"The War Against Illegal Drug Production and Trafficking:

An Economic Evaluation of *Plan Colombia*."

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Outline

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1. Introduction and contribution.

· This paper provides a thorough economic evaluation of anti-drug policies implemented in Colombia between 2000 and 2006 under the so-called *Plan Colombia*.

· *Plan Colombia* is the official name of a program that, among other things, provides the institutional framework for the military alliance between the US and Colombia in the war against illegal drug production and trafficking, and the organized criminal groups associated with these activities.

The stylized facts

→ In Colombia, where about 70% of the cocaine consumed in the world is produced, the United States and the Colombian governments have allocated large amounts of resources to this war during the current decade under *Plan Colombia*.

According to the Colombian National Planning Department (DNP), the US government spent about $3.8 billion dollars in subsidies to the Colombian government for its war against illegal drug producers and traffickers between 2000 and 2005. Colombia, on the other hand, spent about $6.9 billion during the same period.

About 1/2 of the Colombian expenses (about $3.4 billion) and about 3/4 of the US subsidies (about $2.8 billion) have gone directly to the military components of the war against drug production, trafficking, and the organized criminal organizations associated with these activities (DNP, 2006, Table 2).

Nevertheless, most available measures show that cocaine availability in consumer countries has not gone down significantly, nor prices of cocaine have shown any increasing tendency, as may have been expected given the huge intensification of this war (see Mejía and Posada, 2008).

→ While the number of hectares cultivated with coca crops in Colombia has decreased by about half (from about 163.000 in 2000 to about 80.000 in 2006) as a result of the intense aerial eradication campaigns, potential cocaine production in Colombia has only decreased from 690,000 kilograms per year in 2000 (right before the start of Plan Colombia) to about 645,000 kilograms per year in 2006.

This apparently paradoxical outcome - that is, the large decrease in the cultivation of coca crops necessary to produce cocaine, the relatively small decrease in potential cocaine production, and the relatively stable trend in the wholesale and retail prices for cocaine - is mostly explained by a large increase in yields per hectare and productivity measures...

→ This strategic response from illegal drug producers and traffickers to the policies implemented under *Plan Colombia* are not surprising once one looks at the profit margins associated with the production and trafficking of cocaine: while a pure gram of cocaine is worth 1/10th of its weight in gold at the farmgate in producer countries, the same pure gram is worth more than 8 times its weight in gold at the retail level in the streets of NY or Chicago.

· With the previous stylized facts in mind, the general impression is that programs aimed at reducing the production and trafficking of illegal drugs have proved to be relatively ineffective in reducing the amount of drugs that reach consumer countries.

· Some observers have even argued that the war against drugs is "self-defeating". However, whether this is true or not is not the relevant policy question. Instead, we argue that the relevant policy question is: AT WHAT COST? That is, what is the cost of making "significant" advances in this war?

→ The problem: little of a systematic nature is known about the effects, costs, and efficiency of anti-drug policies implemented under *Plan Colombia*.

What we do...

· In this paper we construct a model of the war against illegal drug production and trafficking where there are strategic interactions between the actors involved in this war. We explicitly model illegal drug markets (in producer and consumer countries), which allows us to account for potential feedback between policies, market outcomes, and the strategic responses of the actors involved in this war that are likely to arise in large scale policy interventions such as *Plan Colombia.*

· Importantly, we use data from the war on drugs in Colombia (before and after *Plan Colombia*) as well as observed outcomes from the cocaine markets to calibrate the unobservable parameters of the model. We then use the results from the calibration exercise to estimate important variables that are relevant for policy purposes.

· The results from the calibration of the model are then used to carry out simulation exercises, where we assess the effects of increasing the US and Colombian budgets allocated to *Plan Colombia*. The results from these simulations will shed some light on the costs and benefits of making "important advances" in the war on drugs in the future.

2. The Model.

· We model the war against drug production and trafficking as a sequential game in which there are $4 + n$ actors involved. These actors are:

→ the State of the drug producing country (the State),

→ the State of the drug consumer country (the interested outsider),

→ a group of n illegal drug producers,

→ the drug trafficker, and

→ a (wholesale) drug dealer in the border of the consumer country.

Stages

1. The interested outsider grants the subsidies $(1-\omega)$ and $(1-\Omega)$ to strengthen the resolve of the State in the war against illegal drug production and trafficking, respectively.

2. The State engages the n illegal drug producers in a conflict over the arable land that is suitable for cultivating the crop necessary to produce the illegal drug .

3. The n drug producers fight against each other for the control of the land that the State does not control.

4. Once the illegal drug producers know how much land they control (that is, how much of the raw material they have to produce the illegal drug), they decide how much to invest in those factors that are complementary to land in the production of illegal drugs, such as chemicals, workshops, and other materials necessary to produce the illegal drug. Combining the complementary factors with land they produce the illegal drug.

5. In this stage of the game the drug trafficker and the State engage in an interdiction sub-game, where the State tries to capture the illegal drug shipments by blocking the routes that the drug trafficker uses to transport the drugs and, in turn, the drug trafficker tries to avoid the State's interdiction efforts.

6. Once the drug trafficker knows the expected probability of a drug shipment surviving interdiction, he has to decide how much of the illegal drug he buys from the drug producers. Combining routes and cocaine the drug trafficker then "produces" illegal drug shipments.

7. Finally, the drug trafficker sells the illegal drugs that survive the State's interdiction efforts in the border of the consumer country to a wholesale drug dealer.

Demand for drugs from the drug dealer in the consumer country

The demand for drugs in the consumer country is given by the following (generic) demand function:

$$Q_f^d = \frac{a}{P_f^b}, \tag{1}$$

where Q_f^d denotes the demand for drugs, $a \geq 0$, P_f is the wholesale price of the illegal drug in the border of the consumer country, and b is the price elasticity of the demand for drugs by drug dealers in the consumer country.

The drug trafficker

The drug trafficker's problem is to maximize profits, which are given by:

$$\max_{\{Q_d,t\}} \pi_T = P_f Q_f - P_d Q_d - t. \tag{2}$$

where the first term in equation 2 is the wholesale price of drugs in the consumer country, P_f, times the quantity of drugs successfully exported, Q_f, the second term is the cost of buying drugs in the producer country, where P_d is the price of drugs at the farmgate. The last term, t, is the amount of resources invested by the drug trafficker to avoid the interdiction of drug shipments.

The trafficking technology

We will assume that the drug trafficker combines routes, κ, with illegal drugs bought in the producer country, Q_d, to "produce" illegal drug shipments to the border of the consumer country, Q_f . However, we will assume that only a fraction $h \in [0,1]$ of the possible routes are not interdicted by the State. Formally, we will assume that the drug trafficking technology is given by:

$$Q_f = (\kappa h)^{1-\eta} Q_d^{\eta}, \tag{3}$$

where $\eta \in (0,1)$ captures the relative importance of cocaine bought in the producer country in the trafficking technology and $(1-\eta) \in (0,1)$ the relative importance of the drug trafficking routes.

The interdiction technology

Let h be the fraction of routes that survive the State's interdiction efforts. The interdiction technology is such that h is determined by a standard contest success function, by:

$$h = \frac{\gamma t}{\gamma t + s}, \tag{4}$$

where s is the amount of resources that the State invests in interdiction such as radars, airplanes, go-fast boats, etc., t the amount of resources that the drug trafficker invests in trying to avoid interdiction such as submarines, go-fast boats, airplanes, pilots, drug mules, corruption of the State's officials to avoid being captured, etc., and $\gamma > 0$ is a parameter that captures the relative effectiveness of the resources invested by the drug trafficker in avoiding the State's interdiction efforts.

The State of the drug producer country

The objective of the state at this stage is to minimize the sum of the costs associated with illegal drug trafficking. More precisely, the problem of the state is,

$$\min_{\{s\}} \; C_T = \; c_2 P_f Q_f + \Omega s, \tag{5}$$

where, in addition to other variables and parameters already defined, c_2 is the net cost faced by the State per unit of income that the drug trafficker is able to obtain from the trafficking of illegal drugs.

Nash equilibrium of the drug trafficking sub-game...

The Nash equilibrium of the drug trafficking sub-game is described by t^*, s^*, h^*, Q_d^d, (Domestid demand) and Q_f^s (Final supply) as functions of the parameters of the model and market prices, P_d and P_f (yet to be determined).

(Analytical solutions in the paper...).

The Drug Producers:

We assume that illegal drugs are produced using the following technology:

$$Q_{d,i} = \lambda r_i^{\alpha} l_i^{1-\alpha}, \quad \text{with } 0 < \alpha < 1, \tag{6}$$

where $Q_{d,i}$ is the amount of drugs produced by the $i-th$ drug producer, $\lambda > 0$ is a productivity parameter, r_i the amount of resources complementary to land, such as chemicals, workshops, etc., and l_i is the amount of land that the $i-th$ drug producer controls, where

$$l_i = q f_i L. \tag{7}$$

q is the fraction of land not controlled by the State, f_i is the fraction of the land that is not controlled by the State and that is under the $i-th$ drug producer's control, and L is the total land that can potentially be used to cultivate the illegal crop.

The objective of the drug producers is to maximize profits, that is,

$$\max_{\{x_i, y_i, r_i\}} \pi(x_i, y_i, r_i) = P_d Q_{d,i} - (x_i + y_i + r_i), \tag{8}$$

by first choosing x_i, then y_i and finally r_i.

The State and the Conflict for Land:

The State's problem at this stage is to minimize the costs associated with illegal drug production, more precisely:

$$\min_{\{z_i\}} \quad C_P = c_1 P_d Q_d + \omega \sum_{i=1}^{n} z_i,$$

where z_i are resources invested in the conflict for land against illegal drug producer i, and c_1 is the net cost for the State per unit of income that the drug producers are able to obtain from illegal drug production.

Conflict for Land Technology:

q, the fraction of land not controlled by the state, is given by:

$$q = \frac{1}{L}\sum_{k=1}^{n}(1-g_k)L_k = \frac{1}{n}\sum_{k=1}^{n}(1-g_k), \tag{9}$$

where g_i is determined by the following contest success function:

$$g_i = \frac{z_i}{z_i + \phi x_i} \tag{10}$$

and f_i is determined by

$$f_i = \frac{y_i}{y_i + \sum_{k \neq i} y_k} \tag{11}$$

The Nash equilibrium of the drug production sub-game:

The Nash equilibrium of the drug production sub-game is described x_i^*, z_i^*, q^*, y_i^*, f_i^*, r_i^*, and Q_d^s (Domestic supply) as functions of the parameters of the model and market prices, P_d and P_f (yet to be determined).

Drug Market Equilibrium:

$$Q_d^s(P_d, P_f) = Q_d^d(P_d, P_f) \tag{12}$$

and

$$Q_f^s(P_d, P_f) = Q_f^d(P_d, P_f). \tag{13}$$

Solving these equations we obtain the equilibrium values for Q_f, Q_d, P_f, and P_d as a function only of the parameters of the model.

(Analytical solutions in the paper...).

The Interested outsider:

The equilibrium quantity of drugs that are successfully produced and exported can be expressed as a function of q, h, and the parameters of the model, by:

$$Q_f^* = Cq^{\zeta}h^{\chi}, \tag{14}$$

where, again, ζ, χ, and C are functions of the structural parameters of the model

The choice of optimal subsidies:

The problem of the interested outsider is:

$$\min_{\{\omega,\Omega\}} Q_f^* \tag{15}$$

$$\text{subject to:} \qquad M_o \leq \overline{M},$$

where: $M_o = n(1-\omega)z^* + (1-\Omega)s^*$.

In any internal solution, we must have (unless the solution is in a corner...)

$$\left(\frac{\partial M_o}{\partial Q_f}\right)_q = \left(\frac{\partial M_o}{\partial Q_f}\right)_h = \Lambda,$$

where Λ is the marginal cost of reducing Q_f^* by one unit (one kilogram) when the subsidies to the two fronts of the war on drug production and trafficking are allocated efficiently. In a corner solution we could either have $\omega^* = 1$ or $\Omega^* = 1$.

3. Calibration Strategy.

· We use the available information from the war on drugs in Colombia (before and after *Plan Colombia*) to calibrate all the parameters of the model. Most of the data used comes from UNODC and the Colombian government. Robustness checks with ONDCP data (White House) were conducted with no significant changes in the results.

· We will take an average of the outcomes observed between **1999 and 2000** as the reference point **before** *Plan Colombia* and averages for **2005 and 2006** as the reference point **after** *Plan Colombia*.

Plan Colombia: Before and after.

	Before PC	After PC
Final Price	37900	35862
Domestic Price	1485	1860
Final Supply from Colombia	561000	474000
Domestic Supply	687500	645000
Hectares with cocaine	161700	82000
Productivity per Hectare	4,25	7,86
Percentage of Land with Cocaine Crops	32,3%	16,4%
Seizures by Colombian Authorities	87000	113000
Percentage Not Seized	87,2%	81,8%
Colombia Expenses	420'000.000	566'000.000
(Assuming a 35% increase)		
USA Expenses	0	465'000.000
Supply in Consumer Countries	718000	745000
Percentage of USA Cocaine Supplied by Colombia	78%	63%

Calibration results: Important Parameters

Parameter	Value
ω	0,51
Ω	0,67
η	0,07
α	0,73
b	0,67
c_1	0,40
c_2	0,05
ϕ	2,33
γ	0,36

Some important endogenous variables of the model

Allocations to the war on drugs in Colombia:

$$x_i^* \simeq 33.6\ m \quad y_i^* \simeq 80.3\ m \quad r_i^* \simeq 439.1\ m$$

$$t^* \simeq 2.86\ b$$

$$z_i^* \simeq 399\ m \quad s^* \simeq 233\ m$$

Costs from illegal drug production and trafficking:

$$\text{With} \quad : \quad c_1 \simeq 0.4, \quad \text{if } P_d \simeq \$1860, \text{ then } c_1 P_d \simeq \$760/kg. \tag{16}$$
$$\text{Also } TCP^{COL} \simeq \$490 \text{ million.} \tag{17}$$

and,

$$\text{With} \quad : \quad c_2 \simeq 0.05, \quad \text{if } P_d \simeq \$35.800, \text{ then } c_2 P_d \simeq \$1,790/kg \tag{18}$$
$$\text{Also } TCT^{COL} \simeq 848 \text{ million.} \tag{19}$$

Total costs of the war on drugs for Colombia:

$$C_T \simeq 1.02 \text{ billion per year.} \tag{20}$$

$$C_P \simeq 900 \text{ million per year.} \tag{21}$$

The intensity of conflict:

$$IC = t^* + s^* + \sum_i (x_i^* + y_i^* + z_i^*) \simeq 4,1 \text{ billion dollars.}$$

Returns from illegal drug production and trafficking:

$\pi_i^{***} \simeq \$46,7$ millions per year. $\pi_T^* \simeq 12,9$ billions per year.

$Av.\ return\ from\ DP \simeq 8.4\%$ $Av.\ return\ from\ DT \simeq 318\%$!!

Marginal costs of fighting the war on drugs:

$$MC_{\omega}^{US} = \$118.438 \qquad MC_{\Omega}^{US} = \$4.279$$
$$MC_{\omega}^{COL} = \$9.796 \quad MC_{\Omega}^{COL} = \$2.243$$

However, under an efficient allocation we would have had:

$$1 - \omega^* \simeq 0 \qquad 1 - \Omega^* \simeq 0,636.$$

Had the subsidies been allocated efficiently, that is, no subsidies for eradication and all for interdiction efforts, we find that cocaine supply in consumer countries would have been 11% lower than it actually was. That is, instead of being about 474,000 kilograms it would have been about 420,480 kilograms.

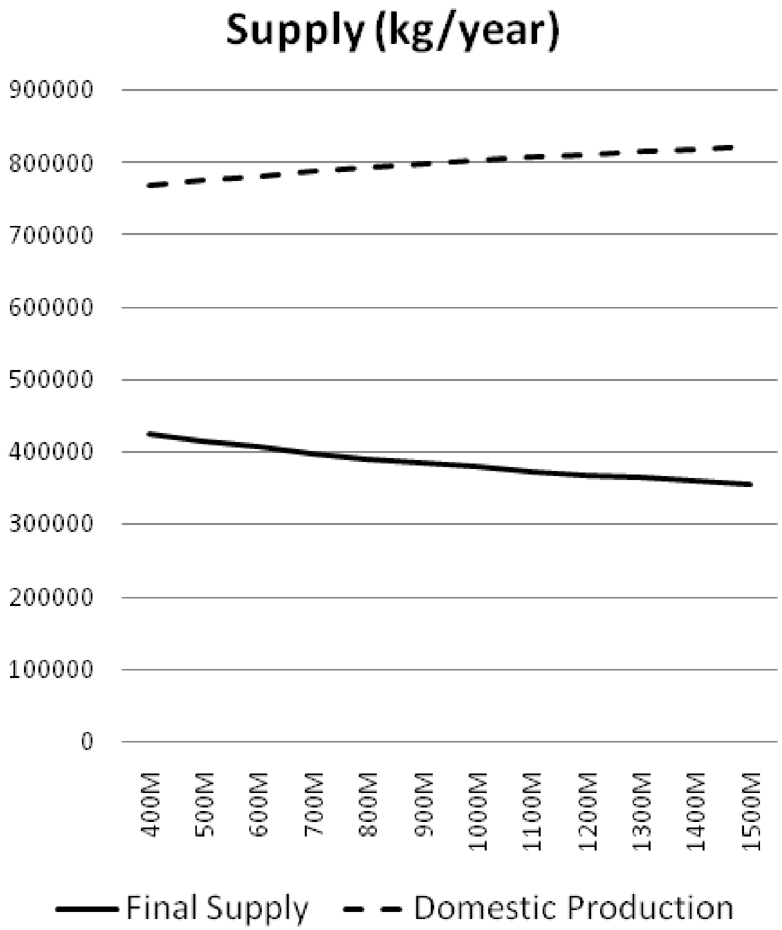
$$MC_{\omega^*}^{US} = \$67.679 \qquad \mathbf{MC}_{\Omega^*}^{US} = \$10.141$$
$$MC_{\omega^*}^{COL} = \$19.314 \quad MC_{\Omega^*}^{COL} = \$2.470$$

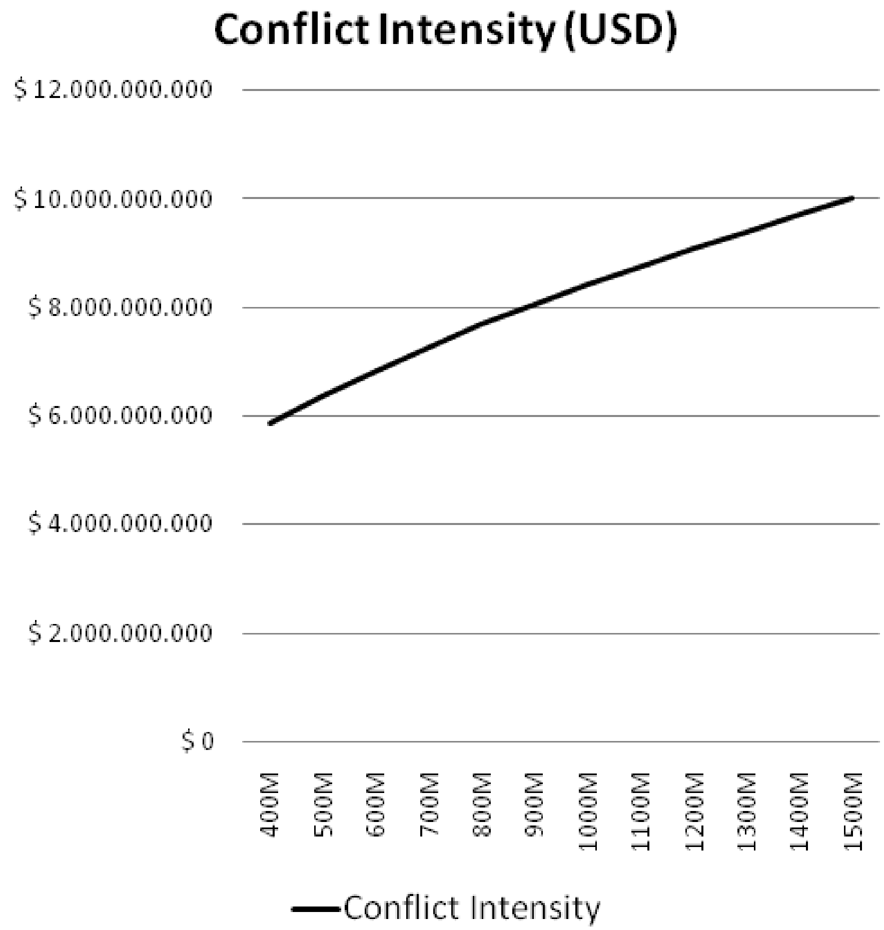
4. Simulations

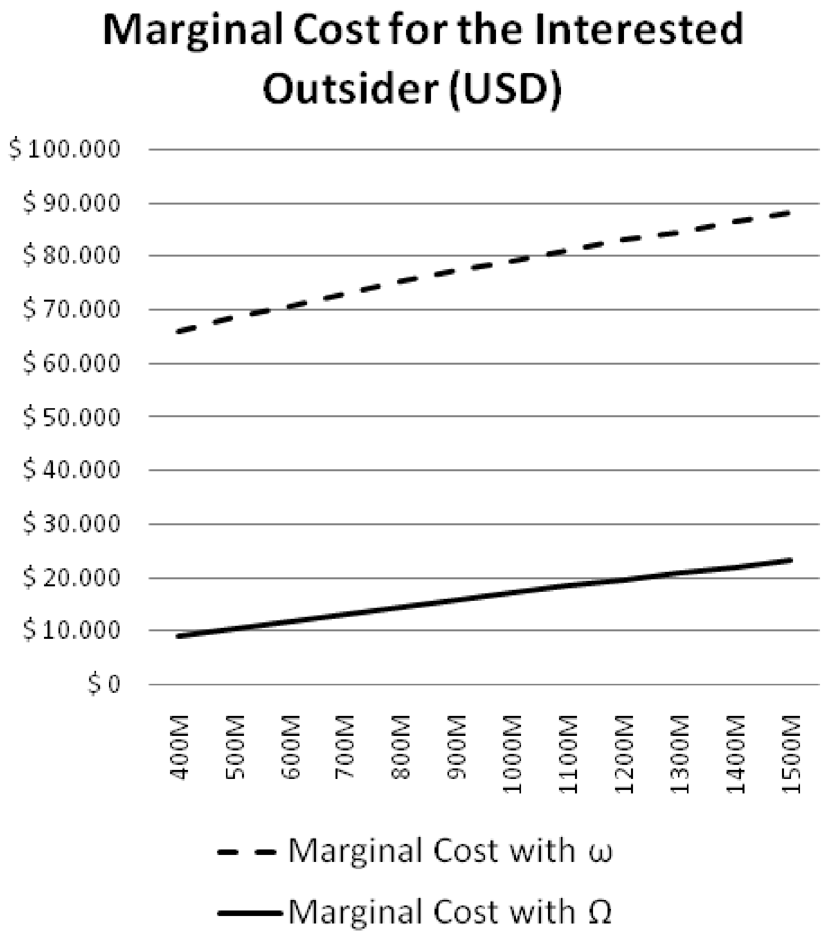
·We now study the response of some of the endogenous variables of the model when M_o, the US budget allocated to the reduction of cocaine supply, changes exogenously. We will assume that the subsidies from the interested outsider are allocated efficiently. The following set of figures show the results from these simulations.

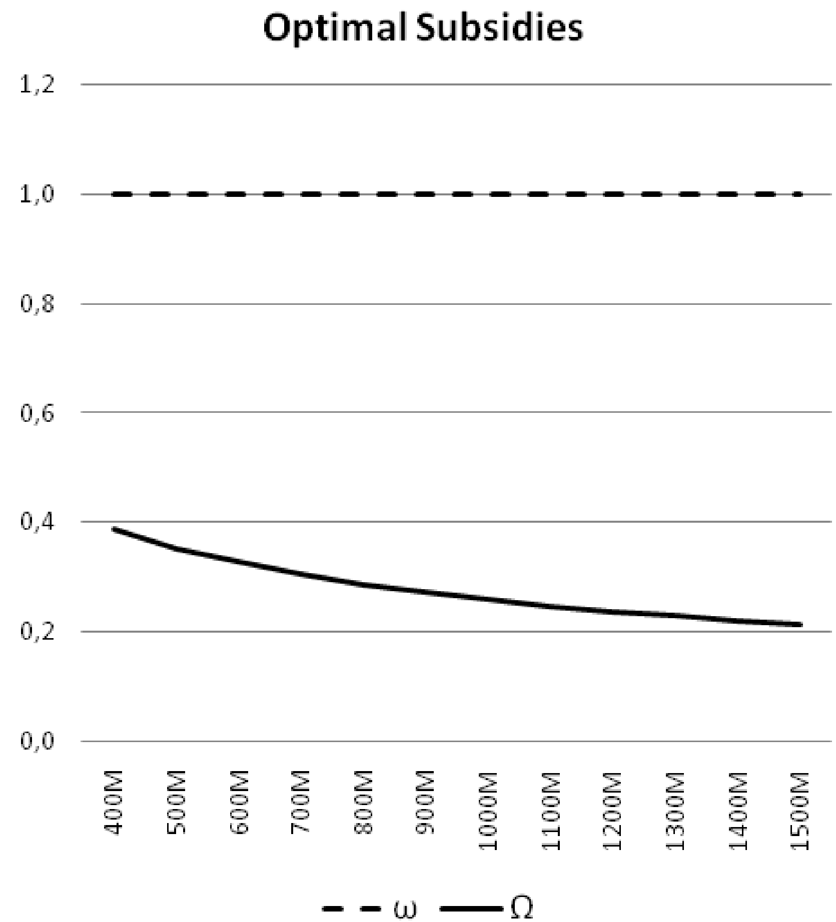
Calibration results: Variables of Interest

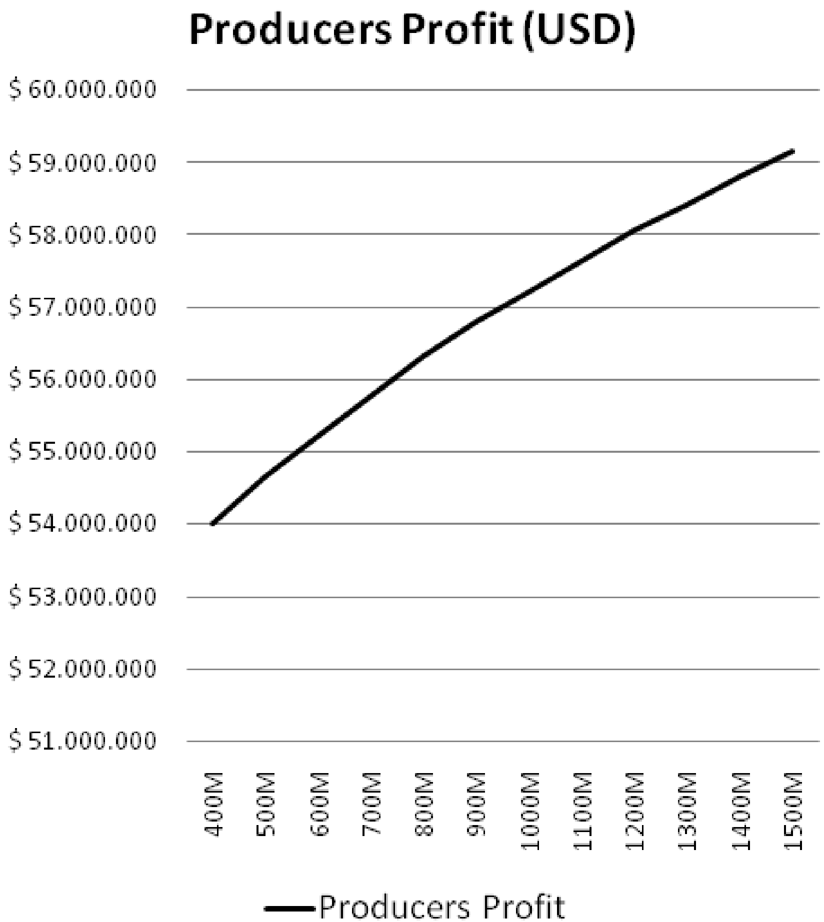
Variable	Actual	Efficient Allocation (M=0.46 billion)	Efficient Allocation (M=1.5 billions)
ω	0.51	1	1
Ω	0.67	0.36	0.21
Q_f	474tm	420tm	355tm
P_f	35.862	42.909	55.130
Q_d	645tm	774tm	823tm
P_d	1.860	1.643	1.680
IC	4b	6b	10b


Supply (kg/year)
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
400M
500M
600M
700M
800M
900M
1000M
1100M
1200M
1300M
1400M
1500M
Final Supply
Domestic Production


Conflict Intensity (USD)
$ 12.000.000.000
$ 10.000.000.000
$ 8.000.000.000
$ 6.000.000.000
$ 4.000.000.000
$ 2.000.000.000
$ 0
400M
500M
600M
700M
800M
900M
1000M
1100M
1200M
1300M
1400M
1500M
Conflict Intensity


Marginal Cost for the Interested Outsider (USD)
$ 100.000
$ 90.000
$ 80.000
$ 70.000
$ 60.000
$ 50.000
$ 40.000
$ 30.000
$ 20.000
$ 10.000
$ 0
400M
500M
600M
700M
800M
900M
1000M
1100M
1200M
1300M
1400M
1500M
Marginal Cost with ω
Marginal Cost with Ω


Optimal Subsidies
1,2
1,0
0,8
0,6
0,4
0,2
0,0
400M
500M
600M
700M
800M
900M
1000M
1100M
1200M
1300M
1400M
1500M
ω
Ω



Producers Profit (USD)
$ 60.000.000
$ 59.000.000
$ 58.000.000
$ 57.000.000
$ 56.000.000
$ 55.000.000
$ 54.000.000
$ 53.000.000
$ 52.000.000
$ 51.000.000
400M
500M
600M
700M
800M
900M
1000M
1100M
1200M
1300M
1400M
1500M
Producers Profit

Traffickers Profit (USD)
$ 12.200.000.000
$ 12.000.000.000
$ 11.800.000.000
$ 11.600.000.000
$ 11.400.000.000
$ 11.200.000.000
$ 11.000.000.000
$ 10.800.000.000
$ 10.600.000.000
$ 10.400.000.000
$ 10.200.000.000
$ 10.000.000.000
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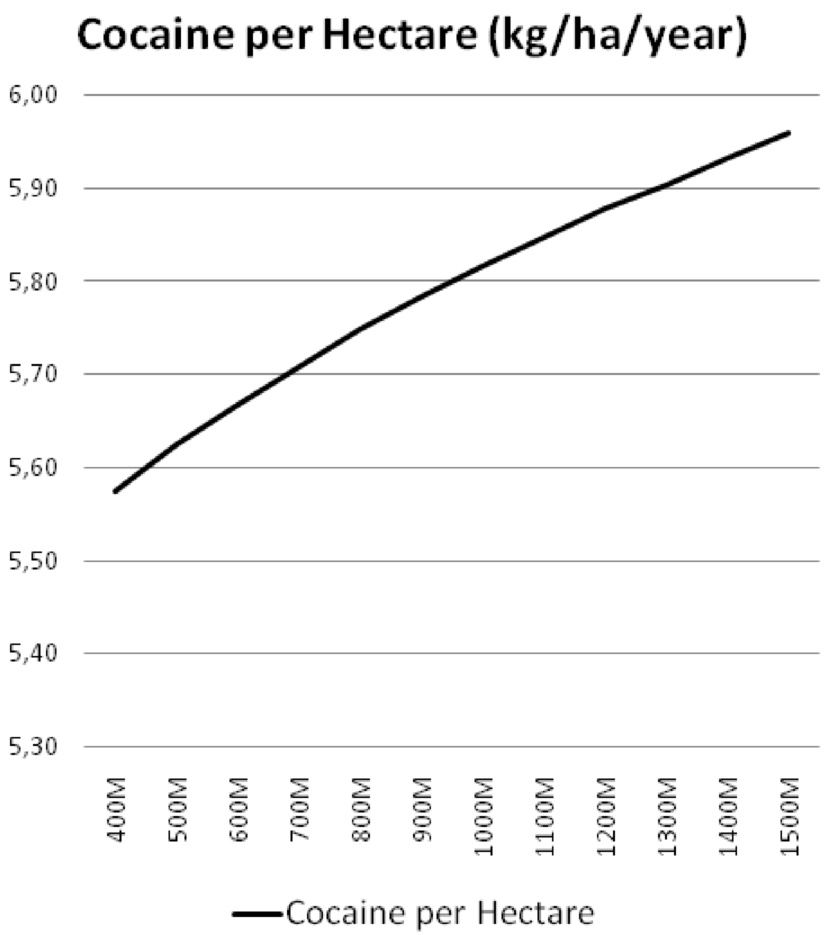
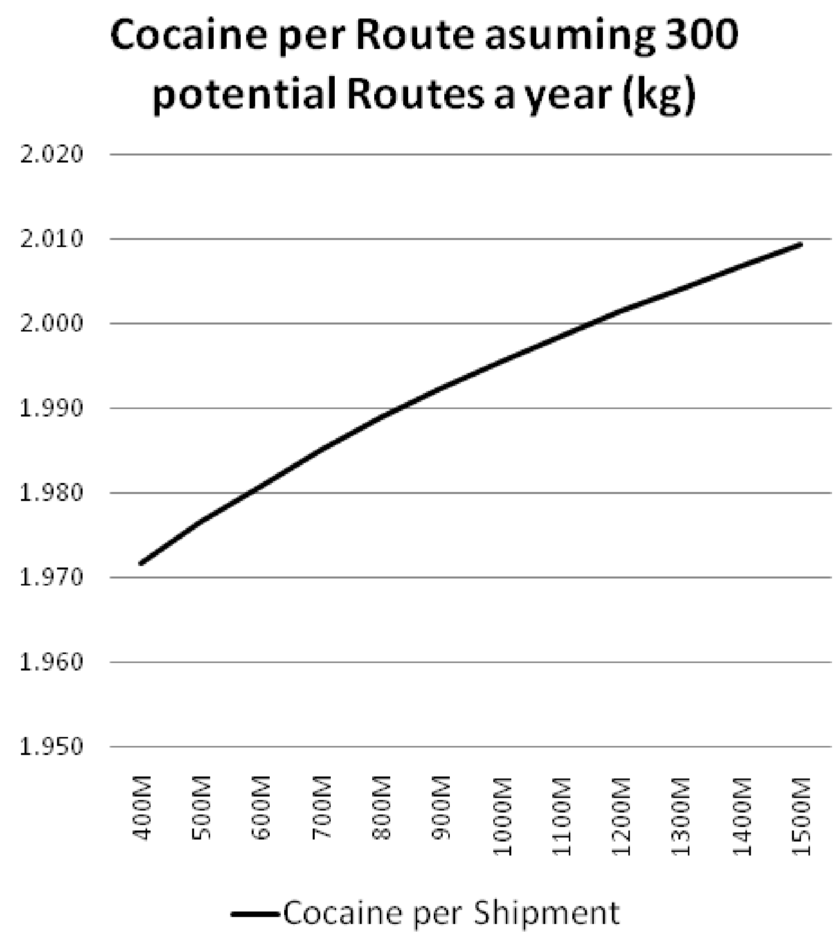
1300M
1400M
1500M
Traffickers Profit



Cocaine per Hectare (kg/ha/year)
6,00
5,90
5,80
5,70
5,60
5,50
5,40
5,30
400M
500M
600M
700M
800M
900M
1000M
1100M
1200M
1300M
1400M
1500M
Cocaine per Hectare



Cocaine per Route asuming 300 potential Routes a year (kg)
2.020
2.010
2.000
1.990
1.980
1.970
1.960
1.950
400M
500M
600M
700M
800M
900M
1000M
1100M
1200M
1300M
1400M
1500M
Cocaine per Shipment

5. Why is the war on drugs so costly / ineffective?

Our results imply that the elasticity of Q_f with respect to M_0, by subsidizing the State's conflict with the drug producer for the control of arable land, is about 0.014, whereas the elasticity of Q_f with respect to M_o, by subsidizing the interdiction efforts, is about 0.102.

What makes this elasticities so low (and different)?...

i. A low price elasticity of demand [$b = 0.67$]. Source country control interventions shift the supply to the left with very little effects on the quantity because the demand for illegal drugs is inelastic.

ii. High values for the relative effectiveness of the drug producers in the conflict with the state and the relative effectiveness of the drug traffickers in avoiding interdiction efforts [$\phi = 2.33$ and $\gamma = 0.36$].

iii. A relative low importance of the factor being contested: land in the case of the war against drug production [$1 - \alpha = 0.27$], and drug routes in the case of the war against illegal drug trafficking [$1 - \eta = 0.93$].

5. Concluding remarks

· Modelling the motivations and choices of the actors involved in the war on drugs with economic tools (more precisely, with game theory tools) is an important step towards the understanding of the observed outcomes and future prospects of this apparently-ineffective war.

· In this paper we developed a game-theoretic model of the war against drug production and trafficking and use available evidence from the cocaine market as well as stylized facts of the war on drugs in Colombia to calibrate all the unobservable parameters of the model. Importantly, we estimated important variables that are key to evaluating the effectiveness, efficiency, and costs of the war on drugs in Colombia as well as its future prospects.

· The framework developed in this paper as well as the estimates of key variables should help policy makers objectively evaluate current anti-drug policies and, hopefully, guide them in the process of shaping more sound strategies in the war against illegal drugs.

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