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Law Enforcement and Concentration in Illicit Markets*

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Abstract

In this paper we endogenize the horizontal structure of illicit markets. The key assumption is that the probability of detection of a criminal organization depends on its market share. We show that a tougher law enforcement policy encourages criminal entrepreneurs to let other organizations into the market. On the one hand a tougher law enforcement policy reduces the quantities supplied by each criminal organization. On the other hand it induces the creation of new firms, which cancels out the decrease in individual production at the aggregated level. Finally, it is shown that equilibrium price and quantity are independent of the law enforcement level, whereas the objective of public policies is to reduce the consumption of illicit goods such as drugs. Thus, the increase in resources allocated to detection is ineffective.

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1 Introduction

In most developed countries, political authorities have taken up a struggle in order to reduce drugs trafficking. In particular, the United States have implemented a "war on drugs" since the beginning of the 1980s. The federal budget devoted to drugs control has kept growing since then. It has risen from $1.6 billion in 1991 to 11 billion in 1991, and to 18 billion in 2001. The proportion of this budget dedicated to the drug trafficking control has grown up year after year in relation to the one dedicated to treatment and prevention. 54 percent of the budget was allocated to supply control in 1981. This figure reached 65 percent in 1991 and 67 percent in 2001 (U.N.ODCCP, 1997 ; U.S.ONDCP, 2002).

The prohibition of some drugs and its law enforcement is principally motivated by one objective. Replying to security and public health concerns authorities want to reduce the drugs use nationwide. In this way, in 1988 the Office of National Drug Control Policy was created and was delegated the responsibility of creating policy goals and objectives for the federal government. Its strategy was the reduction of the illicit drug use: "the highest priority of our drug policy must be a stubborn determination further to reduce the overall level of drug use nationwide - experimental first use, 'casual' use, regular use and addiction alike." (Reuter and Caulkins, 1995).

The justification of this law enforcement policy is the following. A tougher enforcement should raise drugs sellers' costs, thus raise drugs prices, make drugs less accessible, and renforce messages that drugs are disapproved of and harmful. Higher drugs prices should reduce demand, the price elasticity of the demand being different from zero despite much wisdom about this question.[1] But, it proves that, notwithstanding toughly increased enforcement, many youngsters see drugs as quite easy to get, heroin and cocaine prices are declining (Lee, 1993; Caulkins, 1995a; Reuter, 1997). Using data from drug purchases reported in the Drug Enforcement Administration's System to Retrieve Information from Drug Evidence (STRIDE) between January 1981 and June 1998, Rhodes, Laynes, Johnston, and Hozik (2000) build a statistical model to estimate import and retail prices paid for cocaine and heroin. Import and retail prices per pure gram of cocaine have dropped, respectively, from 75 dollars in 1981 to 25 in 1998 and from 400 to 170. The heroin retail average price decreased of 50 percent between these two dates and the import price fell from 500 to 200 dollars.

In addition to the internal enforcement policy, the United States' drug

[1] See Becker, Grossman and Murphy (1991) for a theoretical analysis and Caulkins (1995b), Saffer and Chaloupka (1999), Breteville-Jensen and Biørn (2001) for empirical studies.

policy consists of an international facet targeted on the three cocaine producing countries: Colombia, Bolivia and Peru. Military aid to these countries, justified as a part of efforts to reduce the flow of narcotics to the United states, has grown rapidly since the beginning of the 1990s. For instance, in January 2000 the Clinton administration announced a \$1.3 billion aid for Colombia in order to finance, among other things, the purchase of sixty helicopters and the servicemen's training. Despite the resources allocated to this policy, the war on drugs in Colombia over the decade did not merely fail to curb the growth of the drug trade and what with corruption, but actually proved counterproductive.

Bagley (2001) considers the US drug policy in Colombia as a failure. Of course, the partial decimation of the Medellin and Cali cartels hindered the emergence of a "narco-state" in that country. But, these cartels were rapidly replaced with smaller, less notorious but equally violent trafficking organizations or "cartelitos" throughout Colombia. Thus, among the most important unintended consequences were the explosion of cocaine and heroin cultivation, the dispersion and proliferation of organized crime, and the expansion and intensification of violence. The four or five cartels have been replaced by about forty medium organizations and around 3000 small entrepreneurs (OGD, 1999). The new firms' entry disperses supply on these drug markets. These new smaller trafficking groups operate from many secondary cities and small towns where they could bribe and intimidate local officials to obtain protection for their activities in relative anonymity (Bagley, 2001). The drug trafficking is still a flourishing activity in that country.

The DEA (1996) confesses that aggressive drug law enforcement efforts in Colombia and Peru have forced traffickers to relocate some of their trafficking operations to other countries like Brazil, Ecuador, and Venezuela. This has contributed towards the emergence of new independent Bolivian, Peruvian, and Mexican trafficking organizations and towards the growth of the production. The authors of a DEA report (1996) themselves conclude with these words: "Traditional enforcement strategies and intelligence collection programs designed to target the major Colombian cartels may not provide optimum results against a fragmented cocaine industry comprised of hundreds of smaller, but significant, Latin American trafficking organizations. The international drug law enforcement community must explore new and innovative strategies to confront successfully the evolving cocaine trade into the 21st Century."

More generally, anti-drug international organizations and national polices have decided to coordinate their efforts in order to make up a more effective law enforcement all over the world. The largest criminal groups (Colombian cartels, Italian mafia, Chinese Triads, Pakistan and Turkish godfathers, *etc.*)

have become the privileged targets of repressive institutions. The networks size determines the adjustment of the repressive authorities effort. Their size itself attracts the police's attention. The public opinion knows these networks and claims particular efforts from law enforcement authorities to break them up. Faced with such a policy the majority of great size networks get reorganized and split up in smaller, more flexible and more viable units. For example, in Italy, in Campania more precisely, supergrasses (*pentiti*) utilization has allowed the arrest of Camorra's main godfathers, implicated, among others, in drug trafficking. Instead of getting rid of this organization, these operations have contributed to its scattering and the multiplication of criminal organizations. Including a dozen or so groups in 1983, this mafia has currently about one hundred of such groups which include about 6000 members (Labrousse, 1997).

Thus, despite a tougher drug law enforcement policy, drug trade keeps growing and, in some countries, new criminal organizations appear and have the power to break into economics and political structures. The growth of the number of criminal organizations following a tougher drug law enforcement is one of the main puzzles of drug law enforcement policies. It is necessary to understand the cause of this failure. Narcotics markets cannot be analyzed with traditional mechanisms because of the illegal nature of exchanged goods. Analysis errors, which justify the resort to agressive drug law enforcement policies, perhaps set at this level. Indeed, repression justification neglects the fact that drug trafficking is based on a market. So there appear some strategic interactions between market actors. Moreover, in this activity, no ownership is protected by the police. Market actors cannot go to court. They thus recourse to all possible means in order to settle their disagreements. This breeds a growth of corruption and violent behavior and increases negative externalities related to drug trade.

The purpose of this paper is to try to explain the counter-intuitive multiplication of criminal organizations following repressive authorities' attacks against traffickers and, more particularly, larger criminal organizations. Our analysis is based on the fact that repression affects the horizontal structure of illicit markets. The main hypothesis of our model is that the criminal entrepreneurs' probability of detection depends on their market share. We show that a tougher drug law enforcement policy encourages them to let other organizations into the drug trade. Thus, we bring to the fore the increase in the number of organizations by endogenizing formation of criminal groups. The law enforcement effectively reduces quantities supplied by each criminal organization, but it induces the creation of new firms, which cancels out the decrease in the individual production at the aggregated level. More generally, we show that equilibrium drug price and quantity are independent from law enforcement efforts, whereas the aim of public policies is to reduce drug consumption.

A tougher law enforcement thus induces a scattering of criminal organizations preventing from the emergence of monopolistic structures on these illegal markets. While the favorable framework is the competition in legal field, the monopoly in illicit activities seems to be the effective market structure for authorities, because it induces high market prices and weak consumed quantities (Buchanan, 1973).

We achieve some conclusions very nearby the ones of Mansour, Marceau, and Mongrain (2001) with a different framework and by generalizing them to any number of organizations. They effectively study how three criminal entrepreneurs can get organized to form one, two, or three gangs, according to possible coalitions. They integrate, in addition to law enforcement related costs which are function of sold quantity and of the number of criminal entrepreneurs in the gang, fix costs representing economies of scale on this illegal market and traffickers' market power. They thus show, on the one hand, that, for a given number of gangs, a rise of law enforcement efforts decreases consumed quantities. On the other hand, under some restrictive conditions, a rise of deterrence leads to an increase in the number of gangs and to an increase in the sold illegal goods quantities.

This paper proceeds as follows. In the next section, we present the model assumptions. An illustrative example is proposed in section 3 in order to give intuitions of the model. We describe the change from monopoly to duopoly structure, then from duopoly to triopoly structure following an increase in law enforcement efforts. The model is next generalized to n criminal organizations and results are proposed in section 4. We conclude in section 5.

2 Hypotheses

The unit being used to express quantities of the good is the average quantity exchanged between traffickers and importers, for example. This means that, by exchanging q units, a trafficker carries out, on average, q transactions.

Let us consider the market of a prohibited good subject to an active law enforcement policy. Three types of agents are actors on such a market: law enforcement authorities, criminal organizations, and consumers.

2.1 The detection

The drug trade is prohibited and the authority sets up a law enforcement policy. To deter and punish traffickers, drug law enforcement authorities use two tools.

The first one consists of spread effort by law enforcement authorities in order to apprehend criminal entrepreneurs. This first tool determines arrest frequency of drug traffickers. Let d the probability to be arrested for a illicit drugs trafficker when he is alone in the market. This probability depends on resources made use of by public authorities and on police technology. We assume that a political choice which implies $d = 1$ is not optimal, because this would be too costly. Consequently, we impose $d < 1$. If a supplier is a monopolist, then all police resources concentrate on his activities.

When there are n criminal organizations, police “tries to keep two pots on the boil”. Repressive agents chase after several offenders at the same time. The probability of detection of a criminal entrepreneur depends positively on the room he takes in the market. We thus assume that this probability is a function of the organization’s market share. The larger the criminal entrepreneurs, the greater their visibility and their risk of detection. A counter-argument to this hypothesis consists in saying that the larger the criminal firms, the more they have resources to bribe public agents, bypass and neutralize law enforcement efforts. To justify our assumption, we refer to the reading of Choiseul-Praslin (1991). He explains that medium size criminal firms capable of seizing all opportunities because of their flexibility and their quickness of reactions, want repressive authorities to throw out the greater traffickers or cartels whose size reaches the one of real trusts. Moreover, as we mentioned in the introduction the public opinion knows these cartels and want authorities to arrest their chiefs. According to Choiseul-Praslin, their size itself attracts the repressive agents’ attention.[2]

When there are several criminal firms, the parameter d is thus the probability of detection of one unit of drug circulation or of a transaction by repressive authorities. The detection of one unit of drug circulation is equiprobable. The expression $\frac{q_i}{\sum_{j=1}^{n} q_j}$ represents the probability that its unit belongs to a criminal firm or that the transaction is the work of this organization.

The probability that trafficker i gets himself arrested, d_i, depends linearly on his market share:

$$d_i = d \frac{q_i}{\sum_{j=1}^{n} q_j}.$$

The term d_i is thus the probability of detection of firm i from units it exchanges or, similarly, transactions it carries out. The more important a

[2]Numerous historical examples exist: the Sicilian mafia in 1960s, the “French Connexion” in 1970s, Italian mafias in 1990s.

trafficker is in the market, the higher his probability of being arrested. We consider that there is no possible error in the enforcement process. Criminal entrepreneurs are arrested at the time of a transaction, so policemen catch traffickers red-handed and intercepted drugs quantities are evidence of the offence. Consequently, arrested entrepreneurs are systematically sentenced.

2.2 The sanction

The second tool is a sanction, fine or imprisonment, paid by the entrepreneur in case of arrest and conviction. We assume that the judicial system imposes on the criminal entrepreneur a sanction described by $S : \mathbb{R}_+ \rightarrow \mathbb{R}_+$, which is a monotonic increasing function of exchanged quantities q_i.

In the United States, the Controlled Substances Act, which is the legal foundation of the government's struggle against the abuse of drugs and other substances and which defines sentences for trafficking, plans different sanctions according exchanged drug quantity by offenders. For example, at the time of a first conviction, if the offender has exchanged between 100 and 999 grams of heroin, he or she shall be sentenced to a term of imprisonment which may not be less than 5 years or more than 40 years or/and a fine not to exceed \$2 billion. If a person has been engaged in distributing more than 1 kilogram, this person shall be sentenced to a term of imprisonment which may not be less than 10 years or more than life, a fine not to exceed \$4 billion, or both. Thus anti-drug acts allow a large magnitude for sentences in order to fit the latter to the arrested trafficker's "size".

In Mansour, Marceau, and Mongrain's (2001) model the sanction depends on the number of criminal entrepreneurs in the gang. In our model, like Poret (2002), we assume that the sanction is a linear function of the trafficked quantity:

$$S(q_i) = sq_i.$$

At first sight, as the direct cost of a fine is low for society, public authorities could draw up a fine at its maximal level ($s \to +\infty$). This would lead to eradicate criminality in society (Becker, 1968). But a large part of the literature about the economics of crime attempts to show the optimality of a non-maximal sanction [3]. In this model, we thus assume that $s < +\infty$.

From these two repression tools, we build a law enforcement intensity index e such that $e \equiv sd$, equal to the expected unitary sanction for a trafficker in monopoly in the market. Thus, the cost imposed by law enforcement

[3] see surveys about this subject by Cameron (1988), Garoupa (1997), Marceau and Mongrain (1999)

efforts on a criminal organization i is equal to:

$$d_i S(q_i) = e \frac{q_i^2}{\sum\limits_{j=1}^{n} q_j}.$$

The trafficker's law enforcement cost depends on the law enforcement intensity e, on his/her market share, which represents the relative size of the trafficker i, and on his/her absolute size q_i. This cost is increasing and convex in q_i. In our model, law enforcement cost, which derives from the risk and costs of detection, is not equivalent to a tax imposed on sold quantities, or a constant unitary cost, as suggested in many analyses (Eatherly, 1974 ; Chiu, Mansley, and Morgan, 1998 ; Jepsen and Skott, 2002). It depends on supplied quantities by the organization's competitors. Everything being equal, if a criminal firm j increases its production, law enforcement cost of the organization i decreases, because of the diminishing of the latter's market share. Positive externalities present in the context of criminal activities are taken into account.

2.3 Criminal organizations

Criminal organizations meet the demand, which is defined by a inverse demand function $P(q)$, with $P'(q) < 0$, $P''(q) \leq 0$, and $P^{(3)} \leq 0$, where $q = \sum\limits_{j=1}^{n} q_j$ represents total exchanged quantity in the market.

The competition on the illicit drug market is not very intense, especially in small areas. Moreover, traffickers do not directly raise drug price. They diminish the quantity of pure product per dose, that is, the quality of the drug sold. Thus we assume that the competition between criminal organizations is *à la Cournot*. The marginal production cost of one unit of illicit drug is equal to c, normalized to zero.

Given law enforcement efforts, each criminal organization chooses drugs quantities that it is going to sell by taking its competitors' sold quantities into account. The aim of the trafficker i is to maximize his expected profit $\pi_i(q_i)$. His program is thus the following :

$$\max_{q_i} \pi_i(q_i) = P\left(\sum_{j=1}^{n} q_j\right) q_i - e \frac{q_i^2}{\sum\limits_{j=1}^{n} q_j}. \qquad (1)$$

Criminal organizations' expected profits depend, as usual, on the others' production. For a fixed number of firms, we know that a rise in law enforcement efforts, by increasing the marginal cost of each trafficker, induces at the equilibrium a decrease of produced quantities. But, the number of organizations can change. If n is variable, standard conclusions could be refuted. The following section illustrates this idea.

3 An illustrative example

The following example brings to the fore the change from a monopoly to a duopoly, then to a triopoly, on illicit markets, as law enforcement intensity grows up. Results and graphic representations are proposed in the two following subsections.

3.1 The entry of criminal entrepreneurs

To be able to realize graphic representations of results, we use in this section a linear inverse demande function: $P(q) = a - bq$.

Let us assume that a illicit market is dominated by a cartel and that public authorities run a active repressive policy against this organization. Its program is thus the following:

$$\max_{q} \left(P(q) - e\right) q,$$

because it is alone in the face of repression agents.

The first order condition allows us to obtain sold quantities by the monopoly $q^M = \frac{a-e}{2b}$ and its expected profit $\pi^M = \frac{(a-e)^2}{4b}$. The condition $e < a$ allows to guarantee the illicit market existence. If law enforcement intensity is too high, illegal market cannot stand out. Consequently, we can assume that the condition $e < a$ is satisfied in our model.

Monopoly expected profit and consumed quantities are right decreasing in law enforcement intensity e. Assume that one starts from a relatively low repression level. By increasing law enforcement intensity, we end up at the objective of drug use reduction and of illegal profit decrease. But we can look at if the monopoly does well to let an other organization into the market in order to reduce law enforcement efforts that it undergoes.

In duopoly situation, each criminal organization wants to maximize its profit with respect to the quantity that it is going to sell by taking into account the quantity sold by the other organization. Given the quantity trafficked by the criminal organization j, q_j, the program solved by organization i is:

$$\max_{q_i} P\left(q_i + q_j\right) q_i - e\frac{q_i^2}{q_i + q_j}.$$

In this case, the first order condition allows us to obtain the profit of each duopolist $\pi^D = \frac{a}{3b}\left(\frac{a}{3} - \frac{e}{4}\right)$ and the total exchanged quantities by the two criminal organizations $q^D = \frac{4a-3e}{6b}$. The condition, which guarantees the market existence, becomes $e < \frac{4}{3}a$. This condition is less restrictive than the one which is necessary in the monopoly framework. In other words, for intermediate values of law enforcement intensity, $\left(a < e < \frac{4}{3}a\right)$, a duopoly continues being active while the monopoly leaves the market.

By comparing equilibrium expected profits in the two possible market structures, monopoly and duopoly, it is easy to show that the monopoly expected profit becomes smaller than the duopoly's one when law enforcement intensity e is higher than the value $e^M = \frac{5-\sqrt{5}}{6}a$. Thus, when the repression intensifies and reaches a certain threshold, the monopoly has to let another organization into the drug market.

In the same way, from a certain level of law enforcement intensity, when the market is made up of two criminal entrepreneurs, we can check whether individually each of them can thwart a new increase in law enforcement intensity by allowing a third one to enter the market.

In the situation where three traffickers are in competition on the illicit market, each chooses the quantity that he sells by considering as given quantities sold by his competitors.

$$\max_{q_i} P\left(\sum_{j=1}^{3} q_j\right) q_i - e\frac{q_i^2}{\sum_{j=1}^{3} q_j}.$$

Results of each of the three traffickers' program give the individual expected profit $\pi_i^T = \frac{1}{432b}(3a+e)(9a-5e)$. The total exchanged quantity by criminals organizations in the market becomes $q^T = \frac{9a-5e}{12b}$. The existence condition is then $e < \frac{9}{5}a$. Thus, when law enforcement intensity increases and reaches some values, $\left(\frac{4}{3}a < e < \frac{9}{5}a\right)$, the duopoly can no more be active in the market, while the triopoly is always in its place. It is interesting to notice that the existence condition is all the less restrictive that the number of organizations increases.

As well in this case, we compare expected profits realized by criminal organizations according the market structure. When law enforcement intensity e becomes higher than the value $e^D = \left(3 - \frac{2\sqrt{30}}{5}\right)a$, threshold higher than e^M, individual expected profits of the two organizations present in the market become smaller than the one that they realize by letting a third trafficker into the market.

3.2 Expected individual profits and total quantity

From previous results, we depict in figure 1 the change from a horizontal structure to another by individual expected profits π_i in function of law enforcement intensity e. In order to construct this graph, we give the following values for demand parameters: $a = 100$ and $b = 1$.

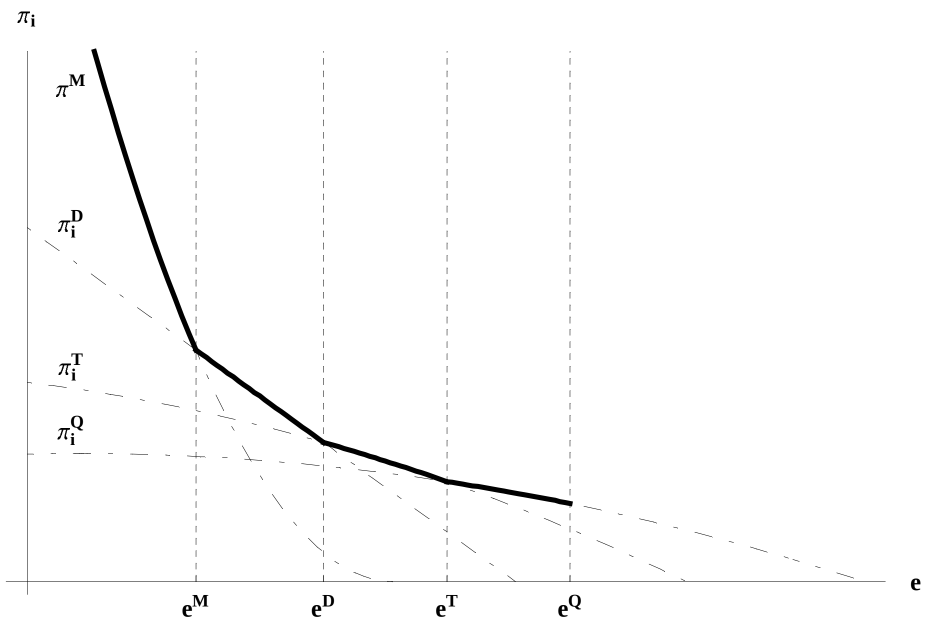

Figure 1: Individual profits

Thus the horizontal structure of the illicit market evolves according to law enforcement intensity. As law enforcement intensity increases, criminal organizations must let new competitors enter the market in order to reduce the decrease of their profits. Even if a more intense competition leads to a loss of profits for the organizations, the latter earn a reduction of their costs. As the probability of arrest depends on the market share of the organization, the fact of being numerous in the market allows to reduce the cost imposed by drug law enforcement for each criminal organization.

Likewise, we depict total drug quantity consumed by users according to the horizontal structure of the market and to the law enforcement intensity (see figure 2).

When law enforcement intensity is initially low, that is, when the illicit market is monopolistic, a relatively low rise of this variable entails a diminishing of the consumption, which is the aim of public policy. But, if the rise

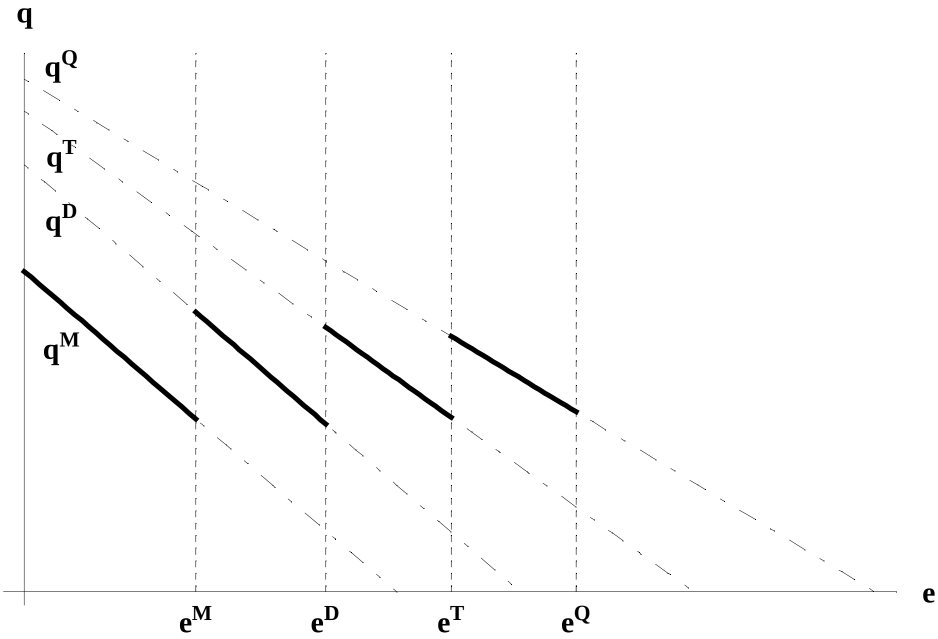

Figure 2: Total consumed quantity

of law enforcement efforts is too high, this could lead to a situation where the market becomes competitive and where drug consumption becomes higher than the initial level.

At each structure change, following an increase in law enforcement intensity, it appears a jump in the total quantity of consumed drugs. A more repressive policy can thus lead to an increase in drug consumption when the market becomes more competitive. The endogenization of the market structure entails a discontinuity of $q(e)$.

With this example, in terms of public policy, authorities in charged with the drug law enforcement policy should fix law enforcement intensity just at a level less than the threshold e^M. The minimum quantity is effectively always at the thresholds level e^M, e^D, and e^T, where criminal organizations are indifferent between letting go in a new trafficker in the market or not. Law enforcement efforts being costly, it is better to set law enforcement intensity at its minimum possible level, e^M.

We obtain here the same qualitative results that Mansour, Marceau, and Mongrain (2001). But their model considers only three gangs at the maximum. Now we generalize these results to any number of criminal organizations.

4 Law enforcement efforts and horizontal structure

In the first subsection we study the extension of the previous example to a number of criminal firms n. The second subsection presents effects of an increase in law enforcement intensity on illicit market horizontal structure and on quantities consumed at the equilibrium.

4.1 Generalization to n criminal organizations

Criminal firms engage in Cournot competition with costs related to the anti-drug law enforcement policy. Given the number of criminal organizations n, each of them solves the program (1):

$$\max_{q_i} \pi_i(q_i,\, q,\, n,\, e) = P\left(\sum_{j=1}^{n} q_j\right) q_i - e\frac{q_i^2}{\sum_{j=1}^{n} q_j},$$

with $q = \sum_{j=1}^{n} q_j$.

We can write the first order condition as

$$q_i P'(q) + P(q) - e\frac{q_i(2q - q_i)}{q^2} = 0,\ \forall i = 1, ..., n.$$

Due to symmetry, we can show that, for all i and j, $q_i = q_j = \frac{q}{n}$.

The second order condition is satisfied for all i since $P(q)$ is assumed concave. We effectively obtain:

$$\frac{d^2\pi_i}{dq_i^2} = 2P'(q) + q_i P''(q) - 2e\frac{\left(\sum_{j=1}^{n} q_j - q_i\right)^2}{\left(\sum_{j=1}^{n} q_j\right)^3} < 0$$

Total sold quantity q candidate solution of the problem is given by the following implicit fonction:

$$qP'(q) + nP(q) = e\frac{2n-1}{n}. \tag{2}$$

Let $\varphi(q) = qP'(q) + nP(q)$. Under hypotheses done on $P(q)$, this function is continuous, decreasing, concave, and $\varphi(0) > 0$. The equation (2) admits a unique positive solution in q if and only if $\varphi(0) > e\frac{2n-1}{n}$, that is, if and only if

$$e < \frac{n^2 P(0)}{2n-1} = \overline{e}. \tag{3}$$

The inequality (3) means that when law enforcement intensity exceeds a certain threshold, illicit market does not exist. But, we are interested in illegal markets which are not eradicated. Moreover, as repression is costly, it is not possible to have $e \to +\infty$. We thus assume that this condition is satisfied. The maximum law enforcement intensity threshold $\overline{e}$ depends on the number of criminal organizations present in the market, n, and is increasing in this variable. We recognize the condition we have obtained in the linear demand case. The market existence condition becomes less restrictive as the number of traffickers increases. The inequality (3) is satisfied whatever n when $e < P(0)$. When $e \geq P(0)$, this inequality is equivalent to:

$$n \geq \frac{e + \sqrt{e(e - P(0))}}{P(0)} = n^0. \tag{4}$$

Then the threshold n^0, with $n^0 > 1$, is the minimum number of criminal organizations necessary to the existence of the illicit market given law enforcement intensity.

The total sold quantity of illicit goods $q(n,\, e)$, determined by the implicit equation (2), depends on the number of criminal organizations present in the illicit drug market n, and so on the market structure.

Before going further on the model, we present a first result which is consistent with conventional wisdom in the illicit drug field.

Proposition 1. *Given a number of criminal organizations, that is, for a fixed market structure, an increase in the law enforcement intensity e leads to a decrease in the total quantity of illicit good and to an increase in its price.*

Proof. By differentiating the equation (2) with respect to q and e and by considering n as a constant, we obtain:
$\frac{\partial q(n,e)}{\partial e} = \frac{2n-1}{n\left[(n+1)P'(q)+qP''(q)\right]} < 0$, as $P'(q) < 0$ and $P''(q) < 0$.
Moreover, as $P'(q) < 0$, we obtain $\frac{\partial P(q)}{\partial e} = P'(q)\frac{\partial q(n,e)}{\partial e} > 0$. □

When the market structure is regarded as given and fixed, a tougher anti-drug law enforcement policy, which aims to reduce the drug consumption, well hits its objective.

Moreover, as in the case of firms with a constant unit cost, the total consumed quantity increase with the number of criminal entrepreneurs present in the market.[4]

4.2 Endogenization of the horizontal structure

Given the illegal nature of studied markets, we can assume that criminal organizations present in the market can control and make vary their number according their interests, either by eliminating physically some competitors or by simply letting some new organizations enter the market.[5]

By assuming that criminal organizations adapt their number according to circumstances, it certainly exits for each trafficker i a number of organizations n_i^* which maximises his expected profit. We assume that firms are identical, and therefore we expect all of them to have similar strategies.[6] Thus we obtain that $n_i^* = n_j^*$ $\forall i, j$. The solution of the program (1) has allowed us to obtain, for all i, the equilibrium quantity $q_i(n,e)$ which depends on the law enforcement intensity, but also on the market horizontal structure characterized by the number of criminal organizations. The expected profit of the trafficker i is then given by:

$$\pi_i\left(q_i(n,\, e),\, n,\, e\right) = P\left(\sum_{j=1}^{n} q_j(n,e)\right) q_i(n,e) - e\frac{\left(q_i(n,e)\right)^2}{\sum\limits_{j=1}^{n} q_j(n,e)}. \tag{5}$$

From results of the previous subsection, we can rewrite the expected profit of the organization i as a function of the number of criminal organizations n and of the law enforcement intensity:

$$\pi_i\big(q(n,\, e),\, n,\, e\big) = \left[P\big(q(n,\, e)\big) - \frac{e}{n}\right]\frac{q(n,\, e)}{n}. \tag{6}$$

Now we determine the optimal number of criminal organizations n^* from the point of view of incumbent organizations. All criminal organizations being identical, we have to solve for each of them the following program:

$$\max_{n} \pi_i\big(q(n,\, e),\, n,\, e\big). \tag{7}$$

[4]Indeed, given a law enforcement intensity level, $\frac{\partial q(n,\, e)}{\partial n} = \frac{nqP'(q)-2(n-1)e}{n^2\left[(n+1)P'(q)+qP''(q)\right]} > 0$, since $P(q)$ is decreasing and concave, and $n \geq 1$.

[5]A trafficker can, for example, remain alone in the market by engaging in a war against potential entrants. This strategy leads to some supplementary costs for a criminal organization. We can neglect them in this model.

[6]Without the homogeneity hypothesis of firms, a coordination problem appears and it is impossible to solve the model.

The optimal number of traffickers $n^*(e)$ for a organization present in the market is implicitly determined by the following equation:

$$n^*(e)P\big(q(n^*(e),\, e)\big) = 2e. \tag{8}$$

The proof of this result is given in appendix A.

The figure 3, which depicts the individual expected profit as a function of n for a given value of the law enforcement intensity, with the hypothesis of a linear demand function, gives a idea of the form of $\pi_i\big(q(n,\, e),\, n,\, e\big)$.

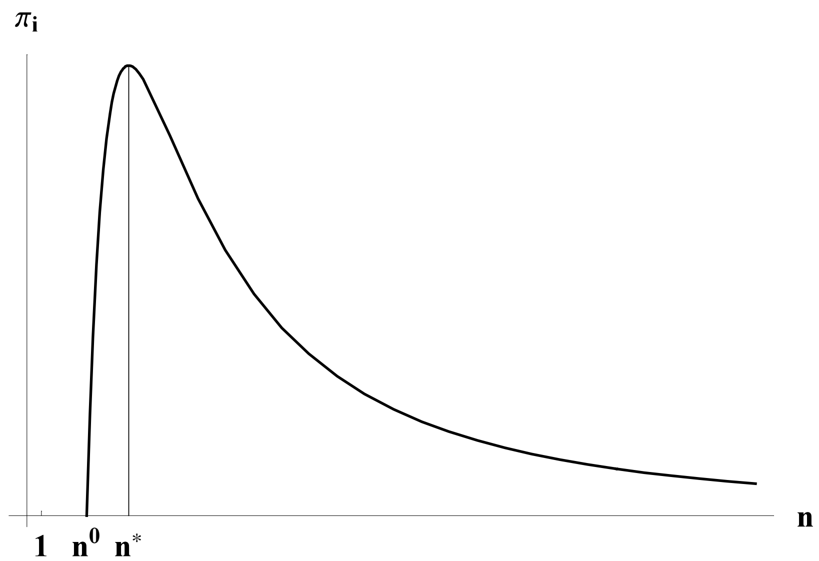

Figure 3: Individual profit

The number of criminal firms $\widetilde{n}$ which cancels out the individual expected profit is given by $\widetilde{n}P\left(q(\widetilde{n},\, e)\right) = e$. But, this number is lower than n^0, defined as the minimum number of organizations which guarantees the market existence (see equation (4)).[7] It is not the free entry equilibrium, since, for all $n > n^0$, the individual expected profit is positive. The number of traffickers corresponding in fact to free entry is $n^{\mathrm{fe}} = +\infty$. As $P(q)$ is concave, when n tends to infinity, q tends towards a finite value, and then $\pi_i\big(q(n,\, e),\, n,\, e\big)$ tends towards zero.

The optimal number of criminal entrepreneurs $n^*(e)$ depends on law enforcement intensity e. It is then interesting to study the effect of the repression on the number of criminal organizations wished for by the latter already present on the illicit market.

[7] The condition $n > \widetilde{n}$ is nevertheless the market existence condition when $e < P(0)$.

Proposition 2. *The optimal number of criminal organizations $n^*(e)$, that each entrepreneur present in the market would like to see appearing in the market, is increasing with law enforcement intensity e.*

Proof. See the appendix A. □

When law enforcement authorities increase the law enforcement intensity, criminal organizations are well advised to let news competitors enter the market. Thus, as the number of traffickers increases, illegal activities become more important in the economy.

While, in the legal sphere, each firm would like to be in a monopoly position in order to obtain a maximum profit, in the case of illicit markets presented in this model, due to positive externalities, each criminal entrepreneur wants to be in competition with other traffickers to maximize their profit. On such a market, the illegality itself of the activity means that a trafficker can remain alone to set up the market by physically eliminating his potential competitors. Paradoxically, the proposition 2 shows that, given law enforcement intensity e, a criminal entrepreneur is not well advised to remain in a monopolistic situation. Indeed, in order to avoid undergoing the whole repression, a criminal entrepreneur lets another organization into the market. He faces the following trade-off. By letting go in a new firm, quantities he sells decrease because of a rise in the competition. But, simultaneously, law enforcement efforts he individually undergoes is less high since repressive authorities track down a supplementary criminal organization. A congestion effect in the detection technology appears. When there is a monopoly on the illicit market, whatever the transaction intercepts and the number realized, it is sure that a transaction is due to the monopoly. When there are several criminal organizations, the police can intercept two transactions tied to the same entrepreneur, which is ineffective.

At the optimum, the more the public authorities increase law enforcement efforts, the more the incumbent criminal organizations in the market have incentive to let competitors enter the market and the less they are in conflict among themselves. Traffickers view the entry of new ones in a favorable light and even can favor it. But, if law enforcement intensity decreases, the optimal number of criminal organizations should decrease. This means that, at the short term, a gang war can appear because some traffickers must go out of the market.

In this model, two implicit hypotheses are at work. Firstly, organizations do not incur any control cost of the optimal number of traffickers n^*. Secondly, all the latter perfectly coordinate themselves on n^* due to symmetry. But, our model brings to the fore the evolution of the optimal number of criminal entrepreneurs n^* according to the law enforcement intensity e. This gives an idea of what we would observe in fact.

A future line of research would be to model the game which consists in the control of the number of players in the market. Intuitively, we can think that the cost of letting a player enter the market is null. Conversely, the cost of preventing a potential competitor from entering is relatively high. Thus, in order to limit the number of entrants each criminal organization pays a part of this cost and, by doing so, it helps other organizations. We could expect a free rider phenomenon (Gilbert and Vives, 1986 ; Waldman, 1987). The last effect and the fact that cost of limiting entry is higher than the one of letting into would lead to a observed number of criminal organizations greater that the optimal number n^*.

Furthermore, we can look at the equilibrium total quantity sold by criminal organizations when the number of them is optimal.

Proposition 3. *When the horizontal market structure is endogenous, illicit drug consumption is independent from the law enforcement intensity and is given by the following implicit function:*

$$q^* = \frac{P(q^*)}{-2P'(q^*)}. \tag{9}$$

Proof. See the appendix B. □

At the equilibrium, the total illicit drug quantity consumed only depends on demand parameters. Consequently, drug law enforcement authorities have no influence on narcotic consumption. Whatever the level of law enforcement intensity they choose, total illicit drug quantity consumed by users is the same.

Two effects take place when the law enforcement intensity increases. On the one hand, the quantity sold by each criminal organization decreases.[8] On the other hand, the number of traffickers increases (proposition 2). This totally compensates for the first effect. Thus, resources allocated to traffickers' detection have no effect on the illicit drug consumption. Only the endogenization of the horizontal market structure allows us to bring to the fore these two effects. By considering the market structure as fixed, only the first effect appears.

A related result concerns the link between the aggregated expected profit of crime and the law enforcement intensity.

[8]Indeed, $q_i^*(e) = \frac{\left(P(q^*)\right)^2}{-4eP'(q^*)}$ and then $\frac{dq_i^*(e)}{de} = \frac{\left(P(q^*)\right)^2}{4e^2P'(q^*)} < 0$, because $\frac{dq^*(e)}{de} = 0$.

Proposition 4. *The aggregated expected profit* $\sum_{i=1}^{n} \pi_i$ *is independent from the law enforcement intensity* e *and is equal to:*

$$\sum_{i=1}^{n} \pi_i = \frac{\left(P(q^*)\right)^2}{-4P'(q^*)}.$$

Proof. From the equation (6) which defines the individual expected profit of a criminal organization and by substituting the optimal number of entrepreneurs $n^*(e) = \frac{2e}{P(q^*)}$ and the equilibrium total quantity q^*, we can rewrite the individual expected profit as:

$$\pi_i = \frac{\left(P(q^*)\right)^3}{-8eP'(q^*)}.$$

Symmetry implies $\sum_{i=1}^{n^*(e)} \pi_i = n^* \pi_i$, thus

$$\sum_{i=1}^{n^*(e)} \pi_i = n^*(e) \frac{\left(P(q^*)\right)^3}{-8eP'(q^*)}. \tag{10}$$

By substituting $n^*(e)$ into (10), we obtain the announced result. □

In proposition 2, we have shown that a law enforcement intensification leads to an increase in the number of traffickers in the market. This implies proposition 3 which sets out that an increase of competition offsets the effect of reduction of the individual production in terms of quantities. Consequently, total quantity and price are constant at the equilibrium. We can then conclude that, at the aggregated level, criminal organizations' total receipts are constant. Then, the cost related to the risk of detection and conviction born by a organization is equal to $e\frac{q_i^2}{\sum_{j=1}^{n} q_j}$. At the aggregated level, the law enforcement cost is thus equal to $\sum_{i=1}^{n} e\frac{q_i^2}{\sum_{j=1}^{n} q_j}$. At the symmetric Nash equilibrium, this cost can be writen as $\frac{eq}{n}$. The number of criminal organizations n is increasing in e (proposition 2) and total produced quantity is independent from e. Thus, broadly, any intensification of drug law enforcement efforts leads to a great scattering of crime, what makes it lose its efficiency. The global effect is that total cost which derives from the detection and the sanction remains constant.

A tougher law enforcement policy against traffickers entails a diminishing in individual profit of each of them, but the global profit of organized crime related to illicit drug market is not altered by it. Thus, even if public authorities have a double aim of reducing the illicit drug consumption and of cutting down profits of organized crime, which are a source of negative externalities, a increase in the law enforcement intensity is doomed to failure.

5 Conclusion

It should be no surprise that illicit markets such as those of drugs are sometimes puzzling. Conventional wisdom neglects the fact that law enforcement efforts can have an influence upon market structure. The contribution of this paper stems from the fact that the market structure is endogenous. We show that criminal organizations cancel out law enforcement efforts by letting new traffickers into the market. This increase in the number of criminal entrepreneurs results in a dissipation of law enforcement efforts. Results of this paper are that *i)* a law enforcement policy increases the competition in illicit markets, *ii)* it has no effect on total sold quantity, and *iii)* the aggregated expected profit of an illicit activity is independent from the law enforcement intensity. This simple model could thus partially explain the failure of the war on drugs lead by the United States in Colombia since the beginning of the 1990s. The breaking up of the two great Colombian cartels cannot constitute important achievements for US and Colombian drug enforcement authorities, because this leads to an increase of the competition, of the number of smaller, but efficient criminal organizations, and of drug cultivation and trafficking in Colombia.

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A proof of proposition 2

In order to proof proposition 2, it is necessary to solve the following program:

$$\max_n \pi_i\big(q(n,\, e),\, n\, e\big) = \Big[P\big[q(n,\, e)\big] - \frac{e}{n}\Big]\, \frac{q(n,\, e)}{n}.$$

The first order condition is the following:

$$\frac{\partial \pi_i\big(q(n,\, e),\, n,\, e\big)}{\partial n} = \frac{(n-1)nq'_n(n,\, e) + q(n,\, e)}{n^4}\Big[e + nq(n,\, e)P'\big(q(n,\, e)\big)\Big] = 0.$$

Now $q'_n(n,\, e) = \frac{\partial q(n, e)}{\partial n} = \frac{nqP'(q) - 2(n-1)e}{n^2\big[(n+1)P'(q) + qP''(q)\big]} > 0$, therefore the term $\Psi(n,\, e) = (n-1)nq'_n(n,\, e) + q(n,\, e)$ is positive.

Let $\Phi(n,\, e) = -nq(n,\, e)P'\big(q(n,\, e)\big)$. This function $\Phi(n,\, e)$ is defined on the interval $[0,\, +\infty[$, continuous, positive, increasing in n.

As $\Psi(n,\, e) > 0$ and given properties of $\Phi(n,\, e)$, it exists an unique value of n, n^*, which verifies the first order condition
$\frac{\partial \pi_i\big(q(n,e),n,e\big)}{\partial n} = \frac{\Psi(n,e)}{n^4}\Big[e - \Phi(n,\, e)\Big] = 0.$
It is defined by $\Phi(n^*,\, e) = e$, that is, $-n^*q(n^*,\, e)P'\big(q(n^*,\, e)\big) = e$.

The second derivative of function $\pi_i\big(q(n,\, e),\, n,\, e\big)$ with respect to n is equal to:

$$\frac{\partial^2 \pi_i\big(q(n,\, e),\, n,\, e\big)}{\partial n^2} = \frac{\Psi'_n(n,\, e)n - 4\Psi(n,\, e)}{n^5}[e - \Phi(n,\, e)] - \Psi(n,\, e)\Phi'_n(n,\, e).$$

Now $\left.\frac{\partial^2 \pi_i\big(q(n,e),n,e\big)}{\partial n^2}\right|_{n=n^*} = -\Psi(n,\, e)\Phi'_n(n,\, e) < 0$, therefore n^* is a local maximum. The number of criminal organizations which verifies the first order condition, n^*, being unique, thus it is a global maximum. It is given by the implicit expression:

$$-n^*q(n^*,\, e)P'\big(q(n^*,\, e)\big) = e.$$

Given $q(n,e)$ defined by equation (2), the optimal number $n^*(e)$ can be rewritten:

$$n^*(e)P\Big(q\big(n^*(e),\, e\big)\Big) = 2e.$$

This number depends on the law enforcement intensity e in the following way:

$$\frac{dn^*(e)}{de} = \frac{1 + n^*(e)q'_e\big(n^*(e),\, e\big)S\big(n^*(e),\, e\big)}{-n^*(e)q'_n\big(n^*(e),\, e\big)S\big(n^*(e),\, e\big) - q\big(n^*(e),\, e\big)P'\left[q\big(n^*(e),\, e\big)\right]},$$

with $S\big(n^*(e),\, e\big) = P'\left[q\big(n^*(e),\, e\big)\right] + q\big(n^*(e),\, e\big)P''\left[q\big(n^*(e),\, e\big)\right] < 0$.
As $q'_e\big(n^*(e),\, e\big) < 0$ and $q'_n\big(n^*(e),\, e\big) > 0$, $\frac{dn^*(e)}{de} > 0$.

B proof of proposition 3

The total sold quantity on a illicit market depends directly on e and indirectly through the optimal number of criminal organizations: $q\big(n^*(e),\, e\big)$. The derivative of $q\big(n^*(e),\, e\big)$ with respect to e can be written as:

$$\frac{dq\big(n^*(e),\, e\big)}{de} = q'_n\big(n^*(e),\, e\big)\frac{dn^*(e)}{de} + q'_e\big(n^*(e),\, e\big).$$

As $n^*(e)q\big(n^*(e),\, e\big)P'\big[q\big(n^*(e),\, e\big)\big] = -e$,

$$\frac{dq\big(n^*(e),\, e\big)}{de} = \frac{n^*(e)\big(1-2n^*(e)\big)S\big(n^*(e),\, e\big)\Big(eq'_e\big(n^*(e),\, e\big) + n^*(e)q'_n\big(n^*(e),\, e\big)\Big)}{A}$$

with
$S\big(n^*(e),\, e\big) = P'\left[q\big(n^*(e),\, e\big)\right] + q\big(n^*(e),\, e\big)P''\left[q\big(n^*(e),\, e\big)\right]$ and

$$\begin{aligned} A = -(n^*(e))^2 &\Bigg[(n^*(e)+1)P'\left[q\big(n^*(e),\, e\big)\right] + q\big(n^*(e),\, e\big)P''\left[q\big(n^*(e),\, e\big)\right]\Bigg] \\ &\times\Bigg[n^*(e)q'_n\big(n^*(e),\, e\big)S\big(n^*(e),\, e\big) + q\big(n^*(e),\, e\big)P'\left[q\big(n^*(e),\, e\big)\right]\Bigg]. \end{aligned}$$

Now $\Big(eq'_e\big(n^*(e),\, e\big) + n^*(e)q'_n\big(n^*(e),\, e\big)\Big) = 0$, therefore $\frac{dq\left(n^*(e),e\right)}{de} = 0$.

Moreover, as, at the equilibrium, $n^*(e)P(q^*) = 2e$ and $-n^*(e)q^*P'(q^*) = e$, we obtain total sold quantity at the equilibrium:

$$q^* = \frac{P(q^*)}{-2P'(q^*)}.$$

At the equilibrium, quantity sold by each criminal organization and expected profit carried out by each one are thus respectively:

$$q_i^* = \frac{\big(P(q)\big)^2}{-4eP'(q)} \quad \text{and} \quad \pi_i^* = \frac{\big(P(q)\big)^3}{-8eP'(q)}.$$