Journal of Public Economics 105 (2013) 1–10

Contents lists available at SciVerse ScienceDirect

Journal of Public Economics

journal homepage: www.elsevier.com/locate/jpube

Curbing coca cultivation in Colombia — A framed field experiment

Marcela Ibanez [a,*], Peter Martinsson [b]

[a] Georg-August University of Göttingen, Germany
[b] University of Gothenburg, Box 640, SE-40530 Göteborg, Sweden

ARTICLE INFO

Article history:
Received 22 May 2008
Received in revised form 19 February 2013
Accepted 17 April 2013
Available online 24 April 2013

JEL classification:
C91
C93
D62
K42

Keywords:
Coca cultivation
Colombia
Experiment
Carrots and sticks
Anti-drug policy

ABSTRACT

This paper investigates the efficiency of carrot and stick policies to reduce investment in coca cultivation in rural Colombia. To measure behavioral responses to anti-drug policies, we conducted a framed field experiment with farmers living in one of the most important coca growing areas. Our experimental design allows identifying heterogeneous producer types and measuring their behavioral response to carrots and sticks. We provide an example on how knowledge on distribution types can be used to design an optimal anti-drug policy. We find that about one third of the farmers have moral costs that are high enough to deter them from investing in coca and hence, would require no external incentives. Yet destroying coca completely is prohibitively costly for two fifths of the participants who would require an extremely high compensation or risk of eradication.

1. Introduction

Colombia, the world's leading producer of cocaine (UNODC, 2009), has introduced a strong anti-drug policy to combat cocaine production. The policy uses two main strategies: (i) a stick policy, where coca plants are eradicated by aerial spraying and manual destruction and (ii) a carrot policy, aimed at increasing the relative profit of non-coca agricultural activities by providing monetary subsidies in exchange for not cultivating coca. Although the cost of the anti-drug policy totaled around 5500 million US dollars from 2000 to 2007 (ONDCP, 2006; GAO, 2008), little is known about the efficiency of this policy.

This paper investigates the efficiency of carrot and stick policies to reduce coca cultivation when producers are heterogeneous in terms of risk preferences and moral costs of cultivating coca. Information about each producer type is asymmetric, yet authorities can use the information on distribution of producer's types to design an optimal policy. To identify the types of producers and their behavioral response to carrots and sticks, we implemented a framed field experiment mimicking coca cultivation decision in rural areas in Putumayo, Colombia, one of the regions with the highest levels of coca cultivation in the world.

Previous studies found that eradication had a low effectiveness in reducing coca cultivation compared with alternative source-country anti-drug policies (e.g. Carvajal, 2002; Díaz and Sánchez, 2004; Moreno-Sanchez et al., 2003; Moya, 2005; Tabares and Rosales, 2004; Mejía and Restrepo, 2008).[1] However, the use of aggregated historical data does not allow the investigation of individual motivations to cultivate coca or the evaluation of policy levels outside ranges historically used. Ibanez and Carlsson (2010) use a choice experiment to investigate the relative efficiency of anti-drug policies. Yet, the hypothetical nature of the game could lead to biases in the responses. The nature of illegal activities, the social norms associated to them, and the potential sample selection into the activity, make framed experiments with farmers familiar with coca cultivation a preferable method for analyzing the effectiveness of anti-drug policies. The use of experiments to investigate law compliance has mainly been used to study the effects of the probability and severity of punishment (e.g. Friedland et al., 1978; Ostrom et al., 1992; Alm et al., 1992a,b; Cardenas et al., 2000; Anderson and Stafford, 2003; Fortin et al., 2007; Trivedi et al., 2003, 2005) and largely disregards the effects of positive incentives. Although some laboratory experiments have tested the effect of exogenously and endogenously imposed carrot and stick programs (e.g. Sefton et al., 2007; Sutter et al., 2010), no

* Corresponding author at: Courant Research Center: Poverty, Equity and Growth in Developing Countries, Georg-August Universität. Göttingen, Wilhelm Weber Strasse 2, D-37073 Göttingen, Germany. Tel.: +49 551 39 10677.
E-mail address: mibanez@uni-goettingen.de (M. Ibanez).

[1] For a more general discussion on the effect of coca cultivation on self-employment and standard of living in Colombia see e.g. Angrist and Kugler (2008) and De Franco and Godoy (1992) for the economic consequences in Bolivia.

0047-2727/$ – see front matter
http://dx.doi.org/10.1016/j.jpubeco.2013.04.005

consideration has been given to how they should be mixed. In a laboratory experiment where subjects have the possibility to endogenously punish or reward Andreoni et al. (2003) show that carrots and sticks are complements in enforcing social norms. Unlike them, in our setting the incentives are imposed exogenously, examining an issue relevant for a social planner who wants to implement an efficient policy.

In the law compliance literature, there seems to be a consensus that monetary incentives and risk preferences alone cannot explain the high level of compliance observed (e.g. Andreoni et al., 1998; Cohen, 1999; Fellner et al., forthcoming). A plausible explanation for this apparently inconsistent behavior is that morality – the sense of what is right or wrong – restricts individuals to behave according to what is individually and/or socially considered to be acceptable or moral (Sen, 1977; Etzioni, 1990; Vanberg, 1988; Erard and Feinstein, 1994; Cameron et al, 2009). In this paper we contribute to this branch of literature, by modeling and empirically estimating the moral costs associated with coca cultivation. In particular we use an extended version of Ehrlich's (1973) portfolio model of crime that includes the moral cost associated with participation in illicit activities. Our model resembles Eisenhauer (2004, 2006, 2008) and Eisenhauer et al. (2011), but while they model morality as a lower marginal utility from the income from the illicit activity (criminal act), we consider that morality is reflected in how much individuals internalize the value of the negative externality that the criminal activity generates.[2]

Our experimental design allows identifying heterogeneous types of producers and estimating the willingness to accept a monetary compensation to stop cultivating coca for each producer type. We find that about one third of the participants have a high moral cost and would require no compensation to stop cultivating coca. On the other hand, two fifths of the participants would require that the relative return of the legal activity were 1.8 times that from coca, or would require that the risk of eradication were above 60% to stop cultivating coca. Hence, it is prohibitively costly to target them. The remaining one fourth of the population would be responsive to carrot and stick policies, and should be targeted by the authorities. Our results suggest that carrots should be used in areas that are better integrated to markets, whereas sticks should be used in economically depressed areas.

The remainder of the paper is organized as follows: the next section presents the theoretical framework that guides our analysis. Section 3 presents the experimental design and procedures used. The results and policy implications are presented in Sections 4 and 5. Section 6 concludes with a discussion on open questions on the design of anti-drug policies.

2. Theoretical framework

We consider a partial equilibrium model with two types of agents: producers and a social planner. The N producers and the social planner interact in a two stage game, in which the social planner can be seen as a Stackelberg leader who decides on the optimal balance of carrot and stick policies against coca cultivation, taking into account the effect of the chosen policies on producer's cultivation decisions. We consider that there are heterogeneous types of producers who differ in terms of their moral cost of engaging in coca cultivation and in their level of risk aversion. There is asymmetric information and only the producer knows his own type. Nonetheless, the social planner can use information on the distribution of producer types and incorporate it in the optimization process to find an efficient balance of carrot and stick policies.

[2] We thank a referee for pointing us in this direction.

2.1. The producer's problem

Producers are endowed with L hectares of land and have to decide how to allocate it between coca and an alternative crop in order to maximize expected utility. Each hectare cultivated with coca by producer i (c_i), gives one unit in return, while each hectare cultivated with an alternative crop gives a return of a, where $a < 1$. We assume that all available land is used, so the amount of land cultivated with the alternative crop is (L-c_i). Coca cultivation generates negative externalities such as environmental damage and violence. Let X be the harm generated by each hectare with coca to each of the N community members. Coca cultivation is illegal and with probability p, the plantations can be discovered and destroyed. If this happens, the producer faces a loss which is proportional to the amount of land cultivated, $F(ci)$.[3]

This basic portfolio model of crime can be extended to include the moral cost of cultivating coca. We assume that irrespective of whether authorities discover coca plantation, individuals experience a moral cost of engaging in coca cultivation. We further consider that the moral cost associated with coca cultivation is a convex function of the value of the externality generated. This assumption is consistent with the idea that it is possible to justify small investments in coca motivated – for instance – by subsistence reasons, while large investments are not morally justifiable. Nevertheless, individuals differ in how much they internalize the value of the externality. Let b_i represent be the individual measure on morality or the degree to which individuals internalize the harm generated by coca cultivation. A producer with high morality, $b_i = 1$, internalizes the total magnitude of the externality generated by coca cultivation in the community, while a producer with low moral concerns, $b_i = 0$, does not consider the external effects of her decision.[4] In particular we consider that he moral cost of coca cultivation is given by $(N - 1)Xc_ib_i^2$. Given the above considerations, the optimization problem for the individual producer can be written as:

$$\underset{ci}{Max}\, EU = (1-p)\mathrm{U}\left(c_i + (L-c_i)a - X\sum_{i=1}^{N} c_i - (N-1)Xb_ic_i^2\right) + pU\left(c_i + (L-c_i)a - X\sum_{i=1}^{N} c_i - (N-1)Xb_ic_i^2 - F(ci)\right) \quad (1)$$

The first order condition for an interior solution implies:

$$\frac{1-a-X-2(N-1)Xc_ibi}{1-a-X-2(N-1)Xc_ibi-F} = \frac{-p}{(1-p)}\frac{U'(Y_b)}{U'\left(Y_g\right)} \quad (2)$$

Where $Y_g = c_i + (L-c_i)a - X\sum_N c_i - (N-1)Xc_i^2b_i$ and $Y_b = Y_g - F(c_i)$.

Hence, Eq. (2) implies that the optimal investment is determined by the equality of the marginal rate of transformation of income in case of good and bad luck (left hand side) and the marginal rate of substitution of income for a given level of expected utility (right-hand side). For a maximum to exist, $d^2EU/dci^2 < 0$. Unless, $1 - a - X - 2(N-1) Xc_ib_i - F < 0$, farmers would specialize and cultivate all their land with coca. A Taylor expansion of Eq. (2) around the expected income, $YE = c_i + (L-c_i)a - X\sum_N c_i - (N-1)Xc_i^2b_i - pFc_i$, implies[5]:

$$c_i* = \frac{1-a-X-pF}{(p-1)pF^2R(YE) + 2(N-1)Xb_i} \quad (3)$$

[3] For simplicity assume $F(c_i) = Fc_i$. While other type of sanctions could be imposed (e.g. incarceration) they are rarely applied.

[4] While individuals could derive utility from harming others ($b_i < 0$), we exclude those motivations in our analysis.

[5] Taylor expansion of Eq. (2) around YE implies:

$$(1-p)U'(YE)(1-a-X-2(N-1)Xc_ibi) + (1-p)(1-a-X-2(N-1)Xc_ibi)U''(YE)pFci\,) = -pU'(YE)(1-a-X-2(N-1)Xc_ibi-F) - p(1-a-X-2(N-1)Xc_ibi-F)U''(YE)Fci(p-1).$$

Where $R(YE) = -U''(YE)/U'(YE)$ is the Arrow-Pratt coefficient of risk aversion evaluated at *YE*.

The optimal investment in coca is a function of economic incentives (a and pF) and individual risk and moral preferences ($R(Y)$ and b_i). As it is shown in the Appendix A, for decreasing absolute risk aversion, DARA, the optimal investment in coca, $c_i{}^*$ decrease on moral cost, b_i. Besides similarly as Ehrlich (1973), coca investment decrease with expected cost of eradication, pF, relative return of the alternative, a (for DARA) and the risk aversion, $R(Y)$.

In this paper we try to characterize producers according to moral and risk preferences (b_i and $R(Y)$) and to derive their response to a and p. This characterization allows us to identify the distribution on producer types, which can be used by the social planner (as shown below) to design an efficient anti-drug policy. We use a two-step procedure to characterize producers according to moral cost and risk preferences. In the first step we estimate the individual morality parameter, b_i. When the risk of eradication is zero, $p = 0$, Eq. (3) simplifies to:

$$c_i* = \frac{(1-a-X)}{2(N-1)Xb_i} \tag{4}$$

Regressing the observed investment in coca, ci^*, on different levels of a using non-linear regression model it is possible to obtain an individual estimation of the moral parameter, b_i that does not depend on coefficient of risk aversion, $R(Y)$. The estimated morality coefficients can be normalized using: $\hat{b}_i = \frac{b_i - \min(b_i)}{\max(b_i) - \min(b_i)}$. In a second step, the risk aversion coefficient can be estimated taking into account the estimated measure of morality. Assuming that $U(x) = \frac{x^{(1-\gamma)}}{(1-\gamma)}$ for $\gamma \neq 1$ and $U(x) = \text{Log}(x)$ for $\gamma = 1$, the first order condition for an interior solution (Eq. (2)) implies,

$$\log\left(\frac{p}{(1-p)}\right) + \log\left(\frac{\left(F + a + X + 2(N-1)Xc_i^*\hat{b}_i - 1\right)}{\left(1-a-X-2(N-1)Xc_i^*\hat{b}_i\right)}\right) = -\gamma \log\left(\frac{c_i^* + (L-c_i^*)a - X\sum_N c_i^* - (N-1)Xc_i^{*2}\hat{b}_i}{c_i^* + (L-c_i^*)a - X\sum_N c_i^* - (N-1)Xc_i^{*2}\hat{b}_i - Fc_i^*}\right) \tag{5}$$

Eq. (5) can be written as $y_i = \beta_i X_i + \varepsilon_i$ and estimated for each individual using OLS. The individual coefficient of risk aversion is $\gamma = -\beta_i$.

2.2. The social planner's problem

The problem for the social planner is to minimize the cost of anti-drug policies to push coca cultivation below a given minimum level $\underline{C}$, which can be considered to be the result of a political process. The instruments available to her are carrots and sticks and the question is how to combine them optimally. The optimization problem for the social planner is:

$$\min_{s,p} \; Cost = Ms + Tp \qquad s.t. \quad \sum_{t=1}^{T} w_t C_t(a+s, p, b_t, \gamma_t) \leq \underline{C} \tag{6}$$

We assume that the carrot policy is implemented as a subsidy s that increases the return from the legal activity to $a + s$. Hence, the cost of carrot policy is given by Ms, where M is the number of hectares beneficiary of the subsidy and s is the value of the subsidy per hectare. The stick policy is assumed to be implemented in the form of risk to have coca plants discovered and destroyed by authorities, p. If T is the cost of increasing the risk of destroying coca in one percentage unit, the cost of the stick policy would be Tp. The amount of coca cultivated by each producer type, C_t, is a function on incentives ($a + s$ and p), moral type (b_i) and risk preferences(γ_i). The total amount of coca that results from setting s and p, is the weighted sum of the amount cultivated by each producer type, where w_t represents the weight that producer type t has on the population $\sum w_t = 1$.[6] The optimal balance of carrots and sticks is achieved when the technical rate of substitution of carrots to sticks is equal to the relative price:

$$\frac{\sum_i^T w_t \frac{dC_t}{ds}}{\sum_i^T w_t \frac{dC_t}{dp}} = \frac{M}{T} \tag{7}$$

In order to design an efficient anti-drug policy, the social planner needs a measure of the behavioral response to carrots and sticks by different producer types $\left(\frac{dC_t}{ds}, \frac{dC_t}{dp}\right)$ and estimate the distribution of producer types (w_t). Our experimental design allows obtaining these measures.

3. Experimental design and procedures

In our framed field experiment, the participants were randomly and anonymously matched in groups of five. Each subject was given 10 experimental points that represented the amount of land, labor and capital available to them for investing in two agricultural activities: coca or cattle. Their task was to decide how many points to invest in each.[7] Each person participated in nine treatments that combined three different levels of carrots, a, and three different levels of sticks, p. Participants were told that they could complete their decisions in any order and that they were allowed to go back and change any number they had written down.[8] The relative profits of the alternative, a, was set to be 0.2, 0.44, and 0.68 mimicking real life values. In the survey conducted in parallel with the experiment, the participants stated that the median relative profit of the alternative was 0.1 in 2003 and 0.24 in 2005. Similar to Alm et al. (2009), in our setting participants received information on the probability of eradication. The risk of eradication, p, was set to 0%, 10%, and 30%, also representing real life values.[9] Successful eradication resulted in an income loss of 1.2 points for each point invested in coca, mimicking the fact that spraying destroys coca plantations and also other crops. Lastly, the negative externalities generated by coca cultivation (i.e. social problems, violence and environmental damage) were included in the form of an externality that reduced the income for every subject in the group by 0.17. While there are no estimations on the social cost generated by coca cultivation in Colombia, the cost of crime and violence (which is highly associated with illicit drugs) was estimated to be 17% of GDP between 1991 and 1996 (Trujillo and Babel, 1998).[10]

Table 1 presents the marginal incentives to cultivate coca when individuals do not internalize the negative externality of coca cultivation ($b_i = 0$) in each of the nine treatments, labeled A to I according to the order in which they were presented to respondents. The marginal incentives to cultivate coca are positive, except in treatment I, so for individuals with no moral concerns and no risk aversion, the optimal decision would be to invest in coca. If participants do not

[6] $\sum_t^T w_t C_t(s,p)$ is convex on s and p.

[7] The instructions are available from the corresponding author upon request.

[8] Yet, several public goods experiments have tested for order effect and generally only found a small effect of order (e.g. Fehr and Gächter, 2000). In the future, we suggest testing for this effect by explicitly randomizing the order of the treatments.

[9] We estimated the probability of eradication to be 10 and 25 percent in 2003 to 2005, respectively. The estimations are based on the assumption that in order to destroy one hectare of coca, it has to be sprayed more than four times (Vargas, 1999).

[10] See also Alvarez and Rettberg (2008) survey article on the cost of armed conflict in Colombia.

Table 1
Monetary marginal incentives to cultivate coca.

Profit cattle/coca (a)	Probability of eradication (p)		
	0%	10%	30%
0.2	Treatment A = 0.63	Treatment D = 0.51	Treatment G = 0.27
0.44	Treatment B = 0.39	Treatment E = 0.27	Treatment H = 0.03
0.68	Treatment C = 0.15	Treatment F = 0.03	Treatment I = -0.21

Note: We calculate the marginal monetary incentive for coca cultivation as *1-a-0.17-1.2 p*.

invest in coca under those conditions, it must be that risk aversion or moral considerations deter them to do so.[11]

We conducted the experiment in four different municipalities in Putumayo, one of the poorest regions in Colombia with a long tradition of coca cultivation: Orito, Mocoa, Valle del Guamuez and Puerto Asis. To ensure credibility within the community we contacted local leaders, who then invited people from their community to a meeting with university researchers in order to discuss coca cultivation in the region.[12] Participants were interviewed individually in the morning, while in the afternoon we conducted the experiment. We did not ask for names, addresses or any other identifying information in order to encourage honest answers. To be able to match each individual survey with the corresponding experimental information, we asked the participants to use an identification number that they would be able to remember. The average earnings in the experiment were 19,227 Colombian pesos (COP) and the minimum and maximum earnings were 7000 COP and 25,100 COP respectively which can be compared with a daily wage of 15,000 COP.[13] In total, 164 producers participated in 13 experimental sessions.

4. Results

The descriptive statistics for the main variables used in the analysis is presented in Table 2. Compared with Census data, we find that our sample is representative of the Putumayo population in terms of age and level of education. Although landholders with more than 50 hectares are under-represented in our sample, we find no significant differences between the self-reported sizes of coca fields and those identified by the Coca Cultivation Survey (DNE, 2006). Coca cultivation has a long tradition in the studied region and participants, on average, had five years of experience cultivating coca.

Fig. 1 presents the cumulative distribution of investments in coca for the nine treatments. The horizontal axis shows the number of points invested in coca and the vertical axis the cumulative fraction of participants. Fig. 1A compares treatments with low relative profit ($a = 0.2$) at various relative risk levels, while Fig. 1B and C corresponds to the treatments with intermediate ($a = 0.44$) and high relative profit ($a = 0.68$), respectively. We find: 1) a significant proportion of participants (26%) that invested zero in coca in all treatments, which can be related with high moral cost associated to coca cultivation 2) a very small proportion of participants (1.2%) that invested all their endowment to produce coca, 3) that consistent with the theoretical predictions, the investment in coca decreases significantly with increases in a, and p (according to a Mann–Whitney test at the 5% level),[14] 4) a significant proportion of participants (37%) that invested in coca even in treatment I when there were no economic incentives to do so. This type of behavior can be indicative of habituation to coca cultivation, risk loving behavior, and/or strategic bias (whereby participants try to appear as less sensitive to policies to signal no intention to change). Our implied measure of risk aversion indicates a significantly lower risk aversion for those who invested in coca in this treatment vs. those who did not invest, supporting the risk loving behavior as a plausible explanation (Mann Whitney Rank sum test, prob < 0.01). In addition, the Spearman's rank correlation coefficient indicates that there is a positive and significant correlation between years of experience cultivating coca and non-zero investments in this treatment ($\rho = 0.27$). Hence, while our results support risk loving and habituation to coca cultivation as possible explanatory factors, we cannot rule out that strategic bias might have played a role.

We used the two-step procedure described above to estimate individual parameters of morality, b_i, and risk aversion, r_i. One advantage of using a regression analysis to estimate those parameters is that it allows estimating the parameter that minimizes the distance between predicted and observed behavior in all three decisions. The drawback is that it does not allow estimating the coefficient in cases where there is no variability in investment decisions. Consider for instance an individual who invests one point in treatment A, B and C. To deal with the lack of variability in investments, we estimated the coefficients for hypothetical investments 1,1,0 (slightly more moral) and 1,1,2 (slightly less moral) and impute the mean value for the investment 1,1,1. In the case of a constant zero investment, we used the maximum value of 2.5 for the morality parameter and 4.1 for the risk aversion parameter.

Once we obtained individual estimates of b_i and γ_i, we used cluster analysis to classify participants in four different types that differ in levels of risk aversion and moral cost. First row in Table 3 presents the proportion of participants in each category, while the median values of moral cost and risk aversion are presented in the second and third row, respectively. The last two rows present the proportion of participants who invested in coca and the average amount of points that they invested conditional on a positive investment. We find that 38% of the participants are classified in the low level of morality ($b_i = 0.016$) and low level of risk aversion ($r_i = 1.191$). This type of producer (Type 1) is very likely to invest in coca (about 90% did) and invest relatively larger amounts than other groups. We also find that they invested in coca even in the treatment with high risk and high returns to alternative investments when the expected marginal benefit was negative (68% of those in this group did). On the other extreme we find participants Type 4. They correspond to 27% of the participants and have a high moral cost ($b_i = 1$) and a high level of risk aversion ($r_i = 4.10$). This type of participants are very unlikely to invest in coca (only 3% did) or invest relatively little. The remaining 35% of the participants are classified in two types that have different degrees of risk aversion and morality. Type 2 producers (16% of the participants) have higher moral cost and risk aversion than Type 3 producers and are much more responsive to anti-drug policies.

Given that the identified producer types differ in their responsiveness to carrot and stick policies, it seems relevant to ask whether there are also differences in their observable characteristics. For instance, could the fast expansion of Protestantism that Colombia experienced over the last years bring renewed religious interests and induce changes in morality? Which other observable characteristics can explain differences among producer types? Table 4 presents the results of a multinomial logit model that compares observable characteristics of producer Types 2, 3 and 4 versus the reference group of producer Type 1. We find that there are no significant differences in religious faith across producer types, so religion does not seem to be the one responsible for differences in moral cost associated with coca cultivation. However, we find that Type 3 producers have a

[11] Bernasconi (1998) explains over compliance as result of differentiability of utility function (order of risk aversion).
[12] To avoid any strategic bias, we explained that we were independent researchers and were hence not working for any governmental agency.
[13] At the time of the experiment, 1 USD was equal to 2200 Colombian pesos.
[14] Increases in relative profit have a significant effect at the 5% level on the amount invested only when the relative profit increases from 0.2 to 0.68 (Mann–Whitney test). For intermediate changes, the difference is not significant.

Table 2
Descriptive statistics.

Variable	Sample		Census	Ho: Sample = Census	
	n = 144		n = 59,942		
	Mean	Std. dev	Mean	P-value	Significance
Age	42.090	14.031	41.47	0.751	
Education level					
Less than 3 years of education	0.548	0.499	0.501	0.226	
4 to 5 years of education	0.313	0.465	0.304	0.573	
More than 5 years of education	0.139	0.347	0.174	0.244	
Number of hectares					
Less that 3 hectares	0.337	0.474	0.267	0.059	*
Between 3 and 9 hectares	0.319	0.468	0.303	0.662	
Between 10 and 49 hectares	0.307	0.463	0.266	0.265	
More than 50 hectares	0.036	0.187	0.143	0	***
Average number of hectares with coca	1.17	1.13	1.34[a]	0.199	
Years cultivating coca	5.63	5.21	N.A		
Obligation to comply with the authorities (Abs Disagree = 1, Abs agree = 5)	3.443	0.813	N.A		
Religious beliefs					
Catholic	0.799	0.402	N.A		
Atheist	0.069	0.255	N.A		
Protestant	0.132	0.339	N.A		
Transport cost to market (thousand COP)	2.625	2.209	N.A		

[a] Corresponds to information from Coca Cultivation Census (DNE, 2006).
Note. *, ** and *** denote rejection of null hypothesis at the 10%, 5% and 1% levels respectively.

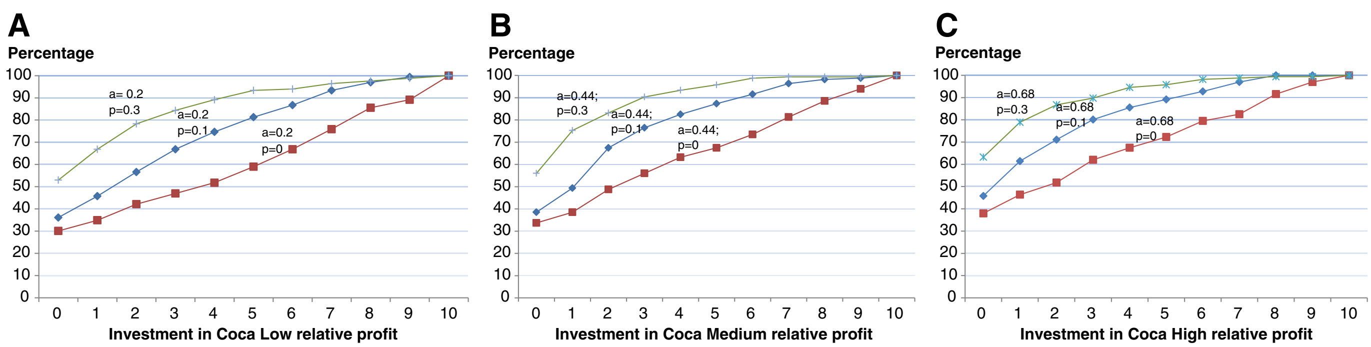

Fig. 1. Cumulative distribution of investments by treatment.

higher index of legitimacy and education than Type 1 producers. We also find that Type 4 producers have less experience with coca and are relatively wealthier than Type 1 producers. This result seems to support Bertolt Brecht view (1928): "*Food comes first, then morals*".

Each participant made nine decisions, hence a random effects probit model and a random effects generalized least squares (GLS) are estimated to analyze the decision to invest in coca and the amount to be invested conditional on a non-zero investment, respectively. Table 5 presents the estimation results for different models of the decision to invest in coca and investment levels conditional on positive investment. The first model only includes the policy variables manipulated in the experiment, i.e. relative profit, a, and probability of eradication, p. The second model adds the implied levels of moral cost and risk aversion. The last model includes in addition, other socioeconomic variables. The estimated marginal effects are calculated at 2005 policy levels ($a = 0.24$ and $p = 0.25$) and at mean values for other variables. As expected, both relative profit (profit from cattle/profit from coca) and expected cost of eradication reduce the likelihood to invest in coca and the amount invested conditional on non-zero investment. The implied morality and risk aversion parameters are also negatively and significantly correlated with the likelihood to invest in coca and the conditional investment. Beliefs about others' investment are positive and significantly correlated with each person's own decision to cultivate,[15] suggesting that coca cultivation is partly driven by social norms and cultural values.[16] Few socio-economic variables significantly affect coca investments. Yet, it is interesting to note that the index of legitimacy, which captures acceptance of statements about support to anti-drug policy and fairness of alternative development programs, is significant in reducing investments in coca. We also find a significant and negative effect in being an Atheist, but given the few observations, we do not want to overemphasize this result.

5. Policy implications

5.1. Willingness to accept to stop cultivating

Using the random utility framework proposed by McFadden (1974) and developed by Hanemman (1984), it is possible to estimate the willingness to accept monetary compensation in order to stop

[15] The correlation between own and others' behavior can be indicative of what in the public good literature is denoted as conditional cooperation (e.g., Fischbacher et al., 2001). Herding behavior is another plausible explanation as participants behave as they believe others will do. Olken (2009) finds that use of perceptions to forecast corruption can lead to misleading results.

[16] The effect of culture on corruption has been studied by Cameron et al. (2009) and Barr and Serra (2010).

Table 3
Distribution of heterogeneous producer types.

		Variable	Risk aversion (r_i)	
			Low	High
		Type	1	2
Moral cost (b_i)	Low	Percentage	0.38	0.16
		Moral cost (b_i)	0.016	0.059
		Risk aversion (r_j)	1.191	4.945
		% Non-zero coca investments	0.899	0.436
		Conditional investment in coca	4.522	2.412
		Type	3	4
	High	Percentage	0.19	0.27
		Moral cost (b_i)	0.019	0.962
		Risk aversion (r_j)	2.265	4.074
		% Non-zero coca investments	0.743	0.032
		Conditional investment in coca	4.144	2.154

cultivating coca-WTA. The indirect utility function for individual i can be written as $U_{ij} = U(y_j, C_i, Z, ei_j)$, where j is the state of the world (status quo is represented by $j = 0$ and the final state by $j = 1$), y represents expected income, C investment in coca, Z is a vector of other socioeconomic variables and e_{ij} is a component of preferences known by the individual but unknown by the researcher. The probability that an individual accepts the subsidy, s, and stops cultivating coca depends on:

$$\Pr ob(U_{i1}(y_i + s, 0, Z_i, e_{i1}) - U_{i0}(y_i, C_i, Z_i, e_{i1})) > 0 \tag{8}$$

Assuming a linear utility function where $U_{i1} = a_j Z_i + b y_i + e_{ij}$, the willingness to accept subsidy s and stop cultivating is given by $WTA \geq -\frac{aZ_i}{b} + \frac{e_{ij}}{b}$. Hence, WTA is a function of the individual socioeconomic and environmental characteristics, Z (e.g. moral cost of cultivating coca, coefficient of risk aversion and risk of eradication).

Fig. 2 presents the estimated willingness to accept that would make participants stop cultivating for different levels of risk of eradication. We present the average results for the four types of producers identified in our sample. As the risk of eradication increases, the willingness to accept compensations to stop cultivating decreases for Types 1, 2 and 3 producers. If the risk of eradication is 25% (as it was in 2005), Type 1 producers would require that the relative return of the legal activity, a, is at least 1.81 times the return from coca, while Types 2 and 3 producers would require a return of 1.41. In other words, it is extremely costly to draw out of coca about 55% of the population. On the other hand, Type 4 producers would not require any compensation to stop cultivating as the moral cost associated with this activity would be enough to deter them from doing it. If the relative return of the legal activity were 0.24 (as it was in 2005) Type 1 producers would require an eradication risk above 60% to stop cultivating, while Type 2 and 3 producers would require risk levels of 18% and 48% respectively. Type 4 Producers would not cultivate even if the risk was zero. Summing up, carrot and stick policies can be used to pull out from coca only a reduced group of producers. All the others either do not need any additional incentive or would require extremely high compensations.

5.2. Total elasticity

From a policy perspective, it is important to evaluate the effectiveness of alternative development (carrot) and eradication (stick) programs. The total elasticity of the investment in coca, ε_c to changes in policy levels, x, can be estimated as:

$$\varepsilon_{cx} = \left(\frac{\partial \text{Prob}[c_i > 1]}{\partial x} \frac{E[x]}{\text{Prob}[c_i = 1]} + \partial E\left[\frac{c_i | c_i > 0]}{\partial x} \frac{E[x]}{E[c_i]} \right) \tag{9}$$

Where c_i is the investment in coca cultivation for farmer I, x is a covariate or a policy and *Prob* is the probability of a non-zero investment in coca. Table 6 presents the decomposition of the total elasticity on the extensive margin (change in the probability of a non-zero investment) and the change in intensive margin (amount investment conditional on a non-zero investment) taking into account the distribution of producer types (weighted sum of elasticity by type k). We observe that farmers respond to carrot and stick policies mainly by reducing the conditional investment (intensive margin) rather than reducing the likelihood to cultivate coca (extensive margin). Yet, the supply of coca is inelastic to changes in carrots and sticks unless the risk of eradication is above 30%. Comparing the effectiveness of carrots and sticks, we find that alternative development is more effective than sticks when the risk of eradication is low and when the return of the alternative is relatively large. At a very low return of the alternative, or a high risk of eradication, sticks would be more effective. This result suggests that social planner should use different policy instruments in economically depressed areas compared to areas in which there are economic alternatives to coca. While in the first area sticks would be relatively more efficient, in the second area it would be preferable to increase economic incentives of legal products.

5.3. Optimal policy

As shown in Eq. (7), the optimal balance of carrots and sticks is achieved when the technical rate of substitution of carrots to sticks is equal to the relative factor price. Table 7 presents the technical rate of substitution for different combinations of carrots and sticks that would have resulted in coca investments similar to those predicted by the model at policy levels in 2005 ($a = 0.24$ and $p = 0.25$).

To estimate the cost ratio of carrots to sticks we consider that Ibanez (2007) estimated that the median profit per hectare with coca was 1064 USD, while the return from the legal activity was 250 USD, for a relative return of the alternative of 0.24. If the relative return of the alternative were increased by 1%, it would cost

Table 4
Comparison of producer types on observable characteristics.

Multinomial logit model	Types		
	2	3	4
Moral cost	Low	High	High
Risk aversion	High	Low	High
Atheist	−0.806	−1.229	0.171
	(1.196)	(1.287)	(0.901)
Protestant	0.499	0.813	0.947
	(0.828)	(0.790)	(0.696)
Years cultivating coca	−0.000623	0.0492	−0.146**
	(0.0505)	(0.0464)	(0.0602)
Index of legitimacy	0.0412	0.646*	−0.0383
	(0.319)	(0.331)	(0.282)
Age	0.0229	0.0307	0.0235
	(0.0207)	(0.0219)	(0.0177)
Female	−0.719	0.532	−0.333
	(0.607)	(0.532)	(0.493)
Education grade (none = 0, basic = 1, primary = 2,more = 3)	−0.000752	0.837***	−0.226
	(0.351)	(0.350)	(0.298)
Transport cost to the market	−0.0971	−0.163	−0.0120
	(0.145)	(0.140)	(0.0943)
Natural logarithm of hectares per capita	0.0521	0.0582	0.352*
	(0.236)	(0.215)	(0.198)
Constant	−1.553	−5.839**	−0.428
	(1.718)	(2.004)	(1.485)
Observations	145		
Pseudo R2	0.1097		

Table 5
Regression results on determinants of cultivating coca.

	Random effects probit model			Random effects linear model		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
	Marginal effects	Marginal effects	Marginal effects	Coef.	Coef.	Coef.
Relative profit cattle (a)	−0.580***	−0.146***	−0.161***	−1.986***	−1.597***	−1.650***
	(0.117)	(0.0346)	(0.0392)	(0.349)	(0.333)	(0.352)
Probability eradication (p)	−2.286***	−0.496***	−0.579***	−10.30***	−8.263***	−8.550***
	(0.202)	(0.0810)	(0.0926)	(0.592)	(0.612)	(0.653)
Implied moral cost (bi)		−0.480***	−0.514***		−2.037*	−1.169
		(0.0561)	(0.0661)		(1.071)	(1.546)
Implied risk aversion (rj)		−0.0603***	−0.0588***		−0.609***	−0.638***
		(0.00627)	(0.00729)		(0.0941)	(0.106)
Expected investments of others		0.0104***	0.00971***		0.0917***	0.0938***
		(0.00159)	(0.00166)		(0.00943)	(0.0102)
Atheist			−0.139***			−0.481
			(0.0521)			(0.563)
Protestant			−0.0611			−0.411
			(0.0386)			(0.468)
Years cultivating coca			−0.000911			0.00462
			(0.00238)			(0.0271)
Index of legitimacy			−0.0322**			−0.125
			(0.0162)			(0.163)
Age			−0.000346			−0.0138
			(0.00105)			(0.0116)
Female			0.0158			−0.0110
			(0.0282)			(0.300)
Education grade (none = 0, basic = 1, primary = 2,more = 3)			0.0162			−0.211
			(0.0170)			(0.181)
Transport cost to the market			−0.000609			−0.180**
			(0.00646)			(0.0703)
Natural logarithm of hectares per capita			−0.00518			−0.0255
			(0.0112)			(0.124)
N	1494	1494	1296	839	825	716
Log likelihood/R2	−534.7	−375.4	−308.3	0.157	0.347	0.400
Chi2	137.5	212.4	193.5	327.1	528.3	494.9
Rho	0.891	0.407	0.342	0.395	0.322	0.305
chi2	910.2	67.65	36.58			

Std error in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

10.9 USD per hectare ((0.24–0.25)*1,064 = 10.64). If 47% of the rural households – those who self-declared to be cultivating coca in 2005 – received the subsidy, the total cost of increasing the return of the legal activity would be 159,527 USD (15,164*10.64 = 159,527). On the other hand, Logan (2006) estimated that the cost of spraying one hectare was 626 USD, while AIDA (2006) estimates a cost of 1682 USD. If we use a conservative estimate and assume that in order to destroy one hectare four hectares need to be sprayed (Vargas, 1999),[17] we estimate that 358 additional hectares would have needed to be sprayed in order to increase the risk of eradication by one percent in 2005.[18] Hence, the cost of increasing the risk of eradication in one percent would be 224,433 USD (358,52*626 =224,433). The cost ratio of carrots to sticks would be 0.71 (159,527/224,433 = 0.71). Comparing this value with the estimated technical rate of substitution implies that the optimal anti-drug policy would be characterize by levels of carrots that are around 0.65 times the return of coca, and sticks or eradication risk close to 0.17. Table 8 presents the relative factor price under different scenarios that combine different values of the subsidy, amount of beneficiaries, cost of eradication and efficiency of eradication programs. For instance, if each beneficiary had received a subsidy of 5 hectares, the relative factor price would have been 3.46. This would imply that the optimal balance of carrots and sticks would be reached when a is between 0.3 and 0.35 and p is between 0.25 and 0.24, respectively.

We want to stress that the analysis that we have conducted here is only indicative. In particular, in our analysis we have made rather crude assumptions about the costs of these policies. For instance, we have ignored the cost of verifying that the beneficiaries of the subsidy do not cultivate coca. In other words we have assumed perfect and free monitoring. We have also made strong assumptions regarding the effectiveness of spraying to destroy coca areas, values that can differ depending on geographical conditions. In our analysis we have also ignored the environmental effects that eradication could have or the long-term effects of the subsidies. While we have shown that information about the distribution of types can bring efficiency gains, we acknowledge that more sophisticated policy designs that are incentive-compatible and follow the revelation principle could also be desirable.

5.4. External validity

Given the potential limitations of framed field experiments to capture individuals' preferences (Levitt and List, 2007), a natural question is how well the behavior in our experiment captures the behavior of

[17] Due to security reasons spraying is done from high altitude. As the herbicide does not hit the coca fields, it is likely that more than 4 hectares need to be sprayed to hit one coca plot.

[18] In 2005 there were 8963 hectares cultivated with coca. Assuming that four hectares need to be sprayed to destroy one hectare with coca implies that to increase the risk of eradication in one percent 358 hectares would have needed to be sprayed (8963*4*0.01 = 358). We assume that social planner know where the coca is located and that there is a fixed cost of discovering coca fields.

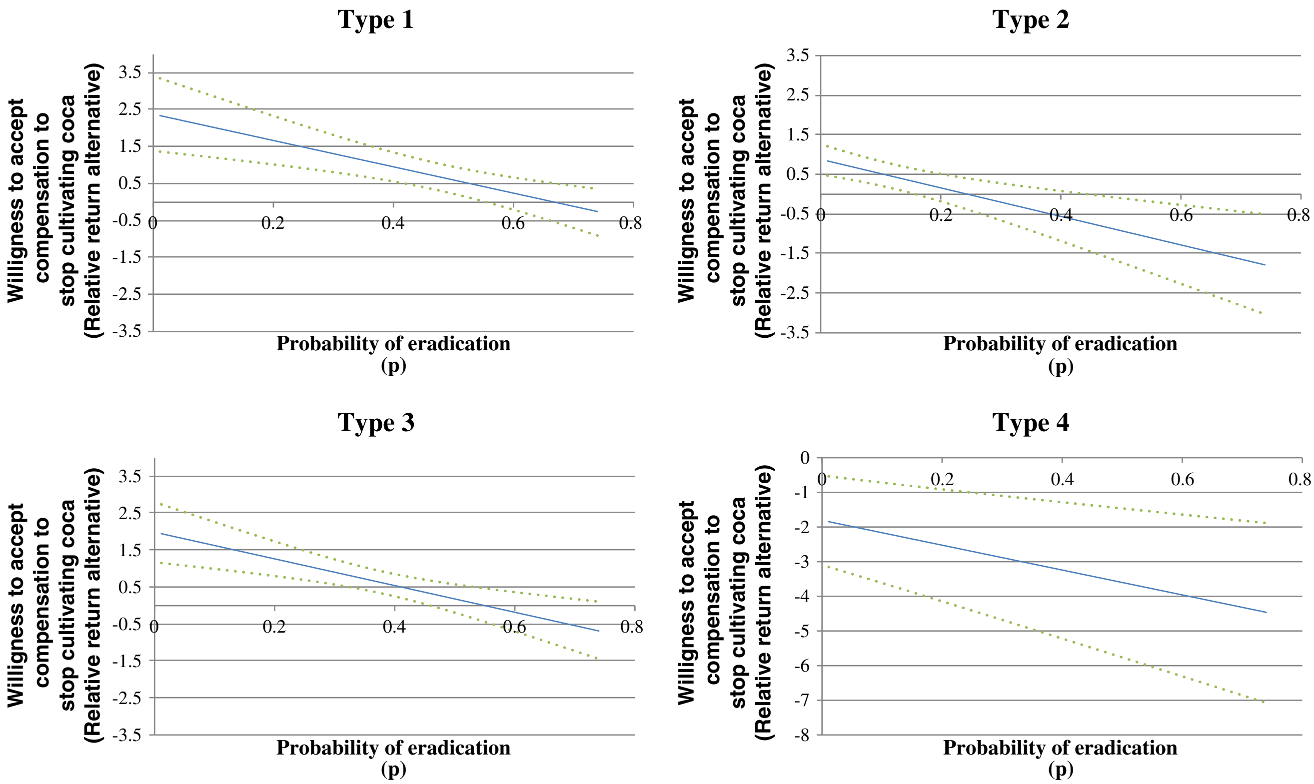

Fig. 2. Relative return necessary to induce participants to stop cultivating coca at different levels of risk of eradication. The vertical axis represents the relative return that would be necessary to make producers willing to stop cultivating coca. Horizontal-axis represents the level of risk of eradication. Green lines represent confidence intervals. A negative willingness to accept imply no compensation.

Table 6
Estimated weighted elasticities.

Elasticity with respect to	Treatment A			Treatment D			Treatment G		
	a = 0.2			a = 0.2			a = 0.2		
	p = 0			p = 0.1			p = 0.3		
	Extensive margin	*Intensive margin*	*Total elasticity*	*Extensive margin*	*Intensive margin*	*Total elasticity*	*Extensive margin*	*Intensive margin*	*Total elasticity*
Relative profit alternative	−0.042	−0.075	−0.117	−0.067	−0.094	−0.161	−0.147	−0.292	−0.439
s.e	(0.001)	(0.000)	(0.003)	(0.000)	(0.007)	(0.012)	(0.000)	(5.756)	(0.345)
Probability of eradication	0.00	0.00	0.00	−0.12	−0.24	−0.36	−0.79	−2.27	−3.07
s.e	(0.00)	(0.00)	(0.00)	(0.00)	(0.02)	(0.02)	(0.00)	(44.76)	(0.96)
	Treatment B			Treatment E			Treatment H		
	a = 0.44			a = 0.44			a = 0.44		
	p = 0			p = 0.1			p = 0.3		
	Extensive margin	*Intensive margin*	*Total elasticity*	*Extensive margin*	*Intensive margin*	*Total elasticity*	*Extensive margin*	*Intensive margin*	*Total elasticity*
Relative profit alternative	−0.128	−0.185	−0.313	−0.197	−0.254	−0.451	−0.403	−0.948	−1.351
s.e	(0.000)	(0.001)	(0.004)	(0.001)	(0.005)	(0.011)	(0.001)	(24.551)	(0.712)
Probability of eradication	0.00	−0.002	−0.003	−0.16	−0.300	−0.461	−0.99	−3.350	−4.337
s.e	(0.000)	(0.000)	(0.000)	(0.000)	(0.006)	(0.011)	(0.002)	(86.765)	(1.338)
	Treatment C			Treatment F			Treatment I		
	a = 0.68			a = 0.68			a = 0.68		
	p = 0			p = 0.1			p = 0.3		
	Extensive margin	*Intensive margin*	*Total elasticity*	*Extensive margin*	*Intensive margin*	*Total elasticity*	*Extensive margin*	*Intensive margin*	*Total elasticity*
Relative profit alternative	−0.266	−0.332	−0.598	−0.395	−0.442	−0.837	−0.758	−1.995	−2.753
s.e	(0.001)	(0.008)	(0.0139	(0.001)	(0.025)	(0.023)	(0.003)	(28.555)	(0.768)
Probability of eradication	0.00	−0.003	−0.004	−0.21	−0.337	−0.546	−1.20	−4.561	−5.764
s.e	(0.000)	(0.000)	(0.001)	(0.000)	(0.019)	(0.020)	(0.003)	(65.294)	(1.161)

Table 7
Technical rate of substitution carrots to sticks.

Relative return alternative	Probability eradication	Predicted investment	Technical rate of substitution
a	p		TRS
0.05	0.3	1.84	28.01
0.1	0.29	1.84	13.41
0.15	0.28	1.83	8.81
0.2	0.27	1.83	6.32
0.25	0.26	1.82	4.87
0.3	0.25	1.82	3.87
0.35	0.24	1.81	3.17
0.4	0.23	1.81	2.65
0.45	0.22	1.87	2.24
0.5	0.21	1.86	2.09
0.55	0.19	1.86	1.75
0.6	0.18	1.85	0.76
0.65	0.17	1.85	0.73

the participants in their everyday life. An alternative to validate the experimental data is to test the predictive power of the estimated models. Table 9 presents the self-reported and the predicted proportional changes in non-zero investments and in the amount investment in coca from 2003 to 2005. We present the results separately for Models 2 and 3 in Table 4. In the predictions, we take into account that the median relative profit of the alternative was 0.1 in 2003 and 0.24 in 2005 and that the probability of eradication was 10 and 25 percent in 2003 and 2005, respectively. All other parameters are evaluated at their mean values. We find that Model 2 overestimates the changes in coca cultivation that result from a tougher policy. Both the likelihood to invest and the conditional investment are significantly different from the observed changes. Controlling for other socioeconomic characteristics, the predictions of Model 3 do not differ significantly from the observed changes on the likelihood to invest in coca. Yet, we find that the model overestimates the effect of conditional investment. This result suggest that subjects bring their experiences and norms to the lab and hence point out the importance of using experienced subjects.

6. Discussion and conclusions

Though the results of the experiment are indicative of how producers react to different policies, further validation is needed and similar studies have to be undertaken in other regions to gather more information to design more cost efficient policies. In terms of policy recommendations, our results indicate that in order to increase the efficiency of anti-drug policies, social planner should consider the large heterogeneity in producer types. While a first approximation would be to include information of the distribution of types, as the example here provided, further research is needed on the design of an incentive structure that allows the revelation of a producer's true type. Our study suggests the need to develop alternative policy instruments in the war on drugs. Given the important role that moral costs play on deterring coca cultivation, campaigns that increase the awareness on the negative effects of coca could be a promising policy alternative. This strategy is particularly important given the extremely high cost of carrots and stick policies.

Acknowledgements

We would like to thank Ali Ahmed, Juan Camilo Cardenas, Fredrik Carlsson, Stephan Klasen, Martin Kocher, Katarina Nordblom, Ashok Rai, Gerhard Riener, Matthias Sutter, co-editor James Andreoni, the two anonymous referees, the participants at the ESA meeting 2006 in Nottingham, the ESA meeting in Tucson 2006, the First Nordic Conference on Behavioral Economics in Oslo, as well as the seminar participants at Universidad de los Andes and University of Gothenburg for their comments. We are very thankful for the hospitality and help from people at Universidad de los Andes, especially Juan Camilo Cardenas, during our fieldwork. Financial support from the Swedish Agency for International Development Cooperation (Sida) to the Environmental Economics Unit at the University of Gothenburg and from the Swedish Research Council (Vetenskapsrådet) is gratefully acknowledged.

Table 8
Relative factor price under different scenarios.

Scenario	Estimations							Assumptions			
	Subsidy	Beneficiaries	Cost carrots	Cost eradication	Add ha sprayed	Cost sticks	Relative price	Hectares with subsidy	% Beneficiaries rural population	Cost spraying per hectare	Hectares sprayed to destroy one cultivated
	s	N	M = s*N	E	Y	T = E*Y	M/T				
1	10.52	15,164	159,527	626	358	224,108	0.71	1	47%	626	4
2	10.52	75,821	797,633	626	358	224,108	3.56	5	47%	626	4
3	21.04	22,585	475,186	626	358	224,108	2.12	1	70%	626	4
4	21.04	112,924	2,375,928	626	358	224,108	10.60	5	70%	626	4
5	10.52	75,821	797,633	1252	358	448,216	1.78	5	47%	1252	4
6	10.52	75,821	797,633	313	358	112,054	7.12	5	47%	313	4
7	10.52	75,821	797,633	626	538	336,788	2.37	5	47%	626	6
8	10.52	75,821	797,633	626	179	112,054	7.12	5	47%	626	2

Table 9
External validity.

Proportional change between 2003 and 2005	Average survey (Std. err.)	Model 2 predicted (Std. err.)	Ho:A = B *t*-test (P-value)	Model 3 predicted (Std. err.)	Ho: A = C *t*-test (P-value)
	A	B		C	
Likelihood to invest in coca	−0.376 (0.074)	−0.518 (0.045)	2.035*** (0.043)	−0.459 (0.057)	1.066 (0.287)
Investment in coca conditional on a non-zero investment	−0.238 (0.045)	−0.439 (0.021)	−3.476*** (0.001)	−0.442 (0.059)	−2.626*** (0.009)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Appendix A

Taking the partial derivative of Eq. (2) with respect to c_i and b_i and solving for $\frac{dc_i}{db_i}$, we obtain:

$$\frac{dci}{dbi} = \frac{1}{J}\left\{\left((1-p)U''\left(Y_g\right)Y_g{}' + pU''(Y_b)Y_b{}'\right)(N-1)Xc_i^2 + \left((1-p)U'\left(Y_g\right) + pU'(Y_b)\right)2(N-1)Xc_i\right\}$$

Where $J = \frac{d^2EU}{dc_i^2} < 0$; $Y_g' = 1 - a - X - 2(N - 1)c_ib_i > 0$ and $Y_b' = 1 - a - X - 2(N - 1)c_ib_i < 0$. Dividing and multiplying the first term in the expression by $-U'(Y)$, we obtain:

$$\frac{dci}{dbi} = \frac{1}{J}\left\{-\left((1-p)R\left(Y_g\right)U'\left(Y_g\right)Y_g{}' + pR(Y_b)U'(Y_b)Y_b{}'\right)(N-1)Xc_i^2 + \left((1-p)U'\left(Y_g\right) + pU'(Y_b)\right)2(N-1)Xc_i\right\}$$

Where $R(Y) = -U''(Y)/U'(Y)$.

However, first order condition for an interior solution implies that in the optimum the following equivalence holds: $(1-p)U'(Y_g)Y'_g = -pU'(Y_b)Y'_b$. Hence, the above expression simplifies to:

$$\frac{dci}{dbi} = \frac{1}{J}\left\{\left(R(Y_b) - R\left(Y_g\right)\right)\left((1-p)U'\left(Y_g\right)Y_g{}'\right)(N-1)Xc_i^2 + \left((1-p)U'\left(Y_g\right) + pU'(Y_b)\right)2(N-1)Xc_i\right\}$$

When individuals have risk preferences that are consistent with decreasing absolute risk aversion – DARA – or increasing absolute risk preference – IARP –, $R(Y_b) - R(Y_g) > 0$, so $\frac{dci}{dbi} < 0$.

Partial equilibrium analysis on dc_i/dp and dc_i/da is exactly the same as in Ehrlich (1973).

References

AIDA (Asociación Interamericana para la Defensa del Ambiente), 2006. Estrategias de desarrollo alternativo en Colombia: La necesidad de acciones más allá de las fumigaciones a cultivos ilícitos, mimeo.

Alm, J., Jackson, B.R., McKee, M., 1992a. Estimating the determinants of tax payer compliance with experimental data. National Tax Journal 45, 107–114.

Alm, J., McClelland, G.H., Schulze, W.D., 1992b. Why do people pay taxes? Journal of Public Economics 48, 21–38.

Alm, J., Jackson, B.R., McKee, M., 2009. Getting the word out: enforcement information dissemination and compliance behavior. Journal of Public Economics 93, 392–402.

Alvarez, S., Rettberg, A., 2008. Cuantificando los efectos económicos del conflicto. Colombia Internacional 67, 192.

Anderson, L.R., Stafford, S., 2003. Punishment in a regulatory setting: experimental evidence from VCM. Journal of Regulatory Economics 24, 91–110.

Andreoni, J., Erard, B., Feinstein, J., 1998. Tax compliance. Journal of Economic Literature 36, 818–860.

Andreoni, J., Harbaugh, W., Vesterlund, L., 2003. The carrot or the stick: rewards, punishments, and cooperation. American Economic Review 93, 893–902.

Angrist, J.D., Kugler, A.D., 2008. Rural windfall or a new resource curse? Coca, income, and civil conflict in Colombia. The Review of Economics and Statistics 90, 191–215.

Barr, A., Serra, D., 2010. Corruption and culture: an experimental analysis. Journal of Public Economics 94, 862–869.

Bernasconi, M., 1998. Tax evasion and orders of risk aversion. Journal of Public Economics 67, 123–134.

Brecht, B., 1928. The Threepenny Opera - Die Dreigroschenoper, Universal edition. (German).

Cameron, L., Chaudhurib, A., Erkala, N., Gangadharan, L., 2009. Propensities to engage in and punish corrupt behavior: experimental evidence from Australia, India, Indonesia and Singapore. Journal of Public Economics 93, 843–851.

Cardenas, J.C., Stranlund, J., Willis, C., 2000. Local environmental control and institutional crowding-out. World Development 28, 1719–1733.

Carvajal, M.P., 2002. Factores explicativos de la presencia de cultivos ilícitos en los municipios de Colombia. (Dissertation) Universidad de los Andes, Bogota.

Cohen, M.A., 1999. Monitoring and Enforcement of Environmental Policy. In: Tietenberg, T., Folmer, H. (Eds.), International Yearbook of Environmental and Resource Economics. Edward Elgar Publishing, Cheltenham.

De Franco, M., Godoy, R., 1992. The economic consequences of cocaine production in Bolivia: historical, local, and macro perspectives. Journal of Latin American Studies 24, 375–406.

Díaz, A.M., Sánchez, F., 2004. Geography of Illicit Crops and Armed conflict in Colombia Document. CEDE 2004-18.Universidad de los Andes, Bogota.

DNE, 2006. Observatorio de Drogas de Colombia 1999–2005. Dirección Nacional de Estupefacientes. Subdirección estratégica y de investigaciones, Bogota.

Ehrlich, I., 1973. Participation in illegitimate activities: a theoretical and empirical investigation. Journal of Political Economy 81, 521–565.

Eisenhauer, J.G., 2004. Economic models of sin and remorse: some simple analytics. Review of Social Economy 62, 201–219.

Eisenhauer, J.G., 2006. The shadow price of morality. Eastern Economic Journal 32, 437.

Eisenhauer, J.G., 2008. Ethical preferences, risk aversion, and taxpayer behavior. Journal of Socio-Economics 37, 45–63.

Eisenhauer, J.G., Geide-Stevenson, D., Ferro, D.L., 2011. Experimental estimates of taxpayer ethics. Review of Social Economy 69, 29–53.

Erard, B., Feinstein, J.S., 1994. The Role of Moral Sentiments and Audit Perceptions in Tax Compliance. Carleton Industrial Organization Research Unit.

Etzioni, A., 1990. The Moral Dimension: Toward a New Economics. Free Press.

Fehr, E., Gächter, S., 2000. Cooperation and punishment in public good experiments. American Economic Review 90, 980–994.

Fellner, G., Sausgruber, R., Traxler, C., 2013. Testing enforcement strategies in the field: threat, moral appeal and social information. Journal of the European Economic Association (forthcoming).

Fischbacher, U., Gächter, S., Fehr, E., 2001. Are people conditional cooperative? Evidence from a public goods experiment. Economics Letters 71, 397–404.

Fortin, B., Lacroix, G., Villeval, M.C., 2007. Tax evasion and social interactions: an experimental approach. Journal of Public Economics 91, 2089–2112.

Friedland, N., Maital, S., Rutenberg, A., 1978. A simulation study of income tax evasion. Journal of Public Economics 10, 107–116.

GAO, 2008. Plan Colombia. US Government Accountability Office (Report. GAO-09-71).

Hanemann, W.M., 1984. Welfare evaluations in contingent valuation experiments with discrete responses. American Journal of Agricultural Economics 66, 332–341.

Ibanez, M., 2007. Who crops coca and why. In: Ibanez, M. (Ed.), Social dilemmas; The role of incentives, norms and institutions. : Economic Studies, 166. Göteborg University.

Ibanez, M., Carlsson, F., 2010. A survey based experiment on coca cultivation. Journal of Development Economics 93, 249–263.

Levitt, S.D., List, J.A., 2007. What do laboratory experiments measuring social preferences reveal about the real world? Journal of Economic Perspectives 21, 153–174.

Logan, S., 2006. Hydras, Balloons wasted Money in los Andes. ISN Security Watch in Buenos Aires.

McFadden, D., 1974. The measurement of urban travel demand. Journal of Public Economics 3, 303–328.

Mejía, D., Restrepo, P., 2008. The war on illegal drug production and trafficking: an evaluation of Plan Colombia. Documentos CEDE, 19. Universidad de los Andes, Bogotá (October 2008).

Moreno-Sanchez, R., Kraybill, D.S., Thompson, S.R., 2003. An econometric analysis of coca eradication policy in Colombia. World Development 31, 375–383.

Moya, A., 2005. Impacto de la erradicación forzosa y el desarrollo alternativo sobre los cultivos de coca. (Dissertation paper) Universidad de los Andes, Bogota.

Olken, B., 2009. Corruption perceptions vs. corruption reality. Journal of Public Economics 93, 950–964.

ONDCP, 2006. The economic cost of drug abuse in the USA 1992–2002. Office of National Drug Control Policy, Washington, United States of America.

Ostrom, E., Walker, J., Gardner, R., 1992. Covenants with and without a sword: self-governance is possible. The American Political Science Review 86, 404–417.

Sefton, M., Shupp, R., Walter, J., 2007. The effect of rewards and sanctions in the provision of public goods. Economic Inquiry 45, 671–690.

Sen, A.K., 1977. Rational fools: a critique of the behavioral foundations of economic theory. Philosophy and Public Affairs 6, 317–344.

Sutter, M., Haigner, S., Kocher, M., 2010. Choosing the stick of the carrot? Endogenous institutional choice in social dilemma situations. Review of Economic Studies 77, 1540–1566.

Tabares, E., Rosales, R., 2004. Políticas de control de oferta de coca: La zanahoria y el garrote. Documento CEDE 2005-10.Universidad de los Andes, Bogota.

Trivedi, V.U., Shehata, M., Lynn, B., 2003. Impact of personal and situational factors on taxpayer compliance: an experimental analysis. Journal of Business Ethics 47, 175–197.

Trivedi, V.U., Shehata, M., Mestelman, S., 2005. Attitudes, incentives and tax compliance. Canadian Tax Journal 53, 29–61.

Trujillo, Babel, 1998. Los costos económicos de la criminalidad y la violencia en Colombia: 1991–1996. Archivos de macroeconomía.Departamento Nacional de Planeación, Bogotá.

UNODC, 2009. World Drug Report. United Nations Office on Drugs and Crime, Vienna.

Vanberg, V., 1988. Morality and economics: De moribus est disputandum. Bowling Green State University. Social Philosophy and Policy Center. Transaction Books, New Brunswick.

Vargas, R., 1999. Fumigación y conflicto. Política antidroga y la deslegitimación del Estado colombiano. TM Editores.