Review of Economic Dynamics 54 (2024) 101238

Contents lists available at ScienceDirect

Review of Economic Dynamics

journal homepage: www.elsevier.com/locate/red

Full Length Article

Immigration, legal status and fiscal impact

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ARTICLE INFO

JEL classification:
J61
J64
J30
E20

Keywords:
Immigration
Search frictions
Fiscal impact
Welfare
Job creation
Immigration policies

ABSTRACT

We develop a general equilibrium model with search frictions in the labor market, wage bargaining and a welfare state, to study the impact of immigrants on the fiscal balance and welfare of natives in the host country. We distinguish immigrants by legal status and account for both their direct fiscal effects, through their tax contributions and transfer receipts, and their indirect fiscal and welfare effects, through their labor-market impact. We calibrate the model to the U.S. economy and find that legal immigrants reduce the tax burden on natives and increase natives' welfare, mainly because their tax contributions greatly exceed the transfers they receive. On the other hand, illegal immigrants' positive welfare impact stems mainly from their positive effect on job creation, which increases income to natives and in turn consumption. A legalization program leads to a fiscal gain, increases natives' welfare and is more beneficial to natives than a purely restrictive immigration policy that reduces the illegal immigrant population.

1. Introduction

Over the last few decades, many developed countries have witnessed rising immigrant inflows. In the United States, for instance, the number of foreign-born residents has increased from around 19 to over 43 million between 1990 and 2015. During the same period, the number of illegal immigrants has grown even more rapidly, from 3 to over 11 million. The rapid inflow of immigrants has spurred heated debate over its economic consequences, such as its potential impact on native workers' wages and employment, and a vast academic literature has emerged, to study mainly the labor-market impacts of immigrants. But the fiscal impact of immigration is also central to this debate. Opponents of immigration often argue that even if the labor-market impact of immigrants is positive or small, we should not overlook the fiscal burden they impose on natives. But do immigrants impose a fiscal burden on natives? And if yes, is it large enough to outweigh any positive labor-market effects on natives' welfare? Although these are important concerns in the debate on immigration, the academic literature on this topic is limited.

In this paper we evaluate the impact of immigration to the U.S. on natives' welfare within a model that accounts for both labor-market and fiscal effects. We contribute to the literature on the fiscal impact of immigration in two ways. First, we develop a rich framework in which immigrants affect the fiscal balance directly, by receiving government transfers and paying taxes, but also indirectly through their impact on the labor market and income in the host country. The standard approach in the literature has

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https://doi.org/10.1016/j.red.2024.101238
Received 3 May 2023; Received in revised form 20 June 2024

Available online 26 July 2024

been to consider these two channels separately, by either focusing on estimating the net fiscal contribution of immigrants, based on observed taxes and transfers or by considering only their indirect fiscal impacts through the labor-market.[3] In our framework, even if immigrants receive transfers in excess of the taxes they pay, they might still reduce the tax burden on natives, by increasing income in the host country. But the opposite is also possible; a strong positive contribution of immigrants to the fiscal balance may outweigh any negative labor-market effects on the fiscal balance and natives' welfare. Second, we distinguish immigrants by legal status and allow them to pay taxes and affect the labor market differently. Accounting for immigrants' legal status allows us to compare the effects of purely restrictive immigration policies that aim to decrease the immigrant, and especially the illegal immigrant population, to a legalization program that grants legal status to illegal residents.

Distinguishing illegal from legal immigrants is important, as they differ in several aspects, thus affect the labor market differently and also contribute to the fiscal balance in different ways. Illegal immigrants are less likely to own capital and firms and more likely to avoid paying some taxes, but face also significantly more restrictions in using public services and welfare benefits than legal immigrants. Moreover, due to their illegal status, they may be restricted to perform certain productive tasks, which are different from those of legal workers, making them better complements in production to native workers than legal immigrants. Given these differences, not distinguishing immigrants by legal status when estimating their fiscal effects may be on oversight, especially for our focus country, the U.S., where a significant fraction of immigrants are unauthorized.[4]

It may be also an oversight to consider that illegal immigrants' restrictions in accessing benefits and ability to avoid taxation, are unrelated to their labor-market effects. If they can avoid paying some taxes, they can settle for a lower wage, while firms can avoid payroll costs by employing them. Having also limited access to welfare benefits, such as unemployment benefits, they might have a worse outside option than legal immigrants, which may also force them to accept lower wages. These might be the reasons why firms can save on labor costs by employing them, increase their profits, and in turn, job creation, employment and income, which then increase also the government's tax revenues. Previous studies on the fiscal effects of immigration overlook such effects either because they do not consider labor-market equilibrium responses or because they do not account for legal status.

Our economy consists of native, legal and illegal immigrant households, firms and the government. Native and legal immigrant households pay taxes on income from wages, dividends, capital and bonds, and also pay consumption taxes. Illegal immigrant households pay only consumption taxes and use their after-tax income for only consumption, because unlike legal immigrants, they do not invest or own firms. On the production side, firms rent capital, hire native, legal and illegal immigrant workers to produce output and pay payroll taxes. There are search and matching frictions in the labor market and wages are determined by bargaining. The government raises revenue by issuing bonds and collecting taxes, provides public goods, pays unemployment benefits to legal immigrants and natives and transfers to all three types of households. We allow for transfers to be allocated differently across natives and immigrants, reflecting the different restrictions they might face in accessing benefits. Because the government must keep the debt sustainable, any fiscal deficit that immigrants generate must be financed through an additional tax, imposed on legal residents. This additional tax constitutes our measure of the fiscal burden that immigrants might impose on natives in our baseline model. We calibrate the model to the U.S. economy and compute the labor market effects and net fiscal and welfare gains or losses with respect to legal as well as illegal immigration and also examine the effects of a legalization program.

Our quantitative exercises show that an increase in either type of immigrants, increases job creation, employment, income (from wages, dividends and capital) and welfare of U.S. natives. A 5% increase in U.S. labor force due to immigration raises the consumption of natives by $1.4\% - 2.2\%$. However, the main reason why legal immigrants increase natives' welfare is their tax contributions, which greatly exceed the benefits they receive, thereby reducing the tax burden on natives. In fact, their direct net fiscal contribution is so large that even if we eliminate their positive effect on job creation and natives' income, their impact on natives' welfare remains positive. Unlike legal immigrants, illegal immigrants' positive welfare impact stems mainly from their positive effect on job creation, as their presence in the labor market reduces firms' average labor costs. While they impose a tax burden on natives, they also increase natives' income from all sources, and this second effect dominates, allowing natives to increase their consumption. Since both legal and illegal immigrants increase natives' welfare, granting legal status to illegal immigrants is more beneficial to natives than a restrictive immigration policy that decreases the number of illegal immigrants. But illegal immigrants increase natives' income by more, whereas legal immigrants pay more taxes. It follows that the legalization of illegal immigrants has a negative impact on natives' income, but reduces the fiscal burden on them. Our simulations show that the second effect dominates. Legalizing all illegal immigrants raises natives' consumption by 0.4%.

In our baseline model we assume that illegal workers are perfect substitutes to native workers in production, which can be viewed as the worst-case scenario for how the former affect the productivity of the latter, since immigration-induced productivity gains among native workers are larger when immigrants differ from natives and thus complement natives in production. This assumption allows us, without loss of generality, to maintain analytical tractability and illustrate more clearly how illegal workers can increase natives' income by reducing firms average labor costs. But this assumption is far from realistic since illegal workers, who are not authorized to work, may be restricted to perform different types of jobs/tasks than legal workers, or even participate in a segmented labor market. We explore these possibilities in a model extension where illegal workers complement legal workers in production. In this case, by granting legal status to illegal immigrants we also give them access to the same production tasks as natives, thereby increasing competitive pressure on native workers. We show that our main results carry through to this model extension. Legalizations

[3] We give an overview of previous studies on the fiscal impacts of immigrants and discuss further how our paper fits in this literature in Section 2.

[4] Approximately 23% of total U.S. immigration in 2017 is estimated to be unauthorized (see e.g. "Key findings about U.S. immigrants," 2020, Pew Research Center report, https://www.pewresearch.org/?p=290738).

have a stronger negative impact on natives' income than in the baseline model, but still increase natives' welfare by reducing the tax burden on natives.

In another model extension, we explore the possibility that immigrants can reduce natives' welfare by "congesting" public services, i.e., by reducing the amount of government goods allocated to native households, instead of increasing the tax burden imposed on them. We also perform various robustness checks with respect to some key parameters, consider a model with skill heterogeneity among the native legal and illegal immigrant populations and imperfect substitution across skills, the possibility that legal immigrants do not invest or own firms, the possibility that some illegal immigrants work on the books and pay income taxes and the possibility that immigrants remit part of their income. Our main results carry through to all cases considered.

The rest of the paper is organized as follows. Section 2 gives a brief overview of related literature and places our paper in the context of this literature. Section 3 presents the model, describes the workings of its main mechanisms, and provides intuition for its main results. Section 4 presents analytical comparative static results for how legal and illegal immigration affect job creation and natives' consumption and welfare, which lie at the heart of the quantitative analysis that follows. Section 5 describes the parameterization of the model and compares the fiscal and welfare effects obtained by increasing legal and illegal immigration and the effects of a legalization program. Section 6 presents the results of the two model extensions. Section 7 concludes.

2. Related literature

Although the literature on the effects of immigration is vast, the number of studies in this literature that center on the fiscal effect of immigration is small. Lee and Miller (2000) estimate the net fiscal impact of raising net immigration into the United States and conclude that is positive but quite small. Dustmann and Frattini (2014) examine the fiscal impact of immigration on the UK economy and find an overall positive effect. Storesletten (2000, 2003) employs an overlapping generations framework and finds that admitting more immigrants can result in net fiscal gains when new immigrants are young and in working age and have high employment rates. These overlapping generations models can easily accommodate age structure and fertility of the immigrant and native populations. However, they exclude immigrants' potential impact on labor market outcomes and welfare of native workers. All the above-mentioned studies adopt mainly an accounting approach by attempting to estimate the net government gains of admitting more immigrants, based on empirical estimates of tax receipts and transfers. They abstract from job-creation responses and welfare effects.

Recent studies, such as Chassamboulli and Palivos (2014), Chassamboulli and Peri (2015, 2020) and Liu et al. (2017), employ models with search and matching frictions to study the labor market effects of immigration. These papers account for the impacts of immigration that work through not only the conventional production complementarity/substitutability channel, but also the job-creation channel. They suggest that by accepting lower wages per unit of productivity, immigrants can help firms reduce labor costs, thus increase firm profits and drive job creation. Albert (2021) extends this framework to allow for a nonrandom hiring mechanism according to which firms may choose to hire immigrants over natives, if the former accept lower wages. While our model has a number of similarities to these models, the most important difference is that they abstract from fiscal effects, since there is no government in these models and no welfare state.

The paper most closely related to ours is Battisti et al. (2018). They also extend the above line of research emphasizing the job-creation effect of immigration, by incorporating a welfare state into the model. They account for the skill composition of immigrants and calibrate their model to 20 OECD countries. However, they do not distinguish between legal and illegal immigration and consider only the effects of changes in the total stock of immigrants. We focus, instead, on differences contingent on immigrants' legal status and examine also the effects of a legalization program.[5] Besides accounting for legal status, we account for consumption-saving decisions, by considering risk-averse households, and we allow for a more detailed and realistic structure for the household and government budget, welfare state and tax system, which we parameterize to match data on U.S. government tax revenues from personal and consumption taxes, taxes contributed by the employers and government outlays to natives and immigrants. Our approach allows for a more comprehensive analysis of immigrants' fiscal impacts not only through the labor market, but also through their tax payments and benefit receipts.

A few more recent contributions use quantitative equilibrium models with a government to study the welfare impact of immigration. Busch et al. (2020) employ an overlapping generations model to simulate the effects of the 2015–2016 wave of predominantly low-skilled refugee immigration to Germany. Iftikhar and Zaharieva (2019) also focus on the German labor market, but employ a search and matching model. Fiaschi et al. (2020) study the effects of a low-skill immigration inflow in Italy, also within a search and matching model. These last two papers incorporate interesting mechanisms for how immigration can affect prices. Ikhenaode (2023) extends the Battisti et al. model to allow natives to endogenously adjust their skill in face of migration, and also distinguishes between young and retired workers. All these studies do not differentiate between legal and illegal immigration, and consider a much simpler fiscal side and government structure. Lastly, Colas and Sachs (2024) adopt a different approach by deriving closed form expressions for the indirect fiscal effects of immigration, based on various labor-market models, and evaluating them based on a detailed empirical quantification of the U.S. tax-transfer system. They abstract, however, from job-creation effects and analyze only effects coming through the conventional production complementarity/substitutability channel.

[5] A few other papers also focus on the effects of illegal immigration. See, among others, Bucci and Tenorio (1996), Djajic (1997), Palivos (2009), and Liu (2010). However, these papers abstract from the job-creation effects of illegal immigration. Chassamboulli and Peri (2015, 2020) and Albert (2021), also distinguish immigrants by legal status, but, as mentioned above, abstract from fiscal effects.

3. The model

Consider an economy inhabited by a continuum of three types of households: the native households of measure n, the legal immigrant households of measure l, and the illegal immigrant households of measure m. The number of members in each household is normalized to 1. All individuals supply their labor inelastically to the labor market. If employed, they produce, while if unemployed, they search for jobs. With a certain probability, an unemployed worker will be matched with a vacant job. But it is also possible that the agent cannot find a job and has to remain unemployed for some time. As a result, individuals face uncertainty in income and consumption. Following Lucas (1990), we assume that all members in the same household will pool their resources together in order to maximize the household's utility. There is one final goods sector, one intermediate goods sector and a government. The government collects taxes and issues government bonds to finance unemployment and other welfare benefits and expenditure on public goods.

3.1. The household's problem

Each household seeks to maximize utility from consumption of private goods. The household's discounted lifetime utility is given by:

$$\sum_{t=0}^{\infty} \beta^t \log c_{i,t}, \tag{1}$$

where $c_{i,t}$ is the household's private consumption, with $i = [n, l, m]$ indexing native, legal and illegal immigrant, respectively, and t indexing time. The parameter $\beta > 0$ is the discount factor. The household's problem is to choose the time paths $\{c_{i,t}, k_{i,t+1}\}_{t=0}^{\infty}$ subject to a budget constraint. The budget constraint differs depending on the type of the household. In particular, for $i = [n, l]$,

$$(1+\tau_c)c_{i,t} + k_{i,t+1} - k_{i,t} + d_{i,t+1} - d_{i,t} = (1-\tau)(w_{i,t}e_{i,t} + r_t k_{i,t} + r_t d_{i,t} + \pi_{i,t}) + b_i u_{i,t} - f_t \tag{2}$$

where b_i is the unemployment benefit, r_t is the rate of return on capital, $w_{i,t}$ is the wage, $u_{i,t}$ and $e_{i,t}$ are the numbers of unemployed and employed, respectively, household members, $d_{i,t}$ is the household's holdings of government bonds, $k_{i,t}$ is capital owned by the households and $\pi_{i,t}$ denotes dividend distributed by the firms. Natives and legal immigrants can accumulate capital, hold government bonds and own firms. Hence, besides labor income they might also receive dividends and capital income and returns from holding government bonds. A no-arbitrage condition requires that the return to capital, r_t, equals the return to government bonds. The natives and the legal immigrants, besides consumption taxes, they pay income taxes and a lump-sum tax. The consumption tax rate is τ_c, the income tax rate is τ and f_t is the lump-sum tax.[6]

Illegal immigrants, on the other hand, pay only consumption taxes and the only income they earn is from supplying labor. For $i = m$ the budget constraint is therefore given by:

$$(1+\tau_c)c_{m,t} = w_{m,t}e_{m,t} + b_m u_{m,t}. \tag{3}$$

The purpose of the lump-some tax f_t is to capture the fiscal burden that immigrants may impose on natives. As we show below, we calibrate the rest of the tax rates to match data on tax revenues. Given the government's tax revenues from income, consumption and payroll taxes (the latter are paid by the employer and are specified below), the lump-sum tax f_t adjusts to cover any additional fiscal deficit immigrants generate, in order to keep the government debt sustainable. We assume that each native or legal immigrant household pays the same amount of lump sum tax. That is, $f_t(n+l) = F_t$, where F_t is the aggregate amount of lump-sum taxes the government needs to collect for its debt to be sustainable.

Notice also that the unemployment benefit, b_i, is allowed to differ depending on the worker type, reflecting differences in their wages and the possibility that immigrants, and especially illegal immigrants have limited access to welfare benefits. In particular, we assume $b_n \geq b_l \geq b_m$.[7]

Solving the native's and legal immigrant's utility maximization problem yields the standard Euler equation:

$$\frac{c_{i,t+1}}{c_{i,t}} = \beta\left[1 + (1-\tau)r_{t+1}\right],$$

whereas, it is straightforward from (1) and (3) that, since illegal immigrants do not invest, they just consume their total income in each period. Hence,

$$c_{m,t} = \frac{w_{m,t}e_{m,t} + b_m u_{m,t}}{1+\tau_c}. \tag{4}$$

A common assumption in the literature (e.g. Battisti et al., 2018) is that only natives invest or own firms, so that all income from bonds, capital and dividends is distributed evenly among natives only. This means setting $\pi_{l,t} = d_{l,t} = k_{l,t} = 0$ and $\pi_{n,t} = \frac{\Pi_t}{n}$,

[6] Our paper adopts the assumption of invariance of fiscal policy over the composition of labor force. Some papers, such as, Alesina et al. (1999) suggest that fiscal policy could be related to ethnic fragmentation.

[7] Since the Personal Responsibility and Work Opportunity Reconciliation Act (PRWORA) of 1996 many federal government benefits (Food stamps, TANF, AFDC and others) were restricted to U.S. citizens only. Hence non-naturalized legal immigrants' income while unemployed was significantly lower. In the 2000's some but not all, states re-instated some of them. Illegal immigrants cannot access any unemployment insurance at all.

$d_{n,t} = \frac{D_t}{n}$, $k_{n,t} = \frac{K_t}{n}$, where Π_t, D_t and K_t are total firm profits, government debt and capital in the economy, respectively, and are specified below. Although the empirical results differ, depending on the data set used, the general consensus in the literature is that immigrants accumulate less wealth than natives, with the largest difference being around 30%-40% less.[8] In our view, the difference is not large enough to justify the extreme assumption that legal immigrants do not invest or own firms. Moreover, it refers to all foreign-born rather than specifically to legal immigrants. Analyses of wealth gaps by immigrants' origin country point to lower wealth accumulation being mainly concentrated on undocumented immigrants, in line with our assumption. For example, based on estimates in Cobb-Clark and Hildebrand (2006) the mean net worth of European immigrants is about 28% higher and that of Asian immigrants is only about 4% lower than that of natives. On the other hand, immigrants from Mexico and Central and South America, which are the typical source regions for undocumented immigration to the U.S., have a much lower mean net worth: about 76% and 51% lower than U.S.-born individuals, respectively. In our baseline model we therefore assume that dividends, bonds and capital are all distributed evenly among natives and legal immigrants, which means setting $\pi_{n,t} = \pi_{l,t} = \frac{\Pi_t}{n+l}$, $d_{n,t} = d_{l,t} = \frac{D_t}{n+l}$ and $k_{n,t} = k_{l,t} = \frac{K_t}{n+l}$. Note that this case implies stronger competition form legal immigrants on natives, as investment income and dividends must be shared over a larger number of individuals, yielding a lower share for natives. We consider the case where only natives invest or own firms as a robustness check in Appendix C.

3.2. Production

Firms operate either in the final or in the intermediate goods sector. Firms in the intermediate sector produce intermediate inputs that are sold in a competitive market. Firms in the final sector buy the intermediate goods and use them together with capital to produce the final consumption good.

3.2.1. Final sector

In the final sector, firms use an intermediate labor input, X, and capital, K, to produce the final good Y, according to

$$Y_t = K_t^{\alpha} X_t^{1-\alpha}. \tag{5}$$

The market for capital is competitive, so that we have

$$r_t = \frac{\partial Y_t}{\partial K_t} - \delta, \tag{6}$$

where δ denotes the depreciation rate of capital. Moreover, since the markets for intermediate inputs and capital are competitive, firms in the final sector do not make any profits.

3.2.2. Intermediate sector

The firms in the intermediate sector produce the intermediate input X using a linear technology, which implies that the number of units produced equals the number of individuals employed in the intermediate sector. That is,

$$X_t = E_{n,t} + E_{l,t} + E_{m,t}, \tag{7}$$

where $E_{n,t} = ne_{n,t}$, $E_{l,t} = le_{l,t}$, $E_{m,t} = me_{m,t}$. Once produced, the intermediate inputs are sold in a competitive market. So that the price of each unit of intermediate input equals the marginal product. Let p_t denote the price of the intermediate input. Then,

$$p_t = \frac{\partial Y_t}{\partial X_t}. \tag{8}$$

In the baseline model, we abstract from skill or other production-related heterogeneity and assume that native and (legal and illegal) immigrant workers are perfect substitutes in the production process. This assumption allows us to keep the productivity p_t equal across the three types of workers, and as shown below, constant. This simplification allows us, in turn, to illustrate more clearly how legal and illegal immigrants can affect the labor market differently, because of their different fiscal sides (putting aside productivity effects). We can maintain analytical tractability in the model and show qualitative results for how differences between legal and illegal immigrants in terms of tax payments and access to welfare benefits, imply, through wage bargaining and firm profits, different effects on job creation and income to natives (Section 4). It should be clarified, however, that this assumption comes without loss of generality for two reasons. First, our focus is to characterize fiscal and welfare impacts on natives overall, instead of distributional productivity effects. We are abstracting from characterizing the different productivity effects that legal or illegal immigrants might have on various subgroups of native workers (e.g. skilled or unskilled), but we are capturing the average effects and we can illustrate them more clearly.[9] Second, this case can be viewed as representing the worst-case scenario regarding the labor market effects of immigrants, since immigration-induced productivity gains among native workers are larger when immigrants differ

[8] We summarize evidence on wealth differences between U.S. natives and immigrants in Appendix B.

[9] These distributional productivity/wage effects have been the focus of previous studies of immigration such as Chassamboulli and Palivos (2014) and Battisti et al. (2018) that focus on characterizing the labor-market effects of immigration. They focus on imperfect substitution across workers with different educational attainment to highlight the distributional effects of immigration-induced changes in the skill composition of the labor force on natives of different skills.

from natives (e.g. in terms of skills) and thus complement natives in production.[10] In other words, in such a model immigrants would increase natives' productivity on average, instead of keeping it constant.

While this assumption is not limiting for our analysis, it is also far from realistic since legal and especially illegal immigrants are likely to complement natives in production because of differences in their skills, but also differences that hinge on the legal/illegal status.[11] For this reason, in Section 6.1, we consider a generalized production function in which illegal immigrant workers, due to the restrictions imposed by their illegal status, are imperfect substitutes for natives and legal immigrant workers. We also discuss there a further generalization of the model, with skill heterogeneity, that captures also skill complementarities and present results for this case in Appendix C.

The value of a job filled with a worker of type $i = [n, l]$ is given by the following Bellman equation.

$$J_{i,t} = p_t - (1+\tau_p)w_{i,t} + \frac{1}{1+r_{t+1}}\left[(1-s)J_{i,t+1} + sV_{t+1}\right], \tag{9}$$

where τ_p is a payroll tax rate, paid by the employer, and s is an exogenous job separation probability. Jobs survive into the next period with probability $(1-s)$ and become vacant otherwise, with value V_{t+1}. For analytical tractability and to illustrate more clearly the main model mechanisms, we assume that the separation rates of natives, legal and illegal immigrants are equal. This assumption is in fact not too strong, since in the U.S., differences in job-finding and job-separation rates (and thus unemployment rates) between immigrants and natives are remarkably small (see e.g. Chassamboulli et al., 2024). Considering, however, that illegal immigrants are more likely to break a match due to repatriations or deportations, we explore this possibility and allow different separation rates for natives, legal and illegal immigrants in our quantitative analysis in Section 5.

We assume that employers do not have to pay payroll tax on the employment of illegal immigrants. Thus, the value of a job filled with an illegal immigrant worker is given by

$$J_{m,t} = p_t - w_{m,t} + \frac{1}{1+r_{t+1}}\left[(1-s)J_{m,t+1} + sV_{t+1}\right]. \tag{10}$$

Unemployed workers and job vacancies are matched via a stochastic technology represented by the matching function $M_t = M(v_t, U_t)$, where v_t is the total number of vacancies, $U_t \equiv U_{n,t} + U_{l,t} + U_{m,t}$ is the total number of unemployed workers. Vacancies are filled with probability $q_t = \frac{M_t}{v_t} = M(1, \frac{1}{\theta_t})$ and workers find jobs with probability $\mu_t = \frac{M_t}{U_t} = M(\theta_t, 1)$, where $\theta_t = \frac{v_t}{U_t}$ denotes the tightness of labor market and q_t is decreasing while μ_t is increasing in θ_t. Firms cannot create vacancies for only native or immigrant workers. In other words, vacancies cannot be targeted towards specific worker types. Hence, natives and immigrants (legal or illegal) all find jobs with probability μ_t.[12]

The evolution of the number of household members that are unemployed is given by:

$$u_{i,t+1} = (1-\mu_t)u_{i,t} + se_{i,t}, \tag{11}$$

where $e_{i,t} = 1 - u_{i,t}$.

There is a flow cost κ of posting a vacancy. The Bellman equation for the value of a vacancy is given by

$$V_t = -\kappa + \frac{1}{1+r_{t+1}}\left\{q_t\left[\phi_t J_{n,t+1} + (1-\phi_t)(\lambda_t J_{l,t+1} + (1-\lambda_t)J_{m,t+1})\right] + (1-q_t)V_{t+1}\right\}, \tag{12}$$

where, as mentioned above, q_t is the probability that a vacant firm will locate a searching worker. Since vacancies cannot be targeted towards a particular worker type, the firm does not know ex-ante whether the vacancy will be filled by a native or an immigrant (legal or illegal) worker. It matches with either a native worker with probability ϕ_t, a legal immigrant worker with probability $(1-\phi_t)\lambda_t$ and an illegal immigrant worker with probability $(1-\phi_t)(1-\lambda_t)$, where $\phi_t \equiv \frac{nu_{n,t}}{nu_{n,t}+lu_{l,t}+mu_{m,t}}$ is the share of natives in total searching population and $\lambda_t = \frac{lu_{l,t}}{lu_{l,t}+mu_{m,t}}$ is the share of searching immigrants that are legal.

The number of vacancies v_t is endogenously determined by free entry. Setting $V_t = 0$ yields the free-entry condition:

$$\frac{\kappa}{q_t} = \frac{1}{1+r_{t+1}}\left[\phi_t J_{n,t+1} + (1-\phi_t)(\lambda_t J_{l,t+1} + (1-\lambda_t)J_{m,t+1})\right]. \tag{13}$$

As explained further below, wages are determined by a bargain between the firm and the worker. Workers are not paid their marginal product and firms in the intermediate sector make profits.[13] In particular, the profits of firms net of vacancy-posting costs are given by

[10] Peri and Sparber (2009), for instance, find that immigration can cause natives to shift occupations to avoid competitive pressure from the presence of immigrants.

[11] For instance, evidence by Manacorda et al. (2012) and Ottaviano and Peri (2012) suggest that immigrants and natives, of even the same skill type, are imperfect substitutes.

[12] In Section 6.1, where we allow for illegal immigrants to be imperfect substitutes for natives and legal immigrants, we also explore the possibility that the labor market is segmented, and illegal immigrants search for jobs in a separate submarket.

[13] Free entry implies that the expected present discounted value of profits from filling a vacancy (right-hand-side of (13)) are equal to the average vacancy posting costs (left-hand-side of (13)) so that the value of a vacancy is zero. However, the expected present discounted profits from filling a vacancy are not the same as the flow profits of a job. While the expected net profits from filling a vacancy are zero, the flow profits of jobs net of vacancy costs are positive.

$$\Pi_t = \left[p_t - (1+\tau_p)w_{n,t}\right] E_{n,t} + \left[p_t - (1+\tau_p)w_{l,t}\right] E_{l,t} + (p_t - w_{m,t})E_{m,t} - \kappa v_t. \tag{14}$$

The value to a worker of being unemployed ($Z_{i,t}$) satisfies:

$$Z_{i,t} = b_i - x_i + \frac{1}{1+r_{t+1}}\left[\mu_t W_{i,t+1} + (1-\mu_t)Z_{i,t+1}\right]. \tag{15}$$

While unemployed the worker receives the benefit b_i, which is determined by the unemployment insurance replacement ratio, minus a search cost x_i, representing a utility cost from being unemployed and searching for a job. We allow for the possibility that immigrants, and especially illegal immigrants, suffer larger utility cost of searching for a job, reflecting factors such as their lack of social network, limited knowledge of labor market institutions and language proficiency. We standardize the search cost of a native worker to 0 and set $x_n = 0$, and we presume $x_m \geq x_l \geq 0$.[14]

The value to a worker of being employed ($W_{i,t}$) satisfies:

$$W_{i,t} = (1-\tau)w_{i,t} + \frac{1}{1+r_{t+1}}\left[(1-s)W_{i,t+1} + sZ_{i,t+1}\right] \text{ for } i = [n,l], \text{ and} \tag{16}$$

$$W_{m,t} = w_{m,t} + \frac{1}{1+r_{t+1}}\left[(1-s)W_{m,t+1} + sZ_{m,t+1}\right]. \tag{17}$$

Notice that the value of being employed changes for illegal immigrants to take into account that they do not pay income taxes.

Wages satisfy the standard Nash bargaining conditions. Let $\eta \in (0,1)$ denote the worker's share of surplus (or bargaining parameter). Then the wage $w_{i,t}$, $i = [n,l]$, must satisfy

$$(1-\eta)(1+\tau_p)\left[W_{i,t} - Z_{i,t}\right] = \eta(1-\tau)\left[J_{i,t} - V_t\right] \tag{18}$$

and the wage $w_{m,t}$ for illegal immigrant workers must satisfy

$$(1-\eta)\left[W_{i,t} - Z_{i,t}\right] = \eta\left[J_{i,t} - V_t\right]. \tag{19}$$

3.3. Government

The government is subject to the following constraint in which deficits are financed by increases in government bonds. Government bonds evolve according to:

$$D_{t+1} = D_t(1+r_t) + G_t + \sum_i b_i U_{i,t} - (\tau+\tau_p)\left(w_{n,t}E_{n,t} + w_{l,t}E_{l,t}\right) - \tau(r_t K_t + r_t D_t + \Pi_t) - \tau_c \sum_i C_{i,t} - F_t,$$

where, $C_{i,t}$ is the aggregate private consumption of households of type i, $U_{i,t}$ is the total number of type-i unemployed workers and G_t is total government spending. In particular, we have $C_{n,t} = nc_{n,t}$, $C_{l,t} = lc_{l,t}$, $C_{m,t} = mc_{m,t}$, and $U_{n,t} = nu_{n,t}$, $U_{l,t} = lu_{l,t}$, $U_{m,t} = mu_{m,t}$.

Government spending G_t is divided into two parts: spending on public goods, denoted by G_t^p and spending on "congestible" goods, denoted by G_t^c, which includes mainly welfare benefits and transfers.[15] Formally, we have $G_t = G_t^p + G_t^c$. To capture the notion of public goods, we assume that G_t^p is independent of the number of immigrants and natives. On the contrary, G_t^c changes with the number of native, legal and illegal immigrant workers. In particular a type-i household generates an amount g_i^c of expenditure on transfers so that $G_t^c = ng_n^c + lg_l^c + mg_m^c$. This part of spending is congestible, meaning that with more users (i.e. with an increase in l or m) the government must raise additional tax revenue in order to maintain the same spending per user (i.e. to maintain g_n^c, g_l^c and g_m^c). In our baseline model, we assume that following an increase in immigration, the government maintains g_n^c, g_l^c and g_m^c by adjusting the lump-sum tax F. We consider the possibility of changing, instead, government spending per household, in Section 6.[16]

The government's fiscal policy $(f_t, \tau_c, \tau, \tau_p)$ must be feasible in the sense that the present value of the stock of public debt goes to zero in infinity (no Ponzi game). The current government debt must therefore equal the net present value of future deficits and surpluses, which gives the following condition:

$$D_t = \frac{\sum_z \left[T_{t+z} + F_{t+z} - \tilde{G}_{t+z}\right]}{\prod_z \left[1 + r_{t+z}(1-\tau)\right]}, \tag{20}$$

[14] There are several ways of modeling the difference between native and immigrant workers. We let immigrants have a higher utility cost of unemployment, as in Chassamboulli and Palivos (2014), Chassamboulli and Peri (2015, 2020) and Battisti et al. (2018). Liu et al. (2017), on the other hand, allow immigrants to have lower job finding rates than natives. Another possibility is that immigrants have different bargaining power, as in Albert (2021). While all these alternative features have a different interpretation, they all play the same role. They can all be used to explain a potential wage gap between natives and immigrants and why firms may be able to extract higher surplus from immigrants than natives.

[15] Throughout the paper we use the term "transfers" to refer to the government spending on congestible goods. In Section 6.2 we consider the possibility that public goods are also subject to congestion.

[16] In our baseline model we assume, for simplicity, that a household's utility depends only on private consumption. Since transfers (and public goods) per household are constant and not affected by the size of the population, this assumption comes with no loss of generality. In the model extension in Section 6.2 where the amount of government goods allocated to each household is allowed to change, we assume that a household's utility depends also on this amount.

where $F_{t+z} = (n+l)f_{t+z}$ is the total lump-sum tax imposed on legal residents, $T_{t+z} \equiv (\tau + \tau_p)\left(nw_{n,t+z}e_{n,t+z} + lw_{l,t+z}e_{l,t+z}\right) + \tau n(r_{t+z}k_{n,t+z} + \pi_{n,t+z}) + \tau l(r_{t+z}k_{l,t+z} + \pi_{l,t+z}) + \tau_c \sum_i ic_{i,t+z}$ is the government's total tax revenue from consumption, income and payroll taxes, $\tilde{G}_{t+z} \equiv G_{t+z} + \sum_i ib_i u_{i,t+z}$ is total government spending (including unemployment benefits) and $G_{t+z} \equiv G^c_{t+z} + G^p_{t+z}$ is government spending on public goods and transfers.

3.4. Equilibrium

An equilibrium for this economy consists of a sequence of allocations $\left\{c_{i,t}, k_{i,t}, \pi_{i,t}, d_{i,t}, f_t\right\}_{t=0}^{\infty}$, a sequence of prices $\left\{p_t, r_t, w_{i,t}\right\}_{t=0}^{\infty}$ and a sequence of matching probabilities $\left\{\mu_t, q_t\right\}_{t=0}^{\infty}$ such that:

1. the free-entry condition in equation (13) is satisfied;
2. the allocations $\left\{c_{i,t}, k_{i,t+1}\right\}_{t=0}^{\infty}$ solve the native, legal and illegal immigrant household's problem;
3. the rate of return on capital r_t satisfies equation (6);
4. the price of intermediate input p_t satisfies equation (8);
5. the wage rates satisfy equations (18) and (19);
6. total dividends satisfy equation (14);
7. the government's set of policies $(f_t, \tau_c, \tau, \tau_p)$ is feasible and the government debt D_t equals the net present value of future deficits and surpluses (equation (20)).

3.5. Steady state

In the rest of the paper we focus on the steady-state equilibrium and examine the long-run consequences of changes in the size and composition of immigrant population. Combining the Euler equation, the households' budget constraint, and the government constraint, the steady-state equilibrium is characterized by:

$$\beta\left[1 + (1-\tau)r\right] = 1, \tag{21}$$

$$(1+\tau_c)c_i = (1-\tau)(w_i e_i + rk_i + rd_i + \pi_i) + b_i u_i - f, \text{ for } i = [n, l] \tag{22}$$

$$(1+\tau_c)c_m = w_m e_m + b_m u_m, \tag{23}$$

$$D = \frac{T + F - \tilde{G}}{r(1-\tau)}, \tag{24}$$

where $T \equiv (\tau + \tau_p)\left(nw_n e_n + lw_l e_l\right) + \tau(rK + \Pi) + \tau_c \sum_i ic_i$, $\tilde{G} \equiv G + \sum_i ib_i u_i$ and $G \equiv G^c + G^p$. The total amount of lump sum tax, F, imposed by the government to keep the debt sustainable is derived from (24) and is paid by natives and legal immigrants in equal proportions so that $f = \frac{F}{n+l}$. As mentioned above, legal immigrants are identical to natives in terms of firm, capital and debt ownership which implies $k_n = k_l = \frac{K}{(n+l)}$, $\pi_n = \pi_l = \frac{\Pi}{(n+l)}$ and $d_n = d_l = \frac{D}{(n+l)}$. The aggregate capital stock and total dividends are given by

$$K = (ne_n + le_l + me_m)\left(\frac{\alpha}{r+\delta}\right)^{\frac{1}{1-\alpha}}, \tag{25}$$

$$\Pi = \left[p - (1+\tau_p)w_n\right] ne_n + \left[p - (1+\tau_p)w_l\right] le_l + (p - w_m)me_m - \kappa v. \tag{26}$$

The unemployment rates of workers of type $i = [n, l, m]$ are given by

$$u_i = \frac{s}{\mu + s} \tag{27}$$

and $e_i = 1 - u_i$.

The free-entry condition can be used to determine the equilibrium value of market tightness, θ, and in turn of μ and q. In particular:

$$\frac{\kappa}{q} = \frac{1}{1+r}\left[\phi J_n + (1-\phi)(\lambda J_l + (1-\lambda)J_m)\right], \tag{28}$$

where

$$J_i = \frac{(1+r)\left[p - (1+\tau_p)w_i\right]}{r+s}, \text{ for } i = [i, n] \tag{29}$$

$$J_m = \frac{(1+r)(p - w_m)}{r+s}. \tag{30}$$

As can be easily verified by inspecting equations (29) and (30), the surplus of a job increases as the wage per unit of productivity falls (i.e. as $p - w_i$ increases). If immigrants accept lower wages per unit of productivity, then firms can save on labor costs by employing them, which drives job creation. This is the driving force behind the job-creation channel of immigration first emphasized

in Chassamboulli and Palivos (2014) and subsequently in Chassamboulli and Peri (2015) and Battisti et al. (2018) among others. In these papers, however, any labor-cost saving effect of immigration vanishes, if immigrants' wages (per unit of productivity) are not lower than those of natives. In our case, by contrast, an additional reason why firms can save on labor costs by employing illegal immigrants relates to payroll costs. Notice that $\tau_p w_i$ enters negatively in J_i, $i = [n, l]$, but not in J_m. Even if illegal immigrants receive higher wages per unit of productivity than natives, firms can still generate larger surplus from employing them (i.e., $J_m > J_n$), because they can avoid payroll costs.[17]

Using (27), we can write

$$\phi = \frac{n}{n+l+m},\ \lambda = \frac{l}{l+m}, \tag{31}$$

and using (25) we can write the price of the intermediate input as

$$p = (1-\alpha)\left(\frac{\alpha}{r+\delta}\right)^{\frac{\alpha}{1-\alpha}},$$

which is fixed and does not depend on immigrant stock or market tightness, θ. This is due to the fact that we assume that native, legal and illegal immigrant workers are perfect substitutes in the production process. In the extension we consider in Section 6.1, where illegal immigrants are imperfect substitutes for natives or legal immigrants, we have two different intermediate inputs, one for legal and one for illegal workers, with different prices. In that case the price of the "legal" labor input increases when the proportion of illegal workers increases.

Wages are given by

$$w_n = \frac{\eta(r+s+\mu)(1-\tau)p + (1-\eta)(1+\tau_p)(r+s)b_n}{(1-\tau)(1+\tau_p)(r+s+\eta\mu)} \tag{32}$$

$$w_l = \frac{\eta(r+s+\mu)(1-\tau)p + (1-\eta)(1+\tau_p)(r+s)(b_l - x_l)}{(1-\tau)(1+\tau_p)(r+s+\eta\mu)} \tag{33}$$

$$w_m = \frac{\eta(r+s+\mu)p + (1-\eta)(r+s)(b_m - x_m)}{r+s+\eta\mu}. \tag{34}$$

The wage in each case increases with the job finding probability μ_t and is a combination of the worker's outside option $(b_i - x_i)$ and productivity (p). The former increases the wage as it improves a worker's bargaining position. It follows that immigrants may bargain for lower wages than natives if they receive lower unemployment benefits or face larger search costs. Wage gaps between natives and immigrants, driven by differences in outside options are the main reason behind the job creation effect of immigration emphasized in previous research. But in our case, wage differences can also arise because of differences in tax contributions. It can be easily verified from (32) and (33) that wages increase with the income tax rate τ and decrease with the payroll tax rate τ_p. Bargaining implies that workers will transfer some of the burden of income taxes to the employer by obtaining higher wages, while the employer will transfer some of the payroll costs to the workers by cutting down on wages. It follows that legal immigrants (who pay taxes as natives do) will bargain for lower wages than natives only if they have worse outside option $(b_l - x_l < b_n)$. Illegal immigrants, on the other hand, may settle for lower wages than natives or legal immigrants for one additional reason: they can avoid paying income taxes.

With the wages in (32)-(34) substituted in, we can write the surplus of jobs filled by natives, legal and illegal immigrants, respectively as

$$\begin{aligned} J_n &= \frac{(1+r)(1-\eta)\left[p - \frac{1+\tau_p}{1-\tau}b_n\right]}{r+s+\eta\mu} \\ J_l &= \frac{(1+r)(1-\eta)\left[p - \frac{1+\tau_p}{1-\tau}(b_l - x_l)\right]}{r+s+\eta\mu} \\ J_m &= \frac{(1+r)(1-\eta)\left[p - b_m + x_m\right]}{r+s+\eta\mu}. \end{aligned} \tag{35}$$

It can be easily verified that since $\tau_p + \tau > 0$, which ensures $\frac{1+\tau_p}{1-\tau} > 1$ then J_m is greater than both J_l and J_n, meaning that firms can extract higher surplus from illegal immigrants, even when their outside option is not worse than that of legal immigrants. If, in addition, natives have better outside option, $b_n \geq b_l \geq b_m$ or $x_m \geq x_l \geq 0$, then we can write $J_m > J_l \geq J_n$, and firms can extract lower surplus from natives than from either of the two types of immigrants.

In the case where $J_m > J_l \geq J_n$, we need to exclude the possibility that a firm that meets a native worker decides not to form an employment relation and continues to search. As shown in Appendix A, for a meaningful equilibrium where natives are employed, the following restriction on the parameter values must hold:

[17] Notice that what matters for the firm's profits is the net productivity $p - w_i$. It makes no difference if differences in net productivity are due to differences in productivity or differences in wages. Illegal immigrants' wages could be lower per unit of productivity, not because their wages are higher, but because they are less productive. This would make no differences for firm profits. In Appendix C we consider a case where the net productivity of illegal immigrants is lower than that of natives. We show that even in that case, saving on payroll costs implies much larger gains from employing illegal immigrants.

$$p > \frac{1+\tau_p}{1-\tau} b_n.$$

Proposition 1. *Existence and Uniqueness.*

Proof. See Appendix A.

Using (31) to substitute for ϕ, λ and (35) to substitute for J_n, J_l and J_m in the free-entry condition (13) we obtain:

$$\frac{\kappa}{q} = \frac{1-\eta}{n+l+m}\left[n\left(\frac{p-\frac{1+\tau_p}{1-\tau}b_n}{r+s+\eta\mu}\right) + l\left(\frac{p-\frac{1+\tau_p}{1-\tau}(b_l-x_l)}{r+s+\eta\mu}\right) + m\left(\frac{p-b_m+x_m}{r+s+\eta\mu}\right)\right]. \tag{36}$$

This condition equates the expected profits from a new job (RHS) to the average vacancy positing cost (LHS). The left-hand side of the above equation is increasing with respect to θ, whereas the right-hand side is decreasing in θ, hence, the steady state exists and is unique.

4. Comparative static results

A key feature of our model is that it accounts for the impact of immigration on job creation. Immigration-induced changes in job creation, employment and production can change natives' consumption and welfare through their impact on natives' income (from supplying labor, holding capital or from dividends). At the same time, by affecting households income, immigration can affect the tax base and impact natives' welfare through changes in the lump-sum tax f. At the heart of these two effects is how immigration affects market tightness. Comparative static results for how changes in the size of immigrant stocks affect market tightness, employment and income are summarized in the following two propositions.

Proposition 2. *An increase in m increases market tightness, wages, capital, dividends and decreases the unemployment rates.*

$$\frac{d\theta}{dm} > 0, \quad \frac{dw_i}{dm} > 0, \quad \frac{de_i}{dm} > 0, \quad \frac{dk_i}{dm} > 0, \quad \frac{d\pi_i}{dm} > 0 \text{ and } \frac{du_i}{dm} < 0.$$

Proof. See Appendix A.

As discussed above, a firm generates larger surplus from hiring an illegal immigrant than either a native or a legal immigrant, for three reasons. Illegal immigrants are willing to accept lower wages, first, because they do not have to pay income taxes ($\tau > 0$) and second, because they have lower income while unemployed ($b_m - x_m < b_l - x_l \leq b_n$). Third, firms can save on labor costs by avoiding to pay payroll taxes on them. We can therefore show that an increase in m, which puts a larger weight in the free entry condition on J_m (see equation (28)) raises the expected profits of new jobs (right-hand side of (36)) and increases θ. This implies a higher job finding probability μ, and in turn, higher employment rates and wages. With more immigrants and higher employment rates the production of the intermediate input X increases and through production complementarities, capital also increases. Finally, dividends also increase since with a higher share of illegal immigrants firms pay on average lower wages and save more on payroll costs, which means larger profits on average.

Consider next an increase in legal immigration l. Legal immigrants will generate larger profits to firms than natives ($J_l > J_n$) only if $b_l - x_l < b_n$, which implies their wage is lower. However, for the reasons explained above, even if their wage is lower than that of natives, employing legal immigrants is still more costly to firms than employing illegal immigrants ($J_m > J_l$). Hence, even if $J_l > J_n$, putting larger weight on J_l in condition (13) does not necessarily increase average firm profits (and thus job creation). While we cannot rule out the possibility that legal immigrants also have a positive job-creation effect, for this to occur natives must have a much better outside option and therefore wage compared to legal immigrants (i.e. b_n must be large relative to $b_l - x_l$). If, on the other hand, their wages are equal ($b_l = b_n$ and $x_n = x_l = 0$), which means $J_l = J_n$, then putting larger weight on J_l certainly decreases average firm profits. It follows that the impact of legal immigration on job creation can be either positive or negative. Specifically,

Proposition 3. *If $b_n > b_l - x_l \geq b_m - x_m$ an increase in l has an ambiguous effect on market tightness, wages, capital, dividends and unemployment rates. If $b_n = b_l - x_l \geq b_m - x_m$ an increase in l has a negative effect on market tightness, wages, capital, dividends and unemployment rates.*

4.1. Welfare of native households

In steady state, the lifetime discounted utility of a native household is given by

$$\Phi = \frac{1}{1-\beta}\log c_n, \tag{37}$$

and

$$c_n = \frac{(1-\tau)(w_n e_n + rk_n + rd_n + \pi_n) + b_n u_n - f}{(1+\tau_c)}.$$

In steady state the government keeps its debt D fixed to its sustainable level by adjusting the tax f. Any additional spending in excess of revenues from payroll, income and consumption taxes is financed by an increase in the lump sum tax f imposed on natives and legal immigrants. If, however, immigration generates a fiscal gain, then f is reduced to maintain government debt at its steady-state level. The expression of the lump sum tax f is

$$f = \frac{Dr(1-\tau) + \tilde{G} - T}{n+l}$$

where, as defined above, $\tilde{G} \equiv G + \sum_i ib_i u_i$, $G \equiv G^c + G^p$, $G^c = ng_n^c + lg_l^c + mg_m^c$ and $T \equiv (\tau + \tau_p)\left(nw_n e_n + lw_l e_l\right) + \tau(rk_n n + rk_l l + \pi_n n + \pi_l l) + \tau_c \sum_i ic_i$.

An increase in immigration will raise government expenditure on transfers G^c, but will also increase total tax revenues T, and may or may not increase government expenditure on unemployment insurance $\sum_i ib_i u_i$. Immigration affects the expenditure on unemployment insurance in two opposing ways. On the one hand, all else equal, more immigrants implies also more unemployed in the labor force, which increases demand for unemployment benefits. On the other hand, if immigration increases firm profits leading to more job creation (an increase in θ and thus μ), then the unemployment rate might fall, leading to lower unemployment insurance payments. Overall, it is not clear that an increase in immigration creates additional fiscal burden to be paid by natives. We can say that an additional fiscal burden is less likely when first, each immigrant household pays more taxes than the amount of transfers it receives (g_l^c or g_m^c), and second, when immigrants have a positive job-creation effect on the host economy, which lowers the unemployment rate, thereby reducing expenditure on unemployment insurance, and increases income from capital (k_n, k_l), dividends (π_n, π_l) wages (w_n, w_l, w_m), thereby increasing government's tax revenues.

Differentiating Φ with respect to m yields

$$\frac{d\Phi}{dm} = \frac{1}{1-\beta}\frac{1}{c_n} \underbrace{\frac{dc_n}{dm}}_{\text{positive/negative}},$$

where

$$\frac{dc_n}{dm} = \frac{\left[(1-\tau)w_n - b_n\right]}{1+\tau_c} \underbrace{\frac{de_n}{dm}}_{\text{positive}} + \frac{(1-\tau)e_n}{1+\tau_c} \underbrace{\frac{dw_n}{dm}}_{\text{positive}} + \frac{(1-\tau)r}{1+\tau_c} \underbrace{\frac{dk_n}{dm}}_{\text{positive}} + \frac{1-\tau}{1+\tau_c} \underbrace{\frac{d\pi_n}{dm}}_{\text{positive}} - \frac{1}{1+\tau_c} \underbrace{\frac{df}{dm}}_{\text{positive/negative}}.$$

As summarized in Proposition 2, illegal immigrants induce job creation leading to higher employment and income for natives. Hence, putting aside fiscal considerations, the presence of illegal immigrants increases the consumption and welfare of natives. However, as discussed above, the effect of illegal immigration on lump sum tax f is ambiguous. On the one hand, illegal immigration induces a job-creation effect to raise employment, wages, capital holdings and dividends, resulting in more tax revenues that can be used to reduce the lump sum tax. On the other hand, an increase in illegal immigration also means more expenditure on transfers, while illegal immigrants pay only consumption taxes. Once fiscal considerations are included, the overall impact of illegal immigration on natives' consumption (and thus welfare) may be positive or negative. Notice, however, that even if the impact of illegal immigrants on f is positive, meaning that they create a net fiscal burden for natives, their effect on natives' welfare may still be positive if their job-creation effect is strong enough to raise natives' income by more than it raises their tax burden.

Legal immigrants, on the other hand, can potentially contribute more to the welfare state, by paying more taxes, but their impact on job creation and thus natives' employment rate and income (from wages, capital and dividends) may be positive or negative, as summarized in Proposition 3. Since legal immigrants pay more taxes than illegal ones, it seems reasonable at first, to assume that the fiscal impact they impose on natives is smaller than that of illegal immigrants. However, this view ignores two aspects. First, legal immigrants may raise expenditure on transfers more than illegal immigrants, since the latter have limited access to welfare programs. What matters for the overall fiscal impact is not tax revenues per se, but tax revenues relative to transfer payments. Second, and more important, this view overlooks the labor market effects. If legal immigrants reduce or have a smaller positive effect on job creation, even if they pay more taxes than the transfers they collect, their overall fiscal effect may be more negative than that of illegal immigrants.

In our quantitative exercise that follows we simulate the full effects of changes in legal and illegal immigration on natives' fiscal burden and welfare, taking into account the labor market impact and the direct net fiscal contribution of each type of immigration.

5. Quantitative analysis

5.1. Parameterization

We parameterize the model to represent the average performance and conditions of the U.S. economy between 2000 and 2010, a period in which the presence of illegal immigrants in the U.S. has peaked to about 11.5 million individuals. To do so we combine three types of parameters. Some are taken from the literature. Others are taken directly from the U.S. data. Finally a third group is

Table 1
Baseline Parameter Values.

Value	*Interpretation*
$r = 0.004$	Monthly real interest rate
$\epsilon = 0.5$	Unemployment elasticity of the matching function
$\eta = 0.5$	Workers' bargaining power
$\alpha = 0.39$	Share of capital in GDP
$\delta = 0.0061$	Monthly depreciation rate
$s_n = 0.0180$, $s_l = 0.0184$, $s_m = 0.0200$	Monthly separation probabilities
$\xi^n = 0.560$, $\xi^{l/m} = 0.575$	Matching efficiency
$n = 1.00, l = 0.11, m = 0.06$	Normalized number of natives, legal and illegal immigrants
$\kappa = 12.6$	Vacancy cost
$D = 10.5$	Government debt
$b_n = 2.32, b_l = 1.93, b_m = 0$	Unemployment flow incomes
$x_l = 13.4, x_m = 26.8$	Search costs
$G^p = 1.23$	Expenditure on pure public good
$g_n^c = 2.35$, $g_l^c = g_m^c = 1.67$	Expenditure on transfers
$\tau = 0.266, \tau_p = 0.062, \tau_c = 0.089$	Tax rates

chosen to match some moments of the data. The parameter choice is summarized in Table 1. We describe here in detail the sources and the methods used to calculate these parameters.

We set the workers' bargaining power to $\eta = 0.5$, a value commonly used in the literature.[18] We use the monthly interest rate $r = 0.4\%$, which implies a yearly real rate of about 5%.[19] We set the share of capital in GDP to $\alpha = 0.39$, which is the value we obtain using data from the Bureau of Economic Analysis (BEA) over the period 2000-2010.[20] Data from the BEA also give a value of 0.0061 for the monthly depreciation rate of the capital stock. We standardized the native labor force to $n = 1$ and set $m = 0.06$ and $l = 0.11$. These numbers equal the average values obtained by dividing the numbers of illegal and legal immigrants in working age (16 to 65) by the U.S.-born labor force in working age.[21]

To ensure that the calibrated model is as accurate as possible, we allow for the job-separation and job finding rates of immigrants and natives to take different values. We use estimates from the Current Population Survey (CPS) reported in Chassamboulli et al. (2024). These estimates give values of 0.018 and 0.019 for the monthly separation rate, and 0.38 and 0.39 for the monthly job finding rate of natives and immigrants, respectively.[22] We also allow for different separation rates for legal and illegal immigrants, reflecting the difference in their repatriation rates due to deportations. Since we are not aware of comparable estimates, we use the monthly return rates of Mexican illegal and legal immigrants, which are 0.0039 and 0.0023, respectively, suggesting a difference in separation rate between illegal and legal immigrants of 0.0016. We therefore set $s_n = 0.018$, $s_m = s_l + 0.0016$ and choose the value of s_l that sets the average separation rate of immigrants to 0.019. To allow for the job finding rates of immigrants and natives to differ, we introduce a shift parameter in the matching function (often called matching efficiency) that depends on the worker's nativity. In particular, we use a Cobb-Douglas matching function, $M^j = \xi^j U^\epsilon v^{1-\epsilon}$, where $j = [n, l/m]$ denotes nativity (native n or immigrant l/m), which gives $\mu^j = \xi^j \theta^{1-\epsilon}$. Following common practice in these models, we set the unemployment elasticity of the matching function to $\epsilon = 0.5$, which is within the range of estimates reported in Petrongolo and Pissarides (2001). We set $\mu^n = 0.38$ and $\mu^{l/m} = 0.39$, and let ξ^n and $\xi^{l/m}$ take the values that match these targets.

We jointly calibrate the remaining 14 parameters of the model (κ, D, b_n, b_l, b_m, x_l, x_m, G^p, τ, τ_p, τ_c, g_n^c, g_l^c, g_m^c) to match the following targets. To pin down κ, the vacancy posting cost, we set the vacancy to unemployment ration to 0.46 as calculated using data on the number of job openings from the Job Openings and Labor Turnover Survey (JOLTS) and the number of unemployed from the CPS. The government debt as a % of GDP is equal to 91% according to data from the OECD (Organisation for Economic

[18] The same value has also been used e.g. in Albrecht and Vroman (2002) and Ljungqvist and Sargent (2004).

[19] We match all the flow rates in the model to monthly rates.

[20] The definition of capital stock includes nonresidential equipment and structures.

[21] Tabulations of data from the U.S. Census Bureau prepared by the Migration Policy Institute (https://www.migrationpolicy.org/programs/data-hub/charts/immigrant-share-us-population-and-civilian-labor-force) show that 14.45% of U.S. civilian labor force between 2000 and 2010 are foreign born giving an estimate of about 28.45 millions of foreign-born workers in the U.S. labor force. Based on estimates from the Pew Research Center (see https://www.pewhispanic.org/interactives/unauthorized-trends/) the average number of unauthorized immigrants in the U.S. over the same period is about 11.1 millions. About 90% of them are in working age so that the total unauthorized population in working age averages to about 10.2 millions. The remaining 18.3 millions of foreign born are considered legal immigrants. Dividing these numbers by the U.S. native labor force in working age we get $l = 0.11$ and $m = 0.06$.

[22] Chassamboulli et al. (2024) report estimates of the average separation and job finding rates of immigrants and natives over the period 2003-2018 (0.021, 0.023 and 0.351, 0.394, respectively). We adjust their estimates to our calibration period and use only years 2003-2010. Notice also that the CPS does not identify the legal status of foreign-born individuals. Albert (2021) uses a method of identifying undocumented immigrants and CPS data over the period from 1994 to 2016 to estimates job finding and separation rates for documented and undocumented immigrants separately. However, he restricts his empirical analysis to high-school dropouts only. He also finds that immigrants and especially undocumented immigrants exhibit higher separation but also job finding rates than natives, while their unemployment rates are very similar.

Co-operation and Development), which gives a value for D. We use the U.S. unemployment replacement ratio of 0.4 for the ratio of unemployment to employment income. We set $b_n = 0.4w_n$, $b_l = 0.4w_l$, but $b_m = 0$, since illegal immigrants cannot access any unemployment insurance benefits. We choose the values for x_l and x_m that match the wage gaps. We set the wage of a native 20% higher than that of a legal immigrant, consistent with the immigrant-native wage gap estimated in Borjas and Friedberg (2009) for year 2000, after controlling for observed abilities such as education and age. We set the wage gap between illegal and legal immigrants to a baseline value of 7.5% (as estimated from the NLSY data at page 621 of Kossoudji and Cobb-Clark, 2002). More recent studies of the legal-illegal immigrant wage gap (Barcellos, 2010) have identified somewhat smaller values estimated to be in the order of 5%. As regards the native-legal immigrant gap, using data from the CPS over a longer period from 1994 to 2016, but restricting the sample to only high-school dropouts, Albert (2021) finds a much smaller value of about 5%. We use these values for wage gaps in robustness checks and also examine how results are affected when we set $x_l = 0$, which sets the wage (per unit of productivity) of legal immigrants almost equal to that of natives, or $x_m = 0$, which sets the wage (per unit of productivity) of illegal immigrants larger than that of natives and significantly larger than that of legal immigrants, in Appendix C.

The remaining 7 parameters (G^p, τ, τ_p, τ_c, g_n^c, g_l^c, g_m^c) determine the government's tax revenues and expenditure on transfers created by each of the three types of households. The standard approach in the literature (e.g. Storesletten, 2000, 2003, and Battisti et al., 2018) is to attribute the cost of transfers equally across immigrants and natives; mainly because of lacking the appropriate data to measure how they change differently with the number of immigrants and natives in the population. We utilize estimates of the ratio of government receipts (tax payments) to outlays (transfer receipts) per immigrant and native from CPS data, provided in an extensive report by Blau and Mackie (2017) (B&M, henceforth), and allow for these costs to be attributed differently to natives and immigrants.[23] Ideally, estimates of fiscal ratios should also distinguish between legal and illegal immigrants. However, the CPS does not identify the legal status of responders, thus estimates are provided for all foreign-born population including also undocumented residents. We therefore set $g_n^c \neq g_l^c = g_m^c$ and choose the values of g_n^c and g_l^c $(= g_m^c)$ that set the fiscal ratios of natives and immigrants in our model equal to those in B&M.

For our calibration of g_n^c and g_l^c to be accurate, tax payments in our calibrated model must include all types of taxes included in B&M's estimates of tax payments. We only have three types of taxes in our model: income (τ), payroll (τ_p) and consumption (τ_c). We use the details on the various types of taxes included in their estimates, provided in their technical Annex (Chapter 8, Section 8.4) to categorize them into these three broad categories: 1. those that are subtracted from households' income, 2. those that are contributed by the employer and 3. those imposed on products. We pin down our values for τ, τ_p and τ_c by targeting total government revenue from these three categories, respectively. The CPS-based individual estimates of government tax receipts and outlays in B&M are adjusted to agree with the totals reported in the annual tables of the National Income and Product Accounts (NIPA). For consistency, we also use NIPA tables (and definitions) to calculate our targets for the three types of government tax revenues, which we find to be 18.3%, 3.3% and 3.8% of GDP, respectively. The taxes subtracted from income (first category) include taxes on individual and corporate income, plus social security contributions by employees (15%), and other personal taxes (3.3%).[24] The second category, includes social security (3.2%) and other payroll taxes (0.08%) contributed by the employers. The third, includes federal, state and local taxes on product, which are mainly sales and excise taxes.

B&M's measures of government outlays include various types of transfers (e.g. social benefits, Medicare, education costs etc.), but also public goods.[25] They estimate fiscal ratios under alternative scenarios for attributing spending on public goods to immigrants and natives, and for immigrants' ownership of U.S. companies and contribution to capital and corporate tax payments (see their Box 8-1 and Table 8-2). In one scenario (scenario 5) they assume that immigrants own shares of U.S. companies, thus pay taxes on capital income and dividends, in line with our assumptions, and also attribute the cost of public goods to the native born only. This means that an additional immigrant does not increase spending on public goods, which is also in line with our assumptions. We therefore pin down the values of g_n^c and g_l^c by targeting the fiscal ratios of natives and immigrants under this scenario, which are equal to 0.766 and 0.933, respectively. Our measure of government outlays to immigrants includes unemployment benefits ($b_l u_l l$) and transfers ($g_l^c l + g_m^c m$). In our measure of outlays to natives, consistent with B&M, besides unemployment benefits and transfers ($b_n u_n n + g_n^c n$), we include spending on public goods. Based on the information they provide in their technical annex, this includes spending on defense, interest payments on public debt, subsidies, transfers and social benefits to the rest of the world. We calculate the total cost of these government expenses from NIPA tables and find it to be 8.7% of GDP, which we include in our measure of outlays to natives, since ignoring it would overestimate our value for g_n^c. Note that B&M's measure of public goods (attributed to natives) excludes expenditure on public investment and other spending such as capital transfer payments. We must include these additional government expenses in our measure of G^p, since ignoring them would underestimate our measure of lump-sum tax f.[26] We therefore get the value for G^p by targeting the total government spending from NIPA tables equal to 34.5% of GDP.

[23] They calculate fiscal ratios for the first, second and third or higher generation immigrants. We use the fiscal ratio of the first-generation immigrants (i.e. the foreign-born) for immigrants in our model, while for natives we use the fiscal ratio of third-plus generation immigrants.

[24] Other personal taxes include motor vehicle and other licences and some property taxes.

[25] They assign the government cost of children, such as schooling costs, to parents. Hence our calibrated transfer receipts per native and immigrant household include also the cost of children.

[26] Likewise, besides tax revenues, government revenues include also income receipts on assets, transfer receipts from businesses and the rest of the world, the surplus of government enterprises and capital transfer receipts. Based on the totals reported in the annual NIPA tables (Table 3.1), averaged over years 2000-2010, these additional revenues are about 6% of GDP, while tax revenues are about 22% of GDP. Ignoring these additional revenues would underestimate government receipts and thus overestimate our measure of lump sum tax f. We therefore add them in our measure of total government revenues in our calibrated model. Note that, while adding the additional government expenses and revenues improves our estimate of the fiscal deficit, it comes without loss of generality, since these additional expenses and revenues are independent of the labor-force size and are not affected by immigration.

5.1.1. Model fit: net fiscal loss/gain per household

In our calibrated model, taxes paid per native and immigrant (legal and illegal pooled together) amount to 26.9% and 16.3% of GDP per capita, respectively. The corresponding estimates for 2013 based on Table 8.2 in B&M, which reports the annual per-capita tax contributions, are 26.8% and 20.4%.[27] While our estimates are very close, especially as regards the tax payments per native, our calibration seems to underestimate the tax payments per immigrant. This may be due to the fact that we assume that all illegal immigrants do not contribute any income or payroll taxes. Studies have estimated between 50% and 75% of undocumented immigrants work on the books and pay income and payroll taxes, using either false social security or individual tax identification numbers.[28] While such tax payments made by illegal immigrants are accounted in the measure of foreign-born's tax contributions in B&M, we overlook them. Because there is no clear evidence about the exact tax contributions of illegal immigrants, we choose to follow the literature and assume in our baseline model that they do not pay such taxes, which is also the worst-case estimate for their overall tax contributions.[29]

We should clarify however, that matching the fiscal ratio is more important than matching the exact tax payments and transfers per immigrant, since what determines the impact on the lump sum tax f is the net direct fiscal loss per immigrant (i.e. transfers minus taxes). Hence, we follow this calibration approach.[30] Despite underestimating tax payments per immigrant, our estimate of net fiscal loss per immigrant is consistent with B&M, since, by underestimating taxes we also underestimate transfers (g_l^c) per immigrant, to match the fiscal ratio. Outlays per immigrant and native are equal to 35% and 22% of per-capita GDP, respectively, based on B&M. We match exactly the outlays per native of 35%, but in our model outlays per immigrant are only 17.5%. Hence, in our calibrated model, the net fiscal loss per native and immigrant as a percentage of per-capita GDP is −8.2% and −1.2%, respectively. The corresponding estimates in B&M are −8.2% and −1.5% (based on Table 8.2, scenario 5), which are quite close.

It is also important to examine whether our calibrated model assigns the net fiscal loss or gain per legal and illegal immigrant, reasonably, since this will be important for the effect of legalizations. In our calibrated model the net fiscal contribution per legal immigrant is positive and equal to 6.4% of per-capital GDP, while an illegal immigrant's transfer receipts exceed his/her tax payments. We find the net fiscal burden per immigrant to be −13.4% of per-capita GDP. Although data on tax contributions and transfer receipts per legal and illegal immigrant separately are limited, comparing our results with available estimates suggests that our calibration is reasonable in this respect.[31] Rector and Richwine (2013) find that the average taxes paid by unlawful immigrant households are 42% of the average amount of benefits they receive.[32] In our model, illegal immigrant households' tax payments are only 21% of the outlays they receive. However, as mentioned above, we exclude all illegal immigrants from income and payroll tax contributions, while in their analysis they assume that only 45% of unlawful immigrant workers work off the books.

One concern is that by underestimating illegal immigrants' tax payments we might be overestimating the labor-cost saving effect they might have on U.S. firms, thereby overestimating their positive effect on job creation. At the same time, we might be overestimating legal immigrants tax payments, by overestimating the income and payroll tax rates (τ and τ_p). To address this concern in Appendix C we consider the case where 50% of illegal immigrants pay income taxes and are subject to payroll taxes. We calibrate the model exactly as described above by matching the fiscal ratios per immigrant and native. This modification brings the tax contributions per immigrant in our calibrated model much closer to the B&M estimate. We get that tax payments per immigrant are 18.4% of per-capita GDP, while estimates of net fiscal losses per native and immigrant remain very close to our baseline model (we get −8.1% and −1.3%, respectively). Looking at the net fiscal contribution per legal and illegal immigrant separately we get, 3.8% and −9.1%, respectively. As expected this calibration lowers the net contribution of a legal immigrant, but also lowers the deficit imposed by an illegal immigrant on average, since 50% of illegal immigrants now pay more taxes. In this version, illegal immigrants' tax payments are 52% of the outlays they receive, much closer to available estimates. As will be verified below, results for the effects of changes in legal and illegal immigration and of a legalization program are almost unchanged. Given also that data on the exact contributions of illegal immigrants to income and payroll taxes are rather limited, we choose to follow the benchmark approach in our baseline model and assume that all illegal immigrants work off the books.

5.2. Quantitative results

We describe here the effects of increasing the numbers of legal and illegal immigrants on labor market variables (unemployment rates, wages, dividends, capital and output) and consumption. We also characterize their fiscal impact, by reporting changes in government expenditure and revenues, and the change in the lump sum tax, f. Table 2 shows the results for the effects of a 5% increase in the labor force caused by an increase in legal and illegal immigration respectively. By considering changes in the labor force of equal size, we want to compare the effects of legal to those of illegal immigration. Table 3 summarizes the consequences of

[27] We divide the estimates reported in the Table 8.2 of B&M with the U.S. GDP per capita in year 2013 to get the percentages.

[28] See the report from the Institute on Taxation and Economic Policy (ITEP), by Gee et al. (2017), for an overview of these studies.

[29] Storesletten (2000) also assumes that illegal immigrants pay no income and payroll taxes.

[30] Dustmann and Frattini (2014) also follow the same approach and target fiscal ratios.

[31] An American Immigration Council report (https://map.americanimmigrationcouncil.org/locations/ national/) shows that in 2021 total tax payments by all immigrants in the U.S. are 2.25% and those by illegal immigrants only are 0.13% of GDP. Our calibration gives 2.37% and 0.18%, respectively. Gee et al. (2017) estimate that illegal immigrants pay on average 8% of their income in state and local taxes, which are primarily consumption taxes. In our model, illegal immigrants pay 8.1% of their income in consumption taxes.

[32] Their calculations are based on data from the U.S. Census Bureau, the 2010 CPS survey and U.S. Bureau of Labor Statistics, and the 2010 Consumer Expenditure Survey.

Table 2
Effects of a 5% Increase in Labor Force due to Legal and Illegal Immigration.

	increase in l	increase in m
Unemployment and Wage Rates:		
u_n	-5.56	-9.12
u_l	-5.56	-9.12
u_m	-5.54	-9.08
w_n	0.13	0.21
w_l	1.20	1.98
w_m	2.10	3.46
Dividends, Capital and Output:		
π_n	6.35	15.25
k_n	0.01	5.44
y	0.27	0.42
Government Expenditures and Revenues:		
Unempl. Ins.	-1.35	-9.12
Transfers	3.70	3.70
Total Exp.	2.41	2.18
Cons. Tax Rev.	6.71	6.67
Income Tax Rev.	5.13	1.96
Payroll Tax Rev.	5.02	0.80
Total Rev.	4.85	2.27
f	-12.02	1.70
Consumption:		
c_n	2.10	1.60
c_l	3.33	3.31
c_m	2.39	3.94

The entries in the Table are % change effects of a 5% increase in the labor force due to legal (l) and illegal (m) immigration.

a legalization program that replaces illegal immigrants with legal ones. Columns 1-4 show the effects of decreasing m by 25%, 50%, 75% and 100%, respectively, while keeping the total number of immigrants the same, by increasing legal immigrants at the same time.

5.2.1. Effects of increasing legal and illegal immigration

As discussed above, in our calibrated model legal immigrants pay taxes in excess of the transfers they receive, but as can be see in column 1 of Table 2, they also improve natives' labor-market outcomes, because they induce higher job creation. This means that their wages are low enough so that their increased presence in the labor market increases firms' expected profits from opening new vacancies. Firms open more vacancies per unemployed worker, the job finding probability increases, the unemployment rate falls, which also leads to lower government spending on unemployment benefits. Workers can bargain for higher wages, since they can now more easily find jobs and their outside option improves.[33] As firms generate more profits, dividend income also increases, and as labor demand increases, demand for capital also increases, leading to also higher capital income.[34] Overall, the increase in the number of legal immigrants leads to higher income to native workers from all sources, reduces the tax burden on natives (f decreases by about 12%) and in turn, increases their consumption. In our calibrated model, legal immigrants reduce the tax burden on natives and increase their welfare, because their direct net fiscal contribution is positive, but also because they increase income in the U.S.

However, their positive direct contribution to the fiscal balance seems to be the main reason why legal immigrants increase natives' consumption. In Table C.1 of Appendix C, we show results for increasing l in the case where legal immigrants' outside option is not worse than that of natives. In particular, we set $x_l = 0$ so that their wage is almost equal to that of natives, and natives and

[33] Table 2 shows that an immigrant's wage increases more, in percentage terms, than a native's wage. This may lead one think that the inflow of legal immigrants benefits immigrants the most. However, the larger percentage change is due to immigrants' wages being lower than those of natives.

[34] As can be seen in Table C.1 of Appendix C, under the assumption that legal immigrants do not invest or own firms, the increase in capital and dividends per native is significantly larger. But calibrating the model to match the fiscal ratio for immigrants yields a smaller value for g_l^c, since legal immigrants tax contributions are smaller in that case. This explains why their fiscal impact is even more positive in that case.

Table 3
Effects of a Legalization Program.

↓ m by:	25%	50%	75%	100%
Unemployment and Wage Rates:				
u_n	1.24	2.52	3.86	5.25
u_l	1.24	2.52	3.86	5.25
u_m	1.23	2.51	3.84	–
w_n	-0.03	-0.06	-0.09	-0.12
w_l	-0.27	-0.54	-0.83	-1.13
w_m	-0.47	-0.95	-1.45	–
Dividends, Capital and Output:				
π_n	-2.22	-4.39	-6.50	-8.56
k_n	-1.39	-2.74	-4.06	-5.35
y	-0.05	-0.11	-0.17	-0.23
Government Expenditures and Revenues:				
Unempl. Ins.	2.39	4.86	7.42	10.06
Transfers	0.00	0.00	0.00	0.00
Total Exp.	0.07	0.14	0.21	0.29
Cons. Tax Rev.	-0.01	-0.02	-0.03	-0.04
Income Tax Rev.	0.77	1.54	2.30	3.04
Payroll Tax Rev.	1.03	2.06	3.07	4.06
Total Rev.	0.63	1.24	1.85	2.45
f	-3.44	-6.75	-9.92	-12.97
Consumption:				
c_n	0.11	0.20	0.28	0.35
c_l	-0.07	-0.16	-0.27	-0.40
c_m	-0.53	-1.08	-1.65	–

The entries in the Table are the % change effects of a legalization program that grants legal status to 25%, 50%, 75% and 100% of illegal immigrants in the labor force. Under the assumption that $g_m^c = g_l^c$ a legalization program has no impact on total government expenditure on transfers (other than unemployment insurance payments).

legal immigrants generate almost equal profits to firms.[35] The positive job-creation effect completely vanishes in this case. In fact, it turns negative as the increased presence of legal immigrants lowers the expected profits of firms, by reducing their chances of matching with an illegal immigrant worker, to whom they can pay a lower wage and also avoid payroll charges. As can be seen, unemployment and expenditure on unemployment insurance increase in this case, while natives' wages, dividends and output per capita fall. Nevertheless, even in this case, we get a significant decrease in f (by 9.4%) when legal immigration increases. Despite the negative income effect, legal immigrants improve the fiscal balance and decrease the tax burden on natives, because their direct tax contributions greatly exceed the transfers they receive.

Illegal immigrants also have a positive impact on natives' consumption, but mainly due to their positive effect on job creation. They help increase natives' consumption by increasing their job finding probability and income from wages, capital and dividends. They also help reduce expenditure on unemployment insurance considerably and, although they do not pay payroll and income taxes, they increase the government's revenues from not only consumption, but also payroll and income taxes, by increasing income to natives and legal immigrants. Despite their strong positive income effect, they impose a tax burden on natives (f increases by 1.7%), meaning that the increased tax revenue is not enough to cover the cost of the benefits they receive. Nevertheless, their positive effect on natives' income dominates over the additional tax burden and natives' consumption increases.

In previous studies emphasizing this job-creation effect of illegal immigrants the key feature is that they earn lower wages per unit of productivity than legal workers (i.e., their net productivity $p - w_i$ is higher). In Appendix C, we examine whether this positive job-creation effect carries through when we increase illegal immigrants' wage per unit of productivity. In Table C.2 we reduce the targeted gap in wages between legal and illegal immigrants to 5% (column 3). We also set $x_m = 0$ (column 5) which sets the wage of illegal immigrants about 3% and 23% higher than that of natives and legal immigrants, respectively.[36] It may be useful to note that setting illegal immigrants' wage higher is equivalent to setting their productivity lower than that of legal workers, since what

[35] Any difference in their wages in this case reflects the differences in their job finding and separation rates, which as mentioned above, are very small. Hence, setting $x_l = 0$ sets native-legal immigrant wage gap to almost 0.

[36] It may be recalled that wages decrease with payroll costs. While illegal immigrants do not receive any unemployment benefits, they can also avoid payroll costs. This explains why their wage is higher when their search cost is zero.

matters for the firms' profits and incentives to create jobs is the net productivity $p - w_i$ (see equations (29) and (30)). We see that even in the latter extreme case, where the net productivity of illegal immigrants' is significantly lower, natives' income, labor-market outcomes and consumption improve with the increase in illegal immigration. There are significant gains from the presence of illegal immigrants in the labor market stemming from the fact that firms that employ them do not have to pay payroll taxes or bear some of the weight of income taxes. Even when we set $x_m = 0$, we get that the value of a job filled by an illegal immigrant to the firm is twice the value of a job filled by a native (specifically, $J_m = 2.07 J_n$).[37]

Comparing the effects of the two types of immigrants we see that illegal immigrants' positive impacts on the unemployment rate and wage of natives are almost double that of legal immigrants, while their positive impacts on dividend and capital income are considerably larger. This is because of the significantly more positive effect that illegal immigrants have on firm profits and job creation incentives. Nevertheless, the impact of legal immigrants on natives' consumption is not smaller than that of illegal immigrants: a 5% increase in the labor force due to legal immigration increases each native's consumption by 2.1%, while the same increase in the size of the labor force due to illegal immigration increases each native's consumption by 1.6%.[38] Despite the much stronger positive labor-market effect of the latter, legal immigrants have a stronger positive impact on natives' welfare, because they reduce significantly the fiscal burden on natives by paying more taxes.

5.2.2. *The effects of a legalization program*

We next consider the effects of a legalization program by decreasing illegal immigrants and increasing legal immigrants at the same time, so that total number of immigrants remains the same.[39] By the legalization program we are essentially increasing the fraction of immigrants that must pay income taxes and whose employers are subject to payroll taxes, face lower search cost and receive higher wages. Since legal and illegal immigrants' transfers are set equal ($g_m^c = g_l^c$), such a shift in the composition of immigrants should leave government spending on transfers, other than unemployment insurance, intact. The legalization program thus influences the fiscal balance and natives' consumption only through its impact on job creation and income, government tax receipts and unemployment insurance payments.

As regards the government's tax receipts, the legalization program has two opposite effects. On the one hand, it ultimately generates more receipts from income and payroll taxes, since legalized immigrants must now pay income taxes and are subject to payroll taxes. On the other hand, as discussed above, legal immigrants are more costly to firms than illegal immigrants and replacing illegal with legal immigrants may have a negative impact on firm profits, job creation and in turn income from wages, dividend and capital. The resulting decrease in tax base implies lower tax receipts. Moreover, any negative effect on job creation from a legalization program will translate into more unemployment insurance payments. We see in Table 3 that in our calibrated model a legalization program indeed discourages job entry and leads to lower wages, higher unemployment rates and more unemployment insurance payments. It also reduces dividends and capital earnings. All these decrease the government's tax revenue. Nevertheless, the increased tax receipts from legalized immigrants dominate over these negative effects. The legalization program increases tax revenues more than it increases spending on unemployment insurance, leading to an improvement in the fiscal balance and a decrease in f.

As regards its impact on natives' welfare, again, there are two opposing channels. On the one hand, it reduces the tax burden on natives, which results in higher consumption for natives. On the other hand, it reduces income to natives with a negative impact on their consumption. In our calibrated model the decrease in the tax burden dominates over the negative income effect, and as a result, the legalization program increases natives' consumption. A legalization program that legalizes all illegal immigrants, decrease the tax burden on natives by 13% and increases natives' consumption by 0.35%.

It is important to point out here that since both types of immigrant increase natives' welfare, a legalization program is more beneficial to natives and has a more positive impact on public finances than a purely restrictive program that removes illegal immigrants from the labor force (e.g., through deportations). As shown in Table C.4, in our calibrated model a purely restrictive policy that eliminates all illegal immigrants from the labor market would increase f by about 0.5% (without taking into account the cost of implementing such a program), increase natives' unemployment rate by about 15% (as opposed to 5.3% by a legalization program), decrease natives' income from dividends and wages by 16.6% and 0.34%, respectively (as opposed to 8.6% and 0.12% by a legalization program) and decrease natives' consumption by 2.2%.

[37] Besides lower net productivity, another reason why hiring illegal immigrants may be costly to firms is the risk of being fined. However, evidence suggest that only a small fraction of employers employing illegal immigrants are affected by fines or other penalties, and the lower wage cost of using unauthorized labor more than compensates for the risk of being fined (see Albert (2021) for an overview of these evidence). It is therefore unlikely that these large gains from employing illegal immigrants will be overturned if the risk of fines is introduced.

[38] These changes in consumption imply an increase in natives' welfare by 1.42% and 1.08%, respectively. In the tables we report only consumption effects, but welfare effects can be easily derived from equation (37). The welfare effects of immigration in Battisti et al. (2018) are similar in magnitude. They find that a 1% increase in immigration to the U.S. increases natives' welfare by 0.05%. We consider a 5% increases in total labor force that translates into a 34.41% increase in total immigrant stock, due to either legal or illegal immigration. Multiplying 0.05 by 34.42 gives 1.72% increase in natives' welfare, close to our results. They consider however risk neutral individuals, thus their welfare measure is essentially total after tax income, which corresponds to our consumption measure. In addition, they consider a uniform increase in immigrant stock, without accounting for legal status.

[39] Following Chassamboulli and Peri (2015), we could add a legalization probability to capture a transition from an illegal immigrant status to a legal one and capture a legalization program by an increase in the legalization probability that produces a certain decrease in the size of the illegal population (and an equal increase in the size of the legal population). However, our main results would be essentially unchanged, since the effects of the legalization program are mainly driven by the resulting changes in the composition of immigrants and not by the actual policy change.

5.2.3. Additional robustness checks

In Appendix C we conduct some further robustness checks for the effects of increasing legal and illegal immigration and of a legalization program in Tables C.1, C.2 and C.3, respectively. Besides setting the search costs of legal or illegal immigrants to zero ($x_l = 0$ or $x_m = 0$) and considering smaller wage gaps between natives and legal immigrants (5%) and between legal and illegal immigrants (5%), we also consider (in column 6 of each table) the possibility that legal immigrants do not own capital, firms or government bonds, which is a common assumption in the literature, the possibility that immigrants remit part of their income (in column 7 of each table) and the case where 50% of illegal immigrant workers contribute to income and payroll taxes (in column 8 of each table).

We find that the effects of illegal immigration are essentially unchanged when legal immigrants do not invest or own firms, but the effects of legal immigration on natives' income from dividends and capital is significantly larger and so is the impact on natives' consumption and consumption tax revenues. Granting legal status to illegal immigrants is more beneficial to natives in this case than in the baseline model, since the increased dividend and capital income benefits natives only. Evidence point to immigrants remitting from 8% to 50% of their income, depending on legal status and country of origin.[40] We simulate the model assuming that both types of immigrants remit 50% of their income, since considering that legal immigrants remit less than illegal immigrants, would add another positive effect from legalizations on natives. Results remain almost intact, since remittances do not alter the households income, and thus income tax payments. They only reduce the household's consumption in the host country, with a small impact on government tax revenue, since most government tax revenue comes from income taxes.[41] Finally, when only 50% of illegal immigrants work off the books, the increase in illegal immigration has a slightly smaller positive effect on job creation and thus employment, since its impact on average firm profits is smaller. But differences in the results overall are very small.

6. Extensions

In this section, we extend the basic model in two different directions. First, we let illegal workers be imperfect substitutes for legal workers. In this model extension the marginal products (productivities) of legal and illegal workers are no longer equal and constant; they depend on the composition of immigrants in terms of legal status. This adds an additional channel through which changes in the numbers of legal and illegal immigrants or changes in the composition of immigrants in terms of legal status, can influence labor market outcomes, and in turn the fiscal balance and welfare. We also consider here the case where the three groups of workers are heterogeneous in terms of skills, and the case where illegal immigrants not only produce a differentiated labor input, but also participate in a segmented labor market, which is isolated from natives and legal immigrants. Second, we consider a version of the model in which immigrants might "congest" the goods and services provided by the government and thus reduce the amount allocated to natives.

6.1. Imperfect substitution

We explore here the possibility that illegal immigrants produce a differentiated labor input, meaning that their labor is not perfect substitute for that of legal immigrants or natives. More specifically, the production function of the final good is still given by (5), but the intermediate labor input, X_t, is now a CES sub-aggregate, namely,

$$X_t = \left[\varrho(E_{n,t} + E_{l,t})^{\sigma} + (1-\varrho)E_{m,t}^{\sigma}\right]^{\frac{1}{\sigma}}, \quad 1 > \varrho > 0, \ \sigma \leq 1, \tag{38}$$

where ϱ is a parameter that governs income shares and σ determines the elasticity of substitution between illegal and legal workers: $1/(1-\sigma)$. Clearly, legal and illegal workers have now different marginal products and hence different prices, $p_{i,t}$:

$$p_{n/l,t} = (1-\alpha)\varrho\frac{Y_t}{X_t}\left(\frac{X_t}{E_{n,t}+E_{l,t}}\right)^{1-\sigma} \tag{39}$$

$$p_{m,t} = (1-\alpha)(1-\varrho)\frac{Y_t}{X_t}\left(\frac{X_t}{E_{m,t}}\right)^{1-\sigma}, \tag{40}$$

where the subscript $i = [n/l, m]$ is used to denote the labor input of legal (native or immigrant) and illegal (immigrant) workers, respectively. The rate of return on capital remains as given by (6). In steady state, the marginal products p_i are no longer fixed and now depend on the composition of the labor force in terms of legal status and market tightness, θ. Since the two labor inputs are imperfect substitutes, an increase in one type of labor will lower the price of its labor input and raise the price of the other labor

[40] See for instance, Amuedo-Dorantes and Pozo (2006) and Yang (2011).

[41] Consistent with the view that some of the immigrant households' consumption must be made in the home country, because some members of the household remain there, in our model remittances reduce only immigrants' consumption in the host country. This is because total investments (capital) respond, through production complementarities, to total labor supply and job creation, which are unrelated to remittances. If, due to remittances, legal immigrants invest less in the host country, then more investment income goes to natives, while total investment income (and thus government's tax revenue) remains the same. We show that results are essentially unchanged when legal immigrants do not invest or own firms in the host country, suggesting that even if remittances reduce immigrants' investments, our main results remain.

input. For instance, an increase in proportion of legal workers will lower $p_{n/l}$, reflecting the increased competitive pressure imposed on them, and increase p_m.

The above CES structure captures the complementarities that arise due to the restrictions imposed by the illegal status. Immigrants that are not authorized to work may be restricted to perform certain productive roles (or tasks), which are different from those of legal workers, thereby complementing legal workers in production, even if their skills are not different from those of legal workers. Legalizations, therefore increase competitive pressure on legal workers (lower their productivity), an aspect missing from the baseline model. We prefer to keep legal (native or immigrant) workers as a homogeneous group in production in this model version also, to make the comparison with the baseline model easier. In the model with skill heterogeneity, the legalized immigrants will compete more with the legal workers whose skills are similar to theirs, and less with those whose skills are different. By considering legal workers as a homogeneous group, we are abstracting from characterizing how the productivity loses will be larger for some subgroups of legal workers and smaller for others, but we are capturing the average effects. Since our focus is to quantify the impacts on natives overall, this comes with no loss of generality, while it allows us to illustrate more clearly the role of the illegal/legal status, which is the focus of this paper. We discuss the more generalized set up that allows for the three groups of workers to be heterogeneous in terms of skills below.

We calibrate the model as described in Section 5.1. As an empirical basis for our choices of σ, we use the estimates reported in Ottaviano and Peri (2012). Based on their estimates, the elasticity between immigrant and native workers of the same skill type $1/(1-\sigma)$ should range from about 6.5 to about 20, meaning that σ should lie somewhere between 0.85 and 0.95. We set $\sigma = 0.9$, which is within this range. Also, in lack of good empirical estimate that can guide our choice of value for ϱ, for the results below we set $\varrho = 0.6$. This value ensures that a firm that meets a native worker will form an employment relation and will not decide to wait for an immigrant worker. It also ensures that all types of workers are employed, that is, an unemployed worker will not turn down an employment opportunity and continue searching.

Table 4 shows the effects of a 5% increase in the labor force due to legal and illegal immigration and of a legalization program that grants legal status to all illegal immigrants. As can be seen, our previous results are robust to the generalized set-up. More specifically, legal immigrants increase natives' welfare and reduce the fiscal burden on natives. Illegal immigrants also have a positive impact on natives' consumption, due to their positive labor market effect, which translates into higher income to natives, while they impose a tax burden on natives, as in the baseline model. Overall, compared to the results in our baseline model, the differences are quantitatively small and they stem mainly from the differences in the productivity of legal and illegal workers in the calibrated model. In this model version, part of the wage gap between legal and illegal workers is due to the lower productivity of the latter. This explains why illegal immigrants have a smaller job creation effect, hence decrease unemployment rates by less than in the baseline model. Despite the decrease in the productivity of legal workers, due to the increased competitive pressure from legalized immigrants, legalizations now have a positive effect on job creation, since by granting legal status to illegal immigrants we are also making them more productive.

It can be further shown that allowing for also skill heterogeneity in the model does not bring any significant changes to our results. In Appendix D we consider a version of the model where legal immigrants and natives can be skilled or unskilled and all illegal immigrants are unskilled (and remain unskilled after legalization). Skilled and unskilled labor are complements in production and the labor market is segmented by skills. Illegal immigrants search for unskilled jobs together with unskilled legal (immigrant and native) workers, but their labor complements that of unskilled legal workers, reflecting the restrictions they face due to their illegal status. In this version of the model, changes in the skill composition of the labor force affect the marginal product of workers whose labor becomes relatively more abundant (scarce) negatively (positively). For instance, an increase in the number of (unskilled) illegal immigrants increases the marginal product of skilled legal workers by more than it increases the marginal product of unskilled legal workers. But as can be verified from the results summarized in Table C.5, the labor-market effects on natives and legal immigrants averaged across skills are very similar to the simpler model without skill heterogeneity and so are the fiscal and welfare effects.[42]

Despite producing a differentiated labor input, we assumed so far that illegal immigrants search in the same market as legal immigrants and native workers. One could argue, however, that if due to the restrictions imposed by their illegal status, illegal immigrants produce a differentiated labor input, then jobs created for illegal immigrants may be different than those targeted towards legal immigrants or natives. That is, the market for illegal immigrants may be segmented, meaning that illegal immigrants do not "compete" for the same jobs as natives and legal immigrants. If markets are segmented, then illegal immigrants affect incentives to create jobs for natives (or legal immigrants) only through their impact on marginal product $p_{n/l}$, implying a much smaller positive job-creation effect on natives. That is, an increase in the proportion of illegal immigrants in the group of job seekers no longer increases the expected profits of jobs suited for natives or legal immigrants, because illegal immigrants participate in a different labor market (see Appendix E for a short description of the model with segmented markets).[43]

We show results for this case in Appendix C, Table C.6. The main results carry through. In fact, under segmented markets the job-creation effect of legal immigrants on natives is slightly more positive, since increasing their presence in this case, does not reduce the

[42] Following Chassamboulli and Peri (2015) we calibrate the model assuming that skilled workers are those with some college education and we set the elasticity of substitution between skilled and unskilled labor to 2, based on estimates from Ottaviano and Peri (2012). The share of skilled workers is set to 0.54, which is the average (over years 2000 and 2010) share of US-born workers with some college education. We target the wage premium for workers in the US who have at least some college education, to pin down productivity differences between skilled and unskilled workers. Based on IPUMS USA data 2000-2010 we find it to be on average equal to 68%.

[43] As shown in Appendix E, in this case there are two different job creation conditions: one that determines vacancies suited for legal immigrants and natives and one that determines vacancies suited for illegal immigrants. Thus, expected profits from opening vacancies for natives do not depend on the size of illegal immigrant population.

Table 4
Effects under Imperfect Substitution.

	↑ in l	↑ in m	legalization
Unemployment and Wage Rates:			
u_n	-6.37	-5.92	-0.16
u_l	-6.37	-5.92	-0.16
u_m	-6.35	-5.90	–
w_n	0.13	0.57	-0.52
w_l	1.39	1.83	-0.59
w_m	2.10	-5.95	–
Dividends, Capital and Output:			
π_n	6.42	9.40	-2.29
k_n	0.07	4.61	-5.08
y	0.33	-0.37	0.05
Government Expenditures and Revenues:			
Unempl. Ins.	-2.20	-5.92	4.40
Transfers	3.69	3.69	0.00
Total Exp.	2.38	2.27	0.13
Cons. Tax Rev.	6.80	5.50	0.11
Income Tax Rev.	5.19	1.83	3.15
Payroll Tax Rev.	5.08	0.96	4.04
Total Rev.	4.90	2.06	2.54
f	-12.37	3.05	-14.08
Consumption:			
c_n	2.17	1.37	0.40
c_l	3.57	2.56	0.49
c_m	2.43	-5.66	–

The entries in the Table are the % change effects of a 5% increase in the labor force due to legal (l) and illegal (m) immigration and a legalization program (legalization) that legalizes all illegal immigrants in the labor force, in the model extension where illegal immigrants are imperfect substitutes for natives and legal immigrants (see Section 6.1).

chances that firms match with an illegal immigrant worker who generates larger profits to firms. As regards the impact of increasing the number of illegal immigrants, the positive job-creation effect is much smaller, as expected, but remains large enough to generate a positive welfare effect on natives. It is noteworthy that the job creation effects of a legalization program are much more beneficial compared to the case where legal and illegal workers participate in the same market, leading to larger decrease in the tax burden on natives and a larger increase in their consumption.

6.2. Public service congestion and welfare

A common argument against immigrants is that they congest public services thereby reducing natives' welfare by reducing the amount of services available to natives. In this section we explore this possibility. In our baseline model an increase in the number of immigrants does not reduce the amount of government goods and services per native or immigrant household; it can only generate more (or less) taxes to be contributed by native and legal households through changes in the lump-sum tax f. In the alternative set up we analyze here, there is no lump sum tax f. Instead, we allow for government spending to change depending on tax revenues as the government attempts to keep its debt sustainable. Changes in the number of immigrants thus influence government spending and the amount of this spending allocated to each household.

The household derives utility from private consumption, as above, but also from goods and services provided by the government. The household's discounted lifetime utility is given by:

$$\sum_{t=0}^{\infty} \beta^t \left[\log(c_{i,t}) + \psi_i \log(g^c_{i,t}) \right] \tag{41}$$

where $g^c_{i,t}$ is the amount of government goods and services allocated to a household of type-i and ψ_i is the relative preference parameter. The rest of the model assumptions and equations remain exactly as in the baseline model. The only difference is that there is no lump-sum tax, i.e. $f_t = 0$, since the government now adjusts its spending G_t in order to keep its debt sustainable, given its tax receipts. It may be recalled that $G_t \equiv G^p_t + G_t{}^c$; government spending is divided into public goods G^p_t and spending on congestible goods G^c_t. Since (by definition) public goods are non-congestible, meaning that spending on these goods does not increase with the

size of the population, we assume G_t^p is fixed and the government adjusts only the provision of G_t^c. We discuss this assumption further below.

In steady state, the government debt must be fixed to its sustainable level (see equation (24) with $F = 0$) and government spending on congestible goods must therefore satisfy:

$$G^c = T - \sum_i i b_i u_i - Dr(1-\tau) - G^p, \tag{42}$$

where as above $T \equiv (\tau + \tau_p)\left(nw_n e_n + lw_l e_l\right) + \tau(rk_n n + rk_l l + \pi_n n + \pi_l l) + \tau_c \sum_i i c_i$.

We assume that access of native, legal and illegal immigrants to congestible goods and services can differ by the proportions, $\rho_n = 1$, $\rho_l \leq 1$ and $\rho_m \leq 1$. Therefore, the amount of these goods allocated to a type-i household is given by

$$g_i^c = \frac{\rho_i G^c}{\rho_n n + \rho_l l + \rho_m m}.$$

From equation (42) we see that an increase in the number of immigrants will increase G^c if it raises tax revenue T in excess of spending on unemployment benefits $\sum_i i b_i u_i$. As discussed above, this can happen either because immigrants pay enough taxes, which is more relevant for legal immigrants, or because they benefit firms, inducing them to create jobs, and increase income in the host country. However, irrespective of what drives it, an increase in G^c does not necessarily mean that natives' welfare increases. Even if due to immigration G^c increases, the amount allocated to each native g_n^c may decrease, if immigrants congest government goods and services, which is more likely to occur when they face few restrictions in using them (i.e., ρ_m or ρ_l is close to 1, which implies full access by immigrants).

We calibrate the model as described in Section 5.1. The only difference here is that we do not match targets on total public spending G, since it is determined endogenously. In our baseline model where we match the B&M receipts to outlays ratios we get $G^p = 0.32G$, which implies that 68% of total government spending (on goods other than unemployment benefits) is on congestible goods. To make comparison with the results in the baseline case easier, we set the value of G^p by targeting this ratio. In lack of evidence that can accurately guide our choice of values for parameters ρ_l and ρ_m, we set $\rho_l = \rho_m = 1$, implying maximum congestion from immigrant workers. If one accepts that, due to restrictions by law, immigrants' and especially illegal immigrants' use of government goods and services is lower than that of natives, then by setting $\rho_l = 1$ or $\rho_m = 1$, we are overestimating the congestion generated by immigrants. Finally, we set $\psi_n = \psi_l = \psi_m = 0.56$, which based on Ni (1995), lies at the upper end of estimates for the relative preference for public consumption.

Results are shown in Table 5. Notice that this modification does not alter the model's predictions regarding the labor market impact of immigrants. Hence, as can be seen, changes in unemployment, wages, dividend and capital income of natives, as well changes in government unemployment insurance payments and revenues from payroll and income taxes remain as in the baseline model. The new feature here is that immigration can change natives' welfare by changing g_n^c. These effects are summarized in the lower panel of Table 5. In line with our baseline model, both types of immigrants increase natives' welfare and private consumption c_n, but legal immigrants increase also g_n^c, while illegal immigrants decrease it. A legalization program thus increases g_n^c, but decreases c_n, since legal immigrants pay more taxes, but increase natives' income by less. Our results show that the increase in g_n^c dominates and the legalization program increases natives' welfare.[44]

It is important to point out, however, that these results are based on the assumption that illegal immigrants face no restrictions in using government goods and services ($\rho_m = 1$). It can be shown that setting $\rho_m < 0.76$, meaning that government benefits allocated to illegal-immigrant households are no more than 76% of those allocated to legal-immigrant households, ensures that the impact of also illegal immigration is positive on g_n^c (in Table C.7 we show results for $\rho_m = 0.7$). In this case legalizations benefit natives by less, as legal immigrants use government goods and services by more than illegal ones.

Another issue concerns our division of government spending into congestible and non-congestible goods. There is no clear-cut way of splitting the various types of government spending into those two categories. While transfers are clearly private, some public goods may be also subject to congestion, as with more immigrants the government must devote additional resources in order to maintain equal quality or benefit to natives. While our calibration is quite conservative as regards the types of government spending we include in our measure of public goods (as discussed in Section 5.1, G^p includes mainly defence and interest payments) we also examine the extreme case where all government spending is subject to congestion (i.e. we set $G^p = 0$ so that $G^c = G$). As shown in Table C.7, in this case g_n^c decreases with both types immigrants. But this negative effect remains small relative to their positive impact on private consumption and, even in this case, both types of immigrants have a small but positive impact on natives' welfare. In all cases considered, both types of immigrants have a positive impact on natives' welfare. Therefore, in this model extension also, a legalization program is more beneficial to natives than a restrictive policy that reduces the number of immigrants in the labor force.

[44] Of course, this depends on the relative preference for public consumption. Setting the preference parameter to $\psi = 0.33$, which based on Ni (1995) is the lowest estimate for the relative preference for public consumption, turns the impact of legalization on natives' welfare negative, as the negative effect on private consumption dominates in this case. But even in that case, it can be shown that legalizations are more beneficial to natives than restrictive immigration policies such as deportations.

Table 5
Immigrants' Congestion Effects.

	↑ in l	↑ in m	legalization
Unemployment and Wage Rates:			
u_n	-5.56	-9.12	5.25
u_l	-5.56	-9.12	5.25
u_m	-5.54	-9.08	–
w_n	0.13	0.21	-0.12
w_l	1.20	1.98	-1.13
w_m	2.10	3.46	–
Dividends, Capital and Output:			
π_n	6.35	15.25	-8.56
k_n	0.01	5.44	-5.35
y	0.27	0.42	-0.23
Government Expenditures and Revenues:			
Unempl. Ins.	-1.35	-9.12	10.06
Transfers	7.14	3.87	2.98
Total Exp.	4.64	2.22	2.32
Cons. Tax Rev.	4.90	6.03	-1.10
Income Tax Rev.	5.13	1.96	3.04
Payroll Tax Rev.	5.02	0.80	4.06
Total Rev.	4.60	2.19	2.31
Consumption and Welfare:			
c_n	0.24	1.62	-1.41
c_l	1.01	3.06	-2.30
c_m	2.39	3.94	–
g_n^c	2.04	-1.08	2.98
ϕ_n	0.71	0.51	0.12
ϕ_l	1.18	1.34	-0.38
ϕ_m	2.05	1.91	–

The entries in the Table are the % change effects of a 5% increase in the labor force due to legal (l) and illegal (m) immigration and a legalization program (legalization) that legalizes all illegal immigrants in the labor force, in the model extension in which immigrants can reduce the amount of government goods and services allocated to each household (see Section 6.2).

7. Conclusions

An important concern in the public debate over immigration is on its fiscal impact. Since legal and illegal immigrants differ in many aspects, thus affect the labor market and tax base differently, and also contribute to the fiscal balance in different ways, it is important to distinguish illegal from legal immigrants. However, most research on this subject overlooks this dimension. Our paper investigates the welfare and fiscal impact of legal and illegal immigration by developing a dynamic general equilibrium model that explicitly takes into account the job-creation effect of immigration. We allow legal and illegal immigrants to have different tax contributions and face different restrictions in the use of welfare benefits and public services. In our model the overall effect of each of the two types of immigration on natives' welfare depends on two interrelated dimensions. On the one hand, by paying taxes and consuming the public good, immigrants can have a direct fiscal effect. On the other hand, through the job creation channel, immigrants can influence the host country's wages and employment opportunities, output, firm profits and in turn the fiscal balance. We demonstrate that these two dimensions cannot be seen in isolation as they are not exogenous to each other; whether immigrants pay taxes and receive benefits or whether the firms that employ them can avoid payroll taxes has important implications for firms' labor costs, and in turn, job creation, output and the tax base.

In our calibrated baseline economy, we have found that an increase in either type of immigrants increases the welfare of the natives, but the main reason for the increase in natives' welfare can differ. For legal immigrants, the first dimension is more important. Their positive effect on natives' welfare stems mainly from their positive direct fiscal impact as their tax contributions greatly exceed the transfers they receive. Illegal immigrants, on the other hand, increase natives' consumption, through their positive effect on job creation and natives' income. We have shown that these results are robust in a calibrated version of the model where illegal immigrants are imperfect substitutes for natives and legal immigrants and participate in a segmented labor submarket. We have also shown that our main results carry through when we allow immigrants to reduce natives' welfare by reducing the amount of government goods and services available to natives. Our analysis also sheds light on the potential effects of immigration policies and specifically of how to deal with illegal immigration. We have shown that a program that legalizes illegal immigrants leads to a fiscal gain and an increase in natives' welfare and is more beneficial to natives than a purely restrictive program that removes illegal immigrants from the host-country's labor force.

By considering heterogeneity in immigrant legal status and addressing relevant policy questions, such as the effects of legalizations, our approach complements previous analyses centered on the implications of search frictions for the welfare and fiscal effects of immigration. But it can still be extended in various dimensions, such as to account for fiscal redistribution among different generations. With the intergenerational feature, we can examine how legal and illegal immigration affect the burden of aging population differently. In this case, legal immigrants can increase the number of contributors to the pension scheme, but they also are more likely to stay and retire in the host country. Illegal immigrants, on the other hand, make less pension contributions, but they are more likely to return home, while their children could help overcome the burden of population aging. Moreover, similar to our paper, the impact of immigrants on social insurance programs hinges also on their labor market impact, which also depends on their legal status. Therefore, it is important to disentangle the strength of each possible dimension when examining the pension effect of legal and illegal immigration.

Data availability

Data will be made available on request.

Acknowledgment

We thank the Editor and the anonymous referees for helpful comments. Liu acknowledges the research support from the National Social Science Fund of China (#23BJL038).

Appendix A. Proofs

A.1. Restrictions on parameter values

To ensure that all types of workers are employed, all surpluses must be positive. Given the Nash sharing rule this requires that all J_i are positive. For $J_n > 0$, it is necessary and sufficient to assume that $p > \frac{(1+\tau_p)b_n}{1-\tau}$. Given that $J_m > J_l \geq J_n$, $p > \frac{(1+\tau_p)b_n}{1-\tau}$ implies also that $J_l > 0$ and $J_m > 0$.

The assumption that $p > \frac{(1+\tau_p)b_n}{1-\tau}$ guarantees also that $J_n > V = 0$. Thus, a firm that meets a native worker will form an employment relation and will not decide to wait for an immigrant worker, despite the fact that the latter generate more surplus to firms.

A.2. Proof of Proposition 1

Differentiating the left-hand side (LHS) of equation (36) with respect to θ yields

$$\frac{\partial LHS}{\partial \theta} = -\frac{\kappa}{q^2} q'(\theta) > 0.$$

Differentiating the right-hand side (RHS) of equation (36) with respect to θ yields

$$\frac{\partial RHS}{\partial \theta} = -\frac{\eta(1-\eta)\mu'(\theta)}{(r+s+\eta\mu)^2(n+l+m)} \left[n\left(p - \frac{(1+\tau_p)b_n}{1-\tau}\right) + l\left(p - \frac{(1+\tau_p)(b_l - x_l)}{1-\tau}\right) + m\left(p - b_m + x_m\right)\right] < 0.$$

The LHS of equation (36) is increasing with respect to θ, whereas the RHS is decreasing in θ. It follows that the curves of the LHS and the RHS intersect only once. Therefore, the steady-state equilibrium exists and is unique.

A.3. Proof of Proposition 2

Consider an increase in illegal immigration m. Differentiating the RHS of equation (36) with respect to m yields

$$\frac{\partial RHS}{\partial m} = \frac{1-\eta}{r+s+\eta\mu} \frac{1}{(n+l+m)^2} \left[n\left(\frac{1+\tau_p}{1-\tau} b_n - (b_m - x_m)\right) + l\left(\frac{1+\tau_p}{1-\tau}(b_n - x_l) - (b_m - x_m)\right)\right] > 0.$$

Differentiating the LHS of equation (36) with respect to m yields

$$\frac{\partial LHS}{\partial m} = 0.$$

An increase in m shifts the curve of the RHS to the right, while it does not change the position of the LHS curve. As a result, an increase in m leads to a higher θ. Moreover, given equations (32)-(34) and (27), we show that $\frac{dw_i}{dm} > 0$, $\frac{du_i}{dm} < 0$ and $\frac{de_i}{dm} > 0$. Combining $\frac{de_i}{dm} > 0$ with equations (21) and (25), we show $\frac{dk_i}{dm} > 0$.

Using the free-entry condition in (36), together with (27) we can write total dividends (in (26)) as:

$$\Pi = \frac{\kappa}{q} r(n+l+m)\left(\frac{\mu}{\mu+s}\right).$$

Given $\frac{dq}{d\theta} < 0$, $\frac{d\mu}{d\theta} > 0$ and $\frac{d\theta}{dm} > 0$, it follows that $\frac{d\Pi}{dm} > 0$, which also implies $\frac{d\pi_i}{dm} > 0$.

Appendix B. Evidence on wealth differences between U.S. immigrants and natives

Cobb-Clark and Hildebrand (2006) utilize household data drawn from the 1987, 1990-1993 and 1996 Survey of Income and Program Participation (SIPP) to compare U.S. native and foreign-born wealth. Based on their estimates the mean net worth of immigrants is about 30% lower than that of U.S.-born. The gap in financial wealth is the largest, about 50% and the gap in real estate wealth is the smallest, about 18%. More recent estimates in Seto and Bogan (2013) using the 2001-2003 SIPP panel sets, give a smaller immigrant-native gap in financial wealth of 22%. Hao (2004) exploits the 1992-1993 panels of the SIPP and shows much smaller gaps in net total and financial wealth, about 5%-6%. Luik and Steinhardt (2016) explore data from the Health and Retirement Study (HRS) and find that the average net financial wealth of (older) immigrants is about 63% of that of (older) natives. Using the same data set, Love and Schmidt (2019) find similar results. The results in Amuedo-Dorantes and Pozo (2002) using data from the 1979 Youth Cohort of the National Longitudinal Surveys, suggest that immigrants save to a greater extent than natives. Others, such as Osili and Paulso (2006) examine differences in the percentage of immigrants and natives holding various financial assets and find gaps in the range of 10% to 15%. As Cobb-Clark and Hildebrand (2006) point out, all the above-mentioned data sets do not gather information about assets held off-shore, but it is likely that off-shore assets are disproportionately under-reported and it may be most useful to think of them as capturing U.S.-based wealth only. Regarding firm ownership, Kerr and Kerr (2020) show that immigrants start about 25% of all U.S. firms in the Survey of Business Owners data during 2008–2012, and this share rises to above 40% in states like California and New York. Kallick (2012) shows further that firms owned by immigrants include not only small businesses, but also 18% of all Fortune 500 companies.

Cobb-Clark and Hildebrand (2006) also show the wealth levels of foreign-born households that do not hold U.S. citizenship are significantly lower than those of foreign-born U.S. citizens (about 47,000 less, with the mean net worth of all foreign-born estimated to approximately 90,000 dollars). Love and Schmidt (2015), highlight similar differences in wealth across immigrants of different ethnicity, suggesting that much of the overall gap in wealth can be accounted for by the lower wealth holdings of Hispanics. Likewise, Seto and Bogan (2013) show that immigrants from countries with international financial market integration, same language and cultural proximity to the U.S. show higher similarity in financial participation rates to U.S. natives.

Appendix C. Additional robustness checks and extensions

Table C.1
Effects of Legal Immigration - Robustness Checks.

	Baseline	$x_l = 0$	$\frac{w_l}{w_m} = 1.05$	$\frac{w_n}{w_l} = 1.05$	$x_m = 0$	$k_l = 0$ $d_l = 0$ $\pi_l = 0$	remit. 50%	50% of m pay tax
Unemployment and Wage Rates:								
u_n	-5.56	0.48	-5.67	-2.14	-7.58	-5.56	-5.56	-5.69
u_l	-5.56	0.48	-5.67	-2.14	-7.58	-5.56	-5.56	-5.69
u_m	-5.54	0.48	-5.65	-2.13	-7.55	-5.54	-5.54	-5.67
w_n	0.13	-0.01	0.13	0.05	0.18	0.13	0.13	0.13
w_l	1.20	-0.01	1.23	0.15	1.64	1.20	1.20	1.23
w_m	2.10	-0.08	1.98	0.46	0.41	2.10	2.10	1.58
Dividends, Capital and Output:								
π_n	6.35	-0.80	6.48	2.16	8.53	11.95	6.35	6.49
k_n	0.01	-0.28	0.01	-0.15	0.10	5.28	0.01	0.01
y	0.27	-0.02	0.27	0.10	0.36	0.27	0.27	0.27
Government Expenditures and Revenues:								
Unempl. Ins.	-1.35	5.77	-1.47	2.79	-3.46	-1.35	-1.35	-1.48
Transfers	3.70	4.23	3.70	4.08	3.78	2.83	3.27	4.19
Total Exp.	2.41	2.96	2.41	2.77	2.40	1.84	2.13	2.73
Cons. Tax Rev.	6.71	6.29	6.71	6.48	6.78	7.16	4.34	6.46
Income Tax Rev.	5.13	5.17	5.14	5.21	5.31	5.11	5.13	5.15
Payroll Tax Rev.	5.02	5.24	5.03	5.22	5.22	5.02	5.02	5.03
Total Rev.	4.85	4.84	4.85	4.89	5.00	4.89	4.52	4.82
f	-12.02	-9.38	-12.06	-10.44	-12.64	-15.16	-12.09	-9.94
Consumption:								
c_n	2.10	1.33	2.12	1.64	2.31	4.00	2.11	1.87
c_l	3.33	1.33	3.37	1.80	3.90	5.56	6.69	3.09
c_m	2.39	-0.10	2.27	0.57	0.80	2.39	2.39	2.23

The entries in the Table are % change effects of a 5% increase in the labor force due to legal immigration. The first column shows results for the baseline model and the next seven columns results for four robustness checks: setting the search cost of legal immigrants to 0 (column 2), setting the legal/illegal wage gap to 5% (column 3), setting the native/legal immigrant wage gap to 5% (column 4), setting the search cost of illegal immigrants to 0 (column 5), immigrants do not own government bonds, capital or firms (column 6), 50% of immigrants' disposable income is remitted (column 7), 50% of illegal immigrants pay income and payroll taxes (column 8).

Table C.2
Effects of Illegal Immigration - Robustness Checks.

	Baseline	$x_l = 0$	$\frac{w_l}{w_m} = 1.05$	$\frac{w_n}{w_l} = 1.05$	$x_m = 0$	$k_l = 0$ $d_l = 0$ $\pi_l = 0$	remit. 50%	50% of m pay tax
Unemployment and Wage Rates:								
u_n	-9.12	-7.86	-8.69	-8.38	-0.65	-9.12	-9.12	-8.56
u_l	-9.12	-7.86	-8.69	-8.38	-0.65	-9.12	-9.12	-8.56
u_m	-9.08	-7.83	-8.66	-8.35	-0.65	-9.08	-9.08	-8.53
w_n	0.21	0.19	0.20	0.20	0.02	0.21	0.21	0.20
w_l	1.98	0.18	1.89	0.60	0.14	1.98	1.98	1.86
w_m	3.46	1.25	3.03	1.79	0.04	3.46	3.46	2.39
Dividends, Capital and Output:								
π_n	15.25	13.51	14.70	14.22	5.56	15.25	15.25	14.54
k_n	5.44	5.38	5.42	5.40	5.01	5.44	5.44	5.41
y	0.42	0.36	0.40	0.38	0.01	0.42	0.42	0.39
Government Expenditures and Revenues:								
Unempl. Ins.	-9.12	-7.86	-8.69	-8.38	-0.65	-9.12	-9.12	-8.56
Transfers	3.70	4.23	3.70	4.08	3.78	2.83	3.27	4.19
Total Exp.	2.18	2.56	2.20	2.45	2.48	1.62	1.91	2.52
Cons. Tax Rev.	6.67	6.61	6.67	6.64	6.53	7.12	4.34	6.27
Income Tax Rev.	1.96	1.69	1.92	1.77	1.21	1.96	1.96	1.91
Payroll Tax Rev.	0.80	0.56	0.76	0.63	0.06	0.80	0.80	0.75
Total Rev.	2.27	2.07	2.24	2.13	1.68	2.34	1.96	2.19
f	1.70	4.44	1.90	3.60	5.61	-1.39	1.61	3.68
Consumption:								
c_n	1.60	1.06	1.54	1.23	0.47	2.17	1.62	1.25
c_l	3.31	1.06	3.17	1.62	0.65	3.04	3.70	2.82
c_m	3.94	1.65	3.49	2.23	0.07	3.94	3.94	3.36

The entries in the Table are % change effects of a 5% increase in the labor force due to illegal immigration. The first column shows results for the baseline model and the next seven columns results for four robustness checks: setting the search cost of legal immigrants to 0 (column 2), setting the legal/illegal wage gap to 5% (column 3), setting the native/legal immigrant wage gap to 5% (column 4), setting the search cost of illegal immigrants to 0 (column 5), immigrants do not own government bonds, capital or firms (column 6), 50% of immigrants' disposable income is remitted (column 7), 50% of illegal immigrants pay income and payroll taxes (column 8).

Table C.3
Effects of a Legalization Program - Robustness Checks.

	Baseline	$x_l = 0$	$\frac{w_l}{w_m} = 1.05$	$\frac{w_n}{w_l} = 1.05$	$x_m = 0$	$k_l = 0$ $d_l = 0$ $\pi_l = 0$	remit. 50%	50% of m pay tax
Unemployment and Wage Rates:								
u_n	5.25	12.00	4.37	9.07	-7.56	5.25	5.25	4.15
u_l	5.25	12.00	4.37	9.07	-7.56	5.25	5.25	4.15
w_n	-0.12	-0.28	-0.10	-0.21	0.18	-0.12	-0.12	-0.10
w_l	-1.13	-0.28	-0.94	-0.65	1.64	-1.13	-1.13	-0.90
Dividends, Capital and Output:								
π_n	-8.56	-14.61	-7.82	-12.11	3.32	-3.62	-8.56	-7.64
k_n	-5.35	-5.65	-5.31	-5.52	-4.77	-0.23	-5.35	-5.30
y	-0.23	-0.55	-0.19	-0.41	0.38	-0.23	-0.23	-0.18
Government Expenditures and Revenues:								
Unempl. Ins.	10.06	18.04	9.14	14.70	-3.34	10.06	10.06	8.92
Transfers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Exp.	0.29	0.53	0.26	0.43	-0.10	0.29	0.29	0.26
Cons. Tax Rev.	-0.04	-0.53	-0.03	-0.31	0.26	-0.04	-0.14	0.12
Income Tax Rev.	3.04	3.32	3.12	3.29	4.24	3.01	3.04	3.14
Payroll Tax Rev.	4.06	4.51	4.15	4.44	5.33	4.06	4.06	4.17
Total Rev.	2.45	2.62	2.52	2.62	3.42	2.43	2.44	2.54
f	-12.97	-12.49	-13.35	-12.97	-18.56	-13.17	-12.92	-12.99
Consumption:								
c_n	0.35	-0.07	0.46	0.15	1.95	1.65	0.34	0.50
c_l	-0.40	-0.07	-0.14	-0.20	3.47	1.89	2.30	-0.06

The entries in the Table are % change effects of a legalization programm that legalizes all illegal immigrants in the labor force. The first column shows results for the baseline model and the next seven columns results for four robustness checks: setting the search cost of legal immigrants to 0 (column 2), setting the legal/illegal wage gap to 5% (column 3), setting the native/legal immigrant wage gap to 5% (column 4), setting the search cost of illegal immigrants to 0 (column 5), immigrants do not own government bonds, capital or firms (column 6), 50% of immigrants' disposable income is remitted (column 7), 50% of illegal immigrants pay income and payroll taxes (column 8).

Table C.4
Effects of Decreasing Illegal Immigration.

Decrease in m by:	25%	50%	75%	100%
Unemployment and Wage Rates:				
u_n	3.01	6.41	10.27	14.72
u_l	3.01	6.41	10.28	14.72
u_m	3.00	6.38	10.23	–
w_n	-0.07	-0.15	-0.24	-0.34
w_l	-0.65	-1.38	-2.20	-3.15
w_m	-1.13	-2.41	-3.85	–
Dividends, Capital and Output:				
π_n	-4.05	-8.17	-12.36	-16.64
k_n	-1.42	-2.85	-4.30	-5.77
y	-0.14	-0.29	-0.47	-0.68
Government Expenditures and Revenues:				
Unempl. Ins.	3.01	6.41	10.27	14.72
Transfers	-0.95	-1.89	-2.84	-3.79
Total Exp.	-0.54	-1.07	-1.59	-2.09
Cons. Tax Rev.	-1.74	-3.50	-5.28	-7.09
Income Tax Rev.	-0.55	-1.13	-1.75	-2.40
Payroll Tax Rev.	-0.26	-0.56	-0.89	-1.27
Total Rev.	-0.63	-1.28	-1.96	-2.68
f	-0.16	-0.16	0.02	0.45
Consumption:				
c_n	-0.49	-1.01	-1.59	-2.24
c_l	-1.03	-2.18	-3.44	-4.87
c_m	-1.29	-2.73	-4.35	–

The entries in the Table are % change effects of decreasing the number of illegal immigrants m, by 25%, 50%, 75% and 100%.

Table C.5
Effects with Skill Heterogeneity.

	increase in l	increase in m	legalization
Unemployment and Wage Rates:			
u_n	-6.33	-5.29	1.11
$u_{n,s}$	-7.12	-1.51	0.51
$u_{n,u}$	-5.35	-9.96	1.86
u_l	-6.33	-5.29	0.37
$u_{l,s}$	-7.12	-1.51	0.51
$u_{l,u}$	-5.35	-9.96	1.86
u_m	-5.33	-9.93	–
w_n	0.14	0.65	-0.56
$w_{n,s}$	0.04	2.19	-0.72
$w_{n,u}$	0.29	-2.21	-0.27
w_l	1.35	1.79	-11.96
$w_{l,s}$	1.13	2.77	-0.91
$w_{l,u}$	1.81	-0.16	-0.85
w_m	2.19	-8.24	–
Dividends, Capital and Output:			
π_n	7.07	11.94	-5.18
k_n	0.08	4.55	-6.53
y	0.33	-0.43	-1.48
Government Expenditures and Revenues:			
Unempl. Ins.	-2.37	-4.24	4.02
Transfers	3.69	3.69	0.00
Total Exp.	2.38	2.32	0.12
Cons. Tax Rev.	6.80	5.36	-2.52
Income Tax Rev.	5.20	1.88	1.58
Payroll Tax Rev.	5.08	1.00	2.46
Total Rev.	4.97	1.56	2.61
f	-12.42	3.23	-8.07
Consumption:			
c_n	2.18	1.44	-0.96
c_l	3.55	2.52	-10.90
c_m	2.46	-7.79	–

The entries in the Table are the % change effects of a 5% increase in the labor force due to legal (l) and illegal (m) immigration and a legalization program (legalization) that legalizes all illegal immigrants in the labor force, in the model extension with skill heterogeneity (see Appendix D). The subscripts u and s denote "unskilled" and "skilled," respectively.

Table C.6
Effects under Segmented Markets.

	increase in l	**increase in m**	**legalization**
Unemployment and Wage Rates:			
u_n	-7.40	-0.29	-7.28
u_l	-7.29	-0.29	-7.18
u_m	-0.03	0.39	–
w_n	0.15	0.43	-0.35
w_l	1.52	0.56	0.91
w_m	0.64	-7.62	–
Dividends, Capital and Output:			
π_n	7.28	18.15	-10.40
k_n	0.05	4.44	-4.94
y	0.30	-0.53	0.20
Government Expenditures and Revenues:			
Unempl. Ins.	-2.03	-0.29	-1.77
Transfers	3.63	3.63	0.00
Total Exp.	2.34	2.39	-0.05
Cons. Tax Rev.	6.77	4.86	0.74
Income Tax Rev.	5.22	1.48	3.61
Payroll Tax Rev.	5.11	0.45	4.68
Total Rev.	4.92	1.68	3.00
f	-12.65	5.17	-16.71
Consumption:			
c_n	2.25	0.86	1.04
c_l	3.80	1.04	2.36
c_m	0.64	-7.62	–

The entries in the Table are the % change effects of a 5% increase in the labor force due to legal (l) and illegal (m) immigration and a legalization program (legalization) that legalizes all illegal immigrants in the labor force, in the model extension where illegal immigrants are imperfect substitutes for natives and legal immigrants and search in a separate market (see Appendix E).

Table C.7
Immigrants' Congestion Effects – Robustness checks.

	$G^c = 0.68G$ **(baseline)**			$G^c = G$			$\rho_m = 0.7$		
	↑ **in** l	↑ **in** m	legal.	↑ **in** l	↑ **in** m	legal.	↑ **in** l	↑ **in** m	legal.
	Unemployment and Wage Rates:								
u_n	-5.56	-9.12	5.25	-5.56	-9.12	5.25	-5.56	-9.12	5.25
u_l	-5.56	-9.12	5.25	-5.56	-9.12	5.25	-5.56	-9.12	5.25
u_m	-5.54	-9.08	–	-5.54	-9.08	–	-5.54	-9.08	–
w_n	0.13	0.21	-0.12	0.13	0.21	-0.12	0.13	0.21	-0.12
w_l	1.20	1.98	-1.13	1.20	1.98	-1.13	1.20	1.98	-1.13
w_m	2.10	3.46	–	2.10	3.46	–	2.10	3.46	–
	Dividends, Capital and Output:								
π_n	6.35	15.25	-8.56	6.35	15.25	-8.56	6.35	15.25	-8.56
k_n	0.01	5.44	-5.35	0.01	5.44	-5.35	0.01	5.44	-5.35
y	0.27	0.42	-0.23	0.27	0.42	-0.23	0.27	0.42	-0.23
	Government Expenditures and Revenues:								
Unempl. Ins.	-1.35	-9.12	10.06	-1.35	-9.12	10.06	-1.35	-9.12	10.06
Transfers	7.14	3.87	2.98	4.87	2.64	2.03	7.14	3.87	2.98
Total Exp.	4.64	2.22	2.32	4.64	2.22	2.32	4.64	2.22	2.32
Cons. Tax Rev.	4.90	6.03	-1.10	4.90	6.03	-1.10	4.90	6.03	-1.10
Income Tax Rev.	5.13	1.96	3.04	5.13	1.96	3.04	5.13	1.96	3.04
Payroll Tax Rev.	5.02	0.80	4.06	5.02	0.80	4.06	5.02	0.80	4.06
Total Rev.	4.60	2.19	2.31	4.60	2.19	2.31	4.60	2.19	2.31
	Consumption and Welfare:								
c_n	0.24	1.62	-1.41	0.24	1.62	-1.41	0.24	1.62	-1.41
c_l	1.01	3.06	-2.30	1.01	3.06	-2.30	1.01	3.06	-2.30
c_m	2.39	3.94	–	2.39	3.94	–	2.39	3.94	–
g_n^c	2.04	-1.08	2.98	-0.13	-2.25	2.03	1.96	0.31	1.40
ϕ_n	0.71	0.51	0.12	0.08	0.15	-0.14	0.68	0.91	-0.33
ϕ_l	1.18	1.34	-0.38	0.46	0.86	-0.60	1.15	1.76	-0.86
ϕ_m	2.05	1.91	–	1.19	1.35	–	2.28	2.67	–

The entries in the Table are the % change effects of a 5% increase in the labor force due to legal (l) and illegal (m) immigration and a legalization program (legal.) that replaces all illegal immigrants by legal immigrants, in the model extension where immigrants can reduce the amount of government goods and services allocated to each household (see Section 6.2). Columns 2-4 show the effects when congestible goods are 68% of total government spending (as in the baseline calibration in Section 5.1), columns 5-7 show the effects when all government goods and services are congestible and columns 8-10 the effects when illegal immigrants access to congestible government goods is restricted to 70% of that of natives and legal immigrants.

Appendix D. Skill heterogeneity and imperfect substitution

The set up of the final good sector remains as in the baseline model (see Section 3). The intermediate production sector changes to take into account 1. that skilled and unskilled workers are imperfect substitutes in production and 2. that legal and illegal unskilled workers are imperfect substitutes in production. The production of the intermediate input X is given by:

$$X_t = [\chi(X_{s,t})^{\omega} + (1-\chi)(X_{u,t})^{\omega}]^{\frac{1}{\omega}}$$

where $X_{s,t}$ is the "skilled" and $X_{u,t}$ the "unskilled" labor input. The elasticity of substitution between the two types of labor is given by $\frac{1}{1-\omega}$. The number of units of the skilled labor input $X_{s,t}$ is determined by the number of skilled natives and legal immigrants employed in the intermediate sector: $E_{n,s,t}$ and $E_{l,s,t}$, respectively. The number of units of the unskilled labor input $X_{u,t}$ is determined by a CES structure, because legal and illegal unskilled workers are imperfect substitutes.

$$X_{s,t} = E_{n,s,t} + E_{l,s,t}$$

$$X_{u,t} = [\rho(E_{n,u,t} + E_{l,u,t})^{\sigma} + (1-\rho)E_{m,t}^{\sigma}]^{\frac{1}{\sigma}}$$

where, following similar notation, $E_{n,u,t}$ and $E_{l,u,t}$ give the numbers of unskilled natives and legal immigrants, and $E_{m,t}$ the number of illegal immigrants employed in the intermediate sector. All illegal immigrants are assumed to be unskilled. The elasticity of substitution between legal and illegal unskilled workers is given by $\frac{1}{1-\sigma}$.

Since skilled natives and legal immigrants are identical in production, there are three types of labor in this model, each has a different marginal product and therefore price. These are the skilled labor with price $p_{s,t}$, the unskilled-legal labor with price $p_{u,t}$ and unskilled-illegal labor with price $p_{m,t}$. Prices are given by the marginal product of each type of labor as follows:

$$p_{s,t} = \chi \left(\frac{X_t}{X_{s,t}} \right)^{1-\omega}$$

$$p_{u,t} = (1-\chi)\rho \left(\frac{X_t}{X_{u,t}} \right)^{1-\omega} \left(\frac{X_{u,t}}{E_{n,u,t} + E_{l,u,t}} \right)^{1-\sigma}$$

$$p_{m,t} = (1-\chi)(1-\rho) \left(\frac{X_t}{X_{u,t}} \right)^{1-\omega} \left(\frac{X_{u,t}}{E_{m,t}} \right)^{1-\sigma}.$$

There are two separate sub-markets one for skilled and one for unskilled workers. In other words, there are two types of vacancies, those targeted towards skilled and those targeted towards unskilled workers. There are two Bellman equations, one for each type:

$$V_{s,t} = -\kappa + \frac{1}{1+r_{t+1}} \left\{ q_{s,t} \left[\phi_{s,t} J_{n,s,t+1} + (1-\phi_{s,t}) J_{l,s,t+1} \right] + (1-q_{s,t}) V_{s,t+1} \right\}$$

$$V_{u,t} = -\kappa + \frac{1}{1+r_{t+1}} \left\{ q_{u,t} \left[\phi_{u,t} J_{n,u,t+1} + (1-\phi_{u,t})(\lambda_t J_{l,u,t+1} + (1-\lambda_t) J_{m,t+1}) \right] + (1-q_{u,t}) V_{u,t+1} \right\}$$

where $q_{s,t}$ is the probability that a vacant firm with a skilled vacancy will find a match and $q_{u,t}$ is the probability that a vacant firm with an unskilled vacancy will find a match. Note that the former matches with either a native worker, with probability $\phi_{s,t}$, or a legal immigrant worker, with probability $(1-\phi_{s,t})$ where $\phi_{s,t} \equiv \frac{nS_n u_{n,s,t}}{nS_n u_{n,s,t} + lS_l u_{l,s,t}}$ is the share of natives in total searching population of skilled workers. The latter matches with either a native worker, with probability $\phi_{u,t}$, or an immigrant worker, with probability $(1-\phi_{u,t})$ where $\phi_{u,t} \equiv \frac{n(1-S_n)u_{n,u,t}}{n(1-S_n)u_{n,u,t} + l(1-S_l)u_{l,u,t} + m u_{m,t}}$ is the share of natives in total searching population of unskilled workers. If it matches with an immigrant, the latter can be legal with probability λ_t or illegal with probability $1-\lambda_t$ and $\lambda_t = \frac{l(1-S_l)u_{l,u,t}}{l(1-S_l)u_{l,u,t} + m u_{m,t}}$, is the share of unskilled legal immigrants in the total number of unskilled immigrants searching for a job. We use S_n and S_l to denote the shares of natives and legal immigrants, respectively, in the labor force that are skilled. Recall that all illegal immigrants are assumed to be unskilled. $u_{i,j,t}$, $i = [n,l]$, $j = [s,u]$ denotes the unemployment rate of skilled (s) and unskilled (u), natives (n) and legal immigrants (l); $u_{m,t}$ is the unemployment rate of illegal immigrants (who are all unskilled). It may be recalled that n, l and m denote the share of natives, legal and illegal immigrants, respectively, in the labor force.

The value of a job filled with a legal worker (native or immigrant) and an illegal (unskilled) worker remain as in the baseline model. They only change to account that the prices of the three types of labor inputs are different: $p_{s,t}$, $p_{u,t}$ and $p_{m,t}$.

$$J_{s,t} = p_{s,t} - (1+\tau_p) w_{s,t} + \frac{1}{1+r_{t+1}} \left[(1-s) J_{s,t+1} + s V_{s,t+1} \right]$$

$$J_{u,t} = p_{u,t} - (1+\tau_p) w_{u,t} + \frac{1}{1+r_{t+1}} \left[(1-s) J_{u,t+1} + s V_{s,t+1} \right]$$

$$J_{m,t} = p_{m,t} - w_{m,t} + \frac{1}{1+r_{t+1}} \left[(1-s) J_{m,t+1} + s V_{t+1} \right].$$

Since there are two types of vacancies, those suited for skilled workers, $v_{s,t}$, and those suited for unskilled workers, $v_{s,t}$, two free-entry conditions, $V_{u,t} = 0$ and $V_{u,t} = 0$ determine the market tightness $\theta_s \equiv \frac{v_{s,t}}{U_{n,s,t} + U_{l,s,t}}$ and $\theta_u \equiv \frac{v_{u,t}}{U_{n,u,t} + U_{l,u,t} + U_{m,t}}$, respectively, in each sub-market:

$$\frac{\kappa}{q_{s,t}} = \frac{1}{1+r_{t+1}} \left[\phi_{s,t} J_{n,s,t+1} + (1-\phi_{s,t}) J_{l,s,t+1} \right]$$

$$\frac{\kappa}{q_{u,t}} = \frac{1}{1+r_{t+1}} \left[\phi_{u,t} J_{n,u,t+1} + (1-\phi_{u,t})(\lambda_t J_{l,u,t+1} + (1-\lambda_t) J_{m,t+1}) \right].$$

As in the baseline model, U denotes the number of unemployed.

The value to a worker of being unemployed satisfies:

$$Z_{i,j,t} = b_i - x_i + \frac{1}{1+r_{t+1}} \left[\mu_{j,t} W_{i,j,t+1} + (1-\mu_{j,t}) Z_{i,j,t+1} \right] \text{ for } i = [n,l] \text{ and } j = [s,u]$$

$$Z_{m,t} = b_m - x_m + \frac{1}{1+r_{t+1}} \left[\mu_{u,t} W_{m,t+1} + (1-\mu_{u,t}) Z_{m,t+1} \right]$$

where $\mu_{j,t}$ is the probability that a native or legal immigrant of skill type j will find a job and $\mu_{m,t}$ is the probability that an illegal (unskilled) immigrant will find a (an unskilled) job. As in the baseline model, the value to a worker of being employed satisfies:

$$W_{i,j,t} = (1-\tau) w_{i,j,t} + \frac{1}{1+r_{t+1}} \left[(1-s) W_{i,j,t+1} + s Z_{i,j,t+1} \right] \text{ for } i = [n,l] \text{ and } j = [s,u]$$

$$W_{m,t} = w_{m,t} + \frac{1}{1+r_{t+1}}\left[(1-s)W_{m,t+1} + sZ_{m,t+1}\right]$$

and wages satisfy the Nash bargaining conditions.

Since there are two types of vacancies and two separate sub-markets there are also two different matching functions. $M_{s,t} = M(v_{s,t}, U_{n,s,t} + U_{l,s,t})$ gives the number of matches between skilled natives or legal immigrants and the vacancies that are suited for them. Likewise, $M_{u,t} = M(v_{u,t}, U_{n,u,t} + U_{l,u,t} + U_{m,t})$ gives the number of matches between unskilled natives and legal or illegal immigrants and (unskilled) vacancies. Hence, $q_{s,t} = \frac{M_{s,t}}{v_{s,t}} = M(1, \frac{1}{\theta_{s,t}})$, $\mu_{s,t} = \frac{M_{s,t}}{U_{n,s,t}+U_{l,s,t}} = M(\theta_{s,t}, 1)$, $q_{u,t} = \frac{M_{u,t}}{v_{u,t}} = M(1, \frac{1}{\theta_{u,t}})$ and $\mu_{u,t} = \frac{M_{u,t}}{U_{n,u,t}+U_{l,u,t}+U_{m,t}} = M(\theta_{u,t}, 1)$.

The evolution of the number of household members that are unemployed is given by:

$$u_{i,j,t+1} = (1-\mu_{j,t})u_{i,j,t} + se_{i,j,t} \text{ for } i = [n,l] \text{ and } j = [s,u]$$

$$u_{m,t+1} = (1-\mu_{u,t})u_{m,t} + se_{u,t}$$

where $e_{i,j,t} = 1 - u_{i,j,t}$ and $e_{m,t} = 1 - u_{m,t}$.

Finally, total dividends change to take into account that there are two types of firms/vacancies and workers and prices are now given by $p_{s,t}$, $p_{u,t}$ and $p_{m,t}$.

$$\begin{aligned}\Pi_t = &\left[p_{s,t} - (1+\tau_p)w_{n,s,t}\right]E_{n,s,t} + \left[p_{u,t} - (1+\tau_p)w_{n,u,t}\right]E_{n,u,t}\\ &+ \left[p_{s,t} - (1+\tau_p)w_{l,s,t}\right]E_{l,s,t} + \left[p_{u,t} - (1+\tau_p)w_{l,u,t}\right]E_{l,u,t}\\ &+ (p_{m,t} - w_{m,t})E_{m,t} - \kappa(v_{s,t} + v_{u,t}).\end{aligned}$$

Appendix E. Segmented markets and imperfect substitution

The set up of the government, the final good sector and households' problem, remains as in the baseline model (see Section 3). Only the intermediate production sector changes to take into account 1. that illegal immigrants are imperfect substitutes for natives and legal immigrants, and thus prices of labor inputs are now $p_{n/l,t}$ (given by (39)) and $p_{m,t}$ (given by (40)), and 2. that there are two separate sub-markets one for legal immigrants and natives and one for illegal immigrants.

The values of jobs filled with workers of type $i = [n,l]$, remain as in the baseline model, the only difference is that now the price of the labor input is $p_{n/l,t}$. The same holds for the value of a job filled by an immigrant worker. It only changes to take into account that the price of the labor input is $p_{m,t}$.

$$J_{i,t} = p_{n/l,t} - (1+\tau_p)w_{i,t} + \frac{1}{1+r_{t+1}}\left[(1-s)J_{i,t+1} + sV_{t+1}\right] \text{ for } i = [n,l]$$

$$J_{m,t} = p_{m,t} - w_{m,t} + \frac{1}{1+r_{t+1}}\left[(1-s)J_{m,t+1} + sV_{t+1}\right].$$

There are now two types of vacancies, those suited for natives/legal immigrants, $v_{n/l,t}$, and those suited for illegal immigrants, $v_{m,t}$. There are two Bellman equations, one for each type:

$$V_{n/l,t} = -\kappa + \frac{1}{1+r_{t+1}}\left\{q_{n/l,t}\left[\phi_t J_{n,t+1} + (1-\phi_t)J_{l,t+1}\right] + (1-q_{n/l,t})V_{n/l,t+1}\right\}$$

$$V_{m,t} = -\kappa + \frac{1}{1+r_{t+1}}\left\{q_{m,t}J_{m,t+1} + (1-q_{m,t})V_{m,t+1}\right\}$$

where $q_{n/l,t}$ is the probability that a vacant firm with a vacancy suited for a native or legal immigrant will find a match and $q_{m,t}$ is the probability that a vacant firm with a vacancy suited for an illegal immigrant will find a match. Note that the former matches with either a native worker, with probability ϕ_t, or a legal immigrant worker, with probability $(1-\phi_t)$ where $\phi_t \equiv \frac{nu_{n,t}}{nu_{n,t}+lu_{l,t}}$ is the share of natives in total searching population of natives and legal immigrants.

There are two free-entry conditions, $V_{n/l,t} = 0$ and $V_{m,t} = 0$ determining tightness, $\theta_{n/l} \equiv \frac{v_{n/l,t}}{U_{n,t}+U_{l,t}}$ and $\theta_m \equiv \frac{v_{m,t}}{U_{m,t}}$, respectively, in each sub-market:

$$\frac{\kappa}{q_{n/l,t}} = \frac{1}{1+r_{t+1}}\left[\phi_t J_{n,t+1} + (1-\phi_t)J_{l,t+1}\right] \tag{43}$$

$$\frac{\kappa}{q_{m,t}} = \frac{1}{1+r_{t+1}}J_{m,t+1}. \tag{44}$$

The value to a worker of being unemployed satisfies:

$$Z_{i,t} = b_i - x_i + \frac{1}{1+r_{t+1}}\left[\mu_{n/l,t}W_{i,t+1} + (1-\mu_{n/l,t})Z_{i,t+1}\right] \text{ for } i = [n,l]$$

$$Z_{m,t} = b_m - x_m + \frac{1}{1+r_{t+1}}\left[\mu_{m,t}W_{m,t+1} + (1-\mu_{m,t})Z_{m,t+1}\right]$$

where $\mu_{n/l,t}$ is the probability that a native or legal immigrant will find a job and $\mu_{m,t}$ is the probability that an illegal immigrant will find a job. As in the baseline model, the value to a worker of being employed satisfies:

$$W_{i,t} = (1-\tau)w_{i,t} + \frac{1}{1+r_{t+1}}\left[(1-s)W_{i,t+1} + sZ_{i,t+1}\right] \text{ for } i = [n,l]$$

$$W_{m,t} = w_{m,t} + \frac{1}{1+r_{t+1}}\left[(1-s)W_{m,t+1} + sZ_{m,t+1}\right]$$

and wages satisfy the Nash bargaining conditions.

Since there are two types of vacancies and two separate sub-markets there are also two different matching functions. $M_{n/l,t} = M(v_{n/l,t}, U_{n,t}+U_{l,t})$ gives the number of matches between natives or legal immigrants and the vacancies that are suited for them. Likewise, $M_{m,t} = M(v_{m,t}, U_{m,t})$ gives the number of matches between illegal immigrants and vacancies. Hence, $q_{n/l,t} = \frac{M_{n/l,t}}{v_{n/l,t}} = M(1, \frac{1}{\theta_{n/l,t}})$, $\mu_{n/l,t} = \frac{M_{n/l,t}}{U_{n,t}+U_{l,t}} = M(\theta_{n/l,t}, 1)$, $q_{m,t} = \frac{M_{m,t}}{v_{m,t}} = M(1, \frac{1}{\theta_{m,t}})$ and $\mu_{m,t} = \frac{M_{m,t}}{U_{m,t}} = M(\theta_{m,t}, 1)$.

The evolution of the number of household members that are unemployed is given by:

$$u_{i,t+1} = (1-\mu_{n/l,t})u_{i,t} + se_{i,t} \text{ for } i = [n,l]$$

$$u_{m,t+1} = (1-\mu_{m,t})u_{m,t} + se_{m,t}$$

where $e_{i,t} = 1-u_{i,t}$ and $e_{m,t} = 1-u_{m,t}$.

Finally, total dividends change to take into account that prices are now given by $p_{n/l,t}$ and $p_{m,t}$.

$$\Pi_t = \left[p_{n/l,t} - (1+\tau_p)w_{n,t}\right]E_{n,t} + \left[p_{n/l,t} - (1+\tau_p)w_{l,t}\right]E_{l,t} + (p_{m,t} - w_{m,t})E_{m,t} - \kappa(v_{n/l,t} + v_{m,t}).$$

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