

Education, Labor and Crime: A three-periods time-allocation model

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Abstract

This article aims at studying the impact of a given incentive scheme on criminal behavior. A dynamic model of time allocation between investment in human capital, labor and criminal activity is developed, assuming that these activities are substitutable and endogenous. Several results appear, among which our attention focuses on the transmission channels of legal opportunities long-term influence of the severity of sanctions. Two extensions are discussed to manage the ambiguity of an increase in repression: heavier penalty for repeat offenders and compensation of stigma on legal market.

Keywords : Crime, Time allocation, Sanction.

JEL : J22, K14, K42.

Introduction

Each government is looking for a balance to establish a security policy, both by encouraging the legal activity and discouraging illegal activity. For example, in France, few prison laws have been as challenged as the Act of August 10, 2007 on minimum sentences for repeat criminals and offenders. The dynamics appears to be of paramount importance to understand and discuss such kind of law because crime is precisely a dynamic decision taken during different periods of life. In this paper, several results are highlighted, among which two issues draw more specifically our attention: firstly, youth unemployment and the return on investment in human capital; secondly, the long-term influence of the punishment structure. In the first section, we paint a panorama of theoretical and empirical work to provide an economic rationalization of the crime; the second section presents a dynamic model of time allocation; the third section discusses the implications of this model.

1 - Which economic rationalization of crime?

The idea that offenders respond to the costs and benefits of crime dates to the eighteenth century, when Beccaria and Bentham discussed the concept of deterrence. Becker (1968), then Ehrlich (1973, 1975), provided the first modern and mathematical treatment of the subject, giving a new impetus to the school of thoughts initiated in the 18th century. The main contributions of crime economics can be split into two main categories: the first category of work aims at studying the effects of legal opportunities while the second focuses on risks and costs induced by the choice of illegal activity.

1.1 – The impact of legal opportunities on crime

Most of economic results based on the role of legal opportunities relate to labor market. Many studies, following the work of Ehrlich, have examined the link between labor market functioning - through unemployment or wages - and the level of crime, both by theoretical models, highlighting the arbitration process of the potential criminal, and empirical works which examined the relation between crime rates and their potential determinants through time and space.

The earliest works on the relationship between labour markets and crime focus on the influence of unemployment. A correlation is generally observed between unemployment and crime rates, even if causality and elasticity are not consensual. This knowledge was refined during the 1990s. Gould et al. (1998) studied 582 English counties during the 1980s. They confirmed empirically a strong positive link between unemployment and crime against property. Fougere et al. (2005) confirmed on the basis of data from French Departmental districts, that youth unemployment is one of the main determinants of crime level, notably against property. Results have also been found on the influence of wages. Gould et al. (1998) showed that declining wages for non high school graduates were accompanied by an increase

of various forms of crime. Machin and Meghir (2000), confirm such a result with an analysis of English and Walsh counties over the period 1975-1996¹.

Besides, several studies have been undertaken to assess the efficiency of programs targeting at enhancing legal opportunities. Human capital is central in such a process and must be accumulated through long terms programs as highlighted by the estimations of the University of Maryland (1997). The Perry School Program is probably the best known of them and shows very significant results as demonstrated by several studies (Greenwood et al., 1996; Wilson et Hernstein, 1985). The targeting of such programs to the least educated people seems to be of paramount importance to improve efficiency (Donohue and Siegelman, 1998). Similarly in Europe, the Swedish KrAmi program promotes the integration of young people by education and training programs (Nystrom, 2003). Yet, even if Lochner (2004) formalizes the channels by which human capital plays a key role in the time allocation process between legal and illegal activities, little theoretical evidence has been produced on the dynamics of choice between human capital, labor and criminal activity. The first input of the model is precisely to address such a dynamics.

1.2 – Risks and costs of illegal activity: the impact of sanctions

Two elements must be distinguished in the punishment structure: deterrent effect and incapacitation effect. The economic model formulated by Becker is based on the first one, whereas the goal of incapacitation is to restrict the opportunities for the infliction of harm on others. Shavell (1987) developed a model that evaluated when incapacitation is an optimal policy, but empirical works only begun to distinguish deterrence and incapacitation. Freeman (1997) opposes this approach, arguing that criminal activity is itself subject to a market: if the number of criminals behind bars increases, the profitability of illegal activity is expected to increase, producing new entrants in the illegal market. Thus, there would be a crime equilibrium in which there is not incapacitation effect. If the empirical tests of Levitt (1998) confirm the predominance of deterrence effect, it seems difficult to measure precisely the impact of the two effects.

The probability of being caught is the first lever to discourage criminal activity and the extent of such a dissuasion effect is of prime importance (Nagin, 1998). As deterrence is costly, the basic framework establishes an optimal penalty structure in case of fine as well as imprisonment (Becker 1968 ; Polinsky and Shavell, 1979). Subsequent models have explored the consequences of relaxing various assumptions of the model, examples including limited information (Bebchuk and Kaplow, 1992 ; Garoupa, 1999). Several empirical works have confirmed the influence of the probability of apprehension. Cormann and Mocan (2002) conduct an empirical study of crime in New York. They give credit to the theory of “broken window” popularized by Mayor Rudolph Giuliani and proposed a decade earlier by Wilson and Kelling (1982): the authors take as variable the number of arrests for minor offenses and find a significant elasticity leading them to conclude that the government should increase the number of arrests for minor offenses. Other studies – mainly in the United States – help to a better understanding of the relation between probability of apprehension and crime levels. For

¹ The role of wages can also be analyzed through the prism of income inequality, robustly related to the increasing incidence of crime against property (Chiricos, 1987 ; Freeman, 1994 ; Land et al., 1990). For violence, Merton (1938) or Shaw and McKay (1942) showed that income inequalities are source of social tensions, disorganization and, therefore, of violent crimes. For empirical tests, see Blau and Blau (1982), Kelly (2000) or Fajnzylber et al. (2002).

example, major cities, all things being equal, have higher crime levels than smaller cities. For Glaeser and Sacerdote (1999), a part of this difference can be explained by a lower probability of being caught (according to them, about 20% of the variance between geographical areas). The number of police is of the main levers on the probability of arrest. One of the most prominent empirical studies was the quasi-randomized experiment in Kansas City (Kelling et al., 1974). But, it seems difficult to establish a causal link between the evolution of police and crime levels: since an increase in police often responds to a resurgence of crime, a positive correlation between the two variables does not demonstrate necessarily the failure of police as shown by many studies (Taylor, 1978; Cameron, 1998). An instrumental variable affecting police forces without directly modifying the agents' preferences between legal and illegal activities can overcome this bias. Levitt (1997) focuses especially on election periods, during which an *exogenous* increase in police is usually observed due to citizen concern for security. He finds a significant negative elasticity between police and crime. With a Granger causality technique, Marvell and Moody (1996) also found that increases in police were associated with future declines in crime. Finally, other works focus on the link between probability of apprehension and police technologies. For example, it seems that the use of an extended DNA base would improve the solving of crimes (Donohue, 2005).

Several studies also focus on the impact of the severity and type of sanction. There is a difference between socially costly sanctions and fines. In case of fines, the optimal level depends on the offender's risk aversion (Polinsky and Shavell, 1979 and 1984). In case of imprisonment – the basecase of our paper - most of theoretical and empirical works show a decrease in crime levels - at least in the short term - when sanctions are increased (Kaplow, 1990; Levitt, 1995 and 1996). However, economists have produced little evidence on the effectiveness of incarceration in reducing long-term crime. Indeed, basing economic results on one period may be misleading. As highlighted below, the increase in severity - including imprisonment - creates a drop in long-term employability due to obsolescence of human capital and social stigma (Rasmussen, 1996; Waldfogel, 1994; Lott, 1992). As it becomes more difficult to find a job on the legal market, there is an adverse change in the arbitrage process between legal and illegal activities. Thus, if we analyze several periods, the impact of prison on crime levels appears to be more complex (Furuya, 2002). But, little has been done theoretically on the dynamics of choice in a given penalty structure. The second input of our model is precisely to understand such a dynamics in case of stigmatization on legal market, and discuss solutions to manage the ambiguity of penalty severity. More generally, as several variables play a role in the incentive scheme², we develop a dynamic model of time allocation between investment in human capital, labor and criminal activity, assuming that these activities are endogenous and substitutes.

² Social interactions, even if not taken into account below, can be of importance to explain crime. In the model proposed by Glaeser et al. (1995), the utility of agents is partly based on the observed actions of other agents, thereby justifying an imitation process and a collective equilibrium (See also Sampson et al., 1997). Sah (1991) also highlights the role of social interactions in case of informational imperfection among groups. This may be the case when there is an uncertainty about police and judicial abilities. More generally, the peer effects can act in five ways on criminal decisions 1) The agents may seek information on their type from the environment in order to build own identity 2) Social environment can be of importance in the positioning of potential criminals vis-à-vis the victim 3) A symbolic gain can be considered in case of behavior in line with relatives 4) There could be a collective gain in case of cooperation: more criminals means fewer chances of being caught 5) Finally, the group brings information to the agent in a context of informational imperfection. These five channels help us to understand most of social interaction effects in the criminal choice.

2 – A theoretical model of time allocation between legal and illegal activities

We develop a three periods model of time allocation in which three periods are distinguished: the period when the individual is a minor and usually carries out his legal activities in school; youth, when he usually starts working; more mature age when the agent can have already been the subject of consistent indictment sentences. During each period, a representative agent chooses to allocate time between legal and illegal activities: between education allowing and a criminal activity during the first period; between labor and a criminal activity during the second and third periods. The agent wants to maximize income over the three periods. Two independent markets are considered: one for legal activities, the other for illegal activities. Several assumptions can be made. First, we consider as Ehrlich (1973) that legal and illegal activities are substitutable and not complementary. Obviously this assumption is a simplification of reality since illegal earnings may appear outside as inside of a given legal working framework. Then, we assume that the potential offender is risk neutral. Finally, the actualization rate – and its differences among individuals – is not addressed³.

2.1 – A decision model for the potential offender

Let's see the arbitration process of a given agent between legal and illegal markets during the three periods. t_1, t_2, t_3 correspond to the time allocated to illegal activity during the three distinct periods. For simplicity the duration of each period is standardized to one. Thus, the times allocated to legal activities during these three periods are: $1-t_1, 1-t_2, 1-t_3$. These times can be zero or one for each individual, with corner solutions in order to have no negative values.

First Period

During the first period the agent has no legal revenue. Thus, there is a time allocation between investment in human capital and illegal activity. The latter is remunerated but risky. The expected monetary value earned in first period can be written as follows for a risk neutral individual:

$$V(t_1) = It_1 - \pi ft_1^2$$

I denotes the productivity of criminal activity, ie the income derived per unit of time dedicated to illegal activity (possibly including psychological costs). π represents the probability of being caught *per unit of time dedicated to illegal activities* (we assume linear relation between time devoted to illegal activity and the probability of being caught). It is consistent to assume that the probability of being caught increases with the involvement in crime. Finally, f is the intensity of the penalty imposed on a criminal *per unit of time dedicated to crime* (we assume linear relation between time devoted to illegal activity and the intensity of the sanction). It is also consistent to assume that punishment will be heavier that involvement in illegal activities is important (even if all the crimes are not known by the court). The two last assumptions will be kept in second and third period.

³ For dynamic model with actualization rates and optimal deterrence over several periods, see Davis (1988).

Second period

During the second period, the individual may have a remunerated legal activity. In case of unemployment, the latter earns only a part of their wage. The probability of unemployment appears to be of tremendous importance in time allocation between legal and illegal activities. As part of our model, investment in human capital during the first period influences such a probability. We consider that it can be written:

$$p_c = p_c(t_1) = p_0 - \kappa(1 - t_1)$$

p_c denotes the probability of being unemployed, and p_0 is a baseline probability, linked with the economic situation and the labor market functioning. In the model, human capital investment during the first period affects the income earned in the second period through the probability of unemployment. The more the time spent to develop human capital - as opposed to the choice of illegal activity - the less the probability of unemployment. κ is an estimate of the return on investment in human capital. This parameter of efficiency can be supposed exclusively individual (intellectual and physical ability, concentration, courage...) or partially due to governmental action.

During the second period, the agent has two possible sources of revenue: the legal income received for each unit of time dedicated to legal activity and the illegal income related to criminal activity. The agent allocates time between these two sources of income. It is possible to write as follows the expected monetary value earned in second period for a risk neutral individual⁴:

$$V(t_2) = s(1 - t_2)(1 - p_c(t_1) + ep_c(t_1)) + It_2 - \pi ft_2^2$$

Where s is the income earned by the agent per unit of time dedicated to legal activity and e is the fraction of this income in case of unemployment. The influence of these two parameters can be ambiguous and will be addressed in this model.

Third period

First, we assume that human capital accumulation during the first period has no influence on the probability of unemployment during the third period. The underlying idea is that diploma has a tremendous importance for youth employability, but significantly less for older people. The first periods has an impact on the last period through the following mechanism: someone who has been sentenced to heavy criminal punishment (typically a prison sentence) is stigmatized on legal market. Therefore, the probability of unemployment will be higher than for someone who do not bear this stigma.

The probability of unemployment during the third period can thus have two values:

- p_c' , if the individual has not been convicted

⁴ The accumulation of human capital in « crime industry » is not taken into account in this model. Thus, marginal benefit as well as marginal probability of arrest are not affected by the time dedicated to crime in the first period. Strictly speaking, we should also model this particular accumulation of human capital.

- $p_c' + \sigma(f)$, if the individual has already been sentenced to a penalty causing stigma on labor market. We analyze more precisely later how this logic of stigma works, assuming that this parameter is related to the severity of the sanction, through an increasing function denoted $\sigma(f)$.

For a time t_3 dedicated to illegal activity, the expected monetary value earned by a risk neutral individual can be written as follows⁵:

$$\begin{aligned} V_{nc}(t_3) &= s(1-t_3)(1-p_c' + ep_c') + It_3 - \pi ft_3^2, \text{ if the individual has not been convicted} \\ V_c(t_3) &= s(1-t_3)(1-(1-e)(p_c' + \sigma(f))) + It_3 - \pi ft_3^2, \text{ if the individual has already been} \\ &\text{sentenced to a penalty causing stigma on labor market.} \end{aligned}$$

2.2 – Resolution of the program

In case of a rational and risk neutral agent maximizing the expected monetary value over the three periods (if no preference for the present, which is a strong assumption), the optimization program consists to choose the three durations t_1, t_2, t_3 .

Third period

If the agent has not been sentenced heavily during the second period, the optimization program is based on a probability p_c' of being unemployed:

$$V_{nc}(t_3) = s(1-t_3)(1-p_c' + ep_c') + It_3 - \pi ft_3^2$$

The first order condition gives us a unique interior solution:

$$t_{3nc}^* = \frac{I - s(1 - p_c'(1 - e))}{2\pi f}$$

If $0 < I - s(1 - p_c'(1 - e)) < 2\pi f$ ⁶

⁵ The marginal probability of being caught for the convicted criminals is assumed to be the same as for those who did not. Strictly speaking, they may differ for several reasons. First, because criminals have acquired "knowledge" over time, which should make them more able to evade the police. On the other hand, the police and judicial may have kept traces of them (DNA, crime patterns...) which should make investigations more efficient. The combined impact of these two opposite effects is a priori ambiguous, and we consider that the marginal probability of apprehension is not affected by prior convictions.

⁶ If this condition is not verified, we have corner solutions: $t_{3nc}^* = 0$ if $I - s(1 - p_c'(1 - e)) < 0$ (non negative values). And $t_{3nc}^* = 1$ if $I - s(1 - p_c'(1 - e)) > 2\pi f$ (maximal time devoted to illegality is 1). These two cases correspond to limit cases in which the representative agent dedicates time exclusively to legal or illegal markets.

We can then write the expected monetary value earned after maximizing revenue:

$$V_{nc}(t_{3nc}^*) = s(1 - t_{3nc}^*)(1 - p_c' + ep_c') + It_{3nc}^* - \pi ft_{3nc}^{*2}, \text{ and then :}$$

$$V_{nc}(t_{3nc}^*) = \frac{\left[I - s(1 - p_c'(1 - e)) \right]^2}{4\pi f} + s(1 - p_c'(1 - e))_7$$

If the individual has been sentenced to a penalty causing stigma on labor market, the optimization program is based on a probability $p_c' + \sigma(f)$ of being unemployed:

$$V_c(t_3) = s(1 - t_3)(1 - (1 - e)(p_c' + \sigma(f))) + It_3 - \pi ft_3^2$$

The first order condition gives us a unique interior solution:

$$t_{3c}^* = \frac{I - s(1 - (1 - e)(p_c' + \sigma(f)))}{2\pi f}$$

$$\text{If } 0 < I - s(1 - (1 - e)(p_c' + \sigma(f))) < 2\pi f_8$$

Then, we can write the expected monetary value earned after maximizing revenue:

$$V_c(t_{3c}^*) = s(1 - t_{3c}^*)(1 - (1 - e)(p_c' + \sigma(f))) + It_{3c}^* - \pi ft_{3c}^{*2}, \text{ and then :}$$

$$V_c(t_{3c}^*) = \frac{\left[I - s(1 - (1 - e)(p_c' + \sigma(f))) \right]^2}{4\pi f} + s(1 - (1 - e)(p_c' + \sigma(f)))_9$$

⁷ For corner solutions, we have : $V_{nc}(t_{3nc}^*) = s(1 - p_c'(1 - e))$, if $t_{3nc}^* = 0$, and $V_{nc}(t_{3nc}^*) = I - \pi f$, if $t_{3nc}^* = 1$.

⁸ If this condition is not verified, we have corner solutions : $t_{3c}^* = 0$ if $I - s(1 - (1 - e)(p_c' + \sigma(f))) < 0$; $t_{3c}^* = 1$ if $I - s(1 - (1 - e)(p_c' + \sigma(f))) > 2\pi f$.

⁹ For corner solutions, we have $V_c(t_{3c}^*) = s(1 - (1 - e)(p_c' + \sigma(f)))$, if $t_{3c}^* = 0$, and $V_c(t_{3c}^*) = I - \pi f$, if $t_{3c}^* = 1$.

Comparing the two situations, it is obvious that stigma changes behaviors, with more time dedicated to illegal activities. This is consistent, since the expected gain on legal market is weaker for stigmatized individuals, making illegal market more attractive. We analyze later the key influence played by the severity of the penalty on crime levels.

First and second period

Time allocations for the first two periods are simultaneously determined at the beginning of the first period. Indeed, time allocation in the first period has an impact on the probability of unemployment – and therefore time allocation - in the second period. Moreover, there is not any change of situation between the first and the second period. Thus, it is possible to simultaneously determine time allocation. In this perspective, the agent maximizes the expected monetary value earned over the three periods:

$$V = V(t_1) + V(t_2) + (1 - \pi t_2)V_{nc}(t_{3nc}^*) + \pi t_2 V_c(t_{3c}^*)$$

We can establish the two following relations:

$$t_2^* = \frac{I - s(1 - (1 - e)(p_0 - \kappa(1 - t_1^*))) + \pi(V_c(t_{3c}^*) - V_{nc}(t_{3nc}^*))}{2\pi f} \quad \text{if :}$$

$0 < I - s(1 - (1 - e)(p_0 - \kappa(1 - t_1^*))) + \pi(V_c(t_{3c}^*) - V_{nc}(t_{3nc}^*)) < 2\pi f$ ¹⁰, which depends on the first time t_1^* allocated to crime.

$$t_1^* = \frac{I - s\kappa(1 - e)(1 - t_2^*)}{2\pi f} \quad \text{if :}$$

$0 < I - s\kappa(1 - e)(1 - t_2^*) < 2\pi f$ ¹¹, which depends on the second time t_2^* allocated to crime.

The interior solutions of these two equations can be written as follows:

¹⁰ If this condition is not verified, we have corner solutions : $t_2^* = 0$ if $I - s(1 - (1 - e)(p_0 - \kappa(1 - t_1^*))) + \pi(V_c(t_{3c}^*) - V_{nc}(t_{3nc}^*)) < 0$;

$t_2^* = 1$ if $I - s(1 - (1 - e)(p_0 - \kappa(1 - t_1^*))) + \pi(V_c(t_{3c}^*) - V_{nc}(t_{3nc}^*)) > 2\pi f$.

¹¹ If this condition is not verified, we have corner solutions : $t_1^* = 0$, if $I - s\kappa(1 - e)(1 - t_2^*) < 0$;

$t_1^* = 1$, if $I - s\kappa(1 - e)(1 - t_2^*) > 2\pi f$.

$$t_1^* = \frac{I - s\kappa(1-e) \left(1 - \frac{I - s(1-(1-e)(p_0 - \kappa)) + \pi(V_c(t_{3c}^*) - V_{nc}(t_{3nc}^*))}{2\pi f} \right)}{2\pi f - \frac{s^2\kappa^2(1-e)^2}{2\pi f}}$$

$$t_2^* = \frac{I - s(1-(1-e)(p_0 - \kappa)) + \frac{s\kappa(1-e)}{2\pi f} (I - s\kappa(1-e)) + \pi(V_c(t_{3c}^*) - V_{nc}(t_{3nc}^*))}{2\pi f - \frac{s^2\kappa^2(1-e)^2}{2\pi f}}$$

Hereafter, we also study directly the variable $t_1^* + t_2^*$, which can be written:

$$t_1^* + t_2^* = \frac{2I + \pi(V_c^* - V_{nc}^*) - s(1-(1-e)(p_0 - 2\kappa))}{2\pi f - s\kappa(1-e)}$$

Thus, time allocation between the two markets can be calculated for the three periods as seen above. Such results are based on a supposed-rational arbitrage process between legal and illegal markets.

3 – Implications of the model - analysis and discussion

If the different populations have the same weight, the total time allocated to crime is proportional to the following expression:

$$T^* = t_1^* + t_2^* + \pi.t_2^*.t_{3c}^* + (1 - \pi.t_2^*).t_{3nc}^*$$

It is necessary to examine how this value depends on the different parameters, particularly if the government can modify them in order to change establish a security policy.

3.1 – Legal opportunities and choice of illegal activity: the role of human capital

The first parameter governing the allocation process is the unemployment probability¹². p_0 and p_c' correspond to the reference probabilities of unemployment during the second and

¹² Obviously, the productivity I of criminal activity, has a positive impact on crime levels. An exogenous change in I may be due to a change in the "industry of crime" which modifies the return on illegal activity. The structuring of an organized Mafia with codes of conduct, networks and courts is able to establish a kind of monopoly - or oligopoly if several Mafia coexist. It is also possible to analyze mafia struggle as a decrease in monopoly power and therefore productivity. These analogies with the theory of industrial organization explain

third periods and have a positive effect on crime dedicated to crime. These observations are consistent with most empirical studies. More important, the reference probability in third period has an influence during the two first periods. Indeed, time allocation during the first and second periods depends on the difference $V_c(t_{3c}^*) - V_{nc}(t_{3nc}^*)$. This expression - negative - is due to stigma on the labor market if the agent is apprehended and convicted during the second period. The greater the gap between the two values, the greater the stigma imposed. However, in absolute terms, it is possible to check:

$$\frac{\partial [V_c(t_{3c}^*) - V_{nc}(t_{3nc}^*)]}{\partial p_c} \leq 0$$

This means that if the reference probability of unemployment is high, the deterrent effect of a penalty imposed on labor market during the third period weakens. But, such a probability is assumed to be exogenous and it is also important to address the levers by which governments can deter crime. The return on investment in human capital, characterized by the parameter κ , is assumed to be endogenous. Thus, the probability of unemployment can be considered as endogenous both for the potential offender - it depends on the time dedicated to legal activity in the first period - and for the government - through the parameter κ , as seen above:

$$p_c = p_c(t_1) = p_0 - \kappa(1 - t_1)$$

Thus, the more the time spent to develop human capital in first period - as opposed to choosing an illegal activity - the less the probability of unemployment in second period. The influence of the parameter κ , which can be driven by public investment in education, is a priori ambiguous: there could be a kind of "substitution effect" as in certain models of time allocation between work and leisure. More efficiency in human capital accumulation could drive to increase time in illegal activities during the first period. It is possible to write:

$$\frac{\partial (t_1^* + t_2^*)}{\partial \kappa} = \frac{s(1-e) [2I - 4\pi f + \pi(V_c^* - V_{nc}^*) - s(1 - p_0(1-e))]}{[2\pi f - s\kappa(1-e)]^2}$$

In case of an interior solution, $t_1^* < 1$ and $t_2^* < 1$, then $t_1^* + t_2^* < 2$, which gives us :

$$2I + \pi(V_c^* - V_{nc}^*) - s(1 - (1-e)(p_0 - 2\kappa)) < 4\pi f - 2s\kappa(1-e), \text{ and :}$$

$$2I - 4\pi f + \pi(V_c^* - V_{nc}^*) - s(1 - p_0(1-e)) < 0 ; \text{ then } \frac{\partial (t_1^* + t_2^*)}{\partial \kappa} < 0.$$

As t_3^* does not depend on the parameter κ , we have: $\frac{\partial T^*}{\partial \kappa} < 0$.

the term of "industry of violence" (see notably the survey conducted by Franchetti and Sydney, in the late 19th century's Sicily, cited by Dickie, 2007).

Therefore, it appears that an increase in human capital accumulation efficiency does not lead the agent to spend more time on illegal market in first period as in case of “substitution effect”.

3.2 – Legal opportunities and choice of illegal activity: the role of wages and unemployment revenue

Income per unit of time dedicated to legal activity, denoted s , has clearly a negative influence on t_3^* in both cases: an agent previously convicted or not. What about the two first periods? For example, the agent could allocate much time to illegal market if s is high on the legal market. This would be a kind of “substitution effect” as in standard models of time allocation between work and leisure. If we base our analysis directly on the study of $t_1^*+t_2^*$, it is possible to write:

$$\frac{\partial(t_1^*+t_2^*)}{\partial s} = \frac{\kappa(1-e)[2I-4\pi f+\pi(V_c^*-V_{nc}^*)]-2\pi f(1-p_0(1-e))}{[2\pi f-s\kappa(1-e)]^2}$$

As the time dedicated to crime is not negative, we have necessarily:

$$s\kappa(1-e) < 2\pi f, \text{ which gives us :}$$

$$\frac{\partial(t_1^*+t_2^*)}{\partial s} < \frac{\kappa(1-e)[2I-4\pi f+\pi(V_c^*-V_{nc}^*)]-s(1-p_0(1-e))}{[2\pi f-s\kappa(1-e)]^2}$$

As seen above : $2I - 4\pi f + \pi(V_c^*-V_{nc}^*) - s(1-p_0(1-e)) < 0$; then $\frac{\partial(t_1^*+t_2^*)}{\partial s} < 0$.

$$\text{Thus: } \frac{\partial T^*}{\partial s} < 0.$$

Therefore, it appears that an increase in wages does not lead the agent to spend more time on illegal market as in case of "substitution effect".

However, the impact of generosity in the unemployment revenue (represented through the parameter e) is more ambiguous. Here again, the impact on the time allocated to illegal activity in the third period is negative. But the analysis of the impact during the first two periods is more difficult. It requires to study the expression of $t_1^*+t_2^*$. It is possible to write:

$$\frac{\partial(t_1^* + t_2^*)}{\partial e} = \frac{-s\kappa[2I - 4\pi f + \pi(V_c^* - V_{nc}^*)] + s(s\kappa - 2\pi f p_0)}{[2\pi f - s\kappa(1-e)]^2}$$

As the time dedicated to crime is not negative, we have necessarily:

$$s\kappa(1-e) < 2\pi f, \text{ which gives us:}$$

$$\frac{\partial(t_1^* + t_2^*)}{\partial e} < \frac{s\kappa[-2I + 4\pi f - \pi(V_c^* - V_{nc}^*) + s(1 - p_0(1-e))]}{[2\pi f - s\kappa(1-e)]^2}$$

$$\text{As, } 2I - 4\pi f + \pi(V_c^* - V_{nc}^*) - s(1 - p_0(1-e)) < 0,$$

it is not possible to determine the sign of $\frac{\partial(t_1^* + t_2^*)}{\partial e}$.

This indetermination is quite intuitive. The more the unemployment revenues, the less the crime in second period. In contrast, during the first period, it becomes less important to invest in human capital accumulation in order to avoid unemployment. Indeed, the less the difference between employed and unemployed revenues on legal market, the less the importance of human capital. Thus, it is possible to spend more time on illegal market during the first period. Therefore, unlike affirmative action on low wages, increasing generosity in unemployment revenues can have ambiguous effects.

3.3 – Deterrence and Punishment: the long-term influence of sanctions

The first form of deterrence relates to the probability of being apprehended and sentenced. We called π the probability of being caught per unit of time dedicated to illegal activities. Without ambiguity, an increase in π has a negative impact on crime levels, which is consistent with most of literature. Investment in police and new technologies (video, DNA base...) is able to increase this probability, and it seems necessary to specify numerically the parameters in order to conceive an optimal allocation of public resources and determine an optimal number in police.

The second form of deterrence, which involve an increase in the risk of illegal activity is the penalty imposed to criminals in case of conviction. The impact of the penalty severity is ambiguous and two effects can be distinguished. There is a clear impact (due to dissuasion) for the first two periods. But, for the third period, the impact is ambiguous, as we can see below.

Formally, we assume a positive relation between the severity of sanctions and the stigmatization process on labor market. First, because a prison sentence leads to a distrust of

the prospect employer on the person convicted. Then, because imprisonment did not allow inmates to really invest in human capital, which affects the ability to find employment after release. We assume here that σ increases with the severity of the penalty: $\sigma(f)$, the latter function being increasing. Anticipating stigma on the labor market during the third period if convicted, the agent tends to commit less crime during the first two periods. We can indeed verify without ambiguity the following relation:

$$\frac{\partial(t_1^*+t_2^*)}{\partial f} < 0.$$

During the third period, if the agent has not been convicted t_{3nc}^* is unambiguously decreasing with the severity of the penalty. However, in case of a convicted agent, the variations are more ambiguous:

$$\frac{\partial t_{3c}^*}{\partial f} = \frac{2\pi \left[fs(1-e)\sigma'(f) - \left(I - s(1-(1-e)(p_c' + \sigma(f))) \right) \right]}{(2\pi f)^2}$$

If the expected gains on legal market are weaker for stigmatized agents, illegal activities become more attractive. Therefore, it is no longer possible to establish the sense of variations of t_{3c}^* with the severity of the sanction. The impact on T^* is also ambiguous as long as we do not know the numerical parameters of the model. Such evidence seems to partly contradict the classical theory of deterrence, but is quite intuitive: if the fear of stigma deters crime during the two first periods, the same mechanism reinforces the convicted offenders in a criminal path after the sentence. These findings are consistent with empirical evidence found in part of the literature, especially for young offenders (Lipsey, 1995; Prior and Paris, 2005).

But, average penalty could be only one of the key issues. The modulation and application of the sanction, most notably by taking into account the criminal career, appears very important. After discussion of various crime regulation policies, it is necessary to analyze more carefully how to manage the ambiguity on the penalty severity. Two kinds of proposal are more specifically examined and modeled. Firstly, the possibility to differentiate the sanction between recidivists and first time offenders. Secondly, the development of less stigmatizing sanctions (education programs, paid employment in prison, alternative sentences...).

3.4 – How to manage the ambiguity on penalty severity: a heavier penalty for repeat offenders

In this section, we assume a differentiated penalty between first time and repeat offenders. This practice is common, rooted in our civil and criminal codes, with the - extreme - example of California: "three-strikes-and-you're out". However, it has long been difficult for economists to justify such a distinction. The few existing works have not explicitly analyzed the potential role of stigma on legal market (See notably Polinsky and Rubinfeld, 1991; Burnovsky and Safra, 1994; Chu et al., 2000; Emons, 2003). From our point of view, stigma is indeed a key explanatory factor: whereas stigma reinforces criminal path for convicted agents, an increase in severity acts as an incentive for legal activity.

Formally, call f_1 and f_2 the penalties respectively applied to first time and repeat offenders per unit of time dedicated to crime. In case of a repeat offender it is possible to write:

$$t_{3c}^* = \frac{I - s(1 - (1 - e)(p_c' + \sigma(f_1)))}{2\pi f_2} \quad \text{if } 0 < I - s(1 - (1 - e)(p_c' + \sigma(f_1))) < 2\pi f_2$$

As highlighted above, the stigmatization process gives birth to an ambiguity about the overall effect of penalty severity. In order to analyze more precisely this process, it is possible to calculate $\frac{\partial(t_{3c}^*)}{\partial\sigma}$:

$$\frac{\partial(t_{3c}^*)}{\partial\sigma} = \frac{s(1 - e)}{2\pi f_2} > 0$$

$$\text{And: } \frac{\partial(t_{3nc}^*)}{\partial\sigma} = 0.$$

Moreover, it is possible to calculate :

$$\frac{\partial(t_1^* + t_2^*)}{\partial\sigma} = \frac{\pi}{2\pi f_1 - s\kappa(1 - e)} \frac{\partial(V_c^*)}{\partial\sigma}, \text{ with}$$

$$V_c(t_{3c}^*) = \frac{\left[I - s(1 - (1 - e)(p_c' + \sigma(f_1))) \right]^2}{4\pi f_2} + s(1 - (1 - e)(p_c' + \sigma(f_1)))$$

$$\frac{\partial(t_1^* + t_2^*)}{\partial\sigma} = -\frac{s(1 - e)}{2\pi f_1 - s\kappa(1 - e)} \left[1 - \frac{I - s(1 - (1 - e)(p_c' + \sigma(f_1)))}{2\pi f_2} \right]$$

Therefore, with the differentiation of penalties between first time and repeat offenders, it is possible to write:

$$\lim_{f_2 \rightarrow +\infty} \frac{\partial(t_{3c}^*)}{\partial\sigma} = \lim_{f_2 \rightarrow +\infty} \frac{s(1 - e)}{2\pi f_2} = 0$$

Thus, the severity of the penalty is able to reduce the strengthening of criminal paths. Furthermore, it is possible to maintain the deterrence mechanism for first time offenders. It is based on the penalty f_1 :

$$\lim_{f_2 \rightarrow +\infty} \frac{\partial(t_1^* + t_2^*)}{\partial \sigma} = \lim_{f_2 \rightarrow +\infty} \left\{ -\frac{s(1-e)}{2\pi f_1 - s\kappa(1-e)} \left[1 - \frac{I - s(1-(1-e)(p_c' + \sigma(f_1)))}{2\pi f_2} \right] \right\} = -\frac{s(1-e)}{2\pi f_1 - s\kappa(1-e)} < 0$$

By continuity of these functions, it is then possible to find $\overline{f_2}$ so that :

$$\forall f_2 > \overline{f_2}, \frac{\partial T^*}{\partial \sigma} < 0, \text{ with } T^* \text{ defined as above.}$$

By punishing repeat offenders more severely than first time offenders, it is possible to reduce recidivism while maintaining deterrence of crime. Thus, the impact of severity seems no longer ambiguous¹³. One can object that this kind of solution is highly questionable since it raises the issue of the subsistence of former detainees (remaining stigmatized on legal market). That is why we examine and model below another kind of solution to manage the ambiguity on penalty severity.

3.5 – How to manage the ambiguity on penalty severity: less stigma on legal market

As we know, the level of stigmatization on legal market, denoted σ , is an increasing function of the severity of the sanction. Thus, severity has an ambiguous influence on the expected time dedicated to illegal activity over life. Two kind of options can be considered: compensate the stigma of the sanction by developing education or paid employment in prison, on one hand; develop alternative sanctions, on the other hand. The aim of the first option is to reintroduce a link between prisoners and legal market or to improve the diploma of offenders before release. Obviously, the impact of such a process is difficult to measure. However, it is interesting to formalize this kind of proposal. The expected monetary value earned during the third period can be written as follows:

$$V_c(t_3) = s(1-t_3) \left(1 - (1-e) \left(p_c' + \sigma(f) - \chi(f) \right) \right) + It_3 - \pi ft_3^2$$

$\chi(f)$ denotes the compensation of stigma on legal market due to the education program or paid employment. In theory, the probability of unemployment after release is lowered by such programs. The function $\chi(f)$ is increasing with the length of detention: intuitively, the more the time behind bars, the more the investment in such programs. Then, t_{3c}^* can be written as follows:

¹³ The growth of penalty severity in case of recidivism appears to be well documented. In France, before the Law of August 10, 2007, the rate of imprisonment for recidivism was 51% instead of 25% for all crimes and misdemeanors. Fight against recidivism was accentuated with such a law, reintroducing in the right the concept of minimum sentences for recidivists. According to the article 132-18-1 of French Penal Code, the sentence of imprisonment, confinement or detention for crimes shall not be less than a threshold of one third of the maximum incurred. More generally, if there is not a general inflation of sentences in Europe, the implementation rules, based on the criminal profile of the agent are at the heart of current trends in public policy.

$$t_{3c}^* = \frac{I - s(1 - (1 - e)(p_c' + \sigma(f) - \chi(f)))}{2\pi f}, \text{ which gives :}$$

$$\frac{\partial t_{3c}^*}{\partial f} = \frac{2\pi \left[fs(1 - e)(\sigma'(f) - \chi'(f)) - (I - s(1 - (1 - e)(p_c' + \sigma(f) - \chi(f)))) \right]}{(2\pi f)^2}$$

If the detention programs fully compensate the effect of stigma - $\sigma(f) = \chi(f)$ - a pure deterrent effect of penalty can be considered. Meanwhile, it will provide a decent standard of living for former convicted, which was not the case of the first solution. Such kind of programs, consisting in education or paid employment in prison, seem really interesting, but little empirical evidence has been produced to measure their efficiency. Alternative sentences, such as Community Services, would also tend to reduce the stigmatization phenomenon associated with punishment, because the penalty itself is based on time dedicated to legal activity. Therefore, there is a lower stigma on legal market - no time behind bars - and a change in arbitration process between legal and illegal activities. Other examples of alternative sentences can be evoked. For example, "restorative justice" aims at bringing stakeholders together in order to reach an agreement on the consequences of the offense (See *Referral orders* in Great Britain or *Halt Scheme* in Netherlands). If the results seem to be encouraging (Van Hees, 1999; Maxwell and Morris, 2006), the development of such programs presents tremendous variations among countries (stagnation in France, development in UK and Northern Europe).

Conclusion

The construction of a security policy supposes a deep understanding of criminal behavior. The purpose of this article is to propose theoretical keys based on a dynamic model of time allocation between three endogenous activities: education, legal work and criminal activity. Thanks to this model, the impact of human capital, wages and police is highlighted. But, there is more ambiguity about unemployment revenues and long-term influence of the severity of sanctions. Two extensions are discussed to manage this latter ambiguity: heavier penalty for repeat offenders and compensation of stigma on legal market. Several extensions to this work would deserve to be conducted.

1 - We have considered legal and illegal activities as substitutes instead of being complementary. This assumption is simplifying as illegal earnings may appear outside as inside a legal working framework, and it would be necessary to consider a more general framework enabling to include these two considerations.

2 - We have assumed that the potential offender is risk-neutral, which is also a limiting factor in our analysis. It is possible to refine our model by mobilizing the latest works from Risk Economics in order to delimit more precisely the potential criminals' behavior.

3 - The relation to time could be considered in a model including several periods: the rate of actualization is, in particular, likely critical to the effectiveness of an incentive system.

4 - Social interactions have been briefly discussed, but their role in the choice of time allocation has not been specifically addressed. From our point of view, information diffusion in a context of informational imperfection is one of the most powerful channels

through which group behavior affects individual decision. It may be important to analyze which consequences can arise from that type of scheme in the case of the criminal choice.

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