**INTERNATIONAL ECONOMIC REVIEW**
Vol. 45, No. 3, August 2004

# CRIME AND POVERTY: A SEARCH-THEORETIC APPROACH*

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Numerous studies document that criminal activity is positively related to unemployment and negatively related to educational attainment levels within given communities. We study this phenomenon in the context of a search-equilibrium model, in which agents choose between formal employment and pursuing crime-related activities (theft). Prior to their "occupational choices," agents undertake costly schooling, raising their productivity. Crime acts, in essence, as a tax on human capital by affecting the probability that a worker's earnings (possessions) are subsequently appropriated. There are multiple equilibria. High crime, low levels of educational attainment, long spells of unemployment, and poverty are correlated across them.

## 1. INTRODUCTION

Criminal activity is characterized by several striking empirical features. It is subject to considerable temporal variation, it is geographically concentrated, and it exhibits wide dispersion across communities that possess ostensibly identical economic characteristics. Less affluent cities are disproportionately afflicted: in particular, those characterized by chronic poverty, a poorly educated workforce, and limited access to employment opportunities.

Thus, the United States witnessed a precipitous increase in the crime rate during the 1980s followed by an equally impressive decline during the 1990s. Indeed, at its peak in 1991, about 2 percent of the U.S. workforce—amounting to just over 2 million persons—was incarcerated in federal or state prisons and about 7 percent of the workforce was incarcerated, paroled, or on probation at the reference time. Regarding geographic concentration, Freeman et al. (1996) note that in 1990 the median number of reported street robberies in Los Angeles equaled 4 per 1000 residents. Yet, 10 percent of the neighborhoods had crime rates four times

* Manuscript received April 2003; revised February 2004.

[1] We are grateful for comments and suggestions from Eric Bond, Ken Burdett, Ed Glaeser, Victor Li, Antonio Merlo, Rob Reed, Reinhard Selten, Frank Page, Myrna Wooders, and Randy Wright. The third author also acknowledges financial support from NIH grant 1R01-AA11657-01,02. Earlier drafts at various stages of this research project have been presented at Academia Sinica, National Taiwan, Penn State, Washington–St. Louis, Windsor, the Midwest Economic Theory Conference at Northwestern, the Midwest Macroeconomic Conference at Iowa, the Summer Meetings of the Econometric Society at Cal Tech, the Public Economic Theory Conference in Paris and the IER-PIER Conference on Crime and Public Policy. Needless to say, the usual disclaimer applies. Please address correspondence to: Derek Laing, Department of Economics, Vanderbilt University, 415 Calhoun Hall, Nashville, TN 37235. Phone: 814-777-1773. Fax: 615-343-8495. E-mail: *DXL8@psu.edu*.

greater than the median. As for both temporal and spatial variability, Glaeser et al. (1996) document that the U.S. homicide rate declined by 50 percent between 1933 and 1961 and that: "Ridgewood village reported 0.008 serious crimes per capita, whereas nearby Atlantic City reported 0.34."[2]

Changes in the U.S. crime rate were coterminus with two significant developments in the U.S. labor market: the sharp decrease in the earnings of young unskilled men in the 1980s and the rapid decline in the aggregate rate of unemployment in the 1990s.[3] In view of these parallel developments, this immediately raises the question of whether or not these events are related in some way. Of course, such a connection might be expected to hold on a priori grounds. The reason is that according to the canons of conventional microeconomic wisdom, the decision of whether or not to engage in criminal activities *is* a time allocation problem. As such, changes in the opportunities available to workers in the formal labor market will have a direct and ineluctable impact upon the crime rate, by affecting the opportunity cost of criminal behavior.

Yet, despite this compelling logic, few theoretical models have been constructed to date that can be used to model these connections more formally. This is particularly surprising, in view of the large body of empirical work indicating that not only do labor market opportunities affect criminal behavior, but also that the crime rate itself also affects labor market opportunities.[4] Perhaps the most robust finding in this literature is the documented negative correlation between market wages and crime. Whereas Grogger (1998) estimates that a 20 percent decline in the (youth) wage would lead to a 20 percent increase in the crime rate, Gould et al. (2002) document that changes in the wage can account for up to 50 percent of the trend in violent crimes and in property crimes. Recent studies by Raphael and Winter-Ebmer (2001) and by Gould et al. also indicate that there is a strong positive link between the unemployment and crime rates.[5] Close empirical relationships are also observed between the rate of crime and human capital acquisition. For instance, Lawrence (1995) reports that in 1982: "In the general population, 85% of males 20–29 years of age have finished high school; only 40% of prisoners have done so . . . Six percent of prisoners have had no schooling at all." Indeed, several studies including Witte and Tauchen (1994), Lochner (2004), and

[2] Similar disparities were observed between New York's 1 precinct and 123 precinct, with per capita crime rates of 0.21 and 0.022 respectively.

[3] See Grogger (1998) and the references cited therein. As noted by İmrohoroğlu et al. (2000, 2004) and Merlo (2001), two other profound changes were also taking place at this time that could also account for the changes in the crime rate. First, there were significantly greater expenditures on policing as well as the adoption of new policing tactics in many locations. Second, there was a sizable demographic shift toward a more elderly population. (The vast majority of crimes are committed by those between the ages of 17 and 30.)

[4] Evidence linking the crime rate to human capital accumulation is sparser. For instance, Grogger (1997) shows that propinquent violent crime has a significant and negative effect on educational attainment levels.

[5] These results stand in sharp contrast with earlier work in the area (see, for example, Freeman, 1995), which indicates there is but a modest effect of unemployment on crime. In addition to more plentiful data, the hallmark of the more recent liiterature is carefully controlling for the endogeneity of the work/unemployment decision.

Lochner and Moreti (2001) also indicate that completing high school significantly reduces criminal proclivities.

In this article we propose a dynamic general (search) equilibrium framework that can be used to flesh out and better understand how the opportunities available in the formal labor market affect the crime rate and vice versa.[6] The model we construct captures, in a parsimonious manner, many of the salient stylized aspects of the empirical observations outlined above and illuminates several interesting feedback effects, presently not explored in the literature. Significantly, the crime rate, levels of educational attainment, interdiction rates, and both employment opportunities and wages are all determined endogenously. Perhaps somewhat surprisingly, the resultant framework is highly tractable and admits numerous comparative static experiments that may yield useful policy and empirically testable implications. These include, to name but a few, the effects of an increase in policing expenditures, as well as the effects of more traditional labor market policies, such as employment subsidies intended to foster employment opportunities.

We consider a community that is populated by two types of homogeneous agents, corresponding to firms and workers. Prior to entering the labor market, workers choose: (1) how much human capital to accumulate through (costly) schooling and (2) the "occupation" (namely, work and crime) they intend to pursue.[7] Workers are amoral in that—given identical pecuniary rewards—they are indifferent between committing crimes and pursuing formal employment. Human capital acquired through schooling raises each individual's subsequent productivity upon employment. The interactions between all agents in the model are governed by random matching processes. Thus, in the formal labor market, firms with open vacancies and workers actively seeking jobs are brought together at random points in time through a stochastic matching technology. The flow rate of contacts depends upon the (endogenous) number of participants on each side of the market. Upon a successful match, the firm–worker pair negotiate a wage and production then takes place.[8] Similarly, in the criminal sector, consumers with goods held in inventory randomly encounter criminals who seek to appropriate them. In this setting, the outcome of a match is that either the criminal successfully steals his victim's holdings of the consumption good or else is interdicted by the authorities, at a rate that depends upon, among other things, the resources

[6] It is only recently that economists have begun to study the links between the socio-economic environment and the concomitant rate of crime. Indeed, the early literature on the economics of crime, pioneered by Becker (1968) and Ehrlich (1973), largely focuses on the determinants of malfeasant behavior and attempts to circumscribe the efficacy of punishment as a deterrent. Important recent exceptions include İmrohoroğlu et al. (2000, 2004) who construct general (competitive) equilibrium models of crime. In a recent survey, Merlo (2001) emphasizes the importance of using a dynamic general-equilibrium framework to model criminal behavior.

[7] This latter decision is reversible ex ante, in the sense that at any point a worker can switch from formal employment to crime and vice versa (though this option is not exercised in the stationary steady state).

[8] As we will see, an interesting feature of our equilibrium is that it is characterized by an endogenous distribution of human capital. This should be contrasted with the canonical job search model of Burdett and Mortensen (1998), which treats worker skills as given, but is characterized by a wage distribution.

devoted by the community to such efforts. This framework is particularly suited for analyzing the case in which agents risk losing their assets to crime: It embodies both production and asset holdings. Although the modeling strategy of the formal labor market follows Laing et al. (1995), the construction of a consumption state in which goods may be stolen resembles the coconut inventory state in Diamond (1984). However, in contrast with these two lines of research, our framework considers interactions between the formal labor market and the criminal sector with endogenous occupational choice, which is the central feature of the model.

All agents are rational and forward looking. In making their entry decision, firms are influenced by the average level of human capital in the community (which determines average worker productivity), wages, and the ease with which they can find suitable employees. Similarly, the level of human capital accumulated by each household (as well as its subsequent occupational choice) depends upon the aggregate circumstances that confront it in the community, including, in particular, the extent of criminal activity. The anticipated returns from formal employment depend upon the wage rate, the "tightness" of the labor market, and the crime rate, whereas the benefits of crime depend upon the ease of finding potential victims, the return that accrues from each theft (which, in turn, hinges on the average wage/income in the community), the likelihood of interdiction, and the sanctions imposed by the state in this latter event.

The model exhibits multiple steady-state equilibria, with high crime, low levels of educational attainment, long spells of unemployment, and poverty (low incomes) correlated across them. The multiplicity stems from three distinct positive feedback externalities that lead to greater levels of criminal activity increasing the marginal returns to crime at the individual level. First, for any given level of policing expenditures, an increase in the crime rate reduces the likelihood that any given criminal is interdicted by the authorities. In turn, this lowers the expected costs of committing crime (*the interdiction effect*).[9] Second, an increase in the crime rate lowers the expected returns to formal employment, since workers anticipate that the fruits of their labor are more likely to be stolen by criminals (*the appropriation effect*).[10] At the margin this encourages criminal behavior. Finally, crime acts, in essence, as an *indirect tax on human capital accumulation*, by reducing the value of any given level of schooling. As a consequence, low worker productivity discourages firms from entering the community that raises unemployment, and yields more crime (*the human capital effect*). One of the great merits of the search-equilibrium approach is the ease with which these various feedback channels can be identified separately and studied independently in a parsimonious manner.

1.1. *Related Literature.* Some of the underlying strategic complementarities identified in this article that stem from criminal activity have been studied

[9] A similar externality is studied by Sah (1991) and Freeman et al. (1996) under very different economic structures.

[10] Murphy et al. (1993) isolate a similar effect, but in a model of rent-seeking.

elsewhere in the literature (although in quite different settings). Sah (1991) develops a model in which an increase in the number of criminals reduces the likelihood (for given enforcement expenditures) that any one criminal will be arrested. A similar externality is posited by Freeman et al. (1996). Our model not only admits a microfoundation that generates arrest probabilities *endogenously* but also allows us to perform experiments that maintain a *constant* per capita arrest hazard by endogenously adjusting the level of law enforcement expenditure. We demonstrate the possibility of multiple equilibria, even without the interdiction spillover effect identified by Sah.

Glaeser et al. (1996) consider a "random-graph" framework, in which each agent in the community is conceived of as a point on a lattice. Individual behavior is driven largely through peer group effects: Certain agents imitate the behavior of their nearest neighbor (which is either legitimate or malfeasant). They show that a distribution of (Nash) equilibria may exist. This feature offers valuable insights into the variance of crime rates observed over both time and space. Although both random-graph and search-equilibrium theories may be connected at a somewhat deeper level, for many applications search theory has the decisive advantage of tractability. Moreover, by viewing search as taking place within a given community, the search-equilibrium approach offers a parsimonious framework for studying both *local* informational spillovers and *global* interactions (such as aggregate labor market activity or the effects of changes in police expenditures). As Glaeser et al. note, this remains a desideratum, to their knowledge.

Murphy et al. (1993) explore a different type of externality. In their model, an increase in the level of corruption increases the relative returns to such activities, since the returns from legal activities are appropriated. This complementarity generates multiple equilibria, with high income/low level of corruption and low income/high level of corruption configurations. Although our model also possesses a similar feature of multiple equilibria (by viewing corruption and crime as comparable), in addition we study the effects of criminal activity on human capital accumulation, wages, and the level of economic activity. Moreover, we study the possibility that the proceeds from crime may also be stolen—thieves are both *hunters* and *the hunted*. In this case, although the externality posited by Murphy et al. is absent, we still establish the possibility of multiple equilibria.

Our article is also related to some recent and independent work by Lochner (2004), İmrohoroğlu et al. (2000, 2004), and Burdett et al. (2004). Lochner constructs a simple two-period life-cycle model of crime and educational choices. His main concern is exploring the effect of labor market conditions upon crime and educational choices. Thus, in his model the crime rate neither affects the value of opting for formal employment nor engaging in nefarious criminal activities. Furthermore, an increase in the wage rate automatically increases the opportunity cost of crime. No allowance is made for the possibility that an increase in (formal) workers' income levels might also increase the *value* of theft.

İmrohoroğlu et al. (2000) construct a dynamic general (competitive) equilibrium model of crime and labor supply. They quantitatively evaluate the main determinants of the observed change in the crime rate between 1980 and 1996.

However, in their baseline model, worker skills are assumed to be exogenous. It follows that their model cannot be used to address the issues considered in this article. İmrohoroğlu et al. (2004) construct a political economy model to study the effects of inequality, redistribution, and police expenditures on the crime rate. The search-equilibrium framework considered here can—and indeed is—extended to deal with such policy-related issues. Yet, the main focus of this article is explicating the links that exist between criminal activity and investments in human capital, a subject on which their articles are silent.

Perhaps the closest article in spirit to this one is the search-equilibrium model due to Burdett et al. (2004). Just as in this article, they consider an environment characterized by labor market search and by the random interaction between criminals and formal workers. However, despite this similarity the focus of our two articles is quite different. In their model, all workers and firms are equally productive (there is no scope for workers to acquire human capital). An equilibrium wage distribution arises in their model, in which some firms use high wage payments to reduce costly labor turnover.[11] Workers employed at high-wage firms prefer not committing (property) crimes, because they have too much to lose if they are apprehended, incarcerated, and as a result lose their jobs. It is, however, optimal for workers employed at low-wage firms to commit crimes when they have the opportunity to do so.[12] Their article examines the relationship between the distribution of wages and the level of crime. In our article, an endogenous distribution of *accumulated human capital* arises in equilibrium, as opposed to an endogenous distribution of wages as in Burdett et al. The key property of our equilibrium is that those workers who *acquire skills* become formal workers (and do not commit crimes), whereas those who do not become criminals. Thus, our framework may be viewed as an "occupational choice" model of crime. Note that the endogenous acquisition of human capital is crucial. In its absence, we could not generate an interesting nondegenerate division of "occupations" between formal workers and criminals.[13]

## 2. THE MODEL

We construct a continuous-time model of search and matching. The community is populated by two distinct risk-neutral economic units, corresponding to households and firms (or job vacancies), who discount the future at the rate $r = \delta + \bar{r} > 0$, where $\delta$ and $\bar{r}$ are the (common) death and time preference rates, respectively. Households are also born at the constant flow rate, $\delta$, giving a constant steady-state population, of unity. There is a single perfectly divisible good with a normalized price of unity. The good is storable in unlimited quantity and at zero cost. Before providing a detailed description of the model, we first offer

[11] In equilibrium, both high- and low-wage firms expect to earn zero profits.

[12] This formulation is similar in spirit to the employee crime model of Dickens et al. (1989), in which firms pay "efficiency wages" to deter malfeasant behavior.

[13] Similarly, in Burdett et al. (2004), the imposition of a uniform wage would result, generically, in a degenerate equilibrium in which either all or no workers engaged in crime.

a general overview of its main features, focusing on the three main theaters of economic activity.

(i) *The educational sector:* Prior to making their occupational choice households accumulate human capital, increasing their productivity and wage income upon formal employment. Although all households are ex ante identical, their educational attainment levels may differ ex post. Crucially, educational choices depend upon the subsequent "career" (namely, formal employment or crime) households intend to pursue. Only formal workers choose more than the minimal level of education, as human capital is productive only in this sector.

(ii) *The primary labor market:* In this market job seekers and vacancies are brought together through a stochastic matching technology. All matches are transient and wages are determined in accordance with a (symmetric) Nash bargaining protocol. As soon as the wage is agreed, firms search for new trading partners and workers enter a consumption state, awaiting just the right moment to enjoy the fruits of their labor (this is governed by a Poisson process with parameter $\lambda$). Immediately after consumption, workers search for further job opportunities.

(iii) *The criminal sector:* This sector is populated by thieves who use their labor endowment to prey upon and to steal the goods currently held in inventory by other agents (including possibly other criminals). After a successful robbery, these agents too await the appropriate opportunity to consume and to derive utility from their illicit gains (also at the rate $\lambda$). After consuming their criminal proceeds, agents in this market then immediately search for new victims. We now formally describe the model.

2.1. *Firms.* Each firm possesses a fixed-coefficient's technology that employs the labor services of one worker at a time. Firms maximize the present value of their expected net revenues. Through a suitable choice of units, the output (revenue) produced by a worker, with human capital $s$, is simply: $y = s$. Subsequently, for the purpose of conducting interesting comparative-static exercises, we will perturb the firm's technology by an exogenous shift in average worker productivity: $y = y_0 + s$ (and then evaluate the results around $y_0 = 0$). We further assume that all worker–firm matches are transient and, upon matching, the wage, $w$, is agreed between the two parties according to a symmetric Nash bargain.[14]

The mass of firms in the economy is $V$. There is unrestricted entry, in the sense that any number of firms can instantly enter the labor market and search for workers, after incurring a fixed-entry fee, $v_0 > 0$. This reflects unit capital costs as well as the costs of advertising the vacancy. Improvements in the organization of

[14] As we will see these assumptions, in conjunction with those pertaining to worker preferences, lead to a simple (discrete) wealth distribution. We conjecture that extended employment with continuous flow wages and theft (at random intervals) could be modeled using the methods set out in Diamond and Yellin (1990). However, in this article we are not interested in the properties of long-term employment contracts per se nor the effects of the distribution of wealth on crime.

financial markets that reduce finance costs or alternatively tax incentives geared toward promoting investment lower $v_0$.[15]

2.2. *Households.* Each household is endowed with an indivisible unit of labor that may be supplied inelastically without disutility from effort. Immediately after they are born, households can accumulate human capital $s$ instantaneously by exerting schooling effort.[16] The cost of acquiring human capital is $g(s) = s^{1/\varepsilon}$, where $\varepsilon \in (0, 1)$.[17] Furthermore, we assume that workers acquire human capital only through formal education, ruling out, for example, on-the-job learning.

The division of the ex ante identical (unit) population between formal employment and crime is an optimal *occupational choice* (with populations determined in equilibrium and households free to switch between sectors).[18] After acquiring human capital, households choose between formal employment and crime.[19] Let $N$ denote the mass of households in the primary labor market and let $1 - N$ denote the mass in the criminal sector. Each household (whether a legitimate worker or a criminal) is in either the consumption or acquisition state. Let $C$ and $Q$ denote, respectively, the masses of households in the primary sector and in the criminal sector that are in the consumption state. Similarly, let $U$ and $R$ represent the masses in the acquisition state in the primary and criminal sectors. Thus, we have the following population identities:

$$N \equiv C + U \tag{1}$$

$$1 - N \equiv Q + R \tag{2}$$

In order to ensure that, on the one hand, workers have something "saved" that criminals can actually steal and, on the other hand, to sidestep the difficult distributional issues that generally arise in search equilibrium models that allow

[15] In order to avoid a nontrivial economic problem, in which it is never profitable for firms to enter the labor market, we later posit conditions under which the *equilibrium* educational choice, $s^*$, satisfies: $s^* > r\nu_0$.

[16] It is ready to include a time element by discounting each agent's payoff according to the length of the schooling period.

[17] In Huang et al. (1999) we admit a more general formulation in which the inverse elasticity, $\varepsilon(s)$, varies with $s$. A *sufficient* condition for all of the comparative-static results reported in this article to hold is that $\varepsilon'(s) \geq 0$.

[18] In principle, it is possible to allow households to differ intrinsically in their abilities (both productive and stealing) and/or in their morality. In the present article we prefer not to impose such ex ante heterogeneity. Instead, we seek to show that even with identical ex ante agents, we can obtain nondegenerate equilibria in which agents differ ex post (in particular there are sets of positive measures of criminals and formal workers).

[19] We impose a dichotomous work–crime choice in order to make our points in the simplest possible matter. As a practical matter, many of those engaging in criminal activity undertake formal work as well. This possibility is readily admitted into our framework by assuming that there is also a baseline competitive job that everyone has access to (e.g., "flipping burgers" ). In our model this wage payment in the job is (harmlessly) normalized to zero. In this context, the decision to invest in human capital is tantamount to a decision about whether to accumulate skills in excess of the most basic ones.

for storage, we adopt the following preference structure. At each point in time, households use their (indivisible) unit of labor for either "productive" or "felicity" purposes. In the former case we say that the household occupies the "acquisition state" (seeking goods to hold in inventory and to ultimately consume), whereas in the latter case it occupies the "consumption state" (seeking to derive utility by consuming goods currently held). In the acquisition state households use their unit labor endowment to augment their goods' holdings through either formal employment or through theft. Households in the consumption state use their time to wait for a judicious moment to consume and to derive utility from goods they currently hold in inventory.

Instantaneous utility is given by, $u = c$, where $c$ is the level of consumption. Utility opportunities arise at random points in time, which are governed by a Poisson process with parameter $\lambda$, where $0 < \lambda < r$. This formulation implies that if a household holds any goods in inventory it (1) optimally enters the consumption state and (2) consumes all of its inventory when the first opportunity to do so presents itself.[20] Although households can, at any point in time, costlessly and instantaneously switch back and forth between the acquisition and consumption states they do so only if they successfully acquire goods, consume, or else become the victims of crime.

## 3. MATCHING, STATE-TRANSITION, AND ASSET VALUES

In this section we describe the matching processes in the formal labor market and in the crime sector. These conditions are used to derive key equations governing population dynamics, as agents make the transition between the acquisition and consumption states. We then write down the asset values pertaining to households and firms. To facilitate the exposition, we assume, for the moment, that criminals are not subject to interdiction by the authorities. This extension is incorporated in Section 6 .

3.1. *Formal Labor Matching.* Let $\mu$ denote the flow rate at which workers locate jobs and $\eta$ represent the corresponding rate at which firms locate suitable workers. Although the flow probabilities $\mu$ and $\eta$ are determined in equilibrium, each agent treats them as parametric in making his/her decisions. Since each job is filled by one and only one worker, it follows that

$$\mu U = \eta V = m_0 M(U, V) \tag{3}$$

[20] Part (1) is explained as follows: Suppose that a household unit holds some goods in inventory (if it does not it *must* enter the acquisition state). The household can either seek additional goods or else enter the consumption state. With linear utility and zero storage costs if the former choice were optimal, then the *permanent* deferral of consumption constitutes an optimal plan (since once additional goods are acquired the household faces the same decision problem). Yet, with $r > \lambda > 0$, the household can do better by entering the consumption state (where it almost surely attains positive utility in finite time). Part (2) is trivial, following from the assumption that utility is linear in consumption and from positive discounting, $r > 0$.

where $m_0 > 0$ and $M(\cdot)$ is the matching technology governing the flow rate of contacts between the two sides of the labor market. We assume that $M(\cdot)$ is a strictly increasing, concave, and constant-returns-to-scale function of $U$ and $V$, satisfying (i) the Inada conditions ($\lim_{j\to 0} M_j = \infty$ and $\lim_{j\to\infty} M_j = 0$, with $j \in \{U, V\}$) and (ii) the boundary conditions ($M(0, V) = M(U, 0) = 0$). The term $m_0$ parameterizes the matching efficacy in the labor market. For instance, the establishment of a job placement center in the community or, alternatively, an improvement in communications or transportations infrastructure might be expected to increase $m$ and to raise the flow contact rate for any given population of search workers ($U$) and vacancies ($V$). The properties of the function $M(\cdot)$ ensure the existence of a well-behaved hyperbolic Beveridge curve in $(\mu, \eta)$ space, in which the absence of either side of the market results in zero matches. The constant-returns-to-scale assumption is made for simplicity (our results hold for any well-behaved quasi-concave function of $U$ and $V$).

3.2. *Criminal Activity.* At any given moment a total of $C + Q$ households occupy the consumption state. Let $\alpha$ denote the flow probability with which members of $C$ become crime victims and let $\theta\alpha$ denote the corresponding rate for criminals ($Q$). Here, $\theta$ captures the relative ease ($\theta < 1$) or difficulty ($\theta > 1$) with which criminals can protect their wealth holdings from appropriation by other criminals. We assume that criminals steal all of the goods held in their victim's inventory, but derive utility at the discounted rate $\phi \in (0, 1]$. If $\phi = 1$, they derive the full benefit from consumption, whereas $\phi < 1$ indicates strict discounting (for instance, criminals may incur a real resource cost in "fencing" stolen property). Active criminals, $R$, encounter victims at the flow rate $\beta$. Agents treat the matching probabilities $\alpha$ and $\beta$ as parametric in formulating their optimal decisions.

Behavior in the criminal sector is governed by a simple matching technology in which the flow crime rate depends upon the mass of active criminals ($R$) as well as the (effective) mass of potential victims ($C + \theta Q$). Consider,

$$\alpha(C + \theta Q) = \beta R = \beta_0 B(C + \theta Q, R) = \beta_0 R \tag{4}$$

By definition, since each crime has a victim, the flow robbery rate ($\beta R$) must equal the flow crime rate ($\alpha(C + \theta Q)$), which explains the first equality in (4). The function $B(\cdot)$ is the matching technology, governing the contact rate between robbers and victims, whereas the parameter $\beta_0$ captures (exogenous) aspects of the urban environment, such as the quality of street lighting, policing, population density, etc., which render crime more or less difficult to commit. As in the case of the labor market matching technology, $M(\cdot)$, we assume that the function $B(\cdot)$ is homogeneous to degree 1. Additionally, we assume, for simplicity, that the flow crime rate depends upon the measure of active robbers, $R$, alone.[21] Note that even though this formulation implies the contact rate is pinned down at $\beta_0$, the

[21] As explained below, this feature implies that the steady-state equilibrium is amenable to a simple equilibrium analysis. Discussion of a general crime matching technology will be relegated to Section 5.3.

*returns* to crime, $\phi w$, are endogenous, depending upon, among other things, the conditions that prevail in the labor market.

3.3. *Population Dynamics.* In the primary labor market, workers acquire jobs and move into the consumption state at the flow rate $\mu$. Workers move out of this state either by successfully consuming the fruits of their labor ($\lambda$), death ($\delta$), or else after becoming the victims of crime ($\alpha$). Similarly, criminals enter the consumption state $Q$ after successfully committing a robbery ($\beta$). They exit the state $Q$ either by consuming ($\lambda$), death ($\delta$), or else by themselves becoming the victim of crime ($\theta\alpha$). These considerations yield

$$\dot{C} = \mu U - (\lambda + \alpha + \delta)C \tag{5}$$

$$\dot{Q} = \beta R - (\lambda + \alpha\theta + \delta)Q \tag{6}$$

In the steady state, we must have $\dot{C} = \dot{Q} = 0$.

3.4. *Asset Values.* In order to study agents' optimal choices and the wage agreement, it is first necessary to describe the asset values of households, $J$, and of firms, $\Pi$. At any given point in time, each household occupies one of four states: $C$, $U$, $R$, and $Q$ and each vacancy is either filled ($F$) or unfilled ($V$). Denote the wage income accruing to households from employment by $w$. Consider,

$$rJ_U = \mu(J_C - J_U) \tag{7}$$

$$rJ_C = \lambda w + (\lambda + \alpha)(J_U - J_C) \tag{8}$$

$$rJ_R = \beta(J_Q - J_C) \tag{9}$$

$$rJ_Q = \phi\lambda w + (\lambda + \theta\alpha)(J_R - J_Q) \tag{10}$$

$$\Pi_F = y - w + \Pi_V \tag{11}$$

$$r\Pi_V = \eta(\Pi_F - \Pi_V) \tag{12}$$

These asset values are standard and intuitive. For instance, (7) says that the flow value from job search, $rJ_U$, equals the flow probability of locating employment ($\mu$) times the capital gain that results from entering the consumption state ($J_C - J_U$). In Equation (8) the flow value from occupying the consumption state, $rJ_C$, is made up of two terms: the flow utility derived from consumption, $\lambda w$, and the flow probability of a change in state ($\lambda + \alpha$) times the capital loss from that event ($J_U - J_C$). Note that households anticipate that they may reenter the job-search state, $J_U$, either because they successfully derive utility from their inventory ($\lambda$) or else because their goods are stolen ($\alpha$). Similar interpretations hold for (9) and (10), with the proviso that criminals' payoffs are adjusted by $\theta$ and $\phi$, reflecting the possibility that they may be less or more subject to crime than other members of the community ($\theta$ < or >1) and that they may incur a real resource cost in converting their spoils to goods suitable for consumption ($\phi < 1$). In Equation (11) the value of locating a worker is the value of instantaneous profits $y - w$ plus the value of the open vacancy, $\Pi_V$. Finally, the flow value of opening a vacancy equals the flow probability of locating workers ($\eta$) times the capital gain from this event, $\Pi_F - \Pi_V = y - w$.

## 4. BARGAINING, SCHOOLING, AND OCCUPATIONAL CHOICE

In this section we characterize the (partial-equilibrium) properties of wages, schooling levels, and occupational choices, as well as the steady-state matching and entry conditions. Throughout this section, we set $\theta = \phi = 1$, indicating that criminals and workers are equally likely to be the victims of crime ($\theta$) and that the utility derived from stolen goods is not less than that derived from legitimate ones ($\phi$). Toward the end of Section 5, we analyze the effects of values of $\theta$ and $\phi$ that differ from unity.[22]

4.1. *Wage Determination.* Upon matching, firms and workers bargain over the division of the surplus. We assume that negotiations are instantaneous and that the wage, $w$, is determined according to a symmetric Nash bargaining protocol.[23] The value to workers from accepting employment is $J_C - J_U$ and the value to employers from (instantaneous) production is $\Pi_F - \Pi_V$ ($=y - w$). Under a symmetric Nash bargain, these two are equalized,

$$J_C - J_U = y - w > 0 \tag{13}$$

Substituting the asset values (8), (7), (11), and (12) into (13) yields the wage offer agreed between workers and firms. Defining $\chi(\alpha) \equiv \lambda + r + \alpha$, we have

LEMMA 1 (The Wage). *Under symmetric Nash bargaining between firms and workers, the wage offer is*

$$w(s, \mu, \alpha; \lambda, y_0) = \left[\frac{\mu + \chi(\alpha)}{\lambda + \mu + \chi(\alpha)}\right] s \tag{14}$$

*which satisfies* $\partial w/\partial s > 0$, $\partial w/\partial \mu > 0$, $\partial w/\partial \alpha > 0$, *and* $\partial w/\partial y_0 > 0$.[24]

[22] Note that, at this point, neither the appropriation externality identified by Murphy et al. (1993) nor the interdiction effect studied by Sah (1991) operate, since, respectively, $\theta = 1$ (criminals are just as likely to be the victims of crime) and law enforcement is absent.

[23] Under a symmetric Nash bargain, the surplus (and hence the wage) depends upon the outside options $J_E$ and $J_C$ which, in turn, depend upon the conditions that prevail in the labor market.

[24] Recall that $y = y_0 + s$ and that we conduct perturbation exercises around $y_0 = 0$ to model the effects of increases in average labor productivity.

PROOF. All proofs are in the Appendix.

An increase in worker productivity $y_0$ or education $s$ enlarges the ex post surplus accruing to any given match, which is shared between the two bargaining parties, thus leading to a higher wage. An increase in the worker contact rate, $\mu$, enhances workers' bargaining power and hence raises $w$, by making *alternative* employment opportunities more readily available in the event of disagreement. Since a firm's assets cannot be appropriated, an increase in the crime rate $\alpha$ *raises* $w$ by reducing the total surplus accruing to worker–firm matches: $(J_C + \Pi_F) - (J_U + \Pi_V)$. In bargaining the loss of surplus is shared by both parties, so that both $(J_C - J_U)$ and $(y - w)$ fall. This latter event is accomplished through an increase in $w$. Although the gross wage $w$ rises with $\alpha$, the (expected) net-of-crime wage declines.

4.2. *Educational Choices.* Households that opt for formal employment recognize that education increases the output accruing to each match. Taking all contact rates as given, these agents solve $\max_S\{J_U - g(s)\}$, where the wage is governed by (14). The first-order necessary (and sufficient) condition for a maximum is

$$\frac{\lambda\mu}{r[\lambda + \chi(\alpha) + \mu]} = g'(s) = \frac{1}{\varepsilon}s^{(1-\varepsilon)/\varepsilon} \tag{15}$$

Straightforward manipulation of (15) yields

LEMMA 2 (Schooling Effort). *The schooling effort function for primary-sector workers, $s(\mu, \alpha)$, satisfies*

(*i*) $\lim_{\mu\to 0} s = 0$ *and* $\lim_{\mu\to\infty} s = \bar{s} < \infty$ *where* $\bar{s} \equiv g'(\lambda/r)^{-1}$;
(*ii*) $\lim_{\alpha\to 0} s < \infty$ *and* $\lim_{\alpha\to\infty} s = 0$;
(*iii*) $\partial s/\partial\mu > 0$, $\partial s/\partial\alpha < 0$ *and criminals optimally set* $s = 0$.

The results in Lemma 2 are intuitive. If either $\mu \to 0$ or if $\alpha \to \infty$, then costly education has no value, so that its level is optimally set to zero. With $g(\cdot)$ strictly convex, $s$ is bounded above regardless of how high (low) the value taken by $\mu$ ($\alpha$). An increase in the arrival rate of job opportunities, $\mu$, raises the marginal returns to education and hence the level chosen by workers. In essence, crime, $\alpha$, acts as *a tax on human capital accumulation,* by reducing the returns accruing to formal employment and subsequently the levels of educational attainment. As $\alpha \to \infty$, the tax on human capital accumulation is so great that it completely eliminates any incentive to acquire human capital, implying $s = g(s) = 0$. Finally, criminals optimally set $s = 0$, as education is costly and has no (normalized) direct benefit to them.

4.3. *Steady-State Matching, Entry, and Populations.* The two *steady-state matching* conditions (3) and (4) yield well-behaved Beveridge curves in contact-rate space in the labor market, $SS^M$, and in the criminal sector, $SS^B$.

LEMMA 3 (Steady-State Matching). *The Beveridge curves $SS^M$ and $SS^B$ take the following form:*

$$\eta \equiv \eta^{SS}(\mu; m_0) \tag{16}$$

$$\beta = \beta_0 \tag{17}$$

*and satisfy,* $\partial\eta/\partial\mu < 0$, $\partial\eta/\partial m_0 > 0$ *, and* $\partial\beta/\partial\beta_0 = 1$.

The *SS* locus is downward sloping in $(\mu, \eta)$ space and, under the Inada conditions, asymptotes at each axis. An improvement in the matching efficacy, $m_0$, shifts this locus out. As indicated previously, the value of $\beta$ is uniquely pinned down by $\beta = \beta_0$, implying the $SS^B$ locus is horizontal (in $(\alpha, \beta)$ space) at this value.

The final steady-state condition determines the mass of vacancies, $V$. This must be consistent with the *equilibrium firm-entry* (*EE*) condition: $\Pi_V = (\eta/r)(y - w) = v_0$. Thus,

LEMMA 4 (Equilibrium Entry). *The equilibrium firm-entry locus EE is given by*

$$\eta = \frac{rv_0}{\lambda}\frac{\lambda + \chi(\alpha) + \mu}{s} \equiv \eta^{EE}(s, \mu, \alpha; y_0, v_0) \tag{18}$$

*which possesses the following properties:* $\partial\eta/\partial s < 0$, $\partial\eta/\partial\mu > 0$, $\partial\eta/\partial\alpha > 0$, $\partial\eta/\partial y_0 < 0$ *and* $\partial\eta/\partial v_0 > 0$.

Along the *EE* locus the expected discounted value of ex ante profits is exactly zero. An increase in the worker contact rate, $\mu$ , raises the wage (Lemma 1) and lowers ex post profits. Heuristically, zero ex ante profits are restored through an increase in the vacancy contact rate, $\eta$, making it easier (less time consuming) for firms to find workers. The other results are explained in a similar fashion.

The *EE* locus depends upon the three endogenous variables—the schooling level, $s$, and two contact rates, $\mu$ and $\alpha$. Although our ultimate goal is exploring the general-equilibrium properties of the system, it is helpful to first characterize the properties of the *EE* locus, admitting only endogenous changes in $s$,

$$d\eta^{EE}/d\mu = (\partial\eta/\partial\mu) + (\partial\eta/\partial s)(\partial s/\partial\mu) \tag{19}$$

Equation (19) decomposes the total effect of a change in $\mu$ upon $\eta^{EE}$ into the two indicated components. The direct effect of an increase in $\mu$ is to raise the wage and hence $\eta$, whereas the *indirect human capital effect* raises $s$ and thus lowers $\eta$. These conflicting effects suggest the *EE* locus may not be monotonic in $\mu$.

LEMMA 5 (Nonmonotonic *EE* locus). *For given* $\alpha$, *the EE locus satisfies limiting properties*, $\lim_{\mu\to 0}\eta^{EE} = \eta_0 > 0$ *and* $\lim_{\mu\to\infty}\eta^{EE} = \infty$, *and may possess decreasing segments in* $(\mu , \eta)$ *space*.

For very small values of $\mu$ workers undertake little schooling, as the returns to education are low. As a consequence the work force is relatively low skilled, so that $\eta$ must be sufficiently large to make entry worthwhile for firms. The situation is quite different for very large values of $\mu$. Here education and worker productivity levels are high. Yet, with an extremely tight labor market, workers capture most of the rents from bargaining with firms (the wage, $w$, approaches $y$). In order to cover the ex ante entry cost the contact rate, $\eta$, must be correspondingly large. An increase in $\mu$ has two separate effects: It raises the wage (Lemma 1) and the level of education and productivity of workers (Lemma 2). The former of these effects tends to raise $\eta$, by reducing the instantaneous profits from each successful match, whereas the latter effect tends to lower $\eta$ for analogous (but opposite) reasons. For values of $\mu$ not too large, the education effect may dominate and the *EE* locus may possesses decreasing (in $\mu$) segments.[25] For sufficiently high values of $\mu$, an increase in $\mu$ has little effect on productivity (since $s$ approaches the upper bound $\bar{s}$, defined by $g'(\bar{s}) \equiv (\lambda/r)$—Lemma 2), but raises the wage. However, as $\mu \to \infty$, the *EE* locus converges asymptotically to a ray with a positive slope, $rv_0/\bar{s}$.

4.4. *Occupational Choice.* We now examine the occupational choices (namely, formal employment and crime) made by households. Since all households are ex ante identical the following no-arbitrage condition must hold *if* both the formal labor market *and* the criminal sectors are to coexist in the steady state:

$$\Omega_U \equiv J_U - g(s(\mu, \alpha)) = J_R \tag{20}$$

where $s(\mu, \alpha)$ is determined in accordance with Lemma 2. Condition (20) says that households are just indifferent between, on the one hand, acquiring the (optimal) education level and entering the primary labor market and, on the other, choosing the minimum level of education and engaging in crime-related activities. Note that since formal employment entails costly ex ante education, Equation (20) is satisfied only if $\mu \geq \beta_0$ (if $\mu < \beta_0$ robbers' ex post utility levels exceed that of job seekers).[26] Equation (20) gives the value of $\mu$ for which households are indifferent ex ante, between crime and formal employment. We can then use Equations (7)–(8), (14)–(15), and the definition of $\varepsilon$ to obtain

$$\frac{\chi(\alpha)}{\beta_0 + \chi(\alpha)} \frac{\mu - \beta_0}{\mu} = \varepsilon \tag{21}$$

which implicitly defines an *occupational choice* (*OC*) locus, $\mu = \mu^{OC}(\alpha; \beta_0, y_0)$. Consider

[25] This claim is not simply "pie in the sky," but rather can be demonstrated, by example, through the use of rather elementary simulations. Note also that as $\mu \longrightarrow \infty$, $\eta \to (rv_0)(\lambda + \chi)/\bar{s}$. This externality was first identified in Laing et al. (1995).

[26] It is essential that $\theta = \phi = 1$ for this particular result to hold. Obviously, if $\phi < 1$ (criminals derive "discounted" utility from theft) or if $\theta > 1$ (criminals are more likely to be victims of crime than are formal workers), then it is quite possible for $\mu < \beta_0$ along the OC locus.

CONDITION 1. $(r + \lambda)(1 - \varepsilon)/\varepsilon > \beta_0$

Lemma 6 characterizes the *OC* locus,

LEMMA 6 (Occupational Choice). *Under Condition 1, the no-arbitrage condition* (20) *implicitly defines a function* $\mu = \mu^{OC}(\alpha, \beta_0; y_0)$, *for which* $\Omega_U \equiv J_R$, *which satisfies*

(*i*) $\lim_{\alpha \to 0} \mu^{OC} = \bar{\mu} < \infty$ *and* $\lim_{\alpha \to \infty} \mu^{OC} = \beta_0$;
(*ii*) $d\mu^{OC}/d\alpha < 0$ *and* $d\mu^{OC}/d\beta_0 > 0$.

Condition 1 ensures that $\mu^{OC}(\cdot)$ is well defined and nonnegative for all values of $\alpha \geq 0$. Intuitively, if $\beta_0$ is too high, then no (nonnegative) value of the crime rate, $\alpha$, exists that ensures equality in (20). The limiting properties in Part (i) of Lemma 6 are explained by noting that, as $\alpha \to 0$, then education approaches the upper bound $\bar{s}$ (Lemma 2). In this case, $\mu$ is, by inspection, positive and finite. In contrast, as $\alpha \to \infty$ then $s = g(s) = 0$ as education has no value. With $g(\cdot) = 0$, then $\Omega_U = J_R$ only if $\mu = \beta_0$.

Next, consider the properties described in part (ii). As a general proposition, the *net gain*, $G$, of formal employment relative to criminal activity is given by

$$G = \Omega_U - J_R$$

Obviously, along the *OC* locus $G \equiv 0$ as workers are, by definition, indifferent ex ante between the two sectors. Imagine beginning at a point on the *OC* locus and increasing $\mu$. Ceteris paribus the increase in $\mu$ raises the wage and hence both $\Omega_U$ and $J_R$ *in proportion* (the increase in $w$ implies there is more available for criminals to steal from any given household). However, the increase in $\mu$ also implies formal workers contact jobs at a faster rate. This latter effect gives formal workers the "edge," implying that $G$ increases (i.e., becomes positive). Now consider the effects of an increase in $\alpha$. Ceteris paribus, criminals are hurt *more*—all else being equal—by the increase in the crime rate $\alpha$ than are formal workers, implying that the net gain $G$ further *increases* with $\alpha$.[27] Together these two effects generate the *negative relationship* between $\mu$ and $\alpha$ along the *OC* locus reported in the lemma. The second result, $d\mu^{OC}/d\beta_0 < 0$, is easy to derive and understand. First, we have already seen that, ceteris paribus, an increase in $\mu$ raises $G$. Second, an increase in the predation rate $\beta_0$ reduces $G$ unambiguously, since $\Omega_U$ is independent of $\beta_0$ and $J_R$ increases with it. As a result $\mu$ and $\beta_0$ increase together along the OC locus.

[27] Recall under the assumption of $\theta = 1$ criminals and formal workers face the same chances of being robbed. To see why, under these circumstances, criminals are hurt more by an increase in criminal activity $\alpha$, consider the following extreme case. Specifically, assume that the formal worker contact rate satisfies, $\mu \to \infty$, which implies their *unemployment* state is transient. This implies that the crime rate, $\alpha$, has no effect on formal workers' ex ante utility. (If their inventory is stolen, they instantly replace it—$\mu \to \infty$). In contrast, since $\beta_0$ is finite, an increase in $\alpha$ does *lower* criminals' ex ante utility. As discussed in Section 5.2 if $\theta < 1$, the *OC* locus may possess upward-sloping segments. This gives rise to the possibility of multiple steady-state equilibria.

Based on this monotone relationship between $\mu$ and $\alpha$, it is convenient in the remainder of the formal analysis to work with the inverse function, $\alpha = \alpha^{OC}(\mu; \beta_0, y_0)$, defined by $\mu \equiv \mu^{OC}(\alpha^{OC}(\cdot); \beta_0, y_0)$ on the domain $\mu \in (\beta_0, \bar{\mu}]$, and by $\alpha \equiv 0$ for all $\mu > \bar{\mu}$. Applying Lemma 6, we have the limit properties, $\lim_{\mu \to \beta_0} \alpha^{OC} > 0$ and $\alpha^{OC}(\bar{\mu}, \cdot) = 0$ as well as the characterization, $d\alpha/d\mu < 0$ and $d\alpha/d\beta_0 > 0$, where points above (below) $\alpha^{OC}$ correspond to $\Omega_U - J_R > 0\,(<0)$.

## 5. STEADY-STATE EQUILIBRIUM

From Equations (1), (2), (4), (5), and (6), we can write the steady-state populations of $U$ and $Q$ (and $C$ and $R$) as functions of the contact rates, $\mu$, $\alpha$, and $\beta$ and the population $N$,

$$U = \frac{\beta(\delta + \lambda)}{\alpha\mu + \beta(\delta + \lambda + \mu)} \tag{22}$$

$$R = \frac{\alpha\mu}{\alpha\mu + \beta(\delta + \lambda + \mu)} \tag{23}$$

$$N = \frac{\beta\mu(\delta + \lambda)(\delta + \lambda + \mu + \alpha)}{(\delta + \lambda + \alpha)[\alpha\mu + \beta(\delta + \lambda + \mu)]} \tag{24}$$

where from the population identities, (1) and (2), $C$ and $Q$ are then determined. Define

DEFINITION 1 (Steady-State Equilibrium). A steady-state equilibrium is a tuple of population masses, a wage rate, an education level, and contact rates, $\nu \equiv \{(U^*, C^*, Q^*, R^*), (s^*, w^*), (\mu^*, \eta^*), (\alpha^*, \beta^*)\}$ satisfying

(i) the population identities (1) and (2);
(ii) Lemmas 1 and 2 that determine the wage, $w$, and education, $\hat{s}$;
(iii) the steady-state matching conditions (Lemma 3);
(iv) the equilibrium entry (EE) locus (Lemma 4);
(v) the occupational choice (OC) locus (Lemma 6).

The equilibrium is called *nondegenerate* if $s^* > 0$ and $0 < N^* < 1$ (i.e., if education is strictly positive and if there is a positive measure of agents in each occupation).

5.1. *Existence and Characterization of Equilibrium.* The model possesses a convenient recursive structure that helps delimit the conditions under which steady-state equilibrium exists and characterizes its resultant properties. Substituting the inverse $OC$ locus and the optimal education schedule into the $EE$ locus (18) gives

$$\eta = \eta^{EE}(s(\mu, \alpha^{OC}(\mu; \cdot)), \mu, \alpha^{OC}(\mu; \cdot)) \equiv \eta(\mu; \cdot) \tag{25}$$

which is solely a function of one endogenous variable, $\mu$, defined on the domain $\mu > \beta_0$ (noting that for $\mu \geq \bar{\mu}, \alpha = 0$). By construction, Equation (25) embodies the behavior described in Lemmas 1, 2, 4, and 6 and Equation (17) in Lemma 3. Equation (25) together with the *SS* locus (16), forms a two-by-two system in $(\mu, \eta)$ space, whose solution—if it exists—yields steady-state values for $\mu^*$ and $\eta^*$. The other endogenous variables are recovered recursively. Specifically, $\mu^*$ gives $\alpha^* = \alpha^{OC}(\mu^*; \beta_0, \cdot)$. The populations $U^*$, $Q^*$, $C^*$, $R^*$, and $V^*$ are then derived from $\mu^*$, $\eta^*$, $\alpha^*$, and $\beta^*$ (as are $w^*$ and $s^*$). Finally, simple substitution gives the asset values, $J^*$, for formal workers and for criminals. Consider,

CONDITION 2. $m_0 > \underline{m}_0$, where $\underline{m}_0$ solves $\eta^{SS}(\beta_0; \underline{m}_0) = \frac{rv_0}{\lambda} \frac{2\lambda + r + \bar{\alpha} + \beta_0}{s(\beta_0, \bar{\alpha})}$.

PROPOSITION 1 (Existence). *Under Conditions* 1 *and* 2*, a nondegenerate steady-state equilibrium exists.*

Condition 2 is sufficient to ensure the existence of a nondegenerate steady state.

Figure 1 illustrates the *EE* and *SS* loci, together with steady-state equilibria as points *A*–*C*. The existence of a nondegenerate steady-state equilibrium is, under the present circumstances, of some independent interest. Recall that so far the model is essentially one describing the "Wild West." It captures a lawless society (i.e., there is no police enforcement), all agents are ex ante homogeneous and *amoral*, and all households (whether criminal or noncriminal) face the same crime rate ($\theta = 1$) and earnings opportunities ($\phi = 1$). Yet, even under these austere circumstances, some agents opt for formal employment. Intuitively, the market "prices" each activity so that both remain active in equilibrium.

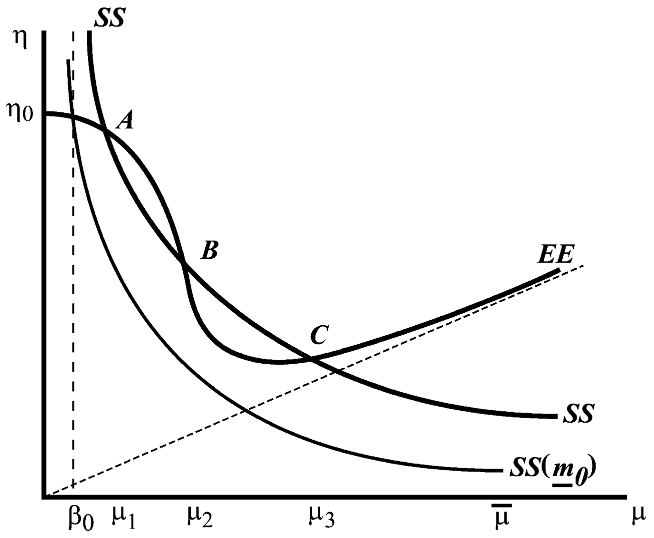


FIGURE 1

STEADY-STATE EQUILIBRIUM

The parameter $m_0$ governs the matching rate between job searchers and vacancies. If $m_0$ is "too low" each household engages in crime. Yet, with all agents opting for crime, $N^* = V^* = s^* = 0$ (which is the degenerate equilibrium). Conversely, with a sufficiently active labor market, $\mu > \bar{\mu}$, there are no criminals and hence no crime, $\alpha^* = 0$. The properties of $g(s)$ ensure $s$ is bounded above: $\lim_{\mu\to\infty} s(\mu, 0) = \bar{s} < \infty$ (where $g'(\bar{s}) \equiv \lambda/r$—see Lemma 2). Thus, the$EE$ locus, Equation (25), converges to a ray with a positive slope, $r\nu_0/\bar{s}$.

PROPOSITION 2 (Multiplicity). *Under Conditions* 1 *and* 2, *multiple nondegenerate steady-state equilibria may emerge.*

Figure 1 illustrates equilibrium points $A$–$C$ for $m_0 > \underline{m}_0$. In this case, Condition 2 is satisfied and the $EE$ locus cuts the SS locus for exactly three times. In general, there may be more than the four nondegenerate equilibrium points when the $EE$ locus exhibits more turning points, or there may be exactly two equilibria when Condition 2 does not hold and the $EE$ locus cuts the SS locus from above.

In the remainder of this section we examine the properties of the steady-state equilibrium and compare economic outcomes in the case of multiple equilibria. Proposition 3 describes the comparative-static properties of steady-state equilibrium points such as $A$ and $C$ in Figure 1.[28] Since firms reach ex ante zero profit, the ex ante welfare measure is simply $\Omega_U^* \equiv J_U^* - g(s^*)$, for any fixed value of $\nu_0$.[29]

PROPOSITION 3 (Characterization of the Steady-state Equilibrium). *Around any steady-state equilibrium in which* $(d\eta^{EE}/d\mu) - (d\eta^{SS}/d\mu) > 0$, *we have:*

*(i) an improvement in labor market efficacy (higher) or productivity (higher) raises the level of education (higher $s^*$), encourages participation in the formal labor market and firm entry (higher $N^*$ and $V^*$), and reduces the rates of crime and unemployment (lower $\alpha^*$* and $U^*$);

*(ii) an increase in the predation rate (higher $\beta_0$) or the entry cost (higher $\nu_0$) lowers the level of education, discourages participation in the formal labor market and firm entry, and leads to higher crime and unemployment rates;*

*(iii) while an improvement in labor market efficacy or productivity raises economic welfare (higher $\Omega_U^*$), an increase in the predation rate, $\beta_0$, lowers it.*

The ultimate source of usufruct, and hence the utility derived by workers, firms, and criminals, stems from the goods produced during job seeker/vacancy matches. An improvement in labor market efficacy (i.e., an increase in $m_0$) raises the contact rates $\mu^*$ and $\eta^*$, which speeds up flow production. This encourages participation in the formal labor market by households ($N^*$ rises), reduces the primary unemployment rate $U^*$, and stimulates the entry of firms ($V^*$ increases). One

[28] We do not solve for the local dynamics around steady-state equilibrium points. This is a difficult problem. However, points such as A and C satisfy Samuelson's Correspondence Principle. Moreover, for large-enough values of $m_0$ such points always exist (Proposition 1).

[29] Thus, it is not valid to conduct comparative-static exercises of this welfare measure with respect to changes in $v_0$.

consequence of this population shift is that the crime rate, $\alpha^*$, falls. Moreover, the reduction in crime and the increased ease of locating work further fosters human capital accumulation (stimulating additional entry by firms). The rise in flow output translates into greater flow consumption levels for all agents, thus raising ex ante welfare levels.

A productivity improvement (again, modeled as a perturbation in $y_0$ around $y_0 = 0$) fosters human capital accumulation and the entry of firms (which further encourages education by raising $\mu^*$) and lowers unemployment in the formal sector. In turn, at the margin, households switch from crime to formal employment, which lowers the crime rate (again, further increasing education). An increase in the predation rate, $\beta_0$, encourages criminal activity and raises unemployment, lowering both educational attainment levels and ex ante welfare. Finally, a reduction in the entry cost, $\nu_0$, leads to the entry of a greater number of firms. The increased ease of finding work reduces the unemployment rate, raises education levels, and lowers the crime rate.

Given that the SS locus is strictly decreasing in the contact rate $\mu$, multiple equilibria—if they exist—can be ranked by $\mu^*$ (see Figure 1).

PROPOSITION 4 (Properties of Multiple Equilibria). *Consider an economy with $n \geq 3$ (nondegenerate) multiple equilibria indexed by i in which, after ordering $\mu_1^* < \cdots < \mu_n^*$,*

*(i) the crime rate $\alpha_i^*$ and the formal sector unemployment rate $U_i^*$ decrease with i;*
*(ii) primary sector activity, $N_i^*$, educational attainment, $s_i^*$, and vacancies, $V_i^*$, all increase with i;*
*(iii) the equilibria are Pareto rankable, with welfare levels strictly increasing in i.*

A high contact rate, $\mu^*$, encourages formal employment (at the expense of criminal activity), stimulates human capital accumulation, and promotes entry by firms. Since all goods ultimately consumed are produced from matches between job seekers and vacancies, an increase in $\mu^*$ leads to higher steady-state consumption and, hence household welfare levels.[30] Equilibrium selection is driven by self-fulfilling prophecies regarding performance of the primary labor market. Thus, in Figure 1, the equilibrium at point $C$ generates higher education and welfare levels than the equilibrium points illustrated as $A$ and $B$. The expectation of a robust labor market (high $\mu^*$) fosters education by workers and entry by firms. In turn, this discourages criminal activity, further promoting education by workers and additional entry by firms. Point $A$ is a low-level equilibrium for similar, but converse, reasons.

Our multiple equilibria results may be compared to the model of corruption developed by Murphy et al. (1993). They explore an appropriation externality in which an increase in the corruption rate increases its relative returns (since

[30] In equilibrium, firms earn exactly zero ex ante returns. It follows that welfare levels hinge solely on households' ex ante utility levels: $J_U^* - g(s^*)$ (which is equal to $J_R^*$) for any nondegerate equilibria.

the returns from legal activities are appropriated). This complementarity generates multiple equilibria, with high-income/low-corruption and low-income/high-corruption configurations. Although our model also possesses this feature of multiplicity, we can establish the possibility of multiple equilibria even if the appropriation externality is absent, as the proceeds from crime may also be stolen (thieves are both the "hunters" and "hunted").[31] In addition, we study the effects of criminal activity on human capital accumulation, wages, and the level of economic activity.

It is interesting that Propositions 3 and 4 have established a positive correlation between the unemployment rate and the crime rate as well as a negative correlation between the level of education and the crime rate. Then applying Lemma 1, we can conclude a negative correlation between the wage rate in the primary labor market and the crime rate. These findings are consistent with empirical evidence summarized in the introduction.

5.2. *The Case of $\phi < 1$ and $\theta \neq 1$.* Up to this point, we have assumed that $\phi = \theta = 1$, indicating that there is no resource cost in fencing stolen property and that criminals are subject to the same rate of crime, $\alpha$, as are members of the formal labor market. For given $\mu$ the *OC* locus is $[1 - \frac{\beta_0\phi}{\mu}(\frac{\chi(\alpha)+\mu}{\lambda+r+\theta\alpha+\beta})]J_U = g(s)$, or, utilizing (15),

$$1 - \frac{\beta_0\phi}{\mu}\left(\frac{\chi(\alpha)+\mu}{\lambda+r+\theta\alpha+\beta_0}\right) = \frac{g(s)}{J_U} = \varepsilon \tag{26}$$

The left-hand side of (26) is the ex post return of formal employment relative to criminal activity. The right-hand side is the ex ante cost-to-benefit ratio for undertaking education.

Understanding the effects of allowing a fencing cost $\phi < 1$ is trivial. It simply lowers the ex post returns to crime for all values of $\alpha$ and $\mu$ . The case of $\theta \neq 1$ is more interesting. Suppose, as in Murphy et al. (1993), that criminals are in a better position than are workers to protect their holdings from appropriation (i.e., $\theta < 1$). Differentiating the left-hand side of (26) with respect to $\alpha$ implies that its sign depends solely on $sgn\{(\lambda + r + \mu)\theta - (\lambda + r + \beta_0)\}$. With $\mu > \beta_0$, this is positive at $\theta = 1$ and negative for $\theta = 0$. In the former case, the *OC* locus can have at most one fixed point, whereas in the latter it may have more than one. Intuitively, with $\theta = 0$ an increase in the crime rate raises the relative returns to crime as only legal proceeds are stolen. As a result, the reinforcing effects may lead to a coexistence of high-crime and low-crime equilibria. Consider,

CONDITION 3. $\theta < (\lambda + r + \beta_0)/(\lambda + r + \mu) < 1$.

PROPOSITION 5 (Appropriation Effect). *Under Condition 3, for each $\mu$ Equation* (26) *may have more than one fixed point in $\alpha$ and the OC locus is a correspondence in* $(\alpha, \mu)$ *space.*

[31] Of course, adding the appropriation effect will create another channel of multiplicity (see Proposition 5).

We have already established the possibility of multiple equilibria in the case wherein the $OC$ locus is a (single-valued) function. The possibility that the $OC$ locus is a (multi-valued) correspondence provides another source of multiplicity.

5.3. *General Crime-Matching Technology.* In the benchmark model, we restricted our attention to a simple matching technology in the crime sector $B(C + \theta Q, R) = R$. In this subsection, we inquire whether our main findings remain unchanged if we assume instead that $B(\cdot)$ is a more standard, strictly increasing, concave, and constant-returns-to-scale function of $C + \theta Q$ and $R$, satisfying the Inada conditions and the usual boundary conditions $B(0, R) = B(C + \theta Q, 0) = 0$. Under this more general matching technology, the key changes are the steady-state matching relationship in the crime sector and the occupational choice locus. These relationships are now given by, respectively,

$$\beta = \beta^{SS}(\alpha; \beta_0)$$

$$\frac{\chi(\alpha)}{\beta^{SS}(\alpha; \beta_0) + \chi(\alpha)} \frac{\mu - \beta^{SS}(\alpha; \beta_0)}{\mu} = \varepsilon$$

where $d\beta^{SS}/d\alpha < 0$ and hence, the left-hand side of the modified $OC$ locus is increasing in both $\alpha$ and $\mu$. Note, crucially, that the modified $OC$ locus must be still downward sloping in $(\alpha, \mu)$ space and that, as a consequence, our comparative static results remain valid. However, the conditions for the existence of a nondegenerate steady-state equilibrium are no longer as clean. Furthermore, conducting a (analytic) policy exercise of the sort conducted in Section 6 would become much more difficult.

## 6. CRIME AND PUNISHMENT

Up to this point, criminals are assumed subject neither to interdiction by the authorities nor to punishment for the crimes they commit. Yet, an important issue in jurisprudence is the appropriate setting of legal remedies for the purposes of deterring crime and for protecting the innocent. Furthermore, communities, often with seriously limited resources, must determine appropriate levels of police expenditures. At a broader level, if society opts for a prison system, choices must also be made regarding the treatment of the incarcerated. At one extreme, there is the "short-sharp-shock" treatment, which emphasizes the punitive possibilities associated with incarceration; at the other, the authorities may focus on the rehabilitation opportunities afforded during an individual's prison time. In this section, we extend the model set out above to examine these issues formally. In order to facilitate the exposition, we deemphasize the labor market details throughout this section. Specifically, let $\mu = \mu_0$ (exogenous) and let $w = s$.[32]

[32] It is possible to derive this endogenously in the formal model by assuming a fixed supply of vacancies and that workers have all the bargaining power with firms. Moreover, a generalization to allow for a fixed sharing rule, $w = \bar{\omega} s$ with $\bar{\omega} \in (0, 1)$, will not change the main conclusions.

6.1. *Policing and Legal Penalties.* The ranks of the police, $P$, are filled by individuals from outside the community under study.[33] The supply of police is perfectly elastic at a flow wage normalized to unity, implying that $P$ also equals the flow expenditure on policing. Upon arrest and conviction, households are subject to legal penalty and their inventory holdings are confiscated and destroyed.[34] For simplicity, we consider only an instantaneous (nonpecuniary) utility penalty, $Z$ at the point of arrest.[35]

Further assume that police expenditures are financed by a lump sum (flow) tax, $\tau$, on each household (i.e., a per capita household tax). Budget balance then gives $P = \tau$. The broad nature of the tax base is important. For instance, if the tax is levied only on formal workers, then it distorts households' ex ante occupational choices. We focus on studying and isolating the effects of policing efforts on crime, rather than any effects that arise from distortionary taxes. Thus, the legal environment is summarized by the tuple, $(F, P) \in R^2_+$.

6.2. *Convictions.* We allow the legal process to be imperfect, in that prosecutorial and forensic blunders imply all agents are subject to arrest and conviction at the rate $q_0$ whenever police expenditure, $P$, is positive. However, expenditures on policing enable the community selectively to apprehend and to convict members of the underground criminal fraternity, $Q + R$. Let $q$ denote the flow conviction rate of members of $Q + R$ resulting from police efforts, where we assume that members of $Q$ and $R$ are subject to a common conviction rate to reduce the notational burden. Thus, the conviction hazard rates for criminals and noncriminals are $q + q_0$ and $q_0$, respectively.

Absent police expenditures, the judicial process is nondiscriminating: both criminals and noncriminals face the same flow probability, $q_0$, of arrest and conviction. However, should the community increase police enforcement relative to the population of the underground criminal fraternity, denoted as $\pi \equiv \frac{P}{Q+R}$, the conviction hazard rates for criminals would increase. Thus, $q = q(\pi)$, with $q(0) = 0$, $q' > 0$, $\lim_{P \to 0}, q/q_0 = 1$ (random conviction), and $\lim_{P \to \infty}, q/q_0 = \infty$ (no conviction of the innocent, or, no type-II errors). Since all agents are infinitesimal, they treat $q$ and $q_0$ as parametrically given.

[33] In contrast, if the police are recruited from the community the (lump-sum) taxes used to finance the police wage bill simply represent transfer from one group (workers and firms) to another (the police). In this case, the welfare cost of policing stem from the reduction in available productive manpower. The present formulation is much simpler, since the police wage is exogenous to the community and the population inflows into and outflows from the police force can be neglected.

[34] Unpleasant distributional complications arise if property is returned to the original owner. The assumption that the proceeds from crime are destroyed is made for simplicity, as it rules out such seizures as a source of police financing.

[35] Alternatively, one may assume that convicted households are incarcerated, during which time they receive a flow utility equal to zero, and are released (paroled) at random points in time. This is, however, beyond the scope of the present article. Moreover, considerations of pecuniary fines imply that the government budget constraint becomes much more complex, without adding much corresponding additional insight.

6.3. *School, Occupational Choice, and Steady-State Population.* With the possibility of arrest and conviction, the key asset values become

$$\Omega_U \equiv \max_{s\geq 0}\left[\frac{\lambda\mu_0}{\chi(\alpha)+\mu_0}\frac{s}{r}-q_0\frac{Z}{r}\right]-g(s)-\frac{P}{r} \tag{27}$$

$$J_R \equiv \frac{\lambda\beta_0}{\chi(\alpha)+\beta_0}\frac{s}{r}-\left[q_0+q\left(\frac{P}{Q+R}\right)\right]\frac{Z}{r}-\frac{P}{r} \tag{28}$$

Equations (27) and (28) are structurally very similar. In addition to the absence of the education cost term, $g(s)$, Equation (28) differs from (27) only in the replacement of (i) of $\mu_0$ by $\beta_0$, which is the matching rate relevant to criminals, and (ii) $q_0$ by $(q_0+q)$, which is the arrest hazard rate pertinent for criminals.

From (27), optimal schooling yields $\frac{\lambda}{r}\frac{\mu_0}{\chi(\alpha)+\mu_0}=g'(s)$, or, by applying the functional form of $g$,

$$s(\alpha)=\left(\frac{\lambda}{r\varepsilon}\frac{\mu_0}{\chi(\alpha)+\mu_0}\right)^{\frac{\varepsilon}{1-\varepsilon}} \tag{29}$$

where it is obvious that $s$ is decreasing in $\alpha$ and $\lim_{\alpha\to\infty}, s(\alpha)=0$.

Equalizing (27) and (28) implicitly defines the modified *OC* locus, which takes into account optimal schooling,

$$q(\pi)Z=\Psi(\alpha)\equiv\frac{\lambda s(\alpha)}{\chi(\alpha)+\mu_0}\left[\varepsilon\mu_0-\frac{\mu_0-\beta_0}{\chi(\alpha)+\beta_0}\right] \tag{30}$$

where $\Psi(\alpha)$ is generally a nonmonotonic function of $\alpha$, satisfying $\lim_{\alpha\to\infty}, \Psi(\alpha)=0$. In order to focus on an interesting equilibrium in which crime arises, we assume that the expected net benefit to criminal activity is positive in the absence of policing. Thus, we impose

CONDITION 4. $(\mu_0-\beta_0)/\mu_0>\varepsilon\,(r+\lambda+\beta_0)$.

Under this assumption, the crime rate corresponding to zero conviction hazard is $\alpha_0\equiv(1/\varepsilon)(\mu_0-\beta_0)/\mu_0-(r+\lambda+\beta_0)>0$. This is the horizontal intercept of the modified *OC* locus in $(\alpha,\pi)$ space.

This locus gives, for each $\pi$, the crime rate, $\alpha$, at which households are just indifferent ex ante between formal work and crime (provided such a value exists).

Finally, utilizing (4) (with $\theta=1$) and (23), we can obtain the modified *SS* locus, which gives the relative police force

$$\pi=\left(1+\frac{\delta+\lambda}{\mu_0}+\frac{\alpha}{\beta_0}\right)P \tag{31}$$

which is increasing in the crime rate $\alpha$ and has a vertical intercept $\pi_0 \equiv (1 + \frac{\delta+\lambda}{\mu_0})P > 0$ in $(\alpha, \pi)$ space.

6.4. *Equilibrium Analysis.* We are now prepared to modify the concept of equilibrium.

Definition 2 (Steady-State Equilibrium with Punishment). A steady-state equilibrium with punishment is described by a pair $(\alpha^*, \pi^*)$ satisfying the modified *OC* and *SS* loci, (30) and (31).

Any tuple $(\alpha^*, \pi^*)$ on the *OC* locus is consistent with optimizing behavior on the part of households. Furthermore, if this pair also lies on the *SS* locus, all populations are invariant through time. In summary, once a pair $(\alpha^*, \pi^*)$ satisfying both loci is found, the other variables, including $s^*$, $C^*$, $U^*$ and $(Q + R)^*$, can be recovered recursively.

Although the labor market contact rate is assumed given as $\mu_0$, multiple equilibria may still arise from the positive feedback interactions between the crime rate, $\alpha$, and the conviction hazard $q$ alone (which depends on policing, $\pi$). This result is quite striking. It says, in essence, absent *labor market feedback* effects, criminal activity alone is *insufficient* to generate multiple equilibria. What is required is the joint interactions between criminal behavior and enforcement.

When police expenditure is nil ($P = 0$), we have, by construction, $q = 0$. For any nondegenerate value of police expenditures $P > 0$, an increase in the crime rate $\alpha$ reduces the probability with which any given member of the criminal fraternity, $Q + R$, is subject to arrest (the interdiction effect). In turn, this raises the individual returns to crime. Consider,

Proposition 6 (Steady-State Equilibrium with Punishment).

(i) *If $P = 0$, then there is a unique equilibrium $(\alpha^*, \pi^*) = (\alpha_0, 0)$.*
(ii) *For any given value of $P > 0$, multiple steady-state equilibria may exist, where there is always a zero-crime degenerate equilibrium with $\alpha^* = 0$ for any $P$, $Z > 0$.*

In the absence of police expenditures, the *SS* locus holds automatically and the modified *OC* locus gives rise to the equilibrium $(\alpha_0, 0)$. If $P > 0$ and $\alpha = 0$, then comparing (27) and (28) yields $\Omega_U > J_R$. In this case, all households opt for formal employment, which reconfirms $\alpha^* = 0$ as an equilibrium.

In Figure 2, we illustrate the results based on a numerical exercise that yields two nondegenerate equilibrium points $A$ and $B$ (with $A$ representing the high-crime equilibrium). Welfare levels across the equilibria are Pareto rankable and decrease with the crime rate $\alpha$. The equilibrium depicted at $A$ possesses natural comparative-static properties. For instance, an increase in police expenditures $P$ or the legal penalty $Z$ lowers the crime rate $\alpha$. Interestingly, whereas the latter always reduces the conviction hazard rate, the former need not be so (depending crucially on whether the modified *OC* locus is upward-sloping in the neighborhood of equilibrium point $A$).

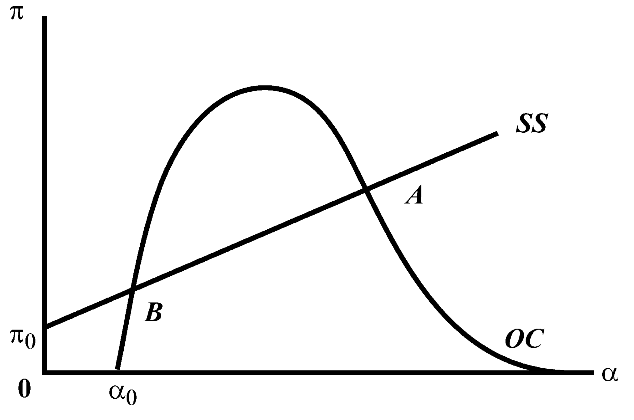


FIGURE 2

STEADY-STATE EQUILIBRIUM WITH PUNISHMENT

Finally, it is worth bearing in mind that throughout this section we have assumed that $\mu_0$ is given. Allowing $\mu_0$ to adjust endogenously would give rise to an additional source of multiple equilibria, for the reasons already described in Section 5.

## 7. CONCLUDING REMARKS

We study the accumulation of human capital, crime, and unemployment in the context of a simple search-equilibrium model. In determining the level of human capital they wish to accumulate, agents take into account not only the cost of acquiring human capital but also the (endogenously determined) crime rate. Crime acts, in effect, as a tax on the returns to human capital. There are multiple equilibria. High crime, low levels of educational attainment, unemployment, and poverty are correlated across them. The selection of a particular equilibrium outcome is based primarily on self-fulfilling prophecies.

Our model admits many potential extensions, and we mention just two of them. First, we assume that individuals make a dichotomous choice between work and crime. In practice, most criminals also secure formal employment at various points, often committing crime during their spare time. We believe we could model this phenomenon by introducing leisure as an argument in the utility function and allowing ex ante productive heterogeneity. A second set of extensions deals with the possibility of incarceration after arrest. In this environment, one issue of great concern is the potentially deleterious effects of extended periods of incarceration on human capital levels.

## APPENDIX

This appendix provides proofs of lemmas and propositions presented in the main text.

PROOF OF LEMMA 1 (The Wage). The Bellman equations (7)–(12) give,

$$
\begin{aligned}
J_U &= [\lambda\mu/(\mu + \chi)](w/r) \\
J_C &= [\lambda(\mu + r)/(\mu + \chi))](w/r) \\
J_R &= [\lambda\beta/(\beta + \chi + (\theta - 1)\alpha)](\phi w/r)\, A1 \\
J_Q &= [\lambda(\beta + r)/(\beta + \chi + (\theta - 1)\alpha](\phi w/r) \\
\Pi_V &= \eta(y - w)/r = \nu_0
\end{aligned}
\tag{A.1}
$$

where $\chi \equiv \lambda + r + \alpha$. Using (A.1) in (13) yields $\lambda w/(\chi + \mu) = y - w$. This is solved as (14) in the text. The partial derivatives are obtained through standard methods. ■

PROOF OF LEMMA 2 (Education). By substituting the wage (14) into the asset value (A.1),

$$\max_{s\geq 0}\{J_U - g(s)\} = \max_{s\geq 0}\{[\lambda\mu/(\lambda + \mu + \chi)][s/r - g(s)\} \tag{A.2}$$

The program is convex, so, under Conditions 1, the first-order conditions are necessary and sufficient for a maximum. Thus,

$$[\lambda\mu/(\lambda + \mu + \chi)](1/r) = g'(s) \tag{A.3}$$

which implicitly defines the optimal schooling level, $s(\mu, \alpha)$. The derivatives are obtained by totally differentiating Equation (A.3). By L'Hospital's rule, $\lim_{\mu\to\infty}[\lambda\mu/(\lambda + \mu + \chi)](1/r) = (\lambda/r)$. This implicitly defines the educational upper bound, $\bar{s}$, by $(\lambda/r) \equiv g'(\bar{s})$. Similarly, $\lim_{\alpha\to\infty}[\lambda\mu/(\lambda + \mu + \chi)](1/r) = 0$, which gives $s = 0$. For $\alpha = 0$, then $\chi = \lambda + r$. Direct substitution then gives $\lambda\mu/(\mu + 2\lambda + r)](1/r) \equiv g'(s(\mu))$. ■

PROOF OF LEMMA 3 (Steady-State Matching). Under constant returns to scale,

$$\mu U = \eta V = V m_0 M(U/V, 1) = V m_0 M(\eta/\mu, 1) \tag{A.4}$$

Equation (A.4) implicitly defines the *SS* locus, $\eta = \eta^{SS}(\mu; m_0)$. Straightforward differentiation establishes the properties. ■

PROOF OF LEMMA 4 (The *EE* locus). With unrestricted entry, the ex ante return from entering the market, $\Pi_V - \nu_0$, must be zero. Hence, $(y - w)\eta = r\nu_0$. Using the wage Equation (14) yields

$$\eta = (r\nu_0/\lambda)[(\lambda + \chi + \mu)/y] \tag{A.5}$$

Routine manipulation yields, with Lemma 2, the partial derivative properties. ■

Proof of Lemma 5 (Nonmonotonicity). As $\mu \to 0$, then $s(\cdot) = 0$, since costly education has no value. Equation (4) gives $\eta_0 = [(r\nu_0)/(\lambda s)](\lambda + \chi) > 0$. As $\mu \to \infty$, then $s \to \bar{s}$ (Lemma 2). From (A.5), $\lim_{\mu\to\infty} \eta = \infty$. This establishes the limiting properties of the *EE* locus. Using parameter values similar to those in Laing et al. (1995) gives an *EE* locus that possesses decreasing segments. ■

Proof of Lemma 6 (The *OC* locus). Rewrite Equation (21) as

$$\mu = \frac{\beta_0 \chi}{\chi - (\beta_0 + \chi)\varepsilon} \tag{A.6}$$

Under Condition 1, $\chi - (\beta_0 + \chi)\varepsilon > 0$ for all $(\mu, \alpha)$, ensuring (A.6) is well defined for pinning down a fixed point mapping of $\mu(\alpha)$ on $R_+$. The limiting properties follow directly from (A.6) by straightforward application of the L'hospital's rule. Totally differentiating (21) with respect to $\mu, \alpha$, and $\beta_0$ yields the partial derivatives reported in Lemma 6. ■

Proof of Proposition 1 (Existence). From Lemma 4, the *EE* locus is continuous with $\lim_{\mu\to\beta_0} \eta^{EE} = \frac{r\nu_0}{\lambda}\frac{2\lambda + r + \bar{\alpha} + \beta_0}{y} \equiv \eta_0 > 0$ and $\lim_{\mu\to\infty}\eta^{EE} = \infty$, for given $\alpha$. The properties of $g(s)$ ensure $s$ is bounded above: $\lim_{\mu\to\infty} s(\mu, 0) = \bar{s} < \infty$ (where $g'(\bar{s}) \equiv \lambda/r$). It follows that for large enough $\mu$ the*EE* locus, Equation (25) , converges asymptotically to a ray with a positive slope $r\nu_0/(\bar{s})$, which is linear and increasing in $\mu$. Also, the *SS* locus (16) is strictly decreasing in $\mu$, asymptotes at each axis, and increases in $m_0$. Define $\underline{m}_0$ as a lower bound of $m_0$ to satisfy $\eta^{SS}(\beta_0; \underline{m}_0) = \eta_0$. For any $\eta = \eta^{SS}(\beta_0; m_0) > \eta_0$, which is true for any $m_0 > \underline{m}_0$, the strictly decreasing *SS* locus must intersect with the *EE* locus. This, together with the recursive property of the system of well-defined functions, proves the proposition. ■

Proof of Proposition 2 (Multiplicity). This is trivial. For small value of $m_0$ only the degenerate $s^* = N^* = 0$ equilibrium exists. As shown in Proposition 1, for any given matching technology, $M(\cdot)$, there is a unique $\underline{m}_0$ for which the *SS* and *EE* loci coincide only at a point of tangency. For values of $m_0 > \underline{m}_0$, the *SS* locus may cut the *EE* locus three times or more. ■

Proof of Proposition 3 (Comparative Statics). The derivatives are obtained through routine methods by totally differentiating the *EE* locus and the *SS* locus around a steady-state equilibrium point (using Lemmas 2 and 6). The condition, $(d\eta^{EE}/d\mu) - (d\eta^{SS}/d\mu) > 0$, yields the results. ■

Proof of Proposition 4 (Multiple Equilibria). The inverse *OC* locus implies that the crime rate decreases with $\mu$ (Lemma 6). The schooling effort function $s(\mu, \alpha)$ increases with $\mu$ and decreases with $\alpha$. It follows that higher values of $\mu^*$ lead, unambiguously, to higher values of $s^*$ as both the direct ($\mu$) and indirect ($\alpha$) effects work in tandem. Equation (24), determining the primary sector labor force, $N$, increases with $\mu$ and falls with $\alpha$. It follows that higher values of $\mu^*$ lead to higher values of $N^*$. Finally, a worker's ex ante welfare is given by (20), which increases (decreases) with $\mu$ ($\alpha$). The welfare results are then immediate. ■

PROPOSITION 5 (Appropriation Effect). Recall that the right-hand side of (26) is decreasing in $\alpha$. Given $\theta < (\lambda + r + \beta_0)/(\lambda + r + \mu)$, the left-hand side of (26) decreases with $\alpha$. Thus, multiple solutions may emerge. ■

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