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ORIGINAL PAPER

Counter-intuitive effects of domestic law enforcement policies in the United States

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Abstract In spite of the increase in domestic law enforcement policies in the U.S. drug related crime has followed a non-monotonic trend and cocaine and heroin prices, instead of increasing, have been dropping or remained stable over time. All this in a context of an increase in these drugs' consumption during the 1980s and a small decrease during the 1990s. This paper provides an explanation to these counter-intuitive effects of domestic law enforcement policies. We model how drug lords respond to this type of policy within a conflict framework over the control of distribution activities for illegal drugs, which is novel. The model predicts drug distribution activities, drug prices and drug consumption. These predictions appear to be consistent with the empirical evidence in the United States.

Keywords Drug policy · Conflict · Violent crime

JEL Classification D74 · I18

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1 Introduction

According to the U.S. Office of National Drug Control Policy (ONDCP), the total economic costs of drug use for society was estimated at $168 billion in 2000, which corresponds to about 1.6% of total U.S. GDP. The cost is composed of health care costs, productivity losses, costs of drug related crime, social welfare and the criminal justice system.[1]

Two decades ago, the U.S. government started a “war on drugs” with the objective of reducing the consumption of illegal drugs, and its related costs, by means of domestic law enforcement, demand reduction policies, international drug source policies and interdiction programs. Among all these policies, domestic law enforcement has accounted for almost 50% of the federal budget allocated to this war every year.[2] Implementing domestic law enforcement policies would disrupt domestic drug markets by dismantling the drug networks transporting and distributing drugs throughout the United States and harassing users. This spending should raise drug distribution costs and increase drug prices by, for example, increasing the probability of arrests and/or reducing the drugs available to final users, ultimately reducing drug consumption.

However, while domestic law enforcement spending increased over time in the past two decades,[3] drug distribution activities followed a non-monotonic trend, with increases in the first decade and decreases in the second.[4] Cocaine and heroin prices, two of the main drug problems in the U.S., dropped during the 1980s and were fairly stable during the 1990s, and the estimated consumption of cocaine and heroin somehow surprisingly increased during the 1980s and, in the best scenario, slowly started to decrease during the 1990s.[5]

This paper provides a possible explanation for the counter-intuitive effects of domestic law enforcement expenditures on drug distribution activities and drug prices, and their expected effect on drug consumption. The effect of these expenditures is modeled via the amount of resources drug lords spend on maintaining a drug distribution network. The aim of our analysis is to sharpen the economic intuition on how domestic law enforcement spending affects the behavior of drug lords who sell and distribute drugs.

Domestic law enforcement policies are all possible measures targeting illegal drug distribution and purchasing activities. Instead of considering this spending as a policy increasing the cost of drug distribution as has traditionally been the case, we see it as a policy that effectively disrupts the connection between drug users and suppliers,

[1] Office of National Drug Control Policy 2002 (ONDCP).

[2] According to Everingham and Rydell (1994), in the case of cocaine, domestic law enforcement policies are also three times more cost-effective in reducing drug consumption in the U.S. than international and interdiction programs, but less effective than demand reduction policies.

[3] The other anti-drug policies have followed a similar trend.

[4] Drug distribution activities are studied through the trend on drug related violent crime and via perceived cocaine availability.

[5] See Everingham and Rydell (1994) and Office of National Drug Control Policy (2001), for these estimations.

which has an impact on drug lords in reducing their available demand for drugs.[6] Specifically, we will focus on the demand side effects of this policy and the strategic response by drug lords which then also has indirect supply side effects.

The policy of domestic law enforcement is modeled within a conflict framework between the government and drug lords over the control of distribution channels for illegal drugs, which is novel. The model predicts drug distribution activities, drug prices, and drug consumption in the U.S.. These predictions appear to be consistent with the data.

Let us look at the literature to date on the effect of demand and supply oriented policies on drug distribution activities, drug prices and drug consumption.

Skott and Jepsen (2002) model the effects of law enforcement on drug use, focusing on three features of the drug market: addiction, imperfect competition and the presence of switching costs and consumer loyalty. They find the net effect of this government policy on drug use to be ambiguous and a tough stance may, in some circumstances, be counterproductive. Law enforcement is assumed to affect cost parameters and is implicitly modeled. In our model, however, we focus on the demand effects of law enforcement within the framework of a contest success function yielding different results.

Burrus (1999) analyzes a model of illegal drug dealers as territorial monopolists who wage turf wars against each other. He considers a two-stage game where drug dealers first fight each other to gain a turf where, in period two, they will exercise drug monopolies. As in Skott and Jepsen (2002), government law enforcement is modeled as a linear cost parameter. Larger expenditures on law enforcement are associated with lower profit levels for domestic monopolies and hence, lower sales of drugs. Due to the nature of the war on drugs, it appears natural to map government spending on domestic law enforcement within the framework of a government contest with drug lords, as opposed to simply a cost parameter. Thus, we obtain qualitatively different results. As our aim is to analyze the effects of an exogenous government policy, we do not model the government as an active player.[7]

Chiu et al. (1998) study the trade-off between investing in domestic law enforcement (aimed at local distributors in a Cournot setting) and interdiction of drug supplies at their source (an upstream monopolist). They find the location of enforcement to be irrelevant for the problem and conclude the choice between domestic or international drug enforcement to only be of secondary importance in choosing effective anti-drug policies. Our results differ from their irrelevance result. In our model, domestic (domestic law enforcement) and international or interdiction programs (supply policies affecting the marginal cost of drug production) have different effects on drug use, price and distribution activities.

Poret (2002) analyzes theoretically the effects of (domestic) law enforcement policies on wholesale and retail prices in non-cartelized oligopolistic markets of illegal drugs. The paper focuses on where in the distribution chain the law enforcement is targeted, on the upstream traffickers or the downstream retailers. Poret abstracts

[6] For example, police presence in the streets reduces the possibility of selling drugs and strategies for chasing drug dealers (organizations) and users reduce the demand for drugs.

[7] See Naranjo (2007a) for this extension under the presence of externalities.

from user criminalization so the model thus looks at the supply side effects of law enforcement. Due to the strategic responses of dealers concerning the wholesale and retail prices, an increase in law enforcement can under certain circumstances in fact lead to a decrease in the retail price and an increase in consumption. Also, in contrast with Chiu et al. (1998), the effects of the law enforcement policy will differ depending on where in the distribution chain it is aimed.

Lee (1993) considers a case where dealers sell illegal drugs in a setting of perfect competition. The focus of the paper is to analyze the effects of increased law enforcement aimed at either the supply side (the dealers) or at the demand side (the users). The main costs for both types of market participants are the transaction costs, that is, the probability of arrest and the severity of the penalty. The probability of arrest increases per time unit if the frequency of transactions increases. It is shown, for example, that policies that induce users to demand fewer transactions but larger quantities of drugs at each transaction will have the effect of reducing the transaction costs of dealers and hence shifting the supply curve to the right. Lee also offers this theory as an explanation for some paradoxical historic episodes.

Our paper will focus on the demand side effects of domestic law enforcement. We will, as in Poret (2002) use a non-cartelized Cournot setup on the supply side but add the feature that drug lords can counteract domestic law enforcement efforts by varying the size of the distribution networks.

The paper is structured as follows: We start by presenting some stylized facts on the U.S. market for illegal drugs. Then, we proceed to set up our base line model and present the key results. Section 4 introduces increasing marginal production costs in the base line model. The final section contains a discussion of the results and suggestions for future research.

2 Some stylized facts on the U.S. market for illegal drugs

In this section, we will present some evidence on the expenditure per capita of domestic law enforcement in the United States and its correlation with the cocaine and heroin drug market.[8,9]

2.1 U.S. drug policy

The U.S. government considers the drugs trade as a(n) (illegal) market phenomenon. Consumers and producers are assumed to be sensitive to the usual market parameters such as production and distribution costs and prices. Part of the drug policy is therefore geared towards making production and distribution difficult and expensive, so as to drive up consumer prices, thereby reducing use.

[8] Even though the trends described here have not been statistically tested, we believe these correlations to be indicative of a relationship that needs to be explained. A careful empirical (econometric) study of these relationships would indeed be interesting but is beyond the scope of this paper.

[9] Of course, factors other than domestic law enforcement, such as for example demand reduction and interdiction programs, may affect the cocaine and heroin market.

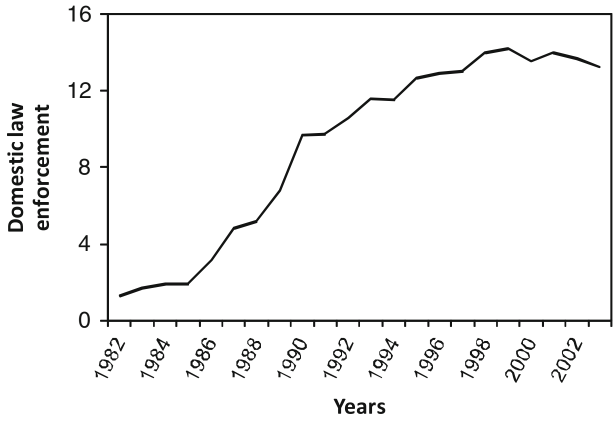

Fig. 1 U.S. annual per capita expenditure on domestic law enforcement (1982–1984 million USD; source: Office of National Drug Control Policy 1995–2002)

According to the Office of National Drug Control Policy in the United States, within the federal budget the domestic law enforcement category consists of money used for the criminal justice system, other research, and intelligence. This spending is aimed at disrupting domestic illegal drug markets by arresting suppliers and consumers and seizing drugs and assets throughout the United States.[10] Figure 1 shows the sharp increase in domestic law enforcement expenditure per capita in the U.S. since 1982.

2.2 Drug distribution networks

Another variable of interest is the size of the criminal activity itself. One possible measure of this is the size, or the manpower, of the distribution networks that drug lords employ. Distribution networks seek to reach and "capture" potential drug users.[11] However, evidence on the size of distribution networks by illicit drug organizations is clearly difficult to find due mainly to the illegal nature. Therefore, we have to infer its trend by looking at some other variables that are likely to be correlated with the development of these networks. One example is the measure of drug related homicides per 100,000 inhabitants. Drug related homicides are expected to be positively correlated with the size of distribution networks. According to Goldstein (1985) conceptual framework, violence can be associated with the illegality of the drug markets (i.e., systemic), which is also supported by empirical evidence.[12] In addition, drug dealers frequently carry large sums of money and valuable drugs and thus, they become "fat targets" for robbery.[13] Therefore, as drug dealers are, on average, prone to violence,

[10] On the contrary, international and interdiction programs would affect drug production and distribution in source countries.

[11] See also Skott and Jepsen (2002) for further references on marketing strategies by drug lords.

[12] See, for example, Resignato (2000) for a discussion.

[13] See Blumstein et al. (2000) for a deeper understanding of this relationship.

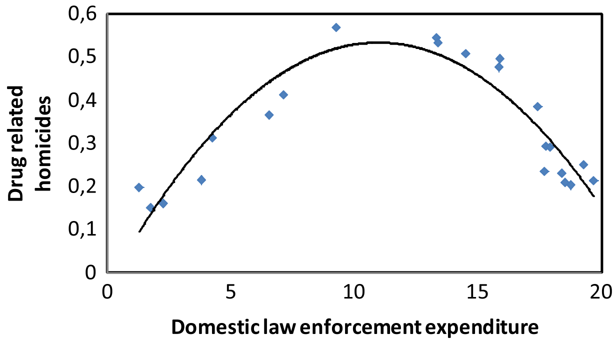

Fig. 2 Annual drug related homicides per 100,000 inhabitants and domestic law enforcement spending per capita (1982–1984 million USD; source: Federal Bureau of Investigations 1995–2001)

more drug dealers imply more violence. Moreover, the negative effects of more drug dealers are not constrained to the illegal drugs market. Most of the drug dealers are poor juveniles in inner cities closely integrated with other youths in their neighborhood. As drug dealers arm themselves with fire arms, some of these weapons are also "diffused" to other youths. When guns become more common, non drug dealing youths may get guns for self-protection or even to achieve social status.[14] Accordingly, fights that would otherwise have been resolved with fists or other less lethal weapons are increasingly resulting in deadly shootings. Hence, the size of distribution networks is likely to be connected to drug related homicides, for a given level of law enforcement.

Figure 2 (with an inserted second-order polynomial trend line) scatter plots the annual total number of drug related homicides with domestic law enforcement policy expenditure per capita in the U.S. for the period 1982–2003.

Drug related homicides appear to have a hump-shaped relationship with respect to domestic law enforcement expenditure per capita.[15] This is a bit surprising as one might expect drug related homicides to monotonically decrease as more law enforcement hits the streets.

Another *possible* example is the measure of perceived drug availability by 12th graders at schools. Since drug organizations target the young population to get new markets it seems that this population's perception of drug availability must be *positively* correlated to the size of the organizations.[16] Figure 3 (with an inserted second-order polynomial trend line) scatter plots the perception of cocaine availability by 12th

[14] These points are studied by Blumstein and Rosenfeld (1998) and Blumstein et al. (2000).

[15] Law enforcement can actually increase violence caused by systemic factors. See Benson and Rasmussen (1991), Benson et al. (1992), and Resignato (2000) for further references. Miron (2001a,b) finds empirical evidence of drug enforcement in the U.S. having been associated with increases in the homicide rate. The mechanisms involved are varied. For example, law enforcement may lead to new turf violence, since disputes within the black market for drugs cannot be peacefully solved within the legal system. Furthermore, law enforcement may also lead to a decreased risk of arrest when committing other types of crimes, as police resources are scarce (and more concentrated on drug related crimes).

[16] Of course, this perception can be also correlated to the size of domestic law enforcement but both the demand effect (i.e., chasing users) and the supply effect (i.e., chasing dealers) of this spending should produce an effect in the same direction on the individual's perception of drug availability.

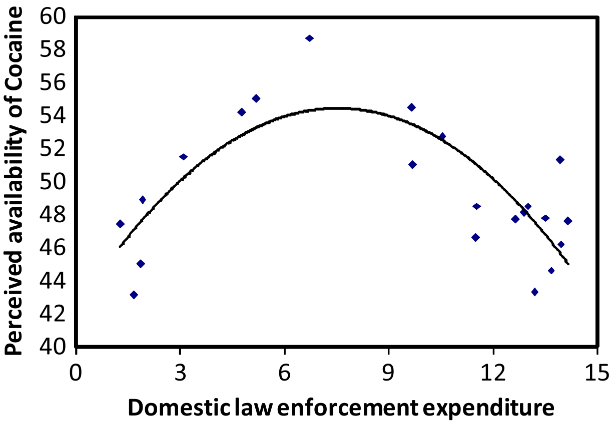

Fig. 3 Cocaine perceived as easy or fairly easy available for 12th graders (%) (source: University of Michigan 2002–2007) and domestic law enforcement spending per capita (1982–1984 million USD; source: Federal Bureau of Investigations 1995–2001)

grades with domestic law enforcement policy expenditure per capita in the U.S. for the period 1982–2003.[17]

As we see in Fig. 3, perceived availability of cocaine has a hump shape with respect to domestic law enforcement expenditure per capita. This is also a bit surprising as one might expect perceived drug availability to monotonically decrease as more law enforcement hits the streets, given a constant or decreasing size of distribution networks.

2.3 Drug prices and consumption

Figures 4 and 5 show the correlation between retail price trends for cocaine and heroin (per one pure gram) in the U.S. and the expenditure per capita of domestic law enforcement policies during the last two decades. While the relationship with the heroin price is definitely negative, cocaine prices did not change in high levels of these policies.[18]

The trends of cocaine and heroin consumption are taken from two different sources. First, Everingham and Rydell (1994) found that cocaine and heroin consumption (in metric tons) increased during the 1980s and has shown a stable to decreasing trend since then, whereas the Office of National Drug Control Policy (2001) found a decreasing trend since 1988. From this evidence, it is fair to say that cocaine and heroin consumption probably increased during the 1980s and decreased during the 1990s. Figure 6 shows the correlation between the estimates for cocaine and heroin consumption since 1988 and the expenditure per capita of domestic law enforcement policies.

[17] Perception of heroin availability by 12th grades follows the same trend.

[18] The purity levels of both drugs have been fairly stable. See Office of National Drug Control Policy (2004) for further references.

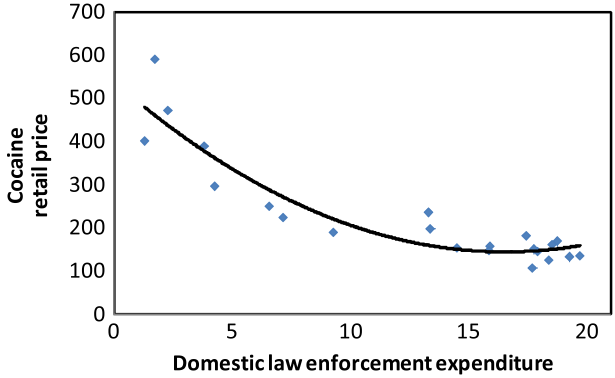

Fig. 4 Real retail price for cocaine (<2 g) and domestic law enforcement expenditure per capita (2002 million USD) (source: Office of National Drug Control Policy 2004)

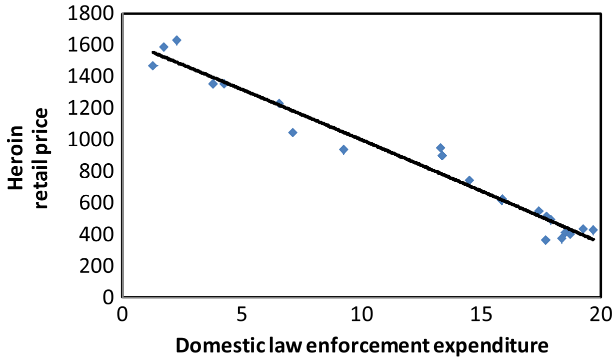

Fig. 5 Real retail price for heroin (<1 g) and domestic law enforcement expenditure per capita (2002 million USD) (source: Office of National Drug Control Policy 2004)

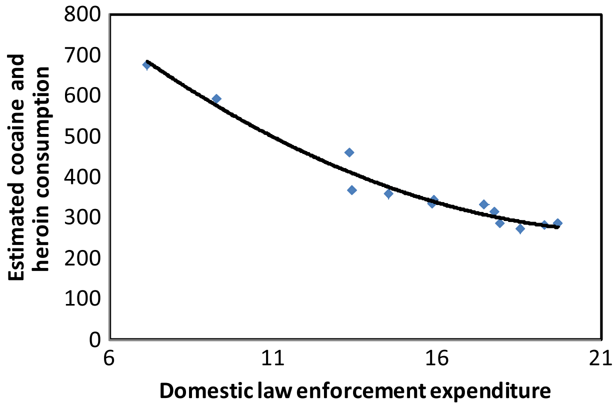

Fig. 6 Cocaine and heroin consumption in the U.S. (in metric tons) and domestic law enforcement expenditure per capita (1982–1984 million USD; source: Office of National Drug Control Policy 2001)

Notice that higher levels of these policies are, as might be expected, correlated with lower levels of cocaine and heroin consumption in the U.S. With these data in mind, we turn to our model.

3 The model

Assume there to be $m > 0$ identical drug lords attempting to sell illegal drugs in a Cournot setting. Each drug lord i does this by spending resources, $x_i \geq 0$, on maintaining distribution activities. We assume that the bulk of these resources are spent on hiring dealers which then make up the distribution network.[19] By investing in distribution activities, the drug lords "secure" a number of users that the government seeks to "eliminate" through domestic law enforcement policies. Once a drug lord "secures" these users, they become available to other drug lords through their oligopoly competition. Hence, investments in distribution activities have a public good feature. This model assumes a state of peace between the drug lords where they compete within a Cournot setting.[20] Other models have studied how drug lord resources have been used to fight for turf within which each drug lord exercises a monopoly (see, for example, Burrus 1999). However, as consumers can go to different turfs within a city, we wish to investigate the role of quantity competition on the size of these distribution activities.

Following Burrus (1999), Mansour et al. (2006) or Poret (2005), for example, we define an individual linear demand function for illegal drugs, $a - bp$, where $a \geq 0$, $b \geq 0$, and the price of drugs $p > 0$. With N being the total number of identical users, if there were no domestic law enforcement policies implemented by a government, $N(a - bp)$ would be the demand faced by drug lords and demand policies such as treatment and prevention programs will then shift this demand. However, the government spends resources on domestic law enforcement policies, d, with the aim of reducing the share of available demand that drug lords can access. These domestic law enforcement policies are, for example, expenditures to chase, catch and prosecute drug dealers and drug users.[21] Domestic law enforcement would then affect the actual demand curve. We define the share of demand that can be reached by drug lords by $z \in [0, 1]$. All else equal, more domestic law enforcement will decrease z. As more domestic law enforcement increases the risk of punishment more potential users are dissuaded from actually buying drugs. z is hence the share of demand that is not dissuaded from buying drugs while $(1 - z)$ is the share of dissuaded demand. The available aggregate demand function then becomes $q^d = zN\,(a - bp)$, or expressed

[19] Levitt and Venkatesh (2000) show that almost 30% of the total cost of selling drugs by a gang comes from gang wages and other 30% comes from costs associated to the size of the organization (e.g., weapons, tributes, funerals, and mercenaries).

[20] See Levitt and Venkatesh (2000) for an empirical discussion on gang war and Naranjo (2008) for a theoretical analysis of the connection between drug markets and violence. Hence, we abstract from any "market stealing effects" between drug lords as a result from individual investments in distribution networks.

[21] As a referee has pointed out, domestic law enforcement policies can have supply and demand effects. In this section we abstract from the supply effects (i.e., increasing marginal costs) of these policies and focus on the demand effects (i.e., reducing the available demand by breaking up the trade between users and dealers). Section 4 investigates possible indirect effects on supply.

in terms of inverse demand:

$$p = \frac{a}{b} - \frac{q^d}{bzN}. \tag{1}$$

Without losing generality, we will assume that $N = 1$ throughout the paper. Let z be a function of how much drug lords and the government spend. Specifically, let the share of aggregate demand available to drug lords, z, be the ratio of total resources spent by all drug lords to the sum of drug lords and government domestic law enforcement spending:[22]

$$z = \frac{\sum_{j=1}^{m} x_j}{\sum_{j=1}^{m} x_j + d}. \tag{2}$$

This is a simple version of a ratio contest success function commonly used in the conflict literature.[23] This specification has the property that investments in distribution activities by an individual drug lord (with the aim of increasing his share of aggregate demand) only increases the share of aggregate demand available to all drug lords.[24] A simple way to think about this is to assume that x_i is the hired number of drug dealers for drug lord i and d the number of police officers assigned to drug crime. If there are many drug dealers and few police officers, the risk of getting caught while purchasing drugs is low and vice versa. Once more, this setup differs from the case where individual investments in distribution activities only affect relative shares (between drug lords), as in Burrus (1999). Our setup follows from the assumption that drug users can pick any drug lord from which to purchase. Hence, we also abstract from any switching costs for drug users if they change their drug dealers.[25]

Apart from investing in distribution activities,[26] drug lords buy drugs from abroad at the constant per unit wholesale price of γ. Although the assumption of a constant marginal cost is commonplace in agricultural production functions,[27] we will investigate the effect of an increasing marginal cost in Sect. 4.

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[22] For mathematical convenience, we assume x and d to be infinitely divisible.

[23] Tullock (1980); see also Hirshleifer (1991) and Skaperdas (1996) for a discussion on contest success functions. Siven and Persson (2001) also discuss a model where the ratio between police officers to criminals increases the probability of arrest.

[24] This feature makes the distribution activities a public good for drug lords. Therefore, in equilibrium, there is an underprovision of distribution activities. To overcome this problem, drug lords may be willing to coordinate. However, to our knowledge there is no evidence of such coordination between and within "drug cartels". We might also think that these investments in an illegal market play a similar role to "cooperative" advertising in legal markets, where firms increase the size of the market by investing in advertising.

[25] See Skott and Jepsen (2002) and Naranjo (2007a,b) for a discussion of the effect of switching costs over drug markets.

[26] Note that the cost of distribution activities, x, does not depend on the amount of drug sales. However, profits made by small quantities are sufficiently large to cover costs of a certain size in a drug lord's organization, and the size of these organizations seems to be sufficiently large so it does not depend on the amount of drugs distributed.

[27] See the economic geography literature, e.g., Krugman (1991).

Having defined the revenue and cost functions, the expected profits of drug lord i are then:

$$\pi_i = pq_i^s - \gamma q_i^s - x_i. \tag{3}$$

Drug lord i is thus faced with a profit maximization problem where he/she must choose the optimal amount to spend on distribution activities and the quantity of drugs to sell, q_i^s, given the expectations of government drug policies and other drug lords. Using Eqs. 1 and 2, and the assumption of market clearing, that is, $q^d = \sum_{j=1}^m q_j^s$, the problem can be stated as:[28]

$$\max_{x_i, q_i^s} \pi_i = \left(\frac{a}{b} - \frac{\sum_{j=1}^m q_j^s}{b} \frac{\sum_{j=1}^m x_j + d}{\sum_{j=1}^m x_j} - \gamma \right) q_i^s - x_i. \tag{4}$$

The first-order condition with respect to q_i^s is:

$$\frac{\partial \pi_i}{\partial q_i^s} = \frac{a}{b} - \frac{2q_i^s + \sum_{j \neq i}^m q_j^s}{bz} - \gamma = 0.$$

Assuming symmetry, $q_i^s = q_j^s = q, \forall j$, and then solving for q yields:

$$q = \frac{bz}{(m+1)} \left(\frac{a}{b} - \gamma \right). \tag{5}$$

We assume that $q > 0$, that is, as we do observe a market for drugs, we are only interested in positive values of q, which implies that $\frac{a}{b} - \gamma > 0$. The first-order condition with respect to x_i is:

$$\frac{\partial \pi_i}{\partial x_i} = \frac{q_i^s \sum_{j=1}^m q_j^s}{b} \left(\frac{d}{\left(\sum_{j=1}^m x_j \right)^2} \right) - 1 = 0. \tag{6}$$

Assuming symmetry ($x_i = x_j = x, q_i^s = q_j^s = q, \forall j$) and solving for x:

$$x = q\sqrt{\frac{d}{bm}}. \tag{7}$$

[28] Following Poret (2002) we abstract from the costs for drug dealers of seized drugs. These costs are likely to be relatively small as dealers only carry small amounts at any given time.

Using Eq. 5 and that symmetry implies $z^* = \frac{mx^*}{mx^*+d}$, simplifying and multiplying by m yields:

$$mx^* = \frac{\sqrt{m}}{(m+1)}\left(\frac{a}{b} - \gamma\right)\sqrt{bd} - d. \tag{8}$$

Hence, in equilibrium, aggregate drug lord expenditure on distribution activities increases in the intercept of the demand curve, a, decreases in the number of drug lords, m, wholesale price, γ, and price sensitivity, b. What is interesting to note is that mx^* has a non-monotonic relationship with government domestic law enforcement policies, d. At low levels of domestic law enforcement spending, the relationship is positive while turning negative at high such levels. Intuitively, at low levels of spending, it pays to fight back if more resources are spent on law enforcement. However, at higher levels, it is better to respond by cutting back, due to the decreasing marginal returns. Note, however, that government spending on other demand oriented programs such as treatment and information programs would be likely to decrease potential demand, that is the variable a. We can see that a decrease in a produces a negative and monotonic response by drug lords.

It may be somewhat surprising that the amount spent on distribution activities is negatively related to the total number of drug lords, m. The opposite relationship might be expected as the total amount of resources spent (in this case on distribution networks) in a typical rent seeking contest is positively related to the degree of competition.[29] However, in this model, the contest involving drug dealers is between the government and the drug lords. The effect of incremental spending is such that it increases the share of demand available to all drug lords, while only drawing resources from the spending drug lord. Hence, the other drug lords free ride. Thus, ceteris paribus, if competition in the drug market increases, the equilibrium expenditure on distribution activities decreases.

We summarize the main comparative statics of Eq. 8 in Proposition 1.

Proposition 1 *The total amount spent on distribution activities, mx^*,* (i) *decreases monotonically in the number of drug lords, m;* (ii) *has a non monotonic relationship with government domestic law enforcement policies, d. At low levels of this spending, the relationship is positive while turning negative at high levels.*

Proof See the Appendix.

We can note that if we believe drug related homicides and the perceived drug availability to be indicators of the size of distribution networks, then part (ii) of the proposition fits the data in Sect. 2.

Let us proceed to examine equilibrium drug use in the economy. First, we find the equilibrium share of available demand, z^*, by using Eq. 8 in Eq. 2:

$$z^* = 1 - \frac{(m+1)}{\sqrt{m}} \frac{1}{\left(\frac{a}{b} - \gamma\right)\sqrt{\frac{b}{d}}}. \tag{9}$$

[29] See, for example, Tullock (1980).

Second, to find the aggregate amount of sold drugs, mq^*, we insert Eq. 9 into Eq. 5 and multiply by m:

$$mq^* = \frac{m}{(m+1)} b\left(\frac{a}{b} - \gamma\right) - \sqrt{bdm}. \tag{10}$$

We see that mq^* decreases, as expected, with price sensitivity, b , wholesale price, γ, and domestic law enforcement policy spending, d, and increases in the intercept of the demand curve, a. Moreover, mq^* has a non-monotonic relationship with respect to the number of competing drug lords, m.[30] At low levels of m, the relationship is positive while turning negative at high levels. Two main effects are at play here: First, a higher m decreases aggregate spending on distribution networks, that is, the free-rider effect, which reduces available demand and thereby limits the amount sold. Second, the increase in (Cournot) market competition decreases the price, which increases demand. Thus, at low levels of competition, an additional drug lord means that more drugs will be sold as the competition effect dominates the free-rider effect. The main comparative statics for the aggregate amount of drugs sold is summed up in Proposition 2:

Proposition 2 *Drug consumption, mq^*:* (i) *Decreases monotonically with government domestic law enforcement policy spending, d;* (ii) *has a non monotonic relationship with respect to the number of competing drug lords, m. At low levels of m, the relationship is positive while turning negative at high levels.*

Proof Immediate with respect d. See the Appendix for m.

We can note that part (i) of the proposition fits the data in Fig. 6.

The equilibrium price in the symmetric case is derived from Eq. 1, noting that $q^d = mq$, where q is given by Eq. 5:

$$p^* = \frac{a}{b} - \frac{m}{(m+1)}\left(\frac{a}{b} - \gamma\right). \tag{11}$$

Notice that equilibrium price is not a function of government domestic law enforcement policy spending, d. Why? Government law enforcement policies affect both the demand and the supply of drugs through z. For example, more domestic law enforcement shrinks demand as it reduces the share of total available demand, which tends to decrease the price. Drug lords then respond by reducing supply, which tends to increase the price. In our model, these two effects cancel out exactly (due to constant average and marginal production costs). The following proposition summarizes the main comparative statics of equilibrium price, Eq. 11:

Proposition 3 *Equilibrium price, p^*:* (i) *Decreases monotonically in the number of drug lords, m;* (ii) *is not affected by domestic law enforcement policy spending, d.*

30 The relationship is non-monotonic, provided that the market is sufficiently profitable. See the Appendix, proof of Proposition 2, for a formal treatment.

The data presented in Sect. 2, however, indicate that drug prices have a negative correlation with domestic law enforcement spending. While other policies, such as treatment and prevention programs, might have a negative effect on drug prices through changes in preferences (i.e., decreasing a), there is also a possibility that domestic law enforcement policies may explain these correlations using a slightly different modeling setup which is investigated in Sect. 4.

4 Increasing marginal production costs

As is clear from Proposition 3, price is, somehow surprisingly, not affected by domestic law enforcement policies in the base line model. This result is due to: (i) the assumption of a constant marginal cost of drug production and (ii) the market scaling effect of demand policies. In this section, we relax the first assumption by introducing an increasing marginal cost of drug production to check the robustness of the predictions from the base line model.[31] What we will do is to add a supply effect from expenditures in domestic law enforcement to the demand effect studied in the previous section. The total cost for a drug lord i is now defined as $\gamma \left(q_i^s\right)^2$. The intuition behind this assumption is the following. The larger is the amount of drugs sold from the producer market, the higher is the share of drugs seized by the government in route to the destination country.

Hence, the profit function is now defined as:

$$\pi_i = pq_i^s - \gamma \left(q_i^s\right)^2 - x_i. \tag{12}$$

Using Eqs. 1 and 2, together with the assumption of market clearing, that is, $q^d = \sum_{j=1}^m q_j^s$, the problem can be stated as:

$$\max_{x_i, q_i^s} \pi_i = \left(\frac{a}{b} - \frac{\sum_{j=1}^m q_j^s}{b} \frac{\sum_{j=1}^m x_j + d}{\sum_{j=1}^m x_j}\right) q_i^s - \gamma \left(q_i^s\right)^2 - x_i. \tag{13}$$

The first-order condition with respect to q_i^s is:

$$\frac{\partial \pi_i}{\partial q_i^s} = \frac{a}{b} - \frac{2q_i^s + \sum_{j \neq i}^m q_j^s}{bz} - 2\gamma q_i^s = 0.$$

Assuming symmetry, $q_i^s = q_j^s = q$, $x_i = x_j = x$, $\forall j \neq i$, and then solving for q yields:

$$q = \frac{a}{(m+1)\left(\frac{mx+d}{mx}\right) + 2b\gamma}. \tag{14}$$

[31] Both increasing and decreasing marginal costs have been proposed in the literature; see Everingham and Rydell (1994).

We assume that $q > 0$, that is, as we do observe a market for drugs, we are only interested in positive values of q. The first-order condition with respect to x_i is:[32]

$$\frac{\partial \pi_i}{\partial x_i} = \frac{q_i^s \sum_{j=1}^m q_j^s}{b} \left(\frac{d}{\left(\sum_{j=1}^m x_j\right)^2} \right) - 1 = 0.$$

Assuming symmetry ($x_i = x_j = x, q_i^s = q_j^s = q, \forall i \neq j$) and solving for x :

$$x = q\sqrt{\frac{d}{bm}}. \tag{15}$$

Combining Eqs. 14 and 15, and multiplying by m, we find the equilibrium aggregate values:[33]

$$mq^* = \frac{ma - (m+1)\sqrt{bdm}}{(m+1) + 2b\gamma}, \tag{16}$$

$$mx^* = \frac{a\sqrt{\frac{dm}{b}} - d\,(m+1)}{(m+1) + 2b\gamma}. \tag{17}$$

Solving for equilibrium price:

$$p^* = \frac{\frac{a}{b}(1 + 2b\gamma) - 2\gamma\sqrt{dbm}}{(m+1) + 2b\gamma}. \tag{18}$$

We summarize the comparative statics of Eqs. 16–18 with respect to the policy variable d in Proposition 4.

Proposition 4 (i) *mq^* decreases in d.* (ii) *mx^* has a concave non-monotonic relationship with respect to d. At low levels of d, the relationship is positive while turning negative at high levels.* (iii) *p^* decreases in d.*

Proof Immediate with respect to $\frac{\partial mq^*}{\partial d}$ and $\frac{\partial p^*}{\partial d}$. See the Appendix for $\frac{\partial mx^*}{\partial d}$.

Note that parts (i) through (iii) of the proposition fits the data in Sect. 2.

We also note that the only qualitative difference, concerning the effect of domestic law enforcement policies, from the baseline model is that price now decreases with them. The intuition behind the result is that as these policies scale down market size

[32] The second-order condition requires the level of domestic law enforcement policies to be sufficiently small with respect to the size of the distribution networks $\left(\frac{4m(1+\gamma b)}{(m-1)^2}(mx) > d\right)$.

[33] If $mq^* > 0$ and $mx^* > 0$, then $\frac{a}{(m+1)}\sqrt{\frac{m}{b}} > \sqrt{d}$.

$\left(\frac{\partial mq^*}{\partial d} < 0\right)$, production costs no longer fall proportionately. A lower volume implies lower marginal costs and a lower price, which appears to be consistent with the data.

The comparative statics with respect to m is shown in Proposition 5.

Proposition 5 (i) *mq^* has a concave non-monotonic relationship with respect to m. At low levels of m, the relationship is positive while turning negative at high levels.* (ii) *mx^* has a concave non-monotonic relationship with respect to m. At low levels of m, the relationship is positive while turning negative at high levels.* (iii) *p^* decreases in m.*

Proof Immediate with respect to $\frac{\partial p^*}{\partial m}$. See the Appendix for $\frac{\partial mx^*}{\partial m}$ and $\frac{\partial mq^*}{\partial m}$.

Hence, we note that a change in m has the same qualitative effects on p^* and mq^* as in the baseline model. mx^* has now, however, a hump-shaped relationship with m (positive derivative at eg $m = 1$ while turning negative, as in the baseline model, at higher levels of m).

5 Discussion

Our model predicts that, ceteris paribus, domestic law enforcement policies produce a non-monotonic response in the amount spent by drug lords on distribution activities (Proposition 2). Thus, we can provide one possible theoretical explanation for the empirical relationship between the two above variables in Sect. 2. When domestic law enforcement spending affects the available demand for drugs and its effect depends on the level of the distribution activities, drug lords may, in fact, increase these activities under low levels of this spending but decrease them under high levels.

As for cocaine and heroin price, Proposition 4 predicts that domestic law enforcement policy expenditure decreases the price through the reduction in market size and the associated decreased marginal production cost. Hence, our model also provides a possible theoretical explanation for the decreasing drug price trend.

In addition, our analysis can predict that even though drug prices may fall constantly, drug consumption may still be reduced by the implementation of domestic law enforcement policies. According to our model, drug consumption will decline with higher expenditures on these policies and responds non-monotonically to the number of drug lords in the drug market. Given the positive trends in this policy spending and the increase in the number of drug lords since the mid-1980s, this prediction seems reasonable.

The increase in drug consumption during the 1980s must be explained by factors other than the level of domestic law enforcement policies. One possible explanation, which is predicted by our model, could be that the drug market started to be affected by an increase in the number of drug lords from a sufficiently low level. This explanation is well supported by empirical evidence which shows how the structure of the market for illegal drugs in the U.S. (and in source countries) started to change from being concentrated to being more competitive. See, for example, the reports by the

United States General Accounting Office (Drug Control reports 1990–2002).[34] This increase in competition can, according to our quadratic cost model, also lead to an initial increase in distribution activities, and, as competition stiffens even more, finally lead to a decrease.

Summing up, our model provides a possible theoretical explanation for the trends in drug distribution and cocaine and heroin price in the U.S. since the beginning of the eighties. It also explains why these prices may have dropped when cocaine and heroin consumption was constantly increasing. These explanations are based on the assumption that drug lords can, to some extent, counteract domestic law enforcement policies by varying the amount spent on distribution activities. The key element of the model is that the fight is between the government and the drug lords over distribution channels, by means of a contest success function. Another key element is the existence of non-violent competition between drug lords. Previous literature has, to a large extent, treated government anti-drug policies as a linear cost parameter in the drug lord's profit function and has downplayed the importance of drug lords' peaceful competition. This produces a monotonic and negative relationship between domestic law enforcement policies and drug distribution and drug consumption. As seen in the data, the relationship between domestic law enforcement policy expenditure and distribution activities, through their positive correlation with drug related violent crime and perceived cocaine availability, appears to be non-monotonic, as would be predicted by our model. The goal of U.S. policy has been to reduce drug consumption by increasing the price of drugs. Our model suggests price to be a poor measure of the success of this policy.

During the mid-eighties, domestic law enforcement policy expenditure was increasing from a low level and did not succeed in decreasing either drug distribution activities or drug consumption. However, as domestic law enforcement policy expenditure has been boosted to a level where drug lords find it optimal to downsize their organizations, distribution activities drop with a small decrease in drug consumption. Hence, at these high levels of domestic law enforcement policy expenditure, two birds may indeed have been killed with one stone. Had it not been for the increased level of competition in the drug market, there might have been a stronger decrease in drug consumption during the 1990s.

To explain U.S. government behavior, we would need to model the government as an active player. The aim of this paper has merely been to derive a best response to government drug policies. We do believe, however, that endogenizing government policy would be a fruitful line for future research. In addition, although endogenizing the number of drug lords looks interesting at first sight, this must be treated with some caution. In the real world, drug lords may form cartels of different sizes. As anti-drug policies can be aimed at breaking some of the larger cartels, this might create the illusion of decreasing the number of drug lords (i.e., cartels) when, in reality, these are

[34] For further references about the effect of anti-drug policies on the size and number of drug organizations, see Poret and Téjédo (2006). Yet another explanation could be a change in consumer preferences or in the price for complements (or substitutes) to these illegal drugs. For example, if marijuana is a complement good to cocaine and heroin, increases in its consumption may have produced the increase in consumption for these other drugs. However, it seems that demand effects have not played any important role in this trend.

increased by the policy as many small cartels may survive.[35] Therefore, if we want to understand the effect of endogenizing the number of drug lords, we should take this effect into account. We do believe that by keeping the number of drug lords exogenous, it is possible to have a good understanding of the counter-intuitive effects of domestic law enforcement policies on the drug distribution activities and drug prices in the United States and on the relationship between drug prices and drug consumption.

Appendix

Proof of Proposition 1 First, we need to show that $\frac{\partial mx^*}{\partial m} < 0$ where $mx^* = -d + \frac{\sqrt{m}}{(m+1)}\left(\frac{a}{b} - \gamma\right)\sqrt{bd}$. Remember that we have assumed $\frac{a}{b} - \gamma > 0$. Then, it is sufficient to show that $\frac{\partial \frac{\sqrt{m}}{(m+1)}}{\partial m} < 0$.

Taking the derivative: $\frac{\partial \frac{\sqrt{m}}{(m+1)}}{\partial m} = \frac{1}{2\sqrt{m}(m+1)} - \frac{\sqrt{m}}{(m+1)^2} < 0$.

Rearranging yields: $m < 2m - 1$, which is true for $m > 1$.

Second, we want to prove that mx^* has a hump-shaped relationship to d for positive values of mx^* and d. It is sufficient to show that Eq. 8 is strictly concave and achieves a maximum for $d > 0$.

First, let us examine the concavity:
$\frac{\partial^2 mx^*}{\partial d^2} = -\frac{\sqrt{m}}{4(m+1)}\left(\frac{a}{b} - \gamma\right)\sqrt{b}d^{-\frac{3}{2}} < 0$.
Hence, we have strict concavity.
Further, at what value of d does Eq. 8 have its peak value?
Setting the first derivative of Eq. 8 with respect to d to zero and solving for d yields:
$d^{\max} = \left(\frac{\sqrt{m}}{2(m+1)}\left(\frac{a}{b} - \gamma\right)\sqrt{b}\right)^2 > 0$. Hence, Eq. 8 peaks for a positive value of d. □

Proof of Proposition 2 We need to show that $mq^* = \frac{m}{(m+1)}b\left(\frac{a}{b} - \gamma\right) - \sqrt{bdm}$ has a hump-shaped relationship to m for positive values of mq^*. For notational convenience, we rewrite

$$mq^* = \frac{m}{(m+1)}\alpha - \beta\sqrt{m}, \tag{19}$$

where $\alpha = b(\frac{a}{b} - \gamma)$ and $\beta = \sqrt{bd}$.

Let us examine how mq^* depends on m:

$$\frac{\partial mq^*}{\partial m} = \frac{\alpha}{(m+1)^2} - \frac{\beta}{2\sqrt{m}}. \tag{20}$$

[35] Poret and Téjédo (2006) and Mansour et al. (2006) further develop this idea.

This will be positive if

$$\frac{2\alpha}{\beta}\sqrt{m} > (m+1)^2. \tag{21}$$

We note that the left-hand side is strictly concave, while the right-hand side is strictly convex in m. For the smallest possible number of drug lords, $m = 1$, the right-hand side equals 4. For Eq. 20 to be strictly positive, $\frac{2\alpha}{\beta}$ must be greater than 4. Due to the concavity of the left-hand side and the convexity of the right-hand side of Eq. 21, increasing m will eventually make Eq. 20 negative. $\frac{2\alpha}{\beta} > 4$ implies that $\alpha > 2\beta$. Plugging $\alpha = 2\beta$ into Eq. 19 yields $mq^* = 0$ for $m = 1$. For any value of $\alpha > 2\beta$, $mq^* > 0$ for $m = 1$. As $\frac{\partial mq^*}{\partial m} > 0$ for $\alpha > 2\beta$ and $m = 1$, we know we are in the positive quadrant. □

Proof of Proposition 4 From Eq. 17, we know that if $m^*x^* > 0$ then $d < \frac{a^2 m}{(m+1)^2 b}$ must hold.

Then, $\frac{\partial m^*x^*}{\partial d} = \frac{1}{\left(\frac{m+1}{b}\right)+2\gamma}\left(\frac{a}{b}\frac{1}{2}\sqrt{\frac{m}{bd}} - \frac{1}{b}(m+1)\right) \gtrless 0$ and simplifying we get: $\frac{a^2}{4(m+1)^2}\frac{m}{b} \gtrless d$. Because $\frac{\partial^2 m^*x^*}{\partial^2 d} = \left(\frac{1}{\left(\frac{m+1}{b}\right)+2\gamma}\right)\left(-\frac{a}{b}\frac{1}{4d}\sqrt{\frac{m}{bd}}\right) < 0$, m^*x^* is concave with respect to d, with $d = \frac{1}{4}\left(\frac{a^2 m}{(m+1)^2 b}\right) > 0$ as the critical point. □

Proof of Proposition 5 We want to show that mq^* is concave with respect to m. First, it is useful to note that for $mq^*$to be positive (see Eq. 16), the following needs to hold: $a > \frac{m+1}{\sqrt{m}}\sqrt{bd}$. The derivative is $\frac{\partial mq^*}{\partial m} = \frac{2a\sqrt{bdm}+b(4a\sqrt{bdm}\gamma - d((1+m)^2+2b(1+3m)\gamma))}{2\sqrt{bdm}(1+m+2b\gamma)^2}$. Evaluate this derivative at the smallest number of firms, that is, $m = 1$. We can disregard the denominator as it is positive for all positive values of m. Factoring and simplifying the nominator we get: $2a\sqrt{bd} - 4bd$. This will be positive if $a > 2\sqrt{bd}$ which is satisfied as mq^* is positive. Hence we have shown that at $m = 1$, $\frac{\partial mq^*}{\partial m} > 0$. Will the value of the derivative decrease as m increases? Looking at the factored nominator again: $\underbrace{a\sqrt{bdm}(2+4b\gamma)}_{\text{Concave in } m.} - \underbrace{bd((1+m)^2 + 2b(1+3m)\gamma)}_{\text{Convex in } m.}$ we see that the positive term is concave in m while the negative term is convex. Hence, mq^* is concave in m. □

Now we need to show the same thing for mx^*. First, it is useful to note that for mx^* to be positive (see Eq. 17), the following needs to hold: $a > \frac{m+1}{\sqrt{m}}\sqrt{bd}$. The derivative is $\frac{\partial mx^*}{\partial m} = \frac{\sqrt{\frac{dm}{b}}(a - am + 2ab\gamma - 4b^2\sqrt{\frac{dm}{b}}\gamma)}{2m(1+m+2b\gamma)^2}$. We want to know the sign of the derivative at the smallest number of firms, that is, at $m = 1$. We can disregard the denominator as it is positive for all positive values of m. It is enough to evaluate the sign of the expression in brackets: $a - am + 2ab\gamma - 4b^2\sqrt{\frac{dm}{b}}\gamma$. It is easy to show that this is positive if $a > 2\sqrt{bd}$ which is satisfied as mx^* is positive. Hence we have shown that at $m = 1$, $\frac{\partial mx^*}{\partial m} > 0$. Will the value of the derivative decrease as m increases?

Looking at the expression in brackets again it is clear that the value of the derivative will decrease as m increases. Hence, mx^* is concave in m.

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