**Crime and the Labor Market:
A Search Model With
Optimal Contracts**

by Bryan Engelhardt, Guillaume Rocheteau
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This paper extends the Pissarides (2000) model of the labor market to include crime and punishment `a la Becker (1968). All workers, irrespective of their labor force status can commit crimes and the employment contract is determined optimally. 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.

Key words: crime, unemployment, search, matching.

JEL code: E24, J0, J63, J64

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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 could affect the labor market. 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, wages 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. Therefore, 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 trade-off that workers face when deciding whether 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 income and so on. It also depends on the punishment that an individual faces if being caught, which occurs with some probability.

Since detected crimes are punished by periods of imprisonment, employed workers' involve-

ment 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 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. (For the sake of completeness, and to assess the extent to which the assumption of an optimal contract matters, we also work out in the Appendix a version of the model with an exogenous wage 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 which 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 and to consider various extensions (such as endogenous human capital and participation in the labor force). In addition, we also calibrate a version of the model with an endogenous distribution of the return to crime opportunities 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 mainly from the sharp reduction in the job-finding rate. Because of the endogene-

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

[2]We also consider extensions of the model that are susceptible to generate multiple equilibria, e.g., by endogenizing workers' human capital; 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.

ity of the distribution of crime opportunities, the total crime rate falls substantially as bargaining power becomes large, i.e., the economy collapses and so there is little to steal.

A a wage subsidy reduces the unemployment rate 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 suggests 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).

We also examine policies that affect the likelihood of catching criminals and the length of jail sentences. 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 of 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. This distinction is important since in the data all types of individuals, in particular employed ones, commit crimes. We formalize different access to crime by allowing an arrival rate of crime opportunities that depends on labor force status.

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

2.1 Environment

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. In Section 5.2, we extend the model to allow for a third use of time: working at home (out of the labor force).

Individuals are risk-neutral and discount at rate $r > 0$. They are not liquidity constrained and can borrow and lend at rate r. An unemployed worker who is looking for a job enjoys utility flow b, which we interpret as the utility from not working.

Upon entering an employment relationship, a worker pays a hiring fee, ϕ, and receives a constant wage, w, thereafter. We establish below that this type of contract is Pareto-optimal for a worker and a firm. The pair (ϕ, w) will be determined through some bargaining solution.[5]

Firms are composed of a single job, either filled or vacant, and discount future profits at rate $r > 0$. Vacant firms are free to enter and pay a flow cost, $\gamma > 0$, to advertise a vacancy. Vacant firms produce no output while filled jobs produce $y > b$.

The labor market is subject to search-matching frictions. The flow of hirings is given by the aggregate matching function $\zeta(U, V)$ where U is the measure of unemployed workers actively looking for jobs and V is the measure of vacant jobs. The matching function, $\zeta(\cdot, \cdot)$, is continuous, strictly increasing, strictly concave with respect to each of its arguments and exhibits constant returns to scale. Furthermore, $\zeta(0, \cdot) = \zeta(\cdot, 0) = 0$ and $\zeta(\infty, \cdot) = \zeta(\cdot, \infty) = \infty$. Following Pissarides' terminology, we define $\theta \equiv V/U$ as labor market tightness. Each vacancy is filled according to a

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[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]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. This type of commitment is present for all wage determination mechanisms. Note also that firms have no incentive to fire their workers once the hiring fee has been paid since their expected profits from opening a new vacancy is zero.

Poisson process with arrival rate $\frac{\zeta(U,V)}{V} \equiv q(\theta)$. Similarly, each unemployed worker finds a job according to a Poisson process with arrival rate $\frac{\zeta(U,V)}{U} = \theta q(\theta)$. Filled jobs receive negative idiosyncratic productivity shocks, with a Poisson arrival rate s, that render matches unprofitable. The measures of employed and unemployed workers are denoted n_e and n_u, respectively.

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 εm, where $m \geq 0$ is a scale parameter and ε is a random draw from a distribution $G(\varepsilon)$ with support $[0, \bar{\varepsilon}]$. We treat m as an exogenous parameter for the time being but will endogenize it below.[6]

A worker who commits a crime is caught and sent to jail with probability π.[7] The measure of those in prison is denoted by n_p. 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 of the crime, εm.[8]

A crime is described as a transfer of utility (or wealth) from the victim to the offender. Each dollar stolen by criminals corresponds to a loss of $1 + \omega$ dollars incurred by victims. If $\omega = 0$ crime is a pure transfer; whereas $\omega > 0$ means that victims also suffer a nonpecuniary cost when robbed. Crimes occur as follows. Each individual meets a potential offender who is unemployed with Poisson rate $n_u \lambda_u$, and a potential offender who is employed with Poisson rate $\lambda_e n_e$.[9] The potential offender has a random opportunity to steal from his victim. Since the model is agnostic about the distribution of wealth, we simply assume that the distribution of crime opportunities is

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[6]An interpretation of m being exogenous is that of a local labor market where crime opportunities come from outside the economy.

[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 a 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 over another.

[8]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 example, the Sentencing Commission Guidlines suggests a period of incarceration ranging from 0 to 6 months for larceny less than $10,000 (75% of thefts are under $10,000) and the criminal has not been convicted more than once. If it is the 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]The assumption that all individuals, including those in jail, are subject to crime is meant to capture the fact that all individuals, even those in jail, can have their property stolen. Furthermore, it guarantees that being in jail does not provide an advantage in terms of the security of one's property that could make jail more attractive. Our results would not be affected significantly if prisoners are not subject to theft.

independent of the victim's labor force status.[10] Hence, the expected loss from crime is

$$\tau^c = n_u \lambda_u (1 + \omega) \mathbb{E}_u [\varepsilon] + \lambda_e n_e (1 + \omega) \mathbb{E}_e [\varepsilon], \tag{1}$$

where $\mathbb{E}_i [\varepsilon]$ is the (endogenous) expected value of the crime committed by an individual with labor force status $i \in \{u, e\}$. Firms do not suffer directly from criminal activities. Finally, individuals have to pay taxes, τ^g, to the government. In order to avoid taxes affecting crime decisions directly, we assume that the burden of taxes falls on all workers including those in jail. We denote $\tau = \tau^c + \tau^g$.

2.2 Discussion

A distinctive feature of our model relative to the standard Pissarides model, or the existing search models of crime (e.g., BLW), is the form of the employment contract. Typically, search models of the labor market assume that the employment contract involves only a constant wage: There is no hiring fee or tenure-dependent compensation. In most instances, these restrictions on the contract space are innocuous because the only thing that matters for the risk-neutral workers and firms is the division of the match surplus (e.g. Shimer (1996)). Put differently, the same division of the match surplus can be achieved with a constant wage, or with a hiring fee and a constant wage, or with some other, more elaborate, wage-tenure contract.

The exact form of the employment contract is more relevant in the presence of search on the job or, more generally, when workers can take actions that affect the duration of the match, such as through crime opportunities. As pointed out by Shimer (2005b) and Stevens (2004), a constant wage may fail to achieve a pairwise Pareto-efficient outcome. Similarly, the restriction to flat-wage contracts in the wage-posting model of Burdett et al. (2003) generates an inefficient turnover of workers and, for some parameter values, a nondegenerate distribution of wages. Moreover, standard bargaining solutions cannot always be used when the contract is restricted to a constant wage since the bargaining set need not be convex (Bonilla and Burdett (2005); Shimer (2005b)). As we show below, an employment contract composed of a hiring fee and a constant wage generates a pairwise optimal outcome in our context. Given that this is the type of contract our model calls

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[10]The loss due to crime is independent of one's wealth, and in principle could be larger than one's income or wealth. For instance, an individual can be the victim of credit card fraud, or can have his car stolen even if he does not own it (e.g., the car is on lease).

for, it is the one we choose to adopt.[11]

Despite the adoption of the optimal contract being theoretically elegant, it may not be empirically relevant. One may wonder if a hiring fee has any counterpart in reality. For instance, the presence of liquidity constraints (especially for young and less skilled workers) may reduce the feasibility of such contracts. Our view is that contracts with hiring fees approximate in a tractable way some features of existing contracts. For instance, a contract with an upfront payment by the worker is just an extreme version of a contract with an upward sloping wage profile over time. Moreover, many employment contracts have an initial probationary period during which wages are lower.[12]

For the sake of completeness, Appendix *B* describes a version of the model without a hiring fee and the wage is set according to some ad-hoc rent sharing rule. A more realistic approach would be to allow for risk-aversion and liquidity constraints (see, e.g., Burdett and Coles (2003)). While these assumptions would likely generate a smoother wage-tenure contract, and an interesting relationship between job tenure and crime involvement, tractability would be lost.

3 Bellman equations

This paper focuses on steady-state equilibria where the distribution of individuals across states, n_e, n_u and n_p, and market tightness, θ, are constant over time. As a consequence, market tightness, matching probabilities and crime rates are also 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

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[11]The fact that a constant wage may be suboptimal when workers can engage in some opportunistic behavior (such as crime opportunities or search on the job) mirrors the discussion about the "bonding critique" in the efficiency wage literature. See Carmichael (1985) and Ritter and Taylor (1997)

[12]For a related discussion, see Chapter 5 in Mortensen (2003).

for individuals' value functions are

$$r\mathcal{V}_u = b - \tau + \theta q(\theta)(\mathcal{V}_e - \mathcal{V}_u - \phi) + \lambda_u \int [\varepsilon m + \pi(\mathcal{V}_p - \mathcal{V}_u)]^+ dG(\varepsilon), \tag{2}$$

$$r\mathcal{V}_e = w - \tau + s(\mathcal{V}_u - \mathcal{V}_e) + \lambda_e \int [\varepsilon m + \pi(\mathcal{V}_p - \mathcal{V}_e)]^+ dG(\varepsilon), \tag{3}$$

$$r\mathcal{V}_p = x - \tau + \delta(\mathcal{V}_u - \mathcal{V}_p), \tag{4}$$

where $[x]^+ = \max(x,0)$. Equation (2) has the following interpretation. An unemployed worker enjoys a utility flow of $b - \tau$ where b is the utility flow from not working 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 $\mathcal{V}_e - \mathcal{V}_u$. 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 εm but is at risk of being caught and sent to jail with probability π, in which case she suffers a capital loss, $\mathcal{V}_p - \mathcal{V}_u$. From (3), an employed worker receives a wage w, loses her job with an instantaneous probability s and has the opportunity to commit a crime with an instantaneous probability λ_e. According to (4), 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 (2) and (3) an individual in state i chooses to commit a crime whenever $\varepsilon \geq \varepsilon_i$ where

$$\varepsilon_u m = \pi(\mathcal{V}_u - \mathcal{V}_p), \tag{5}$$

$$\varepsilon_e m = \pi(\mathcal{V}_e - \mathcal{V}_p), \tag{6}$$

From (5)-(6) the value of the marginal crime that makes an individual in a given state indifferent between undertaking the crime or not, $\varepsilon_i m$, is equal to the expected cost of punishment, $\pi(\mathcal{V}_i - \mathcal{V}_p)$.

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

$$r\mathcal{V}_v = -\gamma + q(\theta)(\phi + \mathcal{V}_f - \mathcal{V}_v), \tag{7}$$

$$r\mathcal{V}_f = y - w - s(\mathcal{V}_f - \mathcal{V}_v) - \lambda_e \pi [1 - G(\varepsilon_e)](\mathcal{V}_f - \mathcal{V}_v). \tag{8}$$

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According to (7), a vacancy incurs an advertising cost γ; finds an unemployed worker with an instantaneous probability $q(\theta)$ in which case it receives the hiring fee, ϕ and enjoys the capital gain $\mathcal{V}_f - \mathcal{V}_v$. According to (8), 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 $\mathcal{V}_v = 0$ and therefore, from (7),

$$\mathcal{V}_f + \phi = \frac{\gamma}{q(\theta)}. \tag{9}$$

From (9), 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 $\mathcal{S} \equiv \mathcal{V}_e - \mathcal{V}_u + \mathcal{V}_f$ as the total surplus of a match (Recall that $\mathcal{V}_v = 0$). From (3) and (8),

$$r\mathcal{S} = y - \tau - r\mathcal{V}_u - s\mathcal{S} + \lambda_e \int_{\varepsilon_e}^{\bar{\varepsilon}} [\varepsilon m - \pi \mathcal{S} - \pi(\mathcal{V}_u - \mathcal{V}_p)] dG(\varepsilon). \tag{10}$$

Equation (10) has the following interpretation. A match generates a flow surplus, $y - \tau - r\mathcal{V}_u$, 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, $r\mathcal{V}_u$. The match is destroyed if an exogenous shock occurs, at Poisson rate s, or if the worker commits a crime and is caught. In the latter case, the value $\mathcal{S}$ of the match is lost and the worker goes to jail which generates an additional capital loss $\mathcal{V}_u - \mathcal{V}_p$. 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 (10), that the surplus of the match is maximized if

$$\varepsilon_e m = \pi(\mathcal{S} + \mathcal{V}_u - \mathcal{V}_p) = \pi \left(\mathcal{V}_e + \mathcal{V}_f - \mathcal{V}_p \right). \tag{11}$$

Comparison of (6) and (11) reveals that if $\mathcal{V}_f > 0$, 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 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. 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

$$(\phi, w) = \arg\max \left(\mathcal{V}_e - \mathcal{V}_u - \phi \right)^\beta \left(\mathcal{V}_f + \phi \right)^{1-\beta}. \tag{12}$$

Lemma 1 *The employment contract solution to (12) is such that*

$$w = y, \tag{13}$$

$$\phi = (1 - \beta)(\mathcal{V}_e - \mathcal{V}_u). \tag{14}$$

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.[13] Since the worker gets the entire output generated by the match, and hence $V_f = 0$, this wage setting guarantees that the worker internalizes the effect of his 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.[14]

4 Equilibrium

In this section we derive conditions for existence and uniqueness of an active (positive employment) equilibrium. We establish that the model has a simple recursive structure and can be reduced to two equations and two unknowns, market tightness (θ) and the reservation value for crime opportunities (ε_u).

The free-entry condition of firms allows us to express the worker's and firm's surpluses from a match as functions of market tightness. From (9), $\mathcal{V}_f = 0$ implies

$$\phi = \frac{\gamma}{q(\theta)}. \tag{15}$$

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. From (14), the expected surplus received by

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[13]Since the firm makes no profit after the hiring fee has been paid, it has no incentive to fire the worker as the value of a vacancy is no greater than the value of a filled job, i.e., $\mathcal{V}_f = \mathcal{V}_v = 0$.

[14]Alternatively, the optimal contract could take the form of a constant wage, w, and a payment from the worker to the firm (a fine) if the worker is caught committing a crime. This transfer would exactly compensate the firm for its lost surplus.

an unemployed worker who finds a job is

$$-\phi + \mathcal{V}_e - \mathcal{V}_u = \frac{\beta}{1-\beta}\phi = \frac{\beta\gamma}{(1-\beta)q(\theta)}. \tag{16}$$

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 (2), (3) and (4), as well as the expression for the worker's surplus, (16), the crime decisions (5)-(6) can be rewritten as follows:

$$\left(\frac{r+\delta}{\pi}\right)\varepsilon_u m = b - x + \frac{\beta}{1-\beta}\theta\gamma + \lambda_u m \int_{\varepsilon_u}^{\bar{\varepsilon}}[1-G(\varepsilon)]\,d\varepsilon, \tag{17}$$

$$\left(\frac{r+\delta}{\pi}\right)\varepsilon_e m = y - x + \frac{(\delta-s)\gamma}{q(\theta)(1-\beta)} + \lambda_e m \int_{\varepsilon_e}^{\bar{\varepsilon}}[1-G(\varepsilon)]\,d\varepsilon. \tag{18}$$

Given θ, (17)-(18) determine a unique pair $(\varepsilon_u, \varepsilon_e)$. Notice that (17)-(18) correspond to standard optimal stopping rules. Also, (17) gives the first relationship between ε_u and θ.

Next, we turn to the determination of market tightness. Substituting (16) into (2) and integrating the integral term in (2) by parts, gives the permanent income of an unemployed worker as:

$$r\mathcal{V}_u = b - \tau + \frac{\beta}{1-\beta}\theta\gamma + \lambda_u m \int_{\varepsilon_u}^{\bar{\varepsilon}}[1-G(\varepsilon)]\,d\varepsilon. \tag{19}$$

From (3) and (19) and using the fact that $\mathcal{V}_e - \mathcal{V}_u = \gamma/[(1-\beta)q(\theta)]$, market tightness satisfies

$$\frac{(r+s)\gamma}{(1-\beta)q(\theta)} = y - b - \frac{\beta}{(1-\beta)}\theta\gamma - \lambda_u m \int_{\varepsilon_u}^{\bar{\varepsilon}}[1-G(\varepsilon)]\,d\varepsilon + \lambda_e m \int_{\varepsilon_e}^{\bar{\varepsilon}}[1-G(\varepsilon)]\,d\varepsilon. \tag{20}$$

Given the thresholds ε_u and ε_e, (20) determines a unique θ. Note that, up to the last two terms on the right-hand side, (20) 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 (6)

$$\varepsilon_e m = \varepsilon_u m + \frac{\pi\gamma}{(1-\beta)q(\theta)}. \tag{21}$$

Substituting ε_e by its expression given by (21) into (20) we obtain a relationship between ε_u and θ,

$$\begin{aligned}\frac{(r+s)\gamma}{(1-\beta)q(\theta)} &= y - b - \frac{\beta}{(1-\beta)}\theta\gamma - \lambda_u m \int_{\varepsilon_u}^{\bar{\varepsilon}}[1-G(\varepsilon)]\,d\varepsilon \\ &\quad + \lambda_e m \int_{\varepsilon_u + \frac{\pi\gamma}{m(1-\beta)q(\theta)}}^{\bar{\varepsilon}}[1-G(\varepsilon)]\,d\varepsilon.\end{aligned} \tag{22}$$

Equation (22) gives the second relationship between ε_u and θ. According to (22), 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:

$$sn_e + \delta n_p = \{\theta q(\theta) + \lambda_u \pi [1 - G(\varepsilon_u)]\} n_u, \tag{23}$$

$$\theta q(\theta) n_u = \{s + \lambda_e \pi [1 - G(\varepsilon_e)]\} n_e, \tag{24}$$

$$n_e + n_u + n_p = 1. \tag{25}$$

According to (23) 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, (24) prescribes that the flows in and out of employment must be equal in steady state. According to (25), individuals are either employed, unemployed, or in jail. Figure 1 diagrams the above-mentioned flows.

Figure 1: Worker Flows
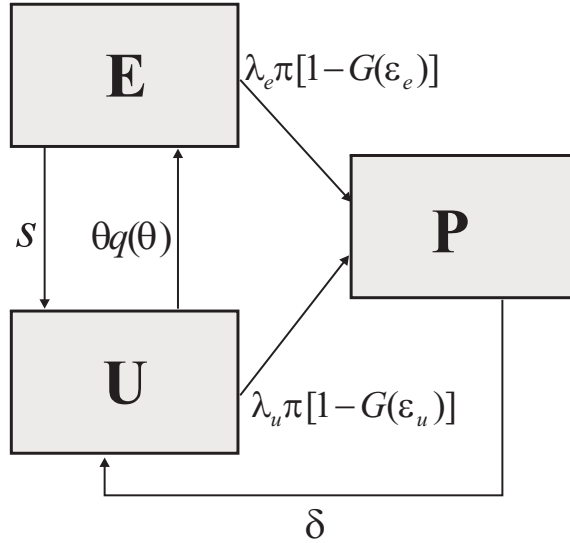
The equilibrium unemployment rate, u, is defined as the fraction of individuals not in jail who are unemployed, i.e., $u \equiv n_u / (n_e + n_u)$. From (24), it satisfies

$$u = \frac{s + \lambda_e \pi [1 - G(\varepsilon_e)]}{\theta q(\theta) + s + \lambda_e \pi [1 - G(\varepsilon_e)]}. \tag{26}$$

As in Mortensen and Pissarides (1994), the unemployment rate decreases with market tightness and increases with the job destruction rate which, in our model, is endogenous and depends on ε_e.

We close the model by computing the expected instantaneous loss incurred by individuals from being victimized. From (1),

$$\tau^c = (1+\omega)m\left[\lambda_e n_e \int_{\varepsilon_e}^{\bar{\varepsilon}} \varepsilon dG(\varepsilon) + \lambda_u n_u \int_{\varepsilon_u}^{\bar{\varepsilon}} \varepsilon dG(\varepsilon)\right]. \tag{27}$$

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 (22);* $\{\varepsilon_u, \varepsilon_e\}$ *satisfies (17)-(18);* $\{n_e, n_u, n_p\}$ *satisfies (23)-(25) and* τ^c *satisfies (27).*

As indicated above, the model is recursively solvable. First, the pair (θ, ε_u) is determined jointly from (17) and (22). Second, knowing (θ, ε_u), one can use (21) to find ε_e. Finally, given $(\theta, \varepsilon_u, \varepsilon_e)$ the steady-state distribution (n_e, n_u, n_p) is obtained from (23)-(25).

Figure 2 represents the determination of the pair (θ, ε_u). We denote *CS* (crime schedule) as the curve representing (17) and *JC* (job creation) as the curve representing (22). 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 case we will focus on in the quantitative section, 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 supply of vacancies in the market increases. The Beveridge curve (26) is denoted $BC(\varepsilon_e)$. It shifts with the reservation value ε_e which, from (21), 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.*

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.

The following proposition provides a simple condition under which there is a unique equilibrium with a positive number of jobs. Denote ε_u^0 as the value of ε_u that solves (17) when $\theta = 0$.

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Figure 2: Equilibrium
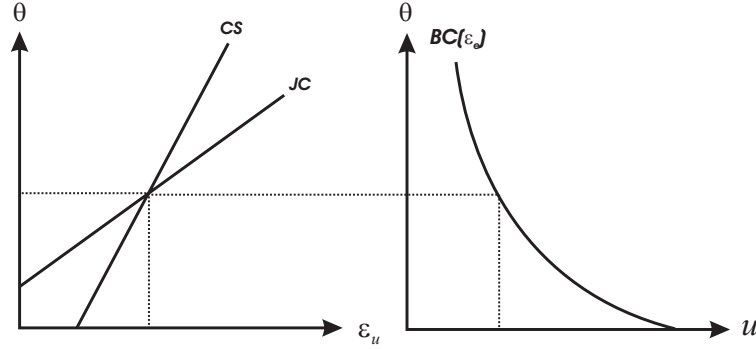
Proposition 1 *There exists a unique equilibrium such that* $\theta > 0$ *if*

$$y - b + (\lambda_e - \lambda_u)m \int_{\varepsilon_u^0}^{\bar{\varepsilon}} [1 - G(\varepsilon)]d\varepsilon > 0. \tag{28}$$

In any such equilibrium, $\varepsilon_e > \varepsilon_u$.

Proposition 1 shows that an 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. (We will see later that there are simple ways to get multiplicity of equilibria.) The condition (28) 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 $\lambda_e = \lambda_u$ in which case (28) reduces to $y > b$.

Proposition 1 also 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 $\lambda_u = \lambda_e$ the crime rate of unemployed workers is larger than the crime rate of employed workers, a fact that is present in the data.[15]

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[15]Data from the Survey of Prison Inmates in State and Federal Correction Facilities gives the labor force status at

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

$$\frac{(r+s)\gamma}{q(\hat{\theta})} = (1-\beta)(y-b) - \beta\hat{\theta}\gamma. \tag{29}$$

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

Proposition 2 *If*

$$\frac{(r+\delta)}{\pi}\bar{\varepsilon}m \leq b - x + \frac{\beta}{1-\beta}\hat{\theta}\gamma \tag{30}$$

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

According to Proposition 2, 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. In this case the model reduces to the Pissarides model.

So far we have taken the distribution of crime opportunities, $mG(\varepsilon)$, as exogenous. This assumption is reasonable if one envisions the economy as a local labor market and the crime opportunities as coming from outside the neighborhood. If one thinks of an entire economy, the distribution of crime opportunities is presumably endogenous and depends on the distribution of wealth, income and other characteristics of the economy. We capture this idea by assuming that m is a continuous function, μ, of the endogenous variables $(\varepsilon_e, \varepsilon_u, \theta)$. This is consistent with several interpretations. For instance, m could be the aggregate output in the economy, $m = n_e y$ where n_e is an implicit function of θ and ε_e.[16] We will assume that $\mu(\varepsilon_e, \varepsilon_u, \theta) > 0$ if and only if $\theta > 0$ –there are crime opportunities as long as the labor market is active.

Proposition 3 *Assume $m = \mu(\varepsilon_e, \varepsilon_u, \theta)$, where μ is continuous, bounded above and strictly positive iff $\theta > 0$. Then, there exists an active equilibrium ($\mu > 0$ and $\theta > 0$) provided that $y > b$.*

So, as long as workers' productivity is greater than the income of unemployed workers there exists an equilibrium with an active labor market. While we can show existence of equilibrium for an endogenous distribution of crime opportunities, we can no longer guarantee uniqueness.

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the time of arrest. This allows us to calculate that the probability of committing a crime when unemployed as 17% and when employed as 3%.

[16] Alternatively, output could be defined as $n_e y - v\gamma$, where $v\gamma$ represents the hiring costs incurred by firms.

To investigate the implications of various policies on welfare in the quantitative section, we define welfare, $\mathscr{W}$, as the sum of all agents' utility flows in steady state,[17]

$$\mathscr{W} = n_u(b - \theta\gamma) + n_e y + n_p x + \int_{\kappa_u}^{\bar{\kappa}} \kappa n_o(\kappa) d\kappa - \tau^g$$

$$- \omega m \left[\lambda_e n_e \int_{\varepsilon_e}^{\bar{\varepsilon}} \varepsilon dG(\varepsilon) + \lambda_u n_u \int_{\varepsilon_u}^{\bar{\varepsilon}} \varepsilon dG(\varepsilon) + \lambda_o \int_{\kappa_u}^{\bar{\kappa}} n_o(\kappa) \int_{\varepsilon_o(\kappa)}^{\bar{\varepsilon}} \varepsilon dG(\varepsilon) d\kappa \right], \quad (31)$$

where $n_p = \int_0^{\bar{\kappa}} n_p(\kappa) d\kappa$, $n_u = \int_0^{\kappa_u} n_u(\kappa) d\kappa$ and $n_e = \int_0^{\kappa_u} n_e(\kappa) d\kappa$.[18]

5 Extensions

In this section we consider two extensions of our model that are relevant for the relationship between the labor market and crime. First, we endogenize workers' productivity by introducing a training decision for unemployed workers. Second, we introduce a decision to participate in the labor force.

5.1 Human capital

As discussed by Freeman (1999) and Lochner and Moretti (2004), the accumulation of human capital by workers is an important determinant of both labor market outcomes and crime decisions. In the following, we lay out a simple extension of our model that endogenizes workers' productivity. Following Boone and van Ours (2004), we assume that unemployed workers can choose a training intensity that determines their level of productivity (general human capital) when matched with a firm. To achieve a productivity level y, the unemployed worker must incur a disutility cost $\chi(y)$ where $\chi'(y) > 0$ and $\chi''(y) > 0$.[19] Once employed, the worker maintains his level of productivity (e.g., through learning by doing).

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[17]See Hosios (1990) and Pissarides (2000) for a similar approach.

[18]Consider a planner who can choose firms' decisions to open vacancies and workers' decisions to commit crimes but who is subject to the matching frictions and who takes π, the technology to catch criminals, and δ, the jail sentence, as given. 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. Furthermore, the socially efficient market tightness is the one that would prevail in the economy without crime when the Hosios (1990) condition is implemented. The first-best allocation can be decentralized only if there is no punishment ($\pi = 0$) and crimes are pure transfers ($\omega = 0$). Even if $\omega = \pi = 0$, the presence of crimes affects the entry decision of firms so that the Hosios (1990) condition for efficiency needs to be adjusted unless employed and unemployed workers receive crime opportunities at the same rate.

[19]Implicit in this formulation is the assumption that human capital fully depreciates from one instant to the next so that the stock of human capital only depends on the investment flow.

The flow Bellman equation for an unemployed worker, (2), can be generalized as follows:

$$r\mathscr{V}_u = \max_y \left\{ b - \tau - \chi(y) + \theta q(\theta)\beta\mathscr{S}(y) + \lambda_u m \int [\varepsilon + \pi(\mathscr{V}_p - \mathscr{V}_u)]^+ dG(\varepsilon) \right\}, \qquad (32)$$

where we used the fact that, from Nash bargaining, $(\mathscr{V}_e - \mathscr{V}_u - \phi) = \beta\mathscr{S}$. According to (32), the unemployed worker chooses his productivity, and hence the size of the match surplus with his future employer. The cost associated with a certain productivity level is due to training. The first-order condition for y is

$$\chi'(y) = \theta q(\theta)\beta\mathscr{S}'(y). \qquad (33)$$

So, the marginal cost of training is equal to the marginal benefit of training which is comprised of three elements: the marginal increase in the match surplus times the worker's share in the match surplus times the job finding rate. As is standard in the search literature, in the presence of bargaining the worker's investment in human capital tends to be too low because of a holdup problem.

In order to simplify the presentation, we assume that $\lambda_e = 0$, i.e., only unemployed workers receive crime opportunities.[20] From (10), the expression for the match surplus is $\mathscr{S}(y) = (y - \tau - r\mathscr{V}_u)/(r+s)$. Hence, the worker's productivity in equilibrium is

$$y = \chi'^{-1}\left(\frac{\theta q(\theta)\beta}{r+s}\right) \qquad (34)$$

(where χ'^{-1} is the inverse of χ'.) The worker's productivity is increasing with market tightness and workers' bargaining power. From the equilibrium conditions (17) and (22), θ and ε_u are increasing functions of y (See Proposition 9). So, there are strategic complementarities between firms' decisions to open vacancies and workers' decisions to invest in training. Hence, depending on the shape of the function $\chi(y)$ the model can exhibit multiple equilibria: Equilibria with high productivity, a tight labor market and low crime can coexist with equilibria with low productivity, depressed labor market and high crime.[21] Even in the absence of multiple equilibria, the model allows for strong spillover effects of policies aimed at reducing workers' training cost. If the marginal cost of training is reduced, workers accumulate more human capital which entices firms to open more vacancies, leading workers to undertake even more training.

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[20]We do not endogenize the crime rate of employed workers in order to avoid technical difficulties with the concavity of the worker's problem. One can show, however, that a necessary condition for optimality is $\chi'(y) = \theta q(\theta)\beta [r+s+\pi\lambda_e(1-G(\varepsilon_e))]^{-1}$.

[21]Search labor models with endogenous human capital can generate multiplie equilibria even without crime decisions. See, e.g., Acemoglu (1997).

5.2 Participation in the labor force

The Survey of Inmates documents that a significant fraction of property crimes are committed by individuals who are neither employed nor searching actively for a job. Following Pissarides (2000, ch. 7) our model can be easily extended to account for a labor force participation decision. Suppose that an individual who is out of the labor force enjoys utility flow κ (expressed in terms of consumption of the final good) and receives crime opportuntites at Poisson rate λ_o.[22] The distribution of the κ's across individuals is $H(\kappa)$. We assume that κ does not affect the utility of unemployed workers because of the indivisibilities in the use of time.

The flow Bellman equations for an individual out of the labor force is

$$r\mathcal{V}_o(\kappa) = \kappa - \tau + \lambda_o \int \left[\varepsilon m + \pi \left(\mathcal{V}_p - \mathcal{V}_o(\kappa) \right) \right]^+ dG(\varepsilon) \tag{35}$$

From (35), an individual out of the labor force enjoys utility κ minus taxes and the expected cost of being victimized and receives the opportunity to commit a crime with an instantaneous probability λ_o. He chooses to commit a crime whenever $\varepsilon \geq \varepsilon_o(\kappa)$ where

$$\varepsilon_o(\kappa)m = \pi \left[\mathcal{V}_o(\kappa) - \mathcal{V}_p(\kappa) \right] \tag{36}$$

From (35), the utility from staying at home is increasing with κ. Hence, there exists a threshold κ_u, the solution to $\mathcal{V}_o(\kappa_u) = \mathcal{V}_u$, such that an individual chooses not to participate in the labor force if $\kappa \geq \kappa_u$. From (5) and (36), $\varepsilon_o(\kappa_u) = \varepsilon_u$; the marginal worker who is indifferent between not participating in the labor force or searching for a job undertakes the same crime opportunities as an unemployed worker. Therefore, from (2) and (35), and using the fact that $\int_{\varepsilon_i}^{\varepsilon} (\varepsilon - \varepsilon_i) dG(\varepsilon) = \int_{\varepsilon_i}^{\varepsilon} [1 - G(\varepsilon)] d\varepsilon$ from integration by parts,

$$\kappa_u = b + \theta q(\theta) \left(\mathcal{V}_e - \mathcal{V}_u - \phi \right) + (\lambda_u - \lambda_o) m \int_{\varepsilon_u}^{\bar{\varepsilon}} [1 - G(\varepsilon)] d\varepsilon. \tag{37}$$

The instantaneous utility from staying at home, the left-hand side of (37), is equal to the sum of the income flow received by an unemployed worker, the expected surplus from finding a job and the difference in the returns from criminal activities for unemployed individuals and individuals out of the labor force, the right-hand side of (37). Other things equal, as the labor market becomes tighter, individuals have higher incentives to participate in the market. Also, if there are more

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[22]One can think of κ as the return from home production or as the utility from leisure activities (such as reading or going to the theater).

opportunities to commit crimes when unemployed, $(\lambda_u > \lambda_o)$, individuals tend to participate more. Substituting $\mathcal{V}_e - \mathcal{V}_u - \phi$ by its expression given by (16) into (37), κ_u satisfies

$$\kappa_u = b + \frac{\beta}{1-\beta}\theta\gamma + (\lambda_u - \lambda_o)m \int_{\varepsilon_u}^{\bar{\varepsilon}}[1 - G(\varepsilon)]d\varepsilon. \tag{38}$$

Finally, we characterize the steady-state distribution of individuals across states. Define $n_i(\kappa)$ such that $\int_E n_i(\kappa)d\kappa$ is the measure of individuals in state i whose utility at home is $\kappa \in E$. Consider individuals who do not participate in the labor force, $\kappa \geq \kappa_u$. The condition that the flows into and out of each state are equal implies

$$n_o(\kappa)\lambda_o\pi[1 - G(\varepsilon_o(\kappa))] = \delta n_p(\kappa), \tag{39}$$

$$n_o(\kappa) + n_p(\kappa) = h(\kappa), \tag{40}$$

where $h(\kappa)$ is the density function associated with $H(\kappa)$. According to (39) the flow of individuals from out-of-the-labor-force to jail, $n_o(\kappa)\lambda_o\pi[1 - G(\varepsilon_o(\kappa))]$, has to be equal to the flow of individuals from jail to out-of-the-labor-force, $\delta n_p(\kappa)$. Consider next workers who participate in the labor market ($\kappa < \kappa_u$). The distribution $[n_u(\kappa), n_e(\kappa), n_p(\kappa)]$ obeys the flow equations (23) and (24) and $n_e(\kappa) + n_u(\kappa) + n_p(\kappa) = h(\kappa)$.

The equilibrium unemployment rate u, defined as the fraction of individuals in the labor force who are unemployed, is still given by (26). The participation rate is computed as the fraction of individuals who are not in jail who choose to participate in the labor market. It satisfies

$$\mathcal{P} = \frac{\int_0^{\kappa_u} n_e(\kappa)d\kappa + \int_0^{\kappa_u} n_u(\kappa)d\kappa}{1 - \int_0^{\bar{\kappa}} n_p(\kappa)d\kappa}. \tag{41}$$

As before, the model can be solved recursively. In particular, it is easy to show that the variables κ_u and $\varepsilon_o(\kappa)$ do not affect the equilibrium conditions for θ, ε_e and ε_u. Using the Bellman equations (4) and (35), the crime decision (36) can be rewritten as follows:

$$\left(\frac{r+\delta}{\pi}\right)\varepsilon_o(\kappa)m = \kappa - x + \lambda_o m \int_{\varepsilon_o(\kappa)}^{\bar{\varepsilon}}[1 - G(\varepsilon)]d\varepsilon. \tag{42}$$

Hence, the crime decision of individuals out of the labor force is determined independently from other labor market variables. From (42), $\varepsilon_o(\kappa)$ is an increasing function of κ so that individuals with higher utilities at home commit fewer crimes.

Proposition 4 *In any equilibrium where $\theta > 0$, $\varepsilon_e > \varepsilon_u$ and $\varepsilon_o(\kappa) \geq \varepsilon_u$ for all $\kappa \geq \kappa_u$.*

The proof of Proposition 4 is straightforward and is therefore omitted. It shows that unemployed workers are less picky than individuals out-of-the-labor-force when choosing which crime opportunities to commit.

6   Calibrated example

We calibrate the model with endogenous participation in the labor force and endogenous distribution of crime opportunities (m is equal to the aggregate output of the economy). [23] 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 $b = 0.4$.[24] We follow Garibaldi and Wasmer (2005) and assume that the distribution of utilities in the home sector $H(\kappa)$ is exponential. We calibrate the mean of the distribution, $\mu_h = 0.844$, so the model's participation rate matches the participation rate in 2004, which was 66%.

The matching function is assumed to be Cobb-Douglas, $\zeta(U,V) = AU^\eta V^{1-\eta}$ with constant returns to scale and we set $\eta = 0.5$, which is in the ballpark of estimates in the literature (see Petrongolo and Pissarides, 2001). 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).[25]

We construct the job finding and job separation rates using the methodology in Shimer (2005a). For the years 1951-2003 the job finding rate is 0.45 per month, implying that 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 $\gamma = 0.513$.[26] The job separation rate is found to be 0.034, implying an annualized rate of 0.408, i.e., jobs last, on average, about 2 years.

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[23]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.

[24]The choice of the value for b, taken from Shimer (2005a) is controversial, see Hagedorn and Manovskii (2006) for an alternative calibration.

[25]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 (2005a) and Flinn (2006).

[26]For a given job finding rate, $\theta q(\theta)$, θ and γ appear as a product in the equilibrium conditions. Letting $\Theta \equiv \theta \gamma$, irrespective of the target for θ the model will generate the same Θ. Hence, one can normalize θ to one without loss of generality.

The crimes considered are Type I property crimes as defined by the FBI, which includes larceny, burglary, and motor vehicle theft.[27] 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. We assume that the technology to catch criminals is costly, and maintaining individuals in jail involves some real resources. Following İmrohoroğlu, Merlo, and Rupert (2000), the cost of a technology, π, takes the form

$$\pi = 1 - C(\pi)^{-\nu},$$

and their estimate is $\nu = 0.044$. The cost of a prisoner is estimated to be \$22,650.[28] We choose the level of taxes to finance both types of expenditures on crime. The mean length of incarceration for those convicted of a property crime was 16 months in 2002, so that $\delta = 0.75$. Since we do not have much information on the utility or disutility from being in jail, we let $x = 0$.[29]

The average amount stolen is approximately \$1243, calculated as the ratio of the dollar value stolen divided by the number of crimes. The average per capita loss from crime is calculated by taking the dollar value stolen divided by the number of individuals and normalized by the wage, implying $\tau^c = 0.002$.[30] We assume that the distribution of the value of crime opportunities $G(\varepsilon)$ is exponential and allow for the endogeneity of the returns to crime, so that aggregate output is the scale factor of this distribution, $m = n_e y$.[31] We choose the mean of the exponential, μ_g, to target the average amount stolen. The remaining parameters $\lambda_e = \lambda_u = \lambda_o$ target the overall crime rate. Weighting the expected dollar value stolen in each state by the proportion of crimes committed

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

[28]The estimate for the cost of a prisoner comes from the survey State Prison Expenditures (2001) which includes the operating and capital costs of holding an inmate.

[29]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.

[30]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.

[31]The log-normal and uniform distributions were also tried. The results from the log-normal 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 exponential.

in each state gives the result $\mu_g = 0.0167$ and $\lambda_e = \lambda_u = \lambda_o = 0.599$. Finally, Cohen (1988) calculates the average costs of property crime to the victim, including pain and suffering, to be $1374.[32] Therefore, we calibrate $\omega = 0.105$.

In calibrating the model we compute a constant wage, $\bar{w}$, which is equivalent to the wage profile of a worker including the payment of the hiring fee. This is done using the following result,

$$y = \bar{w} + \{r + s + \lambda_e \pi [1 - G(\varepsilon_e)]\} \phi. \tag{43}$$

We set $y = 1$ by assumption, and using the chosen parameters, find the constant wage, $\bar{w}$, to be 0.96 of productivity, y. We use median weekly earnings in the CPS as our measure of $\bar{w}$ and after converting to an annual basis find $\bar{w} = \$31,616$. We then normalize all dollar figures in the data (taxes, average amount stolen, cost of imprisonment, etc.) by $\bar{w}/0.96 = \$33,051$.

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
μ_h	0.844	mean of exponential home utility distribution
γ	0.513	flow 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
λ_i	0.599	arrival rate of crime opportunities
μ_g	0.0167	mean of exponential crime distribution
ω	0.105	dead-weight loss from crime

7   Labor market policies

There are a number of papers that analyze how the labor market may affect crime. Machin and Marie (2004), show that changes in unemployment benefits affected crime in the U.K. Fougere

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[32]We calculate the cost of crime to the victim by taking the loss for each type of property crime, adjusting by the CPI, and then averaging the costs from the different classifications by their proportion of Type I property crimes.

et al. (2003) present evidence that workers in France who do not receive unemployment benefits tend to commit more property crime. Gould, Weinberg, and Mustard (2002) document that workers' compensation is an important determinant of crime. Boone and van Ours (2004) discuss the effectiveness of various "active" labor market policies and argue that policies aimed at increasing workers' human capital are more successful to bring unemployed workers back to work. Lochner (2004) argues that the accumulation of human capital could be effective in reducing crime. 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. In this section we examine qualitatively and quantitatively how changes in such 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. Note that b is composed of the utility of not working, 0.4, and transfers received from the government, $b - 0.4$..[33]

Proposition 5 *Assume m is exogenous. 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 5 establishes that the measure of vacancies per unemployed falls as well as unemployed workers' incentives to commit crimes. It could also be checked that a higher b raises κ_u and hence a larger fraction of individuals participate in the labor force.

Changing the value of being unemployed will also affect crime decisions of the employed. Suppose that the value of being unemployed, $\mathcal{V}_u$, increases. The crime rate of employed workers

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[33]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).

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.[34] 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 0.05 to 0.051 as shown in Table 2.[35] In addition, the findings 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 42.4 to 42.6. A change in b has a negative effect on welfare by altering firms' decisions to enter the market. For our numerical example, the best policy is no change in b.[36]

Table 2: Effects of Changing Unemployment Benefits (b)

			b		
	0.2	0.3	0.4	0.5	0.6
Labor Force					
Employed (%)	61	61	61	61	61
Unemployed (%)	4	4	5	5	6
Not in Labor Force (%)	34	34	34	34	33
Crime					
Pr(Commit Crime | e)	0.049	0.05	0.05	0.051	0.051
Pr(Commit Crime | u)	0.074	0.073	0.072	0.07	0.068
Pr(Commit Crime | o)	0.025	0.025	0.024	0.024	0.023
Total Crime Rate (per 1000 persons)	41.9	42.2	42.4	42.6	42.6
Change in Welfare	-0.05%	-0.01%	–	-0.02%	-0.1%

7.2 Workers' bargaining strength

In the following, we will consider two different policies that affect payments to workers. We start with the effect of a change in workers' bargaining power. While β may not necessarily be

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

[35]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 studied.

[36]Labor force percentages may not sum to 100% due to rounding.

viewed as a policy parameter, it may be influenced by government's tolerance vis-a-vis unions, for instance.

Proposition 6 *Assume m is exogenous. 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.*

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 β 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. By similar reasoning, it could be shown that an increase in workers' bargaining power raises participation in the labor force if $\beta < \eta(\theta)$ and decreases it if $\beta > \eta(\theta)$

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.

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 (compensation is $\bar{w}$, defined in 43) of about 30%, generates a reduction in the total crime rate of about 35%. On the other hand, raising workers' bargaining power from 0.5 to 0.99, which corresponds to an increase in workers' compensation of 5%, decreases total crime roughly six fold. These non-linearities are explained by the large changes in workers' job finding rate and the average value of crime opportunities. Unemployment decreases from 5% to 1% as β is reduced from 0.5 to 0.01 but it increases from 5% to 28% as β is increased to 0.99. Moreover, as β increases from 0.5 to 0.99 the value of crime opportunities plummets due to a fall in employment (and hence, m).

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.

Table 3: Changes in Bargaining Power, (β)							
β	0.01	0.05	0.10	0.50	0.90	0.95	0.99
$\bar{w}$	0.682	0.829	0.876	0.957	0.986	0.991	0.997
Labor Force							
Employed (%)	55%	61%	62%	61%	52%	46%	27%
Unemployed (%)	1%	1%	2%	5%	12%	17%	28%
Not in Labor Force (%)	45%	38%	36%	34%	36%	38%	45%
Crime							
Pr(Commit Crime $\mid$ e)	0.023	0.042	0.048	0.05	0.028	0.017	0.001
Pr(Commit Crime $\mid$ u)	0.102	0.088	0.083	0.072	0.055	0.046	0.017
Pr(Commit Crime $\mid$ o)	0.032	0.029	0.028	0.024	0.017	0.013	0.003
Total Crime Rate	27.6	37.7	41.4	42.4	27.4	20.2	6.5
Change in Welfare	-10.73%	-4.46%	-2.45%	–	-2.51%	-4.63%	-11.42%

7.3 Wage subsidies

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

$$(\phi,w) = \arg\max \left(\mathcal{V}_e - \mathcal{V}_u + \varphi - \phi\right)^{\beta} \left(\mathcal{V}_f + \phi\right)^{1-\beta}. \tag{44}$$

Therefore, $\phi = (1-\beta)(\mathcal{V}_e - \mathcal{V}_u + \varphi)$ 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 (17) and (18). The equilibrium value for θ becomes

$$(r+s)\left[\frac{\gamma}{(1-\beta)q(\theta)} - \varphi\right] = y - b - \frac{\beta}{1-\beta}\gamma\theta + \lambda_e m \int_{\varepsilon_e}^{\bar{\varepsilon}}[1-G(\varepsilon)]\,d\varepsilon - \lambda_u m \int_{\varepsilon_u}^{\bar{\varepsilon}}[1-G(\varepsilon)]\,d\varepsilon \tag{45}$$

Proposition 7 *Assume m is exogenous. An increase in φ: raises θ, ε_e and ε_u.*

Wage subsidies are payments made by the government to each successful match. They promote job creation and they lower the incentives of employed and unemployed workers to commit crimes. Quantitatively, a wage supplement equal to 10% of worker's yearly output reduces the crime rate by about 5%. The optimal wage subsidy is 0.026.

Table 4: Effects of Wage Subsidies (φ)

	φ					
	0.0	0.026	0.05	0.1	0.15	0.2
	Labor Force					
Employed (%)	61	62	62	63	64	65
Unemployed (%)	5	5	5	5	5	5
Not in Labor Force (%)	34	33	33	32	31	31
	Crime					
Pr(Commit Crime $\mid$ e)	0.05	0.05	0.049	0.048	0.047	0.046
Pr(Commit Crime $\mid$ u)	0.072	0.071	0.07	0.069	0.068	0.066
Pr(Commit Crime $\mid$ o)	0.024	0.024	0.024	0.024	0.023	0.023
Total Crime Rate	42.4	42.1	41.9	41.3	40.7	40.1
Change in Welfare	-	0.002%	0%	-0.015%	-0.046%	-0.09%

7.4 Subsidies to vacancy creation

Consider a policy that subsidizes the creation of vacancies. We interpret such a policy in our model as a reduction in γ.

Proposition 8 *Assume m is exogenous. 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 4%. (This result is surprisingly different from the one derived for the wage subsidies.) We assume hiring subsidies are taxed by a lump sum transfer. Therefore, welfare is obtained by subtracting $n_u\theta d\gamma$ from (31) where $d\gamma$ is the amount of the hiring subsidy to each vacancy, corresponding to the tax necessary to finance the reduction in γ. For our calibration, the introduction of hiring subsidies lowers welfare.

Notice that a policy that would increase the effectiveness of the matching process between unemployed workers and vacancies (think of an increase in A), e.g., by promoting employment agencies, is qualitatively equivalent to a reduction in γ.

Table 5: Effects of Hiring Subsidies (γ)

			γ		
	0.31	0.41	0.51	0.61	0.71
Labor Force					
Employed (%)	63	62	61	61	60
Unemployed (%)	4	4	5	5	5
Not in Labor Force (%)	33	34	34	34	34
Crime					
Pr(Commit Crime | e)	0.055	0.053	0.05	0.048	0.046
Pr(Commit Crime | u)	0.073	0.072	0.072	0.071	0.071
Pr(Commit Crime | o)	0.025	0.025	0.024	0.024	0.023
Total Crime Rate	45.9	44	42.4	41	39.8
Change in Welfare	-0.15%	-0.03%	–	-0.02%	-0.06%

7.5 Worker's productivity

In the following, we consider the effects of an exogenous increase in workers' productivity. (See Section 5.1 for a methodology to endogenize y).

Proposition 9 *Assume m is exogenous. An increase in y: increases θ, ε_e and ε_u.*

As workers' productivity, y, increases a larger measure of firms enter the market. Graphically, the *JC* curve shifts upward and both θ and ε_u increase. The wage, which is equal to productivity, increases, which reduces the crime rate of employed workers.

The calibration adds another dimension to the relationship between productivity and the crime rate. Specifically, as productivity rises so does the value of crime opportunities. Therefore, the opportunity costs of committing crime is rising at the same time as the average benefit. Quantitatively, the opportunity cost of being caught outpaces the rising value of crime. In particular, increasing output by 10% decreases the probability of committing crime for each labor force status by roughly 10%.[37]

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[37]In principle, we should also take into account the training cost to assess the welfare effects of a change in y.

Table 6: Effects of Changing Productivity (*y*)

	0.9	0.95	1	1.05	1.1
			y		
	Labor Force				
Employed (%)	57	59	61	63	65
Unemployed (%)	5	5	5	5	5
Not in Labor Force (%)	38	36	34	32	30
	Crime				
Pr(Commit Crime $\mid$ e)	0.055	0.053	0.05	0.048	0.046
Pr(Commit Crime $\mid$ u)	0.078	0.075	0.072	0.069	0.066
Pr(Commit Crime $\mid$ o)	0.025	0.025	0.024	0.024	0.023
Total Crime Rate	44.7	43.6	42.4	41.2	39.8
Change in Welfare	-4.97%	-2.53%	–	2.61%	5.29%

8 Crime policies

Imposing harsher punishments on criminals or increasing apprehension probabilities are obvious ways to reduce crime.[38] However, such changes may also affect the labor market through the outcome of the bargaining process and the duration of jobs. In the following we consider: policies that improve the technology to catch criminals and punishment through the length of jail sentences.

8.1 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.

The quantitative findings with respect to π are substantial as seen in Table 7. Increasing the probability of being caught committing a crime by about 10% cuts the total crime rate by about 30%. A higher probability to catch criminals raises market tightness, but the effect is small.[39]

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[38]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%.

[39]The optimal value of π, 0.061 is given in the last column of the table; however, it is sensitive to the assumption

Table 7: Changes in Criminal Apprehension(π)

			π			
	0.017	0.018	0.019	0.02	0.021	0.061
			Labor Force			
Employed (%)	61	61	61	61	61	61
Unemployed (%)	5	5	5	5	5	5
Not in Labor Force (%)	34	34	34	34	34	34
			Crime			
Pr(Commit Crime | e)	0.065	0.057	0.05	0.044	0.039	0
Pr(Commit Crime | u)	0.09	0.08	0.072	0.064	0.057	0.001
Pr(Commit Crime | o)	0.032	0.028	0.024	0.021	0.018	0
Total Crime Rate	55.2	48.4	42.4	37.2	32.6	0.2
Change in Welfare	-0.03%	-0.01%	–	0.01%	0.03%	0.16%

8.2   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 10 *Assume m is exogenous and $\lambda_e = \lambda_u$. An increase in δ: decreases θ; decreases ε_e and ε_u.*

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 8. Increasing the rate of release after incarceration from 0.75 to 0.8 (corresponding to a decline of about one month in jail) increases the total crime rate by about 15%.[40]

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that all individuals receive crime opportunities at the same rate (See our discussion in the section on welfare) and the

Table 8: Changes in Jail Sentences(δ)

| | δ | | | | | |
	0.65	0.7	0.75	0.8	0.85	< 0.035
	Labor Force					
Employed (%)	61	61	61	61	61	61
Unemployed (%)	5	5	5	5	5	5
Not in Labor Force (%)	34	34	34	34	34	34
	Crime					
Pr(Commit Crime | e)	0.037	0.044	0.05	0.057	0.064	0
Pr(Commit Crime | u)	0.053	0.062	0.072	0.081	0.091	0
Pr(Commit Crime | o)	0.016	0.02	0.024	0.029	0.033	0
Total Crime Rate	30.8	36.5	42.4	48.4	54.5	0
Change in Welfare	0.03%	0.01%	–	-0.01%	-0.03%	0.17

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.

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

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estimate for the cost function $C(\pi)$.

[40]The optimal value for δ is small, less than 0.035. As indicated earlier, this result depends on our assumption that $\lambda_e = \lambda_u = \lambda_o$ as well as our estimate for the cost of maintaining an individual in jail.

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 (6) and (11) shows that the match surplus is maximized iff $\mathcal{V}_f = 0$. From (8), $\mathcal{V}_f = 0$ requires $w = y$. Finally, the first-order condition of (12) with respect to ϕ yields (14).■

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

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

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

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

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

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

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 (17) and (22) one obtains

$$\frac{(r+s)\gamma}{(1-\beta)q(\theta)}+\left(\frac{r+\delta}{\pi}\right)\varepsilon_u m = y-x+\lambda_e m\int_{\varepsilon_u+\frac{\pi\gamma}{m(1-\beta)q(\theta)}}^{\bar{\varepsilon}}[1-G(\varepsilon)]d\varepsilon. \tag{46}$$

From (46), it can be checked that θ is a strictly decreasing function of ε_u. So if a solution to (17) and (46) exists then it is unique. Denote $\varepsilon_u(\theta)$ the solution ε_u to the equation (17). Since $b-x>0$ then $\varepsilon_u(\theta)>0$. Furthermore, $\varepsilon_u(\theta)$ is non-decreasing in θ. Define $\Gamma(\theta)$ as

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

An equilibrium is then a θ that solves $\Gamma(\theta) = 0$. Using the expression for $\left(\frac{r+\delta}{\pi}\right)\varepsilon_u(\theta)m$ given by (17), we have

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

So if (28) holds then $\Gamma(0) > 0$. Furthermore, $\Gamma(\infty) = -\infty$. Therefore, a solution to $\Gamma(\theta) = 0$ exists and it is such that $\theta > 0$. Given θ, (17) gives a unique ε_u and (60) yields a unique ε_e. Finally, given $(\theta, \varepsilon_u, \varepsilon_e)$ the system (24)-(25) can be solved closed-form to give

$$n_p = \frac{\lambda_u\pi[1 - G(\varepsilon_u)]u + \lambda_e\pi[1 - G(\varepsilon_e)](1 - u)}{\delta + \lambda_u\pi[1 - G(\varepsilon_u)]u + \lambda_e\pi[1 - G(\varepsilon_e)](1 - u)},$$

$$n_u = u(1 - n_p),$$

$$n_e = (1 - u)(1 - n_p),$$

where u is defined in (26).

Finally, the result according to which $\varepsilon_e > \varepsilon_u$ comes from (21).∎

Proof of Proposition 2   From Proposition 1, no crime occurs in equilibrium iff $\varepsilon_u \geq \bar{\varepsilon}$. From (20) if $\varepsilon_u \geq \bar{\varepsilon}$ then $\theta = \hat{\theta}$. From (17) the condition $\varepsilon_u \geq \bar{\varepsilon}$ requires (30).∎

Proof of Proposition 3   For any exogenous m, Proposition 1 has established that an equilibrium exists and is unique. Hence, there exists a unique triple $[\varepsilon_e(m), \varepsilon_u(m), \theta(m)]$ and $\theta(m) > 0$ if (28) holds. With endogenous m, we look for the following fixed point:

$$\mu[\varepsilon_e(m), \varepsilon_u(m), \theta(m)] = m \tag{47}$$

From (28), if $y > b$ then $\theta(0) > 0$ and hence $\mu[\varepsilon_e(0), \varepsilon_u(0), \theta(0)] > 0$. Furthermore, $\mu[\varepsilon_e(m), \varepsilon_u(m), \theta(m)]$ is a continuous and bounded function of m. Hence, there exists a $m > 0$ solution to (47).∎

Proof of Proposition 5   The pair (ε_u, θ) is uniquely determined by (17) and (46). Differentiating these two equations, it is straightforward to show that $d\varepsilon_u/db > 0$ and $d\theta/db < 0$. From (18) the sign of $d\varepsilon_e/db$ is the same as $s - \delta$.∎

Proof of Proposition 6   The pair (ε_u, θ) is determined by (17) and (46). 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 (17) and (46) can now be rewritten as

$$\left(\frac{r+\delta}{\pi}\right)\varepsilon_u m = b - x + \frac{\beta}{1-\beta}q^{-1}\left[\frac{\gamma}{(1-\beta)\tilde{\gamma}}\right]\gamma + \lambda_u m \int_{\varepsilon_u}^{\bar{\varepsilon}}[1-G(\varepsilon)]d\varepsilon, \tag{48}$$

$$(r+s)\tilde{\gamma} + \left(\frac{r+\delta}{\pi}\right)\varepsilon_u m = y - x + \lambda_e m \int_{\varepsilon_u + \frac{\pi}{m}\tilde{\gamma}}^{\bar{\varepsilon}}[1-G(\varepsilon)]d\varepsilon. \tag{49}$$

Equations (48) and (49) 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 (48) increases in β if $\beta < \eta(\theta)$. Differentiating (48) and (49) 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 (18) which can be reexpressed as

$$\left(\frac{r+\delta}{\pi}\right)\varepsilon_e m = y - x + (\delta - s)\tilde{\gamma} + \lambda_e m \int_{\varepsilon_e}^{\bar{\varepsilon}}[1-G(\varepsilon)]d\varepsilon. \tag{50}$$

From (49) 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 7   As φ increases the curve associated with (45) moves upward in the space (ε_u, θ) while the curve associated with (17) is unaffected. Thus, both ε_u and θ increase. From (21) ε_e increases.■

Proof of Proposition 8   Following the proof of Proposition 6, we adopt the following change of variable: $\tilde{\gamma} = \gamma/[(1-\beta)q(\theta)]$. The pair $(\tilde{\gamma}, \varepsilon_u)$ is determined by (48) and (49) which can be rewritten as

$$\left(\frac{r+\delta}{\pi}\right)\varepsilon_u m = b - x + \beta p \circ q^{-1}\left[\frac{\gamma}{(1-\beta)\tilde{\gamma}}\right]\tilde{\gamma} + \lambda_u m \int_{\varepsilon_u}^{\bar{\varepsilon}}[1-G(\varepsilon)]d\varepsilon, \tag{51}$$

$$(r+s)\tilde{\gamma} + \left(\frac{r+\delta}{\pi}\right)\varepsilon_u m = y - x + \lambda_e m \int_{\varepsilon_u + \frac{\pi}{m}\tilde{\gamma}}^{\bar{\varepsilon}}[1-G(\varepsilon)]d\varepsilon. \tag{52}$$

where $p(\theta) = \theta q(\theta)$ and $\circ$ is the composition operator. Equation (51) gives a positive relationship between ε_u and $\tilde{\gamma}$ while (52) defines a negative relationship between ε_u and $\tilde{\gamma}$. It can be checked from (51) and (52) that $d\varepsilon_u/d\gamma < 0$ and $d\tilde{\gamma}/d\gamma > 0$. From (18) the sign of $d\varepsilon_e/d\tilde{\gamma}$ is the same as $\delta - s$. Finally, from (17) ε_u increases if $\theta\gamma$ increases which implies $d\theta/d\gamma < 0$.■

Proof of Proposition 9   Equation (17) is independent of y or s. Therefore, it is easy to show from (17) and (46) that both θ and ε_u increase following an increase in y or a decrease in s. From (21) one can show that

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

Similarly, $\frac{d\varepsilon_e}{ds} < 0.$ ■

11 Appendix B: The model with a constant wage and no hiring fee

In this Appendix a version of the model where employment contracts are restricted to flat wages. To keep the description as close as possible to Pissarides (2000), the wage is set to split the surplus from the match between the worker and the firm. It solves:

$$(1-\beta)(\mathscr{V}_e - \mathscr{V}_u) = \beta \mathscr{V}_f, \tag{53}$$

where $\beta \in [0,1]$ is the worker's share in the match surplus.[41] From (7) and the fact that $\mathscr{V}_v = 0$ (from the free-entry of firms), $\mathscr{V}_f = \gamma/q(\theta)$. From (8),

$$\frac{\gamma}{q(\theta)} = \frac{y-w}{r+s+\lambda_e\pi[1-G(\varepsilon_e)]}. \tag{54}$$

The average recruiting cost of a firm, the left-hand side of (54), is equal to the expected profits of a filled job, the right-hand side of (54). Notice that the job destruction rate is endogenous and depends on the employed worker's crime behavior.

Let us turn to the determination of the equilibrium wage. From (53) and the fact that $\mathscr{V}_f = \gamma/q(\theta)$, the surplus of an employed worker satisfies

$$\mathscr{V}_e - \mathscr{V}_u = \frac{\beta\gamma}{(1-\beta)q(\theta)}. \tag{55}$$

From (2) and (3), one can compute the surplus of an employed worker as follows:

$$[r+s+\theta q(\theta)](\mathscr{V}_e - \mathscr{V}_u) = w - b + \lambda_e m \int_{\varepsilon_e}^{\bar{\varepsilon}} [1-G(\varepsilon)]\,d\varepsilon$$
$$- \lambda_u m \int_{\varepsilon_u}^{\bar{\varepsilon}} [1-G(\varepsilon)]\,d\varepsilon. \tag{56}$$

Substituting $\mathscr{V}_e - \mathscr{V}_u$ by its expression given by (55) into (56) we find the following expression for the wage:

$$w = b + [r+s+\theta q(\theta)]\frac{\beta\gamma}{(1-\beta)q(\theta)}$$
$$+ \lambda_u m \int_{\varepsilon_u}^{\bar{\varepsilon}} [1-G(\varepsilon)]\,d\varepsilon - \lambda_e m \int_{\varepsilon_e}^{\bar{\varepsilon}} [1-G(\varepsilon)]\,d\varepsilon. \tag{57}$$

---

[41]It should be emphasized that this wage mechanism is not the outcome of an axiomatic bargaining solution (like Nash). As discussed in Shimer (2005b) and Bonilla and Burdett (2005), in the presence of search on the job (in our case, search for crime opportunities) the bargaining set may not be convex which prevents the use of standard bargaining solutions. Here, we follow Pissarides (1994) who uses an arbitrary rent sharing rule in a model with search on the job.

Notice from (57) that the wage depends on the availability of crime opportunities for unemployed and employed workers. For instance, if $\lambda_u = \lambda_e$ then the wage is larger than the one that prevails in the no-crime economy (for given θ). This is so because the presence of crime opportunities reduces the difference between the value of an employed worker and the value of an unemployed one.

Now, we can find the equilibrium condition for the supply of vacancies. Substitute w by its expression given by (57) into (54) to obtain

$$
\left(\frac{r+s}{1-\beta}\right)\frac{\gamma}{q(\theta)} = y - b - \frac{\beta\theta\gamma}{(1-\beta)}
$$
$$
-\lambda_u m \int_{\varepsilon_u}^{\bar{\varepsilon}} [1-G(\varepsilon)]\,d\varepsilon + \lambda_e m \int_{\varepsilon_e}^{\bar{\varepsilon}} \left[1-G(\varepsilon)-\frac{\pi\gamma}{mq(\theta)}g(\varepsilon)\right]d\varepsilon, \tag{58}
$$

where $g(\varepsilon)$ is the density function of $G(\varepsilon)$. For given crime thresholds, (58) determines a unique value for market tightness.

Crime decisions are determined as follows. Using the Bellman equations (2), (3) and (4), as well as (55), (5)-(6) can be rewritten as

$$
\left(\frac{r+\delta}{\pi}\right)\varepsilon_u m = b - x + \frac{\beta}{1-\beta}\theta\gamma + \lambda_u m \int_{\varepsilon_u}^{\bar{\varepsilon}} [1-G(\varepsilon)]\,d\varepsilon, \tag{59}
$$
$$
\left(\frac{r+\delta}{\pi}\right)\varepsilon_e m = w - x - s\frac{\beta\gamma}{(1-\beta)q(\theta)} + \lambda_e m \int_{\varepsilon_e}^{\bar{\varepsilon}} [1-G(\varepsilon)]\,d\varepsilon. \tag{60}
$$

From (55), and the fact that $(\varepsilon_e - \varepsilon_u)m = \pi(\mathcal{V}_e - \mathcal{V}_u)$,

$$
\varepsilon_e - \varepsilon_u = \frac{\pi\beta\gamma}{m(1-\beta)q(\theta)}. \tag{61}
$$

Definition. A steady-state equilibrium with a rent sharing rule and no hiring fee is a list $\{\theta, \varepsilon_u, \varepsilon_e, n_e, n_u, n_p\}$ such that: θ satisfies (58); $\{\varepsilon_u, \varepsilon_e\}$ satisfies (59)-(60); $\{n_e, n_u, n_p\}$ satisfies (23)-(25) and τ that satisfies (27).

The model can be solved recursively. Equation (59) gives a positive relationship –called the crime schedule– between ε_u and θ. Indeed, from (59),

$$
\left.\frac{d\theta}{d\varepsilon_u}\right|_{CS} = m(1-\beta)\frac{r+\delta+\pi\lambda_u[1-G(\varepsilon_u)]}{\pi\beta\gamma} > 0.
$$

Substitute ε_e by its expression given by (61) into (58) to obtain a second relationship between θ

and ε_u,

$$\left(\frac{r+s}{1-\beta}\right)\frac{\gamma}{q(\theta)} = y - b - \frac{\beta}{(1-\beta)}\theta\gamma$$

$$-\lambda_u m \int_{\varepsilon_u}^{\bar{\varepsilon}} [1 - G(\varepsilon)]\,d\varepsilon + \lambda_e m \int_{\varepsilon_u + \frac{\pi\beta\gamma}{m(1-\beta)q(\theta)}}^{\bar{\varepsilon}} \left[1 - G(\varepsilon) - g(\varepsilon)\frac{\pi\gamma}{mq(\theta)}\right]d\varepsilon. \tag{62}$$

From (62),

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

The sign of this expression is ambiguous. For a given solution (ε_u, θ) to (59) and (62), one can easily find the other endogenous variables.

Proposition. There exists an active equilibrium of the economy with rent-sharing if

$$y - b + (\lambda_e - \lambda_u)m\int_{\varepsilon_u^0}^{\bar{\varepsilon}} [1 - G(\varepsilon)]\,d\varepsilon > 0. \tag{63}$$

Proof. Denote $\varepsilon_u(\theta)$ the unique solution to (59) and define

$$\begin{aligned}
\Gamma(\theta) &\equiv \left(\frac{r+s}{1-\beta}\right)\frac{\gamma}{q(\theta)} - y + b + \frac{\beta}{(1-\beta)}\theta\gamma \\
&\quad + \lambda_u m \int_{\varepsilon_u(\theta)}^{\bar{\varepsilon}} [1 - G(\varepsilon)]\,d\varepsilon - \lambda_e m \int_{\varepsilon_u(\theta) + \frac{\pi\beta\gamma}{m(1-\beta)q(\theta)}}^{\bar{\varepsilon}} \left[1 - G(\varepsilon) - g(\varepsilon)\frac{\pi\gamma}{mq(\theta)}\right]d\varepsilon.
\end{aligned}$$

An equilibrium value for θ is a solution to $\Gamma(\theta) = 0$. It is easy to check that $\Gamma(0) =$

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

where ε_u^0 is the value of ε_u that solves (59) when $\theta = 0$. From (63), $\Gamma(0) < 0$. Furthermore, $\Gamma(\infty) = \infty$. Hence, by continuity of the function $\Gamma(\theta)$, there exists a $\theta > 0$ solution to $\Gamma(\theta) = 0$. ∎

If m is endogenous and depends on the labor market outcome, as in Proposition 3, equilibrium exists provided that $y > b$. We cannot use the same reasoning as in the proof of Lemma 2 to establish uniqueness. We can only show uniqueness for some particular cases. For instance, if $\lambda_e = 0$, employed workers receive no opportunities to commit crimes, then $\left.\frac{d\theta}{d\varepsilon_u}\right|_{JC} < \left.\frac{d\theta}{d\varepsilon_u}\right|_{CS}$ which guarantees that the crime schedule and the job creation schedule cannot intersect more than once in the (ε_u, θ) space.

In order to illustrate the role of the hiring fee in our benchmark model, we revisit the quantitative effects of the experiments above. In general, the findings are not considerably different

from those with a hiring fee and therefore display the relevant tables without discussion. Table 9 provides a summary of the parameters that were recalibrated, Table 10 examines a change in unemployment benfits, Table 11 examines a change in bargaining power, Table 12 examines a change in hiring subsidies and Table 13 examines a change in criminal apprehension.

Table 9: Parameters

μ_h	0.844	mean of exponential home utility distribution
γ	0.513	recruiting cost
$\lambda_e = \lambda_u = \lambda_o$	0.400	flow of crime opportunities
μ_g	0.0189	mean of exponential crime distribution

Table 10: Effects of Changing Unemployment Benefits (b)

	b				
	0.2	0.3	0.4	0.5	0.6
	Labor Force				
Employed (%)	61	61	61	61	61
Unemployed (%)	4	4	5	5	6
Not in Labor Force (%)	34	34	34	34	33
	Crime				
Pr(Commit Crime | e)	0.053	0.052	0.052	0.052	0.051
Pr(Commit Crime | u)	0.063	0.062	0.061	0.06	0.058
Pr(Commit Crime | o)	0.023	0.023	0.022	0.022	0.021
Total Crime Rate	42.8	42.7	42.4	42.2	41.7
Change in Welfare	-0.05%	-0.01%	–	-0.02%	-0.1%

Table 11: Changes in Bargaining Power, (β)

β	0.01	0.05	0.1	0.5	0.9	0.95	0.99
$\bar{w}$	0.681	0.829	0.876	0.957	0.986	0.991	0.997
Labor Force							
Employed (%)	55%	61%	62%	61%	52%	46%	27%
Unemployed (%)	1%	1%	2%	5%	12%	17%	28%
Not in Labor Force (%)	45%	38%	36%	34%	36%	38%	45%
Crime							
Pr(Commit Crime | e)	0.082	0.071	0.066	0.052	0.029	0.018	0.001
Pr(Commit Crime | u)	0.083	0.073	0.07	0.061	0.049	0.041	0.017
Pr(Commit Crime | o)	0.028	0.027	0.026	0.022	0.016	0.012	0.004
Total Crime Rate	57.8	53.9	51.6	42.4	26.5	19.7	6.8
Change in Welfare	-10.85%	-4.52%	-2.49%	–	-2.51%	-4.62%	-11.42%

Table 12: Effects of Hiring Subsidies (γ)

	γ				
	0.31	0.41	0.51	0.61	0.71
Labor Force					
Employed (%)	63	62	61	61	60
Unemployed (%)	4	4	5	5	5
Not in Labor Force (%)	33	34	34	34	34
Crime					
Pr(Commit Crime | e)	0.055	0.054	0.052	0.051	0.05
Pr(Commit Crime | u)	0.062	0.062	0.061	0.061	0.06
Pr(Commit Crime | o)	0.023	0.023	0.022	0.022	0.022
Total Crime Rate	44.6	43.5	42.4	41.6	40.8
Change in Welfare	-0.14%	-0.03%	–	-0.02%	-0.07%

Table 13: Changes in Criminal Apprehension(π)

	π				
	0.017	0.018	0.019	0.02	0.021
	Labor Force				
Employed (%)	61	61	61	61	61
Unemployed (%)	5	5	5	5	5
Not in Labor Force (%)	34	34	34	34	34
	Crime				
Pr(Commit Crime $\mid$ e)	0.065	0.058	0.052	0.047	0.042
Pr(Commit Crime $\mid$ u)	0.074	0.067	0.061	0.055	0.05
Pr(Commit Crime $\mid$ o)	0.029	0.026	0.022	0.02	0.017
Total Crime Rate	53	47.5	42.4	38	34.1
Change in Welfare	-0.02%	-0.01%	–	0.01%	0.02%