When Brute Force Fails: An Economic Formalization *

Santiago Vélez† Daniel Mejía‡

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Abstract

This paper develops a model where a government simultaneously confronts heterogeneous drug trafficking organizations (DTOs). If the government allocates its resources according to a violence ranking between those organizations, then the DTOs' problem is strategic as their utility depends on the violence decision of others. We elicit two situations. In the first one the government induces a separating equilibrium while in the second it induces a pooling equilibrium. In the first situation, the optimal allocation of resources results in a situation where the resources allocated to each DTO are somehow proportional to their levels of violence. In the second one, by means of making an announcement that it will concentrate all of its resources in the most violent DTO, under the assumption that the government has a sufficiently high amount of resources, it induces a pooling equilibrium in which all DTOs decide to exercise no violence. This result formalizes Mark Kleiman's dynamic concentration theory.

Keywords: Deterrence, optimal enforcement, violence.

JEL–Numbers: D74, D81, D82, K42.

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†Universidad de los Andes; e-mail: s.velez55@uniandes.edu.co, código: 200622913, Article submitted for master's degree dissertation.

‡Universidad de los Andes, Associate professor, Bogotá, Colombia.

1 Introduction

In all countries in which drug trafficking or drug producing takes place, drug related violence is a central public policy problem. In those countries, Drug Trafficking Organizations (DTOs) have become the *de facto* rulers in vast areas within their territories. Nevertheless, Mexico has recently been the country with the most acute and visible problem of drug related violence. In the six years of Felipe Calderón's administration, more than 60,000 drug related killings occurred. During that administration, the Mexican Federal Government declared an open war against DTOs. The fact that the sharp increase of drug related homicides coincides approximately with the beginning of the war has generated a wide controversy regarding whether or not such increase in violence is related to the federal government's strategy of directly confronting DTOs.

On the one hand, authors like Guerrero (2010) have argued that most of the escalation of violence results from the federal government's strategy. For instance, the dismantling of DTOs has been driven by a beheading strategy. Several DTOs' leaders have been neutralized to date, either being killed or captured by the government. However, this led to new surges of violence in the areas where their criminal work took place. Guerrero explains this fact as ensuing from tensions within the DTO to decide who will occupy the vacant position, and from other DTOs taking advantage of the momentary void of power in order to expand their business. The beheading strategy has thus generated a spread of violence throughout the Mexican territory, leading to several harmful side effects. For instance, many areas of Mexico have witnessed increasing rates of other profitable forms of violence such as extortion and kidnappings. The overall result has been a sharp increase of violent murder rates. Rios (2012) supports Guerrero's position and argues that this interaction between the beheading strategy and the new surges of violence, generated by the temporary void of power, generates a "self-reinforcing violent equilibrium".

On the other hand, several authors have positions contrary to those of Guerrero. For instance, Calderón et al. (2012) argue that the aforementioned beheading strategy results in a temporary rise of violence levels but in lower levels of violence in the long run, while Castillo, Mejía and Restrepo (2012) argue that violence in Mexico has also been affected by the success of the Colombian war against drug trafficking. Chabat (2010) and Astoraga (2010) argue that the previous Mexican authorities' "tolerance" regarding drug trafficking created a violence-enabling environment.

As long as drugs remain illegal and criminal groups control illegal drug market rents, the question regarding how a government could deter drug related violence efficiently is one of its most important public policy problems. Mark Kleiman (2011) has argued that a government may accomplish this goal by creating disincentives for the decision of DTOs to use violence to fulfill their objectives. That DTOs find it less profitable to be more violent is the way to do this. This may be accomplished by violence-targeted enforcement. Kleiman proposes a way in which this method could be developed. He argues that if a government creates a violence-related metric applied to all DTOs over a period of time, then it can announce that it will target the DTO ranked first in that metric. He argues that this strategy would result in all DTOs pooling into an equilibrium characterized by low levels of violence.

In this paper we develop a model in which the government and the DTOs interact and analyze the public policy problem regarding how a government confronting several DTOs simultaneously should allocate its enforcement resources among them. We assume that violence is the means by which DTOs acquire income in an illegal market. We make the simplifying but realistic assumptions that while the objective of the government is to minimize the aggregate level of violence, the objective of the DTOs is to maximize profits.

We model this interaction for two different cases. In both of them the government plays first by announcing how its allocation of resources takes place and then the DTOs decide their optimal levels of violence. Moreover, DTOs behave as neoclassical firms, e.g. as profit maximizing firms that face decreasing marginal returns from exercising violence and increasing costs. The costs DTOs face depend on the opportunity costs of violence and the costs of attracting the government's enforcement resources. The costs of attracting the government's attention is what differs in the two cases. In the first case the government's announcement and its corresponding allocation results in a separating equilibrium while in the second case it results in a pooling equilibrium characterized by zero violence. Nevertheless, we show that the aforementioned result depends on the amount of enforcement resources the government has.

In the first case, the government announces an allocation of resources according to a ranking of DTOs based on their use of violence. In this situation, the choice of violence by each DTO becomes necessarily strategic, because each DTO must anticipate the violence level of others in making its optimal violence decision. Therefore a negative concern for *violence status* may be induced by an allocation of resources according to a ranking of violence. Here we model *violence status* as an ordinal rank in the distribution of violence in a simultaneous move game. In order to solve this game, a symmetric Nash equilibrium is assumed, where all DTOs decrease their violence level simultaneously[1]. Then the existence

[1] From this fact it follows that we model violence status as in Frank (1985).

of such equilibrium is formally demonstrated.

Treating violence status strategically allows us to derive an optimal allocation of scarce enforcement resources across different DTOs. This follows from the fact that when the government announces its allocation of resources, it anticipates all DTOs' moves.

Up to this point we have only dealt with a separating equilibrium. However, in the second case, we show that under the assumption that the government has enough resources to deter any DTO when concentrating all of its resources on it, if the government announces that it will concentrate all its resources in the most violent DTO, this results in a pooling equilibrium in which all DTOs decide to exercise no violence[2]. However we show that if the government does not has enough resources in order to deter the the most violent DTO either a Nash equilibrium does not exist or the government's strategy does not changes the DTO's level of violence.

The previous result supports the theory developed by Mark Kleiman (2011), known as *dynamic concentration* theory, in which the best allocation of resources under a dynamic time frame is achieved by applying this strategy whenever having a sufficiently high amount of resources. Moreover, we show this strategy is optimal even on a one-shot game.

The rest of the paper is organized as follows. Section 2 introduces a benchmark model in which the government and DTOs do not interact and therefore the amount of violence of DTOs is the same as in the case where the government does not confront DTOs. Section 3 develops the model in which DTOs interact according to a violence ranking. Section 4 presents a version of the model where the government announces it will concentrate all enforcement efforts on the most violent DTO, and shows how Mark Kleiman's theory holds even in a static setting. Section 5 concludes.

2 The Benchmark Case

In the benchmark case presented in this section, we assume that there are no strategic interactions between the government and DTOs[3]. We assume that DTOs behave as neoclassical firms, e.g. as profit maximizing firms that face decreasing marginal returns from exercising violence and increasing costs. In this case, the DTO's optimization condition, when choosing

[2]The fact that we allow pooling equilibrium is what motivated us to model violence status as in Frank (1985) rather than as in Hopkins and Kornienko (2004)

[3]The following scenarios result in this situation: the government does not confront DTOs, it assigns the same amount of resources to all of them or it assigns its resources directly to DTOs regardless of their violence levels

the optimal level of violence, is the classical result of marginal benefits equal to marginal costs.

We assume that all DTOs are equal in all relevant dimensions except in the degree of efficiency with which they are able to generate income using violence. This efficiencies allow us to recreate situations such as the one in which DTOs, for instance, have to confront each other over the control of drug trafficking routes, from which they derive income out of drug trafficking activities. The efficiency with which they generate income with violence will be denoted by A.

The DTOs' profits function can be broken down into two elements. If we denote the violence decision of DTOs by a, the first element, $AP(a)$, is a conventional income function that depends only on the violence level chosen by each DTO. The second, $-a$, defines the opportunity costs of violence. We assume that DTOs face constant diminishing marginal income returns from violence (i.e., we assume that $P'(a) > 0$ and $P''(a) < 0$). Therefore we assume that $P(a) = a^{\beta}$ where β is a constant that measures diminishing returns and $\beta \in [0, 1]$.

DTO i's problem is:

$$\underset{a_i}{\text{Max}}\, A_i a_i^{\beta} - a_i \tag{1}$$

with the first order condition being:

$$a^{bc}(A_i) = (\beta A_i)^{\frac{1}{1-\beta}} \tag{2}$$

The previous level of violence is the benchmark level of violence of the DTOs. In the next section a model in which the government deters the use of violence by inducing a *violence status* is developed.

3 Deterring with *Status*

We now develop an asymmetric game in which the government and DTOs interact. The asymmetry follows from the fact that the government does not know the DTOs' degree of efficiency to make violence profitable and also each DTO ignores the other DTOs' efficiency. The objective of the government is to minimize the aggregate level of violence while the proloblem of the DTOs is to maximize profits.

In this case the government plays first announcing how the allocation of enforcement resources is going to take place according to a ranking of violence of DTOs. Therefore each DTO must anticipate the levels of violence of the other DTOs when deciding its level of violence.

After the government makes its announcement, the DTOs decide their optimal level of violence taking into account that they receive direct benefits from the exercise of it but face the cost of attracting the government's attention. In this model we consider a continuum of DTOs whose degree of efficiency is distributed on a finite support.

The timing of the model is as follows. Nature plays first, giving each DTO a type (an efficiency with which they produce profits with violence, A_i). Then the government announces the share of enforcement resources, z, allocated to each position in the violence ranking. Finally DTOs decide their level of violence, again denoted by a.

We now introduce the agents involved in the game in more detail. This is done in the same order in which they appear when solving the model by backward induction.

3.1 The Drug Trafficking Organization's Problem

Consider the problem of a DTO that must decide its optimal level of violence. As in the benchmark case, assume that DTOs behave as neoclassical firms. Nevertheless, in this problem DTOs must deal with the cost of attracting government enforcement resources in a different way than in the previous model. We are going to model this cost under the assumption that DTOs are affected by their relative position in a violence ranking, since the government announces how its resources will be allocated based on a violence ranking across DTOs.

We shall assume a continuum set of DTOs, identical in all relevant aspects except in their degree of efficiency, as shown in their technology to produce income. Each DTO is given a technology, A, which is private information and is an independent draw from a common distribution. This is described by a cumulative distribution function $\mathcal{F}(A)$ which is twice continuously differentiable with a strictly positive density over the support $[A_{min}, A_{max}]$ with $A_{min} > 0$.

We follow the methodology presented in Frank (1985) regarding the construction of status rankings. Suppose violence is distributed among DTOs with density function $r(a)$ and that a_0 is the smallest violence level of all DTOs. Then, a DTO with violence level $a = a_i$ would be ranked as:

$$R(a_i) = \int_{a_0}^{a_i} r(a)da \tag{3}$$

Therefore, $R(a_i)$ is the relative position of a DTO with violence level a_i in the violence ranking. Notice that $R(a)$ is a number between 0 and 1, indicating the percentile ranking of a in the population of a values. In this model, we assume that the government's allocation of enforcement resources is a function of this ranking. We define this distribution henceforth as $g(R(a))$. Therefore, if we define the government's enforcement resources as constant z, we may establish the costs of attracting the government's attention as $g(R(a))z$.

Assuming further that their income and costs function behave as in the benchmark case, the profits function to be applied to all DTOs is:

$$\Pi(a) = AP(a) - a - g(R(a))z \tag{4}$$

We assume that $P(.)$ is nonnegative, strictly increasing, strictly quasiconcave and twice differentiable. Therefore, each DTO maximizes its profits function, as stated above.

In the context of this game we seek a *symmetric equilibrium*. Such an equilibrium will be a Nash equilibrium in which all DTOs will use the same strategy, $a(A)$, mapping from the degree of efficiency to the level of violence.

Assume for the timebeing that $a(A)$ is increasing and differentiable. If we assume that all DTOs apply such an equilibrium strategy, then the probability that a DTO i with violence technology A_i and violence choice a_i will have a higher violence level than an arbitrarily chosen DTO j is $R(a_i) = Pr(a_i > a(A_j)) = Pr(a^{-1}(a_i) > A_j) = \mathcal{F}(a^{-1}(a_i))$. Hence we may restate the maximization problem of the DTOs as:

$$\underset{a_i}{\text{Max}}\, A_i P(a_i) - a_i - g(\mathcal{F}(a^{-1}(a_i)))z \tag{5}$$

Assuming that the problem is well defined and that its maximum is characterized by its first order condition, then the unique separating equilibrium (if it exists) must satisfy the following differential equation:

$$a'\left[a^{-1}(a_i)\right] = \frac{g'(\mathcal{F}(a^{-1}(a_i)))f(a^{-1}(a_i))z}{A_i P_a - 1} \tag{6}$$

In the above equation $a' = \frac{\partial a}{\partial A}$, $g' = \frac{\partial g}{\partial A}$ and $f(a^{-1}(a_i))$ is the density distribution of the technology. Henceforth assume that DTOs follow the equilibrium path explicitly given by the above equation. Therefore, replacing $a^{-1}(a_i) = A_i$ and noticing that $g'(A) = \frac{dg}{dA} =$

$g'(\mathcal{F}(a^{-1}(a_i)))f(a^{-1}(a_i))$, we may rewrite the above expression as:

$$a' = \frac{g'(A)z}{A_i P_a - 1} \tag{7}$$

Note that, in this problem, the following relation holds under the symmetric Nash equilibrium: $\Pi_A > 0$. This means that the DTO with the lowest A, i.e. the one with lowest degree of efficiency, is the one that will reveal its type in equilibrium. Therefore, the DTO with the lowest efficiency exercises its benchmark level of violence.

3.2 The Government's Problem

Now consider the problem of a government that must decide how to allocate its resources in an optimal manner in order to minimize the aggregate level of violence. When doing so the government anticipates the equilibrium path followed by the DTOs. In this case we can write the government's objective function as:

$$\underset{g(A_i)}{\text{Min}} \int_{A_{min}}^{A_{max}} a(A_i, g(A_i)) f(A_i)\, \mathrm{d}A_i \tag{8}$$

Naturally, the constraint that the government faces is:

$$\int_{A_{min}}^{A_{max}} g(A_i) f(A_i)\, \mathrm{d}A_i = 1 \tag{9}$$

Also notice that since the government expects the DTO with the lowest degree of efficiency to reveal its type, the optimal allocation of resources for that particular DTO is $g(A_{min}) = 0$. With the above equations we may derive the following first order condition:

$$\frac{a'}{g'} = \lambda \tag{10}$$

where λ is the Lagrange's multiplier associated with the budget constraint.

The above equation says that the government faces diminishing marginal returns when concentrating resources in a particular position in the violence ranking. Therefore its optimal condition is to have the same marginal benefits when concentrating resources among all positions. In other words, the last unit of defense resources allocated to each position must have the same return in terms of decreasing the aggregate level of violence. Recall that when we developed the DTOs' problem we assumed a symmetric Nash equilibrium. Having $\lambda > 0$ is a *sufficient* condition to obtain an increasing separating equilibrium.

In order to solve the problem explicitly we must solve the system of differential equations formed with the government's optimality condition as shown in equation (10) and the DTO's equilibrium path (equation (7)). We are going to develop the following example to explicitly show how this process takes place.

3.2.1 Example

Let us develop the simple example in which: $A_{max} = 10$, $A_{min} = 1$, $P(a) = \sqrt{a}$ and the DTOs' distribution of A is uniform among the support $[A_{min}, A_{max}]$. Therefore, by means of inserting the equilibrium path followed by DTOs in the government's optimality condition and solving the resulting equation for $a(A_i)$ we obtain:

$$a(A_i) = \frac{A_i^2}{4\left(1+\frac{z}{\lambda}\right)^2} + C \tag{11}$$

In the above equation, C is an integration constant that must be solved later on, in order to have $a(A_{min}) = \frac{A_{min}^2}{4}$.

Inserting the above equation in the government's optimality condition and solving for $g(A_i)$ we obtain:

$$g(A_i) = \lambda \frac{A_i^2 - A_{min}^2}{4\left(1+\frac{z}{\lambda}\right)^2} \tag{12}$$

Recall that λ is an integration constant that allows us to satisfy the government's resource constraint. Notice that since $\frac{\lambda}{4\left(1+\frac{z}{\lambda}\right)^2}$ is a constant there is a unique allocation of resources regardless of the amount z. Also, notice that since the DTO with the lowest degree of efficiency reveals its type, the aforementioned optimal allocation results in a marginal cost to the amount of violence higher than the one done by the least violent DTO.

In Figure 1 we show the optimal level of violence for DTOs with different technologies. In Figure 2 we show the government's optimal allocation of resources.

From figure 1, notice that a *symmetric Nash* equilibrium indeed exists, i.e. DTOs follow an increasing equilibrium path. Also note that, as z increases, the violence levels change; nevertheless, they keep the same trend. In figure 2, notice that there is a unique optimal allocation for every amount of resources possible and that under this allocation, the government assigns a higher amount of resources to DTOs with higher degrees of efficiency.

Up until now, we have shown the optimal allocation for the government under the as-

Figure 1: Evolution of the level of violence as z increases.

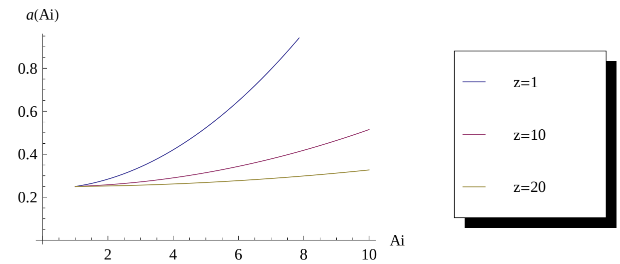
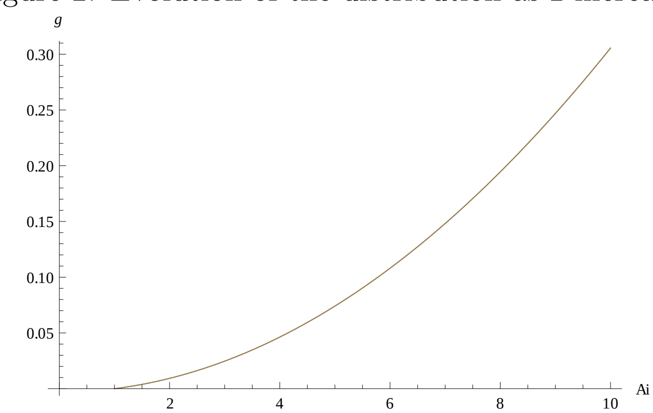


Figure 2: Evolution of the distribution as z increases.



sumption of a separating equilibrium. In the next section we model what would happen if the government allocates all of its resources in the most violent DTO, i.e. the case in which $g(R(a_{max})) = 1$.

4 Mark Kleiman's Dynamic Concentration Theory

In this section we delve into what would happen, under the framework we have followed until now, if the government applies the violence deterring strategy proposed by Mark Kleiman (2011). The following text exposes the deterrence strategy underlined by Kleiman's *dynamic concentration theory*:

> Mexico's different problem calls for a different strategy: creating disincentives for violence at the level of the largest trafficking organizations. Those six organizations vary in their use of violence; total violence would shrink if market shares changed in favor of the currently least violent groups or if any group reduced its violence level. Announcing and carrying out a strategy of violence-targeted enforcement could achieve both ends. The Mexican government could

> craft and announce a set of violence-related metrics to be applied to each organization over a period of weeks or months. Such a scoring system could consider a group's total number of killings, the distribution of its targets (among other dealers, enforcement agents, ordinary citizens, journalists, community leaders, and elected officials), its use or threat of terrorism, and its nonfatal shootings and kidnappings. Mexican officials have no difficulty attributing each killing to a specific trafficking organization, in part because the organizations boast of their violence rather than trying to hide it. At the end of the scoring period, or once it became clear that one organization ranked first, the police would designate the most violent organization for destruction. That might not require the arrest of the kingpins, as long as the targeted organization came under sufficiently heavy enforcement pressure to make it uncompetitive. The points of maximum vulnerability for the Mexican trafficking organizations might not even be within Mexico. U.S. law enforcement agencies believe that for every major domestic distribution organization in the United States, they can identify one or more of the six dominant Mexican trafficking organizations as the primary source or sources. If the U.S. Drug Enforcement Administration were to announce that its domestic target-selection process would give high priority to distributors supplied by Mexico's designated "most violent organization," the result would likely be a scramble to find new sources. Removing an organization would not reduce total smuggling capacity; someone would pick up the slack. But the leaders of the targeted trafficking group would, if the program were successful, find themselves out of business. The result might be the replacement of more violent trafficking activity by less violent trafficking activity. Less happily, it could lead to a temporary upsurge in violence due to the disruption of existing processes and relationships. But in either case, if the destruction of the first designated target was followed by an announcement that a new target selection process was under way using the same scoring system, there would be great pressure for each of the remaining trafficking groups to reduce its violence level to escape becoming the next target. The process could continue until none of the remaining groups was notably more violent than the rest (Kleiman, 2011, p. 100)

The above quotation describes Kleiman's *dynamic concentration theory*. In the next section we apply said theory to the framework developed until now.

4.1 The Equilibrium under the new Government's Strategy

Assume that there are $N \in \mathbb{N}^+$ DTOs. Consider the problem of a DTO who must decide its optimal level of violence. Again, assume that DTOs behave as neoclassical firms. Nevertheless, in this problem, DTOs must deal with another cost, namely that of attracting all of the government's enforcement resources when being the most violent DTO.

The government has a constant amount of enforcement resources, again denoted by z. Since it is concentrating those resources on the most violent DTO we now rewrite the DTOs' profit function as:

$$\Pi(a_i) = \begin{cases} A_i P(a_i) - a_i - z, & \text{si } a_i > a_j \ \forall i \neq j \\ A_i P(a_i) - a_i - \frac{z}{N}, & a_i = a_j \ \forall i \neq j \\ A_i P(a_i) - a_i, & \text{si } \exists j : a_j > a_i \end{cases} \tag{13}$$

We elicit three situations. In the first one the government has enough resources to deter the most violent DTO. In the second one it has an amount of resources high enough to make it profitable for the most violent DTO to mimic the second most violent DTO, but it does not have enough resources to deter it. In the third case its enforcement resources do not even make it profitable for the most violent DTO to mimic the second most violent one. In each case the equilibrium achieved drastically differs.

Case 1. *We are now going to show why a separating equilibrium under Kleiman's strategy is not possible. Assume that the government's enforcement resources are high enough so that if they are concentrated in a particular DTO, the benefits that DTO derives from violence are negative. In other words, they are sufficient to drive that DTO out of business. Therefore, we are assuming that for any DTO i if i is the target, then $\Pi_i \leq 0 \ \forall \ a_i$.*

Assume further that we expect the resulting equilibrium to satisfy the following condition: no matter what equilibrium strategy is followed by DTOs, whenever $A_i > A_j$ then $\Pi_i\left(a(A_i)\right) > \Pi_i\left(a(A_j)\right)$. This condition is sufficient to obtain the desired relationship between the violence ranking and the DTO's efficiency in using violence to produce profits.

Suppose the government applies Kleiman's strategy. Assume that DTOs follow a separating equilibrium as stated before: All DTOs follow an increasing strategy $a(A_i)$ mapping from the efficiency to the levels of violence. Then any increasing separating equilibrium strategy does not satisfy the aforementioned condition. This is due to the fact that the profits of the DTO with the highest degree of efficiency are negative. Therefore, the profits of the other DTOs, with lower efficiency, are strictly higher.

Hence, when dealing with Kleiman's strategy one cannot obtain a separating equilibrium while satisfying the aforementioned condition.

Now assume any pooling equilibrium in which $a(A) = a^p > 0$. Then we can always find a infinitesimal amount ϵ such that:

$$AP(a^p) - a^p - \frac{z}{N} < AP(a^p - \epsilon) - (a^p - \epsilon) \tag{14}$$

Hence there the only possible pooling equilibrium is $a(A) = 0$. The only thing left to demonstrate is that no DTO is willing to deviate from the zero violence pooling equilibrium to a higher violence level. The aforementioned condition is always satisfied if:

$$A_{max}P(a^{bc}) - a^{bc} - z \leq -\frac{z}{N} \tag{15}$$

Therefore the government needs a sufficiently high amount of resources in order to obtain the zero violence pooling equilibrium.

Case 2. *This is the same case as the one previously shown with the exception that the condition 16 is not satisfied. Therefore, either everyone has incentives to lower their levels of violence on an infinitesimal amount, or a DTO exists which has incentives to raise its violence level to the benchmark level. In either case, someone has incentives to deviate and therefore the equilibrium does not exist under this scenario.*

Case 3. *This is a case in which the most violent DTO does not have incentives to deviate from its benchmark level of violence to the benchmark level of violence of the second most violent DTO. Therefore we have:*

$$A_{max}P(a^{bc}) - a^{bc} - z \geq A_{max}P(a^2) - a^2 - \frac{z}{2} \tag{16}$$

Hence the equilibrium in this case is a separating one in which $a(A) = a^{bc}(A)$.

Notice that in the first case, where the government has a sufficiently high level of enforcement resources, we obtained the desired result of having the DTOs in a zero violence equilibrium. However, no conclusions can be drawn from the second case, where the government has a high amount of resources but not enough to deter the most violent DTO. This is due to the fact that we demonstrated no equilibrium exists. In the third case, where the government has a small amount of enforcement resources, we obtained the undesirable result of the DTOs exercising their benchmark levels of violence.

This model supports the theory of *dynamic concentration* developed by Kleinman (2011). It shows how the announcement of the government to concentrate all of its resources in the most violent DTO deters the exercise of violence in all DTOs.

This model supports Kleiman's strategy and furthermore supports the prediction it makes, namely that DTOs would end in a low violence pooling equilibrium. Nevertheless, Kleiman supports this as ensuing from the fact that, with such strategy, the government would make low violent drug trafficking more profitable than violent drug trafficking. Notice that in this model this does not happen. Therefore, even though Kleiman's strategy and conclusions are the same as the ones obtained within this model, the arguments that support them differ and therefore give this theory an additional credence. Moreover, Kleiman argues that the government must apply such strategy until DTOs end up having the same violence level. This model supports the fact that, even if they end up having the same level, the government can apply Kleiman's strategy and they should optimally end up in the same level of violence even under a one-shot game.

Nevertheless, this model shows that the government needs a sufficiently high level of enforcement resources, relative to the most violent DTOs' profit in the absence of the government, in order to be able to apply this strategy successfully.

5 Conclusions

In this paper we analyze the public policy problem regarding how a government should allocate scarce resources to fight organized crime with the objective of reducing violence. To do so, we develop a model in which the government confronts several criminal organizations. We do this under two different scenarios. In both of them we model this organizations as neoclassical firms as a way to reflect the fact that they receive direct benefits from crime itself.

The fist case developed is one in which the government announces an allocation of resources according to a ranking of crime. Therefore, the choice of crime levels becomes necessarily strategic, because each criminal agent must anticipate the violence level of others in making its optimal violence decision. Therefore a negative concern for crime status may be induced by an allocation of resources according to a ranking. In this model a decrease in the overall amount of violence is accomplished. We discuss how the optimal allocation of resources results in the last unit of it being allocated to each position having the same marginal return in terms of decreasing crime.

The second case developed is one in which the government applies Kleiman's *dynamic concentration* strategy (2011). This strategy argues that the government should announce that it will target the most violent criminal organization in a given period. Moreover, the government should announce it will concentrate all its resources on attacking that particular organization. Kleiman predicts that when applying this strategy during several periods, eventually all criminal organizations would end up having the same (low) level of violence. We show that this is possible even in a one-shot game. Moreover, we show that the pooling equilibrium that arises under this strategy results in zero levels of violence. This result gives an additional support to Kleiman's strategy, since nothing could be more desirable for a government than having all criminal agents with a zero level of violence. Nevertheless, this great result is conditioned by the fact that the government has enough enforcement resources to be able to deter the most violent criminal organization.

Therefore, our paper concludes that, given the appropriate conditions, the government should apply Kleiman's *dynamic concentration theory.*

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A Deterring with *Status*: Discrete Case

We now consider the game where the government confronts $N \in \mathbb{N}^+$ DTOs. In this case, the government deduces the DTOs' technologies with order statistics. This due to the fact that all of the degrees of efficiency are obtained with the same distribution and that is common knowledge.

In this problem, the probability of a DTO i to be the *k-th* DTO is:

$$P_k(A_i) = \frac{N!}{(k-1)!(N-k)!}\mathcal{F}(A_i)^{N-k}(1-\mathcal{F}(A_i))^{k-1}f(A_i) \tag{17}$$

In the above equation $\frac{N!}{(k-1)!(N-k)!}$ is the number of possibilities with which a particular DTO results being the *k-th* DTO with the highest degree of efficiency and $\mathcal{F}(A_i)^{N-k}(1 - \mathcal{F}(A_i))^{k-1}f(A_i)$ is the probability that each of the aforementioned possibilities occur.

Denote with g_k the fraction of resources allocated in the k-th position of the violence ranking. Therefore, we may rewrite the maximization problem of the DTOs as:

$$\underset{a_i}{\text{Max}}\, A_iP(a_i) - a_i - \sum_k P_k g_k z \tag{18}$$

We assume that DTOs follow a separating equilibrium $a(A_i)$. Following a similar procedure to the one in the continuous problem, we find that the equilibrium path followed by DTOs is:

$$a' = \frac{\sum_k \frac{\partial P_k}{\partial A_i} g_k z}{A_iP_a - 1} \tag{19}$$

Notice that, since $\frac{d(1-\mathcal{F}(A_i))}{dA_i} < 0$, assigning any amount to the least violent DTO is inefficient (for the government in terms of decreasing violence). We may consider that assigning a positive amount to the least violent DTO results in an incentive to all DTOs to increase their level of violence. Hence we expect that under an optimal allocation of resources, no resources are assigned to the least violent DTO. On the other hand, the converse is true. Assigning any amount of resources to the most violent DTO results in an incentive to all DTOs to decrease their level of violence. All assignments to other positions result in an incentive to the more violent DTOs to increase their violence level and an incentive to the less violent DTOs to decrease their violence level. With this we conclude that any increasing array of the fraction of resources allocated to each position of the violence ranking results in an overall decrease of the violence levels. Nevertheless, in order to find the optimal allocation of resources we must solve a maximization problem that results from the solution to the previous equation.

Unfortunately this problem does not always have a trivial solution. Nevertheless, whenever the distribution from which the degrees of efficiency are obtained is uniform, the problem has a solution.

Therefore we are going to develop the particular case where we have $\beta = \frac{1}{2}$, $A_{max} = 10$, $A_{min} = 1$, $N = 5$ and the DTOs' degree of efficiency follows a uniform distribution in the support $[A_{min}, A_{max}]$. Suppose $a(A_i)$ takes the form:

$$a(A_i) = \frac{A_i^2}{4(1+c)^2} \tag{20}$$

As in the continuous problem, the optimal allocation of resources does not depend on the amount of resources. Figure 5 shows the optimal allocation of resources, in terms of the fraction assigned to each position, for the problem at hand.

As we expected, the optimal allocation results in high amounts of resources allocated to the most violent DTO and no resources to the least violent one.

Figure 3: Optimal array of when $N = 5$.