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Labor Market Effects of Immigration Policies Border Enforcement and Amnesty

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Abstract We explore the effects of tighter border enforcement and an amnesty on the wages and unemployment rates of natives and immigrants. We extend the Mortensen-Pissarides labor market model to include individuals authorized to work and illegal workers in a framework that accounts for voluntary return migration. Furthermore, we study the effects of an amnesty when a proportion of illegal workers pays payroll taxes. Our results show that the effect of changes in border enforcement on the number of illegal workers in the United States is theoretically ambiguous. While tighter border enforcement deters illegal migration of prospective workers, it also changes the incentives of those already in the United States decreasing return migration. If tighter border enforcement increases the number of illegal workers in the economy, it will also increase the wages of natives as market tightness increases. Our findings show that the larger the proportion of illegal workers paying payroll taxes, the larger will be the decrease in wages, and the smaller the increase in unemployment generated by the decrease in the number of illegal workers in the economy that will follow an amnesty.

Keywords Illegal immigration · Border enforcement · Return migration · Search and matching models

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Introduction

In the last four decades, unauthorized immigration has become one of the most important economic and political issues in the United States. The number of unauthorized immigrants steadily increased between 1990 and 2007 when it peaked at 12.2 million. The Great Recession changed that trend. We observed a decrease in 2008 and 2009, but estimates show that the number of unauthorized immigrants in the United States has stabilized since the end of the Great Recession to reach 11.1 million in 2014.[1]

Since 2005, immigration reform has been a controversial issue among policymakers. Even though efforts to pass a comprehensive immigration bill have been discussed in Congress (Border Protection, Anti-terrorism, and Illegal Immigration Control Act of 2005; Comprehensive Immigration Reform Act of 2006; Border Security, Economic Opportunity; Immigration Modernization Act of 2013) lack of agreement has characterized the recent history of the immigration reform. While there is a broad consensus that comprehensive reform is needed, the terms in which this reform has to be done have been subject to intense debate. Major policy proposals had centered mainly around two types of changes: (1) increases in border control, and (2) the creation of a pathway toward legal status.[2]

Even though changes to the immigration system have potentially broad implications, little research has been devoted to analyzing the effects that different policies would have on the US labor market. In this paper, we analyze the effects of two immigration policies intended to decrease the number of unauthorized workers in the United States: border enforcement and amnesty. We use a model that includes individuals authorized to work and illegal workers in a framework that accounts for voluntary return migration. Moreover, we analyze the effect of amnesty when a proportion of the illegal workers pays payroll taxes.

Border control and taxes paid by undocumented workers became two controversial topics during the 2016 presidential election. Questions regarding the effect that building a wall along the US-Mexico border would have on the inflow of undocumented workers into the United States, and the degree to which undocumented workers pay federal, state, and local taxes have constantly been raised. Previous research has

[1] Krogstad et al. (2016).

[2] The U.S. has not enacted a significant amnesty program since 1986 when IRCA granted legal status to 2.7 million workers. In the absence of immigration reform at the federal level, on June of 2012 was announced the Deferred Action for Childhood Arrivals Program (DACA). Individuals protected under the program are eligible for work authorization. On November 20, 2014, President Obama announced the creation of the Deferred Action for Parents of Americans and Lawful Permanent Residents Program (DAPA) and the expansion of DACA. On June 23, 2016, the Supreme Court decided to leave in place an appeals court ruling blocking DAPA and the extended DACA program. On September 5, 2017, President Trump announced the end of the program with a six-month delay. Immigrants with DACA permits that expire before March 5, 2018, can apply for a two-year renewal. Recipients with permits expiring after March 5 will lose their work authorization and other benefits of the program.

pointed out the ambiguous effect that border enforcement could have on migration flows since both, inflows and outflows respond to it. While there is evidence that border enforcement deters migration, it also lengthens the duration of immigrants in the United States (Angelucci 2012; Lessem 2015). Concerning taxes, there is evidence that employers report and pay taxes on the wages paid to undocumented workers.[3] Hotchkiss et al. (2015) using data from the Georgia Department of Labor estimate that 22 percent of the total undocumented workers in the state of Georgia paid payroll taxes in 2004. Using data from the Survey of Migration to the Northern Border (EMIF) between 1999 and 2005 we calculate that between 20 and 27 percent of the undocumented Mexican workers in the United States pay payroll taxes.

The effect of immigration on the wages of natives and immigrants is a topic that has been widely studied and has generated interesting debates given the variety of results found (Borjas 2003; Borjas and Katz 2007; Card 2005; Ottaviano and Peri 2012). Moreover, there is extensive literature studying the effects of immigration status on the wages of unauthorized workers themselves. Kossoudji and Cobb-Clark (2002) estimate the wage benefit received by illegal workers who obtained amnesty under the Immigration Reform and Control Act of 1986. Using a sample of young Latino men who came to the United States as unauthorized workers and received amnesty, they find that the benefit of legalization was approximately 6 percent. Mukhopadhyay and Oxborrow (2012) estimate the wage gain of having permanent residency versus a working temporary visa for highly skilled workers. They find that temporary workers earn less than permanent workers and report that the limited mobility associated with temporary visas could be one of the leading explanations for this result.

This paper contributes to that literature by exploring the effects of immigration by using a search and matching model. We use a Mortensen-Pissarides style labor market model (Mortensen and Pissarides 1994) to capture the effect of two immigration policies on two critical dimensions in a general equilibrium setting: wages and unemployment rates. The Mortensen-Pissarides model has become one of the most important frameworks used to study the unemployment and welfare effects of labor market policies. This model is characterized by the existence of search and matching frictions. Each period firms post vacancies in search for workers and a matching function determines the flow of new matches between firms and workers. Wages are determined by Nash bilateral bargaining. After a match is formed and a wage bargained, production starts, the output is sold, and the wage is split according to the bargaining rule.

To assess the effect of immigration policies on the labor market outcomes of US natives and Mexican immigrants, the model includes individuals authorized to work or "legal" workers (natives and immigrants with work authorization), and workers without work authorization or "illegal" workers (undocumented immigrants).[4] While

[3]The Social Security Administration (SSA) tracks the wages reported by employers that cannot be linked to a real SSN in the called Earnings Suspense File (ESF). The dramatic growth of the ESF has been attributable to the growth in unauthorized immigrants (GAO 2015).

[4]Through the paper we use the term "legal" workers referring to natives and immigrants with work authorization, and "illegal" workers referring to immigrants without work authorization.

hundreds of thousands of immigrants enter the United States every year, almost half of these migrants return to their home country within twelve months (Reyes and Mameesh 2002; Gitter et al. 2008). In this model, immigration decisions may not be permanent. Individuals consider the benefits of living in Mexico and the United States and decide whether to migrate from or return to Mexico to maximize their expected utility.

Three previous studies have analyzed the effects of immigration on labor market outcomes using search and matching models. Chassamboulli and Palivos (2014) examine the impact of the skill-biased immigration influx to the United States observed between 2000 and 2009. They find that skilled and unskilled native workers gained in terms of employment and wages when natives and immigrants were imperfect substitutes.

Liu (2010) develops a search and matching model that incorporates natives and immigrants. In this model all immigrants are undocumented. They are identical to natives; they face similar job search conditions and search costs. The main finding is that an increase in illegal immigration generates gains for natives. Chassamboulli and Peri (2015), incorporate legal and illegal migration to their model and study the effect of a decrease in the number of illegal immigrants in the economy. They find that an increase in the number of undocumented workers decreases the unemployment rate of native low-skilled workers and increases income per native. While their model accounts for the possibility of deportation, it does not account for voluntary return migration.

Our contribution to the current literature is threefold. First, in our model, we account for voluntary return migration. While the number of deportations has increased over the last decade going from 189 thousand in 2001 to 333 thousand in 2015 (Gonzalez-Barrera and Lopez 2016), a large number of deportees do not return to their home country. Once they are released by immigration authorities, a significant proportion of deportees tries to re-enter the United States. Using a survey conducted among migrants returned to Mexico by US Border Patrol authorities in 2014, we find that approximately 80 percent of the immigrants who stayed in the United States more than 30 days report intention to re-enter the United States within the next three months. This proportion increased to 90 percent when migrants stayed more than 90 days. We obtain similar findings when using a survey conducted among return migrants in 2014. 92 percent of the immigrants who stayed in the United States more than 30 days, returned to Mexico of their own free will, and only 8 percent of them were returned by immigration and customs authorities.[5] These findings highlight the importance of incorporating voluntary return migration in our search and matching model with immigration.

Additionally, our study considers the case in which a proportion of undocumented migrants pay payroll taxes. While there is considerable evidence that undocumented workers pay payroll taxes, no previous study has analyzed the potential effects that immigration policies would have in an economy where illegal workers can be paid off the books or can get formal jobs and have taxes withheld. Finally, we calibrate

[5]Calculations obtained using the subsample of workers deported to Mexico and the subsample of return migrants from the Survey of Migration to the Northern Border (EMIF).

our model by using a rich dataset on Mexican migration. We use information from the Survey of Migration to the Northern Border (EMIF), a cross-sectional survey that samples the flows of migrants between Mexico and the United States in the northern border region of Mexico. The survey provides information on the labor market outcomes of Mexican workers in the United States, their legal status, and their socioeconomic characteristics. Using a survey that includes legal and illegal workers in the United States allow us to calculate the parameters necessary to calibrate our model accurately.[6]

A key finding of this paper is that an increase in border enforcement that doubles migration costs would increase the number of illegal workers by 0.3 percent, increase the wages of legal workers by 0.03 percent, and decrease the wages of illegal workers by 0.45 percent. The model predicts that the effect of changes in border enforcement on the number of illegal workers in the United States is theoretically ambiguous. While tighter border enforcement deters illegal migration of prospective workers, it also changes incentives for those already in the United States decreasing return migration. Consequently, if tighter border enforcement increases the number of illegal workers in the economy (the decrease in return migration is larger than the deterrence effect), tighter border enforcement will increase the wages of natives and have an ambiguous effect on the wages of illegal workers. According to the model, an increase in the number of illegal workers would increase firms' incentives to open positions since firms' probability of finding a worker with a low outside option increase. The increase in the number of vacancies increases the probability of finding a job, increasing the wages, and decreasing the unemployment rate of natives and legal immigrants. These results have important policy implications. Failure to account for return migration might lead us to overestimate the efficacy of border enforcement in decreasing the number of illegal workers in the country. A policy increasing border enforcement might increase the population of illegal workers in the United States.[7]

Moreover, when we study the effect of amnesty, our findings show that the larger the proportion of illegal workers paying payroll taxes, the larger will be the amount of the tax necessary to pay for the increase in unemployment claims. The amnesty will not change the number of workers paying taxes but will increase the number of workers claiming for unemployment benefits. Therefore, the larger the proportion of illegal workers paying taxes, the larger will be the decrease in the wages of legal and illegal workers generated by a decrease in the number of illegal workers in the

[6]Recent studies using EMIF data include Orozco-Aleman and Gonzalez-Lozano (2018) studying the effect of the increase in drug violence in Mexico on migration flows to the United States; Hoekstra and Orozco-Aleman (2017) studying the deterrence effect of the anti-immigration law Arizona SB:1070; and Amuedo-Dorantes et al. (2015) studying the effect of interior enforcement on the likelihood of parent-child separations.

[7]These results are in line with the findings of Angelucci (2012), and Lessem (2015). Angelucci (2012) finds that tighter border enforcement had a positive effect on the stock of illegal immigrants in the United States between 1972 and 1986, and negative effect between 1997 and 2003. Lessem (2015) also finds that enforcement has an ambiguous effect on immigration. An increase in border enforcement makes individuals less likely to migrate but decreases return migration. In her model, the total effect on immigration depends on the assumptions made regarding the allocation of the extra resources.

economy. Regarding unemployment, the larger the proportion of illegal workers paying payroll taxes, the smaller will be the decrease in market tightness, and therefore, the increase in the unemployment rate of legal and illegal workers.[8] We also analyze the potential effect that changes in the costs associated with hiring illegal workers off the books can have on the economy. Our findings show that the increase of fines or of any other cost associated with hiring illegal workers off the books —e.g., prosecution costs or loss of reputation— will decrease market tightness, will increase the probability of hiring workers on the books, and will increase tax revenue. Since illegal workers are not eligible for unemployment benefits, the amount of the tax necessary to pay for the unemployment benefits of legal workers decreases. Since part of the tax is paid by firms and part is paid by workers in the form of lower wages, the increase in the costs associated with hiring illegal workers off the books will increase the wages and welfare of natives and legal immigrants in the United States.

Model

This paper introduces a model with two countries: home country (Mexico) and host country (United States). In this economy, there are two types of equally productive workers: individuals with authorization to work in the United States or "legal" workers (natives and immigrants with work permits),[9] and individuals without work authorization or "illegal" workers.[10] Each period, individuals in Mexico compare their expected earnings in Mexico with their potential earnings in the United States net of moving costs and decide to stay or migrate. We assume that all individuals who migrate to the United States do it illegally.[11] After spending some time in the United States, when an illegal worker loses his job he faces a new decision: he can either return to Mexico or stay in the United States. Once again, he makes his decision by comparing his expected earnings in Mexico and the United States.

The US labor market is formed by firms and workers. Each period firms post a certain number of vacancies in search for workers, and a matching function determines the flow of new matches between firms and workers. When firms post vacancies, they only know the conditional probability that the match will be formed with a legal or

[8]Market tightness, also known as the vacancy-unemployment ratio, equals the number of vacancies per unemployed worker.

[9]Even though DACA does not provide lawful status, since individuals protected under the program are eligible for work authorization, in the model they would be considered legal workers.

[10]We assume that the differences in the job market outcomes of natives and illegal immigrants are due to their illegal status and not to be foreign-born. For that reason, we do not differentiate between legal immigrants and natives. Since only a small proportion of the legal workers are immigrants with work authorization, the terms legal workers and natives can be used indistinctively throughout the paper.

[11]Data from EMIF show that more than 95 percent of the migrants entering the United States for the first time are undocumented. Every year a small number of workers enter the United States with authorization to work using a non-immigrant visa (e.g., H-2A/B, EB-3). To obtain it the employer has to file the petition, establish that there are not enough US workers who are able, willing, qualified, and available to do the work; and that the employment of the immigrant worker will not adversely affect the wages and working conditions of similarly employed US workers. These types of visas are not accessible for the average immigrant.

an illegal worker. Once the match is formed, firms realize the worker's type. Wages are determined by Nash bilateral bargaining with an exogenous surplus sharing rule. After a match is formed and a wage bargained, production starts, the output is sold, and the wage is split according to the bargaining rule. Firms enter the economy until all rents from new vacancy creation are exhausted.

Workers in Mexico and the U.S.

In period t workers in Mexico draw an ε from a density $f(\varepsilon)$ that determines their income in Mexico.[12] Once they observe their ε, they decide whether to stay or migrate. In period $t+1$ a worker who has migrated will receive $U_I - k$ where U_I is the worker's utility of being unemployed in the United States, and k is a measure of his migration costs. A worker who decided to stay in Mexico will receive $B_M(\varepsilon)$ in period $t+1$. Therefore, the expected worker's utility can be written as

$$B_M(\varepsilon) = \varepsilon + \beta \int \max\left\{U_I - k, B_M(\varepsilon')\right\} f(\varepsilon') d\varepsilon'.$$

We define $\overline{\varepsilon}_M$ as the reservation income in Mexico that makes workers indifferent between stay and migrate, so $B_M(\overline{\varepsilon}_M) = U_I - k$. Therefore, workers with $\varepsilon < \overline{\varepsilon}_M$ will migrate to the United States while workers with $\varepsilon > \overline{\varepsilon}_M$ will stay in Mexico.

When an illegal worker in the United States loses his job he faces a new decision: he can either stay in the United States or return to Mexico. In period t an unemployed worker in the United States draws an ε from the density $f(\varepsilon)$ and compares the utility of being unemployed in the United States (U_I) with the expected value of returning to Mexico ($B_M(\varepsilon)$). We define $\overline{\varepsilon}_{US}$ as the reservation income to be received in Mexico that will make a worker indifferent between stay and return, so $B_M(\overline{\varepsilon}_{US}) = U_I$. Therefore, workers with $\varepsilon < \overline{\varepsilon}_{US}$ will stay in the United States, and workers with an $\varepsilon > \overline{\varepsilon}_{US}$ will return to Mexico.

Workers' Value Functions

Each period, workers can be either employed or unemployed. Legal and illegal employed workers produce output y and receive wages w_L and w_I respectively. If a worker loses his job, he joins the unemployment pool. The value function of an unemployed worker is given by

$$U_n = b_n + \beta \left(q(\theta) W_n + (1 - q(\theta)) U_n\right)$$

where $n = L, I$ represents legal and illegal workers, b_n is the unemployment income (e.g., unemployment benefits, leisure), and β is the discount factor. If an unemployed worker finds a job, which occurs with probability $q(\theta)$, his utility in the next period is given by W_n. If he remains unemployed, which occurs with probability $1 - q(\theta)$, his utility is U_n.

[12] Epsilon (ε) can be interpreted as a measure of workers' income in Mexico and is uniformly distributed between ε_1 and ε_2. An individual receives a draw at the start of the period and decides if they want to stay in Mexico and earn ε, or move to the United States.

For legal workers, the utility of being employed is given by

$$W_L = w_L + \beta \left(\delta_L W_L + (1 - \delta_L) U_L\right)$$

where δ_L is the probability that the match will continue next period, and $(1 - \delta_L)$ is the probability that the match will end (job destruction rate). The utility of being employed depends on the worker's wage and the discounted value of his expected utility next period: he will receive W_L if he is still employed, and U_L if he becomes unemployed.

For an illegal worker, the utility of being employed is given by

$$W_I = w_I + \beta \left(\delta_I W_I + (1 - \delta_I)\widetilde{U_I}\right)$$

where δ_I is the probability that the match will continue next period and $(1 - \delta_I)$ is the job destruction rate. His utility depends on his wage and the discounted value of his expected utility next period. If the match continues, he receives W_I. Since an unemployed illegal worker can stay in the United States or return to Mexico if he becomes unemployed, his utility $\widetilde{U_I}$ can be written as

$$\widetilde{U_I} = F(\overline{\varepsilon}_{US})U_I + (1 - F(\overline{\varepsilon}_{US})) \int_{\overline{\varepsilon}_{US}}^{\infty} B_M(\varepsilon') f(\varepsilon' | \varepsilon' > \overline{\varepsilon}_{US}) d\varepsilon'.$$

If the worker stays in the United States, his utility is U_I, and if he returns to Mexico, his utility is $B_M(\varepsilon)$. $F(\overline{\varepsilon}_{US})$ is the probability of having ε lower than $\overline{\varepsilon}_{US}$ (the worker finds optimal to stay in the United States), and $(1 - F(\overline{\varepsilon}_{US}))$ is the probability of having ε higher than $\overline{\varepsilon}_{US}$ (the worker finds optimal to return). It is important to note that the job destruction rate is different between legal and illegal workers and tends to be higher among undocumented workers due to law enforcement —workers can be apprehended and deported— and to the presence of temporary workers in the United States —e.g., target earners—.[13]

Firms' Value Functions

Each period firms post a certain number of vacancies (i.e., job openings) in search for workers at a cost c per unit of time. The flow of new matches between firms and workers is determined by a matching function. If a firm is matched with a legal or an illegal worker where $n = L, I$, its value function is given by

$$J_n = y - w_n + \beta \left(\delta_n J_n + (1 - \delta_n) V\right)$$

where y denotes the output produced, w_n is the wage paid to each type of worker, and V is the value of a firm with an open vacancy. The value of a firm will be given by the output produced net of wages plus the discounted value of the utility of the firm next period. If the match continues, which occurs with probability δ_n, the value of the firm next period is J_n. If the match ends, which occurs with probability $(1 - \delta_n)$, the firm will have an open vacancy, and its utility will be V.

[13] Target earners are migrants who stay in the host country as long as it is required to accumulate savings to reach a particular level of income. Once reaching the target, they return to their place of origin.

The value of a firm with an open vacancy V can be written as

$$V = -c + \beta \left[p(\theta) \left(a J_L + (1 - a) J_I \right) + (1 - p(\theta)) V \right]$$

where $p(\theta)$ is the probability of filling a vacancy, a is the conditional probability that the match will be formed with a legal worker, and $(1 - a)$ is the conditional probability that the match will be formed with an illegal worker. Therefore, the value of a firm with an open vacancy will depend on the cost of posting the vacancy and the discounted value of the firm next period. If the firm fills the vacancy, which occurs with probability $p(\theta)$, its value is J_L if the match is with a legal worker and J_I if the match is with an illegal worker. If the vacancy remains open next period, which occurs with probability $(1 - p(\theta))$, the value of the firm is V.

Concerning the creation of new jobs, we assume free entry into the economy. In equilibrium $V = 0$, which implies that firms create job vacancies until any incremental profit is exhausted. Finally, the conditional probability that the match is formed with a legal worker is given by $a = \frac{u_L}{u_L + u_I}$ where u_L and u_I are the number of unemployed legal and illegal workers, respectively.

Match Formation and Wage Determination

When firms post vacancies they know the conditional probability that the match will be formed with a legal worker (a) and the conditional probability that the match will be formed with an illegal worker $(1 - a)$. If v and u are the number of vacancies and unemployed workers, then in a given period there will be $m(u, v)$ matches between firms and workers. The total number of matches is given by the matching technology

$$m(u, v) = \frac{u v}{(u^\iota + v^\iota)^{\frac{1}{\iota}}}$$

where $u = u_L + u_I$. The matching technology is homogeneous of degree one, increasing and concave in its two arguments, and exhibits constant returns to scale. This matching function was chosen following the specification presented by Den Haan et al. (2000). One of the advantages of using this function over the traditional Cobb-Douglas specification is that this function guarantees matching probabilities between zero and one for any u and v.

Let $\theta = \frac{v}{u}$ be the vacancy-unemployment ratio (or labor market tightness). Then the probability of filling a vacancy $p(\theta)$ and the probability of finding a job $q(\theta)$ are given by

$$p(\theta) = \frac{m(u, v)}{v}, \text{ and } q(\theta) = \frac{m(u, v)}{u} = \theta p(\theta).$$

Note that $p'(\theta) < 0$ and $q'(\theta) > 0$. Therefore, the probability of filling a vacancy is higher when the labor market is not tight, and the likelihood of finding a job is higher when the labor market is tight.

Once a match has been formed, and the firm observes the worker's type, wages are determined by Nash bargaining. Firms and workers have to negotiate, and outside options are worse than an agreement because both parties would need to search again. The Nash solution is to set w_L and w_I to maximize the product surpluses

$$\max_{w_L} (W_L - U_L)^{1-\eta} (J_L - V)^\eta \text{ and } \max_{w_I} (W_I - \widetilde{U}_I)^{1-\eta} (J_I - V)^\eta,$$

where η is a bargaining parameter. Solving for w_L and w_I we find that

$$w_L = (1-\eta)y + \eta(1-\beta)U_L \text{ and } w_I = (1-\eta)y + \eta(1-\beta)\widetilde{U_I}.$$

Notice that the wage depends on productivity as well as on workers' outside options. The difference in the wages of legal and illegal workers is proportional to the difference in the expected utility of unemployment of legal and illegal workers. Therefore, we can identify two mechanisms that affect the wage gap between legal and illegal workers. First, if unemployed legal workers have higher utility flow than unemployed illegal workers, the wage gap will be higher. When bargaining with the firm, legal workers have better outside options than illegal workers, so they get higher wages. Second, if the probability of being terminated is higher for illegal workers, then undocumented workers have a lower utility from being unemployed because their employment relationships are short-lived.[14]

$$w_L - w_I = \eta(1-\beta)(U_L - \widetilde{U}_I)$$

Equilibrium Steady State

In steady state, the flows into and out of unemployment are equal. The steady state condition for unemployment of legal workers is given by

$$u_L = u_L\,(1-q(\theta)) + (1-\delta_L)(\mu_L - u_L)$$

where μ_L is the number of legal workers, and u_L is the number of unemployed legal workers. Each period the number of unemployed workers equals the number of workers who were unemployed last period and did not find a job, and the workers who were employed last period $(\mu_L - u_L)$ and lost their job.

The steady state condition for unemployment of illegal workers is given by

$$u_I = u_I\,(1-q(\theta)) + (1-\delta_I)e_I F(\overline{\varepsilon}_{US}) + (\mu_I - u_I - e_I)F(\overline{\varepsilon}_M)$$

where μ_I is the total number of Mexican workers (in Mexico or the United States), and u_I and e_I are the numbers of unemployed and employed Mexican illegal workers in the United States.

Each period the number of unemployed illegal workers in the United States equals the number of workers who were unemployed last period and did not find a job, the workers who were employed last period, lost their job, and decided to stay in the United States, and the workers from Mexico who decided to migrate this period.

In steady state, the flow of workers entering the United States must equal the flow of workers leaving the country. The number of workers who lost their job and return

[14]Two studies provide evidence that our assumptions are supported by the empirical evidence. Brown et al. (2012) show that employing illegal workers gives firms a competitive advantage, suggesting that the lower wages paid to undocumented workers are associated with their limited job opportunities and mobility. Hotchkiss and Quispe-Agnoli (2013) estimate elasticities of labor supply to the firm. They find that undocumented workers are less sensitive to wage changes than legal workers. They decompose the wage differentials between legal and illegal workers to find that overall, 27 percent of the observed wage differential is the result of differences in their elasticities of labor supply.

to Mexico is equal to the number of workers who decided to migrate to the United States.[15]

$$(1-\delta_I)(1-F(\overline{\varepsilon}_{US}))e_I = (\mu_I - u_I - e_I)F(\overline{\varepsilon}_M).$$

Effects of Immigration Policies

Effects of an Increase in Border Enforcement

In this section, we discuss the effect of an increase in border enforcement quantitatively. Since the model cannot be solved analytically, we provide intuition on the implications of this policy on the labor market outcomes of natives and immigrants. We capture the effect of an increase in border enforcement by changing migration costs. The model predicts that higher migration costs (measured in months of earnings in Mexico) would decrease $\overline{\varepsilon}_M$ which implies that fewer individuals would find it optimal to migrate. Concerning the workers in the United States, the model predicts that $\overline{\varepsilon}_{US}$ increases and more workers would decide to stay in the United States. Therefore, the overall effect of an increase in migration costs in the number of illegal workers in the United States is ambiguous.

If the overall effect is an increase in the illegal population (the decrease in return migration is larger than the deterrence effect), the model predicts that firms will have incentives to increase the number of vacancies since firms' probability of finding workers with low outside option increases. The increase in the number of vacancies increases labor market tightness (θ), the likelihood of finding a job ($q(\theta)$), and therefore, decreases the unemployment rate of both legal and illegal workers (u_L and u_I).

Concerning wages of legal workers (w_L) the model predicts that the increase in the probability of finding a job ($q(\theta)$) will improve workers' outside options increasing their wages.

Finally, for illegal workers, the model predicts that tighter border enforcement has an ambiguous effect on their wages. On the one hand, the increase in the probability of finding a job ($q(\theta)$) improves workers' outside options increasing their wages. However, the increase in migration costs also worsens workers' outside options (workers are less likely to undertake multiple trips to the United States) decreasing their wages.

Quantitative Analysis

Next, we use the model to assess the effects of tighter border enforcement quantitatively. We fix some parameters apriori using values typically used in Mortensen-Pissarides

[15] While the steady state condition is required to guarantee the equilibrium in the model, recent reports on the net flows of migrants between Mexico and the United States seem to support the plausibility of the condition. According to the Pew Hispanic Center immigration from Mexico to the United States has come to a standstill. The net migration flow from Mexico to the United States has stopped and may have reversed. Net migration fell to zero in 2010. Furthermore, for the period 2009-2014 the net flow of immigrants observed a net loss (Passel et al. 2012; Gonzalez-Barrera 2015).

Table 1 Parameters and calibrated targets

Parameter	Value	Source
Output	$y = 1$	Normalization
Discount Factor	$\beta = 0.996$	Pissarides, 09
Bargaining parameter	$\eta = 0.5$	Pissarides, 09
Unemp Income/Leisure Legal	$b_L = 0.71$	Hall & Milgrom, 08
Destruction rate Legal	$1 - \delta_L = 0.034$	Shimer, 05
Destruction rate Illegal	$1 - \delta_I = 0.063$	EMIF
Migration costs	$k = 4$	EMIF
Legal Population in US	$\mu_L = 0.9$	US Census
Illegal Population in US	$\mu_I = 0.1$	Mexico Census, ENNVIH, DHS
Parameter	Value	Calibration Target
Vacancy cost	$c = 0.377$	Wage gap $\frac{w_L}{w_I} - 1 = 0.09$
Distribution parameter	$\varepsilon_2 = 1.51$	Wage gap $\frac{w_{Mex}}{w_{US}} - 1 = -0.84$
Leisure Illegal	$b_I = 0.235$	Unemployment rate $u = 0.10$
Parameter Matching Function	$\iota = 0.691$	Market tightness $\theta = 0.72$

style models. The second group of parameters is set using different data sources on illegal immigration. Finally, the third group of parameters is calibrated to match some targets in the data. The parameters and calibration targets are summarized in Table 1. One of the contributions of this study is to explore different sources of information on the labor market outcomes of legal and illegal workers in the United States. While previous studies have used CPS data to calculate those parameters, the CPS does not differentiate workers by legal status, and the number of undocumented workers is underrepresented.

Since legal and illegal workers are assumed to be equally productive, we set the output produced by both types of workers to $y = 1$. The time unit is a month. Therefore, the discount factor $\beta = 0.996$ reflects an annual discount rate of 4.8 percent (Pissarides 2009). We give the worker and firm equal bargaining power by setting $\eta = 0.5$ (Pissarides 2009). The income equivalent that unemployed legal workers give up to take a job is set at $b_L = 0.71$. It includes both unemployment insurance and the value of time (Hall and Milgrom 2008). Finally, the job separation rate for legal workers $(1 - \delta_L)$ is set to 0.034 which implies that among legal workers jobs last for about 2.5 years on average (Shimer 2005).

To estimate the job separation rate for illegal workers we use data from EMIF.[16] We use a subsample of 13,136 Mexican male illegal workers interviewed between

[16]The survey is conducted in eight Mexican border cities. Within each city, individuals are sampled at different locations, including bus stations, airports, international bridges, and Mexican customs. The EMIF identifies legal and illegal workers, temporary and settled workers, as well as return migrants.

1993 and 2009, who were employed at the time of the survey in the United States, and report information on the duration of their longest job held in that country. We estimate an average job duration of 15.79 months and set the job separation rate for illegal workers $(1-\delta_I)$ to 0.063. Using information from the EMIF, we also estimate the job separation rate for legal immigrants of $(1-\delta_L) = 0.0356$. This estimate was calculated using a sample of 4,108 legal migrants, age 25-65, surveyed between 1993 and 2009. This result is in line with the one reported by Shimer (2005) for US workers of $(1-\delta_L) = 0.034$. It is interesting to note that the job separation rate for illegal workers is larger than that observed among legal workers. This phenomenon occurs due to law enforcement —undocumented workers can be apprehended and deported—, and to the presence of temporary workers in the United States.[17]

Migration costs in months of earnings in Mexico (k) are estimated using smuggler fees, transportation, and other expenses incurred during the trip. Data on average monthly earnings in Mexico prior migration, smuggler fees, transportation, and other expenses are obtained from EMIF. The estimates show that on average, migration costs for workers who entered between 1983 and 2011 were four months of their income prior migration. Migrants paid on average $1,086 in smuggler fees, $132 in transportation and other expenses, while their average monthly income prior migration was $304 (in 2010 dollars).

The proportion of legal and illegal workers in the economy are calculated using population over age 16 and labor force participation from the 2000 and 2010 Mexican Censuses. US population age 16 and older is from the 2000 and 2010 US Censuses. US labor force participation is from the Bureau of Labor Statistics, and the number of illegal Mexican immigrants in the United States is from the Department of Homeland Security and the Pew Hispanic Center. To find an estimate of the number of workers in Mexico who can potentially migrate, we use information from the Mexican Family Life Survey (MxFLS). This representative Mexican survey devotes a section to analyze migration behavior and specifically asks individuals if they would like to migrate. According to the survey, 15 percent of the individuals surveyed reported intention to migrate.[18]

Using the US population over age 16 and the labor force participation, we calculate the number of legal workers in the economy. Using the Mexican population over age 16 and the proportion of Mexicans who report intention to migrate, we calculate the number of potential migrants in Mexico. Finally, the number of undocumented Mexicans in the US labor force is calculated using the illegal Mexican population

[17] Chassamboulli and Peri (2015) do not differentiate between the destruction rate of jobs for legal and illegal unskilled workers in the United States. Using CPS data, they calculate a destruction rate for unskilled workers of 0.032.

[18] Two other surveys inquire about individuals' desire to migrate. The 2007 Gallup Poll "Mexicans and Migration" reports that 9.5% of the sample would like to move permanently to the United States. Latinobarómetro public opinion survey reports that in 2002, 10.5% of the sample responded that they and their families have seriously considered migrating to the United States. These estimates are lower than the one obtained using the MxFLS since they refer exclusively to permanent migrations and migration decision of complete families.

and the labor force participation of Mexicans in the United States (Hoefer et al. 2012; Passel et al. 2014; Passel and Cohn 2009).[19]

The last group of parameters c, ε_2, b_I, and ι are chosen calibrating them to match the wage gap between legal and illegal workers, the wage gap between Mexico and the United States, the US unemployment rate, and labor market tightness. Using information from the EMIF, we estimate a wage gap between legal and illegal Mexican migrants of 9 percent for the period between 1993 and 2011.

EMIF is an appropriate dataset to estimate the wage gap between legal and illegal immigrants since the survey is conducted over an extended period, individuals report their legal status as well as detailed information on the job characteristics (wages, benefits, occupation, and industry). The second target to match is the wage gap between workers in Mexico and the United States. Using data from the 2000 and 2010 Mexican Census and data from the Bureau of Labor Statistics we find that average wages in Mexico were 84 percent lower than those obtained by recent immigrants in the United States. Concerning the unemployment rate, several authors have argued that the targeted steady state rate of unemployment should include more than the rate of workers counted as unemployed as the model does not account for non-participation. For example, Krause and Lubik (2007) use an unemployment rate of 12 percent, Den Haan et al. (2000) 11 percent, Petrosky-Nadeau (2014) 8 percent, and Gertler and Trigari (2009) 7 percent. Using a midpoint between the later authors we set the unemployment rate of 10 percent. Finally, we set $(\theta) = 0.72$, the sample mean for the market tightness between 1960 and 2002 estimated by Pissarides (2009).

The calibrated parameters are the following. The vacancy posting cost per period is $c = 0.377$ (close to the 0.356 found by Pissarides (2009)), the upper bound of the distribution of epsilon is set to $\varepsilon_2 = 1.51$,[20] the unemployment income for illegal workers (leisure) obtained in the calibration is $b_I = 0.235$, and the parameter matching function is $\iota = 0.691$.

[19] To calculate the proportion of legal and illegal workers we use average data between 2000 and 2010. The US population over age 16 was on average 226.3 million, the labor force participation was 65.9%, and the number of legal workers in the labor force was 149.1 million. The Mexican population over age 16 was on average 70.6 million, the number of potential migrants was 10.6 million, and the number of Mexican illegal immigrants in the United States was 5.4 million. This number is calculated using the total number of illegal immigrants in the United States (11.1 million in 2005); the proportion of illegal immigrants in the United States from Mexico (59 percent of the total), and the labor force participation of Mexicans in the United States (82 percent). The number of Mexicans in the US labor force was 16.0 million, 10.6 millions of potential migrants, and 5.37 millions of migrants currently in the United States. The proportion of legal and illegal workers was 90.3 and 9.7 percent, respectively. Similar calculations were done using data from the year 2000 and 2010 separately. The proportion of legal and illegal workers is 91.2 and 8.8 percent using 2000 data, and 90.1 and 9.9 percent using 2010 data. We use a proportion of undocumented workers in the labor force of 10 percent.

[20] Epsilon (ε) follows a uniform distribution between ε_1 and ε_2.

Table 2 Model's predictions - tighter border enforcement increasing migration cost

	Migration Costs (Months of Earnings in Mexico)		Difference
	k=4	k=8	
Vacancy/unemployment ratio	0.720	0.734	0.014
Probability of filling vacancy	0.428	0.425	−0.004
Probability of finding a job	0.308	0.312	0.003
Unemployment rate legal	0.0993	0.0984	−0.0009
Unemployment rate illegal	0.1697	0.1682	−0.0015
Wage legal	0.9713	0.9716	0.03%
Wage illegal	0.891	0.887	−0.45%
Wage gap	0.09	0.095	0.005
Average wage	0.9646	0.9642	−0.04%
Optimal to stay in US (ε_{M})	0.281	0.229	−0.052
Optimal to stay in US ($\varepsilon_{\mathrm{US}}$)	0.844	1.147	0.302
Proportion of illegal workers US ($e_I + u_I$)	0.089	0.092	0.003
Welfare employed legal	236.4	236.5	0.05%
Welfare employed illegal	197.2	195.2	−0.98%
Welfare unemployed legal	235.7	235.8	0.05%
Welfare unemployed legal	195.4	193.5	−0.97%

Results: Effects of Tighter Border Enforcement

Table 2 shows the effect of an increase in border enforcement that doubles migration costs.[21] Migration costs are measured in months of earnings in Mexico before migration. The results show that this policy would increase market tightness. It would decrease the probability of filling a vacancy $p(\theta)$ from 42.8 percent to 42.5 percent and increase the probability of finding a job $q(\theta)$ from 30.8 percent to 31.2 percent. The increase in the probability of finding a job decreases the unemployment rate of legal workers by 0.09 percentage points and the unemployment rate of illegal workers by 0.15 percentage points.

The results show that higher migration costs decrease $\overline{\varepsilon}_M$ and increase $\overline{\varepsilon}_{US}$. Fewer individuals in Mexico find it optimal to migrate, and more workers in the United States find it optimal to stay. The overall effect of the increase in border enforcement is an increase in the number of illegal workers in the United States ($e_I + u_I$) from 8.9 percent to 9.2 percent. These results highlight the importance of accounting for return migration when estimating the effects of different immigration policies. While tighter

[21] Migration costs increased over time, they went from 2.05 months of earnings in Mexico for workers who arrived between 1994 and 1999, to 4.06 months of earnings for those who migrated between 2000 and 2005.

border enforcement deters workers from entering, it also decreases return migration, increasing the illegal population in the United States.

The results also show that the increase in the illegal population in the United States increases the wages of natives and legal immigrants by 0.03 percent. The increase in the probability of finding a job improves workers' outside options, and therefore, increases their wages.

Finally, concerning the wages of illegal workers, the increase in migration costs generates two opposing effects on workers' outside options and wages. On the one hand, the increase in the probability of finding a job improves workers' outside options; on the other hand, higher migration costs worsen workers' outside options since workers are less likely to undertake multiple trips to the United States. The results show that the latter effect dominates; doubling migration costs due to tighter border enforcement decreases the wages of illegal workers by 0.45 percent.

Figure 1 shows the effect of increases in border enforcement measured by increases in migration costs on the wages and unemployment rates of legal and illegal workers. Migration costs are measured in months of earnings in Mexico (horizontal axes). In the baseline scenario, migration cost is set at four months of earnings.

Model with Illegal Workers Paying Payroll Taxes

While some illegal workers, such as day laborers and domestic workers, are commonly paid in cash off the books, there is ample evidence that a significant proportion of undocumented workers in the United States are subject to payroll taxes. Illegal workers frequently obtain formal jobs using false social security numbers or social security numbers that belong to someone else. They have payroll taxes withheld as of any other legal worker in the United States. However, a crucial difference is that they do not file for tax refunds or unemployment benefits.

Model

For simplicity, we assume that there is no movement of workers between Mexico and the United States. Each period firms post a certain number of vacancies, and a matching function determines the flow of new matches between firms and workers.

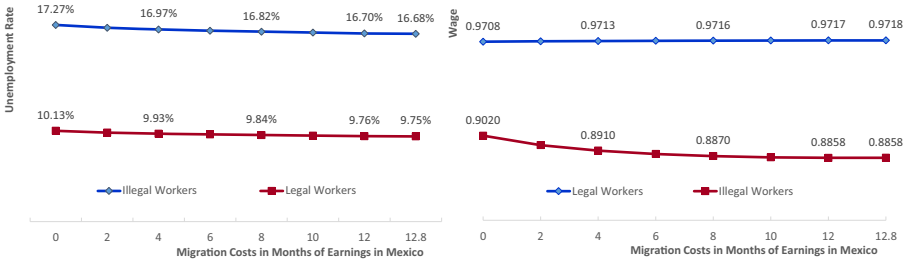

Fig. 1 Effects of tighter border enforcement on wages and unemployment rates for legal and illegal workers

When firms post vacancies, they only know the conditional probability that the match will be formed with a legal or an illegal worker. Once the match is formed, firms realize the worker's type. If the match is done with an illegal worker, the firm decides if the worker is hired on or off the books.

In this framework, a fixed payroll tax (T) is levied on firms for all legal workers and illegal workers hired on the books. The tax revenue is used to pay for the unemployment benefits of legal workers (b_U). Now, the income of unemployment of legal workers will include two components: income received from unemployment insurance (b_U) and the value of leisure (b_O). For illegal workers, the income of unemployment will be the value of leisure (b_I). The value functions of unemployed legal and illegal workers are given by

$$U_L = (b_U + b_O) + \beta(q W_L + (1-q)U_L) \text{ and}$$

$$U_I = b_I + \beta(q(\gamma W_I^T + (1-\gamma)W_I^{NT}) + (1-q)U_I),$$

where γ is the proportion of workers hired by firms on the books, and W_I^T and W_I^{NT} represent the value of an illegal worker employed on and off the books, respectively. In the model the proportion of workers hired on the books is an increasing function of the cost associated with hiring illegal workers off the books (X) —e.g. fines, prosecution costs, loss of reputation or any other cost paid by the firm if authorities discover it is hiring illegal workers— and a decreasing function of the cost of hiring illegal workers on the books.[22] The cost of hiring illegal workers on the books is the payroll tax (T) levied on firms for illegal workers using invalid social security numbers. The proportion of workers hired by firms is determined by $\gamma = \frac{X}{X+T}$.[23]

Alternatively, the cost associated with hiring illegal workers off the books (X) can be interpreted as the benefit of hiring illegal workers on the books. According to the law, employers who knowingly hired an unauthorized alien for employment in the United States or who have knowingly continued to employ an unauthorized alien will be subject to civil fines and criminal penalties. By hiring illegal workers on the books, firms can avoid such penalties as they can argue did not know the illegal status of their workers, and prove it by showing payroll tax records.[24]

The value functions of employed legal, employed illegal on the books, and employed illegal off the books workers are given by

$$W_L = w_L + \beta\left(\delta_L W_L + (1-\delta_L)U_L\right), \; W_I^T = w_I^T + \beta\left(\delta_I W_I^T + (1-\delta_I)U_I\right), \text{ and}$$

$$W_I^{NT} = w_I^{NT} + \beta\left(\delta_I W_I^{NT} + (1-\delta_I)U_I\right),$$

where w_I^T and w_I^{NT} are the wages received by illegal workers on and off the books.

[22] The cost of hiring illegal workers might vary across states, if for example, the E-verify is mandatory or not, or if the state has immigration laws that could increase the penalties for firms hiring illegal workers.

[23] The proportion of workers hired by firms on the books (γ) is endogenous; it is a function of the payroll tax (T), which is also a function of the probability of finding a job $q(\theta)$.

[24] According to USCIS the maximum fines imposed to employers who knowingly hired an unauthorized alien for employment in the United States or to have knowingly continued to employ an unauthorized alien in the United States are the following: $4,313 for each unauthorized alien if it is a first offense, $10,781 for each unauthorized alien in their second offense, and $21,563 for each unauthorized alien in their third or subsequent offense https://www.uscis.gov/i-9-central/penalties.

The firm's value functions are given by

$$J_L = y - w_L - T + \beta\left(\delta_L J_L + (1-\delta_L)\, V\right),\ J_I^T = y - w_I^T - T + \beta(\delta_I J_I^T + (1-\delta_I)\, V),\ \text{and}$$

$$J_I^{NT} = y - w_I^{NT} + \beta\left(\delta_I J_I^{NT} + (1-\delta_I)\, V\right),$$

where J_I^T and J_I^{NT} represent the value of a firm matched with an illegal worker on and off the books, and T is the amount of the payroll tax.

The value of a firm with an open vacancy can be written as

$$V = -c + \beta p\left(a J_L + (1-a)\left\{\gamma J_I^T + (1-\gamma) J_I^{NT}\right\}\right) + \beta\,(1-p)\, V$$

where $p(\theta)$ is the probability of filling a vacancy, $(1-a)$ is the conditional probability that the match will be formed with an illegal worker, and γ is the conditional probability that the match with the illegal worker will be on the books. Concerning the creation of new jobs, we assume free entry into the economy, which implies that firms create job vacancies until any incremental profit is exhausted ($V = 0$).

Wages are determined by Nash bargaining, the solution is to set w_L, w_I^T and w_I^{NT} to maximize the product surpluses:

$$\max_{w_L}(W_L - U_L)^{1-\eta}(J_L - V)^{\eta},\ \max_{w_I^{NT}}(W_I^{NT} - U_I)^{1-\eta}(J_I^{NT} - V)^{\eta},\ \text{and}$$

$$\max_{w_I^T}(W_I^T - U_I)^{1-\eta}(J_I^T - V)^{\eta}.$$

In this model, the payroll tax is used to pay for the unemployment benefits of legal workers. In steady state, tax revenue must equal tax expenditures. Therefore, in the steady state condition, the expenditure on unemployment benefits for legal workers is equal to the tax revenue generated by the payroll tax levied on legal and illegal workers on the books.

$$u_L b_L = T(\mu_L - u_L) + T\gamma(\mu_I - u_I).$$

Quantitative Analysis

The new parameters and calibration targets are summarized in Table 3. The proportion of legal and illegal workers μ_L and μ_I are set at 0.96 and 0.04 respectively. Since in this model there is no movement of workers between Mexico and the United States, now μ_I does not include workers in Mexico.[25] In this model μ_L represents the proportion of legal workers in the United States, and μ_I represents the proportion of illegal Mexican workers in the United States. The income of unemployment for legal workers is set at $b_L = 0.71$ following Hall and Milgrom (2008). The income received from unemployment insurance b_U is set at 0.36, the average unemployment insurance replacement rate for the United States between 1975 and 2004 according to the Department of Labor. Since $b_L = b_U + b_O$, the income from leisure b_O is set at 0.35.

[25] The proportion of illegal workers is estimated using the number of Mexicans in the United States divided by the total population age 16 and older. The proportion of undocumented workers is set at four percent (5.4/149.1=0.04)

Table 3 Parameters and targets in a model with illegal workers paying payroll taxes

Parameter	Value	Source
Output	$y = 1$	Normalization
Discount Factor	$\beta = 0.996$	Pissarides, 09
Bargaining parameter	$\eta = 0.5$	Pissarides, 09
Destruction rate Legal	$1 - \delta_L = 0.034$	Shimer, 05
Destruction rate Illegal	$1 - \delta_I = 0.063$	EMIF
Legal Population in US	$\mu_L = 0.94$	US Census
Illegal Population in US	$\mu_I = 0.06$	Mexico Census, ENNVIH, DHS
Unemp Income Legal $b_L = b_U + b_O$	$b_L = 0.71$	Hall & Milgrom, 08
Unemployment benefits	$b_U = 0.36$	Department of Labor
Leisure	$b_O = 0.35$	Difference
Parameter	Value	Calibration Target
Unemp Income Illegal: Leisure	$b_I = 0.001$	Unemployment rate $u = 0.08$
Vacancy cost	$c = 0.355$	Wage gap $\frac{w_L}{w_I} - 1 = 0.10$
Parameter Matching Function	$\iota = 0.983$	Market tightness $\theta = 0.72$
Cost hiring illegal workers off the books	$X = 0.01$	Proportion of workers on the books $\gamma = 0.25$

The parameter of the matching function is set at $\iota = 0.983$, the vacancy posting cost is set at $c = 0.355$, and the income of unemployment for illegal workers is set at $b_I = 0.001$. These parameters are chosen calibrating them to match the US unemployment rate ($u = 0.08$), labor market tightness ($\theta = 0.72$), and the wage gap between legal and illegal workers ($\frac{w_L}{w_I} - 1 = 0.10$).

In this model, the wage gap between legal and illegal workers is set at 10 percent, one percentage point higher than the one used in our previous model. To set the wage gap, we use two different sources of data. First, using data from EMIF, we estimate that the wage gap between legal and illegal workers, when illegal workers are hired on the books — using workers who signed a contract or received benefits as workers more likely to be on the books — is 2.5 percentage points higher than the one obtained using all workers. The second piece of information used in the calculation is the proportion of workers hired by firms on the books. We use a proportion of workers hired by firms on the books of $\gamma = 0.25$. Hotchkiss et al. (2015) using data from the Georgia Department of Labor estimate that in 2004 22 percent of the undocumented workers in the state of Georgia was included on firm's wage reports, and therefore, paid payroll taxes. Moreover, using data from the EMIF between 1999 and 2005 we calculate that between 20 and 27 percent of the undocumented Mexican workers surveyed were working on the books paying payroll taxes.[26] Therefore, since approximately 25 percent of the workers pay taxes, and the wage gap among

[26] While undocumented workers do not report if they are hired on or off the books in the survey, we use the proportion of workers who reported signing a contract and receiving any benefit as workers likely to be hired on the books.

workers paying taxes is 2.5 percent higher than the gap estimated using all workers, we set the wage gap between legal and illegal workers at ten percent [9 percent +(0.25*2.5percent)].

While the parameter of the matching function and the vacancy posting cost are similar to the ones obtained in our first model, the income of unemployment for illegal workers is significantly lower because this new setting does not account for the possibility of return migration and illegal workers have less alternative options. Finally, the cost associated with hiring illegal workers off the books (X) is set at $X = 0.01$ after calibrating it to match a proportion of workers hired by firms on the books of $\gamma = 0.25$.

Figure 2 shows the relationship between the cost of hiring illegal workers off the books (γ), the value of a firm matched with an illegal worker (off J_I^{NT} and on J_I^T the books), and the proportion of workers on the books (X). If $X = 0$, the value of a firm with a worker off the books is higher than the value of a firm with a worker on the books, therefore, firms will only hire workers off the books, and the proportion of workers on the books is zero $\gamma = 0$. However, as X increases, the gap in the value of firms with workers off and on the books decreases, increasing γ. When $X = 0.2915$, firms will be indifferent between hiring workers on or off the books as the value of firms with both types of workers is equal. In that case, the proportion of workers on the books is $\gamma = 0.5$. When the cost of hiring workers off the books is $X > 0.2915$, the value of a firm with a worker off the books is lower than the value of a firm with a worker on the books. Therefore, firms will continue increasing the proportion of workers on the books until $\gamma = 1$.

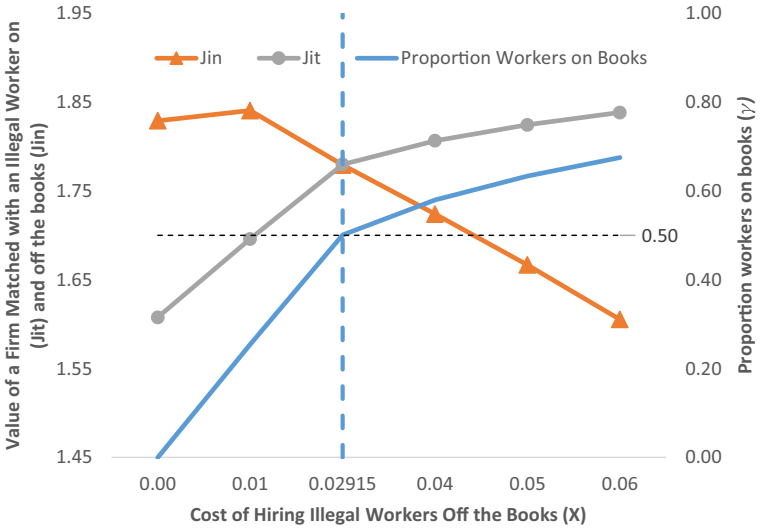

Fig. 2 Value of a firm matched with an illegal worker and the proportion of workers on the books

Results: Changes in the Cost Associated with Hiring Illegal Workers Off the Books

Increases in the penalties imposed on employers hiring illegal workers or of any other cost associated with hiring illegal workers off the books will trigger an increase in the probability of hiring illegal workers on the books. Table 4 shows that an increase in the proportion of illegal workers on the books decreases market tightness (θ), decreases the probability of finding a job $q(\theta)$, and increases unemployment rates.

Changes in the proportion of illegal workers on the books will affect wages in three ways. First, the decrease in market tightness and the increase of the unemployment rates worsen workers' outside options decreasing their wages (outside options effect). Second, the increase in the number of illegal workers on the books will increase tax revenue because now more workers pay the payroll tax (tax effect). Since illegal workers are not eligible for unemployment benefits, the amount of the tax necessary to pay for the unemployment benefits of legal workers decreases. Since part of the tax is paid by firms and part is paid by workers in the form of lower wages, the increase in γ will increase the wages of the workers subject to payroll taxes (legal workers and illegal workers on the books). Regarding illegal workers off the books, the increase in γ decreases their wages.

Table 4 Effects of changes in the cost of hiring illegal workers off the books

	Cost Associated with Hiring Illegal Workers off the Books				
	0.00	0.01	0.02915	0.09	0.27
Proportion illegal workers paying taxes	0.0%	25.5%	50%	75.8%	90.4%
Vacancy/unemployment ratio	0.722	0.720	0.718	0.717	0.716
Probability of filling vacancy	0.574	0.575	0.575	0.576	0.576
Probability of finding a job	0.4143	0.4137	0.4132	0.4126	0.4123
Wage legal	0.9503	0.9505	0.9507	0.9509	0.9510
Wage illegal	0.878	0.865	0.852	0.839	0.832
Wage illegal off the books	0.878	0.867	0.852	0.816	0.723
Wage illegal paying tax	0.863	0.858	0.852	0.847	0.844
Wage gap (w_L/w_I)-1	0.082	0.099	0.116	0.133	0.143
Average wage	0.9474	0.9470	0.9467	0.9464	0.9462
Tax	0.0295	0.0293	0.0291	0.0288	0.0287
Tax revenue/expenditure	0.02621	0.02624	0.02628	0.02631	0.02633
Unemployment rate legal	13.20%	13.21%	13.23%	13.25%	13.26%
Unemployment rate illegal	7.58%	7.59%	7.60%	7.61%	7.62%
Welfare employed legal	233.1	233.1	233.1	233.2	233.2
Welfare employed illegal	190.8	187.9	185.1	182.3	180.7
Welfare unemployed legal	232.5	232.6	232.6	232.6	232.7
Welfare unemployed illegal	189.0	186.1	183.3	180.5	178.9

Table 5 Model's predictions for an amnesty and the revocation of legal status

	Remaining Population after the Amnesty		Baseline	Illegal Population after Legal Status is Revoked	
	2%	3%	4%	6%	8%
Cost hiring workers off the books	0.01	0.01	0.01	0.01	0.01
Proportion illegal workers paying taxes	24.4%	24.9%	25.5%	26.4%	27.3%
Vacancy/unemployment ratio	0.661	0.691	0.720	0.777	0.832
Probability of filling vacancy	0.595	0.585	0.575	0.556	0.539
Probability of finding a job	0.3935	0.4039	0.4137	0.4321	0.4489
Wage legal	0.9481	0.9493	0.9505	0.9525	0.9543
Wage illegal	0.8599	0.8624	0.8647	0.8688	0.8723
Wage illegal off the books	0.8625	0.8649	0.8672	0.8711	0.8746
Wage illegal paying tax	0.8520	0.8549	0.8575	0.8622	0.8662
Wage gap (w_L/w_I)-1	0.103	0.101	0.099	0.096	0.094
Average wage	0.9463	0.9467	0.9470	0.9475	0.9477
Tax	0.0310	0.0301	0.0293	0.0279	0.0267
Tax revenue/expenditure	0.0281	0.0271	0.0262	0.0247	0.0233
Unemployment rate legal	7.95%	7.76%	7.59%	7.29%	7.04%
Unemployment rate illegal	13.80%	13.49%	13.21%	12.72%	12.31%
Welfare employed legal	232.3	232.7	233.1	233.7	234.3
Welfare employed illegal	185.6	186.8	187.9	189.8	191.5
Welfare unemployed legal	231.8	232.2	232.6	233.2	233.8
Welfare unemployed illegal	183.7	185.0	186.1	188.1	189.8

While we can conclude that the wages of illegal workers off the books will decrease, the impact on the wages of legal workers and illegal workers on the books will depend on the magnitude of two effects (lower outside options and tax effect). Table 4 shows that for legal workers the tax effect dominates, an increase of γ increases their wages (w_L). For illegal workers on the books, the outside option effect dominates, and an increase of γ decreases their wages (w_I^T).

Results: Effects of an Amnesty

Columns 1 and 2 of Table 5 show the effect of an amnesty granting legal status to the illegal population in the United States. On the contrary, Columns 4 and 5 show results if instead of granting legal status to illegal workers, legal workers have their work permits revoked.[27] The results show that an amnesty decreases the probability

[27] An example of this type of policy is the cancelation of DACA. If program beneficiaries cannot renew their work permits, they will likely stay in the United States and will continue working as undocumented workers. Another example is termination of the Temporary Protected Status (TPS) for Haitian and Central American immigrants announced by President Trump in November 2017.

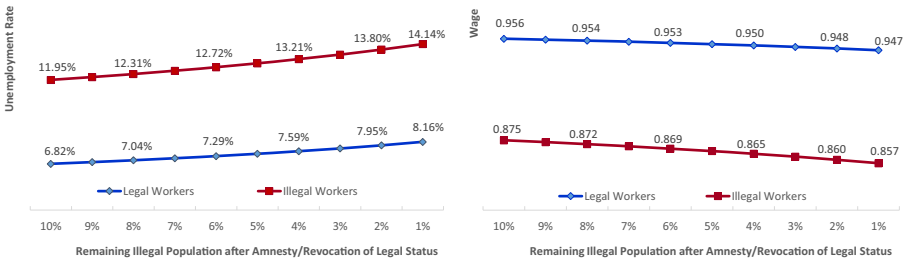

Fig. 3 Effects of an amnesty in a model with illegal workers paying payroll taxes

of finding an illegal worker with a low outside option and therefore, decreases θ. The decrease in θ generates an increase in unemployment. The larger the decrease in the proportion of illegal workers in the economy, the larger will be the decrease in θ. On the other hand, taking away the legal status of workers increases the probability of finding an illegal worker with a low outside option and increases θ. The increase in θ generates a decrease in unemployment. Figure 3 shows the effects of amnesty and revocation of legal status to different proportions of the population on wages and unemployment rates.

Table 5 shows that an amnesty decreasing the illegal population to three percent would increase the wages of newly legalized workers by 9.79 percent, while an amnesty reducing the number of illegal workers to two percent would increase their wages by 9.60 percent. On the other hand, eliminating the legal status of immigrants increasing the proportion of illegal workers to six percent of the population would decrease the wages of newly illegal workers by 8.60 percent. Decreasing the illegal population to three and two percent would decrease the wages of legal workers not affected by the amnesty by 0.12 and 0.25 percent respectively, and the wages of illegal workers not benefited by the amnesty by 0.27 and 0.56 percent respectively.[28]

Table 6 and Fig. 4 show the effect of an amnesty decreasing the illegal population from four percent to two percent for different costs associated with hiring illegal workers off the books —different proportions of illegal workers paid on the books—. Columns 3 and 4 show the baseline scenario (cost set at $X = 0.01$ implying a proportion of illegal workers on the books of $\gamma = 0.25$). Columns 1, 3, 5, 7, and 9 show the results before the policy change ($\mu_L = 0.96$ and $\mu_I = 0.04$), and Columns 2, 4, 6, 8 and 10 show the effects of the amnesty ($\mu_L = 0.98$ and $\mu_I = 0.02$). According to the model, the decrease in θ will be smaller for larger values of γ. If γ is low, which implies, a large number of illegal workers are employed off the books, an amnesty

[28] An amnesty decreasing the illegal population from four to two percent would increase the wages of newly legalized workers by 9.60 percent, would decrease the wages of legal workers not affected by the amnesty by 0.25 percent, and the wages of illegal workers not benefited by the amnesty by 0.56 percent. On the other hand, an amnesty decreasing the illegal population from six percent to three percent would increase the wages of newly legalized workers by 9.27 percent, would decrease the wages of legal workers not affected by the amnesty by 0.33 percent, and the wages of illegal workers not benefited by the amnesty by 0.73 percent. Finally, an amnesty decreasing the illegal population from eight percent to four percent would increase the wages of newly legalized workers by 8.96 percent and would decrease the wages of legal and illegal workers not affected by the amnesty by 0.40 percent and 0.87 percent, respectively.

Table 6 Effects of an amnesty decreasing illegal workers by 50 percent for different costs of hiring illegal workers off the books

	Before Amnesty (1)	After Difference (2)	Before Amnesty (3) Baseline	After Difference (4)	Before Amnesty (5)	After Difference (6)	Before Amnesty (7)	After Difference (8)	Before Amnesty (9)	After Difference (10)
Cost hiring workers off the books	0.00	0.000	0.01	0.000	0.02915	0.000	0.09	0.000	0.27	0.000
Proportion illegal workers paying taxes	0%	−4.8%	25%	−4.1%	50%	−3.0%	76%	−1.6%	90%	−0.7%
Vacancy/unemployment ratio	0.722	−0.060	0.720	−0.059	0.718	−0.058	0.717	−0.057	0.7156	−0.057
Probability of filling vacancy	0.574	0.0206	0.575	0.0204	0.575	0.0201	0.576	0.0199	0.5761	0.0198
Probability of finding a job	0.4143	−0.0205	0.4137	−0.0202	0.4132	−0.0200	0.4126	−0.0198	0.4123	−0.0196
Wage legal	0.9503	−0.242%	0.9505	−0.253%	0.9507	−0.264%	0.9509	−0.274%	0.9510	−0.280%
Wage newly legalized workers	0.8779	8.0%	0.8647	9.6%	0.8521	11.3%	0.8392	13.0%	0.8320	14.0%
Wage illegal	0.878	−0.540%	0.865	−0.555%	0.852	−0.618%	0.839	−0.748%	0.832	−0.857%
Wage illegal off the books	0.878	−0.540%	0.867	−0.542%	0.852	−0.567%	0.816	−0.637%	0.723	−0.764%
Wage illegal paying tax	0.863	−0.639%	0.858	−0.645%	0.852	−0.672%	0.847	−0.727%	0.844	−0.772%
Wage gap (w_L/w_I)-1	0.082	3.95%	0.099	3.37%	0.116	3.44%	0.133	4.06%	0.143	4.65%
Average wage	0.9474	−0.09%	0.9470	−0.08%	0.9467	−0.06%	0.9464	−0.05%	0.9462	−0.04%
Tax	0.0295	5.2%	0.0293	5.7%	0.0291	6.2%	0.0288	6.6%	0.0287	6.9%
Tax revenue/expenditure	0.0262	6.98%	0.0262	6.92%	0.0263	6.86%	0.0263	6.81%	0.0263	6.78%
Unemployment rate legal	7.58%	0.364%	7.59%	0.360%	7.60%	0.356%	7.61%	0.353%	7.62%	0.351%
Unemployment rate illegal	13.20%	0.593%	13.21%	0.586%	13.23%	0.580%	13.25%	0.574%	13.26%	0.571%
Welfare employed legal	233.1	−0.32%	233.1	−0.33%	233.1	−0.34%	233.2	−0.35%	233.2	−0.35%
Welfare employed illegal	190.8	−1.21%	187.9	−1.21%	185.1	−1.27%	182.3	−1.39%	180.7	−1.50%
Welfare unemployed legal	232.5	−0.33%	232.6	−0.34%	232.6	−0.35%	232.6	−0.36%	232.7	−0.36%
Welfare unemployed illegal	189.0	−1.26%	186.1	−1.26%	183.3	−1.32%	180.5	−1.44%	178.9	−1.54%

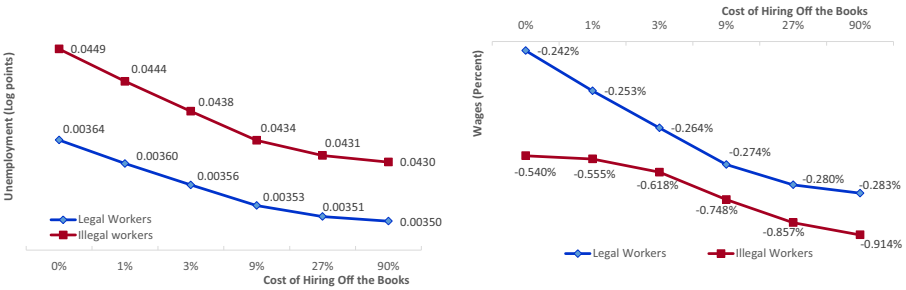

Fig. 4 Effects of an amnesty decreasing illegal workers by 50 percent for different costs of hiring off the books

reducing the illegal population will generate a substantial decrease in θ. On the other hand, if γ is high, and therefore, a large proportion of the illegal workers work on the books (and firms are already paying taxes for those workers), the amnesty will generate a smaller decrease in the number of vacancies and θ.

The decrease in θ decreases the probability of finding a job and increases the unemployment of legal and illegal workers. Since the decrease of θ is smaller for large values of γ, the increase in unemployment rates will also be smaller for higher values of γ.

Effect of an Amnesty on the Wages of Legal Workers The wages of legal workers are affected in two ways. First, the increase in the unemployment rate worsens workers' outside options decreasing their wages (outside options effect). Additionally, the fact that now there is a larger number of unemployed legal workers, the amount of the tax necessary to pay for unemployment benefits will go up, decreasing, even more, the wages of legal workers (tax effect).

The magnitude of the decrease in the wages of legal workers for different values of γ depends on the size of the outside options effect and the tax effect. On the one hand, the decrease of θ and the increase in unemployment rates are smaller for large values of γ. Therefore, the decrease in wages due to worse outside options should be lower for high values of γ. On the other hand, an amnesty increasing the legal population increases the number of workers paying taxes, but also the number of workers claiming unemployment benefits. If a large proportion of illegal workers were paying the tax before the amnesty (high γ), the amnesty will only increase unemployment claims, and therefore, the amount of the tax. Since part of the tax is paid by the firm and part of the tax is paid by workers, a higher tax implies lower wages for legal workers. The results show that the second effect dominates, and the decrease in the wages of legal workers is larger for higher values of γ.

Effect of an Amnesty on the Wages of Illegal Workers Paying Payroll Taxes The decrease in their wages is larger than that observed among legal workers but due to the same mechanisms. First, higher unemployment rates worsen outside options decreasing their wages, and second, higher taxes are necessary to pay for unemployment benefits of the newly legalized immigrants. The magnitude of the decrease in their wages for different values of γ depends on the magnitude of the outside options

effect and the tax effect (the outside options effect is larger for low γ, but the tax effect is smaller for low γ). The results show that the tax effect dominates, and the decrease in the wages of illegal workers on the books is larger for higher values of γ.

Effect of an Amnesty on the Wages of Illegal Workers off the Books The decrease in their wages is larger than that observed among legal workers but lower than those observed among illegal workers on the books. The reason is that they are only affected by the first mechanism (decrease in outside options). Since they are working off the books, the increase in taxes necessary to pay for unemployment benefits does not affect their wages. The results show that an amnesty would decrease the wages of illegal workers off the books, and the effect is going to be larger for higher values of γ.

Summarizing, it is essential to consider that a proportion of illegal workers pay payroll taxes to accurately estimate the effect of an amnesty on the wages of workers. The larger the proportion of illegal workers paying taxes, the larger will be the amount of the tax necessary to pay for the increase in unemployment claims. The amnesty will not change the number of workers paying taxes but will increase the number of workers claiming for unemployment benefits. Therefore, if a significant proportion of illegal workers pay taxes, the decrease in the wages of legal and illegal workers in the economy will be more evident.

Conclusion

We analyze the effects of two immigration policies, an increase in border enforcement and an amnesty on the labor market outcomes of US natives and Mexican immigrants. We use a Mortensen-Pissarides style labor market model that includes individuals authorized to work and illegal workers. One critical feature of our study is that our model accounts for voluntary return migration. Estimates show that 92 percent of the immigrants who returned to Mexico in 2014 did it of their own free will. Failure to account for return migration might lead to overestimating the efficacy of border enforcement in decreasing the number of illegal workers in the country. Border enforcement affects not only the inflows but also the outflows of immigrants from the United States to Mexico.

Another distinctive characteristic of our study is that we consider the case in which undocumented migrants pay payroll taxes. While there is considerable evidence that employers report and pay taxes on the wages paid to undocumented workers, no previous study has analyzed the potential effect that different immigration policies would have in an economy where illegal workers can be paid off the books or can get formal jobs and have taxes withheld.

A key finding of this paper is that immigration policies might have unintended effects. The model shows that an increase in border enforcement has an ambiguous effect on the number of illegal workers in the economy. While tighter border enforcement deters illegal migration of prospective workers, it also changes the incentives for those already in the United States by decreasing return migration. If tighter border increases the number of illegal workers, the model predicts that it will

increase the wages of natives and have an ambiguous effect on the wages of illegal workers. Quantitative results show that tighter border enforcement increases the number of illegal workers, increases the wages of natives and decreases the wages of illegal workers.

We study the effects of an amnesty in an economy where a proportion of illegal workers have formal jobs and pay payroll taxes. The results show that the larger the proportion of illegal workers paying taxes, the larger will be the amount of the tax necessary to pay for the increase in their unemployment claims. The amnesty will not change the number of workers paying taxes but will increase the number of workers claiming for unemployment benefits. Therefore, the larger the proportion of illegal workers paying taxes, the larger will be the decrease in the wages of legal and illegal workers, and the smaller will be the increase in unemployment generated by a decrease in the number of illegal workers in the economy after an amnesty.

Finally, we analyze the potential effects that changes in the costs associated with hiring illegal workers off the books can have on the economy. While most recent policy proposals have intended to decrease the number of illegal workers in the economy with increased border control; enforcement of laws prohibiting the employment of illegal workers is also a key element of a comprehensive strategy to reduce illegal immigration. According to the law, employers who knowingly hired an unauthorized aliens for employment in the United States will be subject to civil fines and criminal penalties. Our findings show that the increase of those fines or any other cost associated with hiring illegal workers off the books will decrease market tightness, will increase the probability of hiring illegal workers on the books, and will increase tax revenue. Since illegal workers are not eligible for unemployment benefits, the amount of the tax necessary to pay for the unemployment benefits of legal workers decreases. Since part of the tax is paid by firms and part is paid by workers in the form of lower wages, the increase in the costs associated with hiring illegal workers will increase the wages and welfare of natives and legal immigrants in the United States.

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