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A choice experiment on coca cropping

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Abstract
Between 1997 and 2005, 5.2 billion USD were invested to reduce cocaine production in Colombia, the world's main cocaine producer. However, little is known about the effectiveness of policies targeting coca cultivation, this paper evaluates the effects of the two main policies: eradication and alternative development. We measure the responsiveness of farmers to eradication and alternative development programs using a survey based experiment. Our results support Becker's (1968) model of crime participation and in addition shed light on other non-monetary factors that affect the coca cultivation decision. Social norms, legitimacy, and poverty are found to be affecting coca cultivation. We find that the responses are to a large extent consistent, and the model prediction of the proportion of farmer growing coca is accurate. We also illustrate how the results can be used to draw policy conclusions, but conclude that better information about the costs is needed.

Keywords: Illegal drugs, Choice experiment, Colombia.

JEL classification: G11, K42, Z12, Z13

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1. Introduction

Following three international conventions on narcotic drugs (UN, 1961, 1971, 1988), Colombia, the largest producer of *cocaine*, started an aggressive campaign against production, transformation and trafficking of drugs in the 1980s. As a result the two main Colombian drug cartels were dismantled, but the areas planted with *coca* started to grow. In the early 1990's, less than 10% of the planted areas with coca in the world were in Colombia; by 2000 that proportion had increased to 74% (UNDCP, 2006). To control the increasing cultivation of *coca* the government implemented two policies: Eradication or destruction of *coca* plants and alternative development or provision of economic support for legal crops. An astonishing 5.2 billion USD (the equivalent of 1% of the Colombian GDP) was spent to control *cocaine* supply in Colombia between 1997 and 2005, but surprisingly little is known about the effectiveness of these anti-drug policies (ONDCP, 2006). This paper contributes to the limited literature that evaluates the effectiveness of eradication and alternative development to control coca cultivation.

Previous empirical studies have tried to evaluate the effectiveness of eradication and alternative development (e.g., Carvajal, 2000; Moreno *et al.*, 2002; Tabares and Rosales, 2005), but face many problems. First, aggregated information does not allow identification of behavioral factors affecting the decision to get involved in illegal activity. Second, policy levels based on historical and regional information are endogenous, and third, the use of matching estimators does not allow evaluating the effects of different policy levels (e.g., Díaz and Sánchez, 2004; Moya, 2005). More generally, the use of revealed preference data limits the analysis to the effects of the policy levels that have actually been implemented, while it is hard to predict the effects of significantly different policy levels.[1] An alternative approach to deal with the above problems is to use survey-based experiments where coca farmers indicate how they would behave under various anti-drug policies. This type of stated preference method has commonly been applied to areas such as environmental economics, health economics, and tax compliance; see for example Alpizar *et al.* (2003), Louviere *et al.* (2000), and Trivedi *et al.* (2005).

The objective of this paper is to study the effectiveness of eradication and alternative development to reduce *coca* cultivation and to study the effect of other monetary and non-

[1] Others (e.g., Kennedy *et al.*, 1993; Riley, 1991) have used an economic model of cocaine production and consumption to simulate the effects of increases in eradication and alternative development, but the measure of effectiveness has then been assumed rather than measured.

monetary factors on the decision to cultivate *coca*. We use unique household level data on Colombian farmers from a hypothetical choice experiment on coca cultivation where respondents state how many hectares they would dedicate to coca at different levels of the relative profitability of the best alternative and of the probabilities of having the plants eradicated. Since the policy levels are varied, we can identify the separate effects of each policy after controlling for other factors affecting coca cultivation. In particular, following the behavioral model of crime we consider the effect of (1) social norms (e.g., Glaeser *et al.*, 1996; Frey, 1997; Elster, 1998; Garoupa, 2003; Calvó-Armengol and Zenou, 2004), (2) morality (e.g., Hausman and McPherson, 1993; Sutignen and Kuperan, 1999; Eiseihauer, 2004), and (3) legitimacy (e.g., Tyler, 1990; Feld and Tyran, 2002; Feld and Frey, 2005). Our sample consists of both coca and non-coca farmers living in Putumayo, one of the regions with a long tradition of coca cultivation in Colombia. Obviously, there are a number of problems in applying a survey-based questionnaire to something as sensitive as coca farming. Nonetheless, we believe that the approach can serve as a good complement to studies using actual behavior.

The rest of the paper is organized as follows. Section 2 presents a simple model on coca cultivation, Section 3 the survey design and Section 4 the econometric model. Section 5 reports the results and Section 6 concludes the paper.

2. A Simple Model of Coca Cropping

The decision to cultivate coca can be analyzed in the framework of traditional models of crime (e.g., Becker, 1968; Allingham and Sandmo, 1972; Ehrlich, 1973). Farmers decide how to allocate their land between coca and an alternative crop. Though coca is more profitable than the alternative, it is also more risky. Coca cultivation is illegal, and authorities may discover and destroy the plants with a probability p. If coca plants are discovered and destroyed, farmers lose their investments and the land is incapacitated, preventing production in the next period.[2] This loss is represented by F. Farmers cultivate coca if it pays-off or if the expected marginal benefit is greater than the expected marginal cost. The amount of land cultivated with coca depends not only on expected costs and benefits but also on a farmer's risk preferences.

[2] In Colombia, the law also dictates imprisonment although this policy is seldom used.

Empirical evidence largely supports the predictions of the traditional models of crime (Cameron, 1988; Freeman, 1999; Eide *et al.*, 2006), however, these models fail to explain why people self-report taxable income correctly, pay TV licenses, or abstain from breaking the law even though the expected cost of being detected is very low (Andreoni *et al.*, 1998; Cohen, 1999; Frey and Torgler, 2004). To explain the departure from self-interested behavior in the rational choice models, the behavioral models of crime consider other non-monetary factors affecting participation in illegal activity. For example, Elster (1989), Posner (1997), and Bowles and Gintis. (1998) propose that in addition to monetary incentives, social norms promote social order. Reputation, stigma, shame, and eventually ostracism serve to sustain the social norms and combat antisocial behavior. On the other hand, Frey (1997), Sutinen and Kuperan (1999), and Torgler (2002), among others, suggest that morality or the intrinsic motivation to do the "right thing" explains why people comply with regulations. A third type of explanation of high compliance levels suggests that compliance with the law depends not only on the internal sense of right or wrong, but also on legitimacy or acceptance of the law and support of the authorities (e.g., Tyler, 1990; Feld and Tyran, 2002; Feld and Frey, 2005). People's compliance increases when they perceive the authorities and the law to be fair, and when they participate in deciding the law.

In summary, the supply of coca, *C*, is a function of monetary factors as: relative profit of the alternative vs. coca cultivation, $\frac{\Pi^{Alternative}}{\Pi^{Coca}}$, the risk of having the plants destroyed, p, and the lost if plants are destroyed, F. Other non-monetary factors are also important in the supply function of coca: social norms, *S*, morality, *M*, and legitimacy or acceptance of the authorities, *L*.

$$C = f\left(\frac{\Pi^{Alternative}}{\Pi^{Coca}}, p, F, S, M, L\right) \tag{1}$$

.

3. The Survey

We used a survey based experiment to measure the responsiveness of farmers to changes in relative profit of an alternative crop and changes in the probability of eradication. The survey included a number of questions regarding individual socioeconomic characteristics, land holdings, profitability of coca and the best alternative and a risk experiment. In addition, to capture the effect of non-monetary factors, the survey included the Moral Judgment Test

(Lind *et al.*, 1985), attitudinal questions on coca production and anti-drug policies and perceptions of coca cultivation. We carefully informed the participants of the academic nature of the study, ensured anonymity, and that all data from the study was confidential and would be revealed only to the research team.

The choice experiment

In the choice experiment, we asked the respondents to state how many hectares they would dedicate to coca at various levels of two attributes: the relative profitability of the best alternative crop and the risk of eradication. The respondents were first reminded of their answers to the questions about how much coca they crop today, the profitability of coca and the best alternative, and their perceived risk of having coca crops destroyed. Figure 1 outlines the scenario.

Figure 1. Scenario of the choice experiment.

In the next section, I would like to ask what you would do if the profitability of the best alternative to coca were different and if the risk of having the crops destroyed changed. I would like you to think what you would have done if the situation were different. In this type of study, people tend to answer in the way they think the researcher wants rather than what they would really do. Please consider carefully what you would do if you had to make these decisions. There are no wrong or right answers; it is all a matter of your own preferences. Take into consideration that others would probably do the same as you.
You said that last year you had ___ ha with coca and that the profit from 1 ha coca was ___ while the profit from the best alternative was ___. In addition, you said that the risk of having your crops completely destroyed by authorities was ___. Assuming that everything else is the same as last year, how many hectares would you plant with coca if the profit from 1 ha of coca were the same as today, but the profit of the best alternative were ___ and the risk of having the crops destroyed were ___

This open-ended question allowed for zero coca cultivation or cultivation of more hectares than actual land holdings, reflecting the fact that the land market is competitive. When the profit from coca cultivation is good, farmers rent, buy or use open access land to establish coca crops. Each participant answered at most the nine choice sets described in Table 1. There were three possible levels of profitability for the alternatives: same as today, higher than today, and lower than today; and three levels of risk of eradication: higher than today, lower than today, and zero. The levels were presented in absolute terms as described below.

[Insert Table 1]

Attribute levels were customized based on the current situation of the farmer in order to make the choice situation more realistic and familiar for the respondents. The profit of the best alternative was customized according to the conversion rates presented in Table 2. The rates depended on the profitability of the best alternative relative to the profitability of coca in 2005. For example, if the profit per ha for coca was 1 million Colombian pesos and the profit per ha for the best alternative was 200,000 pesos, then the profit for coca was 5 times the profit from the alternative. Consequently, for a higher profit of the alternative (lower ratio than today) the conversion ratio was 2.5. This means that the profit of the best alternative crop was 1 million pesos divided by 2.5, or 400,000 pesos. For a lower profit of the best alternative (higher ratio than today), the ratio was 10, making the profit of the best alternative 100,000 pesos. Hence, the respondent was presented a profit of the alternative of 100,000 pesos in the choice sets with lower profitability than today and a profit of 400,000 pesos in the choice sets with higher profitability than today.

[Insert Table 2]

The perceived risk of having the crops destroyed by authorities was measured on a 1-to-5 scale ranging from very unlikely to very likely. The levels used in the choice experiment were based on the perceived risk levels in 2005; see Table 3. In the choice situations, a lower risk than today means that the risk attribute was one unit less than the perceived risk in 2005, while a higher risk than today means that the risk attribute was one unit more than the perceived risk in 2005. In the case of zero risk, the wording "No risk at all to have the crops destroyed" was used. If a respondent perceived it was very unlikely to have the crops destroyed by authorities, then we used the same risk level in the choice sets with lower risk. This means that choice set number 5 was not taken into consideration in the analysis. Similarly, if a respondent perceived having the crops destroyed by authorities as very likely, then the risk attribute remained the same in the choice sets with higher risk. This means that choice set number 1 was not taken into consideration in the analysis.

[Insert Table 3]

Non-monetary factors and socioeconomic characteristics

Following the behavioral models of crime, non-monetary factors are expected to affect the coca cultivation decision. We therefore included a number of questions on social norms, ethics/morality, and on the sense of obligation to comply with the law. To capture the effect of individual socioeconomic characteristics, we also included questions on financial risk preferences and socioeconomic characteristics.

Social norms

To capture the effect of social norms or the effect of group behavior on individual behavior, we used the average density of coca in the municipality during 2002-2003 (note that this is a lagged variable). The density measure reflects the number of hectares with coca per square kilometer of total land area. We used the degree of trust in others and participation in communitarian organizations to capture the fact that the effect of peer behavior can depend on how important peers are to a person (Akerlof, 1997).

Ethics/morality

We used the Moral Judgment Test proposed by Lind *et al.* (1985) to capture preferences for moral arguments also called levels of moral development. The test consists of two social dilemmas. The individual has to state his/her degree of agreement with a series of arguments that justify or oppose the actions taken in the dilemma. According to the level of reasoning used to justify moral dilemmas and following the theory of moral development, individuals can be classified into three levels of moral development (Kohlberg, 1969). At the lowest level of moral development, pre-conventionalists base their arguments on individualistic reasons (rewards and punishment). At the second level, conventionalists base their moral arguments on social reasons (social norms or maintaining social order) and in the last level of moral development, post-conventionalists motivate their arguments in terms of higher reasons (human rights and justice). In addition to level of moral development, we use religiosity to capture morality. Colombia is a mainly Catholic country, but in recent years there has been a rapid expansion of Protestantism, which has renewed religious enthusiasm. Given the dynamics of these new churches, we want to investigate how they have affected coca cultivation.

Sense of obligation to comply with the law

To capture the effect of legitimacy (acceptance of the authorities and the law) on the decision to cultivate coca, we used a measure of conformity with the law. This measure captures the degree of acceptance of a series of statements relative to the existence of the law, fairness of the authorities, participation in defining rules, and effectiveness of rules.

Financial risk preferences

To capture financial risk preferences likely to affect the decision to cultivate coca and the amount of coca that is cultivated, we used a simple risk experiment that follows Binswanger's (1980) design. Table 4 presents the design used in the risk experiment. Participants in the survey were asked to state whether they prefer to crop Option A or Option B, which are equivalent in terms of investment and required effort, but differ in profits. The second column in Table 4 describes Option A, which always gives a profit of 1 million pesos (equivalent to 400 USD), whereas Option B yields equal chances between a higher or a lower profit. Each participant answered the five choice sets presented in Table 4. The first choice set where a participant switched from Option B to Option A allows us to calculate a coefficient of risk aversion if we assume the following functional form of the utility function:

$$U(X) = \frac{X^{1-\rho}}{1-\rho} \quad , \tag{2}$$

where ρ represents the coefficient of relative risk aversion and X the certainty equivalent of the prospect.

[Insert Table 4]

4. Econometric Model

The decision to cultivate coca can be seen as a two-step procedure where farmers first decide whether to cultivate coca or not, and then given that coca is cultivated decide on the number

of hectares to cultivate. We will treat these two decisions as separate decisions.[3] The expected indirect utility of coca cultivation for individual *i* in choice situation *t* is given by:

$$V_{it} = \alpha_1 PDetection_t + \alpha_2 \frac{\Pi_{it}^{Alternative}}{\Pi_i^{Coca}} + \beta' z_i + \varepsilon_{it} \quad (3)$$

The first two variables are the attributes that we are interested in evaluating in the choice experiment: the risk of detection ($PDetection_{it}$) and the relative profitability of the alternative versus coca ($\frac{\Pi_{it}^{Alternative}}{\Pi_i^{Coca}}$). z_i is a vector of individual characteristics including social norms, morality, and legitimacy and risk preferences. Finally, ε_{it} is the stochastic part of the utility. The probability that respondent *i* in choice situation *t* states that he/she would crop coca is:

$$P(Crop) = P(\varepsilon_{it} > -\alpha_1 PDetection_t - \alpha_2 \frac{\Pi_{it}^{Alternative}}{\Pi_i^{Coca}} - \beta' z_i). \quad (4)$$

Since a respondent answers several choice sets, an assumption of independence among responses is questionable since it is likely that the responses are correlated. Following Butler and Moffitt (1982), we therefore specify the error term as:

$$\varepsilon_{it} = u_i + v_{it}; \; u_i \sim N(0, \sigma_u^2); \; v_{it} \sim N(0, \sigma_v^2), \quad (5)$$

where u_i denotes the unobservable individual specific effect and v_{it} denotes the remainder disturbance. The components of the error term are thus independently distributed and we have that the correlation between the errors is:

$$Corr[\varepsilon_{it}, \varepsilon_{is}] = \rho = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2}. \quad (6)$$

This is a random effects binary probit model. Similarly, the number of hectares (Ha Coca) that individual *i* decides to cultivate with coca in choice situation *t* depends on the attribute levels, a vector of socio-economic characteristics, and unobserved heterogeneity, ω_{it}. The conditional number of hectares cultivated with coca in choice situation *t* is:

$$Ha\,coca_{it} = \gamma_1 PDetection_t + \gamma_2 \frac{\Pi_{it}^{Alternative}}{\Pi_i^{Coca}} + \delta' z_i + \omega_{it}. \quad (7)$$

[3] We tried to estimate them with correlation, using a simple selection model, but the model did not converge. One reason could be the low number of observations, but of course, with another specification the model could converge.

Once again, since respondents were subject to different policy scenarios, an assumption of independence among responses is questionable since it is likely that the responses are correlated. We therefore estimate this as a random effects model.

5. Results

In total 152 farmers from four different municipalities in Putumayo (Orito, Mocoa, Puerto Asis, and Valle del Guamuez) participated in the choice experiment. Although some respondents were given a shorter version of the experiment including only the choice sets where the profitability of the best alternative was the same as or higher than today, all respondents are included in the analysis. On average, each respondent answered 6.3 choice sets.

Descriptive statistics

Table 5 presents the descriptive statistics of the variables used in the econometric model. 43% of the farmers that participated in the stated preference study claimed to be cultivating on average 1.32 hectares with coca. The profit of the alternative was on average half the profit from coca. However, there is a large dispersion in the perceived relative profitability of the alternative. We find no significant differences on the distribution of the relative profit among municipalities (Mann-Whitney test, $p>0.05$) except for Puerto Asis which has a significantly lower perceived relative profitability of the alternative than Valle del Guamuez (Mann-Whitney test, $p<0.05$). In addition, we find no significant differences in the distribution of the relative profitability between coca and non-coca farmers (Mann-Whitney test, $p>0.05$) with the exception of Mocoa and Valle del Guamuez (Mann-Whitney test, $p<0.05$) . In the first case non-coca farmers overestimate the relative profitability of the alternative compared with coca farmers and in the second case non-coca farmers underestimate the relative profitability of the alternative compared with coca farmers. Note that 17 participants think that the alternative is actually more profitable than coca.

The average perceived risk of having the crops destroyed by authorities in 2005 was 3.88, which is relatively high on the 1-5 qualitative scale used. We find that there are regional differences in the perceived risk of eradication. The average perceived risk or eradication is

significantly lower in Mocoa (2.75) and Orito (3.62) compared with Puerto Asis (4.29) and Valle del Guamuez (6.5) (Mann-Whitney test, $p > 0.05$). This is consistent with the fact that during 2004 and 2005, the number of sprayed hectares over total hectares with coca was higher for Puerto Asis and Valle than for Mocoa and Orito. Interestingly, coca and non-coca farmers within the same municipality and with the exception of Valle del Guamuez have the same perceptions of the eradication risk (Mann-Whitney test, $p>0.05$).

About one-third of the participants in the choice experiment were women, and the average age of all participants was 40 years. The educational level of the participants was very low: 40% had two years of education or less. In addition, the participants tended to be very risk averse: 46% were classified as extremely or severely risk averse, 21% were classified as having intermediate or moderate risk aversion, and 23% were risk neutral to risk loving. Most of the participants claimed to be Catholics (80%), while around 12% declared to be Protestants.

[Insert Table 5]

Based on the Moral Judgment Test developed by Lind *et al.* (1985), 70% of the respondents were classified as pre-conventionalists (the lowest level of moral development), 26% as conventionalists (the intermediate level of moral development), and the remaining 4% as post-conventionalists (the highest level of moral development). These results are consistent with Aguirre's (2002) findings on moral development in Colombian teenagers. No significant differences were found in the level of moral development between coca and non-coca farmers (proportion test, $p<0.01$). Due to time limitations, 10% of the participants in the choice experiment did not take the Moral Judgment Test, but no significant differences were found between those who took the test and those who did not with respect to age, gender, or educational level.

Econometric results

Table 6 presents the results of (1) the random effects probit model for the decision whether or not to crop coca and (2) the random effects model for the conditional decision on how many hectares to crop with coca. We report the marginal effects evaluated at the sample mean. For the constant and the correlation coefficient, we report the coefficients. For the continuous

variables in the probit model, the marginal effect is the marginal increase in the probability to crop coca associated with a marginal increase in the corresponding variable. For dummy variables in the probit model, the marginal effect is the increase in the probability to crop coca associated with a discrete change from zero to one in the corresponding variable. For the linear model, the marginal effects are simply the change in hectares used for coca.

The estimated correlation between the error terms across decisions, rho, is large and highly significant in both models, which means that we cannot reject the random effects model in favor of a more restrictive model with no correlation.

[Insert Table 6]

Our results support the traditional economic model of crime since increases in risk significantly decrease both the probability to crop coca and the number of hectares with coca. Similarly, increases in the relative profitability of the alternative reduce the likelihood to cultivate coca and the number of hectares cultivated with coca. Our results also support behavioral models of crime since other non-monetary variables significantly affect the likelihood to cultivate coca. Consistent with the hypothesis of habituation and social capital depreciation, we find that respondents with more experience in coca cultivation are more likely to cultivate coca. In addition, farmers in municipalities with more coca are more likely to cultivate coca, reflecting positive peer effects. However, probably as a strategy to adjust for the higher risk of having the crops destroyed, the amount of land cultivated with coca is lower for farmers living in municipalities with higher density of coca. Farmers with a high degree of acceptance of the authorities and the law are less likely to cultivate coca, and crop less coca given that they do crop. Interestingly, and contrary to the prediction of the cognitive theory of moral development, the level of moral development is not significant in explaining the likelihood to cultivate coca, but religious beliefs are. We find that Protestants are more likely to cultivate coca than Catholics. Social capital (trust and participation in communitarian organizations) has no clear effect, though both measures are significant individually in explaining coca cultivation they have opposite signs. Regarding individual characteristics, contrary to what we expected, farmers who are more educated and who are more risk averse are more likely to cultivate coca. While we do not have a clear explanation to why education increases coca cultivation; we think that the positive correlation between risk aversion and the

likelihood to cultivate coca can be explained by the higher perceived risk of the legal activity relative to market conditions (possibility to sell the product, price stability, etc.). Finally, we find that coca cultivation is a result of poverty and isolation from the markets. Respondents who live closer to the markets and who are relatively richer in terms of larger land holdings are less likely to cultivate coca. Larger land holdings allow compensation for the low return of legal products through extensive production.

Validity tests

The hypothetical choice experiments used to capture individual preferences may be subject to multiple limitations. For instance, due to the illicit nature of coca farming, participants would like to appear morally correct and therefore underreport cultivation. In addition, participants may respond in ways they think the interviewer expects, or their behavior could reflect strategic bias. Attempting to avoid the policy, participants may for example falsify their preferences, reporting increases in coca cultivation as a response to increases in the probability of eradication. They may also try to attract compensation by overreacting at positive incentives, e.g., increases in the profit from legal alternatives. Inconsistencies could of course also appear due to cognitive limitations, fatigue effects, or simply random responses. Given the above limitation of the methodology, we carry out a number of consistency tests. For example, a respondent who states that he crops coca today should also state that he would crop if the risk of eradication were reduced, or if the relative profitability of coca were increased. Similarly, a farmer who states that he/she does not crop coca should not crop if the risk were increased, or if the relative profit were reduced. Comparing the responses within the experiment is referred to as an internal consistency test. Comparing the responses in the experiment with the current behavior is referred to as an external consistency test. In total, 18 respondents made at least one inconsistent choice in the choice experiment, and 29 respondents made choices in the choice experiment that were inconsistent with their actual behavior. However, many respondents were both internally and externally inconsistent. Accounting for this, a total of 36 of the 152 respondents were inconsistent. Still, this is a non-negligible fraction of the respondents, although we believe it is inevitable that any choice experiment will contain inconsistent responses. We should also remember that the educational level of the respondents was low, meaning that the respondents may not be deliberately

falsifying their preferences. We estimated the models in Table 6 after removing inconsistent responses, and the results were similar. The absolute values of marginal effects for the risk and relative profit attributes are somewhat larger in the probit model and smaller in the linear model. The most important difference is that the marginal effect of the relative profit attribute is insignificant in the linear model. Most of the other control variables have the same sign and significance, with some exceptions.

An alternative test on the quality of the data is to use the estimated model to forecast the behavior and compare it with self-reported behavior. Therefore, using the estimated coefficients in the model and considering the individual perceived risk of eradication and profitability of the alternative relative to coca in 2003 and 2005, we predict the decision to cultivate coca and the number of hectares to be cultivated for each individual, and compare the findings with the self-reported behavior in both years. Table 7 presents the self-reported and predicted proportion of farmers cultivating coca and hectares cultivated with coca. We cannot reject the null hypothesis of equality between the actual and predicted proportions of farmers who cultivated coca in 2005 (proportion test; $p>0.05$), but we reject the null hypothesis for 2003 (proportion test; $p<0.05$). We also reject the null hypothesis of equal means of self-reported and predicted hectares with coca in 2003 and 2005 (t-test; $p<0.05$). This indicates that though the model does a fairly good job in predicting the proportion of coca farmers in 2005, its predictive power on the number of hectares is limited.

[Insert Table 7]

Policy implications

From a policy perspective, it is important to analyze the effect of changes in the levels of eradication and profitability of the alternative. Table 8 presents the raw results of the choice experiment for the nine choice sets used. The share of respondents who would crop coca and the conditional number of hectares that would be cultivated with coca decrease significantly when the relative profitability of the alternative increases and when the risk of having the crops destroyed increases. The exceptions are marked a, b, and c. The effect on the proportion of farmers who would cultivate coca is non-linear for increases in relative profit of the alternative and risk of eradication. The proportion of coca farmers decreases relatively less from the first to the second row (column) in Table 8 than from the second to the third row

(column). This non-linear effect suggests that alternative development programs have a potential to reduce coca cultivation if the profit from the alternative is not too low. In the same way, eradication can only succeed deterring coca cultivation with high levels of risk (spraying).

Compared with self-reported behavior in 2005, where 43% of the farmers cultivated coca and cultivated on average 1.32 hectares, we find that increasing the risk of destroying the crops does decrease significantly the proportion of farmers who would cultivate coca (proportion test, $p<0.05$), but does not significantly decrease the number of hectares cultivated with coca (Wilcoxon test, $p>0.05$). Further analysis reveals that about 10% of the farmers declared an intention to start cultivation or to cultivate more hectares if the risk were to increase. This can be interpreted either as risk seeking behavior, or as a threat to authorities. None of the participants exhibits consistent risk-seeking behavior through all nine choice sets, indicating that some strategic bias may be present in our sample.

[Insert Table 8]

One way of comparing the relative effects of increases in the relative profit of the alternative with the risk of having the crops destroyed is to look at total elasticity. Table 9 reports the total elasticities of eradication and alternative development estimated from our econometric model. The perceived risk and relative profit were evaluated at three different levels. This because the elasticities are highly dependent on at what values of risk and profit we evaluate them. The first risk level corresponds to the situation before 2001 when there was very little risk of eradication. The second and third levels correspond to the average perceived risk from our sample in 2003 and 2005, respectively. The relative profit is evaluated at the median values in our sample in 2003 and 2005 and in a third case with a high relative profit The total elasticity for the unconditional number of hectares with coca was calculated using the total marginal effect:

$$\frac{\partial E[Ha_i]}{\partial x_i} = \frac{\partial P[Crop_i = 1]}{\partial x_i} E[Ha_i \mid Ha_i > 0] + \frac{\partial E[Ha_i \mid Ha_i > 0]}{\partial x_i} P[Crop_i = 1], \quad (8)$$

where Ha_i is the number of hectares dedicated to coca for farmer i, and x_i is a covariate.

[Insert Table 9]

The elasticities vary considerably even within the range of the levels of risk and profit observed in 2003 and 2005

From a policy perspective it is of course interesting to compare the policies taking into account the costs. It is not easy to obtain estimates of the cost of increasing the risk or the profitability of the best alternative. However, we will make some simple estimations based on the results of our survey. The available data is very uncertain, and therefore the following analysis should be interpreted with great care. We will compare the two policies on the basis of the values in 2005; relative profit of 0.25 and a perceived risk equal to 3.98. So the total elasticity for alternative development is -0.113 and the total elasticity for risk of eradication is -0.433. In Table 10 we present the estimated reductions in hectares in the sampled municipalities by increasing the investment in eradication or in alternative development by 1000 USD under various assumptions. Given the uncertainties about the costs of eradication and the number of hectares covered the alternative development we look at three different scenarios. In the scenarios we consider that in 2005 the number of hectares cultivated with coca was 3 039. Let us begin with the base case. According to the estimated risk elasticity, one percent increase in risk will decrease the number of hectares by 13.2 hectares. In order achieve an average perceived risk of eradication of 3.98, authorities sprayed 7 067 hectares in 2005 at an estimated cost of 640 USD per hectare (Logan, 2006). Assuming that the cost of eradication increases proportionally to the perceived risk, the total cost of one percent increase in risk is 45 229.[4] Hence the effect of spending 1,000 USD in investment in eradication is a reduction of the number of hectares with coca by 0.29 hectares. Let us compare this cost with the cost of achieving the same reduction using alternative development. According to the estimated relative profit elasticity in 2005, one percent increase in relative profit decreases the amount of land with coca by 3.4 hectares. The cost of achieving one percent increase in relative profit is 3.56 USD per hectare. But how many hectares has to be targeted? If the authorities only need to target the 3,000 hectares that currently are cultivated with coca, the effect of spending 1,000 USD in investment in eradication is -0.32 hectares (base case). In this case, alternative development is slightly more cost efficient than spraying. However, if more than the 3,000 hectares need to be covered by

[4] This is most likely not the case in reality. The cost of increasing the perceived risk by one unit of the risk already is high is most likely much higher than if the perceived risk is low.

the alternative program, then the cost effectiveness of alternative development decreases. In scenario 1 in the table we report the effect of spending 1,000 USD given that we have to target 12,000 hectares instead. At the same time, the costs of spraying is highly uncertain, and in scenario 2 we present the case where the economic cost of eradicating one hectare is four times the financial cost of estimated by Logan (2006)[5], i.e. 2,560 instead of 640. In this case the cost effectiveness of spraying is much lower.

[Insert Table 10]

Some warnings regarding this simplified analysis are relevant. We are comparing policies based only on financial cost, but if we consider the non-monetary cost of eradication such as water contamination, destruction of natural areas, productivity losses in soils, and negative health effects, then another picture could emerge. To our knowledge, no previous studies have quantified the environmental impact of eradication. From a distributional perspective, it could be preferable to give monetary incentives to the farmers living in these regions, as they are relatively poor compared to the national average. Moreover, alternative development could have long-term effects not achieved through eradication. When farmers decide to substitute or reduce coca cultivation, they implicitly accept a lifestyle change and consequently become more likely to avoid coca cultivation in the future.

6. Conclusions

This paper contributes to the literature evaluating the policies against coca cultivation. We found that increases in the risk of eradication and increases in the relative profit of the alternative crops reduce the proportion of coca farmers and the number of hectares with coca. These results support Becker's (1968) model of crime. In addition, our results support behavioral models of crime as other non-monetary variables also affect coca cultivation. Experience, density of coca in the municipality, religion, and legitimacy of the authorities were significant in explaining coca cultivation. Coca cultivation is also due to marginality and poverty.

[5] For example consider that in order to destroy one hectare with coca it is needed to spray that hectare more than once.

We used a hypothetical survey method to measure the effects of behavior on the two policies. The experiment gave us valuable information that would have been difficult to obtain from data on actual behavior. A number of respondents gave answers that were inconsistent compared with their current behavior. However, the results of the econometric analysis were not to any large extent affected by these inconsistencies. The data is highly consistent and the econometric model gives an accurate prediction of the proportion of farmers who self-report cultivating coca. The predictions on the number of hectares are less accurate, though.

We also illustrated how the model results can be used to evaluate the two main policies. However, our cost estimates are highly uncertain, and therefore our illustration should be interpreted with great care. Future research should focus on estimating the costs of these two policies.

In our analysis, we ignored the dynamic characteristics of coca cultivation assuming that farmers independently decide how to allocate land in each choice set. However, since coca plants are perennial, the amount of land cultivated with coca depends on past decisions. We asked farmers for the perceived risk of eradication assuming that they were able to imagine how the situation would be if the risk were higher or lower, nonetheless this task may be too demanding considering our low-educated sample. Despite several limitations, this study contributes to the limited body of literature evaluating policies against coca cultivation and we do consider it to be relevant for policy purposes.

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Table 1. Description of choice sets.

Choice set	Profitability of best alternative	Risk of having crops destroyed
1	Same as today	Higher risk than today
2	Lower than today	Higher risk than today
3	Higher than today	Higher risk than today
4	Higher than today	Lower risk than today
5	Same as today	Lower risk than today
6	Lower than today	Lower risk than today
7	Lower than today	Zero risk
8	Higher than today	Zero risk
9	Same as today	Zero risk

Table 2. Conversion table for the profit attribute.

Current profit of coca/ profit alternative	Lower ratio than today	Higher ratio than today
Less than 1	0.7	1.1
1 – 1.1	0.9	1.2
1.2 – 2	1.1	3
2.1 – 3	1.5	5
3.1 – 4	2	7
4.1 – 5	2.5	10
5.1 – 8	3	15
8.1 – 10	4.5	19
10 – 20	5	40
More than 20	10	80

Table 3. Conversion table for the risk attribute.

Perceived risk to have the crops destroyed by authorities in 2005	Lower risk Than today	Zero risk	Higher risk than today
Very Unlikely (1)	-	No risk at all (0)	Not too likely (2)
Not too likely (2)	Very Unlikely (1)	No risk at all (0)	More or less likely (3)
More or less likely (3)	Not too likely (2)	No risk at all (0)	Likely (4)
Likely (4)	More or less likely (3)	No risk at all (0)	Very likely (5)
Very likely (5)	Likely (4)	No risk at all (0)	-

Table 4. Choice sets in risk experiments, profit in thousand Colombian pesos.

Choice set	Option A	Option B		Maximum and Minimum Rho if A is preferred to B in this and subsequent choices
		Lower Prob=0.5	*Higher Prob=0.5*	
1	1 000 000	900 000	1 800 000	7.50 – 3.62
2	1 000 000	800 000	2 400 000	3.62 – 1.19
3	1 000 000	600 000	3 000 000	1.19 – 0.51
4	1 000 000	200 000	3 800 000	0.51 – 0.17
5	1 000 000	0	4 000 000	0.17 – 0.00

Table 5. Descriptive statistics

Variable	Description	Mean	St Dev
Relative profitability of alternative in 2005	Profit best alternative / Profit coca.	0.470	0.899
Perceived risk of eradication in 2005	Risk of having crops destroyed. 1 = very unlikely, 5 = very likely.	3.883	1.457
Age	Respondent age in years.	40.335	12.976
Female	= 1 if respondent is female.	0.334	0.472
Educational level	0 = None, 1 = Basic primary, 2 = Primary complete, 3= More than primary.	1.616	0.922
Risk attitude	Respondent degree of risk aversion. Expressed as the degree of relative risk aversion.	3.271	3.514
Inconsistent risk	Risk preference for prospect A and B changed more than once.	0.175	0.380
Atheist	= 1 if respondent is atheist.	0.077	0.267
Protestant	= 1 if respondent is Protestant.	0.124	0.329
Experience	Number of years cultivating coca.	5.964	5.295
Density coca in municipality	Number of hectares with coca over square kilometers in the municipality 2002-2003.	0.576	0.437
Stated degree of trust	Degree of trust. 1= not at all …..5= Very much.	3.057	1.238
Participation	= 1 if respondent participates in a communitarian organization.	0.599	0.490
Legitimacy	Index of acceptance of the law and the authorities. 1= Low, 5= High.	3.518	0.751
Level of moral development	Level of moral development. 0= Missing information, 1= Pre-conventionalist, 2= Conventionalist, 3 = Post-Conventionalist.	1.209	0.667
Missing level of moral development	= 1 if respondent was missing in Moral Judgment Test.	0.102	0.302
Transport	Transport cost to the closest market in COL 2005.	2.731	2.186
Log hectares per capita	Natural logarithm of farm size per capita.	1.137	1.146

Table 6. Results of the random effects probit and the linear random effects model.

	Random effects probit		**Linear random effects**	
Dependent variable	**Dummy coca cultivation**		**Ha of coca conditional on cultivating**	
Independent Variables	*Marginal*	*P-value*	*Marginal*	*P-value*
Risk of crops destroyed	-0.049	0.000	-0.282	0.000
Relative profitability of alternative	-0.256	0.000	-0.920	0.000
Experience	0.018	0.000	0.091	0.033
Density of coca in municipality	0.396	0.000	-1.457	0.028
Legitimacy	-0.132	0.001	-0.660	0.090
Level of moral development	-0.046	0.171	-0.279	0.527
Missing level of moral development	0.129	0.224	-0.118	0.908
Atheist	-0.099	0.202	-0.177	0.836
Protestant	0.199	0.007	0.822	0.248
Stated degree of trust	-0.039	0.086	0.382	0.073
Participation	0.132	0.008	0.052	0.916
Age	-0.006	0.007	-0.013	0.530
Female	0.039	0.461	-0.737	0.130
Education Grade	0.050	0.074	0.195	0.456
Risk attitude	0.021	0.014	-0.057	0.491
Inconsistent risk	0.198	0.002	0.005	0.994
Transport	0.041	0.000	0.075	0.407
Log hectares per capita	-0.038	0.051	0.342	0.136
Constant	0.332	0.124	5.027	0.033
Rho	0.890	0.000	0.803	
Number of choices	1190		550	
Number of individuals	141		97	

Table 7. Predicted and actual proportion of coca farmers and hectares with coca using individual data in 2003 and 2005 (standard deviations in parentheses.)

Year	*Probability coca cultivation*		*Ha of coca conditional on cultivating*	
	Self-reported (1)	*Predicted (2)*	*Self-reported (1)*	*Predicted (2)*
2005	0.430	0.401	1.319[b]	1.870[b]
	(0.496)	(0.491)	(1.223)	(1.118)
2003	0.665[a]	0.511[a]	1.649[c]	2.156[c]
	(0.473)	(0.501)	(1.343)	(1.170)

a: Significant differences at the 5% level using the proportion test. b, c: Significant differences at the 5% level using the t-test.

Table 8. Proportions of people who would cultivate coca and number of hectares that would be cultivated at different levels of profitability and risk of detection. Standard deviations in parentheses.

	Proportion crop coca			**Hectares cropped conditional on cultivating**		
	Zero risk	*Lower risk*	*Higher risk*	*Zero risk*	*Lower risk*	*Higher risk*
Lower profitability of alternative than today	0.61 (0.49)	0.55[a] (0.5)	0.39 (0.49)	4.03 (4.18)	2.79 (2.73)	2.02 (2.14)
Same profitability of alternative as today	0.59 (0.49)	0.51[a] (0.5)	0.31[b] (0.47)	3.45 (4.33)	2.14 (1.95)	1.52[c] (1.39)
Higher profitability of alternative than today	0.52 (0.5)	0.43 (0.5)	0.27[b] (0.44)	3.1 (3.66)	2.09 (2.29)	1.76[c] (1.86)

a,b: No significant differences at the 5% level using the proportion test. c: No significant differences at the 5% level using the Wilcoxon Test.

Table 9. Total Elasticities for the two attributes in the choice experiment. Standard errors are in parentheses.

Relative Profit	Perceived Risk of Eradication					
	Very unlikely 0.88		More or less likely 2.88		Likely 3.98	
	Alternative Development	Eradication	Alternative Development	Eradication	Alternative Development	Eradication
0.140	-0.062 (0.008)	-0.094 (0.007)	-0.064 (0.009)	-0.315 (0.023)	-0.064 (0.009)	-0.440 (0.031)
0.250	-0.111 (0.015)	-0.094 (0.015)	-0.113 (0.015)	-0.312 (0.022)	**-0.113 (0.015)**	**-0.433 (0.030)**
0.400	-0.177 (0.023)	-0.093 (0.007)	-0.177 (0.023)	-0.306 (0.022)	-0.176 (0.024)	-0.412 (0.029)

Table 10. Estimated reduction in hectares with coca at a 1000 USD increase in Eradication and Alternative development

	Assumptions		**Reduction in Hectares with Coca**	
	Cost of Eradication	**Hectares with Alternative development**	**Alternative development**	**Eradication**
Base Case	640	3 000	-0.32	-0.29
Scenario 1	640	12 000	-0.08	-0.29
Scenario 2	2 560	3 000	-0.32	-0.07