Punishment as a Price Signal
January 2012

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Conference paper: Shandong University, 2012 (edited version)

There is a long and fairly imposing line of economists from Adam Smith to the present who have sought to show that a decentralized economy motivated by self-interest and guided by price signals would be compatible with a coherent disposition of economic resources. These could be regarded, in a well-defined sense, as superior to a large class of possible alternative dispositions. Moreover, the price signals would operate in a way to establish this degree of coherence. It is important to understand how surprising this claim must be to anyone not exposed to this tradition.....It is NOT sufficient to assert that, while it is possible to invent a world in which the claims made on behalf of the "invisible hand" are true, these claims fail in the actual world. It must be shown just how the features of the world regarded as essential in any description of it also make it possible to substantiate these claims. In attempting to answer the question "could it be true?", we learn a good deal about why it might not be true.

(Arrow and Hahn, 1971)

Abstract:

This paper follows the basic idea from Bentham, Beccaria, Becker, and many later economic thinkers, that a general or aggregate theory of crime should be based on the view that crime is a phenomenon, which overall should be explained as agents trying to adapt themselves to institutions. This means that punishment could simply be viewed as a price-signal, toward behavior, which a central planner dislikes. In this paper I suggest an analytic framework where crime could be seen as a result of agents maximizing utility under a time-constraint. Alternatively, agents could also be viewed as companies maximizing income. The implication of this framework is that the standard economic model of crime can actually be trusted as a general framework for analyzing crime because the positive criminologist's view — that crime is a result of irrational agents forced by powers outside their control — could be viewed as a special case of the general economic theory.

Introduction

In 1968, when Gary Becker published his article "Crime and Punishment"(Becker 1968), he reopened Bentham's general view that crime is first at all a consequence of rational adaptive agents. Bentham simply said we should seek to implement institutions, where there is no systematic reason to become a criminal (Bentham 1789). This view should be "the general theory" of crime. Even though Bentham's ideas were formed long before Darwin, one could argue, that Bentham was an early evolutionary thinker in line with Adam Smith´s invisible hand, and the idea that the social system, in general, would adapt itself spontaneously to different circumstances (Hayek 1973-79). Nobody disagrees that some individuals could have some very strange preferences, and therefore, regardless of any price, would be committing crimes anyway. But this should be viewed as a departure from the general rule.

However, at the time when Becker wrote his article in 1968, most criminologists have adopted the so called positive model, that nearly all criminal activity could be stated non-rational, meaning that the economic model should be viewed as a highly special case of the general (irrational) model. Hence, Bentham's view was turned upside down. The *new* idea from this positive criminologist was that criminal behavior was determined by sociological or biological forces outside human control, and that any criminal, therefore, should be treated as a sick person. From this deterministic view, there is no such thing as *a free choice*. No such thing as *adaptive agents* and a spontaneous order, and, of course, no such thing as *evolution* in social systems. Today, some Marx-inspired criminologists even ignore biological evolution, using the assumption that man is *a blank slate*, which is the basis of social constructivism or sociological determinism; see. e.g. (Gottfredson 1990, Pinker 2002).

Economists do not disagree that the sum of all fractions of sociological and biological variables must equal 1. There is also no such thing as a *free spirit* or a *ghost in the machine*, but any human choice is the consequence of an indefinite amount of complexity; so, it is highly unlikely, to believe, we should ever be able to create an aggregate theory built by simply observing individuals. Nobody denies that the basic economic assumption behind rationality, in many cases, is not perfectly true (Kahneman 1984, Kahneman 2003),but this is not to simply say that abstract assumptions are not very useful as a proxy for reality as we move forward. In the physical world, there is no such thing as a perfect vacuum or a frictionless plane. Making abstractions from reality frees us to focus on more important issues and allows us to bring to bear powerful mathematic tools that help extend insight beyond the reach of intuition and experience. This is standard in every branch of science (Jehle G 1998).

Since Becker's influential article, there has been a lot of interest in using the economic methodology to study crime [see (Levitt 2006) or (Polinsky 2006) for comprehensive reviews]. Becker´s article was normative in nature, describing the welfare implications of using the economic methodology. Later, Ehrlich formalized a positive theory ((Ehrlich 1982). Even though many papers, both theoretic and empirical have been produced, not much attention has been given to the more basic formulations. To my knowledge, only Eide (Eide 2006) tried to discuss and formulate a modern microeconomic framework to analyze criminal behavior.

This paper is structured as follows: First, I proposed a simple framework where agents optimize utility under a time constraints. I then show that agents would optimally allocate time across different activities until the marginal utility of one activity equals other activities. Next, I introduced some sort of *punishment* (price signal) imposed by a central planner, for one activity. If this price signal influences the utility function negatively, it follows from deduction, that we can be quite sure that punishment must lower crime. Hence, it is logically impossible, that "nothing works," which was the famous statement by Martinson. (Martinson, 1974). Today, the idea of criminals lacking self-control is very popular among sociologists, but when a standard framework is established, it seems very possible that the idea of an absence of self-control must be closely related to the idea of time-discounting, which is not a general case, but simply a special departure from the economic model. This is no proof for the view that criminologists are not correct in stressing the importance of missing self-control among many inmates. I think this special case is very likely to be highly widespread among criminals, but logically, it cannot be a general case.

In the end of the paper, I suggest that criminological issues, instead of using utility theory, could be analyzed as companies (maybe individually owned) that are trying to maximize income. This means that many criminal acts cannot be analyzed, but in cases where criminals, with reason, are simply trying to maximize income, under some sort of resource restriction, I argue, that this can be a highly effective way to go.

The individual allocation of time

The basic workhorse in this paper is the attempt to take a slightly different route, or more precisely, a more generalized route, away from standard microeconomics. Instead of consuming goods, the agents are consuming time, **T**, on different sorts of activities; i.e. driving a car, eating hot dogs, or stealing pancakes. Because human action always takes some time t, we define the Euclidian space as:

(1) $$\mathbb{R}_{+}^{n} \equiv \{t_1 \ldots t_n | t_i \geq 0, i = 1 \ldots \ldots n\} \subset \mathbb{R}^n$$

We are using the standard assumption of rationality, which means that the agent's preference must at least satisfy:

Completeness*: for all* $t_1, t_2 \ldots \in \boldsymbol{T}$*, we must have that* $t_1 \succcurlyeq t_2$ *or* $t_2 \succcurlyeq t_1$

Transitivity*: for all* $t_1, t_{2,} t_3 \ldots \in \boldsymbol{T}$*, we must have that if* $t_1 \succcurlyeq t_2, t_2 \succcurlyeq t_3$ *then* $t_1 \succcurlyeq t_3$

We will simply ignore any critics of rationality and define a utility function u **(T).**

Definition:

A function u:$t \rightarrow T$, is a utility function representing preference relation $\succcurlyeq$ if for all $t_1, t_2 \ldots \in T$,

(2) $$t_1 \succcurlyeq t_2 <=> u(t_1) \geq u(t_2)$$

Completeness and Transitivity are some necessary conditions for establishing a utility function.[1] But simply for mathematical convenience, we also need the idea of continuity.

[1] These assumptions are the absolute minimum requirement if we want to claim any generalization and jump from one aggregation level to a higher aggregation level.

***Definition**:*

The preference relation $\succcurlyeq A$ is continuous if it preserved under limits. That is, for any sequence of pairs $\{(t_1^n, t_2^n)\}_{n=1}^{\infty}$, with $t_1^n \succcurlyeq t_2^n$ for all n, $t_1 = lim_{n \to \infty} t_1^n$, , $t_2 = lim_{n \to \infty} t_2^n$, we have that $t_1 \succcurlyeq t_2$

Therefore, there exists a continuous utility function U(•) . For a simple proof see (Colell 1995)

If the assumption of **Completeness**, **Transitivity,** and **Continuity** with respect to time consuming is satisfied, we can then move to the question, how the rational agent will maximize the utility, if confronted with different possibilities of human action.

The solution to the standard problem – using time efficiently

Notice that at this point, we say nothing about prices for different sorts of action. The only price for any action t is simply the time involved. If T≡ 1, we can write a time budget line as; $\sum_{i=1}^{n} t_i = 1$ which means the agent faces the following problem:

(3) $$MaxU(T)$$
$$St. \sum_{i=1}^{n} t_i = 1$$

Because t>0, and U (T) is continues, this maximizing problem has at least one unique solution if U(T) is a <u>monotonicity</u> function.

***Definition**:*

The preference relation $\succsim$ on T is monotone if $t_1 \in T$and $t_2 \gg t_1$ implies that $t_2 \succ t_1$

Monotonicity is standard in microeconomics; it simply says that "more is better", meaning in this case that all human action is followed with some positive utility. Actually, we don't need this assumption to establish a unique solution for (1). The weaker assumption of local nonsatiation is satisfactory. In any case, the solution for this nonlinear programming problem is to form the Lagrangian;

(4) $$\mathcal{L}(t,\lambda) = U(t) + \lambda[1 - t]$$

Following the Kuhn-Tucker conditions:

(5) $$\frac{\partial \mathcal{L}}{\partial t_i} = \frac{\partial u}{\partial t_i} - \lambda = 0, \qquad i = 1 \dots \dots n$$

Or if we let $\nabla u(T) = \left[\frac{\partial u}{\partial t_1} \dots \dots .. \frac{\partial u}{\partial t_n}\right]$ denote the gradient vector of u(·) at t, we can write in matrix notation

(6) $$\nabla u^*(T) = \lambda$$

For any two set of human action n=2 we have:

(7) $$\frac{\partial u^*}{\partial t_1} \Big/ \frac{\partial u^*}{\partial t_2} = 1$$

Or put differently in the general case:

(8) $$MRS_{t_j t_k} = \frac{t_j}{t_k}$$

This says that the marginal rate of utility substitution between two sets of actions must equal the relative time involved in these actions. So the maximum principle in (6) simply says that a person will continue with some sort of action until the marginal rate of substitution of that action is equal to the relative price (in this case time involved) between this two sets of action.

An example, two actions and cobb-douglas utility

Consider the case, where there exist only two different ways for an person to allocate time (t_1,t_2). Our agent facing a simple cobb-douglas utility function of the type $U = t_1^a t_2^{1-a}$. The solution to the problem, following (2) is the solution to the problem, taking log:

(9) $$L = a * \log(t_1) + (1-a) * \log(t_2) + \lambda(1 - t_1 - t_2)$$

The solution must solve the following system:

$$\frac{\partial L}{\partial t_1} = \frac{a}{t_1} - \lambda = 0\ , \quad \frac{\partial L}{\partial t_2} = \frac{1-a}{t_2} - \lambda = 0, \quad \frac{\partial L}{\partial \lambda} = t_1 + t_2 - 1 = 0$$

Because $\frac{a}{t_1} - \lambda = \frac{1-a}{t_2} - \lambda$, and because $t_1 + t_2 \equiv 1$, it is straightforward to show that;

(10) $$t_1^* = a\ and\ t_2^* = 1 - a$$

A geometrical interpretation for the pair of t_1 and t_2 is:

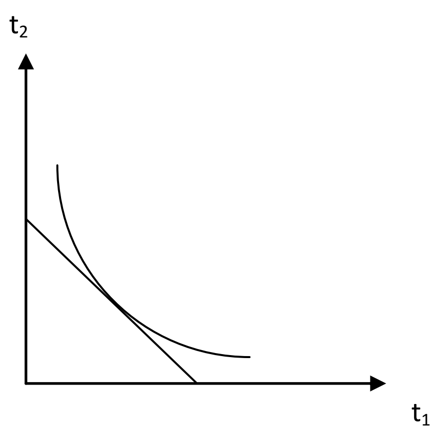

Figure 1

(normal action (good), with monotonicity a>0)

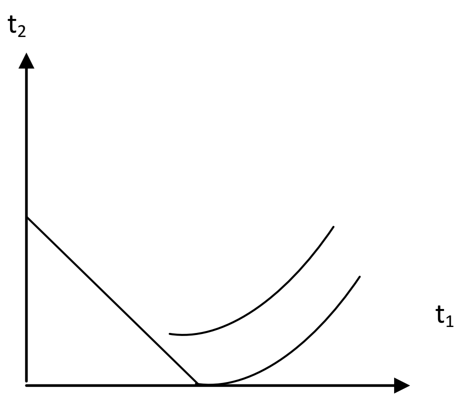

Figure 2

possibility of "bads" without the assumption of monotonicity a<0

Hence nothing in microeconomics in general says, that we should exclude the possibility that a<0, meaning that the activity t_2 is a "bad". This will happen if we do not include the assumption of monotonicity. It is typically easier to simply include the assumption of monotonicity, meaning that $a \geq 0$. Hence, we can interpret the parameter in this simple case as the "strongness" not doing t_2. If $a \rightarrow 1$,then $t_2 \rightarrow 1$, then we have:

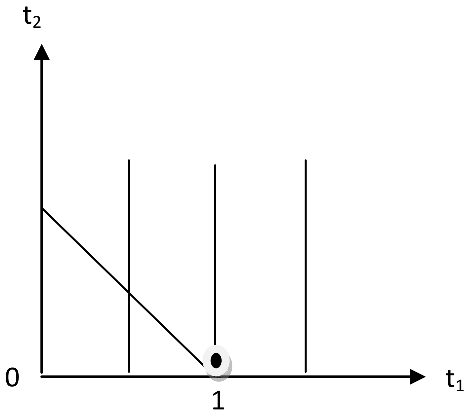

Figure 3

(If a->1, a person will not do any activity t2.)

This simple setup shows that even though 95% of people believe some sort of human actions is "bad", (for example steal from other members of society) maybe because they have some empathy for others, it still means there is 5%, who think this kind of human action is a normal good. Hence there is no reason to argue, that some action, which in general should be regarded as immoral, should not be analyze in rational terms. Rationality in the microeconomic sense of the word is not the same as morality.

When some "bad" human action generates punishment

Suppose we have a situation where any human action (t_1 , t_2 ......t_n) is accompanied by some action from a central planner, which for any sort of action could try/not try to impose some sort of taxation or other form of punishment, τ, for that action. However, in the theory of crime, we normally accept that the probability of punishment, ρ, is not always equal to 1, meaning that the relevant factor for the individual to consider is the accepted loss from committing a crime, ϕ , which in this case could be considered as:

(11) $$\boldsymbol{\phi = \rho\tau}$$

So, when $\rho \to 1, \phi \to \tau$, meaning that the expected punishment must equal the actual one delivered, when an individual is very sure to be detected[2]. It is important to think of $\boldsymbol{\phi}$ as a vector, so that $\boldsymbol{\phi} = \{\boldsymbol{\phi_1}, \boldsymbol{\phi_2} \dots\dots \boldsymbol{\phi_n}\}$

We will then say that:

$\frac{\partial u_i}{\partial \phi_i} < 0$, meaning that any central planner action following one action (called crime) from the individual, will be followed by a punishment, which will give the individual some negative utility impulse. We also recognize that $\frac{\partial \phi_i}{\partial t_i} > 0$, meaning that the expected punishment must be an increasing function of the activity level in t_i. [This expected utility argument could, of course, be expanded further. See e.g. Dhani 2013]

Therefore, the individual must now try to maximize the following system:

(12)
$$\boldsymbol{MaxU = U(t_1, t_2 \dots . t_n, \phi_1(t_1), \phi_2(t_2) \dots . . \phi_n(t_n))}$$
$$St. \sum_{i=1}^{n} t_i = 1$$

If we simply defined the net benefit from doing any action t_i as

(13)
$$U(B_i)=U(t_i)-U(\phi_1(t_1))$$

The system simply collapses to

(14)
$$\text{Max } U(B)$$
$$St. \sum_{i=1}^{n} t_i = 1$$

With the solution as in (6), or reformulated as:

2 Hence we are following the first rule of Bentham (1931): “The evil of the punishment must be made to exceed the advantage of the offense.” And later in chapter 2, Bentham included probability in his second rule as, ”the more deficient in certainty a punishment is, the severer it should be.”

$$\frac{\partial u(B_k)^*}{\partial t_k} * t_k = t_j * \frac{\partial u(B_j)^*}{\partial t_j} \quad (15)$$

Geometrically, we can interpret this as:

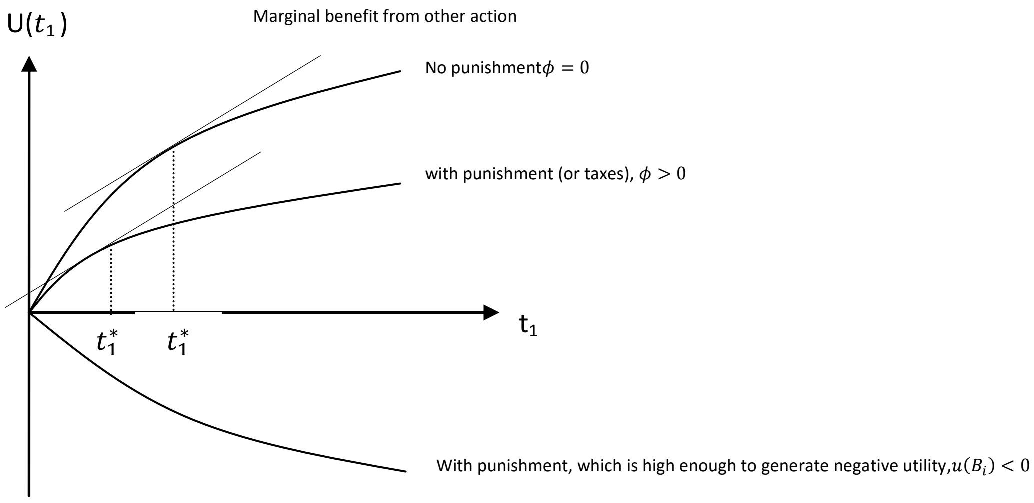

Figure 4 (If a penalty is implemented, this would lower or erase crime)

So, if agents have lower utility from punishment then higher ϕ would simply lower the supply of action t_i.

Alternatively, we could interpret this at the aggregate level:

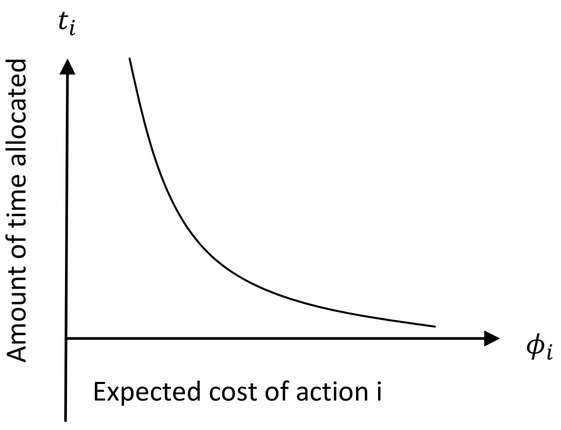

Figure 5: the "demand" for crime at the aggregate level

We could define the elasticity of the supply, with respect to $t_i$as:

(16) $$\varepsilon_i = \frac{\partial t_i}{\partial \phi_i} * \frac{\phi_i}{t_i}$$

Or because $\boldsymbol{\phi = \rho\tau}$

We get:

(17) $$\varepsilon_i = \frac{\partial t_i}{\tau\,\partial \rho_i \rho\,\partial \tau_i} * \frac{\rho_i \tau_i}{t_i}$$

This must be a negative number by definition, because there is a negative utility from punishment. Hence, the conclusion is straightforward. The fundamental logic of microeconomics simply implies that when there exists a human action such as a central planner's "dislike", and if that central planner imposed a punishment (price) for that action as an individual dislike, then the individual will choose, centeris paribus to supply less of that action! This deterrence effect is essentially an empirical question, which we, unfortunately, should not expect to be easy to solve due to the simultaneous biased problems, and because our main focus should be on the non-direct observable marginal agent. { see.e.g. Marvell, 1996; Nagin, 1998; Nagin, 2013}

In summary: The supply of any human action depends on:

1) The preference or utility for that action
2) The benefit from alternative action
3) The expected loss of utility by punishment for that action, either imposed as a rising probability from detection ρ, or as a rising punishment, τ when it is detected.

So, if the standard assumption of microeconomic theory is fulfilled, we can conclude the generalized theory of crime seems to imply that the characteristics of a criminal seem to be those of a person who somewhat dislikes criminal behavior (preferences without emphatics variables), does not have many good time alternatives, and seems NOT to be significantly deterred by punishment.

The last question seems particularly interesting for economists, because it seems plausible to maintain that one scheme of crime is that it generates a utility today, but at what cost come (maybe?!) tomorrow (Wilson 1985). What you are doing today must be paid for with some stream of cost of utility in the future, meaning it is not really the utility value of action we are considering, but the discounted utility of that action. Some economists have tried to interpret this in new models (e.g. Imai 2004, Grass,D. 2008, McCrary 2009)

The discounting of punishment (the special case)

Typically, when agents commit very costly crimes, which highly surpass their initial wealth, societies have to come up with some other alternatives than simply money-transfers. Throughout history, fantasies have been great with respect to alternative punishment (see.e.g. Miller 2005 for an historical overview). But in modern times, it all seems to end up with imprisonment as noted in Foucault’s famous critique (Foucault 1975) This peculiar form of punishment does of course have a caveat.

At this stage, let us consider some rather simple generalized function, determined by the agent’s net present utility of crime in the period between: $[0, a]$. Suppose the agent discount factor could be handled as a constant, which we will denote θ.

The generalized maximizing problem then becomes:

(18)
$$MaxU(t) = \int_0^a U(t_1, t_2 \ldots . t_n, \phi_1(t_1), \phi_2(t_2) \ldots . . \phi_n(t_n))e^{-\theta T}dT$$
$$St. \sum_{i=1}^{n} t_i = 1$$

The solution to this problem is “not dynamic” because the agent is simply maximized at the particular point in time. Therefore the solution is:

(19)
$$\frac{\partial u(B_k)^*}{\partial t_k} * t_k = t_j * \frac{\partial u(B_j)^*}{\partial t_j}$$

This is exactly the same solution as previous. Hence, nothing has been gained in the analysis; now, we have simply included the discount factor in the problem. The discount factor just means that the present value of punishment will somehow be diluted. To see this more easily, let´s define: t_i as all possible human action. $t_j^{'}$as all possible sort of non-criminal act, and t_k° as all possible sorts of criminal acts that will generate some sort of expected punishment ϕ.

So $t_i = t_j^{'} + t_k^{\circ}$ and $t_j^{'} \in t_i$and $t_k^{\circ} \in t_i$. If a person picks his action purely from elements in $t_j^{'}$ in the time interval $[0, b]$ we have that $t_i = t_j^{'}$, and the **net present discount value** of that sequence of action (npv) could be determined as;

(20) $$npv(t_j^{'}) = \int_0^b e^{-\theta T} u(t_j^{'})\, dT$$

If a person picks his action from all the elements in t_i , the present discount value must take into account that there is some expected punishment, which we suggest will take place. That means the agent faces the following utility maximizing problem of time allocation between 0 and b:

(21) $$npv(t_i) = \int_0^b e^{-\theta T} u(t_i)\, dT + \int_a^b e^{-\theta T} u(\phi_i)\, dT$$

Hence the criminal must take into account that in the time interval $[0, b]$ there will be some punishment from the period $[a, b]$:

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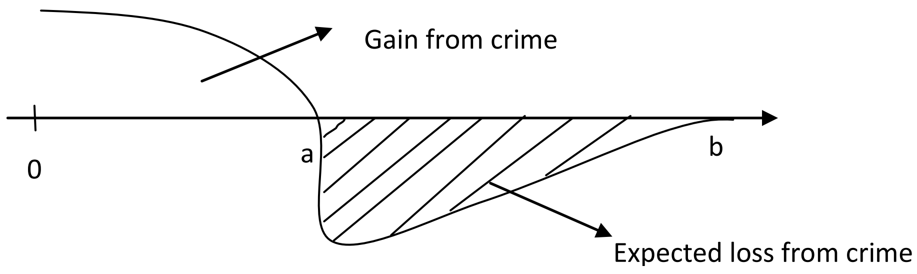

Figure 6: Gains comes first and cost comes later.

Hence a criminal person must take into account the discounted net loss (The area from a to b) when he decides to involve in some illegal action in the time interval $[0, a]$ that gives some benefit (the area from 0 to a). It is evident, that,

(22) $$\lim_{\theta \to \infty} \rho(t^{\circ})u(c(\tau)) -> 0$$

So, as θ grows larger, the expected loss from crime becomes smaller! Hence, there can be no deterrence of a person, who now has a very large discount factor because he simply acts impulsively (not thinking about the future very much). Notice however, that a high discount factor does **not** imply anything regarding the analysis of rational/ irrational behavior. A high discount factor could easily be interpreted as highly rational. What it does mean, however, is that a central planner is not able to fully control crime by deterrence via imprisonment if some persons have a very high discount factor. In such a case, the elasticity is 0.

How likely is this situation? The answer is that it is not very likely. Some people truly are insane, and therefore, seem to have an extremely high discount factor. And some people truly are fanatics, not afraid of any sort of deterrence. But these must be special stories, maybe interesting in the news, but absolutely not the standard case regarding crime. Think about it. Even an animal is able to discount. A thief does indeed go out at night. People do not sell drugs at Saks of Fifth Avenue. And nobody seems to be afraid to be in Central Park in the middle of the day. What people seem to be worried about is situations where there is only a small chance that bad persons will be caught; for example, in “bad neighborhoods, when it is dark”, which is just another way of saying we actually believe, in general, the discount factor is not infinite. The sociological story of high discounting as the “general theory of crime” (Wilson, 1985; Gottfredson, 1990), seems therefore implausible.

That´s not to say the discount problem shouldn’t be a consideration. I believe it should. It´s actually an important issue, because typically you are trying to punish people with time, sending them to jail. Even a small discount factor could easily dilute the deterrence of time spent in jail, meaning that jailing is (perhaps) not a highly efficient weapon of deterrence. Especially not, if at the same time, you have a very low discounted income. This is just another way of saying that fines or direct monetary compensation to the victims, could be considered, in many cases, as a more effective and efficient way of raising the cost of doing crime[3].

The Income Approach

Even though it is powerful, the utility approach to criminal behavior could sometimes be misleading. It is very easy for critics of the economic approach to find counter examples, where the assumptions behind rationality are not fulfilled. The newspapers seem full of examples of criminal behavior where the economic approach seems out of touch with reality. Maybe Bentham was wrong in trying to analyze crime as a utility cost-benefit problem, because while this surely catches the general idea, it also leaves us with a general problem of many counter-examples. Most crime is, anyhow, more or less a game many people play to generate higher income. Even violent crime, which at first sight could seem irrational, has in many cases some correlation to "business." So why not, instead, simply see criminals as single-owned companies or group-owned companies (Gangs) trying to maximize income? Then, we skip persons who sometimes truly are non-rational, and instead concentrate on those criminals who are actually very rational indeed. In general terms, criminal behavior could then be stated as:

(23)
$$\max I = (W_1\,(t_1) * t_1 + W_2(\mathrm{t}^{\circ}) * \mathrm{t}^{\circ} - \phi^{e}(\rho, \tau, \mathrm{i}) * \mathrm{t}^{\circ}$$
$$s.t.\;\; t_1 + \mathrm{t}^{\circ} \equiv 1$$

Where time allocated to crime is denoted t° and $t_1$is alternative income from legal income, we assume that $t_1 + \mathrm{t}^{\circ} \equiv 1$, so that the time spent for total income is fixed. $W_1(t_1) * t_1$ is, therefore, income from legal activities, where w_1 is the wages per time unit of activity $t_{1..}$ $W_2(\mathrm{t}^{\circ}) * \mathrm{t}^{\circ}$is income from non-legal activities where w_2 is the wages per time unit of activity

[3]This is the main point in Becker 1968, and as I see it, one of the most important points in economics regarding crime. Why do we calculate the price of human action in time (time spent in jail) instead of calculating the price in monetary terms, as we actually did before "the birth of the prison"? (see for example: Foucault, Michel. *Discipline and Punish: The Birth of the Prison* 1975)

t_2. Non-legal activities, t°, comes with an expected price $\boldsymbol{\phi}^e$ per unit spent on crime. The expected price will be a function of the probability of being caught, harshness of the punishment,τ, and some discount factor i.

It should be quite reasonable to assume that the agent is facing a decreasing return from committing crime, because “the low fruit” from criminal projects will be done first, meaning that: $\lim_{t^{\circ}\to\infty} W_2(t^{\circ}) -> 0$ and $\lim_{t^{\circ}\to 0} W_2(t^{\circ}) -> \infty$. Assume further, for simplicity, that the alternative W_1 is a constant; hence, we are able to form the simple intuitive problem:

(24)
$$\max I = (W_1 * t_1 + W_2(t^{\circ}) * t^{\circ} - \phi^e(\rho, \tau, \mathrm{i}) * t^{\circ}$$
$$s.t.\ t_1 + t^{\circ} \equiv 1$$

Forming the Lagrange:

(25)
$$L = w_1 * t_1 + W_2(t^{\circ}) * t^{\circ} - \phi^e(\rho, \tau, i) * t^{\circ} + \lambda(1 - t_1 - t^{\circ}) = 0$$

And we get:

(26)
$$\frac{\partial I}{\partial t^{\circ}} = -w_1 + w_2{}'(t^{\circ}) - \boldsymbol{\phi}^{\boldsymbol{e}}(\rho, \tau, \mathrm{i}) = 0$$

Or:

(27)
$$w_2{}'(t^{\circ}) = \boldsymbol{\phi}^{\boldsymbol{e}}(\rho, \tau, \mathrm{i}) + \boldsymbol{w_1}$$

This first order condition is exactly as we should expect. Optimally, the marginal value of committing a crime must match the expected cost plus the alternative value of allocating time to legal activities.

Graphically this says that:

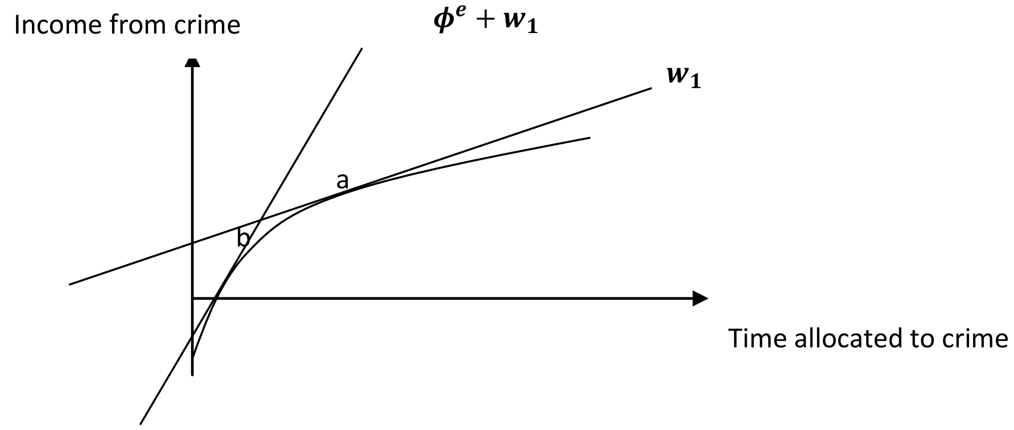

Figure 7: Higher punishment means lower income from crime (Point a is the optimizing amount of time, allocated to doing crime, and b is the optimizing amount, after an expected punishment had been introduced.)

Doing something against crime, meaning making ϕ^e or w_1 higher, is in most cases costly. What is even worse is made clear from the above: that we should expect it to be even more difficult to combat crime as we become more economically successful. The reason is $\lim_{t^\circ \to 0} W_2(t^\circ) -> \infty$, meaning that the return from non-legal activities would be infinite at the margin. Hence, we have an important logical result; namely, that a non-crime society does not exist. Or, speaking differently; that the cost of combating crime, would be infinite at the margin.

If such an income approach to crime is correct, we are able to give some prediction pattern for the people in the business of crime. The general criminal is a person who has:

1. Low market value in the legal-sector; e.g. low human capital.
2. High human capital in the non-legal sector (Low degree of empathy, impatient, not afraid of punishment, not afraid of police, and so on)

If criminal behavior is a general trait in human nature, it will be impossible, because of diminishing return, to eliminate crime or at the least; we should expect the cost in the end would outstrip the benefit. Hence, we should, therefore, assume that a general stable equilibrium should exist.

A bang bang example of the income approach to crime

To illustrate the power of thinking of criminals as "single-owned companies," let's take an example of a young man, who has to make a choice between going to school and building human capital, h, or selling drugs on the street. If he is going to school, his production, for some given market price, w_1, would rise later. The unit price of building human capital is $\widetilde{\mathrm{M}}$, which is the fee for schooling, and w_2, which is the net benefit (after consideration of the expected value of punishment, selling drugs). We will assume that the cost of building human capital is linear, which means that we have:

(28) $$c(h) = (\widetilde{M} + w_2)h$$

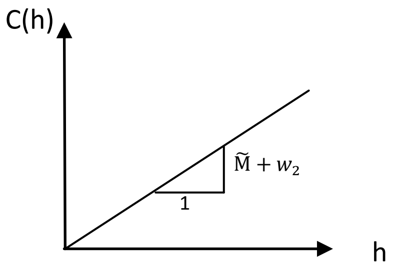

Figure 8: Cost of building human capital is linear

$\widetilde{\mathrm{M}} + \mathrm{w}_2$is therefore the price of adding one extra unit of human capital. We further assume that our single-owned company is able to produce more Q, as the amount of human capital is higher. So:

(29) $$Q = f(h)$$

We assume that the Inada condition is fulfilled, so we assume that the function f follows the Inada conditions: that means that the production function f, $\mathbb{R}_+ \rightarrow \mathbb{R}_+$ should satisfy $f_h(0) = 0$, $f_h^{'}(0) = \infty$, $f_h^{'}(\infty) = 0$

Further, let's define δ as the rate at which human capital deteriorates, and w_1 as the market price of production, ρ as the time preference, and let I be the rate of investment in human capital. Therefore, our single-owned company (young potential drug dealer) has to solve in the time interval $[0; T]$ the following problem:

(30) $$\max \int_0^T e^{\rho t}\left\{w_1(t)f[h(t)] - (\widetilde{M} + w_2)I(t)\right\}dt$$

S.t.

$$\dot{h} = I(t) - \delta h(t),$$

$$h(0) = h_0$$

and $0 \leq I(t) \leq b$ *(0 is the lower bound and b is the upper bound)*

The question now is how much human capital to accumulate, creating higher production, and therefore, income in the future, vis-à-vis, leaving school and selling drugs. It is important to note the price of building human capital is, therefore, an alternative cost (What could be created in the streets as an alternative). The current value of the Hamiltonian is (suppressing t as an argument is):

(31) $$H = \left\{w_1 f(h) - (\widetilde{M} + w_2)I + \lambda(I - \delta h\right\}$$

The costate variable must satisfy;

(32) $$\dot{\lambda} - \rho\lambda = -\frac{\partial h}{\partial h} = -w_1 f'(h) + \lambda\delta$$

(33) $$\widetilde{M} + w_2 = \lambda$$

And we are able to create the system of differential equations as:

(34) $$\dot{\lambda} = \lambda(\rho + \delta) - w_1 f'(h)$$

(35) $$\dot{h} = I - \delta h$$

The first boundary condition, securing a unique solution, is provided by $h(0) = h_0$.

Because h(t) is free, the second boundary condition is provided by the transversality condition $e^{-\rho T}\lambda(T) = 0$

This is a standard optimal problem in capital theory[4], so we move directly to the solutions:

(36) $$w_1 f'(h) = (\widetilde{M} + w_2)\left(\rho + \delta - \frac{(\dot{\widetilde{M}+w_2})}{(\widetilde{M}+w_2)}\right)$$

This simply says that any agent must choose a path where the optimal stock of human capital and the marginal value of adding one more unit of capital is equal to the marginal cost of adding one more unit of capital. In this case, the marginal cost is $(\widetilde{M} + w_2)\,\rho$, which is foregone interest plus $(\widetilde{M} + w_2)\delta$ which could be viewed as depreciation.

Setting $(\dot{\widetilde{M} + w_2}) = 0$ and $\dot{w}_1$=0, we have a system of autonomous differential equations. Further, let $\dot{\lambda}$ =0 and we get the isocline as:

(37) $$\lambda = \frac{w_1 f'(h)}{(\rho+\delta)}$$

Then drawing the phase-diagram, with the boundaries, we get the following;

[4] See for example *Further Mathematics for Economic Analysis*; 2008, Sydsætter, Hammond, Seierstad, Strøm

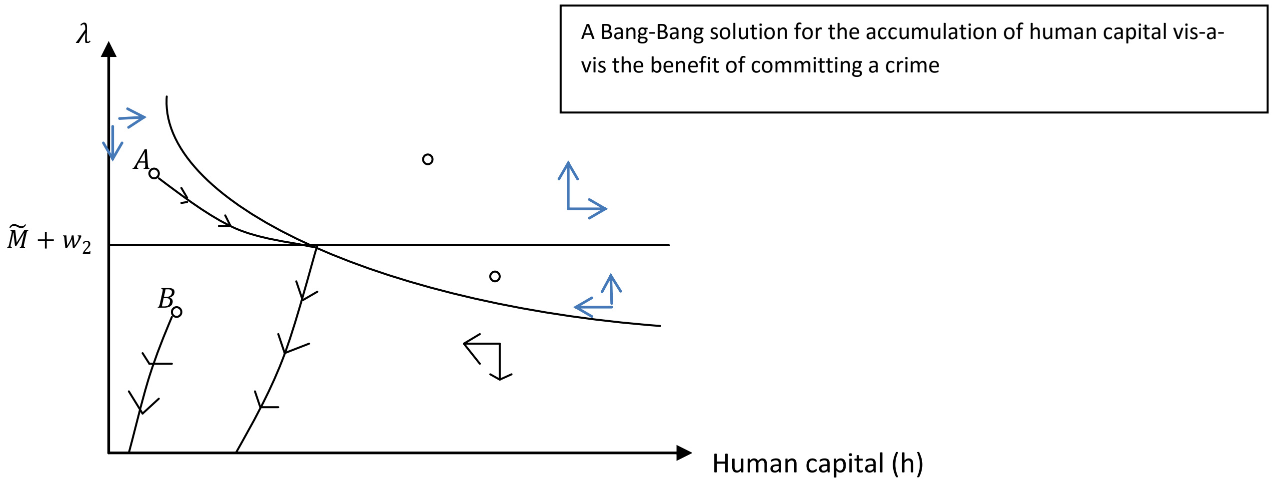

Figure 9: The dynamics of crime vis-à-vis schooling.

The very center of this maximizing problem is the very reasonable idea that the agent is facing a linear cost in human capital (1). Hence, this mean it is either profitable to accumulate human capital as much as possible, or it is not! There is no smooth middle way. This means that if a person is over line $\widetilde{\mathrm{M}} + \mathrm{w}_2$ (e.g. point A), he would accumulate as much capital as possible, and then when he reaches steady state, immediately leave (bang and bang). However, at point (B), the cost of accumulating human capital is too high, so our agent would never accumulate and never reach the steady state.

Intuitively, the result is quite clear. If there is linearity in the cost of accumulation of human capital, a person (A) will accumulate human capital as fast as possible. Hence, he will never be attracted to the streets, because this will lower his intemporal income. When accumulation is complete, he will, in this case, let his human capital deteriorate, harvesting his higher marginal product. If the agent is in point (B), for example selling drugs, is simply too attractive – so he would never start building human capital, but instead leave his human capital to deteriorate.

This kind of model points intuitively to some very compelling results. The important observation is that an agent would start to build human capital if $\frac{\mathrm{w}_1 \mathrm{f}'(\mathrm{h})}{(\rho+\delta)} > \widetilde{\mathrm{M}} + \mathrm{w}_2$ or

(38) $$w_1 f'(h) > (\widetilde{M} + w_2)(\rho + \delta)$$

Hence, everything critically depends on whether the benefit of accumulating human capital is higher than the cost of doing so. From the central planner's point of view, it is at least partly possible to control $\widetilde{M}$ (the cost of schooling) and w_2 (the net benefit from selling drugs) However, a lot critically depends on the agent's perception of his **production function** and the marginal benefit from accumulating human capital, the **deteriorate rate**, and, I think, very importantly, the **discount factor**. If the individual is very impatient, and the value of $w_2 > 0$, it can be nearly impossible to keep such an individual off the streets. Hence, this kind of model seems to suggest that low schooling cost in combination with high and tough punishment, could at least partly offset impatient agents.

Conclusion

In 1968, Becker proposed an economic general theory of crime, thereby conflicting with the idea held by many positive criminologists that criminals, in general, are *sick*. There is still a lot of work to be done before the world is convinced that criminals, in general, are not *sick*, but merely optimizers, using the best of what they have (Becker, 1976). This paper has tried to cast more light on the issue, diving into the microeconomic foundations of criminal behavior. Even though the economic model is not perfectly true in all cases of crime, and even though some criminals truly are not rational in the economic sense, it should be very clear that the economic model is flexible enough to handle many general issues in criminology. In my opinion, from a perspective of social science, and from the perspective of the central planner, the only general model of crime is the economic model.

References:

Becker G. (1968). "Crime and Punishment: An Economic Approach." Journal of political economy76 (2) (march/april) 169-217

Becker G. (1976). The Economic approach to human behavior. U. o. C. Press. University of Chicago Press.

Bentham J. (1789). "The Principles of Morals and Legislation.

http://socserv.mcmaster.ca/econ/ugcm/3ll3/bentham/morals.pdf

Dhami S., Nowaihi, Ali al (2013). An extension of the Becker Proposition to non-expected utility theory. Mathematical Social Science vol 65, Issue 1, January 2013 p.p 10-20

Ehrlich I. (1982). "The optimum enforcement of laws and he concept of justice: A positive analysis." International review of law and economics2 (1) pp.3-27

Eide E. , Rubin P.H. ,Shepherd, J.M. (2006). Economics of Crime.Foundations and Trends in Microeconomics 2(3) pp.205-279.

Foucault M. (1975). Dicipline And Punish; The Birth of Prison.Random House inc.

Gottfredson,M. R., Hirschi T. (1990). A General Theory of Crime, Stanford University Press.

Grass D., Feichtinger G., Tragler G., Caulkins J., Behrens D. (2008). "Optimal Control of Nonlinear Processes, with Applicationin Drugs, Corruption and Terror " Springer-verlag Berlin.

Hayek F. A. (1973-79). "Law, Legislation and Liberty: A new Statement of the Liberal Principles of justice and Political economy vol.1-3.Routledge

Imai S., Krishna K (2004). "Employment, Deterrence, and Crime in a Dynamic Model." International Economic Review 45(3) p.845-872

Jehle G., Reny P. (1998). Advanced Microeconomic Theory, Addison-Wesley Longman Inc

Kahneman D. (2003). "Maps Of Bounded Rationality;Psychology For Behavioral Economics." American Economic Review 93(5) p.1449-1475.

Kahneman D., Tversky A. (1984). "Choices, Values and Frames. Cambridge university press

Levitt S., Miles T. (2006). "Economic contribution to the understanding of crime." Annu.Rev law and social science2 p.147-164.

Marvell T.M., Moody C.E. (1996). "Specification problems. Policy levels and crime rates." criminology34 (4) P.609-646

Mas-Colell A., Whinston M. D., Green J. R. (1995). Microeconomic Theory. Oxford, Oxford University Press.

Mccrary J. (2009). Dynamic Perspectives on Crime Nber Working Paper. UC Berkeley.

Miller W. I. (2005). Eye For an Eye, Cambridge University Press.

Pinker S. (2002). The Blank Slate - The Modern Denial of Human Nature, Penguin Books

Polinsky M., Shavell S. (2006). Public enforcement of law. Handbook of law and economics. Amsterdam, Holland/elsevier sci.

Wilson H. (1985). Crime and Human Nature: The Definitive Study of The Causes of Crime. . New York, Simon & Schuster.