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Keywords : Crime, Time allocation, Sanction. *JEL* : J22, K14, K42.

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Introduction

In France, few prison laws have been as challenged as the Act of August 10, 2007 on minimum sentences for repeat criminals and offendors. It is part of the will of the government to express greater firmness towards such acts. The increase in the number of people incarcerated over the last few years is part of the same objective, while the Ministry of Justice is the only - for the years 2009 and 2010 - to increase its staff, notably due to the recruitment within the Prison Administration. At the same time, a plan dedicated to suburban zones proposed in 2008, includes an increase of 4,000 police officers over three years in the districts the most hit by urban violence, while providing the development of better educational options and second chance schools. It seems that the government is looking for a balance in order to establish a security policy, both by encouraging the legal activity and discouraging illegal activity. For the economist, the question is how to allocate public resources between spending that influences - directly or indirectly - on the level of different forms of criminality.

To answer this question, this paper proposes a theoretical analysis of the incentive system in which is a considered-rational potential offender. A theoretical model of time allocation between investment in human capital, labor and criminal activity, is designed so as to make these three activities endogenous. Several results are highlighted, among which three issues draw more specifically our attention: youth unemployment and the return on investment in human capital, the probability of being caught and the role of the police, the severity of the sanction, its implementing rules and the role of prison policy. In the first section, we paint a panorama of theoretical and empirical work to provide an economic rationalization of the crime, the second section formalizes the elements discussed above, based on a dynamic model of time allocation and the third section discusses the implications of this model by linking them with the empirical literature and policies being currently implemented in Europe.

1 - Which economic rationalization of crime?

Considering from an economic perspective the decision to commit - or not - a crime remains strongly criticized. However, in reality, the economic rationalization of crime is not new, and this approach must first be understood as a reinterpretation and a formalization of thoughts going back to the 18th century, whose pioneers were Beccaria [1] then Bentham [2]. The work of Becker [3] then Ehrlich [4,5], was part of a hot topic corresponding to a noticeable upsurge in acts of delinquency across the Atlantic. Thus, they have given a new impetus to the school of thoughts initiated in the 18th century, thanks to their economic formalisation. Therefore, resolving the question of optimal allocation of resources has required to analyze which incentives make the potential criminal take or not the decision to commit an illegal act. Several forms of modeling coexist.

While Becker's approach is to consider the allocation of resources as a means to minimize the cost of crime for society, Ehrlich addresses the issue in terms of time allocated to illegal activity by an agent. This one can - but it is not always the case - devote all his time to legal activity or illegal activities. This model, better than the one of Becker, enhances porosity, often observed in practice, between legal and illegal activity. It is based on an analogy with standard models where the agent allocates time between work and leisure. It also takes into

account income from legal activity, thereby enriching the determinants of crime by focusing on variables such as unemployment rate or average wage. We adopt this second perspective.

We wish to mobilize the school of thoughts of Crime Economics by providing new insights, particularly to take into account the dynamic aspect of the decision making by an agent. Before that, let us briefly brush the main contributions of this school of thoughts, which can be split into two main categories: the first category of work aims at studying the effects of legal opportunities on the agent propensity for becoming a delinquent and the second focuses on risks and costs induced by the choice of illegal activity. To these two categories - based on individual economic incentives – can be added the understanding of the criminal based upon social interactions. We will briefly discuss the latter without its inclusion in the framework of our model.

1.1 – The impact of legal opportunities on crime

The majority of economic results based on the role of legal opportunities relates 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. First, by theoretical models, highlighting the arbitration process of the potential criminal. Empirical works have also examined the relation between crime rates and their potential determinants through time and space - possibly using fixed effects to isolate certain parameters. Let us summarize the main points presented through literature.

The earliest works on the relationship between labor 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. For example, Gould et al. [6] studied 582 English counties during the 1980s. They confirmed that the link was strong and that a 1% increase in unemployment leads to an increase of 2.2% of crimes against property. Levitt [7,8,9] also verified that there is a causal relation between these two elements, even if it is more tenuous for the acts of violence. Fougere et al. [10] confirmed on the basis of data from French Departmental districts, that youth unemployment is one of the main determinants of the level of crime, notably crimes against property. Considering legal opportunities also supposes to focus on salaries, most notably the lowest, knowing that a lot of offences are usually the choice of less-educated workers moving towards less financially rewarding careers in the legal sector.

Gould et al. [6] showed that these declining wages for non high school graduates were accompanied by an increase of various forms of crime, even if it is the most noticeable for acts of predation. Following a model similar to that of Ehrlich [4], Machin and Meghir [11], based on an analysis of English and Walish counties over the period 1975-1996 also showed that this result is robust. They confirm, in this sense, the model based on Grogger [12] time allocation between legal and illegal activities.

The role of wages can also be analyzed through the prism of income inequality, robustly related to the increasing incidence of crime against property and people [13,14,15]. This double effect is a priori surprising: it is easy to conceive a causal link between inequality and predation, the transmission channel for the phenomena of violence being more complex. However, Merton or Shaw and McKay showed early on that income inequalities are source of

social tensions, disorganization and, therefore, of violent crimes [16,17]. Early empirical tests on this subject dates from the early 1980s [18]. Kelly later applied this prism of explanatory inequalities in both income and education, showing again that these two forms of inequality, measured by Gini coefficients, have a positive impact on the level of violence in the United States [19]. Empirically, studies across large geographical distances lead to a rather satisfactory validation of these theories.

For example, Fajnzylber et al. compiled, for the period 1970-1994, homicides and violent robberies committed in 45 countries. Without ambiguity, the impact of inequality on these crimes is positive [20]. This study could be blamed because of lack of consistency between data from countries whose statistical systems are very different (differences between emerging countries are, from this point of view, much more blatant than inside of Europe). Nevertheless, the main features are consistent with what has been analyzed in the United States, which is hardly surprising. These aspects are highlighted, how the incentive system faced by the potential offender can be handled by the government as part of prevention policies?

It may be necessary to trace the roots of criminal behavior. Many studies have actually related to family structure. As shown by Glaeser and Sacerdote, the rate of single-parent families is a key determinant of differences in crime across American cities [21]. Furthermore, a debate is currently raging in the United States on the role of the legalization of abortion in the recent decline in crime rates [22]. The underlying idea is that abortion is an option for women who do not have material or human resources to bring up a child while pregnant. Legalizing this possibility, making it less dangerous to the health of women and more common could lower the number of unwanted births, more prone to problems of education and, consequently, to the choice of crime.

Besides, several studies have been conducted to assess the efficiency of crime prevention programs, targeting very young children and their parents, companies' internships or police prevention strategies improvement. It is to be noticed that ad hoc programs, low-cost ones (prison visits by children to deter them from attending such a place, for example) are generally not very successful. In contrast, programs conducted in the longer term (to visit relatives dealing with troubled young people, to help with homework ...) seem much more promising, although more expensive [23]. The Perry School Program is probably the best known of them and shows very significant results as demonstrated by several studies [24,25,26]. They are even more significant when the actions are targeted to the least educated people [27]. Other types of programs can be conducted for later ages.

It's acknowledged that almost two thirds of prisoners have not graduated from high school. Theoretically, Lochner shows a correlation between the level of wages, public incitement to education and the level of crime [28]. The chosen econometric specification enables us to quantify the gain due to graduation from high school : nearly \$ 7,000 would be saved by the society only because of the drop in crime. This study confirms that of Greenwood et al. [24], who have examined several types of programs and highlighted that supporting disadvantaged people to acquire a high school diploma - with money or other incentives - has high efficiency. Similarly, in Europe, the Swedish program KrAmi, based on education and training programs, tries to promote the integration of young people who have failed in the legal workplace. First assessments suggest some very good results, first at the social level, but also in terms of reducing crime and recidivism [29]. Now let us consider the impact of

repression policies which focus on deterrence and punishment of criminal activity. Two elements are essential on this side of the incentive scheme introduced by the government: the probability of being apprehended, on one hand and the intensity of punishment, on the other. Many studies have also been conducted on these points in recent decades.

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

In the late 19th century, Durkheim [30] didn't give his full support to punishment, considering its impact at least questionable and, from the best point of view, modest. Economic analysis, supported by recent empirical contribution of econometrics, can provide additional information to this debate. In reality, two elements in the punishment need to be distinguished. First, its deterrent effect, if rational expectations of the agent are assumed. Then, especially for sentences of imprisonment, the incapacitation of sentenced criminals, preventing them from committing further illegal acts.

1.2.1 – Imprisonment: deterrence or incapacitation ?

The economic model formulated by Becker is based on deterrence: the potential criminal arbitrates between legal and illegal activity according to the risks involved in illegal activity and the return on these two kinds of activity. But it is difficult to know if the impact of conviction on crime rates is purely due to criminal deterrence or also to an incapacitation effect – a mechanical removal from the "market of illegal activity." Zedlewski [31] bases is study exclusively on the second effect with a calculus of crime decrease associated with a given time in custody for an offender. Freeman [32] opposes this approach, arguing that criminal activity is itself subject to a market: if a lot of criminals are behind bars, the decrease of competition on this market improves the profitability of illegal activity. The result should be new entrants in the illegal market and an increase in crime levels. Thus, there would be a crime equilibrium in which the number of criminals and the level of crime should not depend on the number of prisoners.

Levitt [33] tries to respond to the controversy by empirical observations during the periods of change in legislation. Suppose a positive shock on the severity of the sentence for motor vehicle theft. The deterrent hypothesis will lead to a substitution of motor vehicle theft to say burglary. However, the incapacitation hypothesis will lead to a decline in both forms of crime. The data show that the deterrence hypothesis is largely dominant. Another method is to rely on punishments respectively applied to juveniles and adults. A sharp decline in criminal involvement is particularly clear at majority, confirming the hypothesis of deterrence by the severity of the sanction. In this paper, we follow Levitt and Freeman, focusing on the deterrent effect of punishment. Two key determinants of crime are then examined: on one hand, the probability of being arrested and convicted, on the other hand, the severity of the penalty.

1.2.2 – Impact of the probability of being apprehended and sentenced

This first issue is closely linked to the role played by the police: to what extent is the latter efficient to increase the probability of arrest? To what extent such probability discourages criminal activity [34]? Obviously, it is 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 [35,36,37].

It is possible to overcome this problem by choosing an instrumental variable affecting police forces without directly modifying the agents' preferences between legal and illegal activities. Levitt [9] focuses especially on election periods, during which an *exogenous* increase in police of about 2% is usually observed due to citizen concern for security. We can find a significant negative elasticity on predation and violence. It is indeed difficult to give recommendations based on these elasticities (lake of precision, poor knowledge of the social costs...). But, the economist finds a saving of around \$ 200m per year and additional policeman, much higher than the cost incurred by the latter. Marvell and Moody [35] also verify a negative causal relationship using data of very high frequency for police staff: it is indeed difficult to change quickly the number of police when crime varies, which limits the endogeneity bias seen above. On a large scale, this relation was verified in the United States, especially during the 1990s, when crime – especially violence - declined deeply: - 76% in San Diego, - 71% in New York, - 69% in Boston for the homicides.

The work of Corman and Mocan [38] is based on this idea. They conduct an empirical study of crime in New York and give credit to the theory of "broken window" popularized by Mayor Rudolph Giuliani and proposed a decade earlier by Wilson and Kelling [39]. A broken window is a signal that nobody cares about the neighborhood. Therefore, it costs nothing to break another one. However, the care of citizens to a place constitutes a strong barrier for those who want to commit crime. The replacement of "broken window" as well as the increase of police patrols is able to provoke a strengthening of the informal control mechanisms of the community. The authors tried to verify empirically this approach by taking as variable the number of arrests for minor offenses. This study – which gave birth to a raging debate - suggests that the crime levels decrease when arrests for minor offenses increase. They find a significant elasticity leading them to conclude that the government should increase both the number of police and 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. It appears for example that major cities, all things being equal, have higher crime levels than smaller cities. For Glaeser and Sacerdote [21], 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). In France, the same theory can probably be verified as we note major differences between cities in the number of police per capita. For example, many suburban cities have fewer police per capita than Paris, while crime rates are higher. 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 [40].

1.2.3 – What about the severity of the penalty?

Several studies also focus on the impact of the severity and type of sanction. The first type corresponds to a sanction which has a cost for the community (in case of prison, for example). Another type of sanction, also studied by Gary Becker, is a system of fines paid by the criminal. In this case, punishment is not an additional cost for the community, but a gain. According to Polinsky and Shavell [41], the optimal solution consists to charge the maximum fine to the offender. However, according to Garoupa [42], it may be optimal if the criminal is

risk averse, to charge a fine below this level. The two systems of sanctions can seem very different: one is - from a financial perspective - a compensation for the community while the other is an expense to deter crime. Lets see more particularly the second system.

It is often difficult to know the real impact of custody sentences because of an endogeneity bias: more crime lead to more incarceration. But when overcrowding forces the authorities to release prisoners earlier than expected, there is an exogenous change in the severity of the sanction. Most of studies show that such a decrease causes - at least in the short term - an increase in crime levels [7]. However, basing such a result on one period may be misleading. As we highlight it more precisely below, the increase in severity - including imprisonment creates a drop in long term employability due to both obsolescence of human capital and mechanism of social stigma [43]. The costs of stigma (unemployment, lower wage...) may even exceed, for the individual, the costs of the sanction itself [44,45]. As it becomes more difficult to find a job on the legal market, there is a cost 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 [46,47]. Moreover, even if a robust causal link was established between severity of sanction and crime levels, it would not prove the necessity of building prisons. In fact, it seems – at least in the United States - that marginal elasticity of increasing severity is low, so that maintenance of an additional inmate induces higher marginal cost than marginal benefit [40]. After having reviewed the most documented variables in the arbitrage process between legal and illegal markets, let's briefly discuss a new evidence which allows to better understand the criminal act.

1.3 – The impact of social interactions on crime

It appears empirically that crime is highly concentrated, both geographically and socially. It seems difficult to explain such a concentration exclusively with arguments based on a classic incentive scheme. In the model proposed by Glaeser et al. [48], the utility of agents is partly based on the observed actions of other agents, thereby justifying an imitation process. For the same gain associated with crime, an individual is more likely to commit an illegal act if relatives are already involved in the illegal market. Conversely, their decision affects the incentive scheme of the relatives. Thus, the spatial concentration of crime could be explained by a collective equilibrium. With a model based on a "collective efficiency" argument, Sampson et al. [49] reach the same kind of result. Sah [50] also highlights the role of social interactions in criminal decision. The group is indeed essential to bring information in a context of informational imperfection. This may be the case when there is an uncertainty about police and judicial abilities: if a message of confidence (a low probability of being apprehended, for example) is conveyed by the group, there will be an increase in crime levels. It is important to note that the "initial conditions" before the crystallization of a "collectively efficient" crime level are so crucial. We find here again the intuition of the theory of "broken windows": a misdemeanor that does not require any repair is one of the initial conditions leading to a high crime level equilibrium.

More generally, the peer effects can act in five ways for criminal decisions. 1) First, the agent may seek information from its environment on his "type" in order to build their own identity [51,52,53] : honest, dishonest, etc ... 2) Social environment can be of paramount importance in the positioning of potential criminals vis-à-vis the victim. For example, the psychological

cost to commit a serious act can drastically reduce - or even turn into a win - when the victim is not respected. The environment is indeed important in this position. 3) It is also possible to consider a symbolic gain to behave as relatives [54]. The stigma mechanism for those who do not comply with the majority choice is due to the same process. 4) Peers can also have an influence through the collective gain that comes from cooperation on the same conduct. This aspect is easily understandable in the case of crime through the example provided by Sah [50]: more criminals means fewer chances of being caught. 5) Finally, the group brings information to the agent in a context of informational imperfection. This kind of behavior does not necessarily lead to collectively optimal choices especially in case of "informational cascade", efficient at individual level but harmful at collective level. These five main channels help us to understand most of social interaction effects in the criminal choice. However, we will not model here the influence of such parameters.

We focus in what follows, on several determinants of crime. In outline it is possible to separate the factors that play on prevention, deterrence and repression. In the system of incentives, several factors seem to play a major role: unemployment, wage levels, probability of being caught, severity of punishment for a given crime...These variables can be partly modified by the allocation of resources adopted by the government (education spending, police expenditures, prison expenses, etc...). It is important to clarify the behavior of a potential offender immersed in this incentive scheme. For this, we develop a dynamic model of time allocation between investment in human capital, labor and criminal activity, assuming that these activities are substitutes.

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

In order to analyze the role of an incentive scheme implemented by the government it appears necessary to take the dynamics into account. For this, we develop a three periods model of time allocation in which three periods are distinguished: the period while 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, the agent chooses to allocate their time between legal and illegal activities: between education allowing to increase human capital 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 their income over the three periods. Two independent markets are considered: one for legal activities, the other for illegal activities. Time allocation between these two markets is based on a system of incentives so that the choice can be modified at each period. Several assumptions can be made. First, we consider as Ehrlich [4] 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 neutral². Finally, we must bear in mind that individuals have different rate of actualization which may explain a greater propensity to choose criminal activity if the benefit is immediate and the penalty delayed [56]. But, we do not take into account this aspect in the proposed model.

² Regarding the perceived risk of being caught, see notably Dionne, Fluet and Desjardins [55], who study empirically the influence of the perception of being arrested on bad driving.

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 respectively 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 time allocated to legal activities during these three periods are: $1-t_1, 1-t_2, 1-t_3$.

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. If t_1 is allocated to the illegal market - a time $1-t_1$ dedicated to investment in human capital - the expected monetary value earned in first period can be written as follows for a risk neutral individual:

 $V(t_1) = (I - \xi) t_1 - \pi f t_1^2$

Here I denotes the productivity of criminal activity, ie the income derived per unit of time dedicated to illegal activity. ξ is the psychological cost associated with a unit of time dedicated to criminal activity. In extremis, it is possible to consider that criminal activity provides a feeling of pleasure, corresponding formally to the case $\xi < 0$. Understanding the psychological costs - or gains - associated with criminal activity is both fascinating and considerably difficult. Killing or stealing are not psychologically neutral. A taste for the forbidden or for violence and, conversely, psychological difficulties with such acts can not be ignored and are really important in the individual decision. If, the "pleasure of crime" has already been studied in economic literature [57], on the contrary, some acts are psychologically terrible for their authors³. External factors can influence these psychological costs or gains. For example, according to Freeman, attending religious services would have a negative impact on criminal choice. π represents the probability of being caught per unit of time dedicated to illegal activities. 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. 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).

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:

³ Let's remember Raskolnikov, the character of Crime and Punishment, confronted with the darkest hallucinations after his murder.

 $p_c = p_c(t_1) = p_0 - \kappa.(1-t_1)$, with :

 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 can be supposed exclusively individual (intellectual and physical ability, concentration, courage...) or partially due to governmental action. The second point of view will be assumed. In this model, it is thus possible to explain youth unemployment with two parameters, p_0 and κ . We must bear in mind that these two parameters can present important variations among individuals, without the qualitative results established below being changed.

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:

$$V(t_2) = s.(1-t_2).(1-p_c(t_1)+e.p_c(t_1))+(I-\xi).t_2-\pi.f.t_2^2$$

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.

Third period

We first 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 past has yet 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

- $p_c' + \sigma(f)$, if the individual has already been sentenced to a penalty causing stigma on labor

market. Following Rasmusen [43], we must bear in mind that the costs of stigma can exceed those of the sanction (lower expected productivity, lower confidence of the employer...). 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 $\sigma(f)$.

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.

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

- $V_{nc}(t_3) = s.(1-t_3).(1-p_c'+e.p_c')+(I-\xi).t_3-\pi.f.t_3^2$, if the individual has not been convicted

- $V_c(t_3) = s.(1-t_3).(1-(1-e)(p_c'+\sigma(f))) + (I-\xi).t_3 - \pi.f.t_3^2$, if the individual has already been sentenced to a penalty causing stigma on labor market.

2.2 – Resolution of the optimization 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 dedicated to illegal activity during the three periods. So we need to solve this optimization program, starting first by the third period, then back to earlier periods.

Third period

During the third period, the individual is older and may have already been sentenced to heavy penalties. Then, we must consider two possible situations, leading to different optimization behavior:

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:

$$V_{nc}(t_3) = s.(1-t_3).(1-p_c'+e.p_c')+(I-\xi).t_3-\pi.f.t_3^2.$$

The first order condition gives us a unique interior solution:

$$t_{3nc}^{*} = \frac{(I-\xi)-s.(1-p_{c}'.(1-e))}{2.\pi.f} \quad \text{if} \quad 0 < (I-\xi)-s.(1-p_{c}'.(1-e)) < 2.\pi.f^{-6}$$

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

⁶ If this condition is not verified, we have corner solutions: $t_{3nc}^* = 0$ if $(I - \xi) - s \cdot (1 - p_c' \cdot (1 - e)) < 0$;

 $t_{3nc}*=1$ if $(I-\xi)-s.(1-p_c'.(1-e))>2.\pi.f$. These two cases correspond to limit cases in which time is exclusively dedicated to legal or illegal markets. In these cases, the incentive systems lead respectively to very low or high remunerations for illegal activities.

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 the criminal has 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 antagonist effects is a priori ambiguous, and we consider at first approximation that the marginal probability of apprehension is not affected by prior convictions.

$$V_{nc}(t_{3nc}^{*}) = s.(1-t_{3nc}^{*}).(1-p_{c}^{'}+e.p_{c}^{'})+(I-\xi).t_{3nc}^{*}-\pi.f.t_{3nc}^{*}^{2}, \text{ and then :}$$

$$V_{nc}(t_{3nc}^{*}) = \frac{\left[(I-\xi)-s.(1-p_{c}^{'}.(1-e))\right]^{2}}{4.\pi.f}+s.(1-p_{c}^{'}.(1-e))^{7}.$$

If the individual has already 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:

$$V_{c}(t_{3}) = s.(1-t_{3}).(1-(1-e).(p_{c}'+\sigma(f)))+(I-\xi).t_{3}-\pi.f.t_{3}^{2}.$$

The first order condition gives us a unique interior solution:

$$t_{3c}^{*} = \frac{(I-\xi)-s.\left(1-(1-e).\left(p_{c}'+\sigma(f)\right)\right)}{2.\pi.f} \text{ if } 0 < (I-\xi)-s.\left(1-(1-e).\left(p_{c}'+\sigma(f)\right)\right) < 2.\pi.f^{8}$$

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

$$V_{c}(t_{3c}^{*}) = s.(1-t_{3c}^{*}).(1-(1-e).(p_{c}^{'}+\sigma(f))) + (I-\xi).t_{3c}^{*}-\pi.f.t_{3c}^{*}, \text{ and then }:$$
$$V_{c}(t_{3c}^{*}) = \frac{\left[(I-\xi)-s.(1-(1-e).(p_{c}^{'}+\sigma(f)))\right]^{2}}{4.\pi.f} + s.(1-(1-e).(p_{c}^{'}+\sigma(f)))^{9}.$$

Comparing the two situations above, it is obvious that stigma changes behaviors in the direction of a more pronounced taste for 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

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

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

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

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. It is thus possible to simultaneously determine time allocation. In this perspective, the agent maximizes the expected monetary value earned over the three periods which can be written as follows:

$$V = V(t_1) + V(t_2) + (1 - \pi . t_2) V_{nc}(t_{3nc}^*) + \pi . t_2 . V_c(t_{3c}^*), \text{ which gives us:}$$

$$(I - \xi) . t_1 - \pi . f . t_1^2 + s . (1 - t_2) . (1 - p_c(t_1) + e . p_c(t_1)) + (I - \xi) . t_2 - \pi . f . t_2^2 + (1 - \pi . t_2) . V_{nc}(t_{3nc}^*) + \pi . t_2 . V_c(t_{3c}^*)$$

with: $p_c = p_c(t_1) = p_0 - \kappa \cdot (1-t_1)$.

We can then establish the two following relations:

$$t_{2}^{*} = \frac{(I-\xi)-s.(1-(1-e).(p_{0}-\kappa.(1-t_{1}^{*})))+\pi.(V_{c}(t_{3c}^{*})-V_{nc}(t_{3nc}^{*}))}{2.\pi.f} \quad \text{if}:$$

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

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

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

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

$$t_{1}^{*} = \frac{(I-\xi)-s.\kappa.(1-e).\left(1-\frac{(I-\xi)-s.(1-(1-e).(p_{0}-\kappa))+\pi.(V_{c}(t_{3c}^{*})-V_{nc}(t_{3nc}^{*}))}{2.\pi.f}\right)}{2.\pi.f}$$

¹⁰ If this condition is not verified, we have corner solutions : $t_{2}^{*} = 0$ if $(I - \xi) - s.(1 - (1 - e).(p_{0} - \kappa.(1 - t_{1}^{*}))) + \pi.(V_{c}(t_{3c}^{*}) - V_{nc}(t_{3nc}^{*})) < 0$; $t_{2}^{*} = 1$ if $(I - \xi) - s.(1 - (1 - e).(p_{0} - \kappa.(1 - t_{1}^{*}))) + \pi.(V_{c}(t_{3c}^{*}) - V_{nc}(t_{3nc}^{*})) > 2.\pi.f$. ¹¹ If this condition is not verified, we have corner solutions : $t_{1}^{*} = 0$, if $(I - \xi) - s.\kappa.(1 - e).(1 - t_{2}^{*}) < 0$; $t_{1}^{*} = 1$, if $(I - \xi) - s.\kappa.(1 - e).(1 - t_{2}^{*}) > 2.\pi.f$.

$$t_{2}^{*} = \frac{(I-\xi)-s.(1-(1-e).(p_{0}-\kappa))+\frac{s.\kappa.(1-e)}{2.\pi.f}.((I-\xi)-s.\kappa.(1-e))+\pi.(V_{c}(t_{3c}^{*})-V_{nc}(t_{3nc}^{*}))}{2.\pi.f-\frac{s^{2}.\kappa^{2}.(1-e)^{2}}{2.\pi.f}}$$

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

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

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. Which conclusions can be deduced from this model for the conception of an incentive scheme by the government?

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 the latter in order to change the system of incentives in which is the potential offender. Other parameters can be considered in first approach as exogenous and will be more briefly discussed.

3.1 – Productivity and psychological cost of criminal activity

First of all, it is consistent to verify that *I*, the productivity of criminal activity, has a positive impact on crime levels. At the governmental level, it is difficult to play on this parameter considered as exogenous. An exogenous change in *I* may be for example due to a change in the "industry of crime" (the structuring of a Mafia or a war between rival clans for example), which modifies the return on illegal activity. Suppose that many criminals coexist. There is a competition - more or less perfect - on the market of illegal activity and low earnings, ie low productivity for a given time dedicated to crime. The structuring of an organized Mafia with codes of conduct, networks and courts is able to increase such a productivity. Furthermore, the elimination of competing groups establishes 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 lead

several analysts to use the term of "industry of violence" to describe this type of organizational structure¹².

In contrast, the parameter ξ represents the psychological cost of a unit of time dedicated to criminal activity (with the possibility of $\xi < 0$, if the agent feels a pleasure to commit a prohibited activity or has an appetite for violence). If positive, this parameter has a negative impact on crime levels. Once again, we consider this psychological cost as exogenous.

3.2 – Unemployment and return on investment in human capital

The probabilities p_0 and p_c ' correspond to the reference probabilities of unemployment during the second and third periods. The following relations are easily verified:

$$\frac{\partial t_1^*}{\partial p_0} \ge 0$$
 and $\frac{\partial t_2^*}{\partial p_0} \ge 0$, which ultimately gives us: $\frac{\partial T^*}{\partial p_0} \ge 0$

Logically, we have also :

$$\frac{\partial t_{3nc}^{*}}{\partial p_c'} \ge 0 \quad \text{and} \quad \frac{\partial t_{3c}^{*}}{\partial p_c'} \ge 0$$

More important, we can write:

$$\frac{\partial t_1^*}{\partial p_c'} \ge 0$$
 and $\frac{\partial t_2^*}{\partial p_c'} \ge 0$

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:

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

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. Time allocated to crime on the first two periods is thus increasing with the reference probability p_c' . Obviously it is possible to check over the three periods: $\frac{\partial T^*}{\partial p_c'} \ge 0$.

¹² See notably the survey conducted by Leopoldo Franchetti and Sonnino Sydney, in the late 19th century's Sicily and cited by Dickie [58].

The impact of the two reference probabilities for unemployment is therefore crucial for crime levels. These observations are consistent with most empirical studies in France [10] or abroad. Freeman and Rogers [59] find an elasticity of around 1.5 between youth unemployment and crime levels. Gould, Weinberg and Mustard [6] find elasticities around 2 for several crimes and misdemeanors. While the studies show mainly an influence on predation acts, the influence on violent acts seems to be lower because less subject to rational calculation [5,6,7]. Let's see below the evolution of youth unemployment in recent years in Europe.



Fig. 1: Youth Unemployment Rate (% Under 25 Years), Source Eurostat

It appears that reported rates are quite stable, with a slight decrease deeply questioned during the last years by the current financial crisis. In any case, the rates recorded in Europe are 1.5 to 2 times greater than for the remaining population. This fact appears therefore crucial, both in terms of society cohesion and crime regulation.

Two factors must be analyzed separately about youth unemployment which can be written $p_c = p_c(t_1) = p_0 - \kappa \cdot (1-t_1)$: firstly, the parameter p_0 assumed to be exogenous. On the other hand the return on investment in human capital, characterized by the parameter κ , 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 . 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. This kind of return is increasing with the parameter κ . We know that public investment in education has a key influence on the latter, which incites agents to invest in human capital and choose legal activity. This is an important part of prevention policies. The influence of this parameter can be evaluated thanks to the expression of $t_1^* + t_2^*$. Indeed, it is possible to write:

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

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

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

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

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

These findings are consistent with empirical evidence found in literature. Improving the return on investment in human capital can be based on actions from a very young age, highly focused on population at risk (to visit relatives dealing with troubled young people, to help with homework, prison visits...) [23]. Other programs for teenagers also showed very satisfactory results. It is indeed largely known that many of the inmates have not graduated high school. Thus, focusing on incentive programs for education appears to be of paramount importance [24,28]. In Northern Europe, this kind of action is more and more often conducted, most of time with good results especially for the reduction of juvenile recidivism [29].

3.3 – 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:

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

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

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

$$\frac{\partial (t_1^* + t_2^*)}{\partial s} < \frac{\kappa.(1-e)\left[2.(I-\xi)-4.\pi.f + \pi.(V_c^*-V_{nc}^*)-s.(1-p_0.(1-e))\right]}{\left[2.\pi.f-s.\kappa.(1-e)\right]^2}, \text{ with as seen above :}$$

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

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"¹³. In France, for example, a governmental action on minimum wage could be one of the means to change s, even if it is difficult to evaluate the power of the government in the evolution of such parameter.

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:

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

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

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

$$\frac{\partial (t_1^* + t_2^*)}{\partial e} < \frac{s.\kappa.\left[-2.(I-\xi)+4.\pi.f-\pi.(V_c^*-V_{nc}^*)+s.(1-p_0.(1-e))\right]}{\left[2.\pi.f-s.\kappa.(1-e)\right]^2}, \text{ with as seen above :}$$

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

¹³ The works of Gould, Weinberg and Mustard [6] or Machin and Meghir [11] – based on a panel data analysis for England and Wales - show that the wages paid to unskilled workers are key determinants of crime levels. These aspects are also of key importance in the model of Grogger [12].

Accordingly, 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. After analyzing the main incentives for legal activity, let's see now the deterrence parameters for illegal activity.

3.4 – Deterrence and Punishment: the role of police

Two forms of deterrence are considered below, which involve an increase in the risks associated with illegal activities. The first one relates to the probability of being apprehended and sentenced while the other is based on the intensity of the penalty. We called π the probability of being caught per unit of time dedicated to illegal activities. Logically, an increase in π has a negative impact on crime levels. Indeed, without ambiguity:

$$\frac{\partial t_1^*}{\partial \pi} \le 0 \ ; \ \frac{\partial t_2^*}{\partial \pi} \le 0 \ ; \ \frac{\partial t_{3c}^*}{\partial \pi} \le 0 \ ; \ \frac{\partial t_{3nc}^*}{\partial \pi} \le 0 \ , \text{ which ultimately gives } : \ \frac{\partial T^*}{\partial \pi} \le 0$$

Here again, these elements are consistent with the literature. Marvell and Moody [35] find an elasticity of around - 0.3 between polices and crime levels. Corman and Mocan [38] find significantly negative elasticities too, which vary according to the crimes, with an average value of - 0.45. Levitt [9] measures the influence of an exogenous increase in police during elections period: the average elasticity would be about - 0.79. On a large scale, these findings have been tested in the United States, with a drastic fall in crime during the 1990s, partly due to the reinforcement and reorganization of police patrols.

Thus, a security policy is based on the probability of being caught and convicted in case of criminal act. Investment in police is able to increase this probability. Let's see the past evolution of police in some European countries.



Fig. 2: Police (per 100 000 inhabitants), Source Eurostat and European Sourcebook.

Most of time, it is possible to observe a relative stability over time in each country while France appears to be slightly above the average. Thus, the differences seem to be more important between countries than between different periods. If the importance of police seems to be understood by most of governments, three remarks must be done. First, it is necessary to specify numerically the parameters in order to conceive an optimal allocation of public resources and determine an optimal number in police [40]. Second, the spatial organization of patrols appears to be of paramount importance: unfortunately, a lot of cities have both high crime levels and low police. Thus, the appropriate number of police need to be evaluated not only at a country level but at a smaller scale. Finally, we must bear in mind that it is possible to improve the efficiency of police expenditures by developing new technologies. This may be the case, for example, of the extension of the DNA base within the population in order to solve several crimes more easily. We do not discuss in detail in this article the issue of technical progress in policing methods.

3.5 – Deterrence and Punishment: the ambiguous effect of the penalty severity

The second form of deterrence, which involve an increase in the risk of illegal activity is the penalty imposed to criminals if they are apprehended and convicted. f is the level of sanction imposed for each unit of time dedicated to crime. If the sanction includes imprisonment, the cost for society consists in the construction, maintenance and human capital necessary to operate. It would be a priori consistent to check that an increase in f results in a decrease of crime levels. It appears clear for the first two periods:

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

But, for the third period, the impact is ambiguous because of stigma. Indeed, it is possible to write:

$$V_{nc}(t_{3nc}^{*}) = \frac{\left[(I-\xi)-s.(1-p_{c}'.(1-e))\right]^{2}}{4.\pi.f} + s.(1-p_{c}'.(1-e)), \text{ and }:$$
$$V_{c}(t_{3c}^{*}) = \frac{\left[(I-\xi)-s.(1-(1-e).(p_{c}'+\sigma(f)))\right]^{2}}{4.\pi.f} + s.(1-(1-e).(p_{c}'+\sigma(f)))$$

In fact, there is 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 convicted¹⁴. Then, because imprisonment did not allow inmates to really invest in human capital, which affects the ability to find employment after release. Therefore, we assume here that σ increases with the severity of the penalty: $\sigma(f)$, the latter function being increasing.

It appears that stigmatization has a deterrent effect. 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:

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

What about 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:

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

It is therefore no longer possible to establish the sense of variations of t_{3c}^* with the severity of the sanction. Therefore, the impact on T^* is also ambiguous as long as we do not know the numerical parameters of the model. This is quite intuitive: if the expected gains on legal market are weaker for stigmatized agents, illegal activities become more attractive (formally: $\frac{\partial t_{3c}^*}{\partial \sigma} \ge 0$). At the theoretical level, there may be cases in which an increase in the severity of

the penalty has a positive effect on crime levels. These theoretical issues have not really been settled by empirical observations, as we have seen above through an analysis of the literature.

¹⁴ See notably the arguments of Rasmusen [43] based on a comparison between the expected productivities of convicted and non convicted persons.

Such evidence seems to partly contradict the classical theory of deterrence. Nevertheless, it is quite intuitive: if the fear of stigma deters crime during the first periods, the same mechanism reinforces the convicted offenders in a criminal path after the sentence. The rate of "recidivism" is thus increased by the stigma on labor market. These findings are consistent with empirical evidence found in literature, especially for young offenders [60,61]. The macroeconomic effects of stigma – and therefore of sanction – are thus ambiguous. One might wonder how these issues interact with the most recent decisions in terms of imprisonment policies in Europe. Let's see it on the chart below:



Fig. 3: Prisoners (per 100 000 inhabitants), Source Eurostat and European Sourcebook.

As seen above, the number of inmates has significantly increased in most of countries and the ambiguity of a severity policy does not seem to have been really taken into account by governments. We know that an endogenous bias may occur in such a measure because this increase may be due to an increase in crime or in police activity. Therefore, it could be appropriate to construct an indicator to evaluate the severity of the penalty. For example, the ratio between the number of prisoners and the number of people sentenced – or sentenced for violence acts - in the same year could be analyzed. This indicator would be homogeneous with a duration¹⁵. However, in the European case, such a ratio appears really difficult to construct because of great differences in judicial systems, which would provoke a bias in such a severity indicator. Thus, the rate of prisoners is able to constitute an important – albeit imperfect – indicator.

As shown more specifically below, 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 of the convicted person, appears very important. After discussion of various crime regulation policies, it is necessary to analyze more carefully how to manage the ambiguity on

¹⁵ For the construction of similar ratios, see notably Levitt [8].

the penalty severity. Two kinds of proposal are more specifically examined and modeled. Firstly, the possibility to differentiate the sanction between recidivists and non convicted agents. Secondly, the development of less stigmatizing sanctions (education programs, paid employment in prison, alternative sentences...).

3.6 – 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 [62,63,64,65]. 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.

Our framework is linked with the analysis conducted by the lawyer Dana [66], who separates, in any sanction a formal component (punishment) from an informal one (stigma). Stigma can be considered as endogenous (because government can decide, for example, public disclosure of criminal's identity) or exogenous. For a given individual, the informal component tends to wane gradually with the number of convictions. Thus, it is necessary to compensate this loss of efficiency by increasing the share of formal sanction. In Dana [66], the intensity of punishment remains constant - even if this argument is not based on the argument of economic efficiency. Our approach is significantly different, in that we focus on the study of economic incentives, which are specifically modified when the agent is condemned.

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:

$$t_{3c}^{*} = \frac{(I-\xi)-s.\left(1-(1-e).\left(p_{c}'+\sigma(f_{1})\right)\right)}{2.\pi.f_{2}} \text{ if } 0 < (I-\xi)-s.\left(1-(1-e).\left(p_{c}'+\sigma(f_{1})\right)\right) < 2.\pi.f_{2}$$

As noticed above the third period stigmatization process gives birth to an ambiguity about the overall effect of penalty severity: if those who are not convicted are deterred by stigma during the second period, those who have been convicted are reinforced in criminal path during the third period. In order to analyze more precisely this process, it is possible to calculate first the

following derivative $\frac{\partial(t_{3c}^*)}{\partial\sigma}$:

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

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

Moreover, for the first two periods:

$$t_1^* + t_2^* = \frac{2.(I - \xi) + \pi.(V_c^* - V_{nc}^*) - s.(1 - (1 - e)(p_0 - 2.\kappa))}{2.\pi.f_1 - s.\kappa.(1 - e)}$$

Then, it is possible to calculate :

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

$$V_{c}(t_{3c}^{*}) = \frac{\left[(I-\xi)-s.(1-(1-e).(p_{c}'+\sigma(f_{1})))\right]^{2}}{4.\pi.f_{2}} + s.(1-(1-e).(p_{c}'+\sigma(f_{1}))), \text{ and then }:$$

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

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

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

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 non convicted agents. It is based on the penalty f_1 :

$$\lim_{f \to +\infty} \frac{\partial \left(t1^* + t2^*\right)}{\partial \sigma} = \lim_{f \to +\infty} \left\{ -\frac{s.(1-e)}{2.\pi.f1 - s.\kappa.(1-e)} \cdot \left[1 - \frac{\left(I - \xi\right) - s.\left(1 - \left(1 - e\right)\left(pc' + \sigma(f1)\right)\right)}{2.\pi.f2} \right] \right\} = -\frac{s.(1-e)}{2.\pi.f1 - s.\kappa.(1-e)} < 0$$

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

$$\forall f_2 > \overline{f_2}, \frac{\partial T^*}{\partial \sigma} < 0$$
, with T^* 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 ambiguous.

The growth of penalty severity in case of recidivism appears to be well documented¹⁶. In France, before the Law of August 10, 2007, the rate of imprisonment for recidivism was already 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 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. Any sentence below this minimum must be justified by the judge (warranties of rehabilitation of the offender, for example). According to the article 132-19-1, the same rule must be applied for less serious offenses. Moreover, juvenile law is deeply amended in order to punish more severely juvenile offenders, particularly if they exceed 16 years.

Thus, 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. For example, an increase in the severity for repeat offenders obeys to an economic rationality, in order to avoid a strengthening of criminal paths. One can object that this kind of solution is highly questionable in terms of welfare, since a convicted person remains heavily stigmatized on legal market and can not - safely reckless – earn money on illegal market. This raises the issue of the subsistence of former detainees, which can not be ignored by the public authority in charge of the incentive scheme. That is why we examine and model below another kind of proposal which allows us to manage the ambiguity on penalty severity without affecting so deeply the subsistence of former prisoners.

3.7 – 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 during the agent's 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 kind of 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 for a person already convicted, but having followed an education program:

$$V_{c}(t_{3}) = s.(1-t_{3}).(1-(1-e)(p_{c}'+\sigma(f)-\chi(f))) + (I-\xi).t_{3}-\pi.f.t_{3}^{2}.$$

 $\chi(f)$ here 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

¹⁶ Under French law, it is important to separate the state of "recidivism" and the state of "repetition". In the first case, there must be a definitive conviction followed by the renewal of the same act committed within the five years following the expiration or limitation of the sentence. If a different act is committed, there is "repetition". Among convicted criminals, if the repetition rate is over 30%, it is barely above 10% for recidivism.

more the time behind bars, the more the investment in such programs. Then, t_{3c}^* can be written as follows:

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

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 solution discussed above. The different programs mainly consist in a gainful occupation or in education programs. Let's see below the trend in the proportion of inmates involved in such programs in French prisons last years.



Fig. 4: Detainees involved in gainful occupations and education programs (%), Source French Justice Statistics.

If education programs slightly increased before stagnation over recent years, it is not the same of gainful occupations. The implementation of such programs is indeed a complex operation, but it might be interesting to develop these mechanisms. Other kind of solutions would tend to reduce the stigmatization phenomenon associated with punishment. Indeed, alternative sentences, such as community services can be of great interest in this perspective. For example, Community services seem to play a very special role because the penalty itself is based on time dedicated to legal activity. Therefore, there is both a lower stigma on legal market - no time behind bars - and a change in arbitration process between legal and illegal activities. Let's see their recent development in some European countries.



Fig. 5: Community services (per 100 000 inhabitants), Source European Sourcebook, French Justice Statistics, Home Office Statistics.

The realities of Community Service in Europe are very different, with a slight average increase. France is characterized by a stagnation whereas Northern countries in Europe have largely developed such programs, as well as United Kingdom (pioneer in such mechanisms). In future research, it would be interesting to understand why these modes of punishment are not more developed, as they frequently appear as priorities. In France, the parliamentary mission headed by Jean-Luc Warsmann [67] paid particular attention to "restore the reality of non-custodial sanctions", both from a qualitative and a quantitative point of view. According to this mission, a massive boost in community services would be of paramount importance. Such recommendations were only partly followed, with a rate of Community Service below other European countries. From our point of view, it would be interesting to put more emphasis on this kind of program as did United Kingdom for example.

Other examples of alternative sentences can also be evoked. For example, "restorative justice" aims at bringing together stakeholders after an offense in order to collectively agree the consequences of it. In practice, if the victims are rarely involved, it is most often a mean for the offender to reduce the caused damages¹⁷. Such measures seem very positive, but sound assessments of long term results are still lacking most notably for recidivism rates. Some

¹⁷ See notably the *Referral Orders* example in Great Britain.

measures exist for the *Halt Scheme* program introduced in Netherlands since the early 1980s. The persons convicted for vandalism or theft must repay or work in order to repair their actions. The results are encouraging - 60% of young people reduce or completely stop their actions - so that this type of system has been extended to the whole Netherlands [68]. Restorative justice is also one of the key elements of the juvenile justice system in New Zealand: the individuals responsible from infringement are called with their families in order to see how to get out of such dynamics. The results appear to be good, with a deep reduction of recidivism [69].

Conclusion

Establishing a security policy assumes that the impact of a system of incentives established by the government on criminal behavior is known. This article has proposed keys of understanding relying on a dynamic model of time allocation between three endogenous activities: education, legal work and criminal activity. Several levers can be mobilized by the government, such as education programs – notably towards young children - and the increase of police. However, the generosity of unemployment allowance and, especially, the severity of the sanction applied to sentenced criminals seem to have much more ambiguous effects. In particular, the second lever seems efficient only under certain conditions we are discussing and which are not yet met in France. Nevertheless, several extensions to this work would deserve to be conducted.

1 - We have considered that legal and illegal activities could be substituted and are not 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 - Agents heterogeneity is equally central and conducting further researches could be relevant for discriminating populations likely to become a delinquent according to parameters not being yet taken into account, such as the parents' standard of living or the living place.

5 - Social interactions have been 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.

6 - At last, we have considered that the populations taken in different periods of their live, have the same weight in society. However, we know that the age pyramid is changing over time, and particularly with a more pronounced ageing of the whole population. Consequently, it would be quite relevant to point out the impact of these demographical changes on the different forms of crime.

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