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Crime and the labor market: A search model with optimal contracts ☆

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ABSTRACT

This paper extends the Pissarides [Pissarides, Christopher A. Equilibrium Unemployment Theory. Cambridge: MIT (2000)] model of the labor market to include crime and punishment à la Becker [Becker, Gary S. "Crime and punishment: an economic approach." Journal of Political Economy 76 (1968): 169–217]. 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 is to decrease crime, but is quantitatively small. Small wage subsidies reduce unemployment and crime rates of employed and unemployed workers, and raise 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.

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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 et al. (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.

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In this paper we develop a tractable model where crime and labor market outcomes are determined jointly. We use this model to assess, qualitatively and quantitatively, the effects of various labor market and crime policies. We adopt the description of the labor market proposed by Pissarides (2000) where the terms of the employment contract are determined via bilateral bargaining and where a free-entry condition of firms makes the job-finding rate endogenous. Both worker's bargaining strength and the exit rate out of unemployment are important determinants of the 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.

Since detected crimes are punished by periods of imprisonment, employed workers' involvement in criminal activities imposes a negative externality on firms by reducing average job duration. This type of externality, which is well understood in models with on-the-job search (crime can certainly be thought of in a similar way), can lead to inefficient separations if the contract space is restricted to flat wages.[1] We take the approach 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.[2]

We prove that equilibrium exists and provide simple conditions for uniqueness.[3] 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. In addition, we calibrate the model to U.S. data to examine the quantitative effects of policy.

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

The effects of a change in worker's compensation are also investigated.[4] Higher worker's bargaining power leads to higher unemployment but it has ambiguous (and highly non-linear) 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 endogeneity of the distribution of crime opportunities, the total crime rate falls substantially as bargaining power becomes large.

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 outweigh 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 et al. (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 is a random draw 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 et al. (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.

İmrohoroğlu et al. (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 affect the labor market.[5]

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

[2] For the sake of completeness, and to assess the extent to which the assumption of an optimal contract matters, we also work out in a companion working paper, Engelhardt et al. (2007), a version of the model with an exogenous rent sharing rule.

[3] In Engelhardt et al. (2007) we consider extensions of the model that are susceptible to generating 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.

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

[5] 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.

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2. Model

2.1. Environment

Time 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.

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.[6]

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 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.

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 non-pecuniary 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 $\lambda_e n_e$.[7] The variables λ_i can be interpreted as the (exogenous) intensities with which an individual in state i (where $i=u$ if unemployed and $i=e$ if employed) looks for (or receive) an opportunity to commit a crime. The potential offender has the opportunity to steal from his victim, but the value of his crime opportunity is εm where ε is a random draw from a distribution $G(\varepsilon)$ with support $[0, \bar{\varepsilon}]$. We treat the scale parameter m as exogenous for the time being but will endogenize it below.[8] Since the model is agnostic about the distribution of wealth, we simply assume that the distribution of crime opportunities is independent of the victim's labor force status.[9] 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.

A worker who commits a crime is caught and sent to jail with probability π.[10] 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.[11]

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

[6] 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. 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.

[7] 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.

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

[9] 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 leased).

[10] 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.

[11] 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 Guidelines 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.

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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 when workers can take actions that affect the duration of the match, such as through on-the-job search or 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 for, it is the one we choose to adopt.[12]

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. Since the presence of liquidity constraints (especially for young and less skilled workers) reduces 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 up-front 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.[13]

Engelhardt et al. (2007) describes a version of the model without a hiring fee and where 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, 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 $i \in \{u, e, p\}$ with zero net wealth is denoted $\mathcal{V}_i$. The flow Bellman equations for individuals' value functions are

$$r\mathcal{V}_u = b - \tau + \theta q(\theta)(\mathcal{V}_e - \mathcal{V}_u - \phi) + \lambda_u \int \left[\varepsilon m + \pi(\mathcal{V}_p - \mathcal{V}_u)\right]^+ \mathrm{d}G(\varepsilon), \quad (2)$$

$$r\mathcal{V}_e = w - \tau + s(\mathcal{V}_u - \mathcal{V}_e) + \lambda_e \int \left[\varepsilon m + \pi(\mathcal{V}_p - \mathcal{V}_e)\right]^+ \mathrm{d}G(\varepsilon), \quad (3)$$

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

where $[x]^+ = \max(x, 0)$. Eq. (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 Eq. (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 Eq. (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 Eqs. (2) and (3) an individual in state i chooses to commit a crime whenever $\varepsilon \geq \varepsilon_i$ where

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

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

[12] 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).

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

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From Eqs. (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, $\pi\,(\mathscr{V}_i - \mathscr{V}_p)$.

3.2. Firms

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

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

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

According to Eq. (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 $\mathscr{V}_f - \mathscr{V}_v$. According to Eq. (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 $\mathscr{V}_v = 0$ and therefore, from Eq. (7),

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

From Eq. (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 $\mathscr{S} \equiv \mathscr{V}_e - \mathscr{V}_u + \mathscr{V}_f$ as the total surplus of a match. From Eqs. (3) and (8),

$$r\mathscr{S} = y - \tau - r\mathscr{V}_u - s\mathscr{S} + \lambda_e \int_{\varepsilon_e}^{\bar{\varepsilon}} \left[\varepsilon m - \pi\mathscr{S} - \pi\left(\mathscr{V}_u - \mathscr{V}_p\right)\right] \mathrm{d}G(\varepsilon). \tag{10}$$

Eq. (10) has the following interpretation. A match generates a flow surplus, $y - \tau - r\mathscr{V}_u$, composed of the output of the job minus taxes (including the loss due to victimization of the worker) and the permanent income of an unemployed person, $r\mathscr{V}_u$. The match is destroyed if an exogenous shock occurs, at Poisson rate s, or if the worker commits a crime and is caught. In the latter case, the value $\mathscr{S}$ of the match is lost and the worker goes to jail which generates an additional capital loss $\mathscr{V}_u - \mathscr{V}_p$. The value of the match also incorporates the crime opportunities undertaken by the employed worker.

Suppose a worker and a firm could *jointly* determine the crime opportunities undertaken by the worker. It can be seen from Eq. (10), that the surplus of the match is maximized if

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

Comparison of Eqs. (6) and (11) reveals that if $\mathscr{V}_f > 0$, the worker's choice of which crime opportunities to undertake and the choice that maximizes the match surplus differ, i.e. the total surplus of the match is not maximized. Employed workers commit too much crime because they do not internalize the negative externality they impose on the firm if they are sent to jail.

We show that by allowing the employment contract to include an up-front 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

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

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

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

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

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.[14] Since the worker gets the entire output generated by the match, and hence $\mathscr{V}_f = 0$, this wage setting

[14] 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., $\mathscr{V}_f = \mathscr{V}_v = 0$.

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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.[15]

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 for the unemployed (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 Eq. (9), $\mathscr{V}_f = 0$ 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 Eq. (14), the expected surplus received by an unemployed worker who finds a job is

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

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

Second, using the Bellman Eqs. (2), (3) and (4), as well as the expression for the worker's surplus, Eq. (16), the crime decisions (5)–(6) can be rewritten as follows:

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

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

Given θ, Eqs. (17)–(18) determine a unique pair (ε_u, ε_e). Notice that Eqs. (17)–(18) correspond to standard optimal stopping rules. Also, Eq. (17) gives the first relationship between ε_u and θ.

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

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

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

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

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

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

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

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

Eq. (22) gives the second relationship between ε_u and θ. According to Eq. (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 $\lambda_u = \lambda_e$.

[15] 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.

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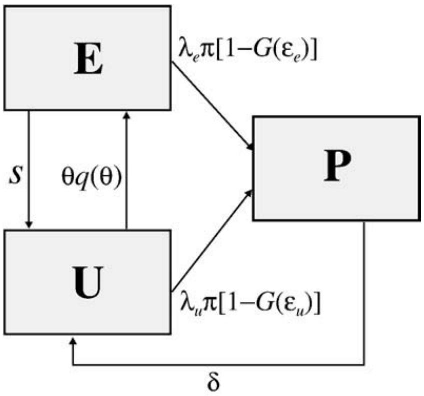

Fig. 1. Worker flows.

Finally, we characterize the steady-state distribution of individuals across states. The distribution (n_u, n_e, n_p) is determined by the following 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 Eq. (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, δn_p. 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, Eq. (24) prescribes that the flows in and out of employment must be equal. According to Eq. (25), individuals are either employed, unemployed, or in jail. Fig. 1 diagrams the above-mentioned 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 Eq. (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 is endogenous, and depends on ε_e.

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

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

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

As indicated above, the model is recursively solvable. First, the pair (θ, ε_u) is determined jointly from Eqs. (17) and (22). Second, knowing (θ, ε_u), one can use Eq. (21) to find ε_e. Finally, given (θ, ε_u, ε_e) the distribution (n_e, n_u, n_p) is obtained from Eqs. (23)–(25).

Fig. 2 represents the determination of the pair (θ, ε_u). We denote CS (crime schedule) as the curve representing Eq. (17) and JC (job creation) as the curve representing Eq. (22). Recall that CS always slopes upward while JC can slope upward or downward, depending on 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 Eq. (26) is denoted BC(ε_e). It shifts with the reservation value ε_e which, from Eq. (21), is uniquely determined from θ and ε_u. In Fig. 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 curie 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.

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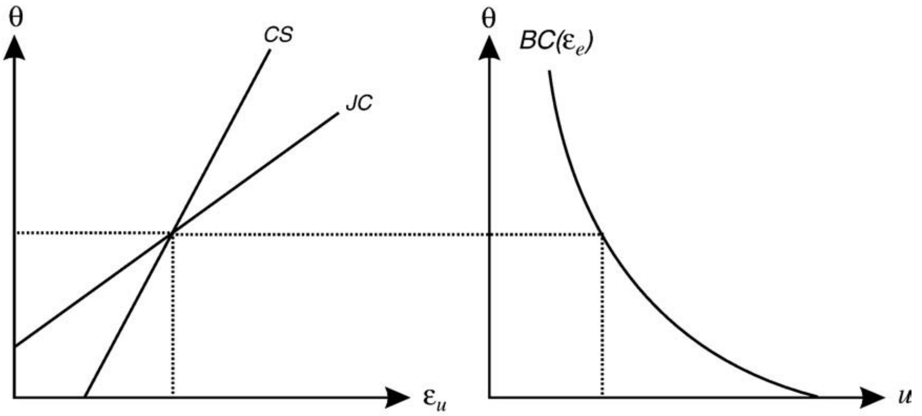

Fig. 2. Equilibrium.

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 Eq. (17) when $\theta=0$.

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

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

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 are no multiple steady-state equilibria in this model. The condition Eq. (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 Eq. (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.[16]

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

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

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.[17] 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.

[16] Data from the Survey of Prison Inmates in State and Federal Correction Facilities gives the labor force status at the time of arrest. This allows us to calculate that the crime rate when unemployed as 17% and when employed as 3%.

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

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Proposition 3. *Assume $m=\mu$ (ε_e, ε_u, θ), 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.

To investigate the implications of various policies on welfare in the quantitative section, we define welfare using a similar approach to that of Hosios (1990) and Pissarides (2000). Letting $\mathscr{W}$ be the sum of all agents' utility flows in steady state we have,

$$\mathscr{W} = n_u(b-\theta\gamma) + n_e y + n_p x - \tau^g - \omega m\left[\lambda_e n_e \int_{\varepsilon_e}^{\bar{\varepsilon}} \varepsilon \mathrm{d}G(\varepsilon) + \lambda_u n_u \int_{\varepsilon_u}^{\bar{\varepsilon}} \varepsilon \mathrm{d}G(\varepsilon)\right]. \quad (31)$$

5. Calibrated example

The unit of time corresponds to 1 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 $b=0.4$.[18]

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 $\eta=0.5$, so that workers' and firms' contributions to the matching process are symmetric. We set the bargaining power of the worker $\beta=0.5$ so that the division of the match surplus internalizes the externalities associated with firms' entry decisions (see Hosios, 1990).[19]

The parameters A and γ are chosen to match the average job-finding rate and the average $v-u$ ratio while s is chosen to match the separation rate. For the years 1951–2003 the job-finding rate, taken from Shimer (2005a), is 0.45 per month, implying that the annualized expected number of job offers, $\theta q(\theta)$, is 5.40. For a given job-finding rate, $\theta q(\theta)$, θ and γ appear as a product in the equilibrium conditions (17) and (22). Hence, one can normalize θ to one without loss of generality; this yields $A=5.40$ and $\gamma=0.513$. The monthly job separation rate, also taken from Shimer (2005a), is found to be 0.034, implying an annualized rate of 0.408, i.e., jobs last, on average, about 2 years.

Turning to the crime sector, the crimes considered are Type I property crimes as defined by the FBI, which include larceny, burglary, and motor vehicle theft.[20] The total number of property crimes, the crime rate (per 1000 persons), and the total dollar amount lost from crime are taken from the Uniform Crime reports (Tables 1 and 24).[21]

The distribution $G(\varepsilon)$, characterizing the crime opportunities, is assumed to be exponential with mean μ_g and is chosen to target the average amount stolen, approximately \$1243 in the data. The scaling factor, m, that endogenizes crime opportunities is taken to be the aggregate output of the economy, $n_e y$. The parameters $\lambda_e=\lambda_u$ target the overall crime rate, which is 42.4 per 1000 persons. Therefore, $\mu_g=0.0118$ and $\lambda_e=\lambda_u=0.417$. Finally, Cohen (1988) calculates the average costs of property crime to the victim, including pain and suffering, to be \$1374. We calculate the cost of crime to the victim by weighting the loss for each type of property crime (adjusted by the CPI) by their proportion of Type I property crimes. Therefore, we set $\omega=0.105$.

The probability of being caught is derived from the number sent to prison (we exclude those sentenced to probation) divided by the number of crimes, implying $\pi=0.019$. 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 $x=0$.

For welfare calculations, we assume that the technology to catch criminals is costly, and maintaining individuals in jail involves some real resources. Following İmrohoroğlu et al. (2000), the cost (not normalized by the wage) corresponding to a technology, π, to catch criminals is given by

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

and we use their estimate of $\nu=0.044$. The cost of a prisoner is estimated to be \$22,650.[22] In our model we assume both types of expenditures are financed by lump-sum taxes.

We normalize all dollar figures in the data (taxes, average amount stolen, cost of imprisonment, etc.) by annualized median weekly earnings in the CPS. In our model the counterpart is taken to be

$$\overline{w} = y - \{r + s + \lambda_e \pi[1 - G(\varepsilon_e)]\}\phi. \quad (32)$$

which is equivalent in discounted terms to the wage profile of a worker including the payment of the hiring fee. Using the chosen parameters gives $\overline{w}=0.96$. Median weekly earnings in the CPS after converting to an annual basis is $\overline{w}=\$31{,}616$. Therefore, \$31,616/0.96 = \$33,051, corresponds to y in our model.

In the tables that follow, the total crime rate is the expected number of crimes per 1000 workers and the crime rates for each type (unemployed or employed) are the expected number of crimes each type commits times 1000. Note that the total crime rate is the weighted average of the unemployed and employed crime rates.

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

[19] However, it does not guarantee that equilibrium is constrained-efficient because of the presence of crime opportunities. Our value for η is in the ballpark of estimates in the literature (see Petrongolo and Pissarides (2001), Shimer (2005a) and Flinn (2006).

[20] We note at the outset of this section that many of the parameters and targets differ depending on the population of interest. For example, the job destruction rate is three times the average for those aged 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.

[21] The FBI defines Forgery, Fraud, and Embezzlement as a Type II offense and does not collect the number of these types of crimes.

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

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Table 1
Parameters

r	0.048	Real interest rate
b	0.400	Unemployed utility flow
β	0.500	Bargaining power of workers
η	0.500	Elasticity of matching function
γ	0.513	Recruiting cost
s	0.408	Job destruction rate
A	5.400	Efficiency of matching technology
x	0.000	Utility flow when in jail
π	0.019	Apprehension probability
δ	0.750	Rate of exit from jail
$\lambda_e = \lambda_u$	0.417	Flow of crime opportunities
μ_g	0.0118	Mean of exponential crime distribution
ω	0.105	Dead-weight loss from crime
ν	0.044	Elasticity of apprehension technology

Table 1 recapitulates the parameters and functional forms used in the calibration.

6. Labor market policies

In this section we examine qualitatively and quantitatively how changes in several labor market policies affect crime and labor market outcomes. The policies we analyze are those that have been mentioned in the literature to reduce crime. Machin and Marie (2004) and Fougere et al. (2003), show that changes in unemployment benefits affected crime in the U.K. and France. Gould et al. (2002) document that workers' compensation is an important determinant of 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.

For our qualitative results (Propositions 4–8), we assume that the distribution of crime opportunities, and hence m, are exogenous. In contrast, our quantitative results are obtained for an endogenous distribution of crime opportunities ($m = n^e y$).

6.1. Unemployment benefits

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, according to our interpretation, b is composed of the utility of not working, 0.4, and unemployment benefits received from the government.[23]

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

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

The crime rate of employed workers depends on the average jail sentence and job duration because employed workers and individuals in jail will ultimately end up in the pool of unemployed, and enjoy $\mathcal{V}_u$.[24] The transition from employment to unemployment occurs at rate s, while the transition from jail to unemployment occurs at rate δ. If $\delta > s$ and $\mathcal{V}_u$ increases 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 employed accept lower and lower valued crime opportunities as b rises, given m. However, when m is endogenous (and equal to $n^e y$) their willingness to commit more crime is offset by the falling return to crime due to the degradation of the labor market and the associated loss in output. As a result, the employed crime rate is almost constant (until $b = 0.6$) but the aggregate crime rate falls due to the drop in the unemployed crime rate, as can be seen in Table 2. In terms of welfare, changing b has a negative effect by distorting firms' entry decisions, and for our numerical example, the distortionary effect outweighs the reduction in crime.

6.2. Workers' bargaining strength

In the next two subsections, we will consider policies that affect payments to workers. We start with the effect of a change in workers' bargaining power. While β may not necessarily be viewed as a policy parameter, it may be influenced by government's tolerance vis-a-vis unions, for instance.

[23] 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).
[24] A related result can be found in Burdett et al. (2003).

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Table 2
Effects of changing unemployment benefits (b)

	b				
	0.2	0.3	0.4	0.5	0.6
Labor force					
Employed (%)	93.8	93.4	92.9	92.2	91.3
Unemployed (%)	6.1	6.5	7	7.7	8.6
Crime					
Employed crime rate	41.3	41.4	41.3	41.2	40.9
Unemployed crime rate	60.5	59	57.5	55.6	53.5
Total crime rate	42.5	42.5	42.4	42.3	41.9
Change in welfare	−0.09%	−0.02%	–	−0.04%	−0.2%

Note: The crime rate for a given population is defined as the number of crimes committed by individuals in this population per 1000 individuals in the same population.

Proposition 5. *An increase in β:*

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

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.[25] Table 3 shows that reducing workers' bargaining power from 0.5 to 0.01, corresponding to a reduction of workers' compensation (compensation is w, defined in Eq. (32)) of about 30%, generates a reduction in the total crime rate of about 20%. 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 three-fold. These non-linearities are explained by the asymmetric response of the workers' job-finding rate. 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 no longer holds. The welfare loss associated with this distortion outweighs any potential gain in terms of reducing criminal activities.

6.3. Wage subsidies

Suppose now that the government pays a (flow) wage subsidy $\varphi>0$ per unit of time to each employed worker. This subsidy is financed by a lump-sum tax of size $n_e\varphi$. The Bellman equation for an employed worker becomes

$$r\mathscr{V}_e = w + \varphi - \tau + s(\mathscr{V}_u - \mathscr{V}_e) + \lambda_e \int \left[\varepsilon m + \pi\left(\mathscr{V}_p - \mathscr{V}_e\right)\right]^+ \mathrm{d}G(\varepsilon). \tag{33}$$

The terms of the employment contract are still $w=y$ and $\phi=(1-\beta)(\mathscr{V}_e-\mathscr{V}_u)$. In the equilibrium conditions (18), (20) and (22), y is replaced by $y+\varphi$, suggesting that an increase in the wage subsidy is equivalent to an increase in workers' productivity (except for welfare considerations).

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

A wage subsidy has two effects on the equilibrium. It has a direct effect on the crime rate of the employed. Since the flow payment to the employed worker (including the wage subsidy) is higher, employed workers incur a larger opportunity cost if sent to jail, and hence they tend to commit fewer crimes. The wage subsidy also has a direct effect on firms' decision to open vacancies. Indeed, through the payment of the hiring fee the firm is able to capture a fraction of the wage subsidy paid to employed workers. Therefore, firms with vacant jobs have higher incentives to enter the market. Graphically, the JC curve shifts upward and both θ and ε_u increase.

The calibration adds another dimension to the relationship between the wage subsidy and the crime rate. Specifically, as the subsidy rises so does the value of crime opportunities (because of the increased employment). Therefore, the opportunity cost of

[25] In Engelhardt et al. (2007) we have worked out a version of the model with no hiring fee. The effects of workers' bargaining strength on total crime are significantly different from the ones we obtain under optimal contracts. In particular, for a calibrated version of the model, the crime rate is always decreasing with β.

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Table 3
Changes in bargaining power (β)

β	0.01	0.05	0.10	0.50	0.90	0.95	0.99
$\overline{w}$	0.682	0.829	0.876	0.957	0.986	0.991	0.997
Labor force							
Employed (%)	98.9%	98%	97.3%	92.9%	80.6%	73.2%	49.5%
Unemployed (%)	1%	1.9%	2.6%	7%	19.3%	26.7%	50.5%
Crime							
Employed crime rate	33.3	40.4	42.5	41.3	26.5	18.4	2.7
Unemployed crime rate	104.5	77.2	69.8	57.5	48.3	43.7	26.3
Total crime rate	34	41.1	43.1	42.4	30.7	25.1	14.6
Change in welfare	−22.72%	−9.03%	−4.89%	–	−5.08%	−9.45%	−24.43%

Note: The crime rate for a given population is defined as the number of crimes committed by individuals in this population per 1000 individuals in the same population.

committing crime is rising at the same time as the average benefit. Quantitatively, as seen in Table 4, a wage supplement equal to 5% of worker's yearly output reduces the crime rate by about 10%. The optimal wage subsidy is 0.084.

As previously indicated, the effects of an increase in φ on the equilibrium are equivalent to those of an increase in y. This is relevant because a large literature (e.g., Lochner (2004)) has emphasized policies aimed at increasing workers' human capital, and hence their productivity (see Engelhardt et al. (2007) for a methodology to endogenize y).

6.4. 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 financed by a lump-sum tax.

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

By reducing the cost to open vacancies, hiring subsidies promote job creation. Unemployed workers benefit from a higher job-finding rate and therefore reduce their involvement in crime. Employed workers commit more crimes if $\delta>s$ (the intuition is similar to the one for an increase in b or β). So the overall effect on crime is ambiguous. Quantitatively, shown in Table 5 reducing the hiring cost from 0.51 to 0.41 leads to an increase in crime of about 3% (this result is surprisingly different from the one derived for the wage subsidies). For our calibration, the introduction of hiring subsidies lowers welfare.

7. Crime policies

The government can have a direct effect on criminal activity by imposing harsher punishments on criminals or investing in police surveillance and technologies to solve crimes.[26] However, such policies also affect the labor market by modifying the outside options of the workers, their employment contract and job duration.

7.1. Apprehension

In our model, the effects of an increase in π on the labor market (job duration and market tightness) 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 quantitative findings with respect to π are substantial as seen in Table 6. Increasing the probability of being caught committing a crime by about 10% cuts the total crime rate by about 20%. A higher probability to catch criminals raises market tightness, but the effect is small.[27]

7.2. Jail sentences

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 8. *Assume $\lambda_e=\lambda_u$. 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.

[26] 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.

[27] For a given δ, the optimal value of π, 0.0637, is given in the last column of the table; however, it is sensitive to the assumption that all individuals receive crime opportunities at the same rate and the estimate for the cost function $C(\pi)$.

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Table 4
Effects of wage subsidies (φ)

ϕ	φ				
	0.025	0.05	0.084	0.15	0.2
Labor force					
Employed (%)	93	93.2	93.3	93.6	93.8
Unemployed (%)	6.9	6.8	6.6	6.3	6.1
Crime					
Employed crime rate	39.2	37.1	34.6	30	26.9
Unemployed crime rate	54.8	52.3	49.1	43.3	39.4
Total crime rate	40.2	38.1	35.5	30.8	27.7
Change in welfare	0.011	0.018%	0.021%	0.011%	−0.009%

Note: The crime rate for a given population is defined as the number of crimes committed by individuals in this population per 1000 individuals in the same population.

Table 5
Effects of hiring subsidies (γ)

	γ				
	0.31	0.41	0.51	0.61	0.71
Labor force					
Employed (%)	94.4	93.6	92.9	92.2	91.6
Unemployed (%)	5.5	6.3	7	7.7	8.3
Crime					
Employed crime rate	44.2	42.7	41.3	40.2	39.1
Unemployed crime rate	57.1	57.3	57.5	57.6	57.7
Total crime rate	44.8	43.5	42.4	41.5	40.6
Change in welfare	−0.28%	−0.05%	–	−0.04%	−0.13%

Note: The crime rate for a given population is defined as the number of crimes committed by individuals in this population per 1000 individuals in the same population.

Table 6
Changes in criminal apprehension (π)

π	π					
	0.017	0.018	0.019	0.02	0.021	0.0637
Labor force						
Employed (%)	92.8	92.9	92.9	92.9	92.9	93
Unemployed (%)	7.0	7.0	7.0	7.0	7.0	7.0
Crime						
Employed crime rate	52.7	46.7	41.3	36.6	32.4	0.2
Unemployed crime rate	70.8	63.8	57.5	51.8	46.7	0.5
Total crime rate	53.9	47.8	42.4	37.6	33.4	0.2
Change in welfare	−0.03%	−0.02%	–	0.01%	0.03%	0.21%

Note: The crime rate for a given population is defined as the number of crimes committed by individuals in this population per 1000 individuals in the same population.

While crime policies have strong effects on criminal behavior they do not affect significantly labor market outcomes. The quantitative findings with respect to δ are substantial as seen in Table 7. 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%.[28]

8. 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). Criminal activities are described in accordance with Becker (1968). Individuals' willingness to commit crimes, 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 the 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.

[28] For a given π the optimal value for δ is small, less than 0.03. As indicated earlier, this result depends on our assumption that $\lambda_e=\lambda_u$ as well as our estimate for the cost of maintaining an individual in jail.

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Table 7
Changes in jail sentences (δ)

δ	δ					
	<0.03	0.65	0.7	0.75	0.8	0.85
Labor force						
Employed (%)	93	92.9	92.9	92.9	92.9	92.8
Unemployed (%)	7.0	7.0	7.0	7.0	7.0	7.0
Crime						
Employed crime rate	0	31.1	36.2	41.3	46.5	51.5
Unemployed crime rate	0	43.3	50.3	57.5	64.6	71.6
Total crime rate	0	32	37.2	42.4	47.7	52.9
Change in welfare	0.22%	0.03%	0.02%	–	−0.01%	−0.03%

Note: The crime rate for a given population is defined as the number of crimes committed by individuals in this population per 1000 individuals in the same population.

Engelhardt et al. (2007) extends the benchmark model in two ways that seem relevant for the relationship between the labor market and crime. First, since the accumulation of human capital by workers is an important determinant of both labor market outcomes and crime decisions, we consider a simple extension of our model that endogenizes workers' productivity. Unemployed workers choose a training intensity that determines their level of productivity when matched with a firm. The worker's investment in human capital tends to be too low because of a holdup problem. Moreover, because of strategic complementarities between workers' training choices and firms' decisions to open vacancies, the model can exhibit multiple equilibria. While these complementarities are not new, in the presence of crime they provide another rationale for why policies aimed at reducing workers' training cost can be desirable.

Second, it is a well known fact (from the Survey of Inmates) that a significant fraction of property crimes are committed by individuals who are neither employed nor searching actively for a job. So, we also extend our model to account for participation decisions in the labor force along the lines of Pissarides (2000). As individuals' utility out of the market increases, they commit fewer crimes. Moreover, unemployed workers are less picky than individuals out-of-the-labor-force when choosing which crime opportunities to commit. Hence, the crime rate of the unemployed is larger than the crime rate of workers out out-of of-the the-labor labor-force, in accordance with the evidence. We show that a decline in preferences towards work at home that generates an increase in the participation rate from 40% to 60% (the magnitude of the increase in female participation over the last 50 years) leads to a 40% rise in crime (female crime more than doubled over the period).

The model could also be extended to take into account additional aspects of crime. For example, firms might observe part of a worker's crime history, leading to the possibility of stigma effects. Another extension would allow for some depreciation of skills while in prison, thus increasing the cost of incarceration. It would also be of interest to allow for ex-ante heterogeneity across workers, which would require taking into account the distribution of wealth across agents.

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

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

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

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

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

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

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

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it is easy to see that

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

□

Proof of Proposition 1. Summing Eqs. (17) and (22) one obtains

$$\frac{(r+s)\gamma}{(1-\beta)q(\theta)}+\left(\frac{r+\delta}{\pi}\right)\varepsilon_u m=y-x+\lambda_e m\int_{\varepsilon_u+\frac{\pi\gamma}{m(1-\beta)q(\theta)}}^{\bar{\varepsilon}}[1-G(\varepsilon)]d\varepsilon. \tag{34}$$

From Eq. (34), it can be checked that θ is a strictly decreasing function of ε_u. So if a solution to Eqs. (17) and (34) exists then it is unique. Denote $\varepsilon_u(\theta)$ the solution ε_u to the Eq. (17). Since $b-x>0$ then $\varepsilon_u(\theta)>0$. Furthermore, $\varepsilon_u(\theta)$ is non-decreasing in θ. Define $\Gamma(0)$ 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 $(\frac{r+\delta}{\pi})\varepsilon_u(\theta)m$ given by Eq. (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 Eq. (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, Eq. (17) gives a unique ε_u and Eq. (18) 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 Eq. (26).

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

Proof of Proposition 2. From Proposition 1, no crime occurs in equilibrium iff $\varepsilon_u>\varepsilon$. From Eq. (20) if $\varepsilon_u>\bar{\varepsilon}$ then $\theta=\hat{\theta}$. From Eq. (17) the condition $\varepsilon_u>\bar{\varepsilon}$ requires Eq. (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 Eq. (28) holds. With endogenous m, we look for the following fixed point:

$$\mu[\varepsilon_e(m),\varepsilon_u(m),\theta(m)]=m. \tag{35}$$

From Eq. (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 an $m>0$ solution to Eq. (35). □

Proof of Proposition 4. The pair (ε_u, θ) is uniquely determined by Eqs. (17) and (34). Differentiating these two equations, it is straightforward to show that $d\varepsilon_u/db>0$ and $d\theta/db<0$. From Eq. (18) the sign of $d\varepsilon_e/db$ is the same as $s-\delta$. □

Proof of Proposition 5. The pair (ε_u, θ) is determined by Eqs. (17) and (34). 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: $\gamma=\gamma/[(1-\beta)q(\theta)]$ Eqs. (17) and (34) can now be rewritten as

$$\left(\frac{r+\delta}{\pi}\right)\varepsilon_u m=b-x+\frac{\beta}{1-\beta}q^{-1}\left[\frac{\gamma}{(1-\beta)\tilde{\gamma}}\right]\gamma+\lambda_u m\int_{\varepsilon_u}^{\bar{\varepsilon}}[1-G(\varepsilon)]d\varepsilon, \tag{36}$$

$$(r+s)\tilde{\gamma}+\left(\frac{r+\delta}{\pi}\right)\varepsilon_u m=y-x+\lambda_e m\int_{\varepsilon_u+\frac{\pi}{m}\tilde{\gamma}}^{\bar{\varepsilon}}[1-G(\varepsilon)]d\varepsilon. \tag{37}$$

Eqs. (36) and (37) determine ε_u and γ The term $\frac{\beta}{1-\beta}q^{-1}\left[\frac{\gamma}{(1-\beta)\tilde{\gamma}}\right]$ on the RHS of Eq. (36) increases in β if $\beta<\eta(\theta)$. Differentiating Eqs. (36) and (37) 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 Eq. (18) which can be reexpressed as

$$\left(\frac{r+\delta}{\pi}\right)\varepsilon_e m=y-x+(\delta-s)\tilde{\gamma}+\lambda_e m\int_{\varepsilon_e}^{\bar{\varepsilon}}[1-G(\varepsilon)]d\varepsilon. \tag{38}$$

From Eq. (37) there is a negative relationship between ε_u and $\tilde{\gamma}$ Therefore, $\text{sign}(d\varepsilon_e/d\beta)=\text{sign}[(s-\delta)]d\varepsilon_u/d\beta$. □

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Proof of Proposition 6. As indicated in the text, y is replaced by $y+\varphi$ in the equilibrium conditions (18), (20) and (22). Hence, we can prove the result for a change in y. Eq. (17) is independent of y. Therefore, it is easy to show from Eqs. (17) and (34) that both θ and ε_u increase following an increase in y. From Eq. (21),

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

□

Proof of Proposition 7. Following the Proof of Proposition 5, we adopt the following change of variable: $\tilde{\gamma}=\gamma/[(1-\beta)q(\theta)]$. The pair (γ, ε_u) is determined by Eqs. (36) and (37) which can be rewritten as

$$\left(\frac{r+\delta}{\pi}\right)\varepsilon_u m = b - x + \beta p \circ q^{-1}\left[\frac{\gamma}{(1-\beta)\tilde{\gamma}}\right]\tilde{\gamma} + \lambda_u m \int_{\varepsilon_u}^{\overline{\varepsilon}} [1 - G(\varepsilon)] d\varepsilon, \tag{39}$$

$$(r+s)\tilde{\gamma} + \left(\frac{r+\delta}{\pi}\right)\varepsilon_u m = y - x + \lambda_e m \int_{\varepsilon_u + \frac{\pi}{m}\tilde{\gamma}}^{\overline{\varepsilon}} [1 - G(\varepsilon)] d\varepsilon. \tag{40}$$

where $p(\theta)=\theta q(\theta)$ and is the composition operator. Eq. (39) gives a positive relationship between ε_u and $\tilde{\gamma}$ while Eq. (40) defines a negative relationship between ε_u and $\tilde{\gamma}$. It can be checked from Eqs. (39) and (40) that $d\varepsilon_u/d\gamma<0$ and $d\gamma/d\tilde{\gamma}>0$. From Eq. (18) the sign of $d\varepsilon_e/d\gamma$ is the same as $\delta-s$. Finally, from Eq. (17) ε_u increases if $\theta\gamma$ increases which implies $d\theta/d\gamma<0$. □

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