

# Immigration, Crimes and Frictional Labor Market

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## Abstract

This paper studies the relationship between immigration and crime in a frictional labor market. Immigration strengthens the labor market in the host country by reducing firms' labor costs. With more immigrants in this labor market, unemployed workers find a job faster but employed workers receive lower value from their jobs. Therefore employees commit more crimes but unemployed workers prefer to stay unemployed. The different criminal behaviors of employed and unemployed workers explain the ambiguity on the effects of immigration. A more generous unemployment insurance system for immigrants increases the unemployment rate and crime rates. An extended incarceration duration and deportation policy reduce crime rates but has no significant impact on labor market outcomes.

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# 1 Introduction

Since the 1970s, immigrants have continuously moved to the United States. The most significant wave of immigrants happened between 1990 to 2010, which increased the population of immigrants from 19.8 million to 40 million. Research on the impact of this wave of immigrants on labor market outcomes and crime rates is not conclusive. Borjas (2003; 2005) finds that immigration reduces natives' wages, but Ottaviano and Peri (2012) and Peri et al. (2015) provide evidence of the opposite effect. Alonso-Borrego et al. (2012) find that immigration has a positive correlation with crime rates, whereas Wadsworth (2010) argues that immigrants reduce crime rates. Bell et al. (2013) provide evidence that asylum waves in the UK increase the property crime rate, but waves of immigrants from A8 countries have opposite effects.<sup>1</sup> Both waves do not affect violent crimes. Bianchi et al. (2012) and Spenkuch (2014) find that immigration has a positive correlation with property crimes only.

This paper studies the effects of immigration on labor market outcomes and crime rates using a search and matching model à la Pissarides (2000). In the model, all immigrants are from countries with worse labor market conditions than in the host country—for example, they may have lower wages and a higher unemployment rate. According to the Current Population Survey (CPS) data in the 1990s, immigrants earned wages about 20% less than natives. It is reasonable to consider that this wage gap comes from the low unemployment value of immigrants for two reasons. First, immigrants have limited access to the social security system, so they are not able to have the same unemployment income and benefits as natives. Second, immigrants lack social networks and communication skills, or have culture conflicts in the host country. Given these difficulties, immigrants must search more intensively than natives and as a result enjoy less leisure when they are unemployed. A lower value of unemployment leads to higher profits for firms, as in the baseline Diamond-Mortensen-Pissarides (DMP) model. As a result, firms expected profits increase when more

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<sup>1</sup>The A8 countries are eight countries that joined the EU in 2004: Poland, Hungary, Czech Republic, Slovakia, Slovenia, Latvia, Lithuania, Estonia.

immigrants search in the labor market. Such a composition change in the labor force leads firms to create more jobs in the labor market, which benefits both native and immigrant workers.

Existing literature concludes that workers' criminal behavior on property crimes is highly related to labor market outcomes. Burdett et al. (2003) and Burdett et al. (2004) document that low-wage workers commit more crimes than those with higher wages, and a high unemployment rate leads to high crime rates. Engelhardt (2010) states that workers who have low unemployment benefits commit crimes. Therefore it is reasonable to link immigration and criminal behavior via the labor market.

Immigrants have lower unemployment value than natives, so unemployed immigrants are more likely to commit crimes. Employed immigrants receive a higher surplus from employment than natives. Therefore, employed immigrants are pickier than employed natives when they confront criminal opportunities. Among all types of workers, employed skilled immigrants are the least likely to commit crimes, while unemployed unskilled immigrants are the most likely to commit crimes. An increase in immigrants directly affects the composition of the workforce. Since the overall crime rate is a weighted average of crimes that are committed by each type of workers, the effect on the overall crime rate depends on the type of immigrants. The crime rate increases with an increase in the number of unskilled immigrants, but decreases with a higher number of skilled immigrants.

The crime rate is also affected by the criminal behavior of workers. The criminal behavior in this paper follows the model of Engelhardt et al. (2008). Workers encounter criminal opportunities at random, but only commit a crime when the payoff is sufficiently high. An increase in immigrants is not able to change the criminal behavior of workers explicitly, but it leads to more job creation in the labor market. Employed and unemployed workers respond to the job creation from immigration differently. With more jobs in the market, unemployed workers prefer to wait for a job instead of getting involved in a criminal activity because they can find jobs faster, which increases the value of unemployment. Employed workers, however,

commit more crimes because their jobs become less valuable. These opposite effects of an increase in immigration on the criminal behavior of employed and unemployed workers may explain the ambiguity of the effect of immigration on crime observed in empirical studies.

The paper calibrates the model to the U.S. labor market data and crime report data in the 1990s. From the 1990s to the 2000s, the unemployment rate in the U.S. decreased by 0.64 and the real wage of natives increases by 0.6%. The model predicts that with the wave of immigrants in the 2000s, the unemployment rate decreases by 0.47 percentage points and the native income increases by 0.29%. This model prediction shows that immigration partially explains the change in labor market outcomes from the 1990s to the 2000s. The crime rate decreases by 0.164 per 1000 population, i.e. the increase in immigrants reduces the total number of criminal offenses nation-wide by approximately 48,347 cases. I also explore the effects on skilled and unskilled immigrants, respectively. The crime rate decreases by 0.213 offenses per 1000 population with the increase in skilled immigrants but increases 0.04 offenses per 1000 population respectively with the increase in unskilled immigrants. These predictions are consistent with the ambiguity of empirical studies.

Finally, the paper studies a number of relevant public policies. First, I consider the effect of giving immigrants access to a more generous unemployment insurance system, so that they receive the same unemployment benefits as natives. This policy raises the unemployment rate of natives by 1.23 percentage points, and lowers the native wage by 0.74%, while increasing the overall crime rate by 0.26 offenses per 1000 population. Second, an extended incarceration duration and deportation policies reduce the crime rate by increasing the opportunity cost of committing a crime. The longer incarceration duration affects the criminal behavior of both natives and immigrants. The crime rate declines by 19.95 offenses per 1000 population when the average jail sentence is extended from 16 months to 48 months. The difference with a change in the deportation policy is that deportation only affects immigrant criminals. With this policy the crime rate drops by 1.42 offenses to 4.45 offenses per 1000 population, which depends on the immigrants' country of origin. Incarceration or deportation policy has

no significant impact on labor market outcomes.

This paper is the first to study the effects of immigration on labor market outcomes and crime jointly in a search and matching framework. I extend the Engelhardt et al. (2008) criminal behavior model with skill bias and the population of immigrants. The most closely related paper on immigration is Chassamboulli and Palivos (2014). Their paper studies a model with two frictional labor markets with skill bias and imperfect substitution between skilled and unskilled labor. The authors show that an increase in immigrants can raise natives' wages and reduce the unemployment rate. Compared to their work, the main contribution of this paper is that this paper discusses the effect of immigration on crime rates.<sup>2</sup> Criminal behavior of workers in this paper is based on Engelhardt et al. (2008). Adding the labor market leads to a new mechanism, as immigration changes the workers' distribution directly. This affects workers' criminal behavior via the labor market, and vice-versa. As the paper shows, this novel mechanism is important to understand the effects of migration policy on the labor market and crime rates.

Other related literature is following. Chassamboulli and Palivos (2013) introduce unskilled immigrants only. Immigrants only show up in the unskilled labor market in the host country and compete with unskilled natives, while there are only native workers in the skilled labor market. Skilled native workers benefit from unskilled immigrants in terms of wages and employment, while the impact of unskilled immigrants on the unskilled labor market outcomes is ambiguous. Chassamboulli and Peri (2015) focus on the effects of illegal immigrants on labor market outcomes with two-country model. They endogenize the migration behavior of legal and illegal immigrants from Mexico, i.e. Mexican immigrants can choose

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<sup>2</sup>I also relax the assumption that workers only search in the market that matches with their skills. However, I provide an extended version with two segmented markets with skill bias in appendix C and show that the results are similar. In addition, I assume that skilled and unskilled workers are perfect substitutes, whereas Chassamboulli and Palivos (2014) assume an imperfect substitution between skilled and unskilled labor. The main mechanism in this model is that an increase in immigrants changes the distribution of workers and affects firms' job creation behavior, and as a result labor market outcomes. Imperfect substitution between skilled and unskilled labor does not affect this mechanism significantly, so to illustrate this mechanism in the simplest way I assume perfect substitution between skilled and unskilled labor.

to stay in Mexico or to migrate to the U.S. In their paper, the presence of illegal immigrants encourage firms to create more jobs, so the unemployment rate in the U.S. decreases and the wages of natives increase. Ortega (2000) and Liu (2010) also study the impact of immigration in a search and matching framework. Ortega (2000) constructs a two-country model in which workers decide whether to search for employment in their own country or to migrate. He proves that the migration equilibria Pareto dominate the non-migration equilibrium. Liu (2010) finds that illegal immigrants lower the job finding rate in the labor market and force native workers to lower their wages.

The paper describes a frictional labor market with skilled and unskilled immigrants in section 2. I solve the steady state equilibrium of the model in section 3. In steady state equilibrium, an increase in the number of immigrants affects the composition of labor force. I discuss the effects of immigration on labor market outcomes and crimes respectively in section 4. In section 5, the model is calibrated to the U.S. labor market data and crime report data in the 1990s. The simulation with an increase in the number of immigration and the comparison to the data are reported in section 6. Section 7 discusses some policy effects on labor market outcomes and crime rates.

## 2 Model

Time is continuous with an infinite horizon. There is a large measure of firms. Both firms and workers are risk neutral and discount their future value at a constant rate  $r$ . There are high skilled workers ( $H$ ) and low skilled workers ( $L$ ) in the labor market. Each worker has an exogenous productivity based on their skill level. The productivity of high skilled workers ( $y_H$ ) is greater than low-skilled workers' productivity ( $y_L$ ), i.e.  $y_H > y_L$ . Workers are either native workers ( $N$ ) who were born in the host country, or immigrant workers ( $I$ ) who were born outside of the host country.<sup>3</sup> The measure of total native workers is normalized to 1.

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<sup>3</sup>The superscript/subscript variable  $i$  represents the skill level of workers, skilled ( $H$ ) or unskilled( $L$ );  $s$  represents the labor market status, employed ( $E$ ), unemployed ( $U$ ), or in prison ( $P$ );  $j$  represents the

The constant fraction of skilled native workers is denoted as  $\gamma$ . The exogenous measure of skilled immigrants and unskilled immigrants are denoted as  $I_H$  and  $I_L$  respectively.

Unemployment exists because of search frictions in the labor market. Only unemployed workers search in the labor market. There is only one labor market. Immigrants legally search for jobs in the host country and firms that hire immigrants do not get fined or punished.<sup>4</sup> Because immigrants lack social security and social networks, or have communication difficulties or other hardships, they receive a lower unemployment income and have to search more intensively to compete with native workers. Therefore, unemployed immigrants receive a lower utility flow than natives. More specifically, when a worker is unemployed she receives an exogenous a flow of utility  $B_H^j = B_L^j$ , which only depends on her immigration status,  $j \in \{N, I\}$  and  $B_i^N > B_i^I$ . The variable  $M$  is the number of matches that are made in this market, following a matching function of the number of vacancies  $V$ , and the measure of unemployment  $U$ ,

$$M \equiv m(V, U). \tag{1}$$

The matching function is continuous, strictly increasing and concave with respect to each of its arguments, and displays constant return to scale. The worker matches with a firm at Poisson rate  $f(\theta) \equiv M/U$ . The variable  $\theta$  is defined as the market tightness in the labor market, which is a vacancy-unemployment ratio. When the worker matches with a firm, she starts producing with productivity  $y_i$ . Exogenous job separation shocks arrive at a Poisson rate  $\delta$ .

Every worker in the economy is a potential victim and criminal. All workers encounter criminal opportunities at an exogenous Poisson rate  $\mu$ . The rate  $\mu$  also equals to the fraction of workers who may commit crimes. The probability of meeting a type- $ij$  unemployed criminal is  $\mu U_i^j$  and the probability of meeting a type- $ij$  employed criminal is  $\mu E_i^j$ . For all

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immigration status, native ( $N$ ) or immigrant ( $I$ ).

<sup>4</sup>All immigrants considered in this model are legal immigrants, including naturalized citizens and permanent residents. Workers can search across markets. The appendix provides an extension of the model with two segmented markets and shows that the results do not change.

$s \in \{E, U\}$ , let  $\mathbb{E}_s(g)$  denote the expected (endogenous) crime value of type- $ij$  criminals with labor force status  $s \in \{E, U\}$ . Therefore, the worker's expected loss from crime is

$$\tau = \mu \left[ \sum_j \sum_i U_i^j \mathbb{E}_U(g) + \sum_j \sum_i E_i^j \mathbb{E}_E(g) \right]. \quad (2)$$

Criminal activities are considered a wealth transfer from victims to criminals. When the worker meets a criminal opportunity, she can observe the value of this criminal opportunity,  $g$ , from the victim. This value is randomly drawn from a known distribution  $F(g)$  with support  $[0, g^{max}]$ . If the value  $g$  is high enough, the worker commits this criminal opportunity. The criminal can be arrested by the police with an exogenous probability  $\pi$ . When the criminal is in jail, she cannot produce, but receives a constant flow of utility  $x$ . Assume that workers value their freedom so that  $x < B_i^j$ . Incarcerated workers are released from the jail and return to the labor market at an exogenous rate  $\rho$ , which is independent of the value of the crime. The government imposes a tax  $\tau$  to prisoners.<sup>5</sup>

Each firm has only one job in the market, either filled ( $F$ ) or vacant ( $V$ ). A firm enters the market freely by posting an identical job vacancy and pays a constant recruitment cost,  $k > 0$ . It matches with an unemployed worker randomly at rate  $q(\theta) \equiv M/V$ . The firm offers an employment contract to its employee. This employment contract requires the worker to pay an one-time hiring fee  $\phi_i^j$  when she get hired, and the firm pays a flow wage  $w_i^j$  to the worker during the duration of the match. Once the production begins, the firm receives the productivity  $y_i$  from the employee. The firm loses its employee when a separation shock arrives or the employee commits a crime and gets arrested.

## 2.1 Bellman Equations

Let  $\Pi_V$  denote the value function of a vacancy and  $\Pi_F$  denote the value function of a filled job. The firm enjoys the capital gain from the match,  $\mathbb{E}(\Pi_F + \phi) - \Pi_V$ , since the firm only

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<sup>5</sup>Assume that there is no criminal activities in jail. Some workers may commit crimes to be safe in jail. This tax ensures that the net utility flow in jail is the same as outside of jail.



knows the distribution of unemployed workers in the market before matching with a worker. Once the match is formed, the firm receives the productivity  $y_i$  from the worker and pays her the wage  $w_i^j$ , which is determined by the employment contract. The firm suffers the capital loss  $\Pi_{F,i}^j - \Pi_V$  when the separation shock occurs or the employee commits a crime and gets caught. Firms have no monetary loss from criminal activities explicitly. Thus, the asset equations of firms are

$$r\Pi_V = -k + q(\theta)[\mathbb{E}(\Pi_F + \phi) - \Pi_V] \quad (3)$$

$$r\Pi_{F,i}^j = y_i - w_i^j - [\delta + \mu\pi(1 - F(\bar{g}_{E,i}^j))](\Pi_{F,i}^j - \Pi_V), \quad (4)$$

where  $\mathbb{E}(\Pi_F + \phi) = \sum_j \sum_i (U_i^j/U)(\Pi_{F,i}^j + \phi_i^j)$ , for all  $i \in \{H, L\}$  and  $j \in \{I, N\}$ .

Denote the value of individual of type  $\{s, i, j\}$  as  $V_{s,i}^j$ . Each individual can be in one of three states  $s$ : employed ( $E$ ), unemployed ( $U$ ) or in prison ( $P$ ). Everyone has a burden  $\tau$  that either comes from the criminal activity or the tax. Employed workers earn wages  $w_i^j$  from firms and suffer a capital loss  $V_{E,i}^j - V_{U,i}^j$  when separation occurs. Unemployed workers receive their a flow of utility  $B_i^j$ . They find a job at a rate  $f(\theta) = \theta q(\theta)$ , which yields a capital gain  $V_{E,i}^j - V_{U,i}^j$ . Upon finding a job, workers must pay the hiring fee  $\phi_i^j$  determined by the employment contract. Both employed and unemployed workers encounter a criminal opportunity at a rate  $\mu$  and commit a crime if the criminal payoff  $K_{s,i}^j(g)$  is strictly greater than the value in the legal sector. The criminal payoff  $K_{s,i}^j(g)$  is a function of the crime value  $g$ . Workers in jail receive a flow utility  $x$ . They are released from jail and return to the labor market as unemployed workers at a rate  $\rho$ , and obtain the capital gain  $V_{U,i}^j - V_{P,i}^j$ .<sup>6</sup>

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<sup>6</sup>To simplify the analysis, I assume that criminals do not have a criminal record when they return to the labor market. The model can be extended to allow for criminal records, but the main mechanism will remain unchanged.

The value functions of workers satisfy the following Bellman equations

$$rV_{E,i}^j = w_i^j - \tau - \delta(V_{E,i}^j - V_{U,i}^j) + \mu \int_0^{g^m} \max\{K_{E,i}^j(g) - V_{E,i}^j, 0\} dF(g). \quad (5)$$

$$rV_{U,i}^j = B_i^j - \tau + \theta q(\theta)(V_{E,i}^j - V_{U,i}^j - \phi_i^j) + \mu \int_0^{g^m} \max\{K_{U,i}^j(g) - V_{U,i}^j, 0\} dF(g) \quad (6)$$

$$rV_{P,i}^j = x - \tau + \rho(V_{U,i}^j - V_{P,i}^j). \quad (7)$$

The criminal decision of a worker depends on the value of the criminal opportunity. A worker commits a crime if the criminal opportunity provides a sufficiently high value, i.e. the payoff from the crime should be greater than her current value of employment or unemployment. The criminal payoff is the net capital gain from the criminal activity. If the worker commits a crime, she gets the crime value  $g$  from the victim. She keeps the value in the legal sector  $V_{s,i}^j$  if she does not get arrested. If the criminal gets arrested, which happens with a probability  $\pi$ , she becomes a prisoner and suffers an expected capital loss  $\pi(V_{P,i}^j - V_{s,i}^j)$ . The payoff of a crime is given as

$$K_{s,i}^j(g) = g + V_{s,i}^j + \pi(V_{P,i}^j - V_{s,i}^j), \quad (8)$$

for all  $i \in \{H, L\}, j \in \{N, I\}$  and  $s \in \{E, U\}$ . Since the worker only commits a crime when the crime payoff is higher than the value of the current state, the reservation crime value determines her criminal behavior, i.e. whether to commit a crime or not. The endogenous reservation value is given as

$$\bar{g}_{s,i}^j = \pi(V_{s,i}^j - V_{P,i}^j) \quad (9)$$

for all  $i \in \{H, L\}, j \in \{N, I\}$  and  $s \in \{E, U\}$ . When the worker meets a victim with a value  $g$  that is strictly greater than the reservation crime value  $\bar{g}_{s,i}^j$ , she commits a crime.

## 2.2 Employment contract

The employment contract is necessary in this model. Risk-neutral firms and workers are only concerned about the division of the match surplus, so any forms of employment contract that can obtain the same division of the surplus should be adopted. The form of the employment contract only depends on the employees' behavior, such as on-the-job search and criminal behavior. The criminal behavior of employees generates inefficient job separations. Similar to models with on-the-job search, the criminal behavior of employees affects the duration of a job. Firms do not know if employees commit crimes or not. The standard Nash bargaining share rule is not able to provide a Pareto-efficient outcome, since they do not consider the asymmetric information of criminal behavior between workers and firms. This situation may shorten the duration of the job, and as a result firms suffer an additional capital loss. Therefore, the model needs a contract that can transfer this loss to employees. Similar to Stevens (2004), I assume that firms offer an employment contract with a hiring fee and a constant wage to their employees. In what follows I show that, as in Stevens (2004), this contract provides a Pareto-efficient outcome.

I assume that there is free entry of firms in the market for vacancies, which implies that  $\Pi_V = 0$ . The total surplus of a match is defined by

$$S_i^j = V_{E,i}^j - V_{U,i}^j + \Pi_{F,i}^j,$$

for type- $ij$  workers. From Equations (4) to (6), the total surplus can be rewritten as

$$rS_i^j = y_i - \tau - rV_{U,i}^j - \delta S_i^j + \mu \int_{\bar{g}_{E,i}^j}^{g^m} [g - \pi S_i^j + \pi(V_{P,i}^j - V_{U,i}^j)] dF(g).$$

Suppose that workers and firms decide the reservation crime value together. When workers and firms match with each other, the value of the match is  $V_{E,i}^j + \Pi_{F,i}^j$ . When the employee commits a crime and gets arrested, the value of a prisoner is  $V_{P,i}^j$  and the job

becomes vacant with value  $\Pi_V = 0$ . Firms do not have a monetary loss from workers' criminal activities explicitly, but they lose their employee and suffer the capital loss from this additional separation. Hence, the expected capital loss of a match caused by a criminal behavior is  $\pi(V_{P,i}^j - V_{E,i}^j - \Pi_{F,i}^j)$ . However, the opportunity cost of a match is higher than the one of employees. Employees do not consider the value of a filled job when they decide to commit a crime. Therefore, they commit more crimes than firms expect and the surplus cannot be maximized. The employment contract is determined by Nash Bargaining, with the bargaining power of workers given by  $\beta \in [0, 1]$ , i.e.

$$(w_i^j, \phi_i^j) = \underset{w_i^j, \phi_i^j}{\operatorname{argmax}} (V_{E,i}^j - V_{U,i}^j - \phi_i^j)^\beta (\Pi_{F,i}^j + \phi_i^j)^{1-\beta}. \quad (10)$$

**Lemma 1.** *The optimal employment contract that solves equation (10) satisfies*

$$\begin{aligned} w_i^j &= y_i, \\ \phi_i^j &= (1 - \beta)(V_{E,i}^j - V_{U,i}^j). \end{aligned}$$

The proofs of all lemmas and propositions are in appendix A. The intuition is the following. According to the optimal contract, the wage of workers equals to their productivity, which only depends on workers' skill. Since the firm pays the productivity as a wage to its employee and has no flow profit from the match, the hiring fee is the only revenue of the firm. The match surplus in this case becomes  $V_{E,i}^j - V_{U,i}^j$ . The worker and the firm share the surplus based on the worker's bargaining power  $\beta$  so that the optimal hiring fee equals to the firm's share of the match surplus. Since the hiring fee covers the firm's share of the surplus, the firm is not concerned about the inefficient separation that is caused by the worker's criminal activities. Firms transfer their risk of losing employees, which is caused by employees' criminal behavior, to workers implicitly.

This employment contract is analytically meaningful to achieve the Pareto-efficiency. However, quantitatively this employment contract does not affect the results significantly.

Appendix B shows the version of the model with the traditional Nash bargaining, similar to the standard Pissarides (2000) model.

### 3 Equilibrium

From equation (3) and  $\Pi_V = 0$ , the job creation condition (JC) is

$$\frac{k}{q(\theta)} = \mathbb{E}(\Pi_F + \phi). \quad (11)$$

In equilibrium, the average cost of posting a vacancy equals to the expected revenue of firms. The left hand side of equation (11) represents the average cost of a match. The job filling rate  $q(\theta)$  is defined as the ratio of matches to vacancies, i.e.  $q(\theta) \equiv M/V$ . Hence,

$$k/q(\theta) = kV/M. \quad (12)$$

The variable  $kV$  is the total cost of all vacancies in the labor market and  $M$  is the number of matches, so equation (12) represents the average cost of matches. The right hand side of equation (11) represents the expected revenue of a match. Given the zero profit condition of vacant and filled jobs ( $\Pi_V = 0, \Pi_{F,i}^j = 0$ ), the hiring fee is the only source of firms' revenue. Firms only know the distribution of unemployed workers before matching with any unemployed workers. Therefore, the expected hiring fee is a weighted average of hiring fee, i.e.  $\phi^e = \sum_i \sum_j (U_i^j/U) \phi_i^j$ . Using (5) and (6), the hiring fee of type- $ij$  is

$$\begin{aligned} \phi_i^j &= (1 - \beta)(V_{E,i}^j - V_{U,i}^j) \\ &= \frac{1 - \beta}{r + \delta + \beta\theta q(\theta)} \left[ y_i - B_i^j - \mu \int_{\bar{g}_{U,i}^j}^{\bar{g}_{E,i}^j} (1 - F(g)) dg \right]. \end{aligned} \quad (13)$$

Given equation (11) and lemma 1, the job creation condition is rewritten as

$$\begin{aligned} \frac{k}{q(\theta)} &= \phi^e \\ &= \frac{1 - \beta}{r + \delta + \beta\theta q(\theta)} \mathbb{E} \left[ y - B - \mu \int_{\bar{g}^U}^{\bar{g}^E} (1 - F(g)) dg \right]. \end{aligned} \quad (14)$$

The measure of type- $ij$  unemployed workers and total unemployed workers are given by workers' flows.

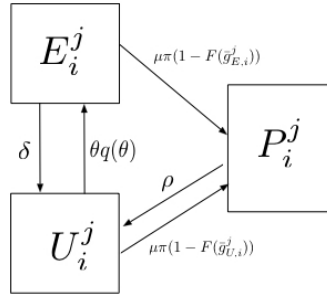


Figure 1: Worker flows

Figure 1 shows workers' flows. There are three states of workers: employed, unemployed and in prison. At steady state, the inflows of each pool equal to its outflows. Equation (15) captures that flows into and flows out of unemployment must be equal. The flows out of unemployment are unemployed individuals who get hired  $\theta q(\theta)U_i^j$ , and individuals who commit a crime and get arrested,  $\eta_{U,i}^j U_i^j$ . The variable  $\eta_{s,i}^j \equiv \pi\mu(1 - F(\bar{g}_{s,i}^j))$  represents the probability that a worker commits a crime and gets caught. The flows into unemployment correspond to employed individuals who lose their jobs  $\delta E_i^j$ , and individuals who are released from jail  $\rho P_i^j$ . Equation (16) represents the flows into and out of employment. Similarly, the flows into employment include individuals that get hired  $\theta q(\theta)U_i^j$ . The flows out of employment are given by employees that suffer a job separation shock  $\delta E_i^j$ , and by employed workers who commit crimes and get arrested  $\eta_{E,i}^j E_i^j$ . The population of type- $ij$  workers is

the sum of employed, unemployed workers and prisoners.

$$\delta E_i^j + \rho P_i^j = [\theta q(\theta) + \eta_{U,i}^j] U_i^j, \quad (15)$$

$$(\delta + \eta_{E,i}^j) E_i^j = \theta q(\theta) U_i^j, \quad (16)$$

$$\gamma = E_H^N + U_H^N + P_H^N, \quad (17)$$

$$1 - \gamma = E_L^N + U_L^N + P_L^N, \quad (18)$$

$$I_H = E_H^I + U_H^I + P_H^I, \quad (19)$$

$$I_L = E_L^I + U_L^I + P_L^I, \quad (20)$$

Using the above flow equations, the steady state measure of unemployment of each type of workers is following

$$U_H^N = \frac{\rho(\delta + \eta_{E,H}^N)\gamma}{\theta q(\theta)(\eta_{E,H}^N + \rho) + (\eta_{E,H}^N + \delta)(\eta_{U,H}^N + \rho)}, \quad (21)$$

$$U_L^N = \frac{\rho(\delta + \eta_{E,L}^N)(1 - \gamma)}{\theta q(\theta)(\eta_{E,L}^N + \rho) + (\eta_{E,L}^N + \delta)(\eta_{U,L}^N + \rho)}, \quad (22)$$

$$U_H^I = \frac{\rho(\delta + \eta_{E,H}^I)I_H}{\theta q(\theta)(\eta_{E,H}^I + \rho) + (\eta_{E,H}^I + \delta)(\eta_{U,H}^I + \rho)}, \quad (23)$$

$$U_L^I = \frac{\rho(\delta + \eta_{E,L}^I)I_L}{\theta q(\theta)(\eta_{E,L}^I + \rho) + (\eta_{E,L}^I + \delta)(\eta_{U,L}^I + \rho)}. \quad (24)$$

Before solving for the equilibrium, the formal definition of the steady state equilibrium is the following.

**Definition 1.** The steady state equilibrium is a set of variables,  $\{\theta, \bar{g}_{E,i}^j, \bar{g}_{U,i}^j, U_i^j, E_i^j, P_i^j, \tau\}$  for all  $i \in \{H, L\}$ ,  $j \in \{N, I\}$ , such that:  $\theta$  satisfies equation (14);  $\{U_i^j, E_i^j, P_i^j\}$  satisfy equations (15) – (20);  $\{\bar{g}_{E,i}^j, \bar{g}_{U,i}^j\}$  satisfy equation (9);  $\tau$  satisfies equation (2).

The equilibrium is recursively solvable. Equations (15) to (20) determine the distribution of workers given any  $\theta$ . The pair of reservation crime values of employed and unemployed workers  $\{\bar{g}_{E,i}^j, \bar{g}_{U,i}^j\}$  are solved jointly by equations (5) to (7) and (9). The expected revenue

of a match is determined by equations (5) and (6). Finally,  $\theta$  satisfies (14).

Figure 2 represents the equilibrium.<sup>7</sup> The equilibrium market tightness is determined by the equality of average recruitment cost, represented by the curve AC, and the expected hiring fee, represented by the curve HF, i.e. the equilibrium is the intersection of the AC and HF curves. With a higher market tightness, the firm needs to wait longer to hire a worker, so the average recruitment cost increases. Hence the AC curve is upward sloping. The slope of the curve HF depends on the workers' distribution and the match surplus. Unemployed workers get hired sooner when the market tightness increases. It increases the value of unemployed workers and shrinks the difference between employed and unemployed workers. As a result, the match surplus decreases with the market tightness. However, the effect on the workers' distribution is ambiguous. Given (21) to (24), the unemployment distribution depends on the market tightness. When the market tightness increases, the measure of unemployment of each type of workers decreases. So does the measure of total unemployment. Under a set of reasonable parameter values, the fraction of each type of unemployed workers  $U_i^j/U$  barely changes. Therefore, the effect of market tightness on the match surplus dominates. The hiring fee is a constant proportion to the match surplus so it decreases with the market tightness as well. The slope of the curve HF is downward sloping.

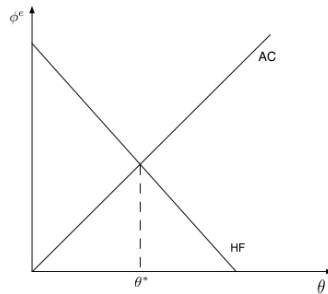


Figure 2: Equilibrium

**Lemma 2.** *The expected hiring fee  $\phi^e$  decreases with  $\theta$ .*

When  $\theta$  goes to zero, there are too many unemployed workers and no vacancy in the

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<sup>7</sup>The concavity of the curves does not affect the determination of the equilibrium. The AC and HF curves are drawn as straight lines for simplification.



labor market. The firm matches with a worker as soon as it posts a vacancy. Hence, the average recruitment cost goes to zero. When  $\theta = 0$ , the expected hiring fee is

$$\phi^e = (1 - \beta) \mathbb{E} \left[ \frac{y - B - \mu \int_{\bar{g}_{U,i}^j}^{\bar{g}_{E,i}^j} (1 - F(g)) dg}{r + \delta} \right]$$

If  $\phi^e > 0$  at  $\theta = 0$ , the curve AC and the curve HF have a unique intersection on  $(\theta, \phi^e)$  space and  $\theta > 0$  at the equilibrium.

**Proposition 1.** *An equilibrium with  $\theta > 0$  exists and is unique if  $\phi^e > 0$  when  $\theta = 0$ . In equilibrium,  $\bar{g}_{E,i}^j > \bar{g}_{U,i}^j$ .*

Proposition 1 also states that unemployed workers are more likely to commit a crime than employed workers in equilibrium. If  $\phi^e > 0$ , then  $V_{E,i}^j > V_{U,i}^j$ . Employed workers have a higher value than when they are unemployed. As a consequence, employed workers have a higher reservation crime value and are pickier than unemployed workers when both of them confront criminal opportunities.

## 4 Effects of Immigration

This section discusses the effects of an increase in the number of immigrants on labor market outcomes and crime rates.

### 4.1 Effects on the labor market

Skilled immigrants have a high productivity and a low unemployment utility flow so that their match surplus is the highest among four types of workers. Unskilled natives have a low productivity but a high unemployment utility so that their surplus is the lowest. Skilled natives have a high productivity and a high unemployment utility, so their surplus is lower than skilled immigrants but higher than unskilled natives. Unskilled immigrants have a low

productivity and a low unemployment utility therefore their surplus is higher than unskilled natives and is lower than skilled immigrants. However, the rank between skilled natives and unskilled immigrants is ambiguous since the difference between their productivity and unemployment utility depends on parameter values. If the unemployment utility of unskilled immigrants is low enough, the difference between the productivity and the unemployment utility of unskilled immigrants can be higher than skilled natives. The rank of hiring fees is the same as the rank of the surplus among all types of workers because the hiring fee is a constant fraction of the match surplus. Lemma 3 concludes the rank of the hiring fee among all types of workers.

**Lemma 3.** *The rank of hiring fee of each type of workers is:  $\phi_H^I > \phi_L^I > \phi_H^N > \phi_L^N$  if  $y_L - B_L^I > y_H - B_H^N$ .*

The expected hiring fee is a weighted average of the hiring fee of all types of workers. With an increase in skilled- $i$  immigrants, the weight of unemployed immigrants ( $U_i^I/U$ ) increases and the weight of unemployed natives ( $U_i^N/U$ ) decreases. Since skilled immigrants provide the greatest surplus among four types of workers, the expected hiring fee increases when the weight of unemployed skilled immigrants increases. When unskilled immigrants increases, however, the expected hiring fee may increase or decrease. Unskilled immigrants provide second highest surplus if the unemployment value of natives is too high, so the expected hiring fee may increase with the increasing share of unemployed unskilled immigrants. However, the share of skilled immigrants decreases with the increase in unskilled immigrants. Therefore, the expected hiring fee increases with unskilled immigrants, only when the surplus of unskilled immigrants is high enough. Figure 3 shows that an increase in the number of immigrants shifts the curve HF to the right and increases the market tightness.

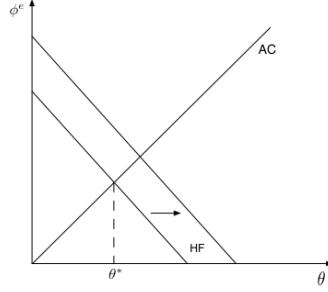


Figure 3: Effects of immigration on labor market

**Lemma 4.** *The expected hiring fee increases*

- i) if  $I_H$  increases;*
- ii) if  $I_L$  increases and  $\phi_L^I > \phi^e$ .*

Intuitively, immigrants have lower unemployment value than natives, so they pay a higher hiring fee than natives. Since the hiring fee is the only revenue of firms, a higher number of immigrants raises the expected revenue of firms, which encourages more firms to enter the labor market and post vacancies. The average cost of a match increases with the increase in the expected revenue, to balance the equality of equation (14) and move to the new equilibrium. Intuitively, firms are able to wait for a longer time to hire a worker with a higher expected revenue. Therefore, the market tightness goes up. Proposition 2 shows the effect of an increase in immigrants on the labor market tightness. According to lemma 3 and lemma 4, the labor market tightness increases with the number of immigrants.

**Proposition 2.** *In equilibrium, the market tightness increases if*

- i) the number of skilled immigrants  $I_H$  increases;*
- ii) the number of unskilled immigrants  $I_L$  increases and  $\phi_L > \phi^e$ .*

## 4.2 Effects on crime

The overall crime rate is a weighted average of crimes that are committed by each type of workers. Immigrants directly affect the workers' distribution. Among all types of workers, skilled immigrant employees are the ones who have the least incentives to commit crimes,

while unskilled unemployed immigrants are the ones who are the most likely to commit a crime. When the number of skilled immigrants increases, the fraction of skilled employed and unemployed immigrants increases, and the fraction of other types of workers decreases. Since skilled immigrants are less likely to commit a crime than other groups of workers, the overall crime rate decreases when there are more skilled immigrants in the labor force. However, the overall crime rate increases when the economy has more unskilled immigrants, who are more likely to commit a crime than others. Spenkuch (2014) and Bell et al. (2013) provide evidence that the crime rate increases with an increase of immigrants from poor countries and educational background. Proposition 3 summarizes the composition effect.

**Proposition 3.** *For a given market tightness  $\theta$ , the overall crime rate increases*

- i) if the number of skilled immigrants  $I_H$  decreases;*
- ii) if the number of unskilled immigrants  $I_L$  increases.*

The other effect comes from the labor market tightness. As shown in (5) to (7) and (9), the reservation crime value depends on the labor market tightness. When the market tightness goes up, unemployed workers are able to get hired quickly. The value of unemployed workers goes up so unemployed workers prefer to stay unemployed and wait for their jobs, instead of committing a crime. The reservation crime value of unemployed workers falls with the market tightness.

When the market tightness increases, the increase in unemployment value shrinks the employment premium and the value of employment goes down. Employed workers eventually end up being unemployed because they either lose their jobs or they are released from prison. The transition rate from employment to unemployment is  $\delta$  and the transition rate from prison to unemployment is  $\rho$ . If the incarceration duration is shorter than the duration of a job, which means  $\rho > \delta$ , and the value of unemployment increases, the value of workers in jail goes up. Therefore, The opportunity cost of committing a crime for employed workers drops and employed workers have more incentives to commit a crime.

**Lemma 5.** *If the market tightness  $\theta$  increases,*

- i)  $\bar{g}_{U,i}^j$  increases;
- ii)  $\bar{g}_{E,i}^j$  decreases if  $\rho > \delta$ .

Immigrants cannot directly affect the criminal behavior of workers, but their impact in the labor market implicitly affects to workers' reservation crime value. According to the effect of immigration on labor market outcomes, the market tightness increases with immigrants. Therefore, the reservation crime value of unemployed workers increases and the one for employed workers decreases when the number of immigrants rises. Proposition 4 and Proposition 5 conclude the effect of immigration on the reservation crime value.

**Proposition 4.** *If the number of skilled immigrants  $I_H$  increases,*

- i)  $\bar{g}_{U,i}^j$  increases;
- ii)  $\bar{g}_{E,i}^j$  decreases if  $\rho > \delta$ .

**Proposition 5.** *If the number of unskilled immigrant  $I_L$  increases and  $\phi_L > \phi^e$ ,*

- i)  $\bar{g}_{U,i}^j$  increases;
- ii)  $\bar{g}_{E,i}^j$  decreases if  $\rho > \delta$ .

According to the composition and criminal behavior effect, the effect of immigration on the overall crime rate is ambiguous analytically. This is consistent with the ambiguity found in empirical studies of the effects of immigration on crime.

## 5 Calibration

I calibrate the parameter values of the model using US data from 1990 to 1999. All the parameters are interpreted annually. As in Krusell et al. (2000), I define skilled workers as the ones who have at least a college degree, and unskilled workers as the ones without any college degree. Using the empirical findings in Chassamboulli and Palivos (2014), in the 1990s the measure of skilled immigrants  $I_H$  is 0.036 and the measure of unskilled immigrants  $I_L$  is 0.089. The measure of skilled native workers  $\gamma$  is 0.274. The total native population is

normalized to 1. The productivity of skilled workers  $y_H$  is also normalized to 1. Relative productivity of unskilled workers to skilled workers  $y_L$  is 0.62, which targets the wage premium between workers with college degrees and without college degrees. Based on the estimation in Petrongolo and Pissarides (2001), I assume the matching function is  $m(V, U) = AU^\alpha V^{1-\alpha}$  and  $\alpha$  to be 0.5. The bargaining power of workers  $\beta$  is 0.5, satisfying Hosios (1990) condition. The average annual job finding rate and job separation rate are 5.4 and 0.408 respectively, which are drawn from Shimer (2005). The equilibrium market tightness  $\theta$  and the constant recruitment cost  $k$  can be determined using (14) with a given job finding rate. The market tightness is normalized to 1 without loss of generality, thus the calibration of the matching efficiency  $A$  equals to 5.4 and the constant recruitment cost  $k$  is 0.5288.

Since the optimal employment contract requires that the wage equals to the productivity of workers, the implied wage can be recovered using

$$\tilde{w}_i^j = y_i - (r + s + \pi\mu(1 - F(\bar{g}_{E,i}^j)))\phi_i^j. \quad (25)$$

The implied wage is the difference between the productivity of workers and the flow hiring fee, which is the second term of (25). The one-time hiring fee can be considered as the present discounted value of a flow hiring fee at each point of time with the discount rate  $r + s + \pi\mu(1 - F(\bar{g}_{E,i}^j))$  during the time of employment. Given (25), the implied wage of skilled native workers is 0.9523 and the one of unskilled natives is 0.5923. Shimer (2005) estimates that the replacement ratio of unemployment and employment income is 0.4. The unemployment utility of skilled natives and unskilled natives are 0.3821 and 0.2369 respectively. Following the estimation of Chassamboulli and Palivos (2014), the wage gap between skilled natives and immigrants is -18.8%, and the wage gap between unskilled natives and immigrants is -19%. Thus the unemployment utility of skilled and unskilled immigrants are -1.7072 and -1.0693 respectively.

I normalize all dollar figures in the data by the annualized earning of workers over 25 years

old with a bachelor degree and above in the CPS from 1990 to 1999, which is \$33708.16. In the crime sector, the overall property crime rate targets the average property crime rate from 1990 to 1999, which is 45.11 criminal offenses per 1000 population from the Uniform Crime Report (UCR). I assume that the crime value follows an exponential distribution.<sup>8</sup> The average property loss per offense is approximately \$1,318.8 so the mean of the exponential distribution is  $g^e = \$1,318.8/\$33,708.6 = 0.0391$ , which targets the average property loss per offense and is normalized by the wage. The Poisson rate of meeting a crime opportunity  $\mu$  targets the crime rate, and equals to 0.0704. Since the loss of crime is a wealth transfer from victims to criminals, I set the expected loss  $\tau$  equal to the mean of crime value. The probability of getting caught is a ratio of the number of people that are sent to jail to the total number of offenses, which is 0.019 following Engelhardt et al. (2008). The mean length of incarceration of property crimes was 16 months in 2002, which is also from Engelhardt et al. (2008). Hence the rate of being released is  $\rho = 0.75$ . Because of lack of information on the utility flow in jail, I normalize this utility flow to  $x = 0$ . The calibration is summarized in Table 1.

## 6 Effects of Immigration: A Numerical Exercise

This section studies the quantitative impact of the immigration waves from 2000 to 2009. Using the findings in Chassamboulli and Palivos (2014), the skilled and unskilled immigrants increased by 0.026 and 0.051 respectively in the 2000s. The simulation results are presented in table 2. Since the productivity in the model is constant and I only focus on the long run equilibrium, I detrend the hourly real wage in the U.S. labor market.<sup>9</sup> The de-trended wage increases 0.6% from the 1990s to the 2000s.<sup>10</sup> The unemployment rate decreases by

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<sup>8</sup>According to the UCR in 2004, the distribution of property crime value has similar shape as an exponential distribution.

<sup>9</sup>The data is from Federal Reserve Bank in St. Louis, from 1990 to 2010, hourly real wages in the U.S.

<sup>10</sup>The hourly wages is highly related to the productivity. Since the productivity in the model is constant, the wages are detrended by the growth of productivity.

0.64 percentage points in the same period.<sup>11</sup> The model predicts that the implied wage of natives increases by 0.29 percentage points with the wave of immigrants. Since immigrants create jobs for both of natives and immigrants, the overall unemployment rate decreases by 0.47 percentage points. Compared with the data and the model predictions, it shows that immigration can partially explain the decrease in unemployment rate and the increase in wages in the 2000s.

Without effects from the labor market, the increase in immigrants in the 2000s decrease the overall crime rate by 0.164 per 1000 population. Table 3 reports the crime rate of each type of workers in the 1990s respectively. Compared to skilled and unskilled immigrants, skilled immigrants have lower incentives to commit a crime than unskilled immigrants. Unemployed skilled immigrants are more willing to commit a crime than employed skilled and unemployed natives, but are less likely to commit a crime than other types of workers. Unemployed unskilled immigrants have the lowest value in the legal sector, and as a result they are the most likely to commit a crime. Employed unskilled immigrants have a higher reservation crime value than unskilled natives and unskilled unemployed immigrants, but lower than other types of workers. If there is a wave of skilled immigrants only, the overall crime rate drops by 0.213 per 1000 population and increases by 0.04 when there is a wave of unskilled immigrants only.

Immigrants also affect the criminal behavior of workers through the labor market. According to propositions 4 and 5, employed workers commit more crimes because jobs become less valuable with an increasing labor market tightness. The opportunity cost of committing a crime for employed workers goes down. Therefore, employed workers have more incentives to commit crimes. Meanwhile, unemployed workers commit fewer crimes. Unemployed workers are hired faster with an increasing labor market tightness. From the 1990s to the 2000s, the model predicts that the crime rate of employed workers increases by 0.46% and the fraction of prisoners who had a job before being arrested increases by 0.46%, while the

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<sup>11</sup>The data estimation is from the CPS, 1990 to 2010, and considers the unemployment rate for workers 16 years and over.



crime rate of unemployed workers and the fraction of prisoners who did not have a job before being arrested decrease. The Survey of Inmates in State and Federal Correctional Facilities in 1997 and 2004 show that the fraction of inmates who had a job before arrested increases 6.06%, while the fraction of inmates who did not have a job before arrested decreases. This survey data supports the model's prediction on the change in criminal behavior of employed and unemployed workers when the number of immigrants increases. The overall crime rate increases by 0.088 when only the criminal behavior of workers changes. Combining with the composition and criminal behavior effect, the overall crime rate decreases by 0.164 per 1000 population, which is equivalent to 48,346.69 nation-wide criminal offenses.<sup>12</sup>

Columns 4 and 5 of Table 2 report the results only with an increase in skilled immigrants. Columns 6 and 7 of table 2 report the results only with an increase in unskilled immigrants. Even though the increase in skilled immigrants is smaller than that in unskilled immigrants, the increase in skilled immigrants has a larger impact than unskilled immigrants. When the economy has more skilled immigrants only, the market tightness increases by 8.25%, which lowers the unemployment rate by 0.25 percentage points and increases wages by 0.16%. When there are more unskilled immigrants, the impacts on labor market outcomes are slightly smaller than those with an increase in skilled immigrants. These results show that i) immigrants do not take over jobs from natives, instead, they create jobs; ii) skilled immigrants provide more surplus to firms than unskilled immigrants.

In the crime sector, the model predicts the overall crime rate decreases by 0.213 (-0.04) offenses per 1000 population with an increase in skilled (unskilled) immigrants. Compared to skilled immigrants, unskilled immigrants are more likely to commit crimes since they have a lower reservation crime value than skilled immigrants. Bell et al. (2013) and Spenkuch (2014) provide empirical evidence that the crime rate in the host country increases with immigrants from less developed countries and decreases with the immigrants from more developed countries.

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<sup>12</sup>The average population in the 2000s in the U.S. is 294,796,911. The estimated number of total criminal offenses is 13,295,340.69.

## 7 Discussion: Policies

This section discusses three policies: an increase in unemployment income; an increase in the duration of incarceration; and a deportation policy.

### 7.1 Unemployment value

Machin and Marie (2006) and Fougère et al. (2009) document that unemployment benefits affect workers' criminal behavior. Because the measure of unemployment value is the only difference between natives and immigrants, I introduce a more generous unemployment insurance system for immigrants. This unemployment insurance system increases the unemployment income of immigrants and makes the flow of the unemployment utility of immigrants equal to natives.

**Proposition 6.** *For all  $i \in \{H, L\}$  and  $j \in \{N, I\}$ , and  $i' \neq i$ , an increase in  $B_i^I$  has the following effects:*

- i)  $\theta$  decreases;*
- ii)  $\bar{g}_{E,i}^N$  and  $\bar{g}_{E,i'}^I$  increases if  $\rho > \delta$ ;*
- iii)  $\bar{g}_{U,i}^N$  and  $\bar{g}_{U,i'}^I$  decreases;*
- iv)  $\bar{g}_{E,i}^I$  decreases;*
- v)  $\bar{g}_{U,i}^I$  increases.*

With this unemployment insurance system, now natives and immigrants are the same in the model. The increasing unemployment utility flow raises immigrants' unemployment value. The employment premium of immigrants declines, and lowers the expected revenue of firms. As a result, fewer firms enter the market and post vacancies. Since the unemployment value of immigrants goes up, immigrants are more patient and wait to find a job. More unemployed workers and fewer vacancies lower the labor market tightness in the equilibrium.

Quantitatively, the market tightness decreases by 29.5 percentage points and increases the unemployment rate of skilled and unskilled natives by 1.23 with this more generous

unemployment insurance system. Because of the drop in the market tightness, the natives' implied wage decreases by 0.7 percentage points. The crime rate increases by 0.26 per 1000 population due to the mixed effects on different types of workers. With a less tight labor market, native employees have high employment value and care about their jobs. Their opportunity cost of committing a crime becomes higher, so they raise their reservation crime value and commit fewer crimes. The crime rate of employed skilled and unskilled natives drop by 1.11 and 0.77 respectively. Unemployed native workers have to wait for a longer time to find a job with a lower labor market tightness. The native unemployment value and the reservation crime value of unemployed natives decline. Therefore, criminal offenses that are committed by unemployed natives increase. The crime rate of skilled and unskilled unemployed natives increase by 0.43 and 0.26 respectively.

Unemployed immigrants enjoy a higher unemployment utility, even though it is hard for them to get hired with a low market tightness. They prefer to stay unemployed rather than to commit crimes. The number of crimes that are committed by unemployed immigrants decreases. As a result, the crime rate of unemployed skilled (unskilled) immigrants decreases by 9.81 (5.68). Employed immigrants, by contrast, commit more crimes. More generous social security system narrows the difference between employed and unemployed immigrants' value even though the market tightness decreases. Employed immigrants have a lower employment premium, so their opportunity cost of committing a crime drops. Therefore, the crime rate of skilled (unskilled) employed immigrants increases by 16.16 (13.67).

When only skilled immigrants' unemployment utility increases, the criminal behavior of unskilled immigrants is only affected by the market tightness. Hence, the crime rate of employed (unemployed) unskilled immigrants decreases (increases) by 1.17 (0.61). The crime rate of skilled employed immigrants increase by 16.82 while the crime rate of skilled unemployed immigrants decreases by 10.07. When only the unskilled immigrants have higher utility flow of unemployment, the criminal behavior of skilled immigrants changes in a similar way. The results are summarized in Table 4.

## 7.2 More severe jail sentences

The average duration of a jail penalty for property crimes is 16 months, which gives an exit rate of  $\rho = 0.75$ . I extend the jail sentence to 32 months and to 48 months, which implies an exit rate  $\rho$  of 0.375 and 0.25 respectively. Table 5 reports the policy effects on labor market outcomes and crime rates.

**Proposition 7.** *With a decrease in  $\rho$ ,*

- i)  $\theta$  increases;*
- ii)  $\bar{g}_{E,i}^j$  and  $\bar{g}_{U,i}^j$  increase.*

A longer jail duration directly lowers prisoners' value. A worker needs to give up more value in the legal sector when he wants to commit a crime. With a longer duration of incarceration, many criminal opportunities cannot provide a sufficiently high value to cover worker's opportunity cost. Therefore fewer workers get involved in criminal activities.

When the reservation crime value increases, workers' value of their illegal outside option decreases. The value in the legal sector goes up and it results in an increase in the match surplus. There are fewer unemployed workers in the market when the jail duration is longer. Criminals have to stay in jail longer, so fewer criminals return back to the labor market. Also, employed workers commit fewer crimes, which lowers the transition rate from employed to unemployed through a criminal activity. When there are fewer unemployed workers in the market, the number of vacancies per unemployed workers increases. Since this incarceration policy affects the criminal behavior of all workers, the workers' distribution barely changes. Therefore, it shifts the curve HF to the right and increases the market tightness in equilibrium.

Quantitatively, there is no significant effect of more severe sentences on labor market outcomes, but this policy reduces crime rates significantly. With the extended custody to 32 months and to 48 months, the overall crime rate decreases by 12.07 and 19.95 per 1000 population.

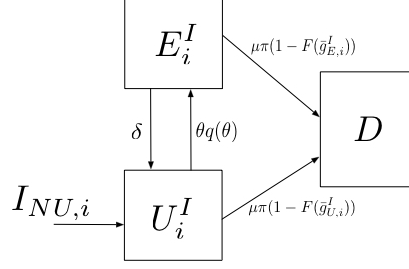


Figure 4: Immigrant flows

### 7.3 Deportation

Under a deportation policy, immigrants who commit a crime and get arrested are sent back to their countries of origin. As the assumption in this model, immigrants are from some countries with worse labor markets than in the host country. Deportation increases the opportunity cost of committing a crime for immigrants, so the reservation crime value of immigrants rises.

I assume that the value of being deported is proportional to the value in prison, i.e. for all  $i \in \{H, L\}$ ,

$$V_{D,i}^I = aV_{P,i}^I,$$

where the variable  $a \in [0, 1)$  is the proportion coefficient. Therefore, the criminal activity payoff of immigrants is  $K_i^I = g + V_{s,i}^I + \pi(V_{D,i}^I - V_{s,i}^I)$  and the reservation value of crime is

$$\begin{aligned} \bar{g}_{s,i}^I &= \pi(V_{s,i}^I - V_{D,i}^I) = \pi(V_{s,i}^I - aV_{P,i}^I). \\ &> \pi(V_{s,i}^I - V_{P,i}^j) \end{aligned} \tag{26}$$

which is higher than the one without deportation.

Since deportation policy reduces the measure of immigrants over time, newly arriving immigrants enter the host country to ensure a steady state distribution with immigrants. All newcomers are unemployed. In steady state, the immigrant flows are given by

$$\begin{aligned}
(\theta q(\theta) + \eta_{U,i}^I)U_i^I &= I_{N,i} + \delta E_i^I \\
(\delta + \eta_{E,i}^I)E_i^I &= \theta q(\theta)U_i^I \\
U_i^I + E_i^I &= I_i
\end{aligned}$$

for all  $i \in \{H, L\}$ , where  $I_{N,i}$  is the measure of newly arriving immigrants. Therefore, the measure of newcomers is

$$I_{N,i} = \frac{I_i[\theta q(\theta)\eta_{E,i}^I + \delta\eta_{U,i}^I + \eta_{E,i}^I\eta_{U,i}^I]}{\theta q(\theta) + \eta_{E,i}^I + \delta}$$

and the measure of unemployed immigrants is

$$U_i^I = \frac{I_i(\delta + \eta_{E,i}^I)}{\theta q(\theta) + \eta_{E,i}^I + \delta}.$$

**Proposition 8.** *With the deportation policy,*

- i)  $\theta$  increases;*
- ii)  $\bar{g}_{s,i}^I$  increases;*
- iii)  $\bar{g}_{U,i}^N$  increases and  $\bar{g}_{E,i}^N$  decreases if  $\rho > \delta$ .*

Deportation policy is aimed at the criminal behavior of immigrants. It increases the cost of committing a crime for immigrants only. Similar to section 7.2, the reservation crime value of immigrants increases so that the immigrants' value of the illegal outside option decreases. The value of legal sector goes up and the match surplus of immigrants increases with deportation. Second, with deportation, there are more unemployed immigrants in the labor market than without deportation. There are two flows into the immigrant unemployment without deportation: employed workers who lose their jobs and prisoners who are released from jail. Only a proportion  $\rho$  to total prisoners are released from jail and return to the labor market as unemployed workers. With deportation, there are also two flows into the immigrant unemployment: employed workers who lose their jobs and newly arrived immigrants. The

flows out of immigrant unemployment are the same with and without deportation. At the steady state, the number of newly arriving immigrants equals to the number of immigrants being deported. If the reservation crime value of immigrants is unchanged, the number of newcomers is larger than the number of immigrants that are released from jail if  $\rho < 1$ . Therefore, the number of unemployed immigrants increases with deportation and the share of unemployed immigrants goes up. Therefore, the labor market tightness increases when the deportation policy is imposed.

There is not enough information to measure the deportation value of immigrants, so I set  $a = 0.1, 0.5$  and  $0.9$  to represent three levels of immigrants' original countries. If an immigrant comes from a country that has similar labor market conditions as the host country or she can re-enter the host country easily, then the coefficient  $a = 0.9$ . If an immigrant comes from a country with a worse labor market (such as a market with a high separation rate, a low market tightness or low wages) than the host country, the coefficient  $a$  becomes  $0.1$ . Table 6 shows the effects of deportation on labor market outcomes and the crime rates. The effect of deportation on the workers' distribution is limited. When the reservation crime value of immigrants goes up with the deportation, the share of unemployed immigrant converges to the one without deportation. The increase in the match surplus by the deportation policy is also small. Therefore, the market tightness increases at a small margin when the deportation policy is imposed. The reservation crime value of native workers only depends on the labor market tightness in this case, so the effect of deportation on the criminal behavior of native workers is not significant. Comparing the case of immigrants from more developed countries ( $a = 0.9$ ) to the case of less developed countries ( $a = 0.1$ ), the effect on the market tightness is almost the same, but the effect on the criminal behavior of immigrants from different countries is various. The crime rate decreases more when the coefficient  $a$  is smaller. When immigrants come from less developed countries, they pay a higher opportunity cost if they commit a crime. Fewer of these immigrants commit crimes under the deportation policy. Thus, for immigrants from a country with a similar labor market condition as the host

country, the crime rate decreases by 1.42 per 1000 population. In the case of immigrants that are from a country that has worse labor market condition than the host country, the deportation policy decreases the overall crime rate by 3.87 ( $a = 0.5$ ) and 4.45 ( $a = 0.1$ ).

## 8 Conclusion

This paper studies the impact of immigration on labor market outcomes and crime jointly. A wave of immigrants encourages firms to create more jobs since it lowers firms' labor cost. The unemployment rate of native decreases and the wage of native workers increases with this wave of immigrants. Immigration affects workers' criminal behavior by changing workers' distribution and raising the labor market tightness. Compared to skilled immigrants, unskilled immigrants are more likely commit crimes because of their poor outside option. Therefore the overall crime rate decreases with an increase in skilled immigrants but increases with an increase in unskilled immigrants. Immigration also affects the criminal behavior of workers by raising the labor market tightness. More employed workers commit a crime if the incarceration duration is shorter than the employment duration. Unemployed workers prefer to wait for their job rather than to commit crimes with this increase in the labor market tightness. Therefore, the effect of immigration on the overall crime rate is ambiguous.

Quantitatively, with the increase in skilled immigrants and in unskilled immigrants observed in the 2000s, the unemployment rate decreases by 0.47 and the crime rate decreases by 0.164 per 1000 population. The model also discusses policy effects. With a more generous unemployment insurance system to immigrants, the unemployment rate and the crime rate increase and the wage of native workers decreases. A longer prison duration and deportation lower the crime rate by increasing the opportunity cost of committing a crime. The former affects the criminal behavior of both native and immigrant workers, but the latter only affects the criminal behavior of immigrants. Thus the magnitude of the effect of incarceration is larger than the deportation policy.



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## A Proofs of Lemmas and Propositions

### Proof of Lemma 1

*Proof.* According to the Nash bargaining, the surplus must be maximized by the optimal employment contract. Compared with the expected capital loss of a match,  $\pi(\Pi_{F,i}^j + V_{E,i}^j - V_{P,i}^j)$ , and the employees' opportunity cost of committing a crime,  $\pi(V_{E,i}^j - V_{P,i}^j)$ , the surplus is maximized iff when  $\Pi_{F,i}^j = 0$ . According to equation (4), the value of a filled job is

$$\Pi_{F,i}^j = \frac{y_i - w_i^j}{r + \delta + \pi\mu(1 - F(\bar{g}_{E,i}^j))}.$$

Therefore,  $\Pi_{F,i}^j = 0$  requires

$$w_i^j = y_i.$$

Solve equation (10),

$$\phi_i^j = (1 - \beta)(V_{E,i}^j - V_{U,i}^j).$$

□

## Proof of Lemma 2

*Proof.* According to equation (14), take the first order derivatives of  $\phi^e$ ,

$$\begin{aligned} \frac{\partial \phi^e}{\partial \theta} &= (1 - \beta) \sum_i \sum_j \left[ \frac{\partial(U_i^j/U)}{\partial \theta} (V_{E,i}^j - V_{U,i}^j) + \frac{U_i^j}{U} \frac{\partial(V_{E,i}^j - V_{U,i}^j)}{\partial \theta} \right] \\ &= (1 - \beta) \sum_i \sum_j \left[ \frac{U(\partial U_i^j / \partial \theta) - U_i^j(\partial U / \partial \theta)}{U^2} (V_{E,i}^j - V_{U,i}^j) \right. \\ &\quad \left. + \frac{U_i^j}{U} \frac{\partial(V_{E,i}^j - V_{U,i}^j)}{\partial \theta} \right]. \end{aligned}$$

According to a set of reasonable parameter value,

$$\frac{U(\partial U_i^j / \partial \theta) - U_i^j(\partial U / \partial \theta)}{U^2} \rightarrow 0.$$

Therefore,

$$\frac{\partial \phi^e}{\partial \theta} \rightarrow (1 - \beta) \sum_i \sum_j \frac{U_i^j}{U} \frac{\partial(V_{E,i}^j - V_{U,i}^j)}{\partial \theta}.$$

The first order partial derivatives of  $(V_{E,i}^j - V_{U,i}^j)$  is

$$\begin{aligned} \frac{\partial(V_{E,i}^j - V_{U,i}^j)}{\partial \theta} &= -(V_{E,i}^j - V_{U,i}^j) \frac{\beta[\partial(\theta q(\theta))/\partial \theta]}{r + \delta + \beta \theta q(\theta)} \\ &< 0 \end{aligned}$$

as  $\partial(\theta q(\theta))/\partial \theta > 0$ . Thus,  $\partial \phi^e / \partial \theta < 0$ .

□

## Proof of Proposition 1

*Proof.* At  $\theta = 0$ ,

$$\frac{k}{q(\theta)} = 0.$$

If

$$\begin{aligned} \phi^e &= (1 - \beta) \mathbb{E} \frac{y - B - \mu \int_{\bar{g}_{U,i}^j}^{\bar{g}_{E,i}^j} (1 - F(g)) dg}{r + \delta} \\ &> 0, \end{aligned}$$

at  $\theta = 0$ ,  $k/q(\theta) < \phi^e$ . According to lemma 2 and  $\partial[k/q(\theta)]/\partial\theta > 0$ , there exists a unique  $\theta$  that  $k/q(\theta) = \phi^e$  and  $\theta > 0$ .

Since  $y_i > B_i^j$  for all  $i \in \{H, L\}$  and  $j \in \{N, I\}$ ,  $V_{E,i}^j - V_{U,i}^j > 0$ . According to (9),

$$\begin{aligned} \bar{g}_{E,i}^j - \bar{g}_{U,i}^j &= \pi(V_{E,i}^j - V_{U,i}^j) \\ &> 0. \end{aligned}$$

Thus,  $\bar{g}_{E,i}^j > \bar{g}_{U,i}^j$  at any equilibrium. □

## Proof of Lemma 3

*Proof.* Equation (13) gives the hiring fee of type- $ij$  workers. It is obvious that

$$\begin{aligned} \phi_H^I - \phi_H^N &= \frac{1 - \beta}{r + \delta + \beta\theta q(\theta)} (B_H^N - B_H^I + \mu \int_{\bar{g}_{U,H}^N}^{\bar{g}_{E,H}^N} (1 - F(g)) dg + \mu \int_{\bar{g}_{E,H}^I}^{\bar{g}_{U,H}^I} (1 - F(g)) dg) \\ &> 0 \end{aligned}$$

as  $B_H^N > B_H^I$  and  $\mu(\int_{\bar{g}_{U,H}^N}^{\bar{g}_{E,H}^N} (1-F(g))dg + \int_{\bar{g}_{E,H}^I}^{\bar{g}_{U,H}^I} (1-F(g))dg)$  is quantitatively small. Therefore,  $\phi_H^I > \phi_H^N$ . Similarly,  $\phi_L^I > \phi_L^N$ . To compare  $\phi_H^I$  and  $\phi_L^I$ , I have

$$\begin{aligned} \phi_H^I - \phi_L^I &= \frac{1-\beta}{r+\delta+\beta\theta q(\theta)} (y_H - y_L - \mu(\int_{\bar{g}_{U,H}^I}^{\bar{g}_{E,H}^I} (1-F(g))dg - \int_{\bar{g}_{E,L}^I}^{\bar{g}_{U,L}^I} (1-F(g))dg)) \\ &> 0. \end{aligned}$$

Therefore,  $\phi_H^I > \phi_L^I$  and similarly  $\phi_H^N > \phi_L^N$ . However, when comparing  $\phi_L^I$  and  $\phi_H^N$ ,

$$\begin{aligned} \phi_L^I - \phi_H^N &= \\ &\frac{1-\beta}{r+\delta+\beta\theta q(\theta)} (y_L - B_L^I - (y_H - B_H^N) - \mu(\int_{\bar{g}_{U,L}^I}^{\bar{g}_{E,L}^I} (1-F(g))dg - \int_{\bar{g}_{E,H}^N}^{\bar{g}_{U,H}^N} (1-F(g))dg)). \end{aligned}$$

Since  $y_L < y_H$  and  $B_L^I < B_H^N$ , the relationship between  $\phi_L^I$  and  $\phi_H^N$  depends on the difference between their productivity and unemployment flow value. If  $y_L - B_L^I > y_H - B_H^N$ ,  $\phi_L^I > \phi_H^N$ .  $\square$

## Proof of Lemma 4

*Proof.* The partial derivatives of the fraction of unemployed immigrants with respect to  $I_H$  and  $I_L$  are

$$\frac{\partial(U_H^I/U)}{\partial I_H} = \frac{\partial(U_H^I/U)}{\partial U_H^I} \frac{\partial U_H^I}{\partial I_H}$$

and

$$\frac{\partial(U_L^I/U)}{\partial I_L} = \frac{\partial(U_L^I/U)}{\partial U_L^I} \frac{\partial U_L^I}{\partial I_L}.$$

Take the first order derivatives of (23) and (24) with respect to  $I_H$  and  $I_L$  respectively, then

$$\begin{aligned} \frac{\partial U_H^I}{\partial I_H} &= \frac{\rho(\delta + \eta_{E,H}^I)}{\theta q(\theta)(\rho + \eta_{E,H}^I) + (\delta + \eta_{E,H}^I)(\rho + \eta_{U,H}^I)} \\ &> 0, \end{aligned}$$

and

$$\begin{aligned}\frac{\partial U_L^I}{\partial I_L} &= \frac{\rho(\delta + \eta_{E,L}^I)}{\theta q(\theta)(\rho + \eta_{E,L}^I) + (\delta + \eta_{E,L}^I)(\rho + \eta_{U,L}^I)} \\ &> 0.\end{aligned}$$

Since  $U = \sum_i \sum_j U_i^j$ ,

$$\begin{aligned}\frac{\partial(U_H^I/U)}{\partial U_H^I} &= \frac{U - U_H^I}{U^2} \\ &> 0\end{aligned}$$

and

$$\begin{aligned}\frac{\partial(U_L^I/U)}{\partial U_L^I} &= \frac{U - U_L^I}{U^2} \\ &> 0.\end{aligned}$$

Therefore,  $\partial(U_H^I/U)/\partial I_H > 0$  and  $\partial(U_L^I/U)/\partial I_L > 0$ . When  $I_H$  or  $I_L$  increases, the fraction of unemployed skilled or unskilled immigrants increases.

According to lemma 3, the hiring fee of skilled immigrants is the highest among all types of workers. When the fraction of skilled unemployed immigrants increases, the expected hiring fee increases. However, when the number of unskilled immigrants increases, it lowers the fraction of skilled immigrant and may decrease the expected hiring fee. The partial derivatives of the expected hiring fee with respect to  $I_L$  is

$$\begin{aligned}\frac{\partial \phi^e}{\partial I_L} &= (1 - \beta) \frac{\partial}{\partial I_L} \left( \sum_i \sum_j \frac{U_i^j}{U} (V_{E,i}^j - V_{U,i}^j) \right) \\ &= \frac{(1 - \beta)}{U^2} \left[ \frac{\partial U_L^I}{\partial I_L} (V_{E,L}^I - V_{U,L}^I) U - \frac{\partial U_L^I}{\partial I_L} \sum_i \sum_j U_i^j (V_{E,i}^j - V_{U,i}^j) \right] \\ &= \frac{1}{U} \frac{\partial U_L^I}{\partial I_L} (\phi_L^I - \phi^e).\end{aligned}$$

Since  $\partial U_L^I / \partial I_L > 0$ ,  $\partial \phi^e / \partial I_L > 0$  if  $\phi_L^I > \phi^e$ . □

## Proof of Proposition 2

*Proof.* According to the proof of lemma 3 and 4, Proposition 2 is proved. □

## Proof of Proposition 3

*Proof.* According to equation (9), the reservation value of employed and unemployed workers are

$$\begin{aligned}\bar{g}_{E,i}^j &= \pi(V_{E,i}^j - V_{P,i}^j) \\ \bar{g}_{U,i}^j &= \pi(V_{U,i}^j - V_{P,i}^j).\end{aligned}$$

Since  $y_H > y_L$  and  $B^N > B^I$ , it is obvious that employed skilled immigrants have highest reservation crime value and unemployed unskilled immigrants most likely commit crimes. It is straight forward to show that the overall crime rate decreases with skilled immigrants and increases with unskilled immigrants. □

## Proof of Lemma 5

*Proof.* According to equations (5), (6) and (9), the reservation crime value of employed and unemployed workers can be written as

$$\bar{g}_{E,i}^j = \frac{\pi}{r + \rho}(y_i + (\rho - \delta)(V_{E,i}^j - V_{U,i}^j) + \mu \int_{\bar{g}_{E,i}^j}^{g^m} 1 - F(g)dg - x). \quad (27)$$

and

$$\bar{g}_{U,i}^j = \frac{\pi}{r + \rho}(B_i^j + \theta q(\theta)(V_{E,i}^j - V_{U,i}^j) + \mu \int_{\bar{g}_{U,i}^j}^{g^m} 1 - F(g)dg - x). \quad (28)$$



Take the first order derivatives of  $\bar{g}_{E,i}^j$  and  $\bar{g}_{U,i}^j$  with respect to  $\theta$ ,

$$\left(1 + \frac{\pi\mu}{r+\rho}(1 - F(\bar{g}_{E,i}^j))\right) \frac{\partial \bar{g}_{E,i}^j}{\partial \theta} = \frac{\pi(\rho - \delta)}{r+\rho} \frac{\partial(V_{E,i}^j - V_{U,i}^j)}{\partial \theta}$$

and

$$\left(1 + \frac{\pi\mu}{r+\rho}(1 - F(\bar{g}_{U,i}^j))\right) \frac{\partial \bar{g}_{U,i}^j}{\partial \theta} = \frac{\pi}{r+\rho} \frac{\partial(\theta q(\theta)(V_{E,i}^j - V_{U,i}^j))}{\partial \theta}.$$

The sign of  $\partial \bar{g}_{E,i}^j / \partial \theta$  is same as  $\partial(V_{E,i}^j - V_{U,i}^j) / \partial \theta$  if  $\rho > \delta$ . According to equation (5) and (6) the employment premium is

$$V_{E,i}^j - V_{U,i}^j = \frac{y_i - B^j - \mu \int_{\bar{g}_{U,i}^j}^{\bar{g}_{E,i}^j} (1 - F(g)) dg}{r + \delta + \beta \theta q(\theta)}. \quad (29)$$

Then

$$\begin{aligned} \frac{\partial(V_{E,i}^j - V_{U,i}^j)}{\partial \theta} &= -\beta \frac{y_i - B^j - \mu \int_{\bar{g}_{U,i}^j}^{\bar{g}_{E,i}^j} (1 - F(g)) dg}{(r + \delta + \beta \theta q(\theta))^2} \frac{\partial \theta q(\theta)}{\partial \theta} \\ &< 0. \end{aligned}$$

Thus,  $\partial \bar{g}_{E,i}^j / \partial \theta < 0$  if  $\rho < \delta$ .

When it turns to  $\partial \bar{g}_{U,i}^j / \partial \theta$ , its sign depends on  $\partial(\theta q(\theta)(V_{E,i}^j - V_{U,i}^j)) / \partial \theta$ . Then

$$\begin{aligned} \frac{\partial(\theta q(\theta)(V_{E,i}^j - V_{U,i}^j))}{\partial \theta} &= (V_{E,i}^j - V_{U,i}^j) \frac{\partial \theta q(\theta)}{\partial \theta} + \theta q(\theta) \frac{\partial(V_{E,i}^j - V_{U,i}^j)}{\partial \theta} \\ &= \frac{\partial \theta q(\theta)}{\partial \theta} \left[ V_{E,i}^j - V_{U,i}^j - \frac{\beta \theta q(\theta)}{r + \delta + \beta \theta q(\theta)} (V_{E,i}^j - V_{U,i}^j) \right] \\ &= \frac{r + \delta}{r + \delta + \beta \theta q(\theta)} \frac{\partial \theta q(\theta)}{\partial \theta} (V_{E,i}^j - V_{U,i}^j) \\ &> 0 \end{aligned}$$

Therefore,  $\partial \bar{g}_{U,i}^j / \partial \theta > 0$ . □

## Proof of Proposition 4

*Proof.* According to proposition 2 and lemma 5, proposition 4 is proved.  $\square$

## Proof of Proposition 5

*Proof.* According to proposition 2 and lemma 5, proposition 5 is proved.  $\square$

## Proof of Proposition 6

*Proof.* When the unemployment utility flow of immigrants increases to the same as native workers, their match surplus decreases to the same as natives. Therefore, the expected hiring fee, which is proportion  $(1 - \beta)$  to the match surplus, decreases. According to (14), the market tightness decreases to balance the equilibrium.

According to equation (6),  $\partial V_{U,i}^j / \partial B_i^j > 0$ . When the unemployment utility flow of skilled- $i$  immigrants  $B_i^I$  increases, the reservation crime value of unemployed immigrant with skill  $i$  is following

$$\begin{aligned}\bar{g}_{U,i}^I &= \pi(V_{U,i}^I - V_{P,i}^I) \\ &= \frac{\pi}{r + \rho}(rV_{U,i}^I - x + \tau)\end{aligned}$$

increases as  $V_{U,i}^I$  increases with  $B_i^I$ . Therefore,  $\partial \bar{g}_{U,i}^I / \partial B_i^I > 0$ . For employed immigrant with skill  $i$ , according to (29), the match surplus of skilled- $i$  immigrant decreases with  $B_i^I$ . Therefore,  $\bar{g}_{E,i}^I$  decreases with  $B_i^I$  if  $\rho > \delta$  given (27).

The reservation crime value of native workers is only affected by the market tightness. Based on lemma 5,

$$\frac{\partial \bar{g}_{E,i}^N}{\partial B_i^I} = \frac{\partial \bar{g}_{E,i}^N}{\partial \theta} \frac{\partial \theta}{\partial B_i^I} > 0$$

if  $\rho > \delta$  and

$$\frac{\partial \bar{g}_{U,i}^N}{\partial B_i^I} = \frac{\partial \bar{g}_{U,i}^N}{\partial \theta} \frac{\partial \theta}{\partial B_i^I} < 0.$$

Similarly, the reservation crime value of immigrants with skill  $i'$ , where  $i' \neq i$ , is also affected by  $\theta$ . Therefore,

$$\frac{\partial \bar{g}_{E,i'}^I}{\partial B_i^I} = \frac{\partial \bar{g}_{E,i'}^N}{\partial \theta} \frac{\partial \theta}{\partial B_i^I} > 0$$

if  $\rho > \delta$  and

$$\frac{\partial \bar{g}_{U,i'}^I}{\partial B_i^I} = \frac{\partial \bar{g}_{U,i'}^I}{\partial \theta} \frac{\partial \theta}{\partial B_i^I} < 0.$$

□

## Proof of Proposition 7

*Proof.* According to (14),

$$\frac{1}{d\rho} \left( d \frac{k}{q(\theta)} \right) = \frac{1}{d\rho} d[(1 - \beta) \sum_i \sum_j \frac{U_i^j}{U} (V_{E,i}^j - V_{U,i}^j)]$$

which can be written as

$$\frac{\partial(\frac{k}{q(\theta)})}{\partial \theta} \frac{\partial \theta}{\partial \rho} = (1 - \beta) \sum_i \sum_j [(V_{E,i}^j - V_{U,i}^j) \frac{\partial(U_i^j/U)}{\partial \rho} + \frac{U_i^j}{U} \frac{\partial(V_{E,i}^j - V_{U,i}^j)}{\partial \rho}].$$

For composition effect,

$$\partial(U_i^j/U)/\partial \rho = \frac{1}{U^2} [U \frac{\partial U_i^j}{\partial \rho} - U_i^j \frac{\partial U}{\partial \rho}].$$

The composition effect is ambiguous analytically. According to the set of parameter value that is applied in this paper, this effect is close to zero.

For match surplus,

$$\begin{aligned} \frac{\partial(V_{E,i}^j - V_{U,i}^j)}{\partial \rho} &= \frac{\partial(V_{E,i}^j - V_{U,i}^j)}{\partial \bar{g}_{E,i}^j} \frac{\partial \bar{g}_{E,i}^j}{\partial \rho} + \frac{\partial(V_{E,i}^j - V_{U,i}^j)}{\partial \bar{g}_{U,i}^j} \frac{\partial \bar{g}_{U,i}^j}{\partial \rho} \\ &= -\mu[(1 - F(\bar{g}_{E,i}^j)) \frac{\partial \bar{g}_{E,i}^j}{\partial \rho} - (1 - F(\bar{g}_{U,i}^j)) \frac{\partial \bar{g}_{U,i}^j}{\partial \rho}] \end{aligned}$$

According to equations (27) and (28),  $\bar{g}_{E,i}^j > \bar{g}_{U,i}^j$  and  $|\partial \bar{g}_{E,i}^j / \partial \rho| < |\partial \bar{g}_{U,i}^j / \partial \rho|$ . Therefore,  $\partial(V_{E,i}^j - V_{U,i}^j) / \partial \rho > 0$ . As a consequence, the effect of incarceration on the market tightness is positive.  $\square$

## Proof of Proposition 8

*Proof.* Take first order derivatives of the match surplus of immigrants with respect to  $a$ ,

$$\frac{\partial(V_{E,i}^I - V_{U,i}^I)}{\partial a} = \frac{-\mu}{r + \delta + \beta\theta q(\theta)} \left( (1 - F(\bar{g}_{E,i}^I)) \frac{\partial \bar{g}_{E,i}^I}{\partial a} - (1 - F(\bar{g}_{U,i}^I)) \frac{\partial \bar{g}_{U,i}^I}{\partial a} \right)$$

According to (26),

$$\begin{aligned} \frac{\partial \bar{g}_{E,i}^I}{\partial a} &= \frac{\partial \bar{g}_{U,i}^I}{\partial a} \\ &= -V_{P,i}^I \\ &= -\frac{x + \rho V_{U,i}^I}{r + \rho} \\ &< 0. \end{aligned}$$

Thus,

$$\begin{aligned} \frac{\partial(V_{E,i}^I - V_{U,i}^I)}{\partial a} &= \frac{-\mu}{r + \delta + \beta\theta q(\theta)} (F(\bar{g}_{U,i}^I) - F(\bar{g}_{E,i}^I)) \frac{\partial \bar{g}_{E,i}^I}{\partial a} \\ &< 0. \end{aligned}$$

Compare the unemployment of immigrants before and after the deportation policy, if the reservation crime value is unchanged, the unemployment with deportation is higher, which

is

$$\begin{aligned}
\Delta U_i^I &= \frac{(\delta + \eta_{E,i}^I)I_i}{\theta q(\theta) + \eta_{E,i}^I + \delta} - \frac{\rho(\delta + \eta_{E,i}^I)I_i}{\theta q(\theta)(\rho + \eta_{E,i}^I) + (\delta + \eta_{E,i}^I)(\rho + \eta_{U,i}^I)} \\
&= \frac{\eta_{E,i}^I(\delta + \eta_{E,i}^I + \theta q(\theta))}{\theta q(\theta)(\rho + \eta_{E,i}^I) + (\delta + \eta_{E,i}^I)(\rho + \eta_{U,i}^I)} \frac{1}{(\theta q(\theta) + \eta_{E,i}^I + \delta)} \\
&> 0.
\end{aligned}$$

Therefore the share of unemployed immigrants increases and the market tightness increases. When the reservation crime value of immigrants increases,  $\eta_{E,i}^I$  decreases so  $\Delta U_i^I$  decreases. Quantitatively, the effect on the market tightness increases a small margin with  $a$ . The effects on  $\bar{g}_{E,i}^N$  and  $\bar{g}_{U,i}^N$  follows Lemma 5.  $\square$

## B The Model without hiring fee

This section shows the model without hiring fee. The value functions of unemployed workers and vacancies are

$$rV_{U,i}^j = B_i^j - \tau + \theta q(\theta)(V_{E,i}^j - V_{U,i}^j) + \mu \int_0^{g^m} \max\{K_{U,i}^j - V_{U,i}^j, 0\} dF(g) \quad (30)$$

$$r\Pi_V = -k + q(\theta)(\Pi_F^e - \Pi_V). \quad (31)$$

The value functions of employed workers and filled jobs are the same as the model with hiring fee. The free entry condition is still satisfied, i.e.  $\Pi_V = 0$ . Following Pissarides (2000) closely, the wage are determined by the Nash bargaining share rule as

$$(1 - \beta)(V_{E,i}^j - V_{U,i}^j) = \beta\Pi_{F,i}^j. \quad (32)$$

From (4), the value of filled job can be written as

$$\Pi_{F,i}^j = \frac{y_i - w_i^j}{r + \delta + \mu\pi(1 - F(\bar{g}_{E,i}^j))}. \quad (33)$$

Given (5) and (30), the premium of employment is

$$V_{E,i}^j - V_{U,i}^j = \frac{w_i^j - B_i^j - \mu \int_{\bar{g}_{U,i}^j}^{\bar{g}_{E,i}^j} 1 - F(g)dg}{r + \delta + \theta q(\theta)}. \quad (34)$$

Substitute (33) and (34) into (32), and rewrite it as

$$(1 - \beta) \frac{w_i^j - B_i^j - \mu \int_{\bar{g}_{U,i}^j}^{\bar{g}_{E,i}^j} 1 - F(g)dg}{r + \delta + \theta q(\theta)} = \beta \frac{y_i - w_i^j}{r + \delta + \mu\pi(1 - F(\bar{g}_{E,i}^j))}. \quad (35)$$

Therefore, the wage is

$$w_i^j = \frac{\beta(r + \delta + \theta q(\theta))y_i + (1 - \beta)(r + \delta + \mu\pi(1 - F(\bar{g}_{E,i}^j)))(B_i^j + \mu \int_{\bar{g}_{U,i}^j}^{\bar{g}_{E,i}^j} 1 - F(g)dg)}{r + \delta + \beta\theta q(\theta) + (1 - \beta)\mu\pi(1 - F(\bar{g}_{E,i}^j))}. \quad (36)$$

Similar to the model with the hiring fee, the free entry condition gives

$$\frac{k}{q(\theta)} = \Pi_F^e, \quad (37)$$

where  $\Pi_F^e = \sum_i \sum_j (U_i^j/U) \Pi_{J,i}^j$ . Equation (37) gives the condition of equilibrium.

Table 7 presents the simulation results with this model. Quantitatively, the results are similar as the model with hiring fee and constant wage. Table 8 shows the results of policy that increases the unemployment utility of immigrants. Table 9 shows the results of policy that increases the duration of incarceration. Table 10 shows the results with deportation policy.

## C The Segmented Markets

This section discusses the model with two segmented markets. The labor market separates into two submarkets, skilled and unskilled markets. Workers can only search in the market that matches with their skills. There is no cross-market search. Firms are indifferent to post vacancy in either skilled or unskilled labor market according to the free entry condition. Similar as the single market model, the bellman equations of individual are following,

$$\begin{aligned}
 rV_{E,i}^j &= w_i^j - \tau - \delta_i(V_{E,i}^j - V_{U,i}^j) + \mu \int_{\bar{g}_{E,i}^j}^{g^{max}} (1 - F(g))dg \\
 rV_{U,i}^j &= B_i^j - \tau + \theta_i q(\theta_i)(V_{E,i}^j - V_{U,i}^j - \phi_i^j) + \mu \int_{\bar{g}_{U,i}^j}^{g^{max}} (1 - F(g))dg \\
 rV_{P,i}^j &= x - \tau + \rho(V_{U,i}^j - V_{P,i}^j).
 \end{aligned}$$

The only difference between single market and segmented markets is that workers are not able to search across markets. The expected value of filled job is the weight average value of skilled (unskilled) natives and immigration, i.e.

$$\mathbb{E}\Pi_{F,i} = \frac{U_i^I}{U_i}(V_{E,i}^I - V_{U,i}^I) + \frac{U_i^N}{U_i}(V_{E,i}^N - V_{U,i}^N).$$

Similarly, the bellman equations of filled job and vacancies are following,

$$\begin{aligned}
 r\Pi_{F,i}^j &= y_i^j - w_i^j - [\delta_i + \pi\mu(1 - F(\bar{g}_{E,i}^j))](\Pi_{F,i}^j - \Pi_{V,i}^j) \\
 r\Pi_{V,i} &= -k_i + \theta_i q(\theta_i)(\mathbb{E}\Pi_{F,i} - \Pi_{V,i}^j + \phi_i^j).
 \end{aligned}$$

According to the employment contract with hiring fee and  $\Pi_{V,i} = 0$ , the surplus maximization derives the  $(w_i^j, \phi_i^j)$  pair satisfies

$$\begin{aligned} w_i^j &= y_i \\ \phi_i^j &= (1 - \beta)(V_{E,i}^j - V_{U,i}^j). \end{aligned}$$

The equilibrium is given by the job creation condition,

$$\begin{aligned} \frac{k_i}{q(\theta_i)} &= \mathbb{E}(\Pi_{F,i} + \phi_i) \\ &= (1 - \beta) \frac{y_i - \mathbb{E}(B + \int_{\bar{g}_{U,i}}^{\bar{g}_{E,i}} (1 - F(g)) dg)}{r + \delta_i + \beta\theta_i q(\theta_i)} \end{aligned}$$

for market  $i \in \{H, L\}$ . Since skilled and unskilled workers search in two separate markets, when only the number of skilled (unskilled) immigrants increases, it affects skilled (unskilled) market only. The effect of immigrants shows in Table 11.



# Tables

Table 1: Calibration results

		description	sources/target
$y_H$	1	Normalized skilled productivity	
$y_L$	0.62	Relative unskilled productivity	The college-plus wage premium: 61.1%
$\beta$	0.5	Bargaining power	Hosios (1990)
$\alpha$	0.5	Elasticity of matching function	Petrongolo and Pissarides (2001)
			Estimated from data:
$r$	0.048	real interest rate	Fed. of Saint Louis
$\delta$	0.408	Annual job separation rate	Shimer (2005)
$\rho$	0.75	Rate of exit from jail	Engelhardt et al. (2008)
$\pi$	0.019	Apprehension probability	Engelhardt et al. (2008)
$I_H$	0.036	Mass of skilled immigrants	
$I_L$	0.089	Mass of unskilled immigrants	Chassamboulli and Palivos (2014)
$\tau$	0.0391	Expected loss of victims	equal to $g^e$
$\gamma$	0.274	Fraction of skilled native workers to total natives workers	Chassamboulli and Palivos (2014)
			Jointly calibrated to match:
$A$	5.4	Match technology	Annual job finding rate:
$k$	0.5288	Fixed recruitment cost	2.29 from CPS in 1990s
$B_{H,N}$	0.3821	Unemployed. flow value, skilled natives	Ratio of unemployed
$B_{L,N}$	0.2369	Unemploy. flow value, unskilled natives	and employed income: 40%
$B_{H,I}$	-1.7072	Unemploy. flow value, skilled immigrant	The skilled native-immigrant
$B_{L,I}$	-1.0693	Unemploy. flow value, unskilled immigrant	wage gap: -19%
$\mu$	0.0704	Arrival rate of criminal opportunity	The unskilled native-immigrant
			wage gap: -18.8%
			$\theta$ normalized to 1

Table 2: Effects of Immigration

	Increase in skilled immigrants and unskilled immigrants		Increase in skilled immigrants only		Increase in unskilled immigrants only	
$\theta$	0.1586	(15.86%)	0.0825	(8.25%)	0.0825	(8.12%)
$u$	-0.4665	(-6.63%)	-0.2548	(-3.62%)	-0.2510	(-3.57%)
$c$	-0.1640	(-0.36%)	-0.2130	(-0.47%)	0.0400	(0.09%)
Skilled natives						
$u_{H,N}$	-0.4700	(-6.63%)	-0.2500	(-3.62%)	-0.2500	(-3.57%)
$\tilde{w}_{H,N}$	0.0027	(0.29%)	0.0015	(0.16%)	0.0015	(0.15%)
$c_{E,H}^N$	0.0940	(0.25%)	0.0510	(0.14%)	0.0500	(0.13%)
$c_{U,H}^N$	-0.1370	(-0.33%)	-0.0740	(-0.18%)	-0.0730	(-0.18%)
Unskilled Natives						
$u_{L,N}$	Same as skilled natives					
$\tilde{w}_{L,N}$	0.0075	(1.51%)	0.0041	(0.82%)	0.0040	(0.81%)
$c_{E,L}^N$	0.0750	(0.16%)	0.0410	(0.09%)	0.0400	(0.08%)
$c_{U,L}^N$	-0.1050	(-0.21%)	-0.0570	(-0.11%)	-0.0560	(-0.11%)
Skilled Immigrants						
$c_{E,H}^I$	0.3610	(1.10%)	0.1970	(0.60%)	0.1940	(0.59%)
$c_{U,H}^I$	-0.7190	(-1.45%)	-0.3930	(-0.79%)	-0.3870	(-0.78%)
Unskilled immigrants						
$c_{E,L}^I$	0.3030	(0.66%)	0.1640	(0.37%)	0.1620	(0.37%)
$c_{U,L}^I$	-0.5180	(-0.90%)	-0.2830	(-0.49%)	-0.2790	(-0.49%)

Note: 1. Skilled immigrants increase by 0.026. Unskilled immigrants increase by 0.051 for the simulation.

2. The variable  $\theta$  is the market tightness,  $c$  is the overall crime rate,  $u$  is the overall unemployment rate,  $\tilde{w}_i^j$  is the implied wage of type- $ij$  workers,  $u_i^j$  is unemployment rate of type- $ij$  workers, and  $c_{s,i}^j$  is the crime rate of type- $ij$  workers under  $s$  labor market status. The subscript  $U$  represents unemployed,  $E$  is employed,  $L$  is unskilled, and  $H$  is skilled. The superscript  $N$  represents native and  $I$  represents immigrant. The unemployment rates are defined as the number of unemployed workers over the population of type- $ij$  of workers, presented as percentage points. The crime rates represents the number of criminal offenses per 1000 population of type- $ij$  of workers.

3. The numbers without parentheses report the change in level. The numbers in parentheses represent the change in percentage.

Table 3: Crime rate of workers

Type of worker	crime rate	Type of worker	crime rate
Natives	47.321	Immigrants	41.905
Skilled employed natives	37.636	Skilled employed immigrants	32.791
Skilled unemployed natives	41.385	Skilled unemployed immigrants	49.714
Unskilled employed natives	48.163	Unskilled employed immigrants	44.189
Unskilled unemployed natives	51.083	Unskilled unemployed immigrants	57.284

Note: This table shows the crime rate of each type of workers, which is the number that criminal offenses per 1000 population of the type- $ij$  of workers.

Table 4: Effects of unemployment value

	increase in $B_H^I$		increases in $B_H^I$		increases in $B_L^I$	
	increases in $B_L^I$					
$\theta$	-0.2948	(-29.5%)	-0.1163	(-11.63%)	-0.1795	(-17.95%)
$u$	1.2320	(17.50%)	0.4154	(5.90%)	0.6755	(9.60%)
$c$	0.2570	(0.57%)	0.0720	(0.16%)	0.1800	(0.40%)
Skilled natives						
$u_{H,N}$	0.0123	(17.5%)	0.4153	(5.90%)	0.6752	(9.60%)
$\tilde{w}_{H,N}$	-0.0071	(-0.74%)	-0.0024	(-0.25%)	-0.0039	(-0.41%)
$c_{E,H}^N$	-0.2430	(-0.65%)	-0.0830	(-0.22%)	-0.1350	(-0.36%)
$c_{U,H}^N$	0.3590	(0.87%)	0.1220	(0.29%)	0.1980	(0.48%)
Unskilled Natives						
$u_{L,N}$	Same as skilled natives					
$\tilde{w}_{L,N}$	-0.0044	(-0.75%)	-0.0015	(-0.25%)	-0.0024	(-0.41%)
$c_{E,L}^N$	-0.1930	(-0.40%)	-0.0660	(-0.14%)	-0.1070	(-0.22%)
$c_{U,L}^N$	0.2740	(0.54%)	0.0930	(0.18%)	0.1510	(0.30%)
Skilled Immigrants						
$c_{E,H}^I$	4.6020	(14.03%)	4.7620	(14.52%)	-0.5090	(-1.55%)
$c_{U,H}^I$	-7.9700	(-16.03%)	-8.2070	(-16.51%)	1.0460	(2.10%)
Unskilled immigrants						
$c_{E,L}^I$	3.7810	(8.56%)	-0.2660	(-0.60%)	3.8670	(8.75%)
$c_{U,L}^I$	-5.9270	(-10.35%)	0.4610	(0.80%)	-6.0500	(-10.56%)

Note: See the footnotes 2 and 3 in table 2 for the definitions of variables and the explanation of rates.

Table 5: Effects of incarceration				
	32 months		48 months	
$\theta$	No significant effects			
$u$	No significant effects			
$c$	-12.0710	(-26.77%)	-19.9460	(-44.23%)
Skilled natives				
$u_{H,N}$	No significant effects			
$\tilde{w}_{H,N}$	No significant effects			
$c_{E,H}^N$	-14.1300	(-37.54%)	-22.1900	(-58.96%)
$c_{U,H}^N$	-15.5380	(-37.55%)	-24.4010	(-58.95%)
Unskilled Natives				
$u_{L,N}$	No significant effects			
$\tilde{w}_{L,N}$	No significant effects			
$c_{E,L}^N$	-11.9140	(-24.74%)	-20.0280	(-41.58%)
$c_{U,L}^N$	-12.6390	(-24.74%)	-21.2450	(-41.59%)
Skilled Immigrants				
$c_{E,H}^I$	-8.6880	(-26.50%)	-14.4760	(-44.15%)
$c_{U,H}^I$	-13.1840	(-26.52%)	-21.9580	(-44.17%)
Unskilled immigrants				
$c_{E,L}^I$	-7.3680	(-16.67%)	-12.8940	(-29.18%)
$c_{U,L}^I$	-9.5680	(-16.70%)	-16.7380	(-29.22%)

Note: See the footnotes 2 and 3 in table 2 for the definitions of variables and the explanation of rates.

Table 6: Effects of deportation

	From poor country ( $a = 0.1$ )		From intermediate country ( $a = 0.5$ )		From over-intermediate country ( $a = 0.9$ )	
$\theta$	0.0004	(0.04%)	0.0004	(0.04%)	0.0005	(0.05%)
$u$	-0.0025	(-0.04%)	-0.0024	(-0.03%)	-0.0019	(-0.03%)
$c$	-4.4530	(-9.87%)	-3.8690	(-8.58%)	-1.4200	(-3.15%)
Skilled natives						
$u_{H,N}$	No significant effects					
$\tilde{w}_{H,N}$						
$c_{E,H}^N$						
$c_{U,H}^N$						
Unskilled Natives						
$u_{L,N}$	No significant effects					
$\tilde{w}_{L,N}$						
$c_{E,L}^N$						
$c_{U,L}^N$						
Skilled Immigrants						
$c_{E,H}^I$	-32.5416	(-99.24%)	-30.6091	(-93.35%)	-13.605	(-41.49%)
$c_{U,H}^I$	-49.3356	(-99.24%)	-46.4070	(-93.35%)	-20.829	(-41.90%)
Unskilled immigrants						
$c_{E,L}^I$	-41.7191	(-94.41%)	-35.2879	(-79.86%)	-11.945	(-27.03%)
$c_{U,L}^I$	-54.0824	(-94.41%)	-45.7630	(-79.89%)	-15.768	(-27.53%)

Note: See the footnotes 2 and 3 in table 2 for the definitions of variables and the explanation of rates.

Table 7: Effects of Immigration (Nash Bargaining)

	Increase in skilled immigrants and unskilled immigrants		Increase in skilled immigrants only		Increase in unskilled immigrants only	
$\theta$	0.1587	(15.87%)	0.0825	(8.25%)	0.0812	(8.12%)
$u$	-0.4667	(-6.63%)	-0.2549	(-3.62%)	-0.2511	(-3.57%)
$c$	-0.015	(-0.03%)	-0.1520	(-0.34%)	0.1340	(0.30%)
Skilled natives						
$u_{H,N}$	-0.4667	(-6.63%)	-0.2549	(-3.62%)	-0.2511	(-3.57%)
$\tilde{w}_{H,N}$	0.0027	(0.29%)	0.0015	(0.16%)	0.0015	(0.15%)
$c_{E,H}^N$	-0.0160	(-0.04%)	-0.0090	(-0.02%)	-0.0090	(-0.02%)
$c_{U,H}^N$	-0.1320	(-0.33%)	-0.0720	(-0.18%)	-0.0710	(-0.18%)
Unskilled Natives						
$u_{L,N}$	Same as skilled natives					
$\tilde{w}_{L,N}$	0.0017	(0.29%)	0.0009	(0.16%)	0.0009	(0.15%)
$c_{E,L}^N$	-0.0120	(-0.03%)	-0.0070	(-0.01%)	-0.0070	(-0.01%)
$c_{U,L}^N$	-0.1010	(-0.21%)	-0.0550	(-0.11%)	-0.0540	(-0.11%)
Skilled Immigrants						
$c_{E,H}^I$	-0.0700	(-0.18%)	-0.0380	(-0.10%)	-0.0370	(-0.10%)
$c_{U,H}^I$	-0.6910	(-1.45%)	-0.3760	(-0.79%)	-0.3700	(-0.78%)
Unskilled immigrants						
$c_{E,L}^I$	-0.0540	(-0.11%)	-0.0290	(-0.06%)	-0.0290	(-0.06%)
$c_{U,L}^I$	-0.4980	(-0.91%)	-0.2700	(-0.49%)	-0.2660	(-0.48%)

Note: See the footnotes 2 and 3 in table 2 for the definitions of variables and the explanation of rates.

Table 8: Effects of unemployment value

	increase in $B_H^I$		increase in $B_H^I$		increases in $B_L^I$	
	increases in $B_L^I$					
$\theta$	-0.2949	(-29.49%)	-0.1164	(-11.64%)	-0.1796	(-17.96%)
$u$	1.2329	(17.50%)	0.4157	(5.91%)	0.6760	(9.60%)
$c$	-0.0540	(-0.10%)	-0.0130	(-0.03%)	-0.0380	(-0.08%)
Skilled natives						
$u_{H,N}$	1.2325	(17.50%)	0.4155	(5.90%)	0.6758	(9.60%)
$\tilde{w}_{H,N}$	-0.0071	(-0.74%)	-0.0024	(-0.25%)	-0.0039	(-0.41%)
$c_{E,H}^N$	0.0410	(0.11%)	0.0140	(0.04%)	0.0220	(0.06%)
$c_{U,H}^N$	0.3440	(0.87%)	0.1170	(0.29%)	0.1020	(0.48%)
Unskilled Natives						
$u_{L,N}$	Same as skilled natives					
$\tilde{w}_{L,N}$	-0.0044	(-0.74%)	-0.0015	(-0.25%)	-0.0024	(-0.41%)
$c_{E,L}^N$	0.0320	(0.07%)	0.0110	(0.02%)	0.0180	(0.04%)
$c_{U,L}^N$	0.2630	(0.54%)	0.0890	(0.18%)	0.1450	(0.30%)
Skilled Immigrants						
$c_{E,H}^I$	-0.8470	(-2.19%)	-0.8740	(-2.26%)	0.1020	(0.26%)
$c_{U,H}^I$	-7.6720	(-16.09%)	-7.8990	(-16.56%)	1.0070	(2.11%)
Unskilled immigrants						
$c_{E,L}^I$	-0.6630	(-1.37%)	0.0490	(0.10%)	-0.6770	(-1.40%)
$c_{U,L}^I$	-5.7080	(-10.39%)	0.4440	(0.81%)	-5.8260	(-10.61%)

Note: See the footnotes 2 and 3 in table 2 for the definitions of variables and the explanation of rates.

	32 months		48 months	
$\theta$	No significant effects			
$u$	No significant effects			
$c$	-12.0520	(-26.72%)	-19.9160	(-44.16%)
Skilled natives				
$u_{H,N}$	No significant effects			
$\tilde{w}_{H,N}$	No significant effects			
$c_{E,H}^N$	-14.2010	(-37.54%)	-22.3020	(-58.96%)
$c_{U,H}^N$	-14.8920	(-37.54%)	-23.3880	(-58.96%)
Unskilled Natives				
$u_{L,N}$	No significant effects			
$\tilde{w}_{L,N}$	No significant effects			
$c_{E,L}^N$	-11.7590	(-24.73%)	-19.7680	(-41.58%)
$c_{U,L}^N$	-12.1110	(-24.73%)	-20.3600	(-41.58%)
Skilled Immigrants				
$c_{E,H}^I$	-10.2530	(-26.48%)	-17.0840	(-44.13%)
$c_{U,H}^I$	-12.6290	(-26.48%)	-21.0420	(-44.13%)
Unskilled immigrants				
$c_{E,L}^I$	-8.0380	(-16.66%)	-14.0680	(-29.16%)
$c_{U,L}^I$	-9.1550	(-16.67%)	-16.0210	(-29.16%)

Note: See the footnotes 2 and 3 in table 2 for the definitions of variables and the explanation of rates.

	From poor country ( $a = 0.1$ )		From intermediate country ( $a = 0.5$ )		From over-intermediate country ( $a = 0.9$ )	
$c$	-4.892	(-10.85%)	-4.156	(-9.44%)	-1.587	(-3.52%)
Skilled Immigrants						
$c_{E,H}^I$	-16.2030	(-41.85%)	-0.03616	(-93.33%)	-0.0384	(-99.24%)
$c_{U,H}^I$	-19.9570	(-41.85%)	-44.5067	(-93.33%)	-47.3216	(-99.24%)
Unskilled immigrants						
$c_{E,L}^I$	-13.2510	(-27.47%)	-38.5143	(-79.85%)	-45.5319	(-94.39%)
$c_{U,L}^I$	-15.0920	(-27.47%)	-43.8630	(-79.85%)	-51.8553	(-94.39%)

Note: See the footnotes 2 and 3 in table 2 for the definitions of variables and the explanation of rates. There are no effect on labor market outcomes and the crime rate of skilled and unskilled native workers.



Table 11: Effects of Immigration (segmented markets)

	Increase in skilled immigrants and unskilled immigrants		increase in skilled immigrants only		increases in unskilled immigrants only	
$\theta_H$	0.1711	(22.45%)	0.1710	(22.45%)	No effects	
$\theta_L$	0.0807	(18.07%)	No effects		0.0807	(18.07%)
$u$	0.4257	(-8.03%)	-0.1332	(-2.51%)	-0.3047	(-5.74%)
$c$	-0.1400	(-0.31%)	-0.2200	(-0.48%)	0.0720	(0.16%)
Skilled natives						
$u_{H,N}$	-0.2611	(-9.39%)	-0.2611	(-9.39%)	No effects	
$\tilde{w}_{H,N}$	0.0010	(0.01%)	0.0010	(0.01%)		
$c_{E,H}^N$	0.0850	(0.22%)	0.085	(0.22%)		
$c_{U,H}^N$	-0.0460	(-0.12%)	-0.0460	(-0.12%)		
Unskilled Natives						
$u_{L,N}$	0.4704%	(-7.51%)	No effects		0.4704	(-7.51%)
$\tilde{w}_{L,N}$	0.0010	(0.16%)				
$c_{E,L}^N$	0.0440	(0.09%)				
$c_{U,L}^N$	-0.0600	(-0.12%)				
Skilled Immigrants						
$c_{E,H}^I$	0.4650	(1.37%)	0.4650	(1.37%)	No effects	
$c_{U,H}^I$	-0.3040	(-0.72%)	-0.3040	(-0.72%)	No effects	
Unskilled Immigrants						
$c_{E,L}^I$	0.2570	(0.56%)	No effects		0.2570	(0.56%)
$c_{U,L}^I$	-0.4060	(-0.74%)	No effects		-0.4060	(-0.74%)

Note: See the footnotes 2 and 3 in table 2 for the definitions of variables and the explanation of rates.