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INDIVIDUAL PRECAUTIONS TO PREVENT THEFT: PRIVATE VERSUS SOCIALLY OPTIMAL BEHAVIOR

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Abstract

A model is examined in which individuals take precautions that reduce the amount stolen if thieves enter their homes; and the amount of theft is influenced by the level of individuals' precautions. It is emphasized that the motive of individuals acting alone to take precautions may include the diversion of theft to others but does not take into account general deterrence. For this and other reasons, the level of precautions exercised by individuals acting alone may differ from their collectively optimal level and also from the socially optimal level (which reflects effort devoted to theft).

INDIVIDUAL PRECAUTIONS TO PREVENT THEFT:
PRIVATE VERSUS SOCIALLY OPTIMAL BEHAVIOR

Steven SHAVELL*

1. Introduction and summary

Individuals act in a variety of ways to protect their property against theft:[1] they lock their doors, purchase alarm systems, hire guards, and so forth. The things that individuals do on their own to reduce theft are of substantial importance. It is notable that private expenditures on security from crime exceed public expenditures.[2]

The object of the present paper is to examine the motive of individuals -- acting alone or acting collectively -- to protect their property from theft and the social motive (to be defined) for individuals to protect their property from theft. To that end, a model is studied in which the only way that property can be protected is by private exercise of precautions; there is no public enforcement of law.

A distinction of importance in the model concerns the ability of a thief to ascertain the nature of an individual's precautions[3] before the thief attempts theft. An *observable precaution* is typified by iron bars on the windows of a house -- these will be visible to a

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[1]For simplicity, I will use the term "individual" (or "victim" or "household") to designate the party from whom property is taken, even though the party may be a firm or some other organization (a museum, for example). I will also refer generally to the taking of property as "theft," even though such taking may be accompanied by threats to persons and therefore be better described by the term "robbery."

[2]See, for example, Cunningham and Taylor (1984), who report private expenditures of $21.7 billion and public expenditures of $13.8 billion. For general descriptions of the nature and scope of private protection, see Kakalik and Wildhorn (1972a, 1972b).

[3]I will use the word "precautions" to describe not only actions that a person may take to prevent theft but also his purchases of security equipment. In a more general model, I would consider not only the precautions an individual takes in response to the risk of theft, but also effects on his work effort. On the latter, see the concluding comments.

thief contemplating entry -- whereas an *unobservable precaution* is illustrated by a household's use of a safe for storing valuables -- a thief may be unable to tell whether there is a safe inside a house before he enters it.[4]

The *goal of a potential victim* of theft is assumed to be minimizing the expected amount stolen plus the costs of precautions, for this sum will constitute the total costs of theft to him.

If precautions are observable, they will have two benefits to a potential victim. First, his precautions may induce a thief to go elsewhere; because a thief can see that a person has put iron bars across his windows, the thief may decide to approach another house. This will be called the *diversion effect* of precautions. Second, precautions may lower the amount that is stolen *if* a thief decides to enter a house. Because it may be difficult to saw through iron bars, the period during which a thief can steal may be reduced, so he may obtain less. The expected decrease in the amount stolen by a thief who enters a house will be called the *theft reduction effect.*

If precautions are unobservable, they will not produce a diversion effect; they will provide only a theft reduction effect. If I install a safe that a thief cannot see until he enters my house, the odds of his entering will not be lowered; my only benefit will be that if he enters, he will have more difficulty in taking my valuables. For this reason, the level of precautions individuals take when precautions are unobservable is lower than when precautions are observable to thieves (Proposition 1).

It has been assumed so far that each potential victim decides on his level of precautions independently of other potential victims, but it is of interest to consider *potential victims' collectively optimal level of precautions,* that which individuals would together agree to exercise in order to minimize the aggregate amount stolen plus aggregate costs of precautions.[5] The benefits to individuals of jointly raising their level of precautions are two. First, as was the case for individuals acting alone, there will be a

[4]I will generally speak of a house as the place that the thief contemplates entering even though there are other possibilities (a car, for example).

[5]The collectively optimal level of precautions may bear on actual practice in certain circumstances. For example, a community organization or a condominium association may decide that everyone should put iron bars on windows or obtain safes for storage of valuables.

theft reduction effect; less will be stolen from any house that a thief enters. But second, there will be a *deterrence effect*. When people make a common decision to raise precautions, the general return to theft will be lowered, and with it the propensity of thieves to engage in theft. When all individuals decide to purchase safes, thieves will have a harder time stealing valuables no matter which house they enter, so there will be less theft. By contrast, when an individual decides only for himself to purchase a safe, he will not view this as having a deterrence effect; he will correctly reason that the propensity of thieves to engage in theft will be determined by the precautions taken by the overall population of households, and thus only negligibly by what he in particular does.[6]

Because victims' collectively optimal level of precautions reflects both the theft reduction effect and the deterrence effect, whereas the benefit to an individual of raising unobservable precautions involves just the theft reduction effect, the level of unobservable precautions chosen by individuals is lower than their collectively optimal level of precautions (Proposition 2a). Individuals acting alone may decide not to install safes, but acting together they may elect to purchase them.

An unambiguous comparison cannot be made in the case of observable precautions, however. The level of observable precautions chosen by individuals may be either higher or lower than their collectively optimal level (Proposition 2b). The benefit to an individual of raising observable precautions consists, recall, of the theft reduction effect and the diversion effect. Thus, the difference between the individual benefit and the collective benefit equals the difference between the diversion effect and the deterrence effect. But the diversion effect may be either above or below the deterrence effect,[7] leading to the ambiguity in the conclusion.

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[6]Another contrast to be explained is that there is no diversion effect when individuals jointly raise precautions. The reason is that if every individual takes a precaution, such as installing iron bars on his windows, none can expect thereby to divert a thief to his neighbor; his neighbor will also have iron bars on his windows.

[7]For instance, the diversion effect following from installing iron bars may be large -- an individual may believe that he will almost certainly induce a thief to go elsewhere -- whereas the deterrence effect may be moderate -- if everyone were to install iron bars, the probability of theft might fall by only half, not almost to zero. To understand how the opposite possibility arises, see footnotes 18 and 19.

The collective goal of victims of theft is different from the *social goal,* which is to *minimize the costs of precautions plus thieves' costs.* This is the total cost of theft to all individuals in society, including thieves.[8] Note that *theft itself is not viewed as a social cost;* the motivation is that it amounts only to a transfer of goods between individuals, victims and thieves.[9] Given the social goal, the social benefit from precautions is due to the deterrence effect; the less theft there is, the less effort thieves devote to their activity. Further, it turns out that, on the margin, the precaution-induced reduction in thieves' effort *equals* the precaution-induced decrease in what thieves would have stolen -- for as thieves are assumed to act in their self-interest, they engage in theft to the point that the cost of theft just equals the amount they can steal. This means that the marginal social value of the deterrence effect equals the marginal value of the deterrence effect to victims of theft.[10] Yet the benefit of precautions to individuals, if acting collectively, comprises not only the deterrence effect but also the theft reduction effect. In consequence, the collectively optimal level of precautions for victims of theft exceeds the socially optimal level of precautions (Proposition 3a). Victims as a group might decide to install safes, because this would deter theft and also would reduce the amount stolen by those not deterred. From a social perspective, however, the reduction in the amount stolen by those not deterred would not be a benefit, so that purchase of safes might not be socially advantageous.

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[8]In a more general model, another social cost of theft would involve the distortion of work effort; see the concluding comments.

[9]The notion that the harm due to theft does not inhere in theft itself but rather in its repercussions is a familiar one. See, for example, Becker (1968, footnote 3) and Tullock (1967).

[10]Although this point is best appreciated from the formal analysis, it may be worthwhile amplifying here. Suppose that some precaution reduces the probability of theft by 10% and that the amount a thief would have taken is $1,000. Then the deterrence value to individuals of the precaution is 10%x$1,000 or $100. The present point is that the social value of the precaution is the same, $100, despite the fact that theft itself is not socially harmful. Each thief must have expended about $1,000 on his last theft (otherwise it would have been profitable for him to engage in more theft). This implies that the reduction by 10% in the likelihood of theft saves society $1,000 in thieves' costs with probability 10%. Hence, the social value of the precaution per household is also $100.

There is, though, no necessary relationship between the socially optimal level of precautions and the levels chosen by individuals, whether precautions are observable or unobservable; the levels chosen by individuals may exceed or be exceeded by the socially optimal level (Proposition 3b). In essence, the explanation is that the benefits that an individual obtains from raising precautions -- the theft reduction effect if precautions are unobservable, and the theft reduction effect plus the diversion effect if precautions are observable -- may exceed or be exceeded by the deterrence effect, the social benefit from raising precautions. It might be that individuals acting alone would decide against installing safes, but that it is in fact socially desirable for safes to be installed because of a large deterrence effect. Or it might be that individuals acting alone would decide to install iron bars because of the diversion effect and the theft reduction effect, but that this would not be socially worthwhile because the deterrence effect alone is not large enough.

As a general matter, therefore, the motive of victims of theft to spend on precautions may diverge from the social motive for different reasons: because an individual, acting alone, may attempt to divert theft to another; because an individual, acting alone, will always overlook the general deterrent effect of his precautions; and because an individual, whether or not acting alone, will always treat the theft reduction effect as an advantage.

In the concluding section of the paper, comments are made on possible extensions to the model and on its interpretation.

Finally, it should be mentioned that the topic considered here is not new. In an interesting article, Clotfelter (1978) discusses the point that the incentives of an individual victim to reduce crime may be different from the incentives of victims as a group.[11] The main contributions of the present paper are that it analyzes a more detailed model of precautions and theft and that it draws the distinction between victims' collective goals and social goals.[12]

[11]Cook (1986, pp. 23-24) contains suggestive remarks along the same lines. See also Png (1990), which is described in footnote 18.

[12]Specifically, in the model of this paper, precautions influence the amount taken if there is theft (as well as the probability of theft); in Clotfelter, precautions do not influence the amount taken, so that there is no theft reduction effect. Also, here there is an explicit account of thieves' behavior (which depends on their ability to observe

2. The model

2.1. Basic assumptions

Each of a large number of identical, risk-neutral households may be a victim of theft and can take precautions against it. The higher a household's precautions, the less that will be stolen if a thief enters the household. Let

x = level of precautions;[13] $x \geq 0$; and

$s(x)$ = amount stolen if a thief enters a household; $s(x) > 0$, $s'(x) < 0$, and $s''(x) > 0$.

Also, let

p = probability that a household is entered.

The determination of p and of x will be discussed below.

Each of a large number of identical, risk-neutral thieves[14] decides how much effort to expend on theft. Define

e = effort expended by a thief on theft; $e \geq 0$; and

$c(e)$ = disutility of effort; $c(0) = 0$, $c'(e) > 0$, and $c''(e) > 0$.

For each unit of his effort, a thief is assumed to enter one household and to obtain $s(x)$. In equilibrium, all households will choose the same x and thieves will be assumed to know what $s(x)$ is.[15] Thus, a thief will choose e to maximize[16]

(1) $es(x) - c(e)$.

Hence, e is determined by

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precautions); this is absent in Clotfelter. Additionally, here the social criterion reflects thieves' effort but does not include the amount stolen; in Clotfelter, victims' welfare is treated as the social criterion, so that, in particular, theft itself is considered to be a social cost but thieves' effort is not.

[13]Assumptions about the observability of precautions by thieves will be made below.

[14]One might imagine that the population of thieves overlaps with the population of potential victims of theft, but there will be no need to be explicit about this.

[15]This assumption is made even though thieves may not be able to observe an individual household's x. The justification is conventional: in equilibrium, thieves will know the distribution of x among households. Since this distribution happens to be degenerate -- all households are the same -- thieves will know the common x.

[16]In a model where different households choose different x, a thief would choose e to maximize $eE[s(x)] - c(e)$, where $E[s(x)]$ is the expected value of $s(x)$.

(2) $s(x) = c'(e)$,

and we can thus write

(3) $e = e(x)$.

Implicitly differentiating (2), we obtain $e'(x) = s'(x)/c''(e) < 0$; the more precautions households take, the less effort thieves spend on theft. We will assume in addition that $e''(x) > 0$.[17]

The probability p of theft facing each household will depend on the effort spent on theft by thieves. Specifically, if

t = number of thieves; and

h = number of households;

then the total number of households entered is $te(x)$, so that

(4) $p = p(x) = (t/h)e(x)$.

Note therefore that $p'(x) < 0$ and $p''(x) > 0$.

To complete the model, we need to specify how households choose x, which will depend on what is assumed about the observability of x by thieves.

2.2. Equilibrium where precautions are unobservable

In this case, we suppose that thieves cannot observe x before entering a household. Therefore, we assume that a household's choice of x will not affect the probability that it rather than another household will be entered. We assume also that a household's choice of x will not influence the amount of effort that thieves expend, since the total number of households is large. Accordingly, we assume that each household treats p as a constant and chooses x to minimize

(5) $ps(x) + x$,

so that x satisfies

(6) $-ps'(x) = 1$;

that is, the marginal *theft reduction effect* $-ps'(x)$ equals the marginal cost of precautions. This equation may be rewritten as

(7) $(t/h)e(x)s'(x) = 1$,

which determines the equilibrium x and thus p. The equilibrium is unique since $-p(x)s'(x)$ falls as x increases. Let us denote the equilibrium x by x_u, where "u" stands for

[17]This assumption is made to guarantee uniqueness of certain solutions to the model.

unobservable.

2.3. Equilibrium where precautions are observable

Now assume that thieves are able to observe something about the x chosen by a household and therefore that if a household increases x, the probability that it will be entered will fall, given the precautions taken by other households. In particular, suppose that[18]

$p(x|x')$ = probability of theft facing a household that takes precautions x, when all other households choose x'; $p(x|x') > 0$; $p_1(x|x') < 0$.

(For our purposes, there will be no need to specify what p is when other households do not choose a common level of precautions.) Each household chooses x to minimize

(8) $p(x|x')s(x) + x$.

The first-order condition determining x is therefore

(9) $-p_1(x|x')s(x) - p(x|x')s'(x) = 1$.

In other words, the marginal *diversion effect* $-p_1(x|x')s(x)$ plus the theft reduction effect equals the marginal cost of precautions. In equilibrium all households are assumed to choose the same x. Since all households face the same probability of theft, $p(x|x) = p(x)$; thus (9) becomes

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[18]A motivation for the assumption that p falls continuously with x is that a thief will decide to enter the household with the lowest perceived level of precautions $x + \varepsilon$, where ε is a continuously distributed error term with mean zero and where ε is independently distributed over households. If so, then $p(x|x')$ for household i equals the probability that $x + \varepsilon_i < x' + \varepsilon_j$ for $j \neq i$; this probability is equal to the probability that $\varepsilon_i < x' - x + \varepsilon_j$ for $j \neq i$ and is continuously decreasing in x. In particular, if x is slightly above x', $p(x|x') > 0$.

According to this motivation, I am taking some license in calling precautions "observable," rather than "imperfectly observable." However, if x is observed without error, then if x is infinitesimally above x', $p(x|x') = 0$; the household is never entered. This extreme effect leads to unnatural conclusions and to a potential problem with the existence of pure strategy equilibrium. When x is observed without error, it is readily shown that the only possible equilibrium is one in which x is so high that there is no theft at all. (For if there is a positive chance of theft in equilibrium, a household could raise x slightly above the equilibrium level x' and thereby escape theft, upsetting equilibrium.) But equilibrium may fail to exist because, even if there is an x such that no one steals, a household may be better off taking no precautions than that high x.

The problem with existence of equilibrium is avoided in Png (1990), who studies a model in which two households choose mixed strategies in observable precautions. Png's paper emphasizes the diversion effect and assumes that the social welfare goal is minimization of the sum of precautions and the expected amount stolen. His paper and this one were written independently of each other.

(10) $-p_1(x|x)s(x) - p(x)s'(x) = 1$,

which determines the equilibrium x, to be denoted x_o, where "o" stands for observable. We will assume that the equilibrium is unique.

2.4. Equilibria in the two cases compared

In the case where precautions are observable, a household obtains two benefits from increasing precautions: not only the theft reduction effect -- reducing how much is taken by thieves who enter -- but also the diversion effect -- reducing the likelihood of entry by shifting it elsewhere. Thus, one would expect the equilibrium level of precautions to be higher when precautions are observable than when they are not.

Proposition 1. The equilibrium level of precautions x_u when precautions are unobservable by thieves is lower than the equilibrium level of precautions x_o when precautions are observable.◂

To demonstrate this, note that if $x < x_u$, then $-p(x)s'(x) > 1$, for $-p(x)s'(x)$ is decreasing in x. Hence, for such x, (10) cannot be satisfied, as $-p_1(x|x) > 0$. And at x_u, the left-hand side of (10) equals $-p_1(x_u|x_u) > 0$. Thus, it must be that $x_o > x_u$.

2.5. Victims' collectively optimal precautions

If victims could agree collectively on a level of precautions, they would do so to minimize

(11) $p(x)s(x) + x$

because they would take into account how their collective, simultaneous choice of x affects the effort thieves devote to theft and thus the probability of theft. The condition determining the victims' collectively optimal precautions is therefore

(12) $-p'(x)s(x) - p(x)s'(x) = 1$.

That is, the marginal *deterrence effect* $-p'(x)s(x)$ plus the marginal theft reduction effect equals the marginal cost of effort. The solution to (12), which will be denoted by x^*, is unique, since $-p'(x)s(x)$ and $-p(x)s'(x)$ are each decreasing in x.

2.6. Victims' collectively optimal precautions compared to equilibrium precautions

Victims' collective benefit from increasing precautions has two components, the deterrence effect -- a reduction in the probability of theft when all households simultaneously increase x -- and the theft reduction effect. A single victim's benefit from increasing precautions when they are not observable is comprised only of the theft reduction effect. This suggests the following result.

Proposition 2a. Victims' collectively optimal level of precautions x^* exceeds the equilibrium level of precautions x_u when precautions are unobservable.◂

To show this, note that the left-hand side of (12) exceeds 1 for $x \leq x_u$; hence, $x^* > x_u$.

One cannot draw an unambiguous conclusion about the relative size of victims' collectively optimal precautions and the equilibrium level when precautions are observable by thieves. The reason is that the difference between the benefits from raising precautions in the two cases equals the difference between the deterrence effect and the diversion effect, and either can be larger.[19] Thus, we have

Proposition 2b. Victims' collectively optimal level of precautions x^* may either exceed, equal, or fall short of the equilibrium level of precautions x_o when precautions are observable.◂

2.7. Socially optimal precautions

Assume that the society's objective is to minimize the sum of the total amount spent by victims on precautions and the disutility of thieves' effort devoted to theft; thus the amount stolen by thieves does not in itself affect social welfare. (Equivalently, assume that the social goal is to maximize the sum of victims' and thieves' expected utilities. To maximize this sum, one must minimize expenditures on precautions plus the disutility of effort on theft.) Recalling that h is the number of households and t the number of thieves, the social goal is minimization of $hx + tc(e(x))$ or, dividing by h, minimization of

(13) $x + (t/h)c(e(x))$.

The first order condition determining the socially optimal x is

(14) $-(t/h)c'(e)e'(x) = 1$,

which says that the marginal reduction in the disutility of effort equals the marginal cost of precautions. Using (4), this may be rewritten as

(15) $-p'(x)c'(e) = 1$,

which, using (2), is equivalent to

(16) $-p'(x)s(x) = 1$.

[19]This is apparent under the interpretation of the previous footnote; for as the error in the observation of x approaches zero, the diversion effect grows unboundedly, and as the error grows large, the diversion effect approaches zero.

In other words, *the marginal social benefit of raising precautions turns out to equal the deterrence effect*, the reduction in the probability of theft multiplied by *the value of what is stolen.* This point is emphasized because the value of what is stolen does not enter directly into social welfare; rather, the disutility of effort does. The explanation is that the disutility of effort to the thief of entering the last house *equals* the value of what he steals from it; that is so because the thief expends effort optimally.

Let us denote the socially optimal level of precautions by x^{**}; it is unique since $-p'(x)s(x)$ is decreasing in x.

2.8. Socially optimal precautions compared to collectively best and equilibrium precautions

As just explained, the social benefit from raising precautions equals the deterrence effect, but victims' collective benefit from increasing precautions is the sum of the deterrence effect and the theft reduction effect. (Of course, the reason that the theft reduction effect is not a social benefit is that what is stolen does not enter into social welfare.) This suggests the next result.

Proposition 3a. The socially optimal level of precautions x^{**} is lower than victims' collectively optimal level of precautions x^*.◂

This follows because the left-hand side of (12) exceeds 1 for $x \leq x^{**}$.

There is no general relationship between the magnitude of the socially optimal level of precautions and the equilibrium levels because the private benefit from raising precautions can either be less than or greater than the social benefit, the deterrence effect. In the case where precautions are unobservable, the private benefit equals the theft reduction effect, and this can be lower than or higher than the deterrence effect. In the case where precautions are observable, the private benefit equals the diversion effect plus the theft reduction effect, and this sum too can be less than or greater than the deterrence effect. Thus, we have

Proposition 3b. The socially optimal level of precautions x^{**} may either exceed, equal, or fall short of the equilibrium level of precautions when precautions x_u are unobservable or when precautions x_o are observable.◂

3. Concluding comments

Several factors not taken into account in the model and points closely related to it are mentioned here.

(a) *Incentives to make unobservable precautions observable.* A possibility that was not considered in the model is that an individual may effectively be able to convert an unobservable precaution into an observable precaution. For example, a person may put a decal on a car window indicating that he has installed an alarm in the car.[20] Clearly, individuals will have an incentive to make precautions observable in such ways, since they then will obtain the benefit of diverting theft, but this benefit may not be socially desirable.

(b) *Work effort and theft.* An effect that was not studied in the model is that theft may influence work effort by lowering the private return to work. Such a change in work effort constitutes a social cost of theft (in addition to individuals' precautions and thieves' effort). However, because individuals bear this component of the social cost of theft, one supposes that they would take it properly into account in deciding on their level of precautions, other things equal.

(c) *Corrective public policy in regard to private precautions.* Because, as indicated in Propositions 3a and 3b, households' decisions about precautions generally diverge from the socially optimal, public policies to increase or to decrease, as the case may be, the privately chosen level of precautions will be desirable (assuming that the state has the information to compute the desirable level of precautions). If the level of precautions would be too low, the state can subsidize them. For instance, the state could support the use of devices allowing individuals to imprint their names on consumer durables, in order to deter theft. On the other hand, if private precautions would be excessive, the state can attempt to reduce them by use of a tax or some other method. It should be observed, though, that the state's ability to alter private precautions is limited by, among other things, its capacity to determine what individuals do with what they buy, and with whether precautions take the form of purchases or instead are behavioral (locking up) and are thus hard to monitor.

(d) *Why there are and should be private precautions.* It was taken for granted in the analysis that individuals have a role in protecting their property, and it was noted

[20]This would be effective as long as the decal displays the brand name of the alarm and is known by thieves to be available only to those in whose cars alarms have actually been installed. If individuals who do not have the alarms can nevertheless obtain the decals, then they would place them on their cars, and soon the decals would cease to serve as definite indicators of the presence of alarms.

that private expenditures on protection in fact exceed public spending. Part of the explanation for this observation and the assumption of this paper is that it is often more efficient for individuals to do things to prevent theft of their property than it is for the state because individuals' activities put them in a position to take precautions cheaply. For example, a person can much more easily lock his house or his car than some state employee; it would be absurd even to contemplate the state's assuming that responsibility. An additional explanatory factor is that individuals frequently possess better information than the state about the need for precautions. I may know more than the state about my vulnerability to theft and the value of installing a lock here or there by virtue of the fact that I live where I do and can see where entry can most easily be made. Hence, it appears understandable and desirable that many things to protect property are done by individuals rather than by the state.

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