H_{T-1} + M_{T-1} + N_{T-1} + \Theta I_{T-1}) \\
&\Psi_T = (1-\tau_T)(H_{T-1}w_{h,T} + N_{T-1}w_{n,T} + (M_{T-1}(1+\epsilon) + \eta I_{T-1})w_{m,T}) + I_{T-1}\gamma(1-\delta-\eta)w_{m,T} \\
&+ g(H_{T-1} + M_{T-1}(1+\epsilon) + N_{T-1} + \eta I_{T-1} + (1-\delta-\eta)\Theta I_{T-1})
\end{aligned}$$

Note that due to the constant population assumption we have $M_T = M_{T-1}$, $N_T = N_{T-1}$ and $H_{T-1} = H_T$. In order to simplify the notation, the time index on the variables representing population groups is dropped. Subtracting the former from the latter:

$$\begin{aligned}
\Delta\Psi =& -\Delta\tau(Hw_{h,T-1} + Nw_{n,T-1} + Mw_{m,T-1}) + \tau_T(Hw_{h,T-1} + Nw_{n,T-1} + Mw_{m,T-1}) \\
&(1-\tau_T)(Hw_{h,T} + Nw_{n,T} + (M(1+\epsilon) + \eta I)w_{m,T}) \\
&- (Hw_{h,T-1} + Nw_{n,T-1} + Mw_{m,T-1}) \\
&+ I_{T-1}\gamma(1-\delta-\eta)w_{m,T} - I_{T-1}\gamma w_{m,T-1} \\
&+ g(H + M(1+\epsilon) + N + I(\eta + (1-\eta\delta)\Theta)) - g(H + M + N + \Theta I) \\
\\
=& -\Delta\tau(Hw_{h,T-1} + Nw_{n,T-1} + Mw_{m,T-1}) \\
&+ (1-\tau_T)(H(w_{h,T} - w_{h,T-1}) + N(w_{n,T} - w_{n,T-1}) + M(w_{m,T} - w_{m,T-1}) + (\epsilon M + \eta I)w_{m,T}) \\
&+ I\gamma(w_{m,T} - w_{m,T-1} - (\delta+\eta)w_{m,T}) + g[\epsilon M + I(\eta - \Theta(\delta+\eta))] \\
\\
=&(1-\tau_T)\Delta W + I\gamma(\Delta w_m - (\delta+\eta)w_{m,T}) + g[\epsilon M + I(\eta - \Theta(\delta+\eta))] \\
&- \Delta\tau(Hw_{h,T-1} + Nw_{n,T-1} + Mw_{m,T-1})
\end{aligned}$$

In the benchmark case, with $\eta > \delta = \epsilon = 0$ and unchanged population structure this becomes:

$$\Delta\Psi = ((1-\tau_T-\gamma)w_{m,T} + g(1-\Theta))\eta I - \Delta\tau(Hw_{h,T-1} + Nw_{n,T-1} + Mw_{m,T-1}) \tag{28}$$

B.3 Variation in total consumption

Total consumption is denoted $C + D$ and S_t is the total savings of the generation born in t.

$$\Delta C + \Delta D = C_T - C_{T-1} + D_T - D_{T-1}$$
$$\Delta C = \frac{\Delta\Psi}{(1+\beta)(1+v)}$$
$$\Delta D = \frac{(R_T S_{T-1} - R S_{T-2})}{1+v}$$
$$= \frac{(\Delta R S_{T-1} + R(S_{T-1} - S_{T-2}))}{1+v}$$
$$= \frac{\Delta R S_{T-1} + R\Delta S}{1+v}$$

In the short run, $\Delta S = 0$ as capital is given by the agents' savings although in the long run, it might no longer be the case. Thus, the short term effect of a shock on total consumption is:

$$\Delta C + \Delta D = \frac{\Delta\Psi}{(1+\beta)(1+v)} + \frac{\Delta R S_{T-1}}{1+v}$$

In the case of amnesty and using the previous results:

$$\Delta C + \Delta D = \frac{\eta I((1-\tau_T-\gamma)w_{m,T-1} + g(1-\Theta)) - \Delta\tau(Hw_{h,T-1} + Nw_{n,T-1} + Mw_{m,T-1})}{(1+\beta)(1+v)}$$
$$- \frac{\eta(1-\gamma)Iw_{m,T-1}}{1+v}$$

B.4 Variation in the income tax rate

The notation used implies that $M_t = M_{t-1}, N_t = N_{t-1}$ and $H_t = H_{t-1}$ such that time indexes can be left out on population variables for notational convenience. The budget constraint before and after a policy shock writes:

$$\tau_{T-1}(Hw_{h,T-1} + Nw_{n,T-1} + Mw_{m,T-1}) = G + g(H + N + M + \Theta I) - v(C_{T-1} + D_{T-1})$$
$$\tau_T(Hw_{h,T} + Nw_{n,T} + (M(1+\epsilon) + \eta I)w_{m,T})$$
$$= G + g(H + N + M(1+\epsilon) + (\eta + (1-\delta-\eta)\Theta)I) - v(C_T + D_T)$$

Taking the difference of the former with the latter:

$$\Delta\tau(Hw_{h,t-1} + Nw_{n,t-1} + Mw_{m,t-1}) =$$
$$= \tau_T(Hw_{h,T-1} + Nw_{n,T-1} + Mw_{m,T-1}) - \tau_T(Hw_{h,T} + Nw_{n,T} + (M(1+\epsilon) + \eta I)w_{m,T}$$
$$+ g(H + N + M(1+\epsilon) + (\eta + (1-\delta-\eta)\Theta)I) - v(C_T + D_T)$$
$$- (g(H + N + M + \Theta I) - v(C_{T-1} + D_{T-1}))$$
$$= g(\epsilon M + \eta I - (\delta+\eta)\Theta I) - v(C_T - C_{T-1} + D_T - D_{T-1})$$
$$- \tau_T(H(w_{h,T} - w_{h,T-1}) + N(w_{n,T} - w_{n,T-1}) + M(w_{m,T} - w_{m,T-1}) + (\epsilon M + \eta I)w_{m,T}$$

leads to the expression:

$$\Delta\tau = \frac{g(\epsilon M + \eta I - (\delta+\eta)\Theta I) - \tau_T \Delta W - v(\Delta C + \Delta D)}{Hw_{h,T-1} + Nw_{n,T-1} + Mw_{m,T-1}}$$

ΔW expresses the change in the taxable income base. In the benchmark, this is equivalent to $\eta I w_{m,T-1}$, which is the sum of the legalized immigrants' wages. Using the developments for ΔW and $\Delta C + \Delta D$ of the previous subsections and $W_{T-1} = (Hw_{h,T-1} + Nw_{n,T-1} + Mw_{m,T-1})$:

$$\begin{aligned}
&\Delta\tau W_{T-1}\\
&\quad =\eta I(1-\Theta)g - \tau_T \eta I w_{m,T-1} - v\left(\frac{1}{(1+\beta)(1+v)}\Delta\Psi + \frac{\Delta RS_{T-1}}{1+v}\right)\\
&\quad =-\tau_T \eta I w_{m,T-1} + \eta I(1-\Theta)g - \frac{v\eta(1-\gamma)Iw_{m,T-1}}{1+v}\\
&\qquad - \frac{v}{(1+\beta)(1+v)}\left(\eta I((1-\tau_T-\gamma)w_{m,T-1} + g(1-\Theta)) - \Delta\tau W_{T-1}\right)
\end{aligned}$$

Rearranging:

$$\begin{aligned}
&\Delta\tau W_{T-1}\left(1 - \frac{v}{(1+\beta)(1+v)}\right)\\
=&\eta I w_{m,T-1}\left(\frac{-\tau_T(1+\beta)(1+v) - v(1-\tau_T-\gamma) + v(1+\beta)(1-\gamma)}{(1+\beta)(1+v)}\right)\\
&+\eta I g\left((1-\Theta) - \frac{v(1-\Theta)}{(1+\beta)(1+v)}\right)\\
=&\eta I\left(\left(\frac{-\tau_T(1+\beta+\beta v) + v(\beta-\gamma\beta)}{(1+\beta)(1+v)}\right)w_{m,T-1} + \left(\frac{(1+\beta+\beta v)(1-\Theta)}{(1+\beta)(1+v)}\right)g\right)
\end{aligned}$$

Multiplying both sides by $\left(\frac{(1+\beta)(1+v)}{(1+\beta+\beta v)}\right)$ and adding/subtracting $(1-\gamma)\eta I w_{m,T-1}$:

$$\begin{aligned}
&\Delta\tau W_{T-1} =\\
&\quad =-\tau_T\eta I w_{m,T-1} + \eta I(1-\Theta)g + \frac{\beta v(1-\gamma)\eta I w_{m,T-1}}{1+\beta+\beta v} + (1-\gamma)\eta I w_{m,T-1} - (1-\gamma)\eta I w_{m,T-1}\\
&\quad =\eta I\left((1-\gamma-\tau_T)w_{m,T-1} + (1-\Theta)g + \frac{(1-\gamma)w_{m,T-1}(\beta v - (1+\beta+\beta v))}{1+\beta+\beta v}\right)
\end{aligned}$$

Using $\Delta\psi_i^\ell = (1-\gamma-\tau_T)w_{m,T-1} + (1-\Theta)g$ and rearranging yields:

$$\Delta\tau = \frac{\eta I}{Hw_{h,T-1} + Nw_{n,T-1} + Mw_{m,T-1}}\left(\Delta\psi_i^\ell - \frac{(1-\gamma)(1+\beta)w_{m,T-1}}{1+\beta+\beta v}\right)$$

This convenient expression states that if a regularized individual's disposable income gain$(g(1-\Theta) + w_{m,T-1}(1-\gamma-\tau_T))$ does not exceed a certain fraction of the legal migrant's wage $\left(\frac{w_{m,T-1}((1-\gamma)(1+\beta))}{1+\beta+\beta v}\right)$, the native workers

pay less taxes on their income.
Further, this result allows an insight in the evolution of the aggregate disposable income (and thus in the economy's savings) by substituting it in (28):

$$\begin{aligned}\Delta\Psi =&\eta I((1-\tau_T-\gamma)w_{m,T-1}+g(1-\Theta))-\left(\Delta\psi_i^\ell-\frac{(1-\gamma)(1+\beta)w_{m,T-1}}{1+\beta+\beta v}\right)\\ =&\frac{\eta I(1-\gamma)(1+\beta)w_{m,T-1}}{1+\beta+\beta v}\end{aligned}$$

B.5 Variation of the income tax rate in the long run

In the long run, the population is constant and the dynamics depend on the capital accumulation. The budget constrains of two succinct periods are:

$$\begin{aligned}\tau_{t+p}W_{t+p}+v(C_{t+p}+D_{t+p})&=g(H_{t+p}+N_{t+p}+M_{t+p}+I_{t+p}\Theta)+G\\ \tau_{t+p-1}W_{t+p-1}+v(C_{t+p-1}+D_{t+p-1})&=g(H_{t+p-1}+N_{t+p-1}+M_{t+p-1}+I_{t+p-1}\Theta)+G\end{aligned}$$

with taxable wage base is $W_{t+p}=H_{t+p}w_{h,t+p}+N_{t+p}w_{n,t+p}+M_{t+p}w_{m,t+p}$
Thus, the change $\Delta\tau_{t+p}$ is:

$$\begin{aligned}&\tau_{t+p}W_{t+p}+v(C_{t+p}+D_{t+p})-\tau_{t+p-1}W_{t+p-1}-v(C_{t+p-1}+D_{t+p-1})=0\\ \Leftrightarrow&\Delta\tau_{t+p}W_{t+p}+\tau_{t+p-1}W_{t+p}-\tau_{t+p-1}W_{t+p-1}\\ &=-v(C_{t+p}+D_{t+p}-C_{t+p-1}-D_{t+p-1})\\ \Leftrightarrow&\Delta\tau_{t+p}=-\frac{\tau_{t+p-1}\Delta W_{t+p}+v(C_{t+p}+D_{t+p}-C_{t+p-1}-D_{t+p-1})}{H_{t+p}w_{h,t+p}+N_{t+p}w_{n,t+p}+M_{t+p}w_{m,t+p}}\end{aligned}$$

C Sensitivity to the elasticity of substitution

The influence of the different elasticities of substitution can briefly be assessed. As shown below, straightforward conclusions on the wage dependence relative to these parameters are not possible. In fact, the results depend heavily on the population structure as well as the other parameters' values. For the elasticity of substitution between native and foreign low-educated workers,

$$\begin{aligned}&\frac{\partial w_m}{\partial\sigma_N}=(1-\alpha)(1-\theta_h)(1-\theta_n)AK^\alpha Q^{\frac{1}{\sigma_H}-\alpha}Q_l^{\frac{1}{\sigma_N}-\frac{1}{\sigma_H}}(I+M)^{\frac{-1}{\sigma_N}}\\ &\left\{\frac{1}{\sigma_N-1}\left(-\alpha p_L+\frac{1}{\sigma_N}+\frac{1}{\sigma_H}(p_L-1)\right)Z_4+\frac{1}{{\sigma_N}^2}ln\left(\frac{M+I}{Q_l}\right)\right\}\end{aligned}$$

where $Z_4 = \left[ln\left(\frac{M+I}{Q_l}\right) + p_N\left(ln\left(\frac{N}{M+I}\right)\right)\right]$, $p_N = \frac{\theta_N N^{\frac{\sigma_N - 1}{\sigma_N}}}{Q_l^{\frac{\sigma_N - 1}{\sigma_N}}}$ and $p_L = \frac{(1-\theta_h)Q_l^{\frac{\sigma_H - 1}{\sigma_H}}}{Q^{\frac{\sigma_H - 1}{\sigma_H}}}$. In the cases of U.K. and Germany, the term in brackets is negative. Thus, $\frac{\partial w_m}{\partial \sigma_N} < 0$ and the higher is the elasticity of substitution between native and foreign low-educated workers, the lower is the wage each one receives.

The same assessment can be made with respect to the elasticity of substitution between the high-and low-educated workers.

$$\frac{\partial w_m}{\partial \sigma_H} = (1-\alpha)(1-\theta_h)(1-\theta_n)AK^{\alpha}Q^{\frac{1}{\sigma_H}-\alpha}Q_l^{\frac{1}{\sigma_N}-\frac{1}{\sigma_H}}(I+M)^{\frac{-1}{\sigma_N}}\frac{1}{\sigma_H^2(\sigma_H - 1)}$$
$$\left\{\sigma_H(1-\alpha)ln\left(\frac{Q_l}{Q}\right) + (1-\alpha\sigma_H)p_H ln\left(\frac{Q_h}{Q_l}\right)\right\}$$

with $p_H = \frac{\theta_H Q_h^{\frac{\sigma_H - 1}{\sigma_H}}}{Q^{\frac{\sigma_H - 1}{\sigma_H}}}$. For both countries, the term in brackets is positive, leading to $\frac{\partial w_m}{\partial \sigma_H} > 0$. Thus, the higher the elasticity of substitution between high-and low-educated workers, the higher is the wage of the latter.

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Institut de Recherches Économiques et Sociales
Université catholique de Louvain

Place Montesquieu, 3
1348 Louvain-la-Neuve, Belgique

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