Property Crime with Private Protection: A Market-for-Offenses Approach[1]

Louis Hotte[2], Fabrice Valognes[3] and Tanguy van Ypersele[4]

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[2]Economics Department and CRED, University of Namur, 8 Rempart de la Vierge, 5000 Namur, Belgium louis.hotte@fundp.ac.be

[3]Facult des Arts et de l'Ingnieur (A.I.) / X, Dept of Economics and Mathematics, The University of Le Havre, F-76057 Le Havre, Cedex France fabrice.valognes@univ-lehavre.fr

[4]Université de Aix-Marseille 2, GREQAM, CEPR, Chateau La Farge, Route des Milles, 13290 Les Milles, France tanguy.vy@univ-aix.fr

Abstract

**Crime with Private Protection:
A Market-for-Offenses Approach**

We analyse property crime in an economy composed of a large number of heterogeneous individuals who need to protect themselves. The crime equilibrium is modeled as a free-access equilibrium in which the match between criminals and victims equates the average returns to crime. The supply and toleration for crime are endogenized taking into account incentives to participate in criminal activities and individual protection decisions. We first observe that individual welfare is positively affected by the gross returns to crime. We then obtain that the share of wealth lost to crime and spent on private protection is the same for all individuals, regardless of their initial wealth. And although the level of economic development has ambiguous effects on the crime rate and the aggregate value of stolen goods, it unambiguously improves the welfare of all, regardless of how the fruits from growth are spread among the population. Finally, we argue that whether redistribution or public enforcement is more effective in reducing crime depends crucially on how well one can target a certain group of individuals.

Keywords: Crime; Private Protection; Public Enforcement; Economic Development; Inequality; Redistribution

JEL classification: D63, D74, K42, O17

1 Introduction

In the literature on the economics of crime, one typically finds public enforcement, private protection, legitimate wage opportunities and income distribution as fundamental determinants of property crime. It is also commonly recognized that these factors interact in the general economy in order to produce an equilibrium level of crime. The precise way in which these interactions take place is thus crucial to our understanding of how, say, economic development, redistribution or public enforcement affect the level of crime. Our analysis is a contribution in this direction.

In order to account for the interactions between the different determinants of crime, we develop a "market-for-offenses" model of crime with heterogeneous individuals and in which the supply of criminal activities and the level of private protection are derived from their maximizing behavior.[1] Many authors would agree that private protection constitutes a crucial element: Levitt (1999) reports that in the USA, "the home security business has grown at an annual rate of 10 percent over the last decade and is now a $14 billion a year business"; Shavell (1991) mentions that "private expenditures on security from crime exceed public expenditures"; DiIulio (1996) points out that the high rates of criminal victimization in inner-city areas can be partly explained by the lack of victims' financial resources to protect their homes. Both extensive surveys by Polinsky and Shavell (2000) and Witte and Witt (2001) mention the fact that accounting for private protection efforts constitutes an important dimension of the crime problem that has not been sufficiently examined yet.

The main challenge one faces when developing a "market-for-offenses" model of crime resides in the difficulty of matching criminals with victims in a tractable and insightful way. Our approach makes use of Gordon's (1954) main result on free access to resources by assuming that in a crime equilibrium, it must be the case that the average payoff to crime is equalized across all victims. It then borrows from the literature on the economics of conflicts by defining an appropriation technology which transforms the respective predation and protection efforts of criminals and victims into respective gains and losses from crime.

In the model, the individual decision to participate in crime depends on its payoff, and so do the allocations of predation efforts by criminals across

[1] The expression "market-for-offenses" was borrowed from Ehrlich (1996).

all the potential victims and the protection decisions taken by those same victims. Hence, our crime equilibrium is somewhat analogous to usual goods markets for it satisfies a supply for crime emanating from individual incentives to engage in crime and a "demand", or tolerance, for crime emanating from individual incentives to be protected against it, while the equilibrium is determined by the crime payoff which equalizes supply and demand. People differ by their wealth, or income opportunities, and we assume that wealthier individuals face a larger opportunity cost of engaging into crime. Property crime gives the opportunity for a criminal to appropriate a share of another individual's wealth. The return to each unit of time spent trying to appropriate from a particular victim will of course depend on how that victim protects itself. But it will also depend negatively on the amount of time spent trying to appropriate from that same victim by all criminals. We also introduce an exogenous public enforcement effort.

We show why the victims are positively affected by the gross returns to crime in the economy.[2] Indeed, since the returns to crime must be the same across all victims, from the standpoint of one victim, a globally higher payoff to crime makes his wealth relatively less attractive, and thus easier to protect. This observation contrasts slightly with the usual approach which assumes that people are concerned about the crime rate. Furthermore, the share of wealth lost to crime and to protection expenditures is the same for all individuals, regardless of their initial wealth. In this respect, the model enables us to tackle the issue of the distributive burden of crime while accounting not only for losses from theft, but also for the oft-neglected protection expenditures (Levitt, 1999).

We obtain that the level of economic development has ambiguous effects on crime and the total value of goods stolen. However, it unambiguously increases the gross payoff to crime. As a result, the welfare of all is improved even though some people do not benefit directly in the development process in the sense that their wealth does not change. Finally, we obtain ambiguous effects for inequality. We show, in fact, that what really matters for crime is not whether income is better distributed or not, but rather how the indifferent criminal, i.e. the one who is indifferent between committing crimes or staying honest, is affected by the distribution.

Public enforcement has the expected effect and conditions under which a

[2]By gross payoff to crime we mean the returns to crime gross of the probability of being apprehended and punished.

specific uniform-tax redistribution scheme will be effective in reducing crime are explored. Finally, we compare the relative effectiveness of public enforcement and redistribution schemes as means of controlling crime. We show, in particular, that if redistribution can effectively target a certain group of potential criminals, then some combination of public enforcement and redistribution will be optimal. But if redistribution schemes are not well targeted, then it may be efficient to make use of public enforcement alone.

On top of these results, we hope that an important contribution of our analysis will reside in its potential as a framework for further empirical studies on crime which incorporates private protection decisions.

In the crime literature, we have found few market-for-offenses models that explicitly endogenize the returns to crime. An early one is that of Skogh and Stuart (1982) who show how public enforcement of property rights can improve the lot of all individuals. This model is close to ours in spirit, with the difference that it considers only homogeneous individuals. Furlong (1987) also concentrates on the issue of public enforcement by cleverly introducing a probabilistic function that matches patrolmen with criminals and considers homogeneous victims. Fender (1999) introduces heterogeneous criminals but still assumes homogeneous victims. Chiu and Madden (1998) propose a market model of burglary in which the equilibrium crime rate is dictated by house prices. Imrohoroglu et al. (2000) do allow for both heterogeneous criminals and victims in an ambitious attempt to calibrate a general-equilibrium model of crime and labor to the U.S.A. economy. But except for Skogh and Stuart (1982), none of the above models account for private protection efforts. Shavell (1991) does analyze individual decisions to protect oneself. However, he concentrates on the issue of observable versus non-observable protection and assumes identical victims and thieves. The model presented in the survey by Ehrlich (1996) is certainly the closest in spirit to ours. Indeed, Ehrlich puts much emphasis on the importance of the elasticities of demand and supply of crime, the main difference being that we derive them explicitly from micro-economic behavior.

Our analysis is also related to the literature on conflicts in which general-equilibrium models of appropriation were also developed.[3] Grossman (1995) considers the issue of income redistribution as a means of reducing "extrale-

[3]Note that the term "appropriation" is typically used instead of "crime" in this literature since in most cases, the state is not present and thus the act of taking from another's belongings cannot be considered illegal, even though it is done against his or her will.

gal appropriations" by workers. He assumes homogeneous potential criminals and does not consider public and private protection. Skaperdas (1992) analyzes the strategic interactions between two individuals who can choose between productive and appropriative activities. Although he does consider heterogeneous individuals, his analysis is limited to just two individuals and does not consider public enforcement. Hirshleifer (1995) similarly considers the case of more than two individuals separately from the case of heterogeneous individuals. Finally, Grossman and Kim (1995) consider the choice between offensive and defensive expenditures among heterogeneous individuals but again, they do so with only two agents.

The paper is organized as follows: Section 2 presents a short survey of empirical findings on crime. Section 3 presents property crime as a free-access problem and derives the decision to engage in criminal activities. The equilibrium conditions are laid out for given protection expenditures. In section 4, protection decisions are derived for each individual. The system of equilibrium equations for the entire crime market is presented in section 5, which accounts for the equilibrium between the aggregate supply and demand for crime and the optimal protection decisions of individuals. Some predictions of the model are derived in section 6 while a few policy implications are considered in section 7. The conclusion proposes some extensions.

2 Some facts and issues on property crime

Our intent here is not to conduct an extensive survey of the literature on crime, but rather to mention a few empirical observations, with some theoretical results, that will provide a framework of discussion for the ensuing analysis.[4]

The obvious question to ask is what motivates individuals to commit crimes. The literature on this being huge if one considers all the social sciences, we restrict ourselves to economic factors. The fact that criminals respond to economic incentives is beyond controversy today for most crimes, and especially property crimes. Becker (1968) was certainly the first to analytically formalize the idea that the supply of offenses by individual criminals

[4] More complete surveys on crime include: Freeman (1999), Eide (2000) and Witte and Witt (2001), especially on empirical results and issues; Bourguignon (1999) on less-developed countries; Polinsky and Shavell (2000) on theory; Ehrlich (1996) on the "market for offenses" approach; and Marceau and Mongrain (1999) on various issues.

is the result of a comparison between the marginal gains and costs of committing an additional crime, where the costs increase with the **probability of detection and severity of punishment**.[5] Ehrlich (1973) then attempted to confront this theory with observations and did find that crime rates were negatively related to the probability and severity of punishment. Further studies tend to confirm the significant, negative effect of probability of apprehension on crime; the effect of severity of punishment is, however, still the subject of some controversy (Eide 2000, 360).[6] [7]

Another important factor that affects the opportunity cost of engaging in crime is the **legitimate wage opportunities** of individuals. This cost includes lost wages while setting up and committing a crime and while in jail, but also the stigma attached to having received a sentence, which tends to reduce future income opportunities. Freeman (1996, 1999) surveys the evidence that labor market opportunities do affect individual decisions to participate in crime. Moreover, Lott (1990) finds that criminals with higher preconviction incomes loose more in terms of post-conviction incomes, and that this is often true in both absolute and relative terms. He also estimates that this reduction in post-conviction income constitutes a major part of the economic penalty imposed on criminals. A short survey by Corman and Mocan (2002), concerning the most recent studies which attempt to correct for difficult methodological issues, confirms that both sanctions and economic conditions have a significant impact on crime, although which of the two has a larger effect remains an unresolved issue.

While few doubt that legitimate income opportunities affect individuals' decisions to take part in crime, significant results seem to be harder to come by with aggregate data. This is probably partly because a **general increase in income** can have the two opposite effects of increasing the opportunity cost of crime in terms of lost wages, and increasing the returns to crime in terms of additional wealth to appropriate. The question is further complicated by the fact that public and private efforts at reducing crime are endogenous (Bourguignon, 1999). Soares (2002) and Bourguignon et al.

[5]Polinsky and Shavell (2000) point out that Becker's model constitutes a formalization of ideas expressed earlier by Jeremy Bentham in 1789.

[6]Although more rare, some are still not convinced about the effect of probability of punishment. For instance, Anderson (2002) has found that, in the case of pick-pocketing, 76% of active criminals do not perceive the risk of apprehension when committing a crime.

[7]For a survey of issues of empirical methodology, see Ehrlich (1996) or Witte and Witt (2001).

(2002), for instance, find no specific link between crime rates and the level of per capita income. And although they both find a significant positive effect of **inequality** on crime, other previous work that tested for inequality did not find any strong link with crime (Bourguignon et al., 2002) . Finally, in a recent study conducted in rural Madagascar, Fafchamps and Minten (2002) conclude that an event that temporarily increases **poverty** results in more crop theft.

The **distribution of the burden of crime** according to people's wealth will also be considered in our model. Levitt (1999) addresses this issue using data from victimization surveys for the United States and finds that in 1974-75, poor households were less victimized by property crimes than richer households, but that this relationship was reversed in 1994-95. He attributes this change to increased investments in private protection by richer households as well as improved protection technology. Glaeser and Sacerdote (1999) also find that in the United States, households with higher income suffer lower chances of being victimized. Turning to Latin America, Gaviria and Pagés (2002) obtain a reversed relationship, i.e. higher income households are relatively more victimized than lower income ones. Kesteren et al. (2000) emphasize the importance of the difference between macro- and micro-analysis, noting that poorer communities are usually associated with higher risk, but that within a community, richer individuals may be more at risk (p. 54).

The simple fact that a group is exposed to a lower crime rate does not necessarily imply that crime imposes a lower burden on this group. As Levitt (1999, p. 88) points out, the burden of crime should also include the **costs of individual protection**. Many believe that the private protection effect is quite important. DiIulio (1996), for instance, believes that differences in private protection investments explain an important part of the high victimization rates of people living in the inner-city areas of the United-States (p. 11). Unfortunately and for obvious reasons, there is very little evidence on this. Another similar problem when comparing the burden of crime on different income groups is that the empirical work on crime typically uses either victimization rates or reported crime rates as the measure of crime and thus does not account directly for the **value of stolen property**. For any given crime, this value can be different between income group and should be included in the equation of the burden of crime. Most probably because of lack of available data, we have not found any study that accounts for these differences.

A final issue to consider concerns the use of **sanctions versus wealth redistribution** as means of controlling crime. As mentioned above, reduced inequality does seem to reduce crime. But it does not mean that, from the point of view of wealthier individuals, redistribution is a more attractive way to reduce crime than heavier enforcement. Freeman (1996) concludes that most crime prevention programs manage to reduce crime, though the effect is usually modest. Moreover, targeting both high-risk youth and recently released prisoners just before they enter the job market can have a large effect relative to their costs, while early social interventions appear to be costly relative to their impact in the long term. But again, this does not tell us if the money would be better spent on the police force. Imrohoroglu et al. (2000) address this question in their general equilibrium model calibrated to fit United States data. They find that at the *pre-existing* equilibrium, redistribution is ineffective since it actually increases the crime rate because of its highly distortionnary effect on the labor market.

3 Property crime as a "free-access" problem

Each individual in the population is indexed by his wealth (or income) level a. The population is distributed according to $G(a)$, with support $(\underline{a}, \bar{a})$. Wealth level a is perfectly observable by all.[8]

3.1 The supply of criminal activities

Each individual can supply up to one unit of his time to criminal activities. The opportunity cost of doing so is equal to a fraction λ of his wealth a. This assumption can be justified as the lost wages from legitimate employment or the expected cost of being caught and punished (see remark 1). In a large economy, we make the assumption that as far as *one* individual is concerned, the return from each unit of time spent on illegal activities is constant. The opportunity cost being also constant, the choice is really all or nothing: if an individual finds that crime pays, he spends his whole unit of available time on it. Denote the return from each unit of criminal activities as v. Then, for an individual of type a, crime will pay as long as

$$(1) \quad v > \lambda a.$$

[8] As we will argue in remark 2, we do not explicitly distinguish between wealth and income levels; the term wealth is used to simplify the exposition.

Remark 1 *Instead of being a fraction of his wealth, the opportunity cost of criminal activities could be interpreted as the probability of being caught and punished. Let* p *be that probability and assume that punishment is equal to a fraction* $1-\eta$ *of an individual's ex-post wealth, with* $\eta \in (0,1)$*. In this case, crime pays if*

$$(1-p)(a+v) + p\eta(a+v) > a \quad \text{or, equivalently,} \quad v > \frac{p(1-\eta)}{1-p(1-\eta)}a. \tag{2}$$

For fixed p *and* η*, the decision to become a thief is thus analogous to the previous one in (1).*

Remark 2 *If punishment takes the form of imprisonment, it can be argued that the wealthier have a higher opportunity cost of jail time, in monetary equivalent, even for those who do not work. Indeed, the rich could always use its wealth to buy land or tools, so as to attain a higher labor productivity. The high-income person would also loose more in terms of lower, post conviction income opportunities due to reputation effects (Lott, 1990). And even if the wealthier person could "buy" justice by affording better defense (Lott, 1987), paying a bribe to an enforcement officer, or influencing a judge, the outlay is likely to be larger the wealthier the person is.*

Due to personal characteristics, some individuals will not engage in criminal activities, regardless of their wealth status. We denote the proportion of potential criminals in the population as $\alpha \in (0,1)$. The total amount of criminal activities will be defined by the marginally indifferent criminal $\tilde{a}$ for which

$$v = \lambda\tilde{a}. \tag{3}$$

As a result, the total supply of criminal activities will be, for any given v,

$$x_s = \alpha G(\tilde{a}) = \alpha G(\frac{v}{\lambda}). \tag{4}$$

3.2 The "demand" for criminal activities

The amount of an individual's wealth lost to crime is a function of both his protection effort, y_a, and the total amount of time, x_a, that criminals spend trying to appropriate from him. This leads us to introduce an appropriation technology as follows:

The appropriation function *The total expected share of individual a's wealth appropriated by criminals is represented by an appropriation function* $\gamma(x_a, y_a) \in (0,1)$, *where* x_a *and* y_a *are, respectively, the total amount of time that criminals spend trying to appropriate from individual a, and the total protection effort that he expends.* $\gamma(x_a, y_a)$ *is assumed homogeneous of degree zero with* $\gamma_x > 0$, $\gamma_{xx} < 0$, $\gamma_y < 0$, $\gamma_{yy} > 0$ *and* $\gamma(0, y_a) = 0$ *for all* y_a.

The zero homogeneity assumption implies that the appropriation function depends only on the ratio of efforts y_a/x_a. Hence, if the levels of crime and protection efforts are both increased by the same factor, the share of expected wealth lost remains the same. [9]

We interpret x_a as the total number of hours spent *trying* to take from a. This includes information gathering about a victim's habits, his protection level, the location of his belongings, etc, as much as the eventual break-in, or attack, time. This means that even if tagged with a positive x_a, a target might never actually loose anything. The fact remains, though, that the higher the x_a, the larger the expected loss.

Note that in order to keep the analysis simple, this probabilistic definition of the appropriation function will force us to assume risk neutral individuals. If we wanted to consider the case of decreasing marginal utilities, we could assume that the appropriation function is deterministic and arrive at the same crime equilibria. This deterministic approach will have important implications when it comes to comparing the welfare of the rich and the poor in section 6.1.

For an individual of wealth a, the expected unit return from crime at his place is thus $a\gamma(x_a, y_a)/x_a$. We adopt the free-access assumption that the average return from crime at any location be the same.[10] This is a safe

[9]This type of appropriation function is referred to as a *contest success function* in the literature on conflicts. There are two large classes of such functions: the ratio form, adopted here, and the difference form, which holds that the degree of success depends on the difference of efforts rather than the ratio. In the present context, the ratio form appears more appropriate. On a discussion about contest success functions, see Skaperdas (1996) and Hirshleifer (1989).

[10]The original work on the free-access problem is that of Gordon (1954). The basic idea is that if a fisherman can freely choose between many fishing grounds, he will go to the one with the highest average productivity. In equilibrium, fishermen will thus allocate their efforts so that all fishing grounds offer the same average productivity. This is considered inefficient as efficiency calls for an equalization of *marginal* productivities. Gordon's model, of course, assumes that no restrictions are placed on accesses to the grounds, which is often not the case as entry can be regulated by the state or by a common agreement between

assumption to make as one would not expect all the criminals in a society to get together in order to increase the efficiency of their criminal activities (except, maybe, in the case of organized crime, which we do not consider here). This implies, for instance, that some criminals may spend more effort in searching and preparing to take from a wealthier person (a larger fish), and/or organize the take in a group which will split the proceeds, while others will act in solo and/or take mostly at random.[11] The upshot is that one would expect that in equilibrium, from the point of view of criminals, the average return per victim is equalized.[12]

Having expressed that expected return as v, we must have, for any $x_a > 0$,

$$(5) \quad \frac{\gamma(x_a, y_a)}{x_a} a = v.$$

This equality defines an implicit relation between x_a and v for an individual of wealth a who spends y_a protecting his wealth. Let us express this implicit relation as $x(a, v, y_a)$. The total "demand" for criminal activities is thus

$$(6) \quad x_d = \int_{\underline{a}}^{\bar{a}} x(a, v, y_a) g(a) da.$$

3.3 The equilibrium supply and demand for crime

In equilibrium, the number of individuals being pushed into crime must be equal to the total number being pulled into it, $x_s = x_d$, or

$$(7) \quad \alpha G(\frac{v}{\lambda}) = \int_{\underline{a}}^{\bar{a}} x(a, v, y_a) g(a) da.$$

This equilibrium is represented in figure 1 for given y_a, $a \in (\underline{a}, \bar{a})$. It is straightforward to check that the equilibrium exists and is unique. For low enough λ or y_a, $a \in (\underline{a}, \bar{a})$, one can get equilibria in which all the potential

the fishermen. In our model or crime, each house can be assimilated to a different "fishing ground" in Gordon's analysis.

[11]Glaeser and Sacerdote (1999) hold a similar line of argument in that "... the returns per crime will rise with density as criminals choose only the more promising victims or criminals will select more victims and the returns per hour of criminal activity will rise with density." (p. S241)

[12]In the case of Shavell's (1991) analysis, this assumption would correspond to the case of observable protection.

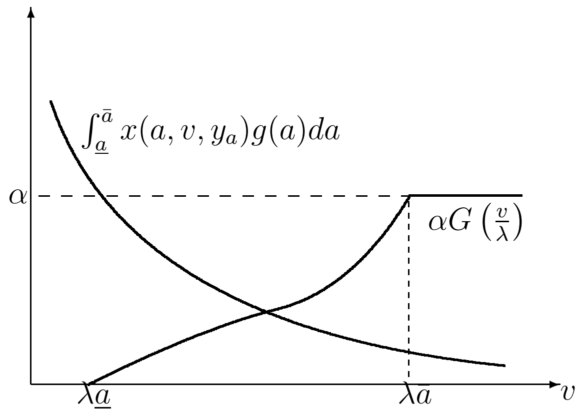

Figure 1: The Equilibrium supply and demand for crime

criminals engage in crime. Conversely, one can find a case where either λ or y_a, $a \in (\underline{a}, \bar{a})$, are large enough to eliminate crime. Note that this last possibility is ruled out if $\lim_{x_a \to 0} \gamma(x_a, y_a)/x_a = +\infty$.

4 The protection problem

We assume that individuals are neutral towards risk and thus seek to maximize the value of their wealth, net of protection expenditures and the expected share lost to criminals. Each individual is unable to affect v, as it is set by relation (7) in the larger economy. However, given v, an individual indirectly sets the level of crime effort against him through the choice of his protection level as described by equation (5). His program can be summarized by the following:

$$(8) \quad \max_{y_a} V_a = a - \gamma(x(a, v, y_a), y_a)a - y_a,$$

The first-order condition for this problem is:

$$(9) \quad \frac{\partial V_a}{\partial y_a} = -a\left(\gamma_x \frac{\partial x_a}{\partial y_a} + \gamma_y\right) - 1 = 0,$$

where

$$(10) \quad \frac{\partial x_a}{\partial y_a} = \frac{\gamma_y}{\frac{\gamma}{x_a} - \gamma_x},$$

as per the implicit relation between x_a and y_a given in (5). The solution to the first-order condition determines the expected final wealth level V_a^* of an individual of initial wealth a. This wealth is net of criminal takings and protection expenditures. In the following, we shall refer to V_a^* as the *useful* wealth.

5 A market-for-offenses equilibrium

Together, equations (5), (7) and (9) fully describe the market-for-offenses equilibrium. The first determines how much crime effort a victim will be subjected to, given its protection effort y_a and the overall payoff to crime; the second matches the total supply and demand for crime in the economy; and the third represents the condition describing each potential victim's optimal protection effort. The endogenous variables are x_a and y_a for $a \in (\underline{a}, \bar{a})$, and v.

It turns out that the analysis of the equilibrium system can be greatly simplified using the homogeneity properties of the appropriation function. By the homogeneity of degree zero, we have $\gamma(x, y) = \gamma(1, y/x)$. Let us introduce function $\rho(r) \equiv \gamma(x, y)$, where r is the individual protection-to-crime effort ratio y/x. The free-access equilibrium condition (5) implies that

$$(11) \quad x_a = \frac{\rho(r_a)}{v} a,$$

$$(12) \quad y_a = r x_a = \frac{r_a \rho(r_a)}{v} a,$$

and, therefore,

$$(13) \quad V_a = a - \rho(r_a)a - \frac{r_a \rho(r_a)}{v} a$$

The victim's first-order condition can now be expressed as

$$(14) \quad \frac{\rho(r^*)}{\rho'(r^*)} + r^* = -v.$$

Since v is set in the general economy, equation (14) implies that in equilibrium, r_a will be the same for all potential victims in the economy, i.e. the protection-to-crime effort ratios will be the same for all. We can therefore

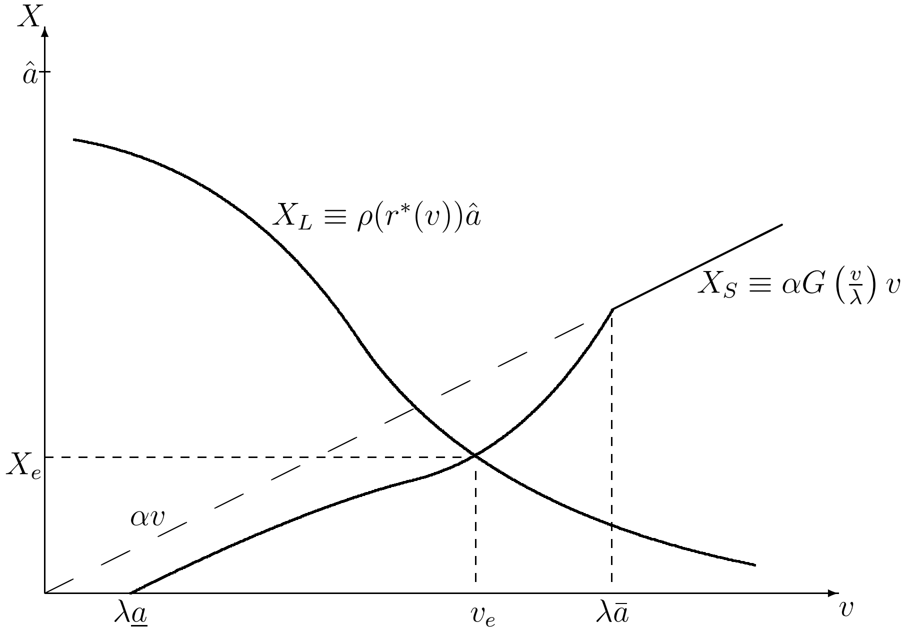

Figure 2: The Equilibrium Level of Crime

drop subscript a in the ensuing analysis. The system simplifies to

(15) $\alpha G\left(\frac{v_e}{\lambda}\right) v_e = \rho(r^*)\hat{a},$

(16) $\frac{\rho(r^*)}{\rho'(r^*)} + r^* = -v_e,$

(17) $x_a^* = \frac{\rho(r^*)}{v_e} a,$

(18) $y_a^* = r^* x_a^* = \frac{r^*\rho(r^*)}{v_e} a,$

where $\hat{a} = \int_{\underline{a}}^{\bar{a}} a g(a) da$ is a parameter that represents the total wealth in the economy (or mean wealth level since the total population has been normalized to one) and subscript e refers to a market equilibrium value. Expressed as it is, the left-hand side of equation (15) represents the aggregate value of stolen property *received* by thieves and is strictly increasing in v. It is represented in figure 2 by curve $X_S \equiv \alpha G\left(\frac{v}{\lambda}\right) v$. The right-hand side of (15) represents the aggregate value of stolen property *lost* by the victims. Making use of the fact that r^* depends only on v as per equation (16), it is strictly decreasing in v. It is represented in figure 2 by curve $X_L \equiv \rho(r^*(v))\hat{a}$. Hence, the equilibrium exists and is unique. In figure (2), the equilibrium values X_e and v_e denote, respectively, the aggregate value of stolen property and the gross payoff to crime.

6 Properties of the equilibrium

Applying the envelop condition to equation (13), the total derivative of useful wealth with respect to any parameter value z of the model will be

$$(19)\quad \frac{\partial V_a^*}{\partial z} = \left[1 - \rho(r^*) - \frac{r^*\rho(r^*)}{v_e}\right]\frac{\partial a}{\partial z} + \frac{r^*\rho(r^*)}{v_e^2}a\frac{\partial v_e}{\partial z}.$$

Individuals will be ultimately concerned about how any policy, or event, affects only two variables: (i) their own initial wealth, a, and (ii) the equilibrium gross returns to crime, v_e. We shall refer to the first effect as the *wealth effect* and the second as the *crime-payoff effect*. The sign of the first effect is obvious. As for the second one, the reason why an increase in the crime payoff increases a victim's net wealth is because it makes his wealth relatively less attractive. One way to see this is thru equation (5) where, for given y_a, an increase in v will reduce the proportion of his wealth lost to crime. Indeed, given that average returns to appropriation are decreasing in x_a, an increase in v must be compensated for by a reduction in x_a. Intuitively, the increased returns to crime in the rest of the economy makes one's own wealth relatively less attractive in equilibrium, thereby making it easier to protect. Hence the following result:

Result 1 *As a general rule, any policy or event that increases v_e will be beneficial to anyone, as long as it does not affect the initial wealth too severely.*

Note that this result contrasts slightly with the common approach in both the empirical and theoretical literature which usually uses victimization rates as the relevant variable assumed to affect people's welfare.[13]

6.1 Comparing the rich and the poor in the economy

From equation (13), the equilibrium ratio of useful-to-initial wealth V_a^*/a will be the same for all individuals, and so will the ratios of crime effort, x_a^*/a, and protection effort, y_a^*/a. This leads us to assert the following:

[13] It also fits well with the argument that since your car is quite average – and dented and rusty – within the Belgian car pool, you are not worried about getting it stolen. You would be a little more worried if you were using the same car in, say, a Latin American large city.

Result 2 *Regardless of initial wealth, in equilibrium, all individuals spend the same share of their wealth on protection expenditures and expect to get the same share of their wealth stolen. The total burden of crime, if expressed as a share of initial wealth, is therefore the same for all.*

Note however that if the equilibrium appropriated share, $\rho(r^*)a$, were seen as a deterministic loss and poor people suffered more heavily from loosing, say, 5% of their wealth than rich people (the equivalent of decreasing relative risk aversion), then one might conclude that in equilibrium, wealthier individuals are less severely affected by crime than poorer ones.[14] Moreover, absolute crime and protection efforts, x_a^* and y_a^*, are both increasing in initial wealth, a, and at the same rate.

If one were to consider the redistributive burden of crime, one would need to account for both the protection efforts and stolen property in *value* terms. Existing empirical work typically ignores the former and measures the latter as the probability of being the victim of a crime, regardless of the values involved. Although more accurate data would be needed to validate this point, we have used data from the International Crime Victimisation Survey (ICVS) for the year of 1996,[15] in order to compare the average losses from burglaries for high-income and low-income groups of individuals in different countries. The groups were created simply by dividing the surveyed population into two groups of equal size, one comprising the richest half, the other the poorest half. The results are reported in Figure 4 in the form of the ratio of average losses of high-income to low-income groups. The data suggest indeed that richer individuals loose more *in value* terms than the poor.[16]

The same data set was then used to compare the protection measures used by richer and poorer individuals. In this case, unfortunately, the ICVS does not directly provide the amounts that individuals spend on preventing crime. They do provide, however, the following list of crime prevention measures that can be adopted: burglar alarms, watch dogs, special grills, special door locks, high fences and watch schemes. For each household, we have computed an index of protection effort equal to the number of measures adopted. For

[14] Could this explain the higher sensitivity of poorer classes to security issues in the 2002 French elections?

[15] The ICVS is based on random population samples. It therefore avoids many biases stemming from the use of data based on reported crimes. See Newman (1999, esp. p. 43) for a discussion of the problems of biases when using reported crimes.

[16] Note that we have chosen only those countries that had the most complete data.

CHART 1 HERE

Figure 3: Rich-to-poor ratios of protection efforts

CHART 2 HERE

Figure 4: Rich-to-poor ratios of stolen values

instance, a household using three of the six possible measures would have an index of three. For both income groups, we have calculated the average prevention index and reported the ratio of rich-to-poor groups in Figure 3 for different countries. Richer households tend to use more protection measures than poorer ones. In an admitedly crude manner, this indicates that richer households protect themselves more than poorer ones.

Figures 4 and 3 together suggest that richer individuals loose more in terms of the value of stolen property, even though they tend to protect themselves more, as predicted by our model.

6.2 Level of economic development

The level of economic development, if simply defined as income per capita, causes an increase in total wealth $\hat{a}$ and a variation of the wealth distribution function, which will now be represented by $G(a;\hat{a})$. Graphically, it causes an upward shift of curve X_L, and a movement of curve X_S which will depend on how the fruits of economic growth are distributed among the population. Figure 5 presents one possibility in which even though the effects of economic growth are fairly well distributed among the population (curve X_S shifts to the right to X'_S by roughly the same amount everywhere), the total value of stolen property increases.

As can be seen in equation (27) of Appendix A, a sufficient condition for the returns to crime to increase is for $G_{\hat{a}}\left(\frac{v}{\lambda};\hat{a}\right)$ to be non-positive, i.e. an increase in the level of economic development reduces the proportion of people that are poorer than the marginal criminal ($\tilde{a}$), which is a reasonable assumption to make. This being the case, one can see from equation (19), where variable z is replaced by $\hat{a}$, that all those who do not directly benefit from economic growth will still get an indirect kickback through the effect on crime. So even though $\partial a/\partial\hat{a}$ is nil for some individuals, the increased wealth

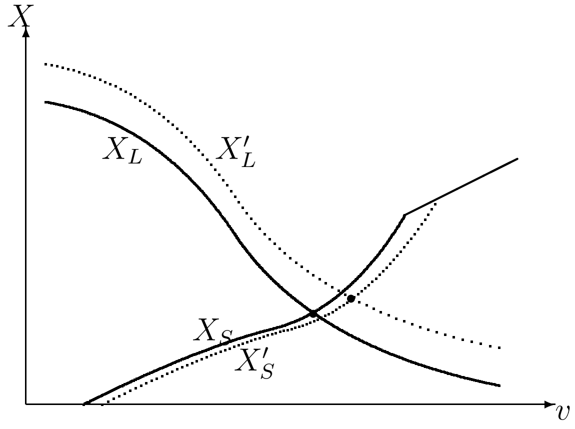

Figure 5: The Effect of Level of Economic Development on Crime

in the rest of the economy makes one's own wealth relatively less attractive in equilibrium, thereby making it easier to protect. Hence, the following result:

Result 3 *An unequal economic growth, that is, one for which the poorer segments of the population do not see their* initial *wealth increase, would still be beneficial for them, as their* useful *wealth increases.*

6.3 Inequality and crime

We consider the effects of a change in income distribution for given total wealth ($\hat{a}$). Since total wealth does not change, the aggregate amount that victims lose to crime, given v, is not affected by a change in the distribution of income. Curve X_L thus remains unchanged (see figure 2). The total amount stolen by thieves, given v, will however be affected since a change in the distribution function $G(a)$ affects curve X_S. It is clear, from figure 2, that whether the equilibrium level of crime X_e increases or not will depend solely on how the initial income of the indifferent criminal, $\tilde{a} = v_e/\lambda$, is affected by the change. If he gets richer, then $G(\tilde{a})$ moves down and his opportunity cost of participating in crime becomes larger. This makes him an honest person. X_S moves down at v_e and the equilibrium crime level X_e is reduced. The opposite will of course take place if the indifferent criminal becomes poorer.

Result 4 *Whether a change in income distribution increases or decreases the crime level depends on its effect on the initial income of the indifferent*

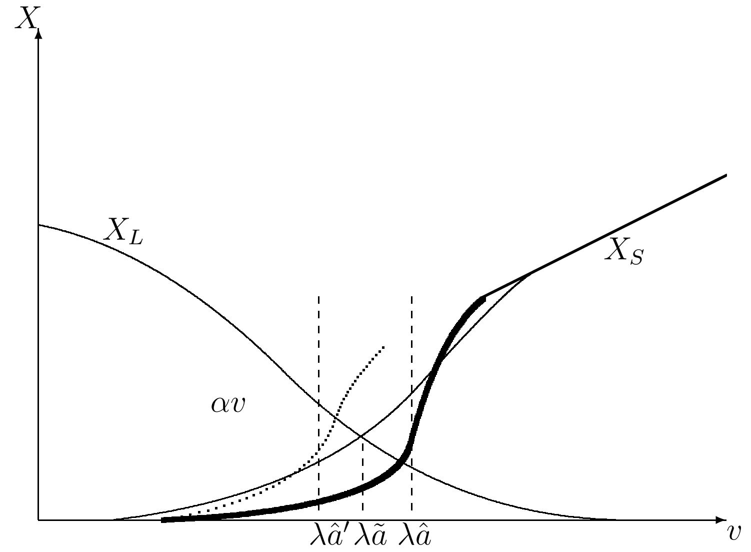

Figure 6: Income distribution and crime

criminal. At the margin, it decreases if, and only if, the latter becomes richer, regardless of whether income is more equally distributed.

For concreteness, let us assume that inequality is reduced in the sense that income distribution $G(a)$ becomes more concentrated around its mean $\hat{a}$. It is shown in figure 6 that crime will decrease if the indifferent criminal has lower initial wealth than the average wealth, i.e. $\tilde{a} < \hat{a}$ (compare the initial thin curve with the thick curve). Otherwise, crime will increase, as depicted by the dotted line which corresponds to a case of reduced inequality when $\tilde{a} > \hat{a}$. This result accords well with Bourguignon et al. (2002), who emphasize the importance of concentrating on a specific part of the income distribution curve in order to verify if inequality does affect crime. They find that in the case of Colombia, "that part of the population which most matters for time fluctuations in the crime rate are thus those individuals whose welfare lies below 80 percent of the mean of the whole population." (p. 8) According to our model, we leave it as an open question if this implies that the marginal criminal in Colombia has an income of 80% of the mean.

7 Policies to reduce crime

7.1 Increasing the opportunity cost of crime or the public enforcement effort

For any individual, the opportunity cost of crime was assumed equal to λa, where λ could be regarded as a measure of the public enforcement effort. It is shown in appendix B that the implicit relation between r and λ is positive. This simply means that more public enforcement results in less crime effort relative to the protection effort, with the result that less wealth will be stolen in equilibrium, i.e. $\rho(r^*)$ decreases. In fact, an increase in λ causes a rightward shift of curve X_S between $\lambda\underline{a}$ and $\lambda\bar{a}$ (see figure 2), while X_L does not depend on λ. This leads us to assert the following:

Result 5 *The gross payoff to criminal activities (v_e) increases with the public enforcement effort, while the aggregate value of stolen property (X_e) decreases.*

Note that at the equilibrium (X_e, v_e), the effect on the reduction of stolen property X_e will be the more important the larger the slope of X_L, or the smaller the slope of X_S, while the converse holds for the payoff to crime v_e. This leads to an interesting conundrum of public policy: an extra unit of public enforcement effort that has a large impact on the aggregate value of stolen property will have a small impact on the payoff to crime, and vice versa. It turns out that a detailed analysis of this issue must take into consideration not only marginal changes, but also the initial equilibrium values. Since this calls for more structure to the model, we leave it to future work.

As for the effect on individuals, it is clear that since v_e increases with λ, everyone is better off (see equation (19)). But such an increase in λ, if brought about by an increase in the public enforcement effort, would require more taxation. It is thus associated with a reduction in initial wealth (a). Now from the second term on the right-hand side of (19), we see that the richer the individual, the larger the gain from an increase in v_e. Consequently, richer individuals would be willing to pay more for such additional public protection since in the first term on the right-hand side of equation (19), the bracketed part is independent of wealth. If the increase in λ is funded with a uniform tax rate τ, equation (19) becomes

$$(20)\quad \frac{\partial V_a^*}{\partial \tau} = \left\{ -\left[1 - \rho(r^*) - \frac{r^* \rho(r^*)}{v_e} \right] + \frac{r^* \rho(r^*)}{v_e^2} \frac{\partial v_e}{\partial \lambda} \frac{\partial \lambda}{\partial \tau} (1-\tau) \right\} a.$$

Not surprisingly considering Result 2, an increase in the uniform tax rate has the same proportional *net* effect on everyone's initial wealth.

Result 6 *Because it increases the equilibrium crime payoff, an increase in the public enforcement effort improves everyone's situation with respect to* *crime. The monetary benefit is linearly proportional to their initial wealth and is therefore more important for richer individuals. The optimal tax rate used to fund the public enforcement effort, if it exists, would have to be uniform.*

7.2 Income redistribution

7.2.1 Redistributing income in order to contain crime

It is sometimes argued that a redistribution of wealth may be used as a means to reduce crime. The previous analysis implies that a necessary condition for this is that the indifferent criminal becomes richer after the redistribution. In that case, we have seen in figure 6 that the gross returns to crime v_e would increase, which has a beneficial effect to all as per the deterrence effect in equation (19). Whether individuals are overall better off or not will depend on how their initial wealth is affected (the initial-wealth effect in (19)). For the poorest individuals, a redistribution scheme should make this last term positive, so that they gain on both counts. As for wealthier individuals who are net contributors to the redistribution scheme, they face a tradeoff between a reduction in their initial wealth and the reduced crime levels. But since redistribution would have no effect without some level of public enforcement, we choose to consider directly the choice between redistribution and public enforcement as two public instruments that can be used to fight crime. We will do this simply by assuming a fixed crime-fighting budget.

7.2.2 Fighting crime with redistribution versus public enforcement

A perennial subject of discussion in the literature on crime is whether the state's money would be better used in a redistributive scheme, rather than direct police enforcement, as a means of reducing crime. In order to analyze this question, let us assume that the state has a fixed budget to spend to fight crime, which we normalize to one, and consider that a share θ of that budget is earmarked for redistribution, while the balance goes to direct public enforcement. An increase in θ boils down to taking money away from the police and redistributing it to some individuals. We introduce a public enforcement function with decreasing returns: $\lambda = \lambda(\theta)$, $\lambda'(\theta) < 0$ and $\lambda''(\theta) < 0$. Now one could think of many ways to redistribute wealth, some more efficient than others to contain crime. We choose to consider two polar schemes: the first one, referred to as *non-targeted*, redistributes evenly and non-discriminatively among a certain range of the poorest segment of the population; the second, which we call *targeted*, specifically targets the marginal criminals. The second scheme is of course the most effective way of redistributing wealth in order to reduce crime. We choose to consider both schemes for realism's sake, knowing that in practice, the marginal criminal will only be imperfectly targeted. Considering the less efficient and the most efficient schemes will allow us to make inferences about intermediate cases.[17]

7.2.3 Non-targeted redistribution versus public enforcement

The total crime fighting budget and the total population being normalized to one, we posit that the share θ of the crime fighting budget is redistributed evenly among proportion ν of the poorest individuals, which strictly includes the marginal criminal. The initial wealth of any receiving individual is thus expressed as $a' = a + \theta/\nu$. As for wealthier individuals, since the crime fighting budget is fixed, their initial wealth remains unchanged so that only the second term on the right-hand side of equation (19) will be affected by a change in θ, i.e.

$$\frac{\partial V_a^*}{\partial \theta} = \frac{r^* \rho(r^*)}{v_e^2} a \frac{\partial v_e}{\partial \theta}, \tag{21}$$

where $\partial v_e / \partial \theta$ is derived in equation (40) of Appendix C.1. We obtain that increasing direct public enforcement at the expense of redistribution is desirable only as long as $\partial v_e / \partial \theta > 0$, which is the case if, and only if,

$$-\frac{v_e}{\lambda^2} \lambda'(\theta) - \frac{1}{\nu} < 0. \tag{22}$$

At the margin, a unit increase in θ increases the wealth of the (former) marginal criminal by $1/\nu$. But the new marginal criminal, characterized by $\tilde{a} = v/\lambda$, has a larger wealth of $-\frac{v_e}{\lambda^2}\lambda'(\theta)$ because $\lambda(\theta)$ has decreased. A reduction in crime will result if the former marginal criminal becomes strictly honest, that is, if condition (22) holds.

[17] Note that the type of redistribution that we have in mind is more than just collecting taxes and redistributing it to the different agents. It should also be interpreted as investments in human capital through subsidized schooling or training programs for the less qualified, universal access to public health services, playgrounds in urban areas, positive discrimination, etc.

Now since ν is considered fixed, this suggests that an economy characterized by a lower v_e is more likely, given $\lambda(\theta)$, to resort to additional redistributive policies instead of direct public enforcement. We have seen in section 6.2 that an economy with a lower aggregate wealth will end up with a lower v_e, *ceteris paribus*. This suggests that in poorer economies, a relatively more intensive use of redistribution policies of the non-targeted type compared to public enforcement may be more effective. We have seen also in section 6.3 that v_e tends to be lower in an economy where income is more equally distributed *and* crime is endemic in the sense that the marginal criminal is richer than the average person, $\tilde{a} > \hat{a}$ (see figure 6). In such economies, therefore, redistribution of the non-targeted type may also be preferred to public enforcement. The converse holds true for an economy where income is more equally distributed *and* crime is non-endemic.

Finally, we have shown in Appendix B that v_e increases with λ. The model therefore does not have enough structure to predict whether ever increasing spending on the police, at the expense of a non-targeted redistributive policy, will eventually be counterproductive.[18] Corner solutions, where either none or the entire crime-fighting budget is spent on the police, cannot be ruled out with a non-targeted redistributive policy.

7.2.4 Targeted redistribution versus public enforcement

For the sake of simplicity, let us assume that indifferent criminals are honest. Obviously, the most effective way to redistribute income in order to reduce crime is achieved by precisely targeting those criminals whose wealth is just below the marginal criminals, since any small amount will make them honest. The trick is thus to give the lowest amount which is sufficient to turn a criminal into a marginal criminal. It is shown in Appendix C.2 that as θ increases, i.e. more money is taken from the police force and redistributed to the marginal criminals, v_e/λ must increase. Now since v_e/λ represents the wealth of the marginal criminal, this means that as θ increases, the wealthiest criminal, still denoted $\tilde{a}$, is now *strictly* poorer than the indifferent criminal. An efficient policy of targeted redistribution is thus to give money to the wealthiest criminal in order to turn him into an indifferent criminal, i.e. he receives an amount $v_e/\lambda - \tilde{a}$. As a result, this policy creates a mass of indi-

[18]Introducing more structure to our model by using more specific functional forms goes beyond our original intent for the present study. It is the object of ongoing research of ours.

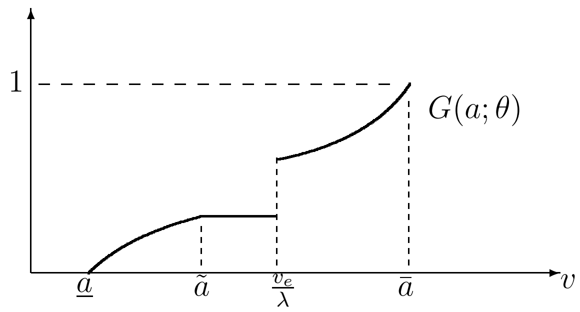

Figure 7: Efficient targeted redistribution

viduals whose wealth equals v_e/λ. The resulting wealth distribution is shown in figure 7. The cost of such a redistribution scheme is $\int_{\tilde{a}}^{\frac{v_e}{\lambda}} \left(\frac{v_e}{\lambda} - a\right) g(a)da$. Since the total budget earmarked for crime fighting redistribution is θ, the general crime equilibrium must now respect the following two equations

$$\text{(23)} \quad \theta = \int_{\tilde{a}}^{\frac{v_e}{\lambda}} \left(\frac{v_e}{\lambda} - a\right) g(a)da,$$

$$\text{(24)} \quad \alpha G(\tilde{a})v_e = \rho(r^*(v_e))\hat{a},$$

where $r^*(v_e)$ is still given by first-order condition (16). Note that without redistribution, $\theta = 0$, thereby making equation (23) irrelevant as $\tilde{a} = v_e/\lambda$, and equation (24) becomes equivalent to the previous equilibrium condition (15).

It is shown in Appendix C.2 that v_e increases with θ if, and only if,

$$\text{(25)} \quad -\frac{v_e}{\lambda^2}\lambda'(\theta) < \frac{1}{\int_{\tilde{a}}^{\frac{v_e}{\lambda}} g(a)da}.$$

This condition is remarkably similar to condition (22) obtained in the case of non-targeted redistribution: at the margin, a one unit increase in θ will be effective in fighting crime if, and only if, it raises the wealth of the indifferent criminals at a faster pace than the increase in $v_e/\lambda(\theta)$, for given v_e. There is one important difference with non-targeted redistribution though, it is that with targeted redistribution, the optimal value of theta is comprised strictly between zero and one (see proof in Appendix C.2). As a result, with perfectly well targeted redistribution, a crime fighting budget should always include a mix of income redistribution and public enforcement. The following summarizes our results on redistribution.

Result 7 *A dollar used for redistribution will be more effective than its use as public enforcement if it results in an increase in the crime payoff. Whether this is so depends on a comparison of the increase in wealth of the* former *indifferent criminal and the wealth of the* new *wealthiest criminal. If the indifferent criminal can be perfectly targetted, then a mix of public enforcement and redistribution will always be desirable. But if perfect targetting is not possible, outcomes with public enforcement only cannot be ruled out as more effective in fighting crime.*

8 Discussion and extensions

Our aim with this study was to fill a gap in the existing literature by introducing private incentives to invest in protection in a market-for-offenses model of crime. In order to achieve this, it was necessary to make use of an appropriation function of the type commonly used in the economics of conflict literature. We also had to make assumptions about the returns to crime at different locations since the crime victims were heterogeneous in their wealth levels and protection decisions. We made the simplifying assumption that in equilibrium, the average (expected) returns to crime had to be the same for all victims.

Our main results indicate that what matters for potential victims is the gross returns to crime in the global economy. Moreover, the poor and the rich loose the same share of their wealth to crime, and similarly for the share spent on protection. Which of the two groups will be worse affected by crime in equilibrium will depend on the marginal utility schedule. Both economic growth and inequality have ambiguous effects on crime. The model is however helpful in underlining which are the important parameters in this respect. We nonetheless show that no matter how the fruits of economic growth are distributed across the community, all individuals will benefit because of the resulting increase in the crime payoff. We also determine which are the important parameters to consider when implementing a redistribution policy aimed at reducing crime, and show that when redistribution can be well targeted, it will be optimal to use a combination of redistribution and public enforcement in order to reduce crime.

Although the analysis has provided us with some useful and intuitively appealing results, we believe that our model lends itself readily to various extensions to study other crime-related issues. For instance, we did not explicitly account for the fact that individuals can normally choose between crime and work, the latter having a wealth creating effect. Such an analysis could help us clarify the two-way relationship that may exist between crime and development. There is also the question of simultaneous participation in both the legitimate labor and crime markets, which is sometimes observed, and may be introduced using decreasing returns to crime at the individual level. One may want to use our set-up to analyze the degree of complementarity and substitutability between private and public protection. And finally, our public enforcement function, when interpreted as the probability of catching a criminal, did not account for the number of criminals. One would think that for a given size of the police force, increasing the number of criminals should reduce the probability of catching each criminal. This could be achieved by introducing a police-to-criminal matching function of the type used in Furlong (1987) and, in a similar fashion to him, the unit cost of the police force should somehow be related to the average wealth of the economy.

APPENDIX

A Level of economic development

Let

$$(26)\quad \psi^A \equiv \alpha G\left(\frac{v_e}{\lambda};\hat{a}\right) v_e - \rho(r^*(v_e))\hat{a} = 0,$$

where $r^*(v_e)$ is defined implicitly as per the first-order condition (16). Then

$$(27)\quad \frac{\partial v_e}{\partial \hat{a}} = -\frac{\psi^B_{\hat{a}}}{\psi^B_v} > 0$$

$$(28)\quad \text{since } \psi^B_{\hat{a}} = \alpha G_{\hat{a}}\left(\frac{v_e}{\lambda};\hat{a}\right) v_e - \rho(r^*(v_e)) < 0 \text{ if } G_{\hat{a}} \leq 0,$$

$$(29)\quad \psi^B_v = \alpha g\left(\frac{v_e}{\lambda}\right)\frac{v_e}{\lambda} + \alpha G\left(\frac{v_e}{\lambda}\right) - \rho'(r^*)\frac{\partial r^*}{\partial v_e}\hat{a} > 0,$$

$$(30)\quad \text{and } \frac{\partial r^*}{\partial v_e} = \frac{-1}{2 - \frac{\rho(r)\rho''(r)}{\rho'(r)^2}} > 0 \text{ by SOC.}$$

Hence,

$$(31)\quad \frac{\partial r}{\partial \hat{a}} = \frac{\partial r}{\partial v}\frac{\partial v}{\partial \hat{a}} > 0,$$

$$(32)\quad \frac{dX_e}{d\hat{a}} = \rho'(r^*)\hat{a}\frac{\partial r^*}{\partial \hat{a}} + \rho(r^*),$$

$$(33)\quad \frac{d}{d\hat{a}}\left(\frac{X_e}{\hat{a}}\right) = \rho'(r^*)\frac{\partial r^*}{\partial \hat{a}} < 0,$$

$$(34)\quad \frac{\partial \tilde{a}}{\partial \hat{a}} = \frac{1}{\lambda}\frac{\partial v_e}{\partial \hat{a}} > 0.$$

B Increasing the opportunity cost of crime

Introduce (16) into (15) to get

$$(35)\quad \psi^A \equiv \alpha G\left(\frac{v}{\lambda}\right) v - \rho(r^*(v))\hat{a} = 0.$$

Hence

$$(36)\quad \frac{\partial v_e}{\partial \lambda} = -\frac{\psi^A_\lambda}{\psi^A_v} = \frac{\alpha g(\frac{v_e}{\lambda})(\frac{v_e}{\lambda})^2}{\alpha[g(\frac{v_e}{\lambda})\frac{v_e}{\lambda} + G(\frac{v_e}{\lambda})] - \rho'(r^*)\frac{\partial r^*}{\partial v_e}\hat{a}} > 0,$$

$$(37)\quad \frac{\partial r^*}{\partial \lambda} = \frac{\partial r^*}{\partial v_e}\frac{\partial v_e}{\partial \lambda} > 0.$$

Using the envelop condition, we get

$$(38)\quad \frac{\partial V_a^*}{\partial \lambda} = \frac{\partial V_a^*}{\partial v}\frac{\partial v}{\partial \lambda} > 0.$$

C Redistribution or public enforcement?

C.1 Non-targeted redistribution

Since the initial wealth of a poor individual is now $a' = a + \theta/\nu$ and it includes the marginal criminal, we now have $\tilde{a} = v_e/\lambda - \theta/\nu$. The crime equilibrium condition becomes

$$(39)\quad \psi^D \equiv \alpha G\left(\frac{v_e}{\lambda(\theta)} - \frac{\theta}{\nu}\right) v_e - \rho(r^*(v_e))\hat{a} = 0.$$

Hence,

$$(40)\quad \frac{\partial v_e}{\partial \theta} = -\frac{\psi_\theta^D}{\psi_v^D} = \frac{\alpha g(\cdot)\left(\frac{v_e}{\lambda^2}\lambda'(\theta) + \frac{1}{\nu}\right) v_e}{\alpha\left[g(\cdot)\frac{v_e}{\lambda} + G(\cdot)\right] - \rho'(r^*)\frac{\partial r^*}{\partial v_e}\hat{a}}.$$

C.2 Targeted redistribution

Proof that v_e/λ is non-decreasing in θ: We proceed by contradiction and suppose that $\frac{\partial}{\partial \theta}\frac{v_e}{\lambda} < 0$. Since $\lambda'(\theta) < 0$, this implies that $\frac{\partial v_e}{\partial \theta} < 0$ and thus $\frac{\partial}{\partial \theta}\left[\alpha G\left(\frac{v_e}{\lambda}\right) v_e\right] < 0$. But since $\frac{\partial r^*}{\partial v} > 0$, we have $\frac{\partial}{\partial \theta}\rho(r^*(v_e))\hat{a} = \rho'(r^*)\frac{\partial r^*}{\partial v_e}\frac{\partial v_e}{\partial \theta}\hat{a} > 0$. This violates general equilibrium condition (24). $\diamond$

The implicit relation between v_e and θ: From (23) and (24), we introduce F^1 and F^2 such that

$$F^1 \equiv \int_{\tilde{a}}^{\frac{v_e}{\lambda}} \left(\frac{v_e}{\lambda} - a\right) g(a)da - \theta = 0,$$
$$F^2 \equiv \alpha G(\tilde{a})v_e - \rho(r^*(v_e))\hat{a} = 0,$$

where $R^*(v_e)$ is still defined by victims' first-order condition (16). Making use of the implicit function theorem, we have

$$(41)\quad \frac{\partial v_e}{\partial \theta} = -\frac{F_\theta^1 F_{\tilde{a}}^2 - F_\theta^2 F_{\tilde{a}}^1}{F_{v_e}^1 F_{\tilde{a}}^2 - F_{v_e}^2 F_{\tilde{a}}^1},$$

where

$$
\begin{aligned}
F_\theta^1 &= -\frac{v_e}{\lambda^2}\lambda'(\theta)\int_{\tilde{a}}^{\frac{v_e}{\lambda}} g(a)da - 1;\\
F_{v_e}^1 &= \frac{1}{\lambda}\int_{\tilde{a}}^{\frac{v_e}{\lambda}} g(a)da \geq 0;\\
F_{\tilde{a}}^1 &= -\left(\frac{v_e}{\lambda} - \tilde{a}\right) g(\tilde{a}) \leq 0;\\
F_\theta^2 &= 0;\\
F_{v_e}^2 &= \alpha G(\tilde{a}) - \rho'(r^*)\hat{a}\frac{\partial r^*}{\partial v_e} > 0;\\
F_{\tilde{a}}^2 &= \alpha g(\tilde{a}) v_e > 0.
\end{aligned}
$$

$\frac{\partial v_e}{\partial \theta}$ will thus be positive if, and only if, F_θ^1 is negative. Moreover, as $\theta \to 0$, we have $\frac{v_e}{\lambda} \to \tilde{a}$, with the result that $\frac{\partial v_e}{\partial \theta} \to +\infty$. And conversely, as $\theta \to 1$, we have $\lambda \to 0$, with the result that F_θ^1 becomes strictly positive. Hence, $\frac{\partial v_e}{\partial \theta}$ is strictly positive for low values of θ while it is strictly negative for high values of θ.

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Chart 1: Rich-to-poor ratios of protection efforts

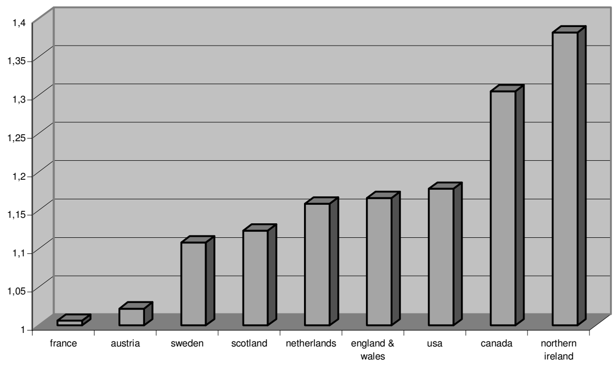

Chart 2: Rich-to-poor ratios of stolen values