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Getting Over the Hump: A Theory of Crime, Credit and Accumulation*

Huw Lloyd–Ellis
Department of Economics, University of Toronto, and CREFÉ

Nicolas Marceau
Département des sciences économiques, Université du Québec à Montréal, and CREFÉ

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Lloyd–Ellis: lloydell@chass.utoronto.ca
Marceau: marceau.nicolas@uqam.ca

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Résumé: Nous construisons un modèle dans lequel la capacité de l'économie à se développer est déterminée de façon endogène par l'interaction entre les ratés du marché du capital et le taux de crime contre la propriété. Dans les premiers stades du développement économique, les crimes contre la propriété croissent en même temps que la richesse s'accumule, les gains que procure l'activité criminelle étant alors d'autant plus élevés. Mais dans les stades de développement ultérieurs, ces crimes diminuent au fur et à mesure que la richesse s'accumule car les ratés du marché du capital sont de moins en moins importants. Dans certaines économies, les crimes contre la propriété, observables dans les premiers stades du développement, ralentissent et éventuellement arrêtent la croissance économique, alors que dans d'autres, l'économie poursuit sa croissance et atteint la phase de déclin de l'activité criminelle. Insistant sur l'importance des ratés endogènes du marché du capital, nous analysons également l'impact de politiques publiques de prévention et de dissuasion du crime.

Abstract: We explore the implications of endogenous credit market imperfections for the relationship between property crime and the process of economic development. In the initial stages of development, property crime rises as the opportunities to gain from illegal activities expand. In later stages, however, crime falls as capital market imperfections are overcome and legal activities become more profitable. We detail the forces which determine whether the crime generated by an economy's early growth will choke off the development process. We also find that endogenous credit constraints reduce the effectiveness of public expenditures that raise expected criminal sanctions, and that spending on *ex ante* crime prevention may be more cost–effective.

Keywords: Crime, property rights, economic development, credit markets.

JEL Classification: O16, K42, N43

1. Introduction

The idea that property crime and other forms of diversion are inherent by–products of the unequal accumulation of wealth has a long tradition in economics. For example, Adam Smith (1776 [1937]) argues that the accumulation of property by some, would generate opportunities for others to gain from criminal activities:

> "Wherever there is great property, there is great inequality. For one very rich man, there must be at least five hundred poor, and the affluence of the few supposes the indigence of the many. The affluence of the rich excites the indignation of the poor, who are often both driven by want, and prompted by envy, to invade his possessions." Adam Smith (1776 [1937], p. 670)

In the absence of adequately enforced property rights, we might therefore expect property crime to *rise* when some individuals accumulate wealth. Since increased insecurity over property is likely to act as a disincentive to investment (see Besley 1995), it follows that the process of economic development could sow the seeds of its own demise. The recent experience of Russia and other transition economies illustrates the potential consequences of the absence of adequate law enforcement on *laissez faire* economic development.[1]

Underlying Smith's analysis is the presumption that while some individuals can generate sufficient incomes via legal activities, others are instead faced with a choice between less productive legal activities and crime.[2] While this could be the result of chance or differences in ability, capital market imperfections may also play an important role. Indeed, capital market imperfections are especially likely when the protection of private property is costly and ineffective. For example, if the private costs of protection against crime are high, the wealthy are more likely than the poor to protect their property. Understanding this, lenders are likely to be more willing to lend to the wealthy than the poor, and at relatively low interest rates. If some potential entrepreneurs are credit–constrained, then the accumulation of wealth could also act to *reduce* the crime rate. Increased wealth will tend to open up new legal opportunities as individuals gain increased access to capital. If, as a result, fewer agents undertake criminal activities, then the security of investments will rise. This should induce further investment, so that still fewer individuals become criminals.

How then should we expect property crime to evolve with the level of development? Will it rise as the opportunities to gain from crime expand, or fall, as access to productive legal opportunities

[1] On the expansion of crime in Russia, see Goldman (1996).
[2] Empirical work by Freeman (1994) confirms that criminal activities do indeed tend to be concentrated amongst less wealthy members of society.

increase? Social historians report that the rapid industrialization of nineteenth century Western Europe was initially accompanied by a rise in property crime rates and then later by a decline.[3] What could account for such a "hump–shaped" pattern? Is it possible that the development process could generate so much crime that growth falls to zero before the economy advances very far? Relatedly, does greater security over private property result in greater economic development by improving investment incentives and access to credit markets, or is it the other way around?

The answers to these questions are of more than pure academic interest. Cross–country income disparities are too wide to be explained by differences in human capital or technology levels alone (Olson, 1996).[4] Differences in institutional arrangements and government policies that discourage crime, corruption and other forms of diversion offer a potential explanation for these disparities. For example, Svensson (1993) finds that the lack of secure property rights has a detrimental impact on growth. Relatedly, Hall and Jones (1997) find a significant positive correlation between output per worker and the extent to which governments adopt "anti–diversionary policies".

In this paper, we explore these issues in the context of a two–period overlapping generations model. When young, agents earn heterogeneous wages that depend on their human capital and employment opportunities. When old, agents choose either to become capitalist entrepreneurs, criminals or to subsist. Entrepreneurs invest in a project, borrowing capital, if necessary, at the market rate of interest, and hiring labor at the market wage rate. Criminals do not produce, but instead randomly invade entrepreneurs and steal their output. Agents who are unable to become capitalists and for whom the returns to diversion are small, subsist on relatively low incomes.

Borrowers can adopt costly private security measures which reduce the probability that their property is stolen. However, lenders cannot observe whether or not this investment is made, and so they must design debt contracts that ensure incentive compatibility. Only wealthy borrowers, who have a large stake in their project, will find it profitable to incur the cost of security. Because less wealthy agents cannot commit *ex ante* to doing so, the interest rate they face includes a risk–premium exceeding that faced by richer borrowers. Since the return on other legal activities is low, these agents are therefore much more likely to pursue a life of crime than wealthier ones.

We characterize the evolution of an economy starting from a low wealth state, holding constant

[3] We discuss this data in more detail in Section 2.

[4] Moreover these factors cannot account for the lack of capital flow towards poorer regions which would, according to the neoclassical model, hasten the convergence between productivity levels (see Barro *et al.* 1995).

the public institutions of property rights enforcement. Initially, few agents have sufficient wealth to qualify for a profitable loan. The remainder are left with the choice of a low income from subsistence or a life of crime. However, the opportunities to gain from crime are constrained by the small number of potential victims. Since there is a surplus of potential criminals, the probability of invasion is driven to its maximum level and so also is the interest rate. In such an "opportunity–constrained equilibrium", there is little demand for the labor supplied by the young generation, and the wages they receive are correspondingly low. However, so long as the average wage exceeds that received by the previous generation, the fraction of agents qualifying for low–interest rate loans grows. As the rate of enterprise expands, so also do the opportunities to gain from criminal activities, so that there is a matching increase in the crime rate.

The economy evolves in this fashion, with both the rate of enterprise and the crime rate gradually expanding, until the inactive subsistence population is exhausted. As before, for a given degree of insecurity, past wage increases continue to expand the number of agents who are eligible for low–interest loans. Now, however, the increased opportunities to undertake productive legal activities draw agents out of the pool of criminals, so that the equilibrium crime rate and the degree of insecurity declines. This generates a secondary effect by reducing the risk premium charged by lenders and raising the fraction of agents who are eligible for low interest loans even further. This in turn drives up the demand for labor and causes the wage to rise. The increased wage generates a further increase in the rate of enterprise in the next generation and a further reduction in the crime rate. The economy continues to develop in this fashion as long as this "criminal–constrained equilibrium" continues to exist.

The economy converges to a long run steady–state. In general, it does not converge to a zero crime rate, but may instead converge to a long run stationary positive crime rate. The nature of the steady–state equilibrium depends crucially on the underlying institutional parameters. If the effectiveness of private security is low and/or the cost is high, the economy may never experience the second phase of development and high crime rates and low productivity will persist in the long run. Otherwise, the economy eventually experiences falling crime and higher long–run productivity.

We also assess the implications of endogenous credit constraints for the effectiveness of public expenditures on alternative crime–deterring institutions. According to Becker (1968) harsher punishments or a greater likelihood of successful prosecution, reduce the payoff to crime and induce more people to undertake productive activities. In our analysis, the fact that individuals are credit–constrained implies that increasing the expected punishment may have little impact on crime.[5] If it requires significant tax increases,[6] then increasing the expected cost of punishment may even be detrimental, actually *raising* the crime rate and lowering productivity. In contrast, public expenditures which reduce the likelihood that criminals will be successful *ex ante,* can have larger effects, even for relatively small tax increases. Such expenditures may include the expansion of local police patrols, spending in support of gun control laws or community–based initiatives such as "neighborhood–watch". By reducing the insecurity associated with property crime, public investments such as these help to reduce the interest rate faced by borrowers and the cost of private security measures. This, in turn, induces greater productive activity and reduces the crime rate.

Our paper is related to the literature initiated by Baumol (1990) and Murphy, Shleifer and Vishny (1993). In these papers, individuals choose between productive and diversionary activities ("rent–seeking") by comparing their relative rewards. Since these rewards are determined by the allocation of individuals between activities, multiple equilibria can arise. The key feature of these equilibria is that high levels of appropriation are associated with low levels of development. Our model may also generate multiple equilibria with this feature, but the mechanism is somewhat different. There can be equilibria with many criminals and a large risk premium, so that credit is inaccessible and output is low. Alternatively, there can be equilibria with no criminals and no risk premium, so that all agents have equal access to productive opportunities and output is high.[7]

The key contribution of our paper, however, is its characterization of the dynamic interaction between crime rates, credit market imperfections and the accumulation of wealth. In the static models discussed above there are no credit constraints, so that differences in occupational choices and investment decisions depend directly on relative ability.[8] In our framework ability matters, indirectly via the wages earned when young, because of the borrowing constraints that agents face when old. This has three key implications which we emphasize in this paper:

[5] Empirical evidence on the impact of punishment on crime rates is mixed (see Ehrlich, 1996). Marceau and Mongrain (1998) survey several alternative theories regarding the impact of punishment on crime.

[6] For example, greater costs might be incurred from expanding the court system or from extending prison terms, etc.

[7] Multiple crime equilibria can also arise in Sah (1991) and Fender (1997) because for a given level of resources allocated to apprehension and punishment, the probability of arrest declines with the crime rate. Glaeser, Sacerdote, and Scheinkman (1996) discuss multiple equilibria in models of crime.

[8] Acemoglu (1995) develops a dynamic version of the Murphy–Shleifer–Vishny story. He shows that their static equilibria are all potential steady–state equilibria. However, there is no accumulation of wealth and the results are driven by forward–looking behavior. See also Baland and Francois (1997).

• History matters — higher investment by one generation, generates an increased demand for labor from the next, which bids up their wages and relaxes their borrowing requirements;
• Opportunity–constrained equilibria can arise — as a result it is possible for the crime rate to rise with output in the early stages of development, before falling again in later stages;
• Policies aimed at *ex ante* crime prevention are likely to be more cost–effective than those focused on *ex post* punishment.

Our work is also related a number of other themes in the literature. Grossman and Kim (1995) develop a static model in which they analyze the relationship between the security of claims to property rights and the level of welfare. In particular, they emphasize the role of activities which are purely defensive, as well as those that are offensive.[9] Although our model also features the endogenous adoption of costly "defensive" security measures, the main role played by them is in generating the credit market failure. Aghion and Bolton (1997) develop a related model of the interaction between credit market imperfections and development. In their paper, production uncertainty is exogenous, whereas here it is endogenously determined by the crime rate.

The remainder of the paper is organized as follows. Section 2 discusses the evidence regarding the evolution of property crime in nineteenth century Britain. Section 3 lays out the assumptions of our model and Section 4 characterizes the macroeconomic equilibrium. In Section 5, we characterize the development process that arises from the model. We provide conditions under which crime rates rise then fall as the economy grows. In Section 6, we consider the implications of credit market imperfections for alternative government policies to discourage criminal behavior. The appendix contains proofs of the main propositions.

2. Property Crime in Nineteenth Century Britain

The evolution of property crime during the British industrial revolution has generated significant debate amongst crime historians. The seminal works in this area are those of Beattie (1974) and Gurr (1976), and Gatrell and Hadden (1972). Jones (1982) summarizes their conclusions as follows:

> "... their findings indicate a fairly gentle rise in the eighteenth–century crime rate, with particularly significant increases in the early Hanoverian period and a more sudden upward movement in property offenses in the last three decades. This last rise became spectacular in the years 1815–17, and continued to cause alarm until the critical turning–point of the mid–century .... in the second half of the century, especially after the 1860s,

[9] Usher (1989) also emphasizes the distinction between defensive and offensive measures.

there was a national decline in the number of offences against persons and property until the end of the century, and beyond ... This picture of major long–term changes in criminal behaviour is complemented by much recent research in Germany, France, Sweden and other parts of the western world." (Jones 1982, pp. 3–4)

Figure 1 illustrates the number of people per 100,000 of the population of England and Wales committed to trial for an indictable offence against property (that is an offence tried before a jury in the superior courts of assize or quarter sessions).[10] These are referred to as indictable committals, and were published from 1805 onwards. Although the returns for some of the early years are missing, the data exhibit a clear upward trend until the middle of the century followed by a downward trend in the last half of the century. A similar pattern has been documented in various sub–regions of Britain (see Jones, 1982, 1992) and in France (see Zehr 1976).[11]

Reported crime statistics are notoriously difficult to interpret. One reason is that increases in policing tend to increase the rates of reporting and detection, thereby artificially increasing the measured crime rate. Also, because crime is an important concern for voters, the authorities may have an incentive to manipulate the statistics.[12] If one takes the reported thefts per 100,000 people in the U.S. at face value, one would find that the crime rate has risen exponentially since the 1960s.[13] However, as one criminologist observes

"...a sober look at the problem shows that there is probably less crime today in the United States than existed a hundred, or fifty, or even twenty–five years ago, and that today the United States is a more lawful and safe country than popular opinion imagines." (Bell 1992, p. 53).

The first question that must be asked, therefore, is whether the data in Figure 1 are representative of the true property crime rate. There were several legal and administrative changes that affected the coverage and collection of this data, but as discussed in Gatrell and Hadden (1972) most of these had little affect on the statistics. However, by changing the definition of an indictable offence, the Criminal Justice Act of 1855[14] created an artificial drop in the number of indictable committals between 1855 and 1856. Unfortunately, although summary committals existed before 1855, the statistics are only available from 1857 onward, and it is not possible to determine what the total

[10] The data is from Gatrell and Hadden (1976).

[11] The rate of all serious offences exhibits a similar hump–shaped pattern. However, this should not be surprising given that property offences constituted over 80% of all offences.

[12] For example, in the early 1970s, following Nixon's election pledge to reduce crime, the District of Columbia Police Department systematically estimated stolen property at a value smaller than $50, thereby diminishing the number of serious larcenies — defined as larceny/theft of a value larger than $50 (see Wright 1985).

[13] The $50 rule, together with inflation, apparently explains the increase in the number of serious larcenies between 1962 and 1973. The FBI stopped using this rule in 1973.

[14] As a result of this Act, all thefts involving property valued at less than five shillings and all other simple thefts, if the accused pleaded guilty, were no longer defined as indictable offenses, but rather were brought before a magistrate on summary jurisdiction.

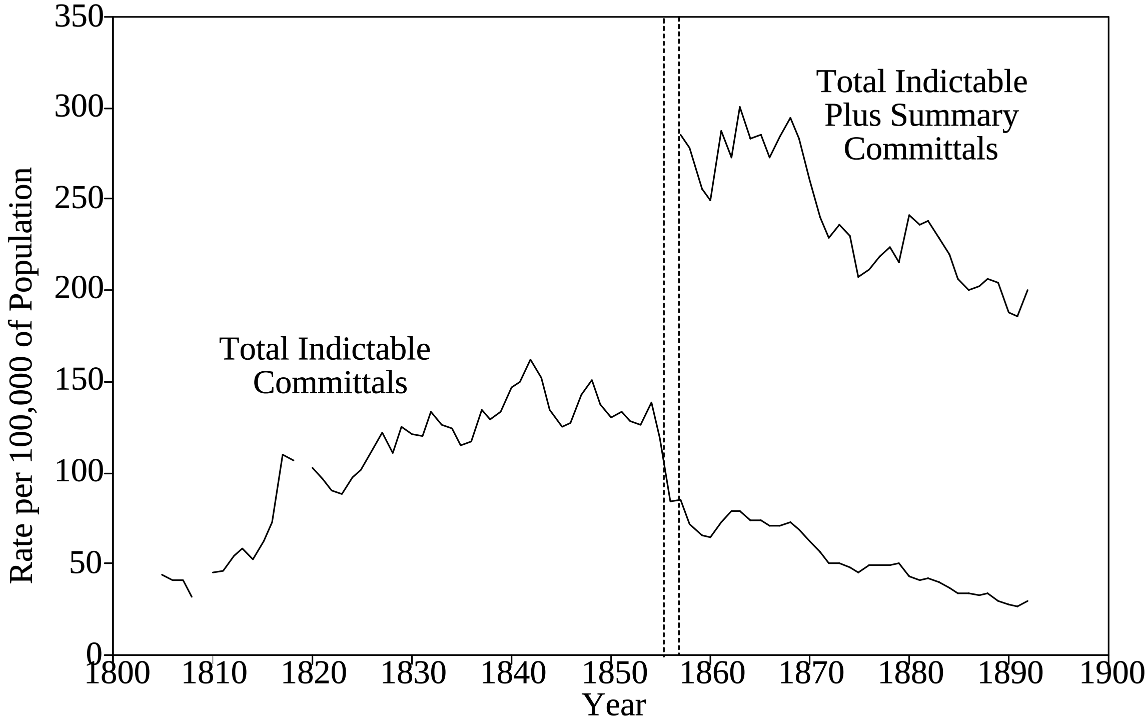

Figure 1: Property Crime in Nineteenth Century Britain (Source: Gatrell and Hadden, 1972)

indictable committals would have been had this redefinition not taken place.[15] Nevertheless, it can be seen that the rate of indictable committals still trends downward after 1857, as does the sum of indictable and total summary committals.[16]

What factors are responsible for the patterns observed? Like Adam Smith, other contemporaries had little doubt about the causes of the initial rise in crime:

> "Crimes have increased among men because property and transactions connected with property have increased." (Wade, 1833, p. 568)

Several short–term variations can be accounted for by other factors, but did not affect the overall trend.[17] There is, however, a debate amongst historians as to whether the period of declining crime during the last half of the century was the result of greater efforts to enforce property rights or improving economic conditions. Although the number of policemen per capita grew in England and Wales during the latter half of the century,[18] there are several reasons to believe that a key causal factor in the reduction of property crime was the improvement in economic conditions.[19] Firstly, increased policing appeared to affect the nature rather than the rate of property crime:

> "unless the officers were on the spot at the time robbery, comparatively few criminals were arrested ... It was largely a case of deciding ... whose area and property to protect and of tracking down suspected persons and known criminals ... the police determined the place, character and perpetrators of crime." Jones (1982, p.177)

Secondly, Gatrell and Hadden (1972) document that prisoners later in the century were drawn from a less educated, hardened criminal class which was relatively less numerous, and less representative of the population as a whole, than was the case earlier in the century. They argue that

> "... fewer 'potentially honest' people, who earlier in the century might have been driven to commit an offence because of want, were now brought before the courts."

3. Analytical Framework

3.1 Endowments and Preferences

In each period t a unit population of two–period lived individuals is born into a small open economy.

[15] This problem did not arise for the Summary Jurisdiction Act of 1879 (see Gatrell and Hadden, 1972).
[16] After 1857, the number of crimes known to the police is also available and exhibits a similar downward trend.
[17] For example, part of the large increase between 1814 and 1817 may be attributed the return of young, active males after the Napoleonic war.
[18] One implication of this is that the rates of detection, reporting and successful prosecution of crimes would have increased, suggesting that the fall in the actual crime rate was even more pronounced.
[19] According to Gurr (1976, p. 96) increased policing can only reduce criminal behaviour "when it reinforces improving socio–economic conditions".

There is no reproduction so that individuals only care for themselves. Each young person is endowed with efficiency units of labor ε, drawn from a time–invariant uniform distribution function $F(\cdot)$, with support $[0, 2H]$. It follows that the aggregate supply of labor efficiency units is given by at H:

$$\int_0^{2H} \varepsilon F(d\varepsilon) = H. \tag{1}$$

The young supply their labor to old producers and receive the equilibrium wage, w_t, per efficiency unit of labor supplied. This, in turn, generates a distribution of incomes amongst these agents when they become old. At $t = 0$, the initial old generation are assumed to have earned a wage per efficiency unit of labor, given by w_0, where w_0 is sufficiently small.[20]

An agent born at time t has preferences described by the linear utility function:

$$u(c_t, d_{t+1}) = c_t + \beta \mathrm{E_t} d_{t+1}, \tag{2}$$

where c_t and d_{t+1} represent consumption when young and old, respectively, β is the discount factor and E_t denotes the expectations operator conditional on time t information. Let $r > 1$ be the gross risk–free interest rate that can be earned on world capital markets. We assume that the rest of the world has identical preferences, so that $r = 1/\beta$. Since the economy is small relative to the rest of the world, competition drives the interest rate on deposits to r. These preferences imply that agents are risk–neutral and that if capital markets were perfect, agents would be indifferent about the timing of their consumption.

3.2 Production

All members of the old generation have access to a subsistence activity which generates a low income, y. However, depending on the equilibrium prevailing, they may be able to earn more by becoming an entrepreneur or a criminal. Those who become entrepreneurs undertake projects that combine a fixed quantity of capital, k, with variable efficiency units of labor, h, according to a simple Cobb–Douglas production technology.[21] Producers choose efficiency units of labor so as to maximize short–run profits:

[20] We clarify what we mean by 'sufficiently small' in Section 4.

[21] The assumption of a fixed–size project is not necessary. All that is required is that investments be larger than some minimum scale, so that low–wealth individuals have to borrow. This investment could include the cost of acquiring specific human capital.

$$\max_{h} \quad Ak^{1-\alpha}h^{\alpha} - w_t h. \tag{3}$$

This yields a demand for efficiency units of labor given by

$$h(w_t) = \left(\frac{\alpha A}{w_t}\right)^{\frac{1}{1-\alpha}} k, \tag{4}$$

and short–run profits $\theta_t k$, where

$$\theta_t = (1-\alpha)\left(\frac{\alpha A}{w_t}\right)^{\frac{\alpha}{1-\alpha}} A. \tag{5}$$

3.3 Crime and Property Rights Enforcement

For reasons described below, a fraction n_t of the population become criminals and attempt to steal the profit of non–criminal producers. We assume that a criminal can attempt to steal from at most one producer and denote the expected income from doing so by X_t. [22] If a crime fails, the victim keeps his profits and the criminal gets nothing. If it is successful, there is still a chance that the criminal will be apprehended and punished.[23] We distinguish between the ***invasion rate***, π_t, — the probability that a crime is attempted against a producer — and the ***crime rate***, n_t — the fraction of the population engaged in criminal activities.

The ability of criminals to achieve their objectives depends on the effectiveness of both public institutions (e.g. police force and the courts) and private security measures, in defining and enforcing property rights. In our economy, the relevant aspects of the system of property rights are summarized by four variables:[24]

• The probability that a crime is successfully deterred in the absence of private security measures, ϕ — this variable depends on the effectiveness of public institutions in preventing crime *ex ante*. Initially we simplify our exposition by assuming that such institutions are ineffective and setting $\phi = 0$. In Section 6, we consider the role of public expenditures that increase ϕ.

• The expected disutility incurred by criminals who are caught and punished, μk — this variable de-

[22] The qualitative nature of our results would not change if criminals could attempt more than one invasion. What is crucial however is that each entrepreneur can only be invaded a small number of times. Normalizing to one significantly simplifies the exposition.

[23] We rule out the possibility that borrowers simply voluntarily default on their loan. We assume that the probability of getting away with such embezzlement is arbitrarily close to zero, since the borrower is easily identified by the lender. In contrast, we assume that output stealing is an anonymous crime, so that the probability of success is much higher.

[24] In general, there are many other dimensions associated with property rights. For example, the right to exclude others from using or consuming the property or the right to privately sell it.

pends on the probability that a criminal is successfully apprehended and prosecuted *ex post*, and on the disutility of the punishment incurred (e.g. imprisonment).[25] Expressing this value as a fraction of k simplifies the exposition. Since k is fixed, there is no loss of generality.

• The probability that a crime is thwarted by private security measures, ρ — we assume that such measures are imperfect $(\rho < 1)$ and costly.

• The cost of private security measures — we assume there exists a market for private security services. The price of protection is p_t. The marginal cost of security is γk in the event of an invasion and is zero otherwise (a convenient normalization). With perfect competition this implies that private security firms earn zero expected profits:

$$p_t = \pi_t \gamma k. \tag{6}$$

Again, expressing variables as a fraction of k simplifies the exposition.

3.4 The Capital Market

At the beginning of the second period of life, if an individual has accumulated wealth $b < k$, he can borrow $(k - b)$ to undertake a project. If he has accumulated $b > k$, he can undertake the project and deposit $(b - k)$ in the bank. He must also choose *ex ante* whether to invest an additional p_t in private security measures. Although the lender can observe the loan size, he cannot observe *ex ante* whether security measures are actually adopted. Only those with sufficient wealth carried over from the first period will find it in their interest to invest in private security. Since there is limited liability, the remainder would rather consume the additional funds and face the greater risk of invasion and default. The lender therefore screens borrowers based on their wealth.[26]

An entrepreneur will undertake private security measures only if his expected profit when the required portion of the loan is invested in security measures, exceeds that when it is simply con-

[25] Since agents are risk–neutral, there is no need to distinguish between effects of the probability of apprehension and the level of sanction.

[26] One way to get around the unobservability of security expenditures is for the banks to provide the security themselves. There are several reasons why this might not be possible. If security measures are transferable, then the existence of a market for security implies that entrepreneurs, if forced to buy from the banks, could simply resell to adjust the amount they wish to consume. Even if security measures are non–transferable, the efficient scale — the compromise between scale economies and agency costs — for firms offering banking services and those providing security services may not be the same. If banks were to offer security, they would not be able to compete with firms specializing in this particular business. Alternatively, we could have assumed that entrepreneurs have to provide an unobservable effort to secure their investment. If effort can also be used to generate income using some other technology, then the moral hazard problem remains and banks have an incentive to screen investors.

sumed

$$(1-\pi_t+\rho\pi_t)\left(\theta_t k - r_t^s[k+p_t-b]\right) > (1-\pi_t)\left(\theta_t k - r_t^s[k+p_t-b]\right) + rp_t, \tag{7}$$

which can be re-written as

$$\rho\pi_t\left(\theta_t k - r_t^s[k+p_t-b]\right) > rp_t. \tag{8}$$

The left hand expression represents the gain in expected profit from investing in private security while the right hand expression is the opportunity cost of doing so. It follows that there exists a critical wealth level,

$$b_t^c = \left(1+\pi_t\gamma - \frac{[\rho\theta_t - r\gamma]}{\rho r_t^s}\right)k = \left(1+\frac{\gamma}{1-\rho} - [1-(1-\rho)\pi_t]\left[\frac{\theta_t}{r}+\frac{\gamma}{1-\rho}-\frac{\gamma}{\rho}\right]\right)k, \tag{9}$$

such that only those with greater wealth will pay the costs of private security. Note that b_t^c is an increasing function of the probability of invasion.

Although individuals with $b \geq b_t^c$ take private security measures, they are only successful in thwarting criminals with probability $\rho < 1$. If the probability that such an individual is invaded is π_t, then the probability that a lender is ultimately repaid by these individuals is $(1-\pi_t+\pi_t\rho)$. Competition amongst lenders drives their profits to zero, so that these individuals are charged an interest rate

$$r_t^s = \frac{r}{1-\pi_t+\pi_t\rho}, \tag{10}$$

where the superscript s denotes 'security'. The net income of borrowing individuals with $b \geq b_t^c$ is therefore $Z_t^s + rb$, where

$$Z_t^s = [1-\pi_t+\pi_t\rho]\theta_t k - r(1+\gamma\pi_t)k, \tag{11}$$

Those borrowers for whom it is too costly to invest in security ($b < b_t^c$) will certainly default with probability π_t. Lenders, understanding this, will charge a greater risk–premium to these borrowers. The probability that an individual with $b < b_t^c$ will repay is $(1-\pi_t)$. Therefore, lenders will charge them

$$r_t^n = \frac{r}{1-\pi_t} > r_t^s, \tag{12}$$

where the superscript n denotes 'no security'. The expected net income of an individual with $b < b_t^c$, were he to become an entrepreneur, is therefore $Z_t^n + rb$, where

$$Z_t^n = (1-\pi_t)\theta_t k - rk. \tag{13}$$

3.5 Occupational Choice and Saving

An agent who earns $w_{t-1}\varepsilon < b_t^c$ in the first period of his life cannot save enough to qualify for a low–interest loan. Since he is risk–neutral and $\beta = 1/r$, he is indifferent between consuming all of his income in the first period and saving some of it to invest in his project. We arbitrarily assume that he consumes all of his first period income. This assumption does not affect any of the results that follow.

An agent who earns first period income $w_{t-1}\varepsilon \geq b_t^c$, will always choose to save at least b_t^c because this will make him eligible for a low–interest loan. However, he is indifferent between consuming the remainder of his income in the first period or saving more than b_t^c. Again we assume, without loss of generality, that he consumes all of his income in excess of b_t^c in the first period.

It follows that we can define a critical level of labor efficiency units given by

$$\varepsilon_t^c = \frac{b_t^c}{w_{t-1}}, \tag{14}$$

and that the expected lifetime utility of an agent born at $t-1$ with ability ε is given by

$$v(\varepsilon; w_{t-1}, X_t, Z_t^n, Z_t^s) = \begin{cases} w_{t-1}\varepsilon + \beta \max[y, X_t, Z_t^n], & \text{if } \varepsilon < \varepsilon_t^c, \\ w_{t-1}\varepsilon + \beta \max[y, X_t, Z_t^s], & \text{if } \varepsilon \geq \varepsilon_t^c. \end{cases} \tag{15}$$

The sequence of events for producers and criminals (i.e. individuals in the second period of their life) is summarized in Figure 2.

4. General Equilibrium

Since the efficiency units of labor supplied by each generation is fixed, it is possible to define a period t equilibrium, given the wage per efficiency unit received in the previous period, w_{t-1}. We then characterize the alternative equilibria that can arise.

A period t **equilibrium** is a vector $\{n_t^\star, \varepsilon_t^{c\star}, \pi_t^\star, w_t^\star, X_t^\star, Z_t^{n\star}, Z_t^{s\star}, r_t^{n\star}, r_t^{s\star}\}$ such that:

• Entrepreneurs choose the level of labor efficiency units to maximize profits, (4).

• The labor market for the young clears at the equilibrium wage, $w_t^\star$.

• Given the invasion rate, $\pi_t^\star$, lenders set their loan rates, $r_t^{n\star}$ and $r_t^{s\star}$, and the critical level, $\varepsilon_t^{c\star}$, to maximize expected profits, (9), (10), (12) and (14). Competition drives these expected profits to

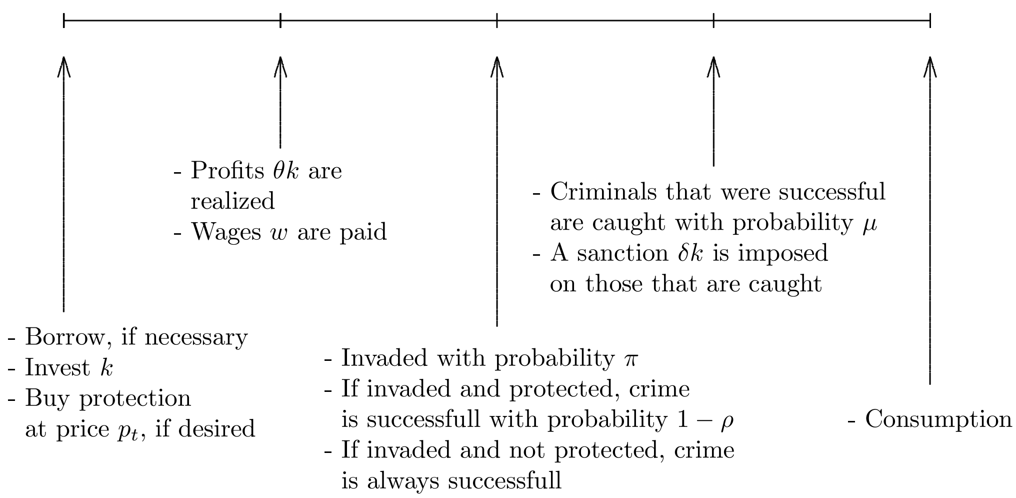

Figure 2: A Representative Period for Producers and Criminals

zero.

• Given their first period incomes, the available interest rates and the invasion rate, agents choose the occupations that maximize their expected utility, (15).

• Agents' beliefs about the invasion rate are consistent with the fraction of the population undertaking criminal activities, i.e. with the crime rate.

4.1 Zero Crime Equilibrium

In a zero crime equilibrium $n_t^\star = 0$, so that $\pi_t^\star = 0$ and $r_t^{n\star} = r_t^{s\star} = r$. For this to be the case, all agents must have income above the critical level and, in equilibrium, they must prefer to produce. In such an equilibrium the market clearing wage must be at its maximum possible level, $\bar{w}$, where

$$\bar{w} = \alpha A \left(\frac{k}{H} \right)^{1-\alpha}, \tag{16}$$

and producers' short–run profit is at its minimum possible level, $\underline{\theta}k$, where

$$\underline{\theta}k = (1-\alpha)AH^\alpha k^{1-\alpha}. \tag{17}$$

The expected net income of all old agents is

$$Z^\star = (\underline{\theta} - r)k. \tag{18}$$

The expected lifetime utility from deviating from this equilibrium by stealing is $w_{t-1}\varepsilon + \beta X^\star$ where

$$X^\star = (1-\rho)[\underline{\theta} - \mu]k. \tag{19}$$

If the parameters are such that $Z^\star > X^\star$ and $\underline{\theta} > r$, then a zero crime equilibrium exists, since all agents prefer to produce and are not constrained from doing so. Note that we assume that $X^\star > y$, so that crime is always preferred to subsistence for all $\theta_t \geq \underline{\theta}$.

4.2 Crime Equilibria

Two distinct types of stable equilibrium featuring positive crime levels are possible:

• **Opportunity–Constrained Crime Equilibrium —** in such an equilibrium the number of potential crimes is constrained by the measure of potential victims, so that producers are invaded with the maximum probability: $\pi_t^\star = 1$. A criminal's expected payoff is $X_t^\star = (1-\rho)[\theta_t^\star - \mu]k$, where

$\theta_t^\star$ is given by equation (5) when evaluated at $w_t^\star$. If he adopts private security measures, an entrepreneur's expected payoff is therefore

$$Z_t^{s\star} = \rho\theta_t^\star k - r(1+\gamma)k. \tag{20}$$

The following assumption ensures that in such an equilibrium all agents who earn more than $w_{t-1}\varepsilon_t^{c\star}$ become entrepreneurs rather than criminals:

Assumption A1:

$$\rho\theta_t - r(1+\gamma) > (1-\rho)[\theta_t - \mu]. \tag{21}$$

Note that so long as this condition holds for $\theta_t = \underline{\theta}$, it must hold for all $\theta_t > \underline{\theta}$.[27] Poorer agents with $\varepsilon < \varepsilon_t^{c\star}$ are better off subsisting than producing because the effective interest rate that they face is infinite and makes their expected net return from production negative:

$$Z_t^{n\star} = -rk < 0. \tag{22}$$

It follows that the measure of entrepreneurs is $1 - F(\varepsilon_t^{c\star})$. Since criminals attempt to steal from one producer, in an opportunity–constrained equilibrium it must be the case that

$$n_t^\star = 1 - F(\varepsilon_t^{c\star}). \tag{23}$$

The expected payoff to any of the remaining agents with $\varepsilon < \varepsilon_t^{c\star}$ from becoming a criminal is zero since there are no remaining victims. Since criminals are exclusively poorer members of the old generation, with $\varepsilon < \varepsilon_t^{c\star}$, it follows that there are $(F(\varepsilon_t^{c\star}) - n_t^\star)$ individuals with $\varepsilon < \varepsilon_t^{c\star}$ who cannot become criminals (and therefore subsist). For an opportunity–constrained crime equilibrium to exist it must be the case that

$$F(\varepsilon_t^{c\star}) > \frac{1}{2}. \tag{24}$$

• **Criminal–Constrained Crime Equilibrium** — in this case the number of crimes is determined by the number of potential criminals. The expected equilibrium payoff to crime is, once again, $X_t^\star = (1-\rho)[\theta_t^\star - \mu]k$. Since the rate of invasion in such an equilibrium is $\pi_t^* < 1$, the expected payoff to wealthy producers must exceed that in the opportunity–constrained equilibrium. Since the expected equilibrium payoff from crime is the same, Assumption A1 implies that $Z_t^{s\star} > X_t^\star$. In such

[27] Assumption A1 also implies that the zero crime equilibrium exists.

an equilibrium there are more than enough potential victims amongst the wealthy, so either all less wealthy agents will become criminals or none will. If all become criminals then $n_t^\star = F(\varepsilon_t^{c\star}) < \frac{1}{2}$ and $\pi_t^\star = F(\varepsilon_t^{c\star})/[1 - F(\varepsilon_t^{c\star})] < 1$. The payoff from deviating by becoming an unsecured producer is

$$Z_t^{n\star} = \left[\frac{1 - 2F(\varepsilon_t^{c\star})}{1 - F(\varepsilon_t^{c\star})}\right] \theta_t^\star k - rk. \tag{25}$$

Because it must be that $X_t^\star > Z_t^{n\star}$ in a criminal–constrained crime equilibrium, it follows that

$$\frac{1}{2} > F(\varepsilon_t^{c\star}) > \frac{\theta_t^\star - r - (1-\rho)[\theta_t^\star - \mu]}{2\theta_t^\star - r - (1-\rho)[\theta_t^\star - \mu]}. \tag{26}$$

In both types of crime equilibrium, no agent with first–period income below $w_{t-1}\varepsilon_t^{c\star}$ ever produces. In other words, in any crime equilibrium the interest rate faced by low income agents is always so high that they are effectively shut out of the capital market and either subsist or engage in criminal activities. As a result, the aggregate demand for labor efficiency units is equal to the demand from each producer (4), multiplied by the measure of agents with $\varepsilon > \varepsilon_t^{c\star}$. The labor market clearing condition is therefore

$$[1 - F(\varepsilon_t^{c\star})] \left(\frac{\alpha A}{w_t^\star}\right)^{\frac{1}{1-\alpha}} k = H. \tag{27}$$

Aggregate equilibrium output $Y_t^\star$ can then be expressed as a function of the fraction of agents with wealth above the critical level:

$$Y_t^\star = AH^\alpha([1 - F(\varepsilon_t^{c\star})]k)^{1-\alpha}. \tag{28}$$

Thus, the model generates a standard aggregate production function in which the level of the capital stock is determined by the crime rate. In the following analysis we will also be interested in the resources devoted to enforcing property rights. The fraction of output allocated to private security measures is given by

$$D_t^\star = \frac{\pi_t^\star \gamma k[1 - F(\varepsilon_t^{c\star})]}{Y_t^*}. \tag{29}$$

5. The Equilibrium Dynamics of Crime and Accumulation

In this section we detail the evolution of an economy which is always in its positive crime equilibrium. To save on notation, we drop the superscript $\star$ and assume that all variables take their equilibrium values. Figure 3 illustrates the equilibrium determination of the crime rate diagrammatically in (ε_t^c, π_t) space. The LC curve illustrates the combinations of π_t and ε_t^c that are consistent with both incentive compatibility in the capital market (9) and (14), and labor market equilibrium (27), and is given by

$$\pi_t^{LC}(\varepsilon_t^c; w_{t-1}) = \frac{1}{1-\rho}\left[1 - \frac{r(1+\frac{\gamma}{1-\rho})k - rw_{t-1}\varepsilon_t^c}{[1-F(\varepsilon_t^c)]^{-\alpha}\underline{\theta}k + \left(\frac{1}{1-\rho} - \frac{1}{\rho}\right)\gamma rk}\right], \tag{30}$$

where we also used (5) and (17) to substitute for $\theta_t^\star$ and $w_t^\star$, thereby introducing $\underline{\theta}$. The PI curve shows how the probability of invasion varies with the critical level of labor efficiency units, and is given by

$$\pi^{PI}(\varepsilon_t^c) = \min\left\{\frac{F(\varepsilon_t^c)}{1-F(\varepsilon_t^c)}, 1\right\}. \tag{31}$$

An increase in the critical labor efficiency level implies that more agents are denied access to the capital market. In a criminal–constrained equilibrium, this increases the probability of invasion. E_1 depicts an opportunity–constrained crime equilibrium, with $\pi_t = 1$. E_2 depicts a criminal–constrained crime equilibrium. As they are drawn, the curves intersect only once where $\pi_t < 1$ and the crime equilibrium is unique. We ensure that this is the case by imposing the following restriction:

Assumption A2:

$$\frac{d\pi^{LC}}{d\varepsilon^c} > \frac{d\pi^{PI}}{d\varepsilon^c}. \tag{32}$$

Lemma 1: *There exists an $\alpha^0 \in (0,1)$ such that if the wage elasticity of labor demand is sufficiently large, $\alpha > \alpha^0$, Assumption A2 holds and the crime equilibrium is unique.*

To understand Lemma 1, note that with a Cobb–Douglas production function, the slope of the LC curve increases with the wage–elasticity of labor demand, $1/(1-\alpha)$. To see this, consider the effect of a decrease in ε^c. The associated expansion in the supply of entrepreneurs, $1 - F(\varepsilon^c)$, raises the demand for labor, drives up the equilibrium wage and reduces the profitability of entrepreneurship. This can be consistent with the incentive compatibility condition only if the probability of invasion is lower. The greater is the wage elasticity, the larger is this effect. So long as the wage elasticity of demand is sufficiently large, the slope of LC exceeds that of PI.

Note finally that combining equations (26) and (31) for the case of a criminal–constrained equilibrium generates a minimal invasion rate consistent with this sort of equilibrium, given by

$$\underline{\pi}_t = \frac{\theta_t - r - (1-\rho)[\theta_t - \mu]}{\theta_t^\star}, \tag{33}$$

and an associated minimal critical ability level, $\underline{\varepsilon}_t^c$, which satisfies

$$F(\underline{\varepsilon}_t^c) = \frac{\theta_t - r - (1-\rho)[\theta_t - \mu]}{2\theta_t - r - (1-\rho)[\theta_t - \mu]}. \tag{34}$$

If the intersection point in Figure 3 falls below $(\underline{\varepsilon}_t^c, \underline{\pi}_t)$, equilibria with positive crime cease to exist because it is always better to be a producer.[28] In this case, the zero crime equilibrium would be the unique equilibrium.[29]

5.1 The Era of Rising Crime

When the initial first–period incomes are low, agents must borrow a large amount in order to produce and to pay for private security. For a given rate of interest and profit rate, few agents have sufficient wealth to satisfy the incentive compatibility condition (8) and hence to qualify for a low–interest loan. The remainder are left with the choice of the subsistence income or a life of crime. However, the opportunities to gain from crime are limited by the small number of potential victims. Since there is a surplus of agents who could be criminals, the probability of invasion is driven to its maximum level and so also is the interest rate. This reinforces the fact that very few agents are sufficiently wealthy to profitably become entrepreneurs. This opportunity–constrained equilibrium is illustrated in Figure 3, where the LC curve intersects the PI curve at E_1.

In the initial period there is little demand for the labor supplied by the subsequent generation, so that the wage they receive is correspondingly low. However, provided that $w_1 > w_0$, a greater fraction of this generation qualifies for a low–interest rate loan than in their parents' generation, so that the critical ability level declines, $\varepsilon_2^c < \varepsilon_1^c$, and the rate of enterprise, $1 - F(\varepsilon_t^c)$, and hence aggregate output, both expand. This can be represented in Figure 2 by a leftward shift of the LC curve. So long as the rate of enterprise remains relatively low (i.e. $1 - F(\varepsilon_2^c) < 1/2$), the expansion is not sufficient to draw all agents out of subsistence, and there is a matching increase in the crime

[28] Since $\theta_t^\star$ declines over time, so does the minimum invasion rate.

[29] Given the parametric assumptions that we have made, a zero crime equilibrium always exists so that, in principle, the economy could jump to it from the positive crime growth path described below at any date t. However, under certain conditions described below, the economy would then remain in a zero crime equilibrium thereafter.

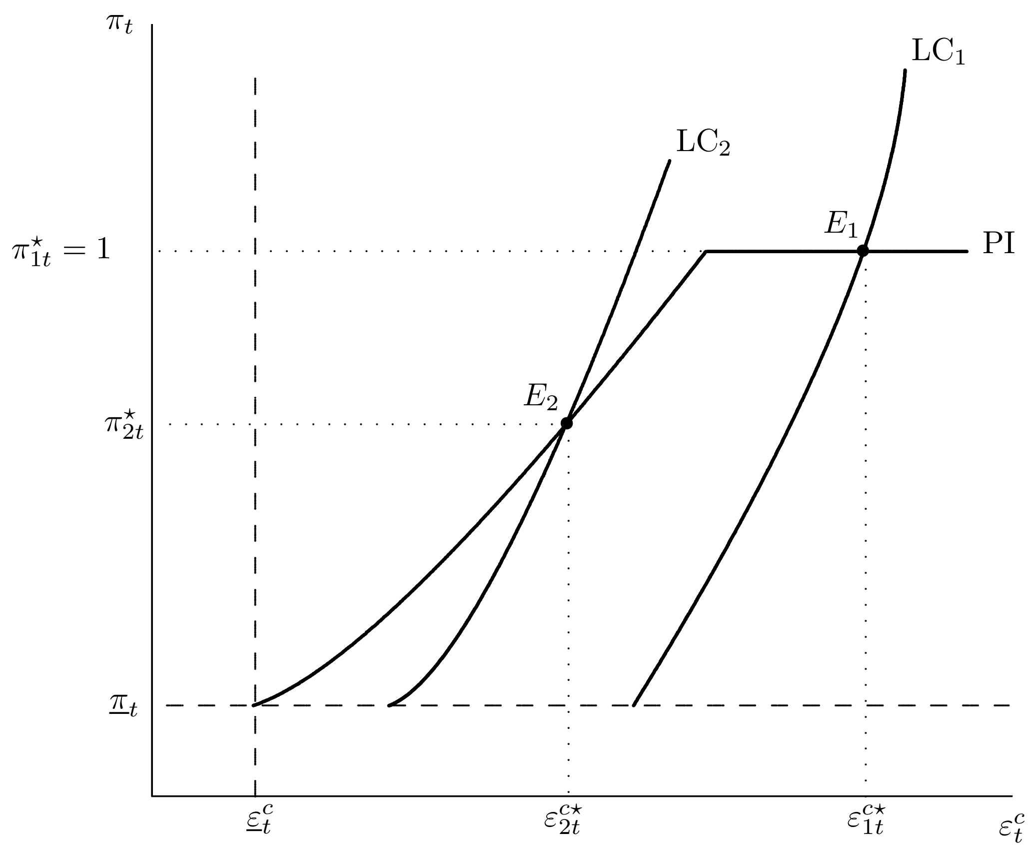

Figure 3: Opportunity–Constrained (E_1) and Victim–Constrained (E_2) Equilibria

rate, $n_2 > n_1$. However, since the invasion probability is already at its maximum, the level of insecurity, π_t, and the lending rate, r_t^s, remain unchanged. With decreasing returns to capital at the aggregate level, the aggregate cost of security grows more rapidly than output, so that the share of output allocated to private security grows, $D_2 > D_1$. Despite this, the demand for labor rises and the wages received by the generation born at $t = 2$ grow in the first–order stochastic sense.

The development process continues in this fashion so long as the LC curve is such that opportunity–constrained equilibria continue to obtain. Increases in the wage allow more agents to undertake projects and output expands. However, so also do the opportunities to gain from property crime and the crime rate increases through time. This phase of the development process is thus summarized by the following proposition:

Proposition 1: *Suppose* $w_1 > w_0$*. Then there exists a* $t^\star \in [0, \infty)$ *such that for all* $t < t^\star$

(a) equilibrium wages rise through time, $w_t > w_{t-1}$*,*

(b) insecurity remains constant at its maximum rate, $\pi_t = \pi_{t-1} = 1$*,*

(c) the rate of enterprise rises, $\varepsilon_t^c < \varepsilon_{t-1}^c$*,*

(d) the crime rate rises, $n_t > n_{t-1}$*,*

(e) the lending rate remains at its maximum level, $r_t^s = r/\rho$*,*

(f) aggregate output expands, $Y_t > Y_{t-1}$*,*

(g) the share of output devoted to private security increase, $D_t > D_{t-1}$*.*

5.2 The Era of Falling Crime

Eventually the economy reaches a date $t^\star$ in which the inactive subsistence population is exhausted and increments in the rate of enterprise are no longer matched by increased crime. A criminal–constrained equilibrium obtains and the next phase of the process begins.

From Proposition 1 we know that $w_{t^\star} > w_{t^\star-1}$, so that the $t^* + 1$ generation is stochastically wealthier than the previous one. For a given level of insecurity, π_t, the critical efficiency level falls (the LC curve shifts to the left) and there is an increase in the fraction of agents who are eligible for a low–interest loan. Now, however, the measure of entrepreneurs exceeds the fraction of agents with first–period income below $w_{t-1}\varepsilon_t^c$ (i.e. $1 - F(\varepsilon_t^c) > F(\varepsilon_t^c)$), so that the equilibrium crime and invasion rates must decline. Indeed, the effect of the expansion in the supply of entrepreneurs can

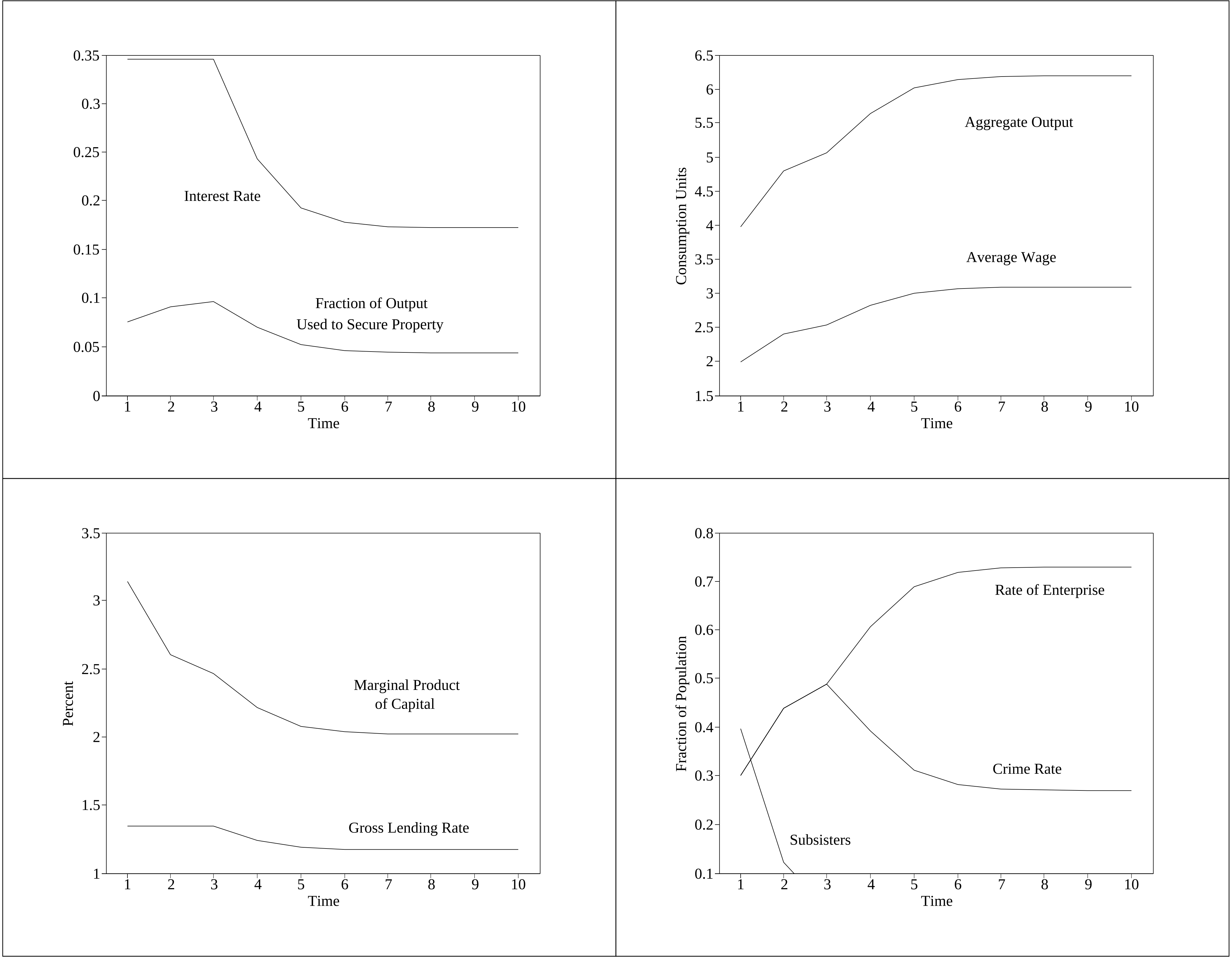
Interest Rate
Fraction of Output
Used to Secure Property
Time
Consumption Units
Aggregate Output
Average Wage
Time
Percent
Marginal Product
of Capital
Gross Lending Rate
Time
Fraction of Population
Rate of Enterprise
Crime Rate
Subsisters
Time

Figure 4: The Equilibrium Dynamics of Crime and Accumulation

now be separated into two components: (1) the supply of criminals contracts so that the probability of invasion falls and the borrowing rate declines, and (2) the demand for labor rises, driving up the equilibrium wage and reducing profits. The net effect of these two forces determines whether expected profits and the rate of enterprise rise in equilibrium. From Lemma 1, however, we know that so long as the wage elasticity of demand is sufficiently large, the second force is relatively small and the first force dominates. The rate of enterprise thus expands until the effect of the decreased profit rate, θ_t, on the fraction of agents who qualify for a loan just offsets the effect of the reduced borrowing rate (see equation 9).

The increased wage generates a further increase in the rate of enterprise in the next generation and a further reduction in the crime rate. The economy continues to develop in this fashion as long as the criminal–constrained equilibrium continues to exist (i.e. as long as the LC curve intersects the PI curve above $\underline{\pi}_t$). Output expands with the rate of enterprise, but the crime rate declines so that the resources used to prevent output from being stolen fall. The equilibrium dynamics can therefore be summarized as follows:

Proposition 2: *There exists a* $t^\star \in [0, \infty)$ *such that if* $t > t^\star$ *then*

(a) equilibrium wages continue to rise, $w_t > w_{t-1}$,

(b) insecurity declines, $\pi_t < \pi_{t-1}$,

(c) the rate of enterprise continues to rise, $\varepsilon_t^c < \varepsilon_{t-1}^c$,

(d) the crime rate declines, $n_t < n_{t-1}$,

(e) the lending rate falls, $r_t^s < r_{t-1}^s$,

(f) aggregate output continues to expand, $Y_t > Y_{t-1}$,

(g) the share of resources devoted to private security declines, $D_t < D_{t-1}$.

Figure 4 illustrates the time paths for the key features of the economy for a parameterized example.[30] In this example, the economy passes through each phase of the development cycle before converging to a positive crime rate. Note that, in addition to the direct cost of resources used to defend property against criminal invasion, the costs of crime also include the loss in output experienced by each generation relative to the zero–crime economy. It is possible for the economy to reach a point at which the equilibrium interest rate becomes so low that the returns to production

[30] Parameter values are $\alpha = 0.5$; $H = 0.5$; $k = 1$; $r = 1.05$; $A = 3$; $\rho = 0.5$; $\gamma = 0.2$.

exceed those from crime for all agents. At this point the economy necessarily jumps to the zero crime equilibrium.

5.3 The Steady State

Figure 5 is useful for understanding the convergence of the economy to its steady–state equilibrium. The WW–curve depicts the relationship between the critical ability level of the old generation and the implied equilibrium wage of the young generation. It is obtained by re–writing (27) to give

$$w^{WW}(\varepsilon^c) = \alpha A \left(\frac{[1 - F(\varepsilon^c)]k}{H} \right)^{1-\alpha}. \tag{35}$$

The EQ–curve depicts the relationship between the equilibrium critical ability level of the old generation and the wage they received in the previous period. Each point on this locus represents the sequence of temporary equilibria described above and is given by combining (30) and (31) to get

$$w^{EQ}(\varepsilon^c) = \frac{k}{\varepsilon^c} \left[1 + \frac{\gamma}{1-\rho} - [1 - (1-\rho)\pi(\varepsilon^c)] \left(\frac{\theta}{r[1 - F(\varepsilon^c)]^{\alpha}} + \frac{\gamma}{1-\rho} - \frac{\gamma}{\rho} \right) \right], \tag{36}$$

where

$$\pi(\varepsilon^c) = \min \left\{ \frac{F(\varepsilon^c)}{1 - F(\varepsilon^c)}, 1 \right\}. \tag{37}$$

That these two curves intersect is guaranteed by the fact that

$$\lim_{\varepsilon^c \to 0} w^{EQ}(\varepsilon^c) = \infty \quad \text{and} \quad \lim_{\varepsilon^c \to 2H} w^{EQ}(\varepsilon^c) = -\infty. \tag{38}$$

If they intersect at a value of $\varepsilon^c < \underline{\varepsilon}^c$, then the unique equilibrium is a zero crime equilibrium. However, if they intersect at a value of $\varepsilon^c > \underline{\varepsilon}^c$, then this intersection represents a steady–state crime equilibrium, that we denote by the vector $\{\tilde{n}, \tilde{\varepsilon}^c, \tilde{\pi}, \tilde{w}, \tilde{X}, \tilde{Z}^n, \tilde{Z}^s, \tilde{r}^n, \tilde{r}^s\}$. The following assumption ensures that, if the steady–state crime equilibrium exists, it is also a unique:

Assumption A3:

$$-\frac{dw^{EQ}}{d\varepsilon^c} > -\frac{dw^{WW}}{d\varepsilon^c}. \tag{39}$$

Proposition 3: *There exists an $\alpha^1 \in (\alpha^0, 1)$ such that if the wage–elasticity of labor demand is sufficiently large, $\alpha > \alpha^1$, then Assumption A3 holds and the economy converges to a unique steady state crime equilibrium.*

In Lemma 1, a sufficiently high–elasticity of demand, $\alpha > \alpha^0$, effectively implied that the EQ–curve is downward sloping. Here we require a stronger sufficient condition to ensure that it is more steeply sloped than the WW–curve.

Figure 5 illustrates a situation in which the steady state occurs at a value of ε^c that is consistent with a criminal–constrained equilibrium. The path towards this steady state is also illustrated. If the initial wage w_0 is sufficiently small, the economy passes through the opportunity–constrained region, before entering the criminal–constrained region and converging to the steady state. However, it is also possible that the point of intersection occurs in the opportunity–constrained region, in which case the economy would converge to an opportunity–constrained steady–state. The type of steady state to which the economy converges depends on whether the WW curve and the EQ curve intersect to the left or right of the boundary $\varepsilon^c = H$ (since $F(H) = \frac{1}{2}$):

Proposition 4: *If*

$$\frac{\alpha A H^\alpha k^{1-\alpha}}{2^{1-\alpha}} + (1-\alpha)\left(\frac{\rho}{r}\right) 2^\alpha A H^\alpha k^{1-\alpha} > (1+2\gamma)k, \tag{40}$$

then the economy converges to a criminal–constrained steady–state. Otherwise, the economy converges to an opportunity–constrained steady–state.

The economy will not reach the second phase if the cost of security is high or if the effectiveness of private security is low. However, high productivity and a productive labor force are factors which will tend to overcome these constraints and allow the economy to reach the phase of declining crime rates.

If the point of intersection occurs at a value of ε^c that is inconsistent with a positive crime equilibrium, the unique steady–state is one with zero crime. Note that if the EQ curve intersects the $\varepsilon^c = \underline{\varepsilon}^c$ boundary at a wage below $\overline{w}$ then, once a zero crime equilibrium occurs, the economy can never revert back to a positive crime equilibrium because the wealth of subsequent generations is sufficiently high to rule out such equilibria.

If Assumption A3 does not hold, then it is possible that the EQ and WW curves intersect more than once, so that there would be multiple steady–state equilibria. Such a situation is illustrated in Figure 6, where S_1, S_2 and S_3 represent three steady state equilibria. Only S_1 and S_3 are stable however, and to which of these the economy converges depends on the initial wage. If $w_0 > \hat{w}$,

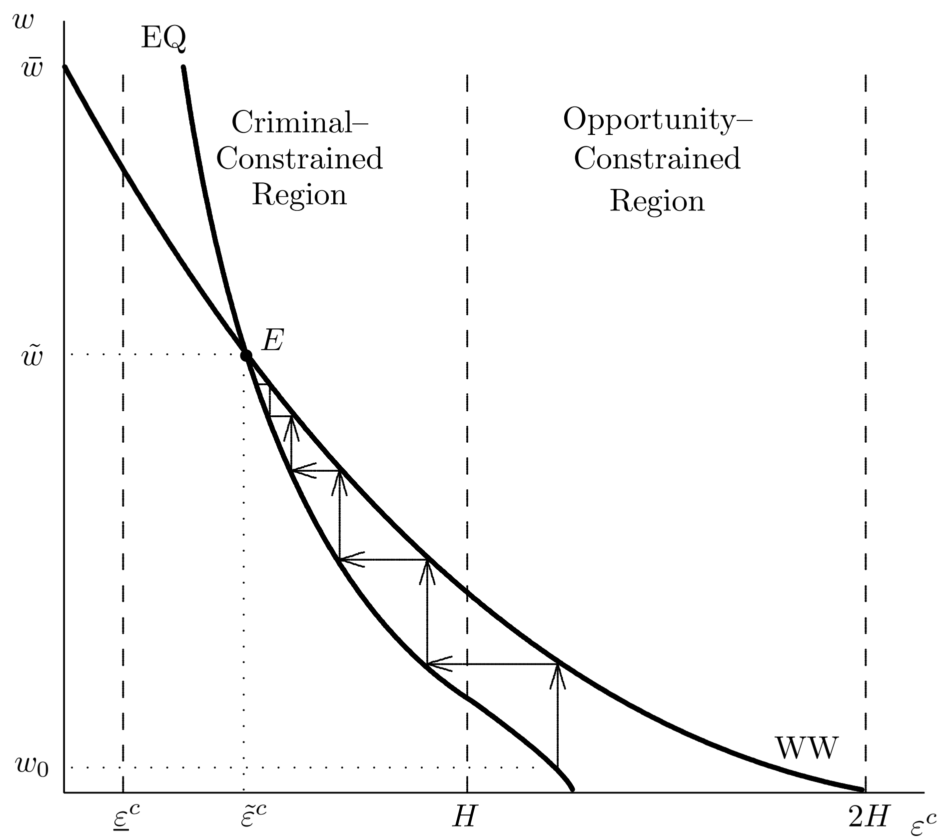

Figure 5: Convergence to a Steady–State Equilibrium

the economy converges to a steady state featuring low crime and high productivity (S_1), whereas if $w_0 < \hat{w}$, the economy converges to a high–crime steady state (S_3). One implication of this case is that a sufficiently large injection of wealth could shift the economy from a high–crime steady–state to a low–crime one.

6. Public Expenditures to Deter Crime

Thus far we have taken as given the effectiveness of public sector institutions used to deter crime, apprehend criminals and impose punishments. In this section, we allow for the possibility that increased public spending may enhance the effectiveness of these institutions. We distinguish between two categories of public policy: (1) punishment — public expenditures that raise the expected cost of being apprehended and/or punished, and (2) prevention — public expenditures that reduce the *ex ante* probability that a crime is successful in the first place. When occupational choices are partly determined by credit constraints, public spending can have quite different consequences depending on whether it enhances the effectiveness of punishment or prevention. Throughout most of this section we simplify the exposition by focusing on a steady state criminal–constrained equilibrium.

6.1 Punishment

Previous related analyses such as those of Becker (1968) and Sah (1991) have emphasized the role of punishment in affecting equilibrium outcomes. In their models, harsher punishments or a greater likelihood of prosecution reduces the payoff to criminal activity, thereby inducing more people to undertake legal activities. However, in the presence of sufficiently severe credit constraints, increasing the expected cost of punishment may have little impact. The reason is that individuals do not choose to become criminals because the payoff is higher than production, but rather because they are constrained from becoming entrepreneurs by their lack of wealth. Such public investment will only have any effect on the equilibrium outcome if the expected punishment is so large that it reduces the expected payoff of a criminal, $\tilde{X}$, below that of an entrepreneur who does not invest in private security, $\tilde{Z}^n$. If it requires significant increases in taxes, then raising the expected cost of punishment may even have a detrimental effect, actually *raising* crime rates and lowering productivity.

To see this more formally, suppose that the government finances its expenditures using a propor-

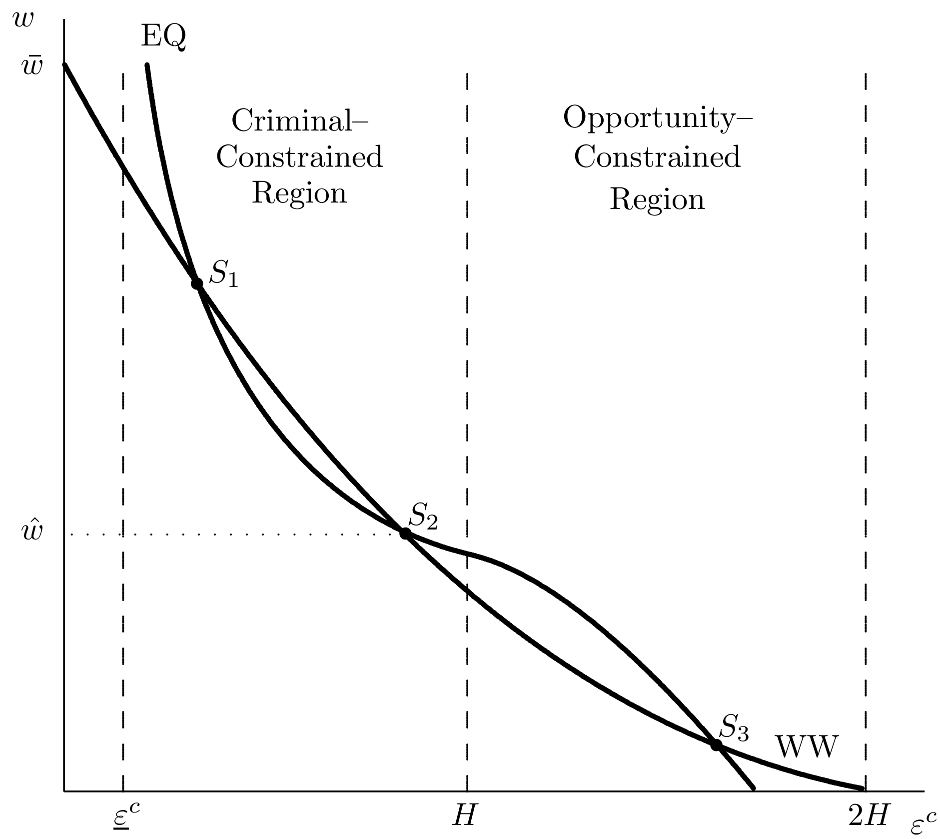

Figure 6: Multiple Steady–State Equilibria

tional tax τ on the wages of the young, so that total expenditure at time t is given by

$$T_t = \tau \tilde{w} H = \tau \alpha \tilde{Y}. \tag{41}$$

This imposition of such a tax reduces the after–tax wealth of agents when they are old and hence effectively reduces the fraction that are able to qualify for a low interest loan.[31] We follow the approach of Sah (1991), and assume that the expected punishment is a function of expenditure per criminal:

$$\mu = \mu \left(\frac{T_t}{n_t} \right) = \mu \left(\frac{\tau \alpha \tilde{Y}}{F(\tilde{\varepsilon}^c)} \right) \tag{42}$$

This formulation captures the idea that the greater the resources per criminal allocated to apprehending and punishment (e.g. the costs of more time in prison), the greater the expected cost perceived by criminals.[32]

Given the steady state equilibrium values, increased investment in punishment raises μ and thereby shifts the boundary $\varepsilon^c = \underline{\varepsilon}^c$ in Figure 5 to the right (see (34)). *Ceteris paribus,* a sufficiently large increase in μ might therefore eventually push the economy into the zero crime equilibrium. Unfortunately, there are two factors offsetting this effect. Firstly, distortion created by the increased taxes required to finance this expenditure cause the EQ–curve to shift to the right, reflecting the fact that the after–tax wealth of the young generation is reduced. This causes the steady–state equilibrium crime rate to rise and entrepreneurial productivity to decline. Secondly, as the steady–state crime rate, $F(\tilde{\varepsilon}^c)$, expands and the tax base, $\alpha \tilde{Y}$, contracts, expenditure per criminal declines, offsetting the effect on μ of the increase in τ. It follows that expenditures which increase the probability of conviction and/or the size of sanctions could have detrimental long–run consequences, actually raising the crime rate and lowering per capita income.[33]

6.2 Prevention

In contrast, public spending which enhances the effectiveness of *ex ante* prevention of successful criminal activity (e.g. police patrols, public security, gun control laws) can have large effects on the margin. By reducing the probability that crimes will initially be successful, prevention reduces the

[31] In this sense it does not matter whether the tax is proportional or lump sum. Note further that the follow arguments would go through if we were to consider a tax on entrepreneurial profits - the borrowing constraint would become more binding.
[32] The exact relationship between μ and spending per criminal is not important for the following argument.
[33] Allowing for a distribution of disutilities associated with criminal acts (e.g. varying moral values), say, might imply that increased punishment would have some impact on the margin. Nevertheless, the presence of credit constraints will still tend to weaken the effect of punishments.

ex ante cost of private security measures and reduces the interest rate faced by borrowers. This, in turn, reduces the critical wealth level required to qualify for a loan, induces greater legal activity and reduces the crime rate.

If public crime prevention reduces the success probability of a criminal to $1-\phi$, then the probability of invasion in the absence of private security measures is $(1-\phi)\pi_t$. Suppose that expenditures on prevention are again financed by taxes on wage income (41), and that the probability ϕ is assumed to be a increasing function of these expenditures per unit of property protected. Then

$$\phi = \phi\left(\frac{T_t}{(1-\alpha)Y_t}\right) = \phi\left(\frac{\alpha\tau}{1-\alpha}\right) \tag{43}$$

This particular formulation is simple because ϕ depends only on the tax rate, and not on any endogenous variables. Moreover it seems reasonable to assume that the greater is the property that is protected by the public sector, the larger the cost of doing so.[34] We assume that private and public security measures are complementary, so that the competitive price of private security measures is now $p_t = \gamma(1-\phi)\pi_t k$, and the EQ–curve (36) is replaced by

$$w^{EQ}(\varepsilon^c;\tau,\phi) = \frac{k}{(1-\tau)\varepsilon^c}\left[1+\frac{\gamma}{1-\rho} - [1-(1-\rho)(1-\phi)\pi(\varepsilon^c)]\left(\frac{\theta}{r[1-F(\varepsilon^c)]^{\alpha}} + \frac{\gamma}{1-\rho} - \frac{\gamma}{\rho}\right)\right]. \tag{44}$$

The WW–curve and $\pi(\varepsilon^c)$ are still given by (35) and (37), respectively.

As described earlier, the increase in τ causes the EQ–curve to shift to the right, so that the equilibrium crime rate increases. However, the resulting increase in ϕ causes the EQ–curve to shift to the left, reflecting the fact that for any give rate of enterprise the degree of insecurity is reduced. Thus, the net equilibrium impact of an increase in public investment in crime prevention depends on whether the increase in ϕ is sufficiently large to outweigh the associated increase in τ and cause the EQ–curve to shift down and to the left. This will be the case if $d\phi/d\tau$ is large enough. If it is, then the steady–state crime rate declines and the long–run level of productivity rises. Thus we have:

Proposition 5: *Suppose the economy initially rests in a criminal–constrained steady–state equilibrium. Then there exists a* $\delta > 0$ *such that if the responsiveness of prevention to an increase in the*

[34] Again the arguments here do not depend on the exact formulation.

tax rate is sufficiently large, $d\phi/d\tau > \delta$ *, then greater prevention increases the steady–state rate of enterprise,* $1 - F(\tilde{\varepsilon}^c)$*, aggregate output,* $\tilde{Y}$*, and the wage,* $\tilde{w}$*, and reduces the invasion rate,* $\tilde{\pi}$*, and the crime rate,* $\tilde{n}$*.*

If instead the economy was initially in an opportunity–constrained steady state, then even if $d\phi/d\tau$ is large enough to ensure that the rate of enterprise expands with τ, the crime rate will rise. This is because the borrowing rate remains high and severely constrains the fraction of agents that can become entrepreneurs. Nevertheless, steady–state output and wage levels would continue to rise despite the increased crime rate. Financing a decrease in ϕ with an increase in τ also has interesting implications for the transitional dynamics. Again suppose that $d\phi/d\tau$ is large enough to ensure that the rate of enterprise expands. Then, starting from an opportunity–constrained equilibrium, this change in the institutions will induce an increase in the crime rate because of the rise in the number of opportunities. But this increase in crime is not inherently bad; it means that the economy will experience the phase of declining crime rates earlier. Put another way, considering a graph representing the evolution of crime through time one would observe an increase in the slope of the rising part of the curve, and a shift to the left of its peak — the economy would get over the hump more rapidly.

7. Concluding Remarks

We have developed a dynamic general equilibrium model linking the process of economic development to the interaction between property crime and credit market imperfections. We used it to illustrate how and why an economy will tend to go through a phase of rising crime followed by a phase of falling crime as it develops. The initial phase corresponds to Adam Smith's hypothesis that property crime would tend to rise with the accumulation of wealth, and arises when credit market constraints are particularly severe. The later phase is consistent the models of Baumol (1990) and Murphy, Schleifer and Vishny (1993) in which economies with lower crime rates tend to be more highly developed. The overall pattern is consistent with the empirical evidence on the evolution of property crime in during the process of industrialization. We characterized the convergence of the economy to its long–run steady–state equilibrium and detailed the factors determining the nature of this equilibrium.

The model also allowed us to illustrate the implications of the interaction between crime and credit constraints for alternative crime–deterring public policies. In a world with no credit constraints, greater investment in institutions which raise the cost and likelihood of apprehension and prosecution have significant equilibrium effects on crime and productivity. However, in the presence of credit market imperfections such policies are likely to be ineffective at best and, if they are costly, may even be detrimental. In such cases, policies that enhance the effectiveness of crime prevention are likely to be a more cost–effective method for reducing crime and increasing long run productivity.

Various extensions of our work are possible. For example, there is no engine for sustained long–run per capita income growth in our model. One way to introduce such an engine would be to allow the aggregate efficiency units of labor (i.e. human capital) or total factor productivity to grow endogenously over time. If the costs of security were to remain constant, then eventually they would become negligible relative to wealth, and the economy would always attain a zero–crime equilibrium in the long run. However, there are reasons to suspect that the cost of private security might also grow over time, as criminals become more sophisticated and gain access to better technologies for pursuing their objectives. In this case, the economy may converge to a long–run growth path with positive crime rates.

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Appendix

Proof of Lemma 1: Differentiating (30) yields

$$\left.\frac{d\pi}{d\varepsilon^c}\right|_{LC} = \frac{rw_{t-1} + [1-(1-\rho)\pi_t]\alpha[1-F_t]^{-\alpha-1}\underline{\theta}k}{2HB(\varepsilon_t^c)}, \tag{A1}$$

where

$$B(\varepsilon_t^c) = (1-\rho)\left([1-F_t]^{-\alpha}\underline{\theta}k - \frac{\gamma}{\rho}rk + \frac{\gamma}{1-\rho}rk\right) \tag{A2}$$

Differentiating (31), recalling that $F(\cdot)$ is uniform, yields

$$\left.\frac{d\pi}{d\varepsilon^c}\right|_{PI} = \frac{1}{2H[1-F_t]^2}. \tag{A3}$$

Let $|\Pi| = \frac{d\pi}{d\varepsilon^c}\Big|_{LC} - \frac{d\pi}{d\varepsilon^c}\Big|_{PI}$, then Assumption A2 can be expressed as

$$|\Pi| = \frac{rw_{t-1}2H[1-F_t]^2 + [1-(1-\rho)\pi_t]\alpha[1-F_t]^{1-\alpha}\underline{\theta}k - B(\varepsilon_t^c)}{2HB(\varepsilon_t^c)[1-F_t]^2} > 0. \tag{A4}$$

Since the denominator is positive, it follows that $|\Pi| > 0$ if

$$rw_{t-1}\overline{\varepsilon}[1-F_t]^2 + [1-(1-\rho)\pi_t]\alpha[1-F_t]^{1-\alpha}\underline{\theta}k - B(\varepsilon_t^c) > 0. \tag{A5}$$

In a criminal–constrained equilibrium, we know that $F_t < \frac{1}{2}$ and $\pi_t < 1$. Thus $|\Pi| > 0$ if

$$rw_{t-1}\overline{\varepsilon}\left(\frac{1}{2}\right)^2 + \rho\alpha\left(\frac{1}{2}\right)^{1-\alpha}\underline{\theta}k - (1-\rho)\left(\left(\frac{1}{2}\right)^{-\alpha}\underline{\theta}k - \frac{\gamma}{\rho}rk + \frac{\gamma}{1-\rho}rk\right) > 0. \tag{A6}$$

Also, if a criminal–constrained equilibrium obtains, then

$$w_{t-1} \geq \alpha A\left(\frac{k}{2H}\right)^{1-\alpha} = \left(\frac{\alpha}{1-\alpha}\right)\left(\frac{1}{2}\right)^{1-\alpha}\frac{\underline{\theta}k}{H}. \tag{A7}$$

Substituting for w_{t-1} in (A6), it follows that $|\Pi| > 0$ if

$$\left(\frac{1}{2}\right)^{1-\alpha}\underline{\theta}\left[\left(\frac{\alpha}{1-\alpha}\right)\left(\frac{r}{2}\right) + \rho\alpha - 2(1-\rho)\right] + \gamma r\left(\frac{2\rho-1}{\rho}\right) > 0. \tag{A8}$$

As $\alpha \to 1$, the first term in brackets becomes arbitrarily large. Thus, there must exist some $\alpha^0 \in (0,1)$ such that $|\Pi| > 0$ for all $\alpha > \alpha^0$.

Proof of Proposition 1: Consider any time period $t < t^\star$ such that the equilibrium which obtains is an opportunity–constrained equilibrium and $w_{t-1} > w_{t-2}$. Since $\pi = 1$, the impact of a wage increase on ε_t^c can be found by totally differentiating (30), to yield

$$\frac{d\varepsilon_t^c}{dw_{t-1}} = \frac{-r\varepsilon_t^c}{rw_{t-1} + \alpha\rho(1-F_t)^{(-\alpha-1)}\underline{\theta}\frac{1}{2H}} < 0. \tag{A9}$$

Thus, the critical efficiency level declines: $\varepsilon_t^c < \varepsilon_{t-1}^c$. Since, in an opportunity–constrained equilibrium, $n_t = 1 - F(\varepsilon_t^c)$, it follows that $n_t > n_{t-1}$, and from (28), $Y_t > Y_{t-1}$. From (29) $D_t > D_{t-1}$, since π_t remains constant and Y_t rises. Finally, differentiating (27) yields

$$\frac{dw_t}{d\varepsilon_t^c} = -\frac{(1-\alpha)w_t}{2H[1-F_t]} < 0. \tag{A10}$$

It follows that $w_t > w_{t-1}$. Since, by assumption $w_1 > w_0$, Proposition 1 follows by induction.

Proof of Proposition 2: Let $t^\star + 1$ be the first time period in which a criminal–constrained equilibrium obtains. From Proposition 1, we know that $w_{t^\star} > w_{t^\star-1}$. In such an equilibrium π_t and ε_t^c are jointly determined according to (30) and (31). Totally differentiating this system of equations yields

$$\begin{bmatrix} 1 & -\frac{\partial \pi^{LC}}{\partial \varepsilon_t^c} \\ 1 & -\frac{\partial \pi^{PI}}{\partial \varepsilon^c} \end{bmatrix} \begin{bmatrix} d\pi_t \\ d\varepsilon_t^c \end{bmatrix} = \begin{bmatrix} \frac{r\varepsilon^c}{B(\varepsilon_t^c)} \\ 0 \end{bmatrix} dw_{t-1}, \tag{A11}$$

Let Π denote the Jacobian matrix on the left–hand side of (A11). Lemma 1 implies that $|\Pi| > 0$, so using Cramer's rule we get

$$\frac{d\pi_t}{dw_{t-1}} = -\frac{1}{|\Pi|}\left(\frac{\partial \pi^{PI}}{\partial \varepsilon^c}\right)\left[\frac{r\varepsilon^c}{B(\varepsilon_t^c)}\right] < 0, \tag{A12}$$

$$\frac{d\varepsilon_t^c}{dw_{t-1}} = -\frac{1}{|\Pi|}\left[\frac{r\varepsilon^c}{B(\varepsilon_t^c)}\right] < 0. \tag{A13}$$

It follows that $\pi_{t^\star+1} < \pi_{t^\star}$ and $\varepsilon_{t^\star+1}^c < \varepsilon_{t^\star}^c$. The crime rate is now given by $n_t = F(\varepsilon_t^c)$, and so $n_{t^\star+1} < n_{t^\star}$. Since $\pi_{t^\star+1} < \pi_{t^\star}$, (10) implies that $r_{t^\star+1}^R < r_{t^\star}^R$. Since $\varepsilon_{t^\star+1}^c < \varepsilon_{t^\star}^c$, (28) implies that $Y_{t^\star+1} > Y_{t^\star}$. The resource costs of crime can be expressed as

$$\begin{aligned} D_t &= \gamma\frac{F(\varepsilon_t^c)}{1-F(\varepsilon_t^c)}\frac{[1-F(\varepsilon_t^c)]}{AH^\alpha([1-F(\varepsilon_t^c)]k)^{1-\alpha}}, \\ &= \left(\frac{\gamma}{AH^\alpha k^{1-\alpha}}\right)\frac{F(\varepsilon_t^c)}{[1-F(\varepsilon_t^c)]^{1-\alpha}}. \end{aligned} \tag{A14}$$

Since this is increasing in ε_t^c, it follows that $D_{t^\star+1} < D_{t^\star}$. Finally, from (27), it must be the case that $w_{t^\star+1} > w_{t^\star}$. Since $w_{t^\star} > w_{t^\star-1}$, Proposition 2 follows by induction.

Proof of Proposition 3: Using (A10) and (A13), Assumption A3 can be written as

$$|\Pi|\left(\frac{(1-\rho)(1-F_t)^{-\alpha}\underline{\theta}k-\left(\frac{1-\rho}{\rho}\right)\gamma rk+\gamma rk}{r\varepsilon_t^c}\right)>\frac{(1-\alpha)\alpha A}{(1-F_t)}\left(\frac{(1-F_t)k}{H}\right)^{1-\alpha}. \quad \text{(A15)}$$

This simplifies to

$$|\Pi|\left((1-\rho)(1-\alpha)A+\left[\gamma r-\left(\frac{1-\rho}{\rho}\right)\gamma r\right]\left[\frac{(1-F_t)k}{H}\right]^{\alpha}\right)>\frac{(1-\alpha)\alpha Ar\varepsilon_t^c}{H}. \quad \text{(A16)}$$

Since in a criminal–constrained equilibrium, $\frac{\varepsilon^c}{2H}<\frac{1}{2}$ and $F(\varepsilon^c)<\frac{1}{2}$, a sufficient condition is

$$|\Pi|\left((1-\rho)+\frac{1}{(1-\alpha)A}\left[\gamma r-\left(\frac{1-\rho}{\rho}\right)\gamma r\right]\left[\frac{(1-F_t)k}{H}\right]^{\alpha}\right)>\alpha r. \quad \text{(A17)}$$

As $\alpha\rightarrow 1$, the left–hand side becomes arbitrarily large. Hence there must exist an $\alpha_1\in(0,1)$ such that the condition holds for all $\alpha>\alpha_1$.

Proof of Proposition 4: The steady state occurs in the criminal–constrained region if

$$w^{WW}(H)>w^{EQ}(H). \quad \text{(A18)}$$

Using (35) and (36), this condition may be written as

$$\alpha A\left(\frac{k}{H}\right)^{1-\alpha}\left(\frac{1}{2}\right)^{1-\alpha}>\frac{k}{H}\left(1+2\gamma-\frac{2^{\alpha}\rho\underline{\theta}}{r}\right). \quad \text{(A19)}$$

Noting that $\theta k=AH^{\alpha}k^{1-\alpha}$ yields

$$\alpha A\left(\frac{k}{H}\right)^{1-\alpha}\left(\frac{1}{2}\right)^{1-\alpha}>\frac{k}{H}(1+2\gamma)-\frac{\rho(1-\alpha)A}{r\left(\frac{1}{2}\right)^{\alpha}}\left(\frac{k}{H}\right)^{1-\alpha}. \quad \text{(A20)}$$

Rearranging gives (40).

Proof of Proposition 5: A steady–state crime equilibrium is a vector $(\tilde{\pi},\tilde{w},\tilde{\varepsilon}^c)$ solving (35), (43) and (37). Totally differentiating this system of equations yields

$$\begin{bmatrix} J_{11} & J_{12} & 1 \\ J_{21} & J_{22} & 0 \\ J_{31} & 0 & -1 \end{bmatrix}\begin{bmatrix} d\tilde{\varepsilon}^c \\ d\tilde{w} \\ d\tilde{\pi} \end{bmatrix}=\begin{bmatrix} J_{1\phi} & J_{1\tau} \\ 0 & 0 \\ 0 & 0 \end{bmatrix}\begin{bmatrix} d\phi \\ d\tau \end{bmatrix}, \quad \text{(A21)}$$

where

$$J_{11} = -\frac{r(1-\tau)\tilde{w}}{(1-\phi)\tilde{B}}-\frac{(1-\rho)\alpha\underline{\theta}k(1-\tilde{F})^{-1-\alpha}\left[\left(1+\frac{\gamma}{1-\rho}\right)rk-r(1-\tau)\tilde{w}\tilde{\varepsilon}^c\right]}{2(1-\phi)H\tilde{B}^2}<0, \quad \text{(A22)}$$

$$
\begin{aligned}
J_{12} &= -\frac{r(1-\tau)\tilde{\varepsilon}^c}{(1-\phi)\tilde{B}} < 0, && \text{(A23)}\\
J_{21} &= -\frac{1}{2H}\tilde{w}^{\frac{-1}{1-\alpha}} < 0, && \text{(A24)}\\
J_{22} &= -\frac{(1-\tilde{F})}{(1-\alpha)}\tilde{w}^{\frac{-2+\alpha}{1-\alpha}} < 0, && \text{(A25)}\\
J_{1\phi} &= \frac{1}{(1-\phi)^2}\left\{\frac{1}{1-\rho} - \frac{\left[\left(1+\frac{\gamma}{1-\rho}\right)rk - r(1-\tau)\tilde{w}\tilde{\varepsilon}^c\right]}{\tilde{B}}\right\} > 0, && \text{(A26)}\\
J_{1\tau} &= -\frac{r\tilde{w}\tilde{\varepsilon}^c}{(1-\phi)\tilde{B}} < 0, && \text{(A27)}\\
\tilde{B} &= (1-\rho)\left[[1-\tilde{F}]^{-\alpha}\underline{\theta}k + \left(\frac{1}{1-\rho} - \frac{1}{\rho}\right)\gamma rk\right] > 0, && \text{(A28)}
\end{aligned}
$$

and where

$$
J_{31} = \begin{cases} 0, & \text{if } \tilde{\varepsilon}^c > H, \\ 1/2H(1-\tilde{F})^2 & \text{if } \tilde{\varepsilon}^c < H. \end{cases} \tag{A29}
$$

Let J denote the 3×3 matrix on the left hand-side of (A21). Assumption A3 implies that $|J| < 0$. It is then possible to obtain that

$$
\begin{aligned}
\frac{\partial \tilde{\varepsilon}^c}{\partial \phi} &= \frac{-J_{1\phi}J_{22}}{|J|} < 0, & \frac{\partial \tilde{\varepsilon}^c}{\partial \tau} &= \frac{-J_{1\tau}J_{22}}{|J|} > 0, && \text{(A30)}\\
\frac{\partial \tilde{w}}{\partial \phi} &= \frac{J_{1\phi}J_{21}}{|J|} > 0, & \frac{\partial \tilde{w}}{\partial \tau} &= \frac{J_{1\tau}J_{21}}{|J|} < 0, && \text{(A31)}\\
\frac{\partial \tilde{\pi}}{\partial \phi} &= \frac{-J_{1\phi}J_{22}J_{31}}{|J|} \leq 0, & \frac{\partial \tilde{\pi}}{\partial \tau} &= \frac{-J_{1\tau}J_{22}J_{31}}{|J|} \geq 0, && \text{(A32)}
\end{aligned}
$$

where for the invasion rate $\tilde{\pi}$, the weak inequality is replaced by an equality for an opportunity–constrained equilibrium, and by a strict inequality for a criminal–constrained equilibrium. The impact on an endogenous variable x of a decrease in ϕ financed by an increase in τ is given by

$$
\frac{dx}{d\tau} = \frac{\partial x}{\partial \tau} + \frac{\partial x}{\partial \phi}\frac{d\phi}{d\tau}, \qquad x = \tilde{\varepsilon}^c, \tilde{w}, \tilde{\pi}. \tag{A33}
$$

Using equations (A30), (A31), and (A32), it can be seen that $\tilde{\varepsilon}^c$ decreases, $\tilde{w}$ increases, and $\tilde{\pi}$ does not increase, if and only if $J_{1\tau} + J_{1\phi}d\phi/d\tau > 0$, or if

$$
\frac{d\phi}{d\tau} > -\frac{J_{1\tau}}{J_{1\phi}}. \tag{A34}
$$

That is, if $d\phi/d\tau$ is sufficiently large and positive. Since a decrease in $\tilde{\varepsilon}^c$ increases steady–state aggregate output, $\tilde{Y}$ and reduces the crime rate, $\tilde{n}$, Proposition 5 follows.