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The War on Illegal Drugs

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Abstract

This paper develops a simple model of the war against illegal drugs in producer and consumer countries. The analysis shows how the equilibrium quantity of illegal drugs, as well as their price, depend on key parametres of the model such as the price elasticity of demand and the effectiveness of the resources allocated to enforcement and prevention and treatment policies. Importantly, the paper studies the trade-off faced by the state of the drug consumer country between prevention policies (aimed at reducing de demand for illegal drugs) and enforcement policies (aimed at reducing the production and trafficking of illegal drugs) and shows how the optimal allocation of resources between these two alternative uses depends, also, on the key parameters of the model. We use available data for the war against cocaine production and trafficking in Colombia, and against consumption in the US, to calibrate some of the unobserved parameters of the model.

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1. Introduction

During the last decade there has been a drastic intensification of the war on drugs, not only in Latin-American producer countries but, also, in the main consumer countries in North America and Europe. For instance, in Colombia, where about 70% of the cocaine consumed in the world is produced, the United States and the Colombian government have allocated huge amounts of resources to this war during the last 7 years under the so-called *Plan Colombia*.[1] According to the Colombian National Planning Department (DNP), the US government has 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, has spent about $6.9 million during the same period. About 1/2 of the Colombian expenses (or about $3.4 million) and about 3/4 of the US subsidies (or about $2.8 million) have gone directly to finance 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 drug 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 large intensification of the war on drugs (see Mejía and Posada, 2008). While the number of hectares cultivated with coca crops in Colombia has decreased 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 590.000 kgs per year in 2006 (see UNODC, 2007).[2] Consistent with the observed data on potential cocaine production just described and relatively stable figures for consumption trends, prices of cocaine at the wholesale and retail levels in consumer countries have shown a relatively stable trend since year 2000.[3]

In the United States, where about half of the cocaine produced in the world is consumed,

[1] *Plan Colombia* is the official name of a program that, among other things, provides the institutional framework for the strategic alliance between the Colombian and United States governments to fight against the production and trafficking of illegal drugs (mainly cocaine) and the organized criminal organizations associated with these activities.

[2] Coca cultivation and cocaine production has slightly increased in the other two producer countries, Bolivia and Peru, during the same period. As a result, total figures for potential cocaine production have remained relatively constant for the last 6-7 years (see UNODC, 2007 and Mejia and Posada, 2008).

[3] Wholesale and retail prices for cocaine decreased rapidly between 1990 and 2000, but since this last year they have remained relatively stable. See Costa Storti and De Grauwe (2007) for an explanation of this phenomenon based on the increased globalization of the illegal drug markets.

the government currently spends about \$12,5 billion dollars in several dimensions of the war on drugs. Approximately 7.7 billion (or about 60%) are spent on policies to reduce the supply of illegal drugs, such as domestic law enforcement, interdiction, and subsidies to drug producer countries, whereas the other \$4,8 billion (or about 40%) are spent on policies aimed at reducing the demand for drugs, such as prevention and treatment of drug addicts.

This paper develops a model of the war against drugs in producer and consumer countries where there are strategic interactions between the actors involved in the war. Namely, the illegal drug producer and trafficker, the state of the drug producer country, the state of the drug consumer country, and drug dealers in consumer countries. On the one hand, in the producer country, the state engages the drug trafficker in a conflict over the fraction of illegal drugs that are successfully produced and exported to the consumer country. We abstract from modelling the conflict between the state and the drug producers for the control of arable land necessary for the cultivation of the illicit crop.[4] On the other hand, the state of the drug consumer country faces a trade-off between prevention policies, aimed at reducing demand for illegal drugs, and enforcement policies, aimed at reducing the supply of drugs in consumer countries. Importantly, we study how anti-drug policies implemented in consumer and producer countries interact and affect each other's effectiveness.

Following the analysis in Grossman and Mejia (2008) we assume that the state of the drug consumer country uses both a stick and a carrot to strengthen the resolve of the state of the drug producer country in its war against illegal drugs. The model shows how the efforts and successes of the state of the drug producer country in the war against illegal drug trafficking depend on this stick and carrot, on the technology of interdiction of drug shipments, and, importantly, on the choice of anti-drug policies in the consumer country. The state of the drug consumer country uses prevention policies and enforcement policies to minimize the consumption of illegal drugs. While the former are aimed at reducing the demand for drugs using educational campaigns and providing treatment to drug addicts, the latter are aimed at reducing the supply of illegal drugs coming from the drug producer countries. The analysis shows how the equilibrium allocation of resources between the two type of policies crucially depends on the price elasticity of demand for the illegal drug in the consumer country and on the effectiveness of prevention and treatment in reducing the demand for drugs. In particular, we show how the relative allocation of resources to

[4]See Grossman and Mejia (2008) and Mejia and Restrepo (2008) for models where this front of the war on drugs is explicitly studied.

enforcement policies should be smaller when the demand for illegal drugs becomes relatively more inelastic.

We calibrate the model using available data on the market for cocaine as well as data on the war against cocaine production, trafficking, and consumption in Colombia and the US respectively. The calibration exercise allows us to recover some important unobservable parameters such as the price elasticity of demand for cocaine, the relative effectiveness of the interdiction efforts, and the effectiveness of prevention policies in reducing the demand for cocaine. Having an estimate of these parameters is important for policy prescription purposes.

The paper's main contribution is the development of a simple analytical framework to understand the motivations and choices of the different actors involved in the war on drugs and how they interact strategically to produce the equilibrium outcomes (quantities, prices, and resource allocations). Importantly, the model is able to account for the feedback effects between policies and market outcomes that arise in a general equilibrium framework. While there have been important attempts to develop models of the war on drugs in producer countries (Grossman and Mejia, 2008 and Mejia and Restrepo, 2008) and the war on drugs in consumer countries (Becker, Grossman and Murphy, 2006, Rydell et al., 1996, and Caulkins, 1993, among others) there is no model in the literature that studies the interaction of anti-drug policies implemented in consumer and producer countries. An important exception is the recent contribution by Chumacero (2006), who develops a dynamic general equilibrium model of the war against illegal crops cultivation, and illegal drug production, trafficking and consumption.[5] His main contribution relies on the calibration of some key parameters of the model that are then used to assess the effects of three alternative policies: making illegal activities riskier, increasing the penalties to illegal activities, and legalization.

The paper includes four sections where this introduction is the first one. The second section, which is the core of the paper, develops the model and explains the motivations and choices of each one of the actors involved in the game. Also, this section derives the equilibrium of the model. Section four presents a simple calibration of the model using available data of the market for cocaine as well as some key figures on the war against cocaine production and trafficking in Colombia and data on the allocation of resources to prevention and treatment in the US. The fourth section concludes.

[5] The title of his paper, "Evo, Pablo, Tony, Diego, and Sonny", is quite suggestive of the fact that he studies the war on drugs at almost all stages: illegal crop cultivation (Evo), drug production (Pablo), drug trafficking (Tony), and drug consumption (Diego).

2. The Model

We model the war against illegal drugs as a sequential game. In the first stage of the game the state of the drug consumer country chooses the optimal allocation of resources between prevention and treatment policies and enforcement policies. The latter take the form of a subsidy to the state of the drug producer country in order to strengthen its resolve in the war against illegal drug producers and traffickers. Both policies have the same objective: reduce the amount of illegal drugs transacted in equilibrium. While prevention and treatment policies are targeted towards the reduction of demand, enforcement policies (the subsidies to the producer country's state) are aimed at thwarting the availability of drugs in the consumer country. That is, at reducing the supply of illegal drugs. In the second stage of the game the state of the drug producer country engages the drug producers and traffickers in a conflict over the fraction of illegal drugs that are successfully exported. Following Grossman and Mejia (2008), we assume that the state of the drug consumer country uses both a stick and a carrot to strengthen the resolve of the state of the drug producer country in its war against illegal drug production and trafficking.

We start with the second stage of the game. That is, with the conflict between the state of the drug producer country and the illegal drug producers and traffickers over the fraction of illegal drugs that are successfully produced and exported.

2.1. The drug trafficking game

2.1.1. The interdiction technology

Let q be the fraction of drugs that survive the state's interdiction efforts. The interdiction technology is such that q is determined endogenously by a standard context success function, by

$$q = \frac{s}{s + \phi r}, \tag{1}$$

where r is the amount of resources that the state invests in the interdiction of drug shipments such as radars, airplanes, fast boats, etc., s the amount of resources that the drug traffickers invest in trying to avoid the interdiction of drug shipments such as submarines, fast boats, airplanes, etc., and $\phi > 0$ is a parameter that captures the relative effectiveness of the resources invested by the state in trying to interdict drug shipments. Note that the fraction q that the drug trafficker successfully exports (equation 1) is an increasing and concave function of the ratio $\frac{s}{\phi r}$.

2.1.2. The drug trafficker

The problem of the drug producer and trafficker is to choose the amount of resources he invests to avoid the interdiction of drug shipments in order to maximize his profits, π_T. That is, the drug trafficker's problem is given by,

$$\max_{\{s\}} \pi_T = p_c q \lambda L - s. \tag{2}$$

The first term in equation 2 is the price of drugs in the border of the consumer country, p_c, times the fraction of drugs that survives interdiction efforts, q, times the amount of drugs produced in the consumer country, λL. This last term is given by the product of the productivity per hectare of land per year, λ, (for instance, the number of kilograms of the illegal drug that can be produced from the cultivation of the illegal crop in one hectare of land in one year[6]) times the number of hectares of land under the drug producers' control, L.[7] The last term, s, denotes the amount of resources invested by the drug trafficker to try to avoid the interdiction of drug shipments.

The first order condition for the drug trafficker's problem in equation 2 is:

$$\frac{\partial \pi_T}{\partial s} = 0 \qquad \Longleftrightarrow \qquad \frac{\phi r}{(s + \phi r)^2} p_d \lambda L \ = 1. \tag{3}$$

Equation 3 describes the reaction function of the drug trafficker to every possible choice of resources by the state in interdiction efforts, r.

2.1.3. The state of the drug producer country

Following Grossman and Mejía (2008) we assume that the state of the drug consumer country uses both a stick and a carrot in an attempt to strengthen the resolve of the state of the drug producer country in its war against illegal drugs. The stick is the threat that the interested outsider will label the state as a narco-state and, as a result, it will be ostracized by the international community.

[6] For the case of cocaine in Colombia, this yield/hectare/year was about 7.4 kg of cocaine in 2006 (see UNODC, 2006).

[7] See Grossman and Mejia (2008) and Mejia and Restrepo (2008) for models that include a conflict between the state and the drug producers for the control of the arable land that is suitable for cultivating the illegal crop.

Let c denote the annual cost in dollars that the state anticipates would result from being labeled as a narco-state. Thus, the expected annual cost associated with the possibility of being labeled as a narco-state equals the product of q and the probability, $D/\lambda L$.

The carrot used by the state of the drug consumer country is a subsidy to the armed forces of the state. This subsidy consists of a fraction, $1-\omega$, of the resources that the state allocates to the interdiction of drug shipments, r.

Assume that, from the perspective of the state of the drug producer country, the decision of the state of the drug consumer country to apply the label narco-state includes a stochastic element.[8] To allow for this stochastic element, let λ denote the number of kilograms of drugs that without interdiction could be successfully produced and exported using the crops harvested on a hectare of land, and let D denote the total amount of hard drugs successfully exported annually, measured in kilograms, where

$$D = q\lambda L. \tag{4}$$

The objective of the state of the drug producer country is to minimize the sum of the costs associated with illegal drug production and trafficking. These costs are given by the sum of the cost of being labeled a narco-state times the probability of this event, plus the cost of fighting the war against drug production and trafficking. The latter is given by the amount of resources invested by the state in interdiction efforts, r, times the fraction that the state pays of these expenses, ω. The problem for the state of the drug producer country is:

$$\min_{\{r\}} \quad C_T = c\frac{D}{\lambda L} + \omega r, \tag{5}$$

where D is determined in equation 4.

The first order condition for the state's maximization problem is:

$$\frac{\partial C_T}{\partial r} = 0 \qquad \Longleftrightarrow \qquad \frac{-\phi s}{(s+\phi r)^2} c + \omega = 0. \tag{6}$$

[8] What we have in mind is the Drug Certification Process, which was stablished in 1986 and where, each year, the US government evaluates the cooperation and meassures taken by all illegal drug producer and transit countries against illegal drug production and trafficking. Those countries that are not certified face many consequences with direct and indirect costs. For instance, "requires the U.S. to deny sales or financing under the Arms Export Control Act; deny non-food assistance under Public Law 480; deny financing by the Export-Import Bank, and withhold most assistance under the FAA with the exception of specified humanitarian and counternarcotics assistance. The U.S. must also vote against proposed loans from six multilateral development banks." see: http://www.usembassy-mexico.gov/bbf/bfdossier_certDrogas.htm

Equation 6 is the state's reaction function to every possible choice of resources by the drug trafficker.

2.2. Drug trafficking equilibrium

Using equations 3 and 6 we can find a LOCUS of points in the space $\left(\frac{r}{s}, p_c\right)$ for which the drug trafficking game is in equilibrium.[9]

Definition 1 (GE LOCUS): All pairs $\left(\frac{r}{s}, p_c\right)$ that satisfy the following expression represent possible equilibria of the drug trafficking game:

$$\frac{r}{s} = \frac{c}{p_c \lambda L \omega}. \tag{7}$$

According to the expression for the GE LOCUS, a higher price of the illegal drug in the consumer country leads to a lower relative spending from the state of the drug producer country in the war on drugs. This is so because a larger p_c increases the marginal returns of allocating resources to avoiding interdiction for the drug trafficker and naturally induces him to fight relatively harder than the state.[10]

Using the expression in equation 7 and replacing it in the drug trafficker's reaction function (equation 3) we can derive an explicit expression for the state's and drug trafficker's level of expenses in the war on drugs (both as functions of the price of drugs in the consumer country, yet to be determined). These two allocations are given, respectively, by:

$$r = \frac{\phi c^2 (\lambda L \omega p_c)^2}{\lambda L \omega^2 p_c \left(\lambda L \omega p_c + \phi c\right)^2}, \tag{8}$$

and,

$$s = \frac{\phi c (\lambda L \omega p_c)^2}{\omega \left(\lambda L \omega p_c + \phi c\right)^2}. \tag{9}$$

In turn, the fraction of illegal drugs that survive the state's interdiction efforts in equilibrium (that is, the successfully exported fraction of drugs) is given by:

$$q = \frac{\lambda L \omega p_c}{\lambda L \omega p_c + \phi c}. \tag{10}$$

[9] Recall that r, s, and p_c are endogenous variables of the model.

[10] This result arises from the assumption that the state's cost from illegal drug production and trafficking does not depend on the price of drugs, but on the drugs succesfully produced and exported relative to potential production.

The fraction of drugs that survives the state's interdiction efforts is an increasing and concave function of the price of drugs, of the fraction of the state's expenses of the war on drugs paid by the state of the drug producer country, ω, and of potential cocaine production, λL. A higher state's relative efficiency in the interdiction of drug shipments, ϕ, or a larger cost of being labeled as a narco-state, c, decrease the fraction of drugs that are successfully exported.

We now turn to the description of the drug market equilibrium.

2.3. Drug market equilibrium

On the one hand, let us assume that the demand for drugs in the border of the consumer country is given by a general demand function where,

$$Q_c^d = \frac{a(l)}{p_c^b}. \tag{11}$$

Q_c^d denotes the demand for drugs by drug dealers in the border of the consumer country, $a(l) \geq 0$, where l denotes the allocation of resources to prevention policies aimed at reducing the demand for illegal drugs in the consumer country such as educational campaigns, treatment of drug addicts, etc. Naturally, we assume that $a'(l) < 0$. That is, more resources allocated to prevention policies reduce the demand for drugs (that is, it shifts the demand for drugs to the left). p_c is the price of the illegal drug in the border of the consumer country, and b is the price elasticity of demand for illegal drugs.

On the other hand, the supply of drugs in the consumer country is given by:

$$Q_c^s = \frac{s}{s + \phi r}\lambda L. \tag{12}$$

According to equation 12, the supply of drugs in the consumer country is given by potential drug production, λL, times the fraction of this production that is not interdicted, q (see equation 1). Note that equation 12 expresses the supply of drugs in the consumer country as a function of the ratio of expenses in the war on drugs in the producer country, r/s.

In the drug market equilibrium we must have that $Q_c^d = Q_c^s$. Equating 11 and 12 and rearranging we can now define a LOCUS of points in the space $\left(\frac{r}{s}, p_c\right)$ for which the illegal drug market is in equilibrium.

Definition 2 (ME LOCUS): All pairs $\left(\frac{r}{s}, p_c\right)$ that satisfy the following expression represent possible equilibria of the drug market:

$$\frac{r}{s} = \frac{\lambda L p_c^b}{\phi a(l)} - \frac{1}{\phi}. \tag{13}$$

In contrast with the GE Locus, a higher price of cocaine in consumer countries leads to a larger relative spending from the state in the war on drugs under the ME Locus. This positive relationship between the ratio of spendings in the war on drugs and the price of the illegal drug in the consumer country arises because a higher ratio $\frac{r}{s}$ means a lower supply of drugs and, given the demand, the price of the illegal drug, p_c, should rise for the drug market to remain in equilibrium.

We can now use both LOCI described above to represent graphically the equilibrium of the second stage of the game. Recall that the GE Locus describes all pairs of points $\left(\frac{r}{s}, p_c\right)$ for which the drug trafficking game is in equilibrium whereas the ME Locus describes all pairs of points $\left(\frac{r}{s}, p_c\right)$ for which the drug market is in equilibrium. The two LOCI are represented in Figure 1.

[INSERT FIGURE 1 HERE].

We can now understand how changes in the parameters of the model shift each one of the two LOCI and how the relative allocation of resources to the war on drugs and the price of drugs change as some of the structural parameters of the model change. Specifically, at this point we focus on changes in the allocation of resources to prevention policies and repression policies (which will be the focus of the analysis once we turn to the first stage of the game). Figure 2 shows how the equilibrium price of drugs and the relative spendings in the war change as l increases (i.e. as a decreases). Figure 3 shows the effect of a decrease in ω (an increase in the subsidy to the armed forces of the state in its war against illegal drug production and trafficking). While an increase in prevention policies aimed at reducing consumption in the consumer country reduces the equilibrium price of drugs and increases the relative spending from the state in the war on drugs (thereby reducing the equilibrium fraction of drugs successfully exported), an increase in the subsidy increases the equilibrium price of drugs in the consumer country and the relative spending of the state in the war on drugs. Note that an increase in the subsidy generates two opposing forces on the ratio r/s : it increases the price of drugs and therefore it increases the incentives for the drug traffickers to invest resources in evading interdiction (as the price of drugs increases) and, also, increases the incentives for the state to invest resources in the war on drugs, as the marginal cost of doing so goes down. The net effect is an increase in the ratio r/s (as shown in Figure 3). Importantly, an increase in the subsidy from the drug consumer country induces an increase in the total resources invested in the war on drugs, $r + s$. That is, an increase in subsidies to the state of the drug producer country increases the intensity of conflict, as measured by the sum of resources invested by the two actors involved in this war.

[INSERT FIGURES 2 and 3 HERE].

The representation of the equilibrium of the model in terms of the two LOCI described before is helpful in order to understand how changes in the parameters of the model affect the relative allocation of resources to the war on drugs. However, the equilibrium of the model can also be represented in a standard supply and the demand framework. Using equation 10, the supply of drugs in the consumer country (that is, the supply of drugs net of interdiction) is given by:

$$Q_c^s = \frac{(\lambda L)^2 \omega p_c}{\lambda L \omega p_c + \phi c}. \tag{14}$$

The demand for drugs, on the other hand, is given by equation 11. The graphical representation of the equilibrium of this stage of the game in a simple supply and demand graph is depicted in Figure 4.

[INSERT FIGURE 4 HERE].

Solving for p_c in both expressions and making $Q_c^s = Q_c^d = Q_c$, we have that the equilibrium quantity of drugs is determined by the following implicit equation, which depends on the parameters of the model and on the two choice variables for the state of the drug consumer country, l and ω, which will be determined endogenously in the next subsection.

$$F(Q_c, l, \omega) = Q_c^{\frac{1+b}{b}} \phi c + a(l)^{\frac{1}{b}} \lambda L \omega (Q_c - \lambda L) = 0. \tag{15}$$

Using the expression for the equilibrium quantity of drugs in the second stage of the game we can now determine the sign of the effect of changes in the parameters of the model on the equilibrium quantity of drugs. The following are the main comparative statics results at this stage:

- $\dfrac{\partial Q_c}{\partial l} = \dfrac{-\partial F/\partial l}{\partial F/\partial Q_c} \leq 0$. An increase in prevention policies in the drug consumer country decreases the amount of illegal drugs transacted in equilibrium. On the one hand, $\partial F/\partial Q_c > 0$, and, on the other hand, $\partial F/\partial l > 0$ because $Q_c - \lambda L < 0$. Recall that λL is potential drug production whereas Q_c is the amount of drugs transacted in equilibrium. With at least some interdiction (that is, with $q < 1$, as it is in fact the case in equilibrium (see equation 10)), the amount of drugs transacted in the market is always lower than potential drug production. Conversely, a decrease in l (i.e. an increase in a) will increase the amount of illegal drugs transacted. We will elaborate more on this point in the next section of the paper when we study the optimal allocation of resources to prevention policies in the drug consumer country.

· $\frac{\partial Q_c}{\partial \omega} = \frac{-\partial F/\partial \omega}{\partial F/\partial Q_c} \geq 0$. A decrease in the subsidy to the drug producer country in its war against illegal drugs (that is, a lower $1 - \omega$) increases the quantity of illegal drugs transacted in equilibrium. Again, this result follows from the fact that $Q_c - \lambda L < 0$. Intuitively, a larger marginal cost of interdiction efforts for the state of the drug producer country will induce it to spend less resources in the interdiction of drug shipments and, as a result, the supply of drugs in the consumer country (net of interdiction) will increase. Again, this point will be elaborated in more detail in the next section of the paper.

· $\frac{\partial Q_c}{\partial \phi} = \frac{-\partial F/\partial \phi}{\partial F/\partial Q_c} \leq 0$ and $\frac{\partial Q_c}{\partial c} = \frac{-\partial F/\partial c}{\partial F/\partial Q_c} \leq 0$. An increase in either the relative efficiency of the state of the drug producer country in the war on drugs or an increase in the cost to the state of the drug producer country of being labeled as a narco-state leads to a negative shift in the supply of drugs. This is because the state would allocate relatively more resources to interdiction efforts and, as a result, the equilibrium fraction of drugs successfully exported (equation 10) will decrease.

· $\frac{\partial Q_c}{\partial \lambda} = \frac{-\partial F/\partial \lambda}{\partial F/\partial Q_c} \geq 0$, and $\frac{\partial Q_c}{\partial L} = \frac{-\partial F/\partial L}{\partial F/\partial Q_c} \geq 0$. An increase in λ, the productivity per hectare of land used for the cultivation of illegal crops, or an increase in L, the land under control of the drug producers, increases the amount of drugs produced and exported in equilibrium. The increase in productivity or in the amount of land controlled by the drug producers shifts the supply curve to the right and, as a result, the price of drugs goes down and the quantity of drugs in equilibrium goes up.

We now turn to the analysis of the first stage of the game. That is, to the choice between prevention policies and policies aimed at curtailing the supply of drugs from producer countries by increasing interdiction.

2.4. Anti-drug policies in the consumer country: prevention and treatment vs enforcement

In the first stage of the game, the objective of the state of the drug consumer country is to minimize the amount of illegal drugs transacted in equilibrium. To achieve this objective the state of the drug producer country combines prevention policies, that seek to reduce the demand for illegal drugs, and deterrence policies in the form of subsidies to the armed forces of the state of the drug producer country in its war against illegal drug production and trafficking.

More formally, the objective of the state of the drug consumer country is:

$$\begin{aligned} \min_{\{l,d\}} \; Q_c \qquad \text{subject to} &\quad : \\ l + d &= M, \quad \text{and} \\ d &= (1-\omega)r^*, \end{aligned} \tag{16}$$

where Q_c is the quantity of illegal drugs transacted in the border of the consumer country in equilibrium, M is consumer country's total budget for prevention and enforcement policies, l is the allocation of resources to prevention policies (i.e. the reduction of demand), and d is the total amount of resources that the state of the drug consumer country grants in subsidies to the state of the drug producer country. The total amount of subsidies, d, is equal to the marginal subsidy, $1-\omega$, times the resources spent by the producer country in the war against drug production and trafficking, r^*. That is, d is the total amount of resources allocated by the state of the drug consumer country to reduce the supply of illegal drugs.

Using equations 8 and 14, and the fact that $d = (1-\omega)r^*$, we can solve for ω in terms of the parameters of the model, the state expenses in subsidies, d, and the quantity of illegal drugs transacted, Q_c, as:

$$\omega = \frac{\frac{cQ_c}{\lambda L}\left(1 - \frac{Q_c}{\lambda L}\right)}{d + \frac{cQ_c}{\lambda L}\left(1 - \frac{Q_c}{\lambda L}\right)}. \tag{17}$$

Replacing the expression for ω obtained in equation 17 we can express the equilibrium quantity of drugs transacted (that is the equilibrium level of Q_c) as a function of the parameters of the model and the two instruments of the state of the drug consumer country, l and d, in the following implicit function:

$$S(Q_c, l, d) = Q_c^{\frac{1+b}{b}} \phi c + a(l)^{\frac{1}{b}} \lambda L \frac{\frac{cQ_c}{\lambda L}\left(1 - \frac{Q_c}{\lambda L}\right)}{d + \frac{cQ_c}{\lambda L}\left(1 - \frac{Q_c}{\lambda L}\right)} (Q_c - \lambda L) = 0. \tag{18}$$

Using the implicit function in equation 18, which determines the equilibrium quantity of the illegal drug as a function of the two instruments of the state of the drug consumer country, the optimal allocation of resources to prevention and enforcement is determined by the following optimality condition:[11]

$$\frac{\partial S(Q_c, l, d)}{\partial l} = \frac{\partial S(Q_c, l, d)}{\partial d}. \tag{19}$$

Intuitively, the optimally condition in equation 19 says that the state in the consumer country will allocate resources to prevention and deterrence policies until the two are equally effective in reducing Q_c at the margin .

Finding the expressions for $\partial S(.)/\partial l$ and $\partial S(.)/\partial d$ from the implicit equation 18, the optimality condition in equation 19, after some algebraic manipulation, becomes:

$$\frac{1}{b}\frac{a'(l)}{a(l)} = -\frac{1}{d + \frac{cQ_c}{\lambda L}\left(1 - \frac{Q_c}{\lambda L}\right)}. \tag{20}$$

In order to find a close form solution to the problem of the drug consumer country's state, let us assume that,

$$a(l) = \frac{A}{l^{\theta}}, \tag{21}$$

where $A > 0$, and $\theta > 0$ is a parameter that captures the efficiency of prevention policies.

Using the functional form for $a(l)$ from equation 21, the optimality condition in equation 20 becomes:

$$\frac{1}{b}\frac{\theta}{l} = \frac{1}{d + \frac{cQ_c}{\lambda L}\left(1 - \frac{Q_c}{\lambda L}\right)}. \tag{22}$$

Finally, using the state's budget constraint and equation 22, the optimal allocation of resources to prevention and enforcement are given, respectively, by:

[11] This optimality condition is obtained using the implicit function theorem to find the expressions for $\frac{\partial Q_c}{\partial l}$ and $\frac{\partial Q_c}{\partial d}$.

$$l^* = \frac{\theta}{b+\theta}M + \frac{\theta}{b+\theta}\frac{cQ_c}{\lambda L}\left(1 - \frac{Q_c}{\lambda L}\right), \tag{23}$$

and,

$$d^* = \frac{b}{b+\theta}M - \frac{\theta}{b+\theta}\frac{cQ_c}{\lambda L}\left(1 - \frac{Q_c}{\lambda L}\right). \tag{24}$$

A few things are worth noticing from equations 23 and 24. First, if the demand for drugs becomes more inelastic (lower b) the optimal allocation of resources shifts towards prevention policies and away from enforcement policies. This result is in line with that of Becker et al. (2006).[12] Second, a higher θ, that is, a higher efficiency of treatment and prevention policies in reducing the demand for illegal drugs, increases the optimal allocation of resources to prevention policies and decreases the allocation of resources to enforcement. Finally, if $\frac{Q_c}{\lambda L} < \frac{1}{2}$, a larger ϕ or c induces the state of the drug consumer country to shift resources towards repression policies and away from prevention policies. This last result can be interpreted as follows: confronted with an increase in ϕ or in c, the state of the drug consumer country is willing to shift resources from prevention towards enforcement policies only if the fraction of drugs interdicted is sufficiently high. This, in turn, is the case only if the state of the drug producer country is already sufficiently effective in interdicting drug shipments or if it faces a sufficiently high cost from the production and trafficking of illegal drugs.

Replacing the optimal allocation d^* from equation 24 in the equation describing the equilibrium value of ω (equation 25) we get:

$$\omega^* = \frac{\frac{cQ_c}{\lambda L}\left(1 - \frac{Q_c}{\lambda L}\right)}{\frac{b}{b+\theta}\left[M + \frac{cQ_c}{\lambda L}\left(1 - \frac{Q_c}{\lambda L}\right)\right]}. \tag{25}$$

Replacing the optimal allocation of resources to prevention policies, l^*, from equation 23 in equation 21 we have that:

[12] A sufficient condition for this result to be true is that $Q_c/(\lambda L) < 1/2$. However, even if this condition does not hold, this result might still hold for a broad range of parameter values. The details of this calculation are available from the author upon request.

$$a^* = \frac{A}{\left[\frac{\theta}{b+\theta}\left(M + \frac{cQ_c}{\lambda L}\left(1 - \frac{Q_c}{\lambda L}\right)\right)\right]^{\theta}} \tag{26}$$

Finally, replacing equations 25 and 26 in equation 15, the equilibrium level of illegal drugs transacted in equilibrium is given by the following implicit equation (this time only as a function of the parameters of the model):

$$S^*(Q_c^*) = Q_c^{*\frac{1+b}{b}}\phi c + \frac{A^{1/b}}{\left[\frac{\theta}{b+\theta}\left(M + \frac{cQ_c^*}{\lambda L}\left(1 - \frac{Q_c^*}{\lambda L}\right)\right)\right]^{\theta/b}} \lambda L \frac{\frac{cQ_c^*}{\lambda L}\left(1 - \frac{Q_c^*}{\lambda L}\right)}{\frac{b}{b+\theta}\left[M + \frac{cQ_c^*}{\lambda L}\left(1 - \frac{Q_c^*}{\lambda L}\right)\right]}(Q_c^* - \lambda L) = 0. \tag{27}$$

3. Calibration strategy and (preliminary) results

This section brings the model developed in the previous section to the data in order to estimate some of the key parameters of the model. We use available data on the market for cocaine, focusing on the case of Colombia, as this is the country where about 75% of the cocaine consumed in the world is produced. Also, we use some key numbers about the war on drugs in Colombia and the US.

Table 1 briefly describes some of the data that will be used in the calibration of the model.[13]

Table 1

Definition	*Variable*	*Observed*
Drug seizures (kg)	$(1-q)\lambda L$	90.000
Cocaine price / kg in the US border (\$/kg)	p_c	32.500
US budget for prevention (\$)	l	500 million
US budget for Plan Colombia (\$)	d	465 million
Hectares of land with coca crops (has)	L	85.000
Kilos of cocaine/hectare/year	λ	$7,4$
Fraction of Colombian expenses subsidized	$(1-\omega)$	$0,6$

[13] For a thorough description of the data on the market for cocaine, the war on drugs, etc. see Mejia and Posada (2008).

Using equations 21, 10, 27, 25, and 23 together we can jointly calibrate b, θ, ϕ, A, and c. Table 2 describes the calibrated values for these parameters.

Table 2

Parameter	*Calibrated value*
b	0.83
θ	0.54
ϕ	1.25
A	$1.27 \mathrm{x} 10^{14}$
c	\$1.75 billion

The estimated value for the price elasticity of demand for cocaine, 0.83, denotes a relatively inelastic demand. This, in some sense, reaffirms the view that the demand for hard drugs is relatively inelastic. θ, which is a parameter that captures the efficiency of prevention policies in reducing the demand for cocaine in the US, is estimated to be about 0.54. This parameter can be interpreted as the percentage reduction in the demand for cocaine for a 1% increase in resources devoted to prevention policies. That is, a 1% increase in prevention and treatment policies decreases the demand for illegal drugs by about 0.54%. The parameter ϕ, which captures the relative efficiency of the state in the interdiction of drug shipments, is about 1.25. That is, one dollar spent by the Colombian state in the interdiction of drug shipments is about 1.25 times more efficient than one dollar spent by the drug trafficker in escaping the state's interdiction efforts.

We calibrate the cost to the Colombian government of illegal drug production and trafficking, c, to be about \$1.75 billion, which is about $1\% - 1,5\%$ of current Colombian GDP. This number lies within the range for this variable assumed in Grossman and Mejia (2008) and is very close to the costs estimated in Mejía and Restrepo (2008).

4. Concluding remarks

The model developed in this paper is a first step towards the understanding of the interrelationship between anti-drug policies in consumer and producer countries. 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 outcomes of this war. This paper develops a simple model of the war on drugs in producer and consumer countries to explain the allocation of resources to this war by the different actors that are involved in it, the equilibrium outcomes, and the response of the latter to exogenous changes in some of the key parameters of the model. Importantly, we explicitly model illegal drug markets which allows us to account for the feedback effects that arise in a general equilibrium framework between policy changes, prices, and the strategic responses of the different actors involved in the war on drugs. In particular, under a broad range of parameter values, if the demand for drugs is relatively inelastic resources in the war on drugs should be shifted away from policies aimed at curtailing the supply of drugs (enforcement policies) and towards policies aimed at reducing the demand for illegal drugs. However, if the state of the drug producer country is relatively more efficient in interdicting drug shipments or if it faces a high cost of being labeled as a narco state, then the optimal allocation of resources by the state of the drug consumer country calls for a reallocation of resources away from prevention and towards enforcement policies.

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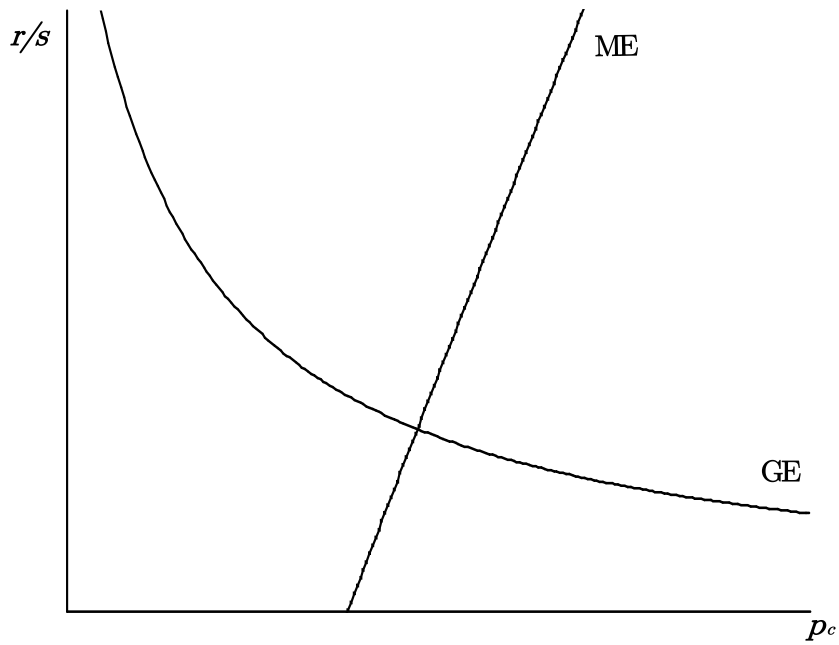

Figure 1: The GE Locus and the ME Locus.

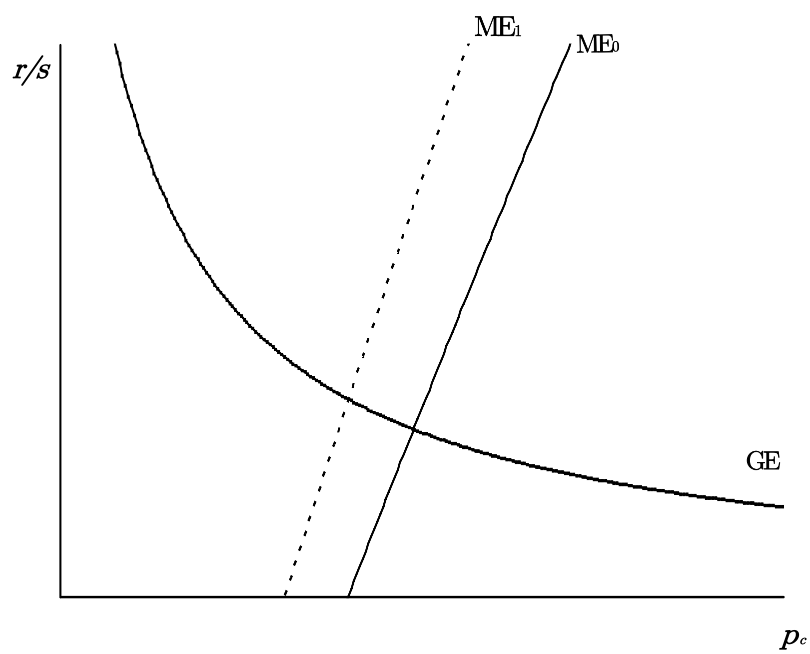

Figure 2: The effect of an increase in prevention policies (increase in l).

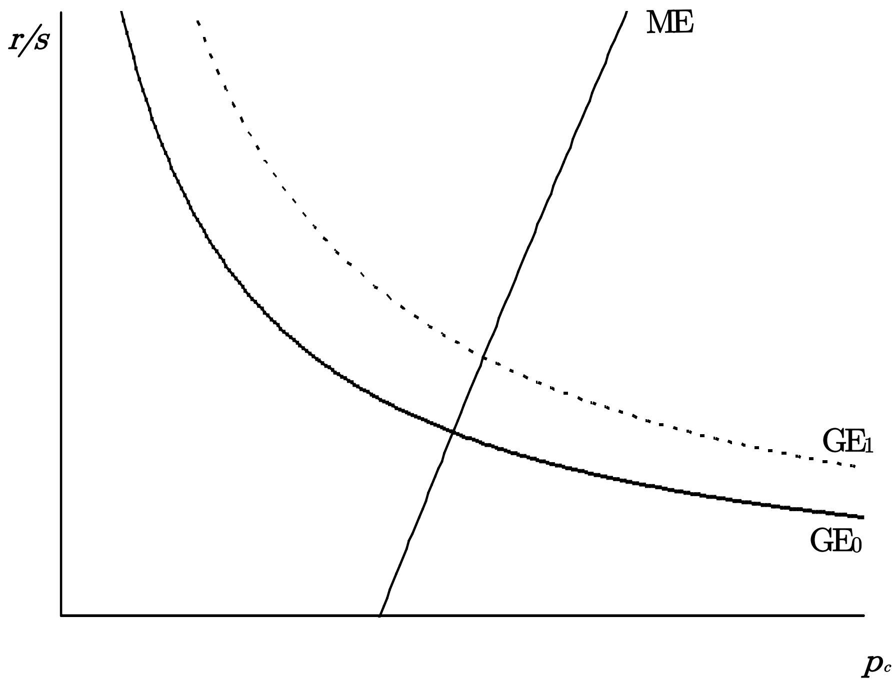

Figure 3: The effect of an increase in the subsidy (decrease in ω).

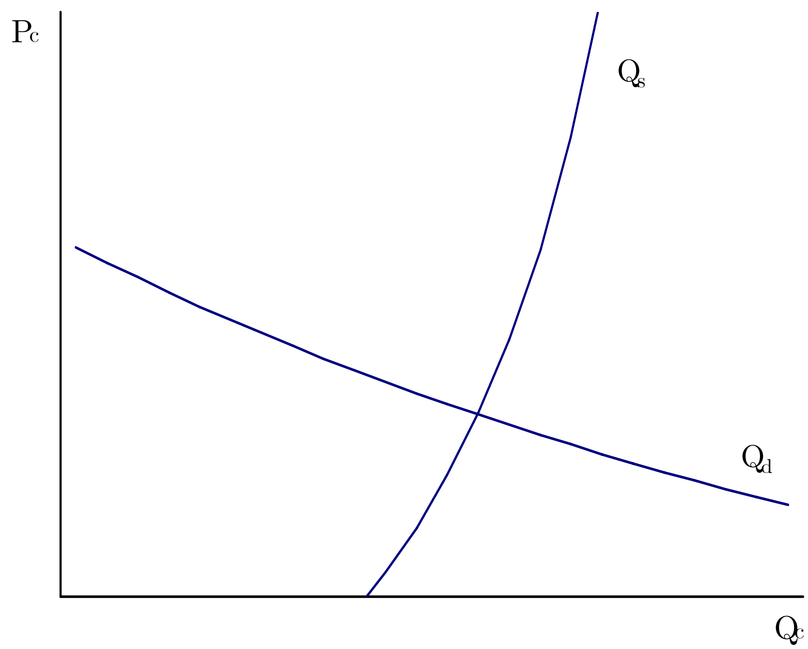

Figure 4: Representation of the equilibrium of the model: Supply and Demand.