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Individual Decision-Making to Commit a Crime: A Survey of Early Models

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1. Introduction

In the paper we present a part of the economics of crime – individual decision-making to commit a crime. This theory started appearing in the literature in the 1960s and especially in the 1970s in an attempt to describe and predict human behavior concerning issues such as offence and crime. Several models have been developed and we discuss them in turn, especially the studies of Becker (1968), Ehrlich (1973) and Heineke (1978).

Because the success of offence is naturally uncertain in these models, we deal with the maximization of the von Neumann-Morgenstern expected utility function. Moreover, we consider the offence risky and therefore encounter portfolio models where the individual allocates the wealth among legal and illegal activities. It is also reasonable to assume that these activities have a time dimension. As a result, individuals allocate time to legal and illegal activity. Determining the level of crime committed it is possible to derive the corresponding supply curve. The early models of the economics of crime are similar to the models of portfolio choice and of the supply of labor.

We do not include in our survey the theory of optimal law enforcement. This theory extends the theory of individual decision-making in several aspects e.g. in the analysis of how law enforcement agents should deal with the unproductive behavior of those who commit crime in order to maximize social welfare. For a survey see (Polinsky – Shavell, 2000). The models of individual decision-making to commit crime are closely related to modern dynamic theories on tax evasion. The survey is in (Slemrod – Yithzaki, 2002).

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We assume that economic agents are rational, in other words, they fulfill the following assumptions in their preferences: completeness, transitivity, reflexivity, nonsatiation, continuity, and strict convexity. These assumptions are sufficient conditions for rational behavior. Due to our assumptions we realize that our analysis of decision-making to commit a crime is most suitable to apply to areas such as the level of pollution that firms generate, robbery, tax evasion or traffic offence. The applicability of these models to emotional crime – or more generally to the case of unstable preferences – is in our opinion ambiguous.

Recently, there has been plenty of theoretical and empirical literature on the problem that individuals do not behave fully rationally.[1] But even if we find that individual decision-making is not always rational (which can actually be caused, to a large extent, by the optimization of the amount of information to be evaluated or by learning), we can think of it as a useful approximation of reality.

In section 2 we present portfolio models on individual decision-making to commit a crime. We discuss the model of time allocation in section 3. We present our conclusions in section 4, followed by two appendices on the derivation of some results of Heineke's model I.

2. Model of Dividing an Individual's Wealth between Legal and Illegal Activities

In this section we present the model of dividing an individual's wealth between legal and illegal activities. We assume that individuals maximize the well-defined von Neumann-Morgernstern expected utility function. As a result, the theory of individual decision-making to commit a crime is the special case of the general theory of rational behavior under uncertainty. An individual's wealth consists of an exogenous (initial) wealth and additional income obtained from legal and illegal activities.[2] Legal activities are without risk. Individuals are able to estimate the probability of all possible opportunities and monetize all the gains and losses.[3]

The models of rational behavior to commit crime in formal economic terms appear in the literature from the 1960s, starting with Becker's (1968) pioneering article *Crime and Punishment*.[4] However, the first attempts to study crime from an economic point of view date back to the 18th and 19th centuries (see (Eide, 1994, p. 48)).

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[1] For a survey of various attitudes towards rationality see (Hamlin, 1986, pp. 1–57). A short survey of early models of the economics of crime is provided by (Milanovic, 1999, pp. 5–11).

[2] Brown and Reynolds (1973) introduce the distinction between initial and additional income.

[3] If we challenge the strict monetization, the results of the early models become more ambiguous. See (Block – Heineke, 1975).

[4] However, there were also some unpublished manuscripts at Columbia University before 1968 such as (Smigel-Leibowitz, 1965) or (Ehrlich, 1967) focused on empirical assessment of crime activities in the U.S. Becker (1996, p. 143) also writes: "I began to think about crime in the 1960s after driving to Columbia University for an oral examination of a student in economic theory."

2.1 Becker's Model

Becker (1968) primarily focuses on minimizing the social loss in income from the crime and not only on the individual decision-making.[5] His article is a seminal work on the economics of crime in formal economic terms and is the basis for all further research.

Becker (1968) argues what is the optimal policy in order to combat crime and how it relates to the means of punishment, public expenditures, probability of conviction, and private enforcement of law. Thus optimal policies to fight crime are part of the optimal allocation of resources. We discuss especially the parts relevant to our survey.

Another of his results is that crime is socially undesirable since the potential offenders spend their time planning and implementing the crime, in other words on unproductive activities, which in turn causes only a violent income redistribution in society. In the modern literature this behavior is called rent-seeking.

Becker (1968) also discusses the economics of crime from the point of view of the individual and stresses the rationality and the liability of the actions. The individual compares the benefits and the costs of committing a crime (or offence). The crime is committed only if $g > pf$, where g is the gain from the crime and the term pf is expected punishment (p stands for probability of punishment and f for fine). Moreover, from the point of view of the enforcer it is rational to increase fines and lower the probability of punishment so that the expected punishment would not change. The only limitation is the offender's wealth.[6] Clearly, it might be difficult for the offender to pay a fine greater than his entire wealth and for the enforcer to collect the fine. However, if this is true, why does the substitution between fines and probability of punishment have weak empirical grounds?

There are at least two answers. First, the enforcer is not led by economic reasoning purely. Vaguely defined justice plays an important role in formulating the enforcer's policies.[7] Second, Polinsky and Shavell (1979) refine Becker's results by considering the attitude towards risk. This together with the recent model of Garoupa (2001) explains why we do not observe this substitution in reality. Garoupa (2001) shows that substitutability between the probability of punishment and fine holds only if the expected punishment is close to the gain from the crime.[8] Otherwise, the relationship can be complementary.

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[5] Becker (1968) does not distinguish between exogenous (initial) wealth and additional income obtained from legal and illegal activities. In this sense, it is disputable to include his model in this section, but all subsequent research comes from its model.

[6] See (Polinsky – Shavell, 1991) for a formal model where differences in wealth are introduced.

[7] Just imagine the case of free-riding on public transportation and being asked (though with probability close to zero) to pay a fine close to your entire wealth.

[8] Garoupa mentions the following hypothetical case: if the wealth of the offender is zero, it makes no sense to enforce, if the wealth becomes positive, then it is rational for enforcement agents to consider to act.

Becker (1968) deduces that the greater elasticity of the change in the probability of punishment over the elasticity of response to the change in fines implies that offenders are marginally risk-lovers. Brown and Reynolds (1973) generalize Becker's model risk implications about entering into illegal activities by showing that relevant elasticities imply nothing about risk attitudes. Later on, there is vast theoretical literature refining the results of Becker's model, such as Ehrlich (1973), Polinsky and Shavell (1979, 1991, 1999) and Garoupa (2001).

2.2 Heineke Model I

Heineke (1978) adds interesting aspects to Becker's model and to the models on tax evasion[9] from the early 1970s. He enriches both the models of portfolio choice and previous models of the economics of crime.

In the model the following notation is used:

W^0 – initial wealth,

x – amount of illegal activity, $0 \leq x \leq 1$,[10]

$W = W(x)$ – wealth is a function of illegal activity,

$g\,(x,\ \alpha)$ – gain from offence, $\partial g / \partial x > 0$, $\partial g / \partial \alpha > 0$, $g\,(0,\ \alpha) = 0$,

$f\,(x,\beta)$ – fine from offence, if detected[11] $\partial f / \partial x > 0$, $\partial f / \partial \beta > 0$, $f\,(0,\ \beta) = 0$,

α – a shift parameter for gains (magnitude of the gains),[12]

β – a shift parameter for losses (severity of the losses),

p – probability of detection,

W^S – wealth when being successful (no fine imposed),

W^U – wealth when being unsuccessful (fine is imposed on the offender),

$u\,(W)$ – von Neumann-Morgenstern utility, $\partial u / \partial W > 0$,[13]

$W^S = W^0 + g\,(x,\ \alpha)$

$W^U = W^0 + g\,(x,\ \alpha) - f\,(x,\beta)$.

The individual's maximize expected utility (EU):

$$E[U(W)] = (1 - p)u(W^S) + pu(W^U) \tag{1}$$

[9] For a contemporary survey of the literature on tax evasion see (Slemrod – Yithzaki, 2002), for tax evasion models preceding Heineke's model I, see (Allingham – Sandmo, 1972), (Kolm, 1973) and (Singh, 1973).

[10] Multiplying x by 100, we can interpret how many percent of the individual's activity is assigned to illegal. Moreover, it is conventionally assumed that the decision-maker divides his/her exogenous initial wealth, W^0 , between legal and illegal activities, hence $W^0 \geq x$. An implication of this is that W^0 is normalized as well.

[11] We assume for simplicity that detection is equal to punishment. That is there are no costs to impose a fine.

[12] E.g. an increase in a moves the function g upwards. The reasoning is similar for other shift parameters.

[13] If $\partial u/\partial W\partial W > 0$, then the individual is a risk lover, if $\partial u/\partial W\partial W < 0$ than the individual is risk averse, if $\partial u/\partial W\partial W = 0$, than the individual is risk neutral.

$$\mu \equiv \frac{\partial EU}{\partial x} = (1-p)\frac{\partial u}{\partial x}(W^S)\frac{\partial g}{\partial x} + p\frac{\partial u}{\partial x}(W^U)(\frac{\partial g}{\partial x} - \frac{\partial f}{\partial x}) = 0 \tag{2}$$

It is clear from the first-order condition that such optimum can exist, since the first term in equation (2) is positive and the second term is negative.[14] It is natural to expect that $\partial g/\partial x < \partial f/\partial x$, that is the additional gain from crime should be less than the additional fine, otherwise all individuals would commit as much crime as possible. On the other hand, the condition for committing additional crime is:

$$\frac{\partial g}{\partial x} > p\frac{\partial f}{\partial x} \tag{3}$$

which means the additional (marginal) gain has to be greater than the expected additional fine.

To make sure that we found the maximum of the expected utility function; the second derivative of the equation (1) must be negative:

$$\begin{aligned}\frac{\partial EU}{\partial x \partial x} &= (1-p)\frac{\partial u}{\partial x \partial x}(W^S)\frac{\partial g}{\partial x}\frac{\partial g}{\partial x} + (1-p)\frac{\partial u}{\partial x}(W^S)\frac{\partial g}{\partial x \partial x} + p\frac{\partial u}{\partial x \partial x}(W^U) \\ &\frac{\partial g}{\partial x}\frac{\partial g}{\partial x} + p\frac{\partial u}{\partial x}(W^U)\frac{\partial g}{\partial x \partial x} - p\frac{\partial u}{\partial x \partial x}(W^U)\frac{\partial f}{\partial x}\frac{\partial f}{\partial x} - p\frac{\partial u}{\partial x}(W^U)\frac{\partial f}{\partial x \partial x} < 0\end{aligned} \tag{4}$$

We can see that inequality (4) can be satisfied independently on the attitude towards risk.

After the exclusion of potential corner solutions ($x = 0, x = 1$), we can find the individual's response to the change of parameters. In other words, how much would a maximizing individual dedicate to illegal activities when there is a change in his/her wealth, the probability of detection, the size of gain and the severity of losses? Under the constant absolute risk aversion we obtain:[15]

$$\partial\mu/\partial W = 0 \tag{5}$$

This means a change in wealth will not affect the incidence of an individual's illegal activities.

Under the decreasing absolute risk aversion we have:

$$\partial\mu/\partial W > 0 \tag{6}$$

As a result, more wealth will bring more crime. Wolpin (1978) shows a rather surprising conclusion from equation (6). Illegal activity decreases

[14] Because p and $\partial u/\partial W > 0$ and $\partial g/\partial x - \partial f/\partial x < 0$.

[15] See *Appendix 1* for a derivation of the results of how the optimal value of x changes with the change of wealth. For more on the behavior towards risk, see (Eide, 1994, pp. 76–80), (Varian, 1992, pp. 177–197) or (Mas-Colell et al., 1995, pp. 183–199).

with increasing unemployment, since a higher unemployment rate implies lower income. The opposite would be intuitively expected. Notice an interesting feature that in this case we cannot explain with the perception quoted by Eide (1994, p. 56): *"[...] misery creates a situation where crime is a rational reaction."* Social norms as Eide (1994) argues can be appropriate for explaining this problem.

On the other hand, using the results of Polinsky and Shavell (1999) and Garoupa (2001) we may argue that it is possible to explain equation (6) by rational behavior at variance with Eide (1994). Low wealth means low opportunity costs and a low probability of being fined by a substantial amount. This inevitable change in the other parameters may in turn explain why equation (6) stands under rational behavior, too.

Under the increasing absolute risk aversion we end up with:

$$\partial\mu / \partial W < 0 \tag{7}$$

This means higher wealth contributes to lower illegal activity. Intuitively, one may expect this result. However, it is important to bear in mind that one's attitude towards risk might be unstable with respect to a substantial change in wealth. An individual with sufficiently low income might enjoy higher expected utility from committing an offence when his/her income slightly increases. Nevertheless, the reverse might happen when income rises substantially (increasing absolute risk aversion assumption with middle-income individuals). In a similar manner, the argument for low-income individuals might be made as well for high-income individuals.

Next, we can derive under some reasonable assumptions the following outcomes:[16]

$$\partial\mu / \partial\beta < 0,\ \partial\mu / \partial p < 0 \text{ and } \partial\mu / \partial\alpha > 0 \tag{8}$$

The results from equation (8) are as follows: more severe punishment causes less crime, as well as a higher probability of detection. On the other hand, higher gains from crime make an individual more likely to get involved in illegal activities. If more severe punishment causes less crime and the most severe punishment is capital, does it mean that we have a straightforward argument in favor of capital punishment? Laying aside "noneconomic" arguments, we can undermine the idea of capital punishment by introducing non-static interactive decision-making (the notion of marginal deterrence) and incomplete information. The popular example is a bank robbery. A robber, closed in upon by police, and knowing that capital punishment is highly probable, would have for example no incentive to spare the life of a potential hostage. Here we considered at least two time periods. Introducing nonstatic interactive decision-making reverses the results in this case completely. Another issue is nonperfect foresight and incomplete information. Once we introduce this concept, it is also likely to sentence an innocent individual to death.

[16] See *Appendix 2* for derivation.

3. Model of Time Allocation

A possible limitation of the portfolio models (Heineke model I in the last section) is that an individual not only has to decide about the optimal level of crime, but also to consider time as an important variable influencing the decision-making.[17] As a result, we encounter models where time is explicitly allocated between legal and illegal activities. We redefine the problem of the individual's maximizing the expected utility as follows:

$$E\ [U\ (W)] = (1-p)\ u\ (W^S) + pu\ (W^U) \tag{9}$$

where:
$W^S = W^0 + L\ (t_L,\delta) + G(t_i,\chi)$,
$W^U = W^0 + L\ (t_L,\delta) + G\ (t_i,\chi) - F\ (t_i,\psi)$,
$L\ (t_L,\delta)$ – function of benefits and costs depending on t_L,
t_L – time spent on legal activity,
δ – a shift parameter for $L\ (t_L,\delta)$,
$G\ (t_i,\chi)$ – gain from the illegal activity,
t_i – time spent on illegal activity,
χ – shift parameter for $G\ (t_i,\chi)$,
$F\ (t_i,\psi)$ – loss, if punished,
ψ – a shift parameter for $F\ (t_i,\psi)$.

The individual maximizes the expected utility with respect to t_i (time spent on illegal activity) and t_L (time spent on legal activity). Because the algebra is very similar to the portfolio model, we do not present the derivations.[18] All the assumptions from the previous model apply, too.

There are two possibilities how to deal with the model. The first, as discussed by Heineke (1978), is the general model with nonfixed leisure time. Hence, $t_i + t_L + t_R = t$, where t means time and t_R is leisure time and both are positive real numbers. The second model does not allow t_R to vary, this means that leisure time is fixed. The second model is developed in Ehrlich (1973).

3.1 Heineke's model II

An individual will maximize the following with respect to t_L and t_i:

$$E\ [U\ (W)] = (1-p)\ u\ (W^S) + pu\ (W^U) \tag{10}$$

The resulting first-order conditions are:

[17] Generally, one may convert time-allocation decision-making to allocation of costs (benefits). Despite this fact, time-allocation models work within a more general context (especially Ehrlich's model, see (Ehrlich, 1973, pp. 522–523)) and explicitly allow for capturing the effects of switching from one activity to another. Moreover, the time allocation models explicitly take into account leisure time as well.

[18] See (Ehrlich, 1973), (Heineke, 1978) or (Eide, 1994) for a survey.

$$\frac{\partial EU}{\partial t_L} = (1-p)\,\frac{\partial u}{\partial t_L}\,(W^S)\,\frac{\partial L}{\partial t_L} + p\,\frac{\partial u}{\partial t_L}\,(W^U)\,\frac{\partial L}{\partial t_L} = 0 \tag{11}$$

$$\frac{\partial EU}{\partial t_i} = (1-p)\,\frac{\partial u}{\partial t_i}\,(W^S)\,\frac{\partial L}{\partial t_i} + p\,\frac{\partial u}{\partial t_i}\,(W^U)\left(\frac{\partial G}{\partial t_i} - \frac{\partial F}{\partial t_i}\right) = 0 \tag{12}$$

The optimal value of t_L depends on the benefits and costs arising from legal activities and is independent of p, W^0, χ and ψ (probability of detection, initial wealth, the magnitude of gains and the size of the imposed fine respectively).[19] But an increase in wealth causes the individual to allocate more of his/her time to legal activities. When $\partial L/\partial t_L = 0$ (the marginal benefits reach zero), one will exert oneself to illegal activities. Again, the examples from the "real world" are clear. One may imagine the case where an individual is able to earn legally only a relatively low income (e.g. due to low abilities or low productivity of the firm before restructuring in a transition period), and where there may then be a temptation to get involved in illegal activities. Moreover, if we consider far less than perfect law enforcement in the beginning of the transitional period, we might explain a significant part of the crime activity through models of individual decision-making and of optimal law enforcement. It is also possible to derive the following inequality:

$$\partial t_i / \partial p < 0 \tag{13}$$

The time involved in illegal activity naturally decreases as the probability of punishment increases.

The outcome of change in the severity of punishment, the magnitude of gains, gains from legal activities and increase of wealth on time allocated to illegal activities (sign of these partial derivatives $\partial t_i/\partial \Psi$, $\partial t_i/\partial \chi$, $\partial t_i/\partial \delta$ and $\partial t_i/\partial W$ respectively) depends on the attitude towards risk.

In the case of constant absolute risk aversion we get:

$$\partial t_i / \partial \chi > 0,\ \partial t_i/\partial \Psi < 0,\ \partial t_i/\partial \delta = 0,\ \partial t_i/\partial W = 0 \tag{14}$$

This means, if there is an increase in the gains from the illegal activities, the individual will concentrate more on it. If the punishment from illegal activities is more severe, then everybody decreases their illegal activities. Increase in the wealth and the magnitude of gains does not influence illegal activities.

In the case of increasing absolute risk aversion we obtain:

$$\partial t_i / \partial \chi > 0,\ \partial t_i/\partial \Psi < 0,\ \partial t_i/\partial \delta < 0,\ \partial t_i/\partial W > 0 \tag{15}$$

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[19] See (Eide, 1994) for mathematical derivation. The technique is roughly the same as in the portfolio model and we do not present it. In the interest of saving space, we also do not always provide the comprehensive commentary to the equations, where the results are the same as for the portfolio model from the previous section.

The results in equation (15) show that an individual devotes less time to illegal activities when a higher severity of punishment is present and when there are better legal opportunities. Increase in the wealth and the magnitude of gains makes the individual tend more towards illegal activities. The results for decreasing absolute risk aversion are the following:

$$\partial t_i / \partial \chi > 0,\ \partial t_i / \partial \delta > 0,\ \partial t_i / \partial W > 0 \tag{16}$$

Higher potential gains as well as higher wealth from illegal activities cause higher crime. Better legal opportunities do not have a negative influence on the incidence of crime committed. The consequence of varied severity of punishment at the level of crime (the sign of $\partial t_i / \partial \Psi$) is indeterminate.

If there is a large independence between legal and illegal activities, the model yields the same result as portfolio Heineke model I.

3.2 Ehrlich's Model

We discuss the model of Ehrlich (1973) in this section. In this model we assume that the total time is fixed and has to be divided between legal and illegal activities. As a result, the more time spent on legal activities, the less may be spent on illegal activities and vise versa. We can rewrite the wealth depending on success in the following manner:

$$W^S = W^0 + L\ (t - t_i, \delta) + G\ (t_i, \chi)$$

$$W^U = W^0 + L\ (t - t_i, \delta) + G\ (t_i, \chi) - F\ (t_i, \Psi)$$

The first-order condition of the optimization of the allocation of time is:[20]

$$\frac{\partial EU}{\partial t_i} = (1-p)\frac{\partial u}{\partial t_i}(W^U)\left(-\frac{\partial L}{\partial t_i} + \frac{\partial G}{\partial t_i} - \frac{\partial F}{\partial t_i}\right) + (1-p)\frac{\partial u}{\partial t_i}(W^S)\left(\frac{\partial G}{\partial t_i} - \frac{\partial L}{\partial t_i}\right) = 0 \tag{17}$$

Rearranging leads to:

$$\frac{\dfrac{\partial G}{\partial t_i} - \dfrac{\partial L}{\partial t_L}}{\dfrac{\partial G}{\partial t_i} - \dfrac{\partial L}{\partial t_L} - \dfrac{\partial F}{\partial t_i}} = \frac{p\,\dfrac{\partial u}{\partial t_i}(W^U)}{(1-p)\dfrac{\partial u}{\partial t_i}(W^S)} \tag{18}$$

The term on the right-hand side describes the individual's indifference curve. After differentiating equation (10) with respect to W and setting $dE\ [U\ (W)] = 0$, we have:

[20] The second-order condition assures the maximum, see (Ehrlich, 1973, p. 527).

$$\frac{dW^S}{dW^U} = \frac{p \dfrac{\partial u}{\partial W^U}(W^U)}{(1-p)\dfrac{\partial u}{dW^S}(W^S)} \tag{19}$$

One can also see that the left-hand term in equation (18) is the marginal rate of substitution between W^S and W^U given the overall time constant. As t_i increases, it will produce a transformation curve, where W^S is substituted for W^U according to the following equation:

$$\frac{\dfrac{\partial G}{\partial t_i} - \dfrac{\partial L}{\partial t_L}}{\dfrac{\partial G}{\partial t_i} - \dfrac{\partial L}{\partial t_L} - \dfrac{\partial F}{\partial t_i}} = \frac{dW^S}{dW^U} \tag{20}$$

In other words, the transformation curve is an opportunity boundary (analogy of budget line) of the individual and is modeled explicitly compared to the previous models. Equation (18) is a necessary and sufficient condition for a strict global maximum, if the individual exhibits dimini-shing marginal utility of wealth as well as diminishing additional wages and constant or increasing marginal penalties.[21] Equations (18), (19) and (20) determine the optimal time allocated to legal and illegal activities (point B in Figure 1). If all the time were devoted to illegal activities, then the individual's optimum would become point C. In addition, if there is only legal activity, the individual will end up at point A. Notice also that the certainty line must lie at the angle of 45°, since we assume that legal earnings are certain and also gains and losses [$G(t_i, \chi)$ and $F(t_i, \Psi)$] are zero and then $W^S = W^U$. Naturally, the transformation curve's domain is $\langle W^0 + G(t) - F(t), W^0 + L(t)\rangle$ and its relevant range is $\langle W^0 + L(t), W^0 + G(t)\rangle$ (see *Figure 1*).

It can be also shown that if a risk-neutral person chooses point B in Figure 1, then the optimum for the risk-lover must be to the left of point B on the transformation curve and to the right for a risk-averse person.

It is clear that individual participates in illegal activities if his/her expected utility increases. To state this formally:

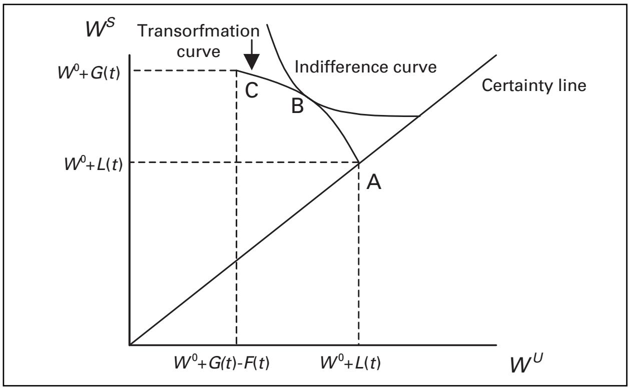
$$\frac{\partial EU}{\partial t_i} > 0 \tag{21}$$

Concretely, when there is no illegal activity, $W^U = W^S$ and thus $u^U = u^S$. Putting equation (19) and (21) together, after rearranging we obtain:

$$p\frac{\partial G}{\partial t_i} - \frac{\partial L}{\partial t_L} > p\frac{\partial F}{\partial t_i} \tag{22}$$

[21] That is, for the transformation curve to be concave (strictly or not) and the indifference curve strictly convex to the origin.

FIGURE 1 Determination of Activity Mix



Source: (Ehrlich, 1973)

The marginal differential gain must exceed the expected punishment in order for crime to occur.

Ehrlich's analysis goes beyond Becker (1968) in some aspects, since the model explicitly explores not only costs, but also benefits. Similarly, Ehrlich's model can predict not only the direction of the changes as was the case of Heineke's model II, but also the magnitude of the legal and illegal activities. Clearly, Ehrlich's model also provides arguments for punishing repeated offenders more severely.

4. Conclusion

Some types of criminal activity are largely explicable by the rational decision-making of individuals. As we could see in our survey of the early models, namely the portfolio and time allocation model, it unsurprisingly brings very similar results. In all cases regardless of attitudes towards risk, a higher probability of punishment lowers the efforts dedicated to committing an offence. The results of the change in the severity of punishment, the magnitude of gains from illegal activities and income are indeterminate and depend on the attitude towards risk.

However, the positive models of individual decision-making to commit a crime do not analyze many aspects of criminal activities such as how law enforcement agents should behave in order to maximize social welfare and the unproductive behavior of those who plan and commit crimes. The models consider only individual decision-making and ignore interactive decision-making, as well as more than one time period decision-making, which is crucial in analyzing e.g. marginal deterrence.[22] It may be derived from the early models that the optimal punishment is maximal. This conclusion

[22] But not all the models are comparative-static models, e.g. Allingham and Sandmo (1972) present also a dynamic model of decision-making of the tax evader, where several time periods are considered in the decision-making.

is drawn because of the nature of the models (comparative static models). The idea of maximal punishment was later undermined.

On the other hand, the models of individual decision-making provide a useful introduction and a guideline to the economics of crime and highlight the fact that it is always the rational individual who is at the center in analyzing the consequences of decision-making.

We conclude with a quotation by Ehrlich (1973, p. 527): "*Recidivism is not necessarily the result of an offender's myopia, erratic behavior, or lack of self control, but may rather be the result of choice dictated by opportunities.*"

APPENDIX 1

Derivation of the sign of $\partial\mu/\partial W$ [equations (5), (6) and (7)]

From the first-order condition (equation (2)) we have $\mu = 0$ and differentiating we get:

$$d\mu = \frac{\partial\mu}{\partial W}\, dW + \frac{\partial\mu}{\partial x}\, dx = 0$$

Rearranging we have:[23]

$$\frac{\partial x}{\partial W} = -\,\frac{\partial\mu/\partial W}{\partial\mu/\partial x}$$

Since $\partial\mu/\partial x$ is negative (second-order condition), it is enough to explore the sign of $\partial\mu/\partial W$ in order to determine the sign of dx/dW. Taking the derivative of μ with respect to W we get:

$$\frac{\partial\mu}{\partial W} = (1-p)\,\frac{\partial\mu}{\partial x\partial W}\,(W^S)\,\frac{\partial g}{\partial x} + p\,\frac{\partial\mu}{\partial x\partial W}\,(W^U)\left(\frac{\partial g}{\partial x} - \frac{\partial f}{\partial x}\right)$$

From the first-order condition (equation (2)) we have:

$$(1-p)\,\frac{\partial g}{\partial x} = -\,p\,\frac{\partial u/\partial x(W^U)}{\partial u/\partial x(W^S)}\left(\frac{\partial g}{\partial x} - \frac{\partial f}{\partial x}\right)$$

Combining we obtain

$$\frac{\partial\mu}{\partial W} = -\,p\,\frac{\partial u/\partial x(W^U)}{\partial u/\partial x(W^S)}\left(\frac{\partial g}{\partial x} - \frac{\partial f}{\partial x}\right)\frac{\partial u}{\partial x\partial W}\,(W^S) + p\,\frac{\partial u}{\partial x\partial W}\,(W^U)\left(\frac{\partial g}{\partial x} - \frac{\partial f}{\partial x}\right)$$

Rearranging leads to

$$\frac{\partial\mu}{\partial W} = -\,p\left(\frac{\partial g}{\partial x} - \frac{\partial f}{\partial x}\right)\partial u/\partial x(W^U)\left[-\,\frac{\partial u/\partial x\partial W\ (W^S)}{\partial u/\partial x\ (W^S)} - \left(-\,\frac{\partial u/\partial x\partial W\ (W^S)}{\partial u/\partial x\ (W^S)}\right)\right]$$

[23] The more proper way would be to solve the derivation by an implicit function as it is in (Eide, 1994), however the results are the same.

where

$$r_A\,(W^S) = -\,\frac{\partial u/\partial x\partial W\;(W^S)}{\partial u/\partial x\;(W^S)}$$

and

$$r_A\,(W^U) = -\,\frac{\partial u/\partial x\partial W\;(W^U)}{\partial u/\partial x\;(W^U)}$$

Finally, we have

$$\frac{\partial \mu}{\partial W} = -\,p\left(\frac{\partial g}{\partial x} - \frac{\partial f}{\partial x}\right)\partial u/\partial x(W^U)\left[r_A\,(W^S) - r_A\,(W^U)\right]$$

Under the constant absolute risk aversion (CARA) $r_A\,(W^S) = r_A\,(W^U)$ and that means $\partial\mu/\partial W = 0$. Under the decreasing absolute risk aversion (DARA) $r_A\,(W^S) < r_A\,(W^U)$ and that means $\partial\mu/\partial W > 0$. Under the increasing absolute risk aversion (IARA) $r_A\,(W^S) > r_A\,(W^U)$ and that means $\partial\mu/\partial W < 0$. We obtain these results because p and $\partial\mu/\partial W\,(W^U)$ are positive and the term $(\partial g/\partial x - \partial f/\partial x)$ is negative. If we recapitulate:

$$\text{CARA} \Rightarrow \partial\mu/\partial W = 0,\ \text{DARA} \Rightarrow \partial\mu/\partial W > 0 \text{ and IARA} \Rightarrow \partial\mu/\partial W < 0.$$

APPENDIX 2

Derivation of $\partial\mu/\partial\beta < 0$, $\partial\mu/\partial p < 0$ and $\partial\mu/\partial\alpha > 0$ from equation (8)

We employ the same technique as in Appendix 1.

First, we show how the severity of fines effects the criminal activity and how the result depends on the attitude towards risk:

$$d\mu = \frac{\partial\mu}{\partial\beta}\,d\beta + \frac{\partial\mu}{\partial x}\,dx = 0$$

Rearranging we get:

$$\frac{dx}{d\beta} = -\,\frac{\partial\mu/\partial\beta}{\partial\mu/\partial x}$$

and then

$$\frac{\partial\mu}{\partial\beta} = p\left[\frac{\partial u}{\partial x\partial\beta}(W^U)\left(\frac{\partial g}{\partial x} - \frac{\partial f}{\partial x}\right)\frac{\partial u}{\partial x}(W^U)\left(-\frac{\partial f}{\partial\beta}\right) + \frac{\partial u}{\partial x}\,(W^U)\,\frac{\partial f}{\partial x\partial\beta}\right]$$

For a risk-averse and risk-neutral individual μ_β is obviously always negative. For a risk-loving individual the result is uncertain, but if the following inequality holds:

$$\frac{\partial u}{\partial x\partial\beta}\,(W^U)\left(\frac{\partial g}{\partial x} - \frac{\partial f}{\partial x}\right)\frac{\partial u}{\partial x}\,(W^U)\left(-\frac{\partial f}{\partial\beta}\right) < \frac{\partial u}{\partial x}\,(W^U)\,\frac{\partial f}{\partial x\partial\beta}$$

then $\partial\mu/\partial\beta < 0$, too.

Second, we show that the increase in the probability of detection always decreases the criminal activity of the individual:

$$\frac{\partial \mu}{\partial p} = -\frac{\partial u}{\partial x}(W^S)\frac{\partial g}{\partial x} + \frac{\partial u}{\partial x}(W^S)\left(\frac{\partial g}{\partial x} - \frac{\partial f}{\partial x}\right) < 0$$

Third, we show how the magnitude of the gain affects illegal activity. After some algebra we get:

$$\frac{\partial \mu}{\partial \alpha} = \frac{\partial u}{\partial W}\frac{\partial g}{\partial x} + \frac{\partial g}{\partial x \partial \alpha}\left(-\frac{\partial EU/\partial W}{\partial \mu/\partial x}\right)$$

Since we already derived CARA $\Rightarrow$ $\partial\mu/\partial W = 0$, DARA $\Rightarrow$ $\partial\mu/\partial W > 0$ and IARA $\Rightarrow$ $\partial\mu/\partial W < 0$. $\partial\mu/\partial x < 0$ is a sufficient condition for maximizing the expected utility and $\partial g/\partial\alpha > 0$. Then we only have to assume the marginal gain must increase, that is $\partial g/\partial x\partial\alpha > 0$, and can derive the sign of $dx/d\alpha$.

As a result, for decreasing absolute risk aversion and constant absolute risk aversion we obtain $\partial\mu/\partial\alpha > 0$. The bigger the gain the more illegal activities will be present. The outcome under increasing absolute risk aversion is indeterminate.

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SUMMARY

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Individual Decision-Making to Commit a Crime A Survey of Early Models

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The authors provide a survey of the most important findings of the early models of the economics of crime, namely the models of Becker, Ehrlich and Heineke. These models study rational individual decision-making about entering into illegal activities. Probability and size of punishment, attitudes towards risk, gains from crime and income are the main variables influencing the results of individual behavior. The authors also discuss weaknesses of these models such as their static nature or the absence of interactive decision-making. The relationship to the theory of optimal law enforcement is also presented.