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Risk, Security, Insurance, and the Cost of Protection*

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In a world of perfect certainty, protection against hazards becomes merely a matter of routine planning and preparation for coming events. Disasters occur only because of lack of discipline to take the necessary adequate precautions. In an uncertain world, the problem of coping with hazards takes on added complexity as the three elements of uncertainty — events, their magnitudes, and their timing — all or in part become unknown. Perfect certainty implies knowledge of all three while uncertainty implies ignorance of only one, although any two or all three may be unknown. The analysis given below will only consider those uncertainties that are insurable — that is, the events are known and their occurrence is subject to some known, well defined probability distribution, but the magnitude and/or the timing of the events are unknown.

The purpose of this paper is to analyze individual purchasing behavior with respect to risk losses, security devices and insurance. The discussion will be couched in terms of criminal activity from the viewpoint of a potential victim. However, the same analysis could equally apply to potential victims of other insurable losses as well. The hypothesis proposed is that decisions to allocate present endowments to either market insurance or self protection are independent of attempts to minimize the costs of total protection (the sum of market insurance and self protection costs). That is, the optimal amounts of market insurance and self protection are inversely related such that expected income can be maximized regardless of the relative distribution of allocations to market insurance and self protection. Specifically, it will be shown that the total cost of protection is independent of the relative amount of insurance and security devices purchased.

Traditional theory holds that the total cost of protection is the sum of costs of security devices plus the costs of insurance. It is theorized, therefore, that the total cost of protection can be minimized by a proper allocation of funds to each of the two components. The first of these premises is a tautology and is not the subject of this discussion. The second premise involves an analysis of choices between certain and expected (uncertain) losses. Again the discussion is centered around criminal activity.

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The costs an individual will experience as a result of the existence of crime will be the sum of his share of the cost of public enforcement, the amount of private protection he prefers and, in the absence of market insurance, the expected cost of being a victim. The first of these costs is not subject to his control and, therefore, in this analysis is shown as a parameter within which he must operate. The two remaining are discretionary in the sense that the individual can alter his expected costs due to criminal activity by increasing his expenditures on private preventative measures. Losses due to criminal and preventative costs may be minimized by allocating funds to private preventative measures up to the point where the last dollar spent just results in an equivalent reduction in the expected cost of being a victim (i.e., the point where the marginal benefit of the measure just equals its marginal cost). But minimizing dollar losses may not be an appropriate goal for the individual where there exist elements of uncertainty (as in the case of expected victim costs). Optimization would occur when allocations were made so that the disutility experienced as a result of a certain loss (private preventative measures) for the last dollar allocated equalled the expected disutility not experienced as a result of the corresponding reduction in the probability of incurring victim costs. Dollar and utility minimization would only lead to identical solutions if the individual were risk neutral. An alternative way of stating the utility condition is that the individual would allocate his funds up to the point where the marginal utility per dollar obtained from the last unit of security purchased just equalled that of the last unit of self insurance[1] (expected victim loss) foregone.

Whereas the utility maximizing condition can be stated it can be achieved only under special circumstances. As Ehrlich and Becker point out, with regard to expenditures on security devices, "Decreasing marginal utility of income is neither a necessary nor a sufficient condition [for optimality]. [Optimality] is always satisfied if the marginal utility of income is constant and may or may not be satisfied if the marginal utility is decreasing or increasing."[2] The remainder of this analysis, therefore, will assume constant marginal utility of income (for utility maximization) or, equivalently, maximization of expected income. In the present context the concern will be the minimization of the total costs of protection.

In the presence of market insurance the issue, then, reduces to the distribution of the costs of total protection among its various forms. For present use, protection will be divided into only two parts: (1) devices, mechanisms, or individuals that provide specific forms of protection, e.g., locks, safes, watch dogs, body guards and the like. For convenience, all of these items will be referred to as security devices; (2) methods of indemnifying losses incurred as a result of crime — that is, market insurance.

In the following analysis, time will be held to a single period. The analysis will concern itself primarily with expected monetary costs in order to demonstrate that allocations to protection measures are perfect substitutes for allocations to market insurance. (i.e., Dollars allocated to one will result in an equal dollar reduction in the cost of the other.) Further assumptions include perfect competition in all relevant markets, known and well defined probability distribution for each type of hazard and known incomes (or cash equivalents) for each asset protected. It is also assumed there are no "loading" or administrative charges on insurance premiums.

Proposition I: The value of a security device is equal to the reduction in the probability of the hazard occurring times the income protected. Or,

$$VSD = (B_0 - B_W)S \qquad (1)$$

Where, VSD = value (cost) of security device with a one period lifetime

BO = probability of hazard (loss) without the device during the period.[3]

B_W = probability of hazard (loss) with the device during the period.

S = income (or cash equivalent) of asset(s) protected which is not realized until the end of the period.[4]

Proposition I must hold for if $VSD < (B_0 - B_W)S$, it would pay the individual to continue purchasing the device since the expected loss avoided is greater than the cost (a certain loss). If $VSD > (B_0 - B_W)S$, it would pay to give up the device since the expected loss is less than the cost of the device. The law of diminishing returns insures that $(B_0 - B_W)S$ falls as additional units of the device are employed.

Proposition II: The period insurance premium is equal to the probability of a loss times the period income (or cash equivalent) of the protected asset(s). Or,

$$I^* = BS \text{ - period insurance premium}^{5} \qquad (2)$$

Again, this proposition must hold for if $I^* > BS$, it would not pay to purchase the insurance, but to become self insured since the premium is greater than the expected loss. Conversely, if $I^* < BS$, market insurance would be the better (less costly) buy. It follows, therefore, that:

$$I = B_0S \text{ and} \qquad (3)$$

$$I' = B_WS \qquad (4)$$

where,

I = insurance premium necessary without security device

I' = insurance premium necessary with security device.

The third and final proposition is the traditional identity of total cost cited earlier,

$$TC_p = VSD + I' \quad (5)$$

The necessary conditions are satisfied to determine the effect of private protection allocations on the total cost of protection. Substituting (1) and (4) into (5), the following is obtained:

$$\begin{aligned} TC_p &= (B_o - B_w)S + B_wS \\ &= B_oS - B_wS + B_wS \\ &= B_oS \end{aligned} \quad (6)$$

This result (6) is exactly the cost of protection if no security device had been employed. The cost of protection is simply transferred dollar for dollar from insurance premiums to security devices as the latter are employed. As a result of this direct transfer, there is no optimum amount of insurance or security devices which minimize the total cost of protection. The combination of insurance and security devices purchased is, therefore, only a function of individual tastes and preferences for each type of loss. Since both losses are certain, the differences between them, as utility producing expenditures, reduce to the following: insurance protection represents, for the most part, compensation after the hazard has occurred while security devices represent a reduction in the incident of the hazard. An individual who purchases relatively more insurance than another, assuming identical risks and assets, is expressing his willingness to accept greater incidence of the hazard and be compensated for it while the latter would rather forego some of the incidence and accept a lower level of total compensation. However, if the compensation is total the individual should be indifferent between the two losses. Compensation is seldom total in a world where pain, suffering and sentiment are difficult to measure. In addition, deductibles and self insurance are often substituted for market insurance by those units whose utility of other cash demanding purchases exceeds the disutility of assuming the additional risks of self insurance — the Friedman-Savage thesis. The presence of less than total compensation would provide an incentive for economic units to purchase varying relative amounts of security.

The conclusion reached is that the total cost of protection, in a single period for "insurable" hazards with no "loading" charges, is independent of the allocations of payments to insurance and security devices. Recognizing that actual insurance premiums are a multiple of the no load premiums, a question that remains is, "Why are individuals willing to pay more for insurance than has been justified by the above analysis?" The difference represents the premium paid in order to avoid the disutility of having to bear the risk of potential losses. Likewise, individuals may also pay prices for security devices in excess of their theoretical value in order to reduce the probability (risk) of potential losses. The price of security devices will, as a result, be higher than their actuarial fair price to cover the costs of administration much the same as insurance premiums. Hence, the presence of "loading" charges should not alter the conclusion that there is no unique combination of insurance and security that will minimize the total cost of protection.

A Mathematical Summary

Ehrlich and Becker did not recognize the conclusions developed here in their earlier article. They apparently ignored the fact that expenditures on self protection (security devices) were also a function of p and that p is a function of the technical ability of varying amounts (in units) of security to reduce expected losses. Transforming our notation to theirs, we can see and verify the arguments given above.

Let, $\pi = I' = B_W S$ $\qquad$ $k_1 = B_O S$ which is constant

$r = VSD = (B_O - B_W)S$ $\qquad$ $k_2 = S$ which is constant

$p = B_W$ $\qquad$ $k_3 = I = B_O S = k_1$

r^* = units of security

Since, $\pi = k_1 - r$

$\pi'(r) = -1$ $\qquad$ (1) $\quad$ which can be verified by,

$\pi = pk_2$ $\qquad$ also.

Therefore, $\pi'(p) = k_2$ $\qquad$ (2)

We know that, $\pi'(r^*) = \pi'(r) \cdot r'(r^*)$

then, $\pi'(r) = \pi'(r^*)/r'(r^*)$.

If $\pi'(r) = -1$

then, $r'(r^*) = -\pi'(r^*)$. $\quad$ (3)

But $\pi'(r^*) = \pi'(p) \cdot p'(r^*)$ $\qquad$ (4)

and $r'(r^*) = p'(r^*) \cdot r'(p)$. $\qquad$ (5)

Substituting (4) and (5) into (3) gives,

$$p'(r^*) \cdot r'(p) = -[\pi'(p) \cdot p'(r^*)]$$

Cancelling $p'(r^*)$ yields, $r'(p) = -[\pi'(p)]$. (6)

If $r = B_oS - B_wS$

$= k_1 - pk_2$

$r'(p) = -k_2$ (7)

Substituting (1) and (7) into (6) yields, $-k_2 = -[k_2]$

thus, $\pi'(r) = -1$ (1) is verified.

The above being subject to the following constraints:

$r'(r^*) > 0 \quad p'(r^*) < 0$

$r''(r^*) \lessgtr 0 \quad p''(r^*) \gtrless 0$

$\pi'(p) > 0$

$\pi''(p) \lessgtr 0$

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FOOTNOTES

[1] Self insurance is herein defined to be the absence of market insurance. It is the assumption by the individual of the risk or probability of a potential loss — the individual has underwritten his own risk. This definition differs from that used elsewhere (Ehrlich and Becker) where it refers to the reduction in the extent of the potential loss.

[2] Ehrlich, Issac and Becker, Gary S. "Market Insurance, Self Insurance, and Self Protection." **Journal of Political Economy**, Vol. 80, No. 4, July/August 1972, p. 639.

[3] The probability (B_O) represents the likelihood that a given hazard will occur for any one particular asset as a result of experience gained by numerous similar "risk" classes. In this manner (B_O) need not be for an unprotected asset, but only one which has a "standard" amount of protection (e.g., handrails on stairs or spring locks on doors).

[4] Losses are assumed total. For partial losses, a separate probability distribution would have to be developed and S would then become the expected value of the loss. Ehrlich and Becker demonstrate that market insurance and "self insurance" (reduction in extent of the loss) are perfect substitutes (pp. 635-636), a conclusion in which I find no fault. In the context of present notation the formula for VSD would become $(B_O - B_W)\alpha S$ where $0 \leq a \leq 1$. The assumption here is that $\alpha = 1$. Since expenditures on α and I are perfect substitutes, the omission of the former is not serious to this analysis.

[5] The insurance premium, recall, is defined here to be the actuarially fair price of the insurance. This argument does not mean to imply that purchasers of insurance would not be willing to pay a price in excess of this amount, but that in the long run and at the margin the total insurance premium would not exceed the actuarially fair price plus the "normal" cost of administration, the latter being abstracted from the present analysis.

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