Crime and the Labor Market: Policy Implications*

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December 11, 2006

Abstract

This paper extends the Pissarides (2000) model of the labor market to include crime and punishment à la Becker (1968). The model is used to study, analytically and quantitatively, the effects of various labor market and crime policies. For instance, a more generous unemployment insurance system reduces the crime rate of the unemployed but its effect on the crime rate of the employed depends on job duration and jail sentences. When the model is calibrated to U.S. data, the overall effect on crime is positive but quantitatively small. Wage subsidies reduce unemployment and crime rates of employed and unemployed workers, and improve society's welfare. Hiring subsidies reduce unemployment but they can raise the crime rate of employed workers. Crime policies (police technology and jail sentences) affect crime rates significantly but have only negligible effects on the labor market.

Keywords: crime, unemployment, search, matching

JEL Codes: E24, J0, J63, J64

*We thank Marco Cozzi, Dale Mortensen, Victor Rios-Rull, Richard Rogerson and Randall Wright for their comments. We also thank the seminar participants at the Federal Reserve Bank of Cleveland and Federal Reserve Board, Texas, Iowa, Penn, Santa Barbara, Singapore (SMU), USC, Western Ontario and the UQAM conference on search and matching. This paper was completed while Rocheteau was visiting the University of Pennsylvania. The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Cleveland or the Federal Reserve System.

1 Introduction

According to Becker (1968) participation in illegal activities is driven by many of the same economic forces that motivate legitimate activities. Therefore, changes in labor market policies that affect individuals' incomes and prospects are likely to affect their criminal behavior as well. A case in point is the Job Seeker's Allowance introduced in the United Kingdom in 1996. The program was instituted to reduce unemployment by decreasing the duration of unemployment benefits. According to Machin and Marie (2004), this reform had the unfortunate effect of increasing crime. Similarly, Fougere, Kramarz, and Pouget (2003) present some (mild) evidence that workers in France who do not receive unemployment benefits tend to commit more property crime. More generally, Hoon and Phelps (2003) advocate the use of labor market policies, such as wage subsidies, to reduce the enrollment of low-skilled workers in criminal activities.

Turning the Becker argument on its head suggests that changes in the crime sector should affect the labor market as well. In the U.S., sentence lengths have been increased in several states, sentencing guidelines have become tougher, and some states have moved to "three-strikes" rules. While it is intuitively plausible that increased deterrence and/or punishment should reduce criminal activity, there is scant research on how this might affect job duration, employment and other outcomes of the labor market.

In this paper we develop a tractable model where crime and labor market outcomes are determined jointly. We use this model to assess, qualitatively and quantitatively, the effects of various labor market and crime policies. We adopt the description of the labor market proposed by Pissarides (2000) where the terms of the employment contract are determined via bilateral bargaining and where a free-entry condition of firms makes the job finding rate endogenous. Both worker's bargaining strength and the exit rate out-of-unemployment are important determinants of the tradeoff that workers face when deciding whether or not to undertake crime opportunities.

In the model all individuals receive random crime opportunities. The willingness to commit an illegal act is represented by a reservation value for crime opportunities above which individuals commit crime. This reservation value depends on current income, prospects for future incomes and so on. An individual who commits a crime faces a probability of being caught, and punishment corresponds to a jail sentence.

Since (detected) crimes are punished by periods of imprisonment, employed workers' involvement in criminal activities imposes a negative externality on firms by reducing average job duration. This type of externality, which is well understood in models with on-the-job search (crime can certainly be thought of in a similar way), can lead to inefficient separations if the contract space is restricted to flat wages.[1] We take the approach (arguably, an approximation) that employees and employers face no liquidity constraints and can write contracts that generate efficient turnover from the point of view of a worker and employer. As shown by Stevens (2004) in a related context, the optimal contract involves an up-front payment by the worker and a constant wage equal to the worker's productivity. One can think of this optimal contract approximating features of existing contracts, such as probationary periods or an upward sloping wage profile. (We also work out in the Appendix a version of the model with an exogenous wage but without a hiring fee.)

We prove that equilibrium exists and provide simple conditions for uniqueness.[2] Individuals' willingness to engage in criminal activities can be ranked according to their labor force status, with unemployed workers being the least choosy in terms of crime opportunities to undertake. To highlight the tractability of the model, we provide a two-dimensional representation of the equilibrium similar in spirit to that in Mortensen and Pissarides (1994). This tractability allows us to study analytically a broad range of policies. In addition, we also calibrate the model to U.S. data to examine the quantitative effects of policy.

We show analytically that a more generous unemployment insurance system reduces the crime rate of unemployed workers but the effect on the crime rate of employed workers depends on the difference between the average length of jail sentences and the average job duration. Quantitatively, the total crime rate increases, although the effect is small.

The effects of a change in worker's compensation are also investigated.[3] Higher worker's bargaining power leads to higher unemployment but it has ambiguous (and highly nonlinear) effects on the crime rates of employed and unemployed workers. The quantitative effects on total crime are large, coming largely from the sharp reduction in the job-finding rate. We obtain similar results if we restrain the employment contract to a constant wage and we consider a mandatory change in the wage.

A wage supplement to employed workers (or a wage subsidy) reduces the unemployment rate

[1] See Burdett and Mortensen (1998), the extensions by Burdett and Coles (2003) and Stevens (2004).

[2] One can consider various extensions of the model that generate multiple steady-state equilibria; however, we find it interesting that a benchmark version of the model predicts a unique equilibrium.

[3] See Freeman (1999) for an extensive review on the relationship between crime and workers' compensation.

and overall crime. On the contrary, hiring subsidies that reduce the cost of advertising vacancies can raise the crime rate of employed workers. From a normative standpoint, our analysis suggest that most labor market policies have a negative effect on welfare: the distortions they introduce in the labor market outweight the potential benefits in terms of crime. A noticeable exception is the wage subsidy case, having a significant and positive effect on welfare by reducing crime, as suggested by Hoon and Phelps (2003, p.16).

We also examine policies that affect the availability of crime opportunities, the likelihood to catch criminals and jail sentences. A policy that reduces the crime opportunities for employed workers can have the paradoxical effect of depressing the labor market, and it can induce unemployed workers to commit more crimes. Quantitatively, the effects of this mechanism on the labor market are negligible, however. Finally, the probability of apprehension and sentence lengths have large effects on crime with virtually no effect on the labor market.

The closest paper to ours is that of Burdett, Lagos, and Wright (2003)– BLW hereafter. There are several key differences between the two formalizations. First, while BLW adopt the wage posting framework of Burdett and Mortensen (1998), we employ the Pissarides model for the reasons stated above. Second, in contrast to BLW we consider optimal employment contracts that internalize the effect of workers' crime decisions on the duration of a match. In BLW the employment contract is restricted to a constant wage which leads to a wage distribution and multiple equilibria. Third, the endogenous participation of firms in our model provides a channel through which criminal activities can distort the allocation and lower welfare. In contrast, the distortions introduced by crime in BLW are due solely to the policy that consists in sending criminals to jail. Fourth, the value of crime opportunities in our model are random draws from a distribution; this allows us to formalize crime behavior as a standard sequential search problem and to obtain endogenous crime rates for individuals in different states. Huang, Liang, and Wang (2004) is also related to our analysis in that they employ a search-theoretic framework with bilateral bargaining. In their model individuals specialize in criminal activities while we let all agents, irrespective of their labor status, receive crime opportunities and commit crimes. We formalize different access to crime by allowing an arrival rate of crime opportunities that depends on labor force status. This distinction is important since in the data all types of individuals, in particular employed ones, commit crimes. İmrohoroğlu, Merlo, and Rupert (2004) calibrate an equilibrium model of crime to explore potential explanations for the decline in property crime over the past few decades. Their model does not have an explicit description of the labor market and is not set up to address how changes in the criminal sector affects the labor market.[4]

2 Model

The environment is similar to Pissarides (2000) extended to allow for criminal activity. Time, t, is continuous and goes on forever. The economy is composed of a unit-measure of infinitely-lived individuals and a large measure of firms. There is one final good produced by firms. Each individual is endowed with one indivisible unit of time that has two alternative, mutually exclusive uses: search for a job, work for a firm.

The instantaneous utility of a flow of consumption, $c(t)$, is simply $c(t)$ and individuals discount at rate $r > 0$. Individuals are not liquidity constrained and can borrow and lend at rate r. An unemployed worker who is looking for a job enjoys a utility flow b. One can interpret b as the utility from not working or as unemployment benefits paid by the government.

We consider employment contracts comprised of an upfront payment when the job is created and a flat wage afterwards. We will establish below that this type of contract is Pareto-optimal for a worker and a firm. Upon entering an employment relationship, a worker pays a hiring fee, ϕ, and receives a constant wage w thereafter.[5] The pair (ϕ, w) will be determined through some bargaining solution. Implicit in this formulation is that the firm commits to the terms of the employment contract. In particular, once the worker pays the hiring fee the firm does not renege on the promised future wage.

Firms are composed of a single job, either filled or vacant. Vacant firms are free to enter the labor market. There is a flow cost, $\gamma > 0$, to advertise a vacancy. Vacant firms produce no output while filled jobs produce $y > b$. Firms are risk-neutral and discount future utility at rate $r > 0$.

The labor market is subject to search-matching frictions. The flow of hirings is given by the

[4]There is also an empirical literature on the relationship between the labor market and crime. See, for instance, Grogger (1998) or Machin and Meghir (2004). Going further, Lochner and Moretti (2004) find empirical evidence that policies aimed at improving labor market opportunities, specifically increasing graduation rates, can substantially reduce crime.

[5]This type of contract can be thought of as an extreme version of a contract with an upward sloping wage profile over time. Another interpretation is that there is an initial probationary period after which wages will be increased. In our environment, any flat wage contract is dominated by a contract with an upward sloping wage profile. So even in the presence of liquidity constraints, the optimal contract would require the wage to increase with tenure. For a related discussion, see Chapter 5 in Mortensen (2003). For completeness, we describe in the Appendix B the equilibrium condition for the model without hiring fee ($\phi = 0$) and exogenous wage.

aggregate matching function $m(U,V)$ where U is the measure of unemployed workers actively looking for jobs and V is the measure of vacant jobs. The matching function $m(\cdot,\cdot)$ is strictly increasing and strictly concave with respect to each of its arguments and it exhibits constant returns to scale. Furthermore, $m(0,\cdot) = m(\cdot,0) = 0$ and $m(\infty,\cdot) = m(\cdot,\infty) = \infty$. Following Pissarides' terminology, we define $\theta \equiv V/U$ as labor market tightness. Each vacancy is filled according to a Poisson process with arrival rate $\frac{m(U,V)}{V} \equiv q(\theta)$. Similarly, each unemployed worker finds a job according to a Poisson process with arrival rate $\frac{m(U,V)}{U} = \theta q(\theta)$. Filled jobs receive negative idiosyncratic productivity shocks, with a Poisson arrival rate s, that render matches unprofitable.[6]

Individuals in the economy receive an opportunity to commit a crime according to a Poisson process with arrival rate λ_i, where i indicates the individual's state: $i = u$ if unemployed and $i = e$ if employed. So, the availability of crime opportunities may depend on one's labor force status. The value of a crime is ε, where ε is a random draw from a distribution $G(\varepsilon)$ with support $[0,\bar{\varepsilon}]$. A worker who commits a crime is caught and sent to jail with probability π.[7] When in jail an individual cannot make any productive use of time but receives a flow of utility x (which can be negative). A prisoner exits jail according to a Poisson process with arrival rate δ. We assume that the average time spent in jail is independent of the value ε of the crime.[8]

All individuals, including those in jail, can be victimized (i.e., they have property that can be stolen).[9] Since the model is agnostic about the distribution of wealth, we simply assume that all individuals incur the same expected instantaneous loss, τ^c, from being victimized which is independent of one's labor force status. Firms do not suffer directly from criminal activities. Each dollar stolen by criminals corresponds to a loss of $1+\omega$ dollars incurred by victims. If $\omega = 0$ then crime is a pure transfer whereas $\omega > 0$ means that victims suffer a nonpecuniary cost or some property is destroyed through theft. Finally, individuals also have to pay taxes, τ^g, to the government. In order to avoid taxes affecting crime decisions directly, we assume that the burden

[6] One could adopt a more general description of the idiosyncratic shocks received by firms and endogenize s. See Mortensen and Pissarides (1994).

[7] Note that in our framework the probability of being caught is independent of the value of the crime. An alternative is to have π as an increasing function of the value of the crime, for example by assigning more police to larger crimes. We do not know of any data in this regard to support one particular assumption.

[8] According to the U.S. Sentencing Commission Guidlines Manual the length of incarceration has more to do with the violent nature of the crime and the number of past offenses than the value of the crime. For a larceny less than $10,000 (75% of thefts are under $10,000) and if the criminal has not been convicted more than once, the Sentencing Commission Guidlines suggests a period of incarceration ranging from 0 to 6 months. If it is the criminals second or third offense then the suggested penalty is 4-10 months. If the theft is violent, such as a robbery, and the crime is still less than $10,000, the guidelines suggest incarceration for 33-41 months.

[9] Our results would not be affected if prisoners are not subject to theft.

of taxes falls on all workers including those in jail. We denote $\tau = \tau^c + \tau^g$.

3 Bellman equations

This paper focuses on steady-state equilibria where the distribution of individuals across states and the measure of vacancies are constant over time. As a consequence, market tightness and matching probabilities are time invariant. In this section we write down the flow Bellman equations for individuals and firms and characterize the employment contract.

3.1 Individuals

An individual is in one of the following three states: unemployed (u), employed (e), or in prison (p). The value of being an individual in state $i \in \{u,e,p\}$ is denoted $\mathscr{V}_i$. The flow Bellman equations for individuals' value functions are

$$r\mathscr{V}_u = b - \tau + \theta q(\theta)(\mathscr{V}_e - \mathscr{V}_u - \phi) + \lambda_u \int [\varepsilon + \pi(\mathscr{V}_p - \mathscr{V}_u)]^+ \, dG(\varepsilon), \tag{1}$$

$$r\mathscr{V}_e = w - \tau + s(\mathscr{V}_u - \mathscr{V}_e) + \lambda_e \int [\varepsilon + \pi(\mathscr{V}_p - \mathscr{V}_e)]^+ \, dG(\varepsilon), \tag{2}$$

$$r\mathscr{V}_p = x - \tau + \delta[\mathscr{V}_u - \mathscr{V}_p], \tag{3}$$

where $[x]^+ = \max(x,0)$. Equation (1) has the following interpretation. An unemployed worker enjoys a utility flow of $b-\tau$ where b is the income (or utility flow) of unemployed workers and τ is the sum of the (expected) cost of being victimized and taxes. A job is found with an instantaneous probability $\theta q(\theta)$. Upon taking a job an individual pays a hiring fee, ϕ (or receives an up-front payment if $\phi < 0$), and enjoys the capital gain $\mathscr{V}_e - \mathscr{V}_u$. When unemployed the individual receives an opportunity to commit a crime with instantaneous probability λ_u. The value of the crime opportunity is drawn from the cumulative distribution $G(\varepsilon)$. If a worker chooses to commit a crime she enjoys utility ε but is at risk of being caught and sent to jail with probability π, in which case she suffers a capital loss, $\mathscr{V}_p - \mathscr{V}_u$. From (2), an employed worker receives a wage w, loses the job with an instantaneous probability s and has the opportunity to commit a crime with an instantaneous probability λ_e. According to (3), an imprisoned worker receives consumption flow x, suffers the loss τ, and exits jail with an instantaneous probability δ. After release a prisoner joins the unemployment pool.

From (1) and (2) an individual in state i chooses to commit a crime whenever $\varepsilon \geq \varepsilon_i$ where

$$\varepsilon_u = \pi(\mathscr{V}_u - \mathscr{V}_p), \quad (4)$$

$$\varepsilon_e = \pi(\mathscr{V}_e - \mathscr{V}_p), \quad (5)$$

From (4)-(5) the value of the marginal crime, that makes an individual in a given state indifferent between undertaking the crime or not, ε_i, is the expected cost of punishment, $\pi(\mathscr{V}_i - \mathscr{V}_p)$.

3.2 Firms

Firms participating in the market can be in either of two states: they can hold a vacant job (v) or a filled job (f). Firms' flow Bellman equations are

$$r\mathscr{V}_v = -\gamma + q(\theta)\left(\phi + \mathscr{V}_f - \mathscr{V}_v\right), \quad (6)$$

$$r\mathscr{V}_f = y - w - s\left(\mathscr{V}_f - \mathscr{V}_v\right) - \lambda_e \pi \left[1 - G(\varepsilon_e)\right]\left(\mathscr{V}_f - \mathscr{V}_v\right). \quad (7)$$

According to (6), a vacancy incurs an advertising cost γ; finds an unemployed worker with an instantaneous probability q in which case it enjoys the capital gain $\phi + \mathscr{V}_f - \mathscr{V}_v$. According to (7), a filled job enjoys a flow profit $y - w$ and is destroyed if a negative idiosyncratic productivity shock occurs, with an instantaneous probability s, or if the worker commits a crime and is caught, an event occurring with an instantaneous probability $\lambda_e \pi[1 - G(\varepsilon_e)]$. Free-entry of firms implies $\mathscr{V}_v = 0$ and therefore, from (6),

$$\mathscr{V}_f + \phi = \frac{\gamma}{q(\theta)}. \quad (8)$$

From (8), the firms' surplus from a match, the sum of the value of a filled job and the hiring fee, is equal to the average recruiting cost incurred by the firm.

3.3 Employment contract

To determine the details of the employment contract we define $\mathscr{S} \equiv \mathscr{V}_e - \mathscr{V}_u + \mathscr{V}_f$ as the total surplus of a match (Recall that $\mathscr{V}_v = 0$). From (2) and (7),

$$r\mathscr{S} = y - \tau - r\mathscr{V}_u - s\mathscr{S} + \lambda_e \int_{\varepsilon_e}^{\bar{\varepsilon}} \left[\varepsilon - \pi\mathscr{S} - \pi(\mathscr{V}_u - \mathscr{V}_p)\right] dG(\varepsilon). \quad (9)$$

Equation (9) has the following interpretation. A match generates a flow surplus, $y - \tau - r\mathscr{V}_u$, composed of the output of the job minus taxes (including the loss due to victimization of the worker) and the permanent income of an unemployed person, $r\mathscr{V}_u$. The match is destroyed if an exogenous shock occurs, with an instantaneous probability s, or if the worker commits a crime and is caught. In this case, the value $\mathscr{S}$ of the match is lost and the worker goes to jail which generates an additional capital loss $\mathscr{V}_u - \mathscr{V}_p$. The value of the match also incorporates the crime opportunities undertaken by the employed worker.

Suppose a worker and a firm could *jointly* determine the crime opportunities undertaken by the worker. It can be seen from (9), that the surplus of the match is maximized if

$$\varepsilon_e = \pi(\mathscr{S} + \mathscr{V}_u - \mathscr{V}_p) = \pi\left(\mathscr{V}_e + \mathscr{V}_f - \mathscr{V}_p\right). \tag{10}$$

Comparison of (5) and (10) reveals that if $\mathscr{V}_f > 0$, the worker's choice of which crime opportunities to undertake and the choice that maximizes the match surplus differ, i.e. the total surplus of the match is not maximized. Employed workers commit too much crime because they do not internalize the negative externality they impose on the firm if they commit a crime and are sent to jail.

We show that by allowing the employment contract to include an upfront fee, ϕ, the worker and the firm can reach a pairwise-efficient outcome.[10] The employment contract (ϕ, w) is determined by the generalized Nash solution where the worker's bargaining power is $\beta \in [0,1]$. The contract satisfies

$$(\phi, w) = \arg\max\left(\mathscr{V}_e - \mathscr{V}_u - \phi\right)^{\beta}\left(\mathscr{V}_f + \phi\right)^{1-\beta}. \tag{11}$$

Lemma 1 *The employment contract solution to (11) is such that*

$$w = y, \tag{12}$$

$$\phi = (1-\beta)\left(\mathscr{V}_e - \mathscr{V}_u\right). \tag{13}$$

Proofs of the lemmas and propositions can be found in the appendix. According to Lemma 1, the wage is set to be equal to the worker's productivity. Since the worker gets the entire output generated by the match this wage setting guarantees that the worker internalizes the effect of their crime decision on the total surplus of the match. The up-front payment is used to split the surplus of the match according to each agent's bargaining power.[11]

[10] In the wage-posting model of Burdett et al. (2003), firms are restricted to post contracts promising a constant wage. This restriction generates an inefficient turnover of workers and, for some parameter values, a nondegenerate distribution of wages. If the employment contract is restricted to a constant wage, the bargaining set may not be convex in which case the Nash solution cannot be used. For an elaboration of this point in a related context, see Shimer (2005).

[11] Alternatively, the optimal contract could take the form of a constant wage, w, and a payment from the worker

4 Equilibrium

In this section we will establish that the model has a simple recursive structure that can be exploited to study the properties of equilibrium. In particular, we will show that the model can be reduced to two equations and two unknowns, market tightness (θ) and the reservation value for crime opportunities (ε_u).

First, we can use the free-entry condition of firms to express the worker's and firm's surpluses from a match as functions of market tightness. From (8), $\mathscr{V}_f = 0$ implies

$$\phi = \frac{\gamma}{q(\theta)}. \tag{14}$$

The gain from filling a vacancy is equal to the up-front payment, ϕ, which equals the average recruiting cost incurred by the firm to fill a vacancy. The expected surplus received by an unemployed worker who finds a job is

$$-\phi + \mathscr{V}_e - \mathscr{V}_u = \frac{\beta\gamma}{(1-\beta)q(\theta)}. \tag{15}$$

The worker's surplus from a match is $\frac{\beta}{1-\beta}$ times the expected recruiting costs incurred by firms.

Second, using the Bellman equations (1), (2) and (3), as well as the expression for the worker's surplus, (15), the crime decisions (4)-(5) can be rewritten as follows:

$$\left(\frac{r+\delta}{\pi}\right)\varepsilon_u = b - x + \frac{\beta}{1-\beta}\theta\gamma + \lambda_u \int_{\varepsilon_u}^{\bar{\varepsilon}} [1-G(\varepsilon)]\,d\varepsilon, \tag{16}$$

$$\left(\frac{r+\delta}{\pi}\right)\varepsilon_e = y - x + \frac{(\delta-s)\gamma}{q(\theta)(1-\beta)} + \lambda_e \int_{\varepsilon_e}^{\bar{\varepsilon}} [1-G(\varepsilon)]\,d\varepsilon. \tag{17}$$

Given θ, (16)-(17) determine a unique pair $(\varepsilon_u, \varepsilon_e)$ of threshold values for crime decisions. Notice that (16)-(17) correspond to standard optimal stopping rules where the left-hand side represents the gain from stopping (expressed in flow terms and adjusted for the probability of being caught) and the right-hand side is the flow gain from continuing to search for opportunities. Also, (16) gives us our first relationship between ε_u and θ.

Next, we turn to the determination of market tightness. Substitute (15) into (1) and integrate the integral term in (1) by parts, the permanent income of an unemployed worker obeys

$$r\mathscr{V}_u = b - \tau + \frac{\beta}{1-\beta}\theta\gamma + \lambda_u \int_{\varepsilon_u}^{\bar{\varepsilon}} [1-G(\varepsilon)]\,d\varepsilon. \tag{18}$$

to the firm if the worker is caught committing a crime. This transfer would exactly compensate the firm for its lost surplus. A loose, but somewhat realistic interpretation of our contract, is to think of ϕ in terms of a probation period. See also Diamond and Maskin (1979) and Mortensen (1982).

From (2) and (18) and using the fact that $\mathscr{V}_e - \mathscr{V}_u = \gamma / [(1-\beta)q(\theta)]$, market tightness satisfies

$$\frac{(r+s)\gamma}{(1-\beta)q(\theta)} = y - b - \frac{\beta}{(1-\beta)}\theta\gamma - \lambda_u \int_{\varepsilon_u}^{\bar{\varepsilon}} [1-G(\varepsilon)]\, d\varepsilon + \lambda_e \int_{\varepsilon_e}^{\bar{\varepsilon}} [1-G(\varepsilon)]\, d\varepsilon. \tag{19}$$

Given the thresholds ε_u and ε_e, (19) determines a unique θ. Up to the last two terms on the right-hand side, (19) is identical to the equilibrium condition in the Pissarides model. If crime activities are more valuable for unemployed workers than for employed ones, i.e., the sum of the last two terms is negative, then the presence of crime opportunities tends to reduce market tightness. Using (5)

$$\varepsilon_e = \varepsilon_u + \frac{\pi\gamma}{(1-\beta)q(\theta)}. \tag{20}$$

Substituting ε_e by its expression given by (20) into (19) we obtain a relationship between ε_u and θ,

$$\begin{aligned} \frac{(r+s)\gamma}{(1-\beta)q(\theta)} &= y - b - \frac{\beta}{(1-\beta)}\theta\gamma - \lambda_u \int_{\varepsilon_u}^{\bar{\varepsilon}} [1-G(\varepsilon)]\, d\varepsilon \\ &\quad + \lambda_e \int_{\varepsilon_u + \frac{\pi\gamma}{(1-\beta)q(\theta)}}^{\bar{\varepsilon}} [1-G(\varepsilon)]\, d\varepsilon. \end{aligned} \tag{21}$$

Equation (21) gives us our second relationship between ε_u and θ. According to (21), if $\lambda_u[1 - G(\varepsilon_u)] > \lambda_e[1-G(\varepsilon_e)]$ then θ increases with ε_u. This condition is satisfied, for instance, if $\lambda_u = \lambda_e$.

Finally, we characterize the steady-state distribution of individuals across states. The distribution (n_u, n_e, n_p) is determined by the following steady-state conditions:

$$sn_e + n_p\delta = \{\theta q(\theta) + \lambda_u \pi [1-G(\varepsilon_u)]\}\, n_u, \tag{22}$$

$$\theta q(\theta) n_u = \{s + \lambda_e \pi [1-G(\varepsilon_e)]\}\, n_e, \tag{23}$$

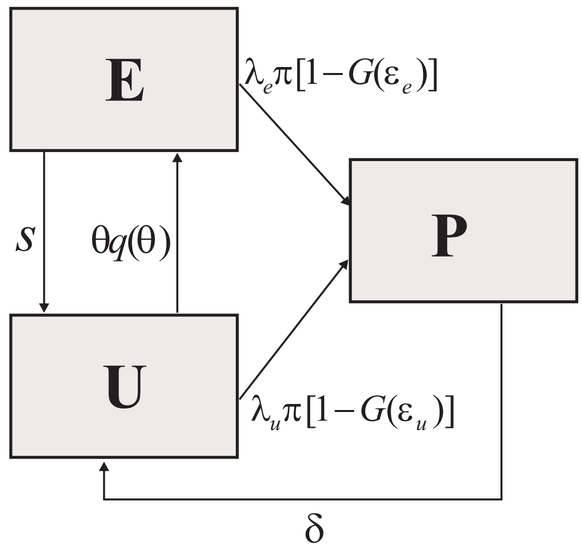
$$n_e + n_u + n_p = 1. \tag{24}$$

According to (22) the flows in and out of unemployment must be equal. The measure of individuals entering unemployment is the sum of the employed workers who lose their jobs, sn_e, and the criminals who exit jail, $n_p\delta$. The flow of individuals exiting unemployment corresponds to individuals finding jobs, $\theta q(\theta) n_u$, or unemployed individuals committing crimes and sent to jail, $\lambda_u \pi [1-G(\varepsilon_u)] n_u$. Similarly, (23) prescribes that the flows in and out of employment must be equal in steady state. According to (24), individuals are either employed, unemployed, or in jail. Figure 1 diagrams the above-mentioned flows.

The equilibrium unemployment rate u is defined as the fraction of individuals not in jail who are unemployed. From (23), it satisfies

$$u = \frac{s + \lambda_e \pi [1-G(\varepsilon_e)]}{\theta q(\theta) + s + \lambda_e \pi [1-G(\varepsilon_e)]}. \tag{25}$$

Figure 1: Worker Flows



As in Mortensen and Pissarides (1994), the unemployment rate decreases with market tightness and increases with the job destruction rate which, in our model, depends on ε_e. The rate at which jobs are destroyed is endogenous, it depends on employed workers' decision to commit crimes.

We close the model by computing the loss incurred by individuals from being victimized. Since each dollar stolen by a criminal generates a loss of $1+\omega$ dollars to its victim, the instantaneous losses that individuals suffer from criminal activities are equal to

$$\tau^c = (1+\omega)\left[\lambda_e n_e \int_{\varepsilon_e}^{\bar{\varepsilon}} \varepsilon dF(\varepsilon) + \lambda_u n_u \int_{\varepsilon_u}^{\bar{\varepsilon}} \varepsilon dF(\varepsilon)\right]. \tag{26}$$

We are now ready to define an equilibrium for the model.

Definition 1 *A steady-state equilibrium is a list* $\{\theta,\ \varepsilon_u,\ \varepsilon_e,\ n_e,\ n_u,\ n_p, \tau^c\}$ *such that:* θ *satisfies (21);* $(\varepsilon_u,\ \varepsilon_e)$ *satisfies (16)-(17);* $(n_e,\ n_u,\ n_p\}$ *satisfies (22)-(24) and* τ^c *that satisfies (26).*

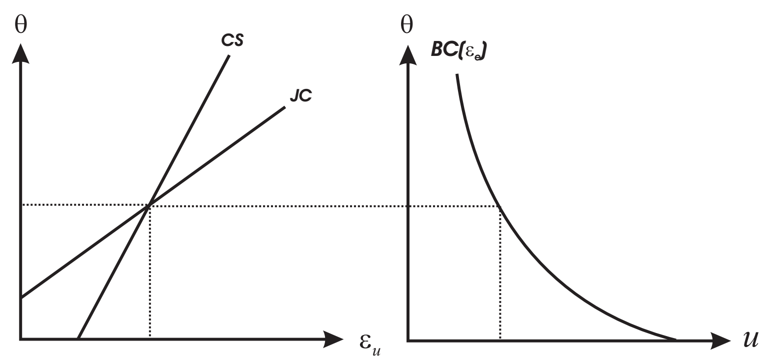
As indicated above, the model is recursively solvable. First, the pair (θ, ε_u) is determined jointly from (16) and (21). Second, knowing (θ, ε_u), one can use (20) to find ε_e. Finally, knowing $(\theta, \varepsilon_u, \varepsilon_e)$ the steady-state distribution (n_e, n_u, n_p) is obtained from (22)-(24).

Figure 2 represents the determination of the pair (θ, ε_u). We denote *CS* (crime schedule) the curve representing (16) and *JC* (job creation) the curve representing (21). Recall that *CS* always slopes upward while *JC* can slope upward or downward depending on the the values of λ_e and λ_u.

In the case where $\lambda_u = \lambda_e$ the two curves slope upward. Along *CS*, as the number of vacancies per unemployed increases, unemployed workers are less likely to commit crimes. Along *JC*, as the frequency of crime by the unemployed falls, the number of jobs in the market increases. The Beveridge curve (25) is denoted $BC(\varepsilon_e)$. It shifts with the reservation value ε_e which from (20) is uniquely determined from θ and ε_u. In Figure 2, the curves *CS* and *JC* intersect once. The following lemma establishes that this result holds in general.

Lemma 2 *In the space* (ε_u, θ) *the curve JC intersects the curve CS from above.*

Figure 2: Equilibrium



Interestingly, the determination of equilibrium is reminiscent of the one in Mortensen and Pissarides (1994) where labor market tightness and the job destruction rate are determined jointly. The *CS* curve in our model is analogous to the job destruction curve in the Mortensen-Pissarides model in that workers' crime decisions affect the duration of a job.

Denote ε_u^0 the value of ε_u that solves (16) when $\theta = 0$. The following proposition provides a simple condition under which there is a unique equilibrium with a positive number of jobs.

Proposition 1 *There exists a unique equilibrium such that* $\theta > 0$ *if*

$$y - b + (\lambda_e - \lambda_u) \int_{\varepsilon_u^0}^{\bar{\varepsilon}} [1 - G(\varepsilon)] d\varepsilon > 0. \tag{27}$$

Proposition 1 shows that equilibrium exists and is unique. So despite the possibility of strategic complementarities between individuals' crime decisions and firms' entry decisions, there is no multiple steady-state equilibria in this model. The condition (27) for firms entering the market requires that the rate at which unemployed workers receive crime opportunities is not too high compared to the arrival rate of crime opportunities for employed workers; obviously, it is satisfied if $\lambda_e = \lambda_u$.

Proposition 2 *In any equilibrium where $\theta > 0$, $\varepsilon_e > \varepsilon_u$.*

Proposition 2 shows that unemployed workers are less picky than other individuals when choosing which crime opportunities to accept. To see this, note that employed workers are paid their productivity, which is larger than the income they receive when unemployed. Therefore, the opportunity cost of being caught and sent to jail is higher for employed workers. In the particular case where $\lambda_u = \lambda_e$ Proposition 2 implies that the crime rate of unemployed workers is larger than the crime rates of employed workers and individuals out of the labor force, a fact that is present in the data as shown below.

The following Proposition provides a condition under which the equilibrium is characterized by no criminal activities. Denote $\hat{\theta}$ the value of market tightness that solves

$$\frac{(r+s)\,\gamma}{q(\hat{\theta})} = (1-\beta)\,(y-b) - \beta\,\hat{\theta}\,\gamma. \tag{28}$$

This is the market tightness that would prevail in an economy without crime.

Proposition 3 *If*

$$\frac{(r+\delta)}{\pi}\bar{\varepsilon} \leq b - x + \frac{\beta}{1-\beta}\hat{\theta}\gamma \tag{29}$$

then the equilibrium is such that $\theta = \hat{\theta}$ and no crime occurs.

According to Proposition 3, there is no crime in equilibrium provided that the probability of being caught is sufficiently high and the time spent in jail is sufficiently long. Interestingly, in this case the model reduces to the Pissarides model.

5 Welfare

We assume that the discount rate is close to 0 and measure society's welfare, $\mathscr{W}$, as the sum of all agents' utility flows in steady state,[12]

$$\mathscr{W} = n_u(b-\theta\gamma)+n_e y+n_p x-\omega\left[\lambda_e n_e\int_{\varepsilon_e}^{\bar{\varepsilon}}\varepsilon dF(\varepsilon)+\lambda_u n_u\int_{\varepsilon_u}^{\bar{\varepsilon}}\varepsilon dF(\varepsilon)\right]. \tag{30}$$

From (30) welfare is the sum of unemployed workers' consumption (b), the output (y) produced in each match, and the utility flows of workers in jail (x) minus the recruiting expenses incurred by firms to find unemployed workers (γ) and the deadweight loss imposed by criminal activities.[13] The planner is subject to the same matching frictions, summarized by $m(U,V)$, as individuals and takes π, the technology to catch criminals, and δ, the jail sentence, as given. So the planner can only choose the entry of vacancies and crime decisions.

To conduct our welfare analysis, we normalize individuals' utility flow in jail to $x=0$ and assume that $b>0$ so that prisoners get the lowest utility. As long as $\pi>0$ the planner would always want to have no crime since otherwise some individuals end up in jail where they are unproductive. By setting $\varepsilon_u=\varepsilon_e=\bar{\varepsilon}$ the planner maximizes the number of individuals who are either employed or unemployed.

From (25) $u=\frac{s}{\theta q(\theta)+s}$ and assuming $\varepsilon_u=\varepsilon_e=\bar{\varepsilon}$ the expression for social welfare can be simplified to

$$\mathscr{W} = \frac{s}{s+\theta q(\theta)}(b-\theta\gamma)+\frac{\theta q(\theta)}{s+\theta q(\theta)}y. \tag{31}$$

According to (31) a fraction $\frac{s}{s+\theta q(\theta)}$ of workers are unemployed and receive b while the remaining fraction are employed and generate output y. The total number of vacancies is $\frac{s\theta}{s+\theta q(\theta)}$ and each vacancy incurs a flow cost γ. Maximizing welfare with respect to θ leads to the following necessary conditions:

$$\frac{s\gamma}{[1-\eta(\theta)]q(\theta)} = y-b-\frac{\eta(\theta)}{1-\eta(\theta)}\gamma\theta \tag{32}$$

where $\eta(\theta)\equiv-\theta q'(\theta)/q(\theta)$ is the elasticity of the matching function. The constrained-efficient allocation prescribed by (32) is independent of the policy (π,δ).

Let us next turn to the comparison of the equilibrium allocation and the optimal one. Suppose first that $\omega=0$ so that crimes are pure transfers. Provided that condition (29) is not satisfied some

[12]See Hosios (1990) and Pissarides (2000) for a similar approach. A full optimal control problem would deliver analogous results.

[13]The number of vacancies in equilibrium is equal to the product of market tightness, θ, and the measure of unemployed workers, n_u.

crimes occur in equilibrium. As a consequence, there is a positive measure of agents who are in jail which creates a welfare loss. This loss can be removed by setting $\pi = 0$.[14] However, in our model the presence of crime opportunities distorts firms' decisions to enter the market. To see this, suppose that $\pi = 0$, and agents take all crime opportunities, $\varepsilon_e = \varepsilon_u = 0$. The equilibrium condition (21), assuming that $r \approx 0$, becomes

$$\frac{s\gamma}{(1-\beta)q(\theta)} = y - b - \frac{\beta}{(1-\beta)}\theta\gamma + (\lambda_e - \lambda_u)\int_0^{\bar{\varepsilon}} [1 - G(\varepsilon)]\, d\varepsilon \tag{33}$$

Compare (32) with the equilibrium conditions (33). If $\lambda_e = \lambda_u$ then the planner's choices coincide with the equilibrium allocation if and only if $\beta = \eta(\theta)$, the Hosios condition holds. If the arrival rates of crime opportunities are not equal for individuals with different labor status, then crime does affect firms' entry decisions. For instance, if $\lambda_u > \lambda_e$ too few firms open vacancies (assuming the Hosios condition holds). Finally, in the case where $\omega > 0$ the constrained-efficient allocation cannot be achieved since when $\pi = 0$ all crime opportunities are undertaken which generates a direct welfare loss to society and if $\pi > 0$ some individuals end up in jail —assuming (29) is not satisfied— which also creates a welfare loss. In the quantitative analysis below we will also take into account welfare costs associated with the fact that the police technology π and the punishment technology δ require real resources.

6 Calibrated example

The model is calibrated to the U.S. labor market, relying extensively on Shimer (2005). We note at the outset of this section that many of the parameters and targets will differ depending on the population of interest. For example, the job destruction rate is three times the average for those age 16-24 (those more at risk of committing crime) and the unemployment rate is substantially higher than for the sample using all workers. Therefore, the quantitative findings depend upon the group being observed.

The unit of time corresponds to one year and the rate of time preference is set to $r = 0.048$. The output from a match is normalized to $y = 1$. The flow of utility when unemployed is $b = 0.4$.[15]

[14] If crimes impose a direct cost on the victim above what is stolen then there would be a welfare loss even if $\pi = 0$. In this case, there would be a motive to raise π above 0 to deter crimes. This happens in our model as a result of other distortions (entry decisions). In the model by Burdett, Lagos and Wright (2003, 2005), crime imposes a cost on society only when individuals are sent to jail. The optimal policy in their model is therefore not to catch or punish criminals.

[15] The choice of the value for b is controversial, see Hagedorn and Manovskii (2006) for an alternative calibration.

The matching function is assumed to be Cobb-Douglas, $m(U,V) = AU^{\eta}V^{1-\eta}$ with constant returns to scale and we set $\eta = 0.5$. We set the bargaining power of the worker, $\beta = 0.5$. Setting $\beta = \eta = 0.5$ means the wage internalizes the congestion and thick market externalities associated with firms' entry decisions, (see Hosios, 1990).[16]

The job finding rate is defined as

$$f_t = 1 - \frac{u_{t+1} - u^s_{t+1}}{u_t}, \tag{34}$$

where u^s_t denotes the number of workers unemployed for less than one month in month t, and u_t be the total number of unemployed in month t. For the years 1951-2003 $f_t = 0.45$ per month, implying the annualized expected number of job offers, $\theta q(\theta)$, is 5.40. The parameters A and γ are chosen to match the average job finding rate and the average $v-u$ ratio. In the model the vacancy to unemployment ratio, θ, is arbitrary and normalized to one. Therefore, we set $A = 5.40$ and $\gamma = 0.513$.

We infer the job separation rate using the two unemployment series given above. In the data, when a worker is separated from her job, she has on average half a month to find a new job before she is recorded as unemployed. Therefore, letting e_t be the number employed in month t we calculate the separation rate as

$$s_t = \frac{u^s_{t+1}}{e_t(1 - \frac{1}{2}f_t)}, \tag{35}$$

which is 0.034. This implies an annualized rate of 0.408, i.e., jobs last, on average, about 2 years.

The crimes considered are Type I property crimes as defined by the FBI, which includes larceny, burglary, and motor vehicle theft. We exclude violent and drug-related crimes because they are not necessarily driven by economic incentives.[17] Finally, the FBI defines Forgery, Fraud, and Embezzlement as a Type II offense and does not collect the number of these types of crimes.

The crime rate (crimes per 1000 persons) is taken from the Uniform Crime Reports for the population sixteen and over. The probability of being caught is derived from the number sent to prison divided by the number of crimes, implying $\pi = 0.019$. We exclude those sentenced to probation when calculating the probability of being caught because individuals on probation or parole may not be forced out of employment. The mean length of incarceration for those convicted of a property crime was 16 months in 2002, so that $\delta = 0.75$. The average per capita loss from

[16]However, as shown above, it does not guarantee that equilibrium is constrained-efficient because of the presence of crime opportunities. Our value for η is between those given in Shimer (2005) and Flinn (2006).

[17]See Cozzi (2005) for an analysis on the link between drugs and crime.

crime is calculated by taking the dollar value stolen divided by the number of individuals and normalized by the wage, implying $\tau^c = 0.002$.[18] Since we do not have much information on the utility or disutility from being in jail, we let $x = 0$.[19]

We assume that the distribution of the value of crime opportunities $G(\mu_g, \sigma_g)$ is log normal.[20] We choose the mean of the log of ε, μ_g and the standard deviation, σ_g, to target the average amount stolen, the remaining parameters $\lambda_e = \lambda_u$ target the overall crime rate. The average amount stolen in the data is approximately \$1243, calculated as the ratio of the dollar value stolen divided by the number of crimes. The crime rates for employed and unemployed (which correspond to $\lambda_i[1 - G(\varepsilon_i)]$ in the model) are 3.6% and 17.2%, respectively. The crime rate when in a particular labor force state is computed as the product of the number of crimes and the percent incarcerated when in the particular state, divided by the number in that state. Unfortunately, there is little direct evidence to assist in choosing σ_g. The benchmark sets $\sigma_g = 1$, and weighting the two expectations of the dollar value stolen for each state by the proportion of crime committed in each state gives the result $\mu_g = -5.951$.[21] Finally, Cohen (1988) calculates the average costs of property crime to the victim, including pain and suffering, to be \$1374. Therefore, we calibrate $\omega = 0.105$.

For our welfare analysis, we assume that the technology to catch criminals is costly, and maintaining individuals in jail involves some real resources. We follow Imrohoroglu, Merlo, and Rupert (2000) and assume that the cost to a technology, π, takes the form

$$C(\pi) = \bar{C}\pi^{\frac{-1}{\nu}}.$$

We estimate $\nu = 0.637$ and $\bar{C} = 7.681$ using police and court expenditures.[22] The cost of a prisoner

[18]The total number of property crimes is reported in the Uniform Crime Reports, 2004, Table 1. The total dollar amount lost from crime is published in the Uniform Crime Reports 2004, Table 24. The population is non-institutional as defined and calculated by the Bureau of Labor Statistics.

[19]We have tested different values for x and have verified that the calibration is basically unaffected. The threshold values ε_i fall as x rises, which decreases our target for μ_g. The effects on the arrival rates of crime are found to be quite small.

[20]Exponential and uniform distributions were also tried. The results from the exponential distribution were not remarkably different. In contrast, the uniform distribution resulted in the calibrated values for the arrival rates of crime opportunities to be very low, nearly two hundred times lower than under the log normal.

[21]We also attempted to calibrate σ_g to target either the elasticity between crime and time incarcerated, or the correlation between business cycle flucuations in unemployment and crime. These targets imply a $\sigma_g < 0.5$ and $\lambda_i < 0.1$, that is individuals receive less than one crime opportunity every ten years on average. In order to stay close to the spirit of the model, we chose to set $\sigma_g = 1$ in order to maintain a sufficiently high arrival rate of crime opportunities.

[22]To estimate the parameters ν and $\bar{C}$, we use the statistical model $\ln C_t = \ln \bar{C} - \frac{1}{\nu}\pi_t + e_t$ where C_t is per capita police and court expenditures, π_t is the probability of being caught, and e_t is an independent and identically normally distributed random term with zero mean and finite variance. Police and court expenditures are taken from the survey on Criminal Justice Expenditure and Employment from 1992 to 2004.

is estimated to be 0.745.[23] We choose the level of taxes to finance both types of expenditures, $\tau^g = 0.745 n_p + \bar{C}(1-\pi)^{\frac{-1}{\nu}}$.

Table 1 provides a summary of the parameters used in the calibration.

Table 1: Parameters

r	0.048	real interest rate
b	0.400	unemployed utility flow
β	0.500	bargaining power of workers
η	0.500	elasticity of matching function
γ	0.513	recruiting cost
s	0.408	job destruction rate
A	5.400	efficiency of matching technology
x	0.000	utility flow when in jail
π	0.019	apprehension probability
δ	0.750	rate of exit from jail
$\lambda_e = \lambda_u$	3.726	flow of crime opportunities
μ_g	−5.963	mean of log normal crime distribution
σ_g	1.000	s.d. of log normal crime distribution
ω	0.105	dead-weight loss from crime
$\bar{C}$	7.681	efficiency of apprehehension technology
ν	0.637	elasticity of apprehehension technology

7 Labor market policies

In this section we examine qualitatively and quantitatively how changes in some labor market policies affect crime and labor market outcomes.

7.1 Unemployment benefits

Over the last decade several countries have reduced the generosity of their unemployment insurance systems in order to increase the incentives of the unemployed to accept jobs and to reduce pressure on wages, for example the Job Seekers Allowance in the U.K. To illustrate the effects of unemployment benefits in our model, we consider an increase in the income flow, b, received by unemployed workers financed by an increase in τ^g.[24]

[23] The estimate for the cost of a prisoner comes from the survey State Prison Expenditures (2001) according to which the operating and capital costs of holding an inmate is $22,650.

[24] Unemployment insurance benefits, in practice, require certain eligibility conditions and are usually terminated after a fixed number of periods. We abstract from these in the model and calibration. For a more detailed treatment, see Holmlund (1998).

Proposition 4 *An increase in b: reduces θ; raises ε_u; decreases ε_e if $\delta > s$ and increases it if $\delta < s$.*

In Figure 2, for given θ, an increase in b provides unemployed workers with lower incentives to commit crimes: The curve CS shifts to the right. For given ε_u, an increase in b raises the threat point of workers when bargaining so that fewer firms enter the market: The curve JC shifts downward. Although the overall effect seems ambiguous, Proposition 4 establishes that the measure of vacancies per unemployed falls as well as unemployed workers' incentives to commit crimes.

Changing the value of being unemployed, however, will also affect crime decisions of the employed. Suppose that the value of being unemployed, $\mathscr{V}_u$, increases. The crime rate of employed workers depends on the average jail sentence and job duration because employed workers and individuals in jail will ultimately end up in the pool of unemployed. [25] The transition from employment to unemployment occurs at rate s, while the transition from jail to unemployment occurs at rate δ. If $\delta > s$ then the value of being in jail tends to increase relatively more, raising the incentive to commit crimes. In contrast, if $\delta < s$ then employed workers commit fewer crimes.

Quantitatively, δ is almost twice s, therefore the crime rate increases for those employed when b rises, though only slightly, from 0.041 to 0.042 as shown in Table 2. In addition, the findings also suggest that, in contrast to the previous studies that focus on the partial equilibrium effect of unemployment benefits on the crime rate of unemployed workers, overall crime increases with the level of unemployment benefits, although the change is quite small, from 42.46 to 43.75.

Welfare is computed as in (30) where we substract the tax $n_u db$ where db denotes the change in unemployment benefits. A change in b has a negative effect on welfare by altering firms' decisions to enter the market so that the best policy is to leave b unchanged.

The job destruction rate is sensitive to the population of interest. Specifically, the job destruction rate is three times the average for those age 16-24, or $s = 1.1$, but relatively the same for females, $s = 0.456$. Therefore, it is possible to observe different comparative statics depending upon the group being observed.

7.2 Worker's compensation

In accordance with Becker (1968), it has been well documented that workers' compensation is an important determinant of crime (Gould, Weinberg, and Mustard (2002)). In the following, we will

[25] A related result can be found in Burdett, Lagos and Wright (2003).

Table 2: Effects of Changing Unemployment Benefits (b)

	b				
	0.2	0.3	0.4	0.5	0.6
	Labor Force				
Employed	94%	93%	93%	92%	91%
Unemployed	6%	7%	7%	8%	9%
	Crime				
Pr(Commit Crime | e)	0.04	0.041	0.041	0.042	0.042
Pr(Commit Crime | u)	0.063	0.062	0.061	0.06	0.058
Total Crime Rate	41.41	41.91	42.46	43.06	43.74
Change in Welfare	-0.08%	-0.02%	–	-0.05%	-0.21%

consider different policies that affect payments to workers.

7.2.1 Workers' bargaining strength

We start with the effect of a change in workers' bargaining power. While β may not necessarily be viewed as a policy parameter, it may be influenced by government's tolerance vis-a-vis unions, for instance.

Proposition 5 *An increase in β:*

- *reduces θ;*
- *increases ε_u if $\beta < \eta(\theta)$ and decreases it if $\beta > \eta(\theta)$;*
- *increases ε_e if $\delta > s$ and $\beta > \eta(\theta)$ or $\delta < s$ and $\beta < \eta(\theta)$, and increases it otherwise.*

The previous Proposition shows that an increase in β has two effects on unemployed worker's utility. On the one hand, workers enjoy a larger share of the match surplus which tends to make them better-off (they pay a lower hiring fee). On the other hand, a higher worker's bargaining power reduces firms' incentives to open vacancies, and therefore also reduces the job finding rate of workers. The former effect dominates if $\beta < \eta$. In this case, ε_u increases so that the unemployed workers are less likely to engage in crime, and more agents participate in the labor force. If $\beta > \eta$ then the opposite happens.

The effect of changing β on the crime rate of employed workers is analogous to that of unemployment benefits described above, i.e., it depends on the ordering of δ to s.

To assess quantitatively the effect of worker's compensation on the labor market and crime, we summarize worker's compensation in one number, an "equivalent wage" called $\bar{w}$.[26] More precisely,

$$\bar{w} = y - \{r + s + \lambda_e[1 - G(\varepsilon_e)]\}\phi. \tag{36}$$

In Table 3, when β increases from a low value to 0.5 (the Hosios condition in our calibration), it raises the value of being unemployed and therefore reduces the likelihood of committing crime by unemployed workers. On the other hand, since $\delta > s$ employed workers commit more crime. For our calibration, the positive effect of an increase in β on the crime rate of the employed dominates and the overall crime rate increases.

The effects on crime of an increase in β above 0.5 are qualitatively symmetric to those described above. The value of being unemployed falls and therefore unemployed workers commit more crimes. Since $\delta > s$ employed workers commit fewer crimes. In the labor market, an increase in β reduces tightness and increases unemployment.

Quantitatively, the relationship between the total crime rate and β is non-monotonic and highly non-linear. Reducing workers' bargaining power from 0.5 to 0.01, corresponding to a reduction of workers' compensation of about 30%, generates a reduction in the total crime rate of about 50%. On the other hand, raising workers' bargaining power from 0.5 to 0.99, which corresponds to an increase in workers' compensation of 5%, increases total crime by 77%.

Welfare is maximized for β close to 0.5. A change of β away from 0.5 distorts the entry of jobs —the Hosios (1990) condition is not satisfied. The welfare loss associated with this distortion outweights any potential gain in terms of reducing the extent of criminal activities.

7.2.2 Mandatory wages

Minimum wage laws are widely used policies that exist in many countries, including the United States, United Kingdom and countries from continental Europe. In the following we consider the effect of a mandatory change in the wage on both the labor market and crime.[27] Since it is

[26]The idea is to use one number that can be compared to the productivity of the match. To derive the expression, note that ϕ is an upfront payment and the worker receives y each period. Simply divide y by the effective discount rate, $r + s + \lambda_e[1 - G(\varepsilon_e)]$.

[27]Flinn (2006) studies the effect of a minimum wage in a related search model of the labor market with endogenous participation.

Table 3: Changes in Bargaining Power, (β)

β	0.01	0.05	0.10	0.50	0.90	0.95	0.99
$\bar{w}$	0.663	0.816	0.866	0.953	0.985	0.99	0.997
				Labor Force			
Employed	99%	98%	97%	93%	81%	73%	49%
Unemployed	1%	2%	3%	7%	19%	27%	50%
				Crime			
Pr(Commit Crime | e)	0.027	0.035	0.037	0.041	0.037	0.035	0.027
Pr(Commit Crime | u)	0.123	0.079	0.07	0.061	0.07	0.079	0.123
Total Crime Rate	28.19	35.53	38.29	42.46	43.73	46.57	75.32
Change in Welfare	-23.06%	-9.15%	-4.94%	–	-5.24%	-9.73%	-25.14%

not obvious how to interpret a minimum or mandatory wage policy in our model with an optimal employment contract, we adopt for this experiment the model without the hiring fee described in Appendix B. This alternative formulation will also allow us to check the robustness of our results to an alternative specification for wage formation.

The effect of a mandatory increase in the wage on labor market outcomes are analogous to those of an increase in β in our benchmark model. A higher wage reduces firms' incentives to open vacancies and raises unemployment. It has two opposite effects on unemployed workers' incentives to commit crime. On the one hand, a higher wage makes the prospect of finding a job more valuable which tends to decrease unemployed workers' crime rate. On the other hand, it becomes harder to find a job which tends to discourage unemployed workers and gives them higher incentives to commit crimes. For $w \leq 0.961$ —the wage that splits the match surplus evenly between the worker and the firm—the first effect dominates and the crime rate of the unemployed decreases. For $w > 0.961$ an increase in the wage raises the crime rate of the unemployed. These results are in accordance with those obtained for a change in β in the model with a hiring fee. A higher wage decreases the crime rate of the employed workers except for very high values of w (in which case the decrease in market tightness makes the value of being employed fall). Quantitatively, the effect on total crime is non-linear and depends on the initial value for the wage. If workers' share in the match surplus is too low compared to their contribution in the matching process ($w < 0.961$ for our calibration) then an increase in the wage can reduce crime significantly. Welfare is maximized for w close to 0.961 which corresponds to the match surplus being divided evenly between the worker and the firm.

Table 4: Effects of Mandatory Wage

	w						
	0.6	0.8	0.95	0.961	0.97	0.98	0.99
	Labor Force						
Employed	99%	98%	94%	93%	91%	87%	77%
Unemployed	1%	1%	6%	7%	9%	13%	23%
	Crime						
Pr(Commit Crime | e)	0.089	0.056	0.042	0.042	0.042	0.043	0.045
Pr(Commit Crime | u)	0.089	0.057	0.047	0.048	0.05	0.054	0.067
Total Crime Rate	88.54	55.66	42.65	42.46	42.73	44.05	49.59
Change in Welfare	-31.57%	-12.23%	-0.12%	–	-0.38%	-1.98%	-7.59%

7.2.3 Wage subsidies

Hoon and Phelps (2003) advocate the use of wage subsidies as a policy instrument to reduce the enrollment of low-skilled workers in criminal activities. Suppose that the government gives each employed worker a salary supplement equal to φ. (Think of φ as the discounted sum of the payments made by the government to employed workers. It would be equivalent to give the subsidy to the firm.) At the time of the negotiation both parties take into account the salary supplement so that the employment contract solves

$$(\phi, w) = \arg\max \left(\mathscr{V}_e - \mathscr{V}_u + \varphi - \phi\right)^{\beta} \left(\mathscr{V}_f + \phi\right)^{1-\beta}. \tag{37}$$

Therefore, $\phi = (1-\beta)(\mathscr{V}_e - \mathscr{V}_u + \varphi)$ and $w = y$. The wage supplement reduces the upfront payment made by the worker while the subsequent wage is unchanged. (Equivalently, the wage profile is less steep.) The equilibrium conditions for ε_e and ε_u are still given by (16) and (17). The equilibrium value for θ becomes

$$(r+s)\left[\frac{\gamma}{(1-\beta)q(\theta)} - \varphi\right] = y - b - \frac{\beta}{1-\beta}\gamma\theta + \lambda_e \int_{\varepsilon_e}^{\bar{\varepsilon}} [1 - G(\varepsilon)]\, d\varepsilon - \lambda_u \int_{\varepsilon_u}^{\bar{\varepsilon}} [1 - G(\varepsilon)]\, d\varepsilon \tag{38}$$

Proposition 6 *An increase in φ: raises θ, ε_e and ε_u.*

Wage subsidies reduce the amount that firms have to pay to workers and, consequently, promote job creation. Since the value of getting a job is higher, unemployed workers are better-off and commit fewer crimes. Similarly, it becomes more costly for employed workers to be caught committing a crime. So the overall crime rate falls. Quantitatively, a wage supplement equal to 10% of worker's yearly output reduces the crime rate by about 11%. The introduction of wage subsidies raises welfare.

Table 5: Effects of Wage Subsidies (φ)

	φ				
	0	0.05	0.1	0.15	0.2
	Labor Force				
Employed	93%	93%	93%	93%	93%
Unemployed	7%	7%	7%	7%	7%
	Crime				
Pr(Commit Crime | e)	0.041	0.039	0.037	0.035	0.033
Pr(Commit Crime | u)	0.061	0.058	0.054	0.051	0.049
Total Crime Rate	42.46	40.01	37.73	35.62	33.66
Change in Welfare	–	0.01%	0.02%	0.03%	0.03%

7.3 Hiring subsidies

A workers' incentives to commit crimes are affected by his current income as well as his prospects in the labor market. For instance, if duration of unemployment gets shorter one expects the crime rate of unemployed workers to fall, everything else being equal. Consider a policy that subsidizes the creation of vacancies. We interpret such a policy in our model as a reduction in γ.

Proposition 7 *A decrease in γ: raises θ and ε_u; decreases ε_e if $\delta > s$ and increases it if $\delta < s$.*

By reducing the cost to open vacancies, hiring subsidies promote job creation. Unemployed workers benefit from a higher job finding rate and therefore reduce their involvement in crime. Employed workers commit more crimes if $\delta > s$. (The intuition is similar to the one for an increase in b or β.) So the overall effect on crime is ambiguous. Quantitatively, reducing the hiring cost from .51 to .41 leads to an increase in crime of about 2%. Welfare is obtained by subtracting $n_u\theta d\gamma$ from (30) where $d\gamma$ is the amount of the hiring subsidy to each vacancy. For our calibration, the introduction of hiring subsidies lowers welfare.

Table 6: Effects of Hiring Subsidies (γ)

	γ				
	0.31	0.41	0.51	0.61	0.71
	Labor Force				
Employed	94%	94%	93%	92%	92%
Unemployed	5%	6%	7%	8%	8%
	Crime				
Pr(Commit Crime | e)	0.042	0.042	0.041	0.041	0.04
Pr(Commit Crime | u)	0.058	0.06	0.061	0.062	0.063
Total Crime Rate	43.3	42.82	42.46	42.17	41.94
Change in Welfare	-0.27%	-0.05%	–	-0.04%	-0.14%

7.4 Labor taxes

As argued by Mortensen and Pissarides (1999) payroll taxes can explain a significant fraction of the differences in terms of labor market performances across countries. We consider a tax on the output of a match and we reinterpret y as the output of the match net of those taxes. We assume that this tax is independent of the split of the match surplus.

Proposition 8 *A decrease in y: reduces θ, ε_e and ε_u.*

As the level of taxes increases, i.e., y decreases, a smaller measure of firms enter the market. Graphically, the JC curve shifts downward and both θ and ε_u increase. The fact that market tightness decreases implies the cost to an unemployed worker of being caught committing a crime decreases. As a consequence, unemployed workers commit more crimes. Similarly, the wage, which is equal to productivity net of taxes, decreases, decreasing employed workers' cost of being caught committing a crime. So the crime rate of employed workers increases.

Quantitatively, increasing output net of taxes by 10% decreases the overall crime rate and the probability of committing crime for each labor force status by roughly 30%.

Changes in taxes on filled jobs are used to finance a transfer of size $-n_e dy$ to all agents where $-dy$ is the change in taxes on productive matches. In accordance with our analysis on wage subsidies, a reduction of taxes on filled jobs is welfare-enhancing.

Table 7: Effects of Changing Productivity (y)

	y				
	0.9	0.95	1	1.05	1.1
	Labor Force				
Employed	92%	93%	93%	93%	93%
Unemployed	8%	7%	7%	7%	7%
	Crime				
Pr(Commit Crime | e)	0.054	0.047	0.041	0.036	0.032
Pr(Commit Crime | u)	0.079	0.069	0.061	0.054	0.048
Total Crime Rate	55.75	48.53	42.46	37.31	32.93
Change in Welfare	-0.12%	-0.04%	–	0.02%	0.03%

8 Crime policies

Imposing harsher punishments on criminals or increasing apprehension probabilities are obvious ways to reduce crime.[28] However, such changes may also affect the labor market through the outcome of the bargaining process and the duration of jobs (which is affected by the crime decisions of employed workers). In the following we consider the effects of a change in three types of policies: polices that affect the availability of crime opportunities, policies that improve the technology to catch criminals, and punishment through the length of jail sentences.

8.1 Availability of crime opportunities

Information campaigns about criminal activities, development of technologies that make payments safer, or an increase in the number of policemen on the street are different ways to reduce the availability of crime opportunities. In the following propositions we consider how the availability of crime opportunities affect individuals' crime behavior and the labor market. We allow for the possibility that the arrival rates of crime opportunities may differ for employed and unemployed workers.

Proposition 9 *A decrease in λ_e: reduces θ, ε_u and ε_e.*

[28] Levitt (2004) argues that crime has fallen in the 90's because of an increase in police surveillance. Bedard and Helland (2000) find sizeable deterrence effects of custody rate and punitiveness changes on female crime. They find that a 10% rise in the custody rate for women reduces female violent crime by approximately 5%. Increasing the average within state prison distance by 40 miles reduces the female violent crime rate by approximately 7%.

A decrease in the arrival rate of crime opportunities for employed workers moves *JC* in Figure 2 downward since the value of being employed decreases. Consequently, both θ and ε_u decrease: market tightness decreases and unemployed workers commit more crimes. Since crime opportunities arrive at a lower frequency, employed workers become less choosy in terms of the crime opportunities they undertake. Therefore, the effect on the crime rate of employed workers, as well as the overall effect on crime, is ambiguous.

Proposition 10 *An decrease in λ_u: increases θ; reduces ε_u; increases ε_e if $\delta > s$ and increases it if $\delta < s$.*

Following a reduction in λ_u, the *CS* curve in Figure 2 moves to the left since unemployed workers become less selective in terms of their crime projects when crime opportunities are less readily available. The curve *JC* moves upward since the fact that workers can commit fewer crimes lowers their disagreement point in the bargaining. So market tightness increases. The effect on the crime rate of employed workers is ambiguous and depends on the sign of $\delta - s$. (The intuition is similar to the one for an increase in b or β.)

Table 8 shows that the quantitative effects of changes in λ_e and λ_u on the labor market are negligible. Although the effect on the crime rate is ambiguous in theory, the total crime rate rises for both experiments in our calibration. The crime rate rises from 42.46 to 62.87 when the employed receive two more crime opportunities per period, from 3.73 to 5.73. The crime rate also rises with an increase in crime opportunities of the unemployed, although the effect is smaller, from 42.46 to 44.76. The reason why a change in λ_u has a smaller effect on the overall crime rate is that it affects a smaller share of the population.

Table 8: Changes in λ_e and λ_u

	λ_e			λ_u			$\lambda_u = \lambda_e$		
	1.73	3.73	5.73	1.73	3.73	5.73	1.73	3.73	5.73
				Labor Force					
Employed	93%	93%	93%	93%	93%	93%	93%	93%	93%
Unemployed	7%	7%	7%	7%	7%	7%	7%	7%	7%
				Crime					
Pr(Commit | e)	0.019	0.041	0.063	0.041	0.041	0.041	0.019	0.041	0.063
Pr(Commit | u)	0.061	0.061	0.061	0.028	0.061	0.094	0.028	0.061	0.094
Total Crime Rate	21.99	42.46	62.87	40.16	42.46	44.76	19.69	42.46	65.17

8.2 Apprehension

The use of new scientific techniques and information technologies can raise the probability of catching criminals. In our model, the effects of an increase in π on the labor market are ambiguous. On the one hand, a higher π tends to reduce employed workers' incentives to commit crimes. On the other hand, criminals are caught more often, which increases the rate of job destruction. The overall effect on job duration is ambiguous and market tightness can increase or fall.

Table 9: Changes in Criminal Apprehension(π)

	π				
	0.016	0.0175	0.019	0.0205	0.022
	Labor Force				
Employed	93%	93%	93%	93%	93%
Unemployed	7%	7%	7%	7%	7%
	Crime				
Pr(Commit Crime | e)	0.064	0.051	0.041	0.034	0.028
Pr(Commit Crime | u)	0.092	0.075	0.061	0.05	0.042
Total Crime Rate	65.65	52.48	42.46	34.72	28.66
Change in Welfare	0.33%	0.17%	–	-0.19%	-0.39%

The quantitative findings with respect to π are substantial as seen in Table 9. Increasing the probability of being caught committing a crime by about 10% cuts the total crime rate by about one third. A higher probability to catch criminals raises market tightness, but the effect is small.[29]

8.3 Jail sentences

It is well accepted that crime deterrence involves some degree of punishment for convicted criminals. Sentence lengths have been increased in several states, sentencing guidelines have become tougher, and some states have moved to "three-strikes" rules. The next proposition characterizes the effect of punishment on the labor market and crime.

Proposition 11 *Assume $\lambda_e = \lambda_u$. An increase in δ: decreases θ; decreases ε_e and ε_u.*

[29]The optimal value of π is close to 0. This result, however, is sensitive to the assumption that all individuals receive crime opportunities at the same rate (See our discussion in the section on welfare) and the estimate for the cost function $C(\pi)$.

An increase in δ, the Poisson rate at which an individual exits jail, moves the *CS* curve to the left. Since the punishment for committing crimes is weaker, both unemployed and employed workers commit more crimes and firms open fewer vacancies. Quantitatively, if the average duration spent in jail rose by 2 months, we would see a drop in total crime by a factor of one quarter. Note that the labor market is unaffected, suggesting that one can likely ignore the effects of crime policies on the labor market.

The quantitative findings with respect to δ are substantial as seen in Table 10. Increasing the rate of release after incarceration from 0.75 to 0.80 (corresponding to a decline of about one month in jail) increases the total crime rate by about 15%.[30]

Table 10: Changes in Jail Sentences(δ)

	δ				
	0.65	0.7	0.75	0.8	0.85
	Labor Force				
Employed	93%	93%	93%	93%	93%
Unemployed	7%	7%	7%	7%	7%
	Crime				
Pr(Commit Crime | e)	0.03	0.035	0.041	0.047	0.053
Pr(Commit Crime | u)	0.043	0.052	0.061	0.071	0.081
Total Crime Rate	31.03	36.56	42.46	48.67	55.18
Change in Welfare	0.04%	0.02%	–	-0.02%	-0.04%

9 Conclusion

A search-theoretic model is constructed and calibrated in which labor market outcomes and crimes are determined jointly. The description of the labor market follows the canonical model of Pissarides (2000) extended to include a participation decision. Criminal activities are described in accordance with Becker (1968). Individuals' willingness to commit crimes (their reservation values for crime opportunities), is endogenous and depends on their labor status, current and future expected incomes, the probability of apprehension as well as the expected jail sentence if caught.

[30]The optimal value for δ is small, approximatively 0.0118. As indicated earlier, this results depends on our assumption that $\lambda_e = \lambda_u$ as well as our estimate for the cost of maintaining an individual in jail.

We show existence and uniqueness of equilibrium under simple conditions. The model generates crime rates that differ across labor force status - the unemployed have the highest propensity to commit crime compared to being employed - a feature that is present in the data. The tractability of the model allows us to qualitatively and quantitatively assess the effects that changing labor market policies (such as unemployment benefits, wage and hiring subsidies) have on the equilibrium. For example, a change in unemployment benefits has different effects on unemployed and employed workers in terms of crime behavior, but the sum of those effects is quantitatively small. Wage subsidies lead to a lower unemployment rate, lower crime rates and higher welfare. We also investigated how crime policies (policies to reduce the availability of crimes, to catch criminals and punishments) affect the labor market. It is shown that quantitatively crime policies have little effects on labor market outcomes but they have large effects on crime behaviors.

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10 Appendix A. Proofs of Lemmas and Propositions

Proof of Lemma 1 According to Nash's axioms, (ϕ, w) must be pairwise Pareto-efficient. Since the up-front payment ϕ allows the worker and the firm to transfer utility perfectly, the wage, w, must be chosen to maximize the total surplus of the match. The comparison of (5) and (10) shows that the match surplus is maximized iff $\mathscr{V}_f = 0$. From (7), $\mathscr{V}_f = 0$ requires $w = y$. Finally, the first-order condition of (11) with respect to ϕ yields (13).■

Proof of Lemma 2 The slope of CS in the (ε_u, θ) space is

$$\left.\frac{d\theta}{d\varepsilon_u}\right|_{CS} = (1-\beta)\frac{r+\delta+\lambda_u\pi[1-G(\varepsilon_u)]}{\pi\beta\gamma}.$$

The slope of JC in the (ε_u, θ) space is

$$\left.\frac{d\theta}{d\varepsilon_u}\right|_{JC} = (1-\beta)\frac{\lambda_u[1-G(\varepsilon_u)]-\lambda_e[1-G(\varepsilon_e)]}{\beta\gamma-\{(r+s)\gamma+\lambda_e\pi\gamma[1-G(\varepsilon_e)]\}\frac{q'(\theta)}{[q(\theta)]^2}}.$$

Observing that

$$\frac{r+\delta}{\pi}+\lambda_u[1-G(\varepsilon_u)] > \lambda_u[1-G(\varepsilon_u)]-\lambda_e[1-G(\varepsilon_e)]$$

and

$$\beta\gamma \leq \{(r+s)\gamma+\lambda_e\pi\gamma[1-G(\varepsilon_e)]\}\frac{-q'(\theta)}{[q(\theta)]^2}+\beta\gamma,$$

it is easy to see that

$$\left.\frac{d\theta}{d\varepsilon_u}\right|_{JC} < \left.\frac{d\theta}{d\varepsilon_u}\right|_{CS}.$$

■

Proof of Proposition 1 Summing (16) and (21) one obtains

$$\frac{(r+s)\gamma}{(1-\beta)q(\theta)}+\left(\frac{r+\delta}{\pi}\right)\varepsilon_u = y-x+\lambda_e\int_{\varepsilon_u+\frac{\pi\gamma}{(1-\beta)q(\theta)}}^{\bar{\varepsilon}}[1-G(\varepsilon)]\,d\varepsilon. \tag{39}$$

From (39), it can be checked that θ is a strictly decreasing function of ε_u. So if a solution to (16) and (39) exists then it is unique. Denote $\varepsilon_u(\theta)$ the solution ε_u to the equation (16). Since $b-x>0$ then $\varepsilon_u(\theta)>0$. Furthermore, $\varepsilon_u(\theta)$ is non-decreasing in θ. Define $\Gamma(\theta)$ as

$$\Gamma(\theta) = y-x+\lambda_e\int_{\varepsilon_u(\theta)+\frac{\pi\gamma}{(1-\beta)q(\theta)}}^{\bar{\varepsilon}}[1-G(\varepsilon)]\,d\varepsilon-\frac{(r+s)\gamma}{(1-\beta)q(\theta)}-\left(\frac{r+\delta}{\pi}\right)\varepsilon_u(\theta).$$

An equilibrium is then a θ that solves $\Gamma(\theta)=0$. Using the expression for $\left(\frac{r+\delta}{\pi}\right)\varepsilon_u(\theta)$ given by (16), we have

$$\Gamma(0)=y-b+(\lambda_e-\lambda_u)\int_{\varepsilon_u^0}^{\bar{\varepsilon}}[1-G(\varepsilon)]\,d\varepsilon.$$

So if (27) holds then $\Gamma(0)>0$. Furthermore, $\Gamma(\infty)=-\infty$. Therefore, a solution exists and it is such that $\theta>0$.■

Proof of Proposition 2 The result according to which $\varepsilon_e>\varepsilon_u$ comes from (20).■

Proof of Proposition 3 From Proposition 2, no crime occurs in equilibrium iff $\varepsilon_u\geq\bar{\varepsilon}$. From (19) if $\varepsilon_u\geq\bar{\varepsilon}$ then $\theta=\hat{\theta}$. From (16) the condition $\varepsilon_u\geq\bar{\varepsilon}$ requires (29).■

Proof of Proposition 4 The pair (ε_u,θ) is uniquely determined by (16) and (39). Differentiating these two equations, it is straightforward to show that $d\varepsilon_u/db>0$ and $d\theta/db<0$. From (17) the sign of $d\varepsilon_e/db$ is the same as $s-\delta$.■

Proof of Proposition 5 The pair (ε_u,θ) is determined by (16) and (39). Differentiating these two equations one can establish that $d\theta/d\beta<0$. In order to determine the effects on ε_u we adopt the following change of variable: $\tilde{\gamma}=\gamma/[(1-\beta)q(\theta)]$. Equations (16) and (39) can now be rewritten as

$$\left(\frac{r+\delta}{\pi}\right)\varepsilon_u=b-x+\frac{\beta}{1-\beta}q^{-1}\left[\frac{\gamma}{(1-\beta)\tilde{\gamma}}\right]\gamma+\lambda_u\int_{\varepsilon_u}^{\bar{\varepsilon}}[1-G(\varepsilon)]\,d\varepsilon, \tag{40}$$

$$(r+s)\,\tilde{\gamma}+\left(\frac{r+\delta}{\pi}\right)\varepsilon_u=y-x+\lambda_e\int_{\varepsilon_u+\pi\tilde{\gamma}}^{\bar{\varepsilon}}[1-G(\varepsilon)]\,d\varepsilon. \tag{41}$$

Equations (40) and (41) determine ε_u and $\tilde{\gamma}$. The term $\frac{\beta}{1-\beta}q^{-1}\left[\frac{\gamma}{(1-\beta)\tilde{\gamma}}\right]$ on the RHS of (40) increases in β if $\beta<\eta(\theta)$. Differentiating (40) and (41) one can show that $d\varepsilon_u/d\beta>0$ if $\beta<\eta(\theta)$ and $d\varepsilon_u/d\beta<0$ if $\beta>\eta(\theta)$. To determine the effect of an increase in β on ε_e we use (17) which can be reexpressed as

$$\left(\frac{r+\delta}{\pi}\right)\varepsilon_e=y-x+(\delta-s)\tilde{\gamma}+\lambda_e\int_{\varepsilon_e}^{\bar{\varepsilon}}[1-G(\varepsilon)]\,d\varepsilon. \tag{42}$$

From (41) there is a negative relationship between ε_u and $\tilde{\gamma}$. Therefore, sign$(d\varepsilon_e/d\beta)$ =sign$[(s-\delta)d\varepsilon_u/d\beta]$.■

Proof of Proposition 6 As φ increases the curve associated with (38) moves upward in the space (ε_u, θ) while the curve associated with (16) is unaffected. Thus, both ε_u and θ increase. From (20) ε_e increases.■

Proof of Proposition 7 Following the proof of Proposition 5, we adopt the following change of variable: $\tilde{\gamma} = \gamma/[(1-\beta)q(\theta)]$. The pair $(\tilde{\gamma}, \varepsilon_u)$ is determined by (40) and (41) which can be rewritten as

$$\left(\frac{r+\delta}{\pi}\right)\varepsilon_u = b - x + +\beta p \circ q^{-1}\left[\frac{\gamma}{(1-\beta)\tilde{\gamma}}\right]\tilde{\gamma} + \lambda_u \int_{\varepsilon_u}^{\bar{\varepsilon}} [1-G(\varepsilon)]\,d\varepsilon, \tag{43}$$

$$(r+s)\,\tilde{\gamma} + \left(\frac{r+\delta}{\pi}\right)\varepsilon_u = y - x + \lambda_e \int_{\varepsilon_u+\pi\tilde{\gamma}}^{\bar{\varepsilon}} [1-G(\varepsilon)]\,d\varepsilon. \tag{44}$$

where $p(\theta) = \theta q(\theta)$. Equation (43) gives a positive relationship between ε_u and $\tilde{\gamma}$ while (44) defines a negative relationship between ε_u and $\tilde{\gamma}$. It can be checked from (43) and (44) that $d\varepsilon_u/d\gamma < 0$ and $d\tilde{\gamma}/d\gamma > 0$. From (17) the sign of $\partial\varepsilon_e/\partial\tilde{\gamma}$ is the same as $\delta - s$. Finally, from (16) ε_u increases if $\theta\gamma$ increases which implies $d\theta/d\gamma < 0$.■

Proof of Proposition 8 Equation (16) is independent of y or s. Therefore, it is easy to show from (16) and (39) that both θ and ε_u increase following an increase in y or a decrease in s. From (20) one can show that

$$\frac{d\varepsilon_e}{dy} = \frac{d\varepsilon_u}{dy} + \frac{\pi\gamma}{(1-\beta)}\left(\frac{-q'}{q^2}\right)\frac{d\theta}{dy} > 0.$$

Similarly, $\frac{d\varepsilon_e}{ds} < 0$. Following the proof in Proposition 4 one can establish that $\mathcal{V}_u$ and κ_u increase with y or $1/s$.■

Proof of Proposition 9 Differentiating (16) and (21) one can establish that $d\theta/d\lambda_e > 0$ and $d\varepsilon_u/d\lambda_e > 0$. From (20), $d\varepsilon_e/d\lambda_e > 0$.■

Proof of Proposition 10 Differentiating (39) and (16), one can establish that $d\varepsilon_u/d\lambda_u > 0$ and $d\theta/d\lambda_u < 0$. According to (17), the sign of $d\varepsilon_e/d\lambda_u$ is the same as the sign of $s - \delta$.■

Proof of Proposition 11 The pair (ε_u, θ) is determined jointly by (16) and (21) where (21) is independent of δ. It is straightforward to show that $d\varepsilon_u/d\delta < 0$ and $d\theta/d\delta < 0$. From (20), $d\varepsilon_e/d\delta < 0$.■

11 Appendix B: Model without hiring fees

In this Appendix we describe succinctly the model without hiring fees ($\phi = 0$) and an exogenous constant wage. Workers' crime decisions are given by (4) and (5) which can be rearranged to get

$$\left(\frac{r+\delta+\theta q(\theta)}{\pi}\right)\varepsilon_u = b - x + \frac{\theta q(\theta)}{\pi}\varepsilon_e + \lambda_u \int_{\varepsilon_u}^{\bar{\varepsilon}} [1 - G(\varepsilon)]\, d\varepsilon \tag{45}$$

$$\left(\frac{r+\delta+s}{\pi}\right)\varepsilon_e = w - x + \frac{s}{\pi}\varepsilon_u + \lambda_e \int_{\varepsilon_e}^{\bar{\varepsilon}} [1 - G(\varepsilon)]\, d\varepsilon \tag{46}$$

Market tightness comes from (6) and (7),

$$\frac{\gamma}{q(\theta)} = \frac{y - w}{r + s + \lambda_e \pi [1 - G(\varepsilon_e)]}. \tag{47}$$

A steady-state equilibrium is then a list $\{\theta, \varepsilon_u, \varepsilon_e, n_e, n_u, n_p\}$ such that: θ satisfies (47); $(\varepsilon_u, \varepsilon_e)$ satisfies (45)-(46); $(n_e, n_u, n_p\}$ satisfies (22)-(24) and τ that satisfies (26).

We recalibrate the model exactly the same as in Section 6 except where the wage is set at the point where the worker and firm surplus from a match is split evenly. The resulting parameter values are in Table 11.

Table 11: Parameters

r	0.048	real interest rate
b	0.400	unemployed utility flow
w	0.961	wage
η	0.500	elasticity of matching function
γ	0.459	recruiting cost
s	0.408	job destruction rate
A	5.400	efficiency of matching technology
x	0.000	utility flow when in jail
π	0.019	apprehension probability
δ	0.750	rate of exit from jail
$\lambda_e = \lambda_u$	0.570	flow of crime opportunities
μ_g	−5.261	mean of log normal crime distribution
σ_g	1.000	s.d. of log normal crime distribution
ω	0.105	dead-weight loss from crime