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The Role of Incentives, Norms and Institutions

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A mi tía Inés y a mi Mamá

Abstract

The subject of this dissertation is social dilemmas. In a social dilemma situation, there is a clear incentive not to cooperate. However, if nobody cooperates, then everybody is worse off than if they had cooperated. The question we try to answer in this dissertation is what prevents non-cooperation. In the first three chapters of the dissertation, we ask why some farmers abstain from cultivating coca despite facing the possibility to do so. In the last chapter, we investigate to what extent motivation to cooperate is stable..

Chapter 1 examines the decision to cultivate coca at the individual level by developing an extended version of the portfolio model of crime that includes: (i) guilt from wrongdoing, (ii) reputation from being different from the group, and (iii) shame from disappointing authorities. In addition, we include the effect of not being able to make a living from the legal activity. Our model suggests that in addition to economic incentives, authorities can use non-economic instruments to discourage coca cultivation, e.g., campaigns to increase awareness of the negative effects of coca cultivation, increases in the participative mechanisms, and institutional transparency. Eradication is effective in reducing the probability to cultivate coca, but the amount of land cultivated increases when farmers lack options in the legal economy to survive.

The theoretical model is tested using a dataset on farmers in Putumayo, a region with a well-established tradition in coca cultivation. Three different methods were used to elicit information on coca cultivation at the individual level: in Chapter 1 we use revealed preferences, or self-reported information, on cultivation in 2003 and 2005, while the next two chapters focus on the evaluation of the effectiveness of eradication and alternative development to control coca cultivation. To measure farmer responsiveness to different policy levels, we use two different experimental approaches: (i) a choice experiment in Chapter 2, where participants are asked how many hectares they would cultivate with coca at different policy levels, and (ii) what Harrison and List (2004) refer to as a framed field experiment in Chapter 3. The experiment uses the structure of a public bad game to mimic land allocation decisions; farmers have some endowment that is equivalent to their productive capital and have to decide how to allocate it between coca and cattle farming. We consider three aspects of coca cultivation in our design: (i) coca is more profitable than cattle, (ii) coca is illegal and there is a risk that authorities will discover and destroy the crops, and (iii) coca generates negative effects to society. To evaluate the effect of the policy we use different relative profits of the alternative crop and various risks of eradication.

In all three chapters, we find that both economic and non-economic factors affect the decision to cultivate coca; farmers cultivate coca because they face different opportunities, risks and needs, but religious beliefs, acceptance to the authorities and social norms also explain coca cultivation. We find that increases in relative profit of the alternative crop and increases in the probability of eradication both reduce coca cultivation. Whether one method is more effective depends on the empirical approach used.

The regularity in our findings in the first three chapters is that own behavior depends on the behavior of others. This relation has been interpreted in the literature as conditional cooperation. Chapter 4 investigates the stability of cooperation preferences at different endowment levels. We find both that conditional cooperation and free-riding are the most common cooperation preferences and that they are stable at different endowment distributions. We find that relatively richer individuals contribute more in absolute terms, although poorer individuals contribute a larger proportion of their endowment.

We conclude that incentives, norms, and institutions affect cooperation.

Key Words: Portfolio Model of Crime, Norms of Behavior, Choice Experiment, Field Experiment, Public goods, Income Heterogeneity, Illegal Drugs, Colombia.

JEL classification: C72, C91, C93, D81, G11, H41, K42, Z12, Z13

Contents

Preface

First of all I want to expresses my gratitude to the Department of Economics at Göteborg University, and the Environmental Economic Unit. The professors, fellow researchers, students, and administrative staff did not only create a friendly environment for academic discussion; they also facilitated and enriched my own research and personal development throughout the last few years. I am tremendously thankful to all of them.

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I dedicate this dissertation to my mother, Julieta Diaz, who gave the best of her life to us. Muchas gracias Mami, La quiero mucho.

Marcela Ibáñez Díaz.

October, 2007

Who crops coca and why?

The case of Colombian farmers[#]

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Abstract

Approximately 1.2% of Colombia's GNP is spent every year on the war on drugs, but very little is known about coca farming decisions at the household level. In order to understand the decision to cultivate coca as well as that of how much land to use for its cultivation, we develop an extended version of the portfolio model of crime that considers the effects of behavioral norms and lack of options in the legal economy. The model is tested using data from a survey with coca and non-coca farmers living in Putumayo, Colombia. We find that coca cultivation decisions are explained by the impossibility of making a living from legal forms of agriculture as well as moral considerations. In addition we find that eradication and substitution programs reduce coca cultivation.

Keywords: Coca; Colombia; Portfolio Model of Crime, Norms of Behavior.

JEL classification: D81, G11, K42, Z12, Z13

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1. Introduction

About 1 billion dollars (1.2% of Colombia's GDP in 2005) are spent every year on controlling the production of cocaine in Colombia (ONDCP, 2006; Alvarado and Lahuerta, 2005). Despite this, between 1997 and 2004, the production of cocaine increased from 230 tons to 340 tons, albeit with the prices remaining almost constant (DNE, 2005). The poor results of this policy to reduce coca production underline the importance of investigating the factors that affect coca cultivation decisions. Some studies (e.g. Carvajal, 2002; Moreno et al., 2003; Díaz and Sánchez, 2004; Tabares and Rosales, 2005; Moya, 2005) have investigated factors affecting coca cultivation at the regional level, finding that municipalities with coca are characterized by marginality, armed conflict and environmental vulnerability. These studies have also evaluated the effect of the two main strategies used to control coca cultivation in Colombia, finding that investments in alternative development programs are effective in reducing the area of land cultivated with coca, while eradication or destruction of coca plants by aerial spraying either increased the area of land given over to coca or had no significant effect. One limitation of these studies is that important behavioral factors that may be affecting coca cultivation cannot be identified with aggregate information. A better comprehension of the economic and non-economic factors that determine the decision to cultivate coca at the household level is needed if actual policies against illicit drugs are to be improved and alternative strategies to tackle their production are devised.

The objective of this paper is to investigate why farmers cultivate coca and how they decide what amount of their land to allocate to coca production. For many farmers, the answer may seem rather obvious: coca is cultivated because it is good business. Indeed, coca is three to five times more profitable than alternative legal products. However, if it is such good business, why do some farmers choose not to cultivate it? In line with traditional models of crime (e.g. Becker, 1968; Ehrlich, 1973; Eide et al., 1994), we expect that lower economic incentives for cultivating coca, higher expected costs of being discovered cultivating coca, and higher levels of risk aversion would discourage farmers from cultivating coca. In addition, studies on law compliance have identified that normative factors such as morality (e.g. Sutinen and Kuperan, 1999; Eisenhauer, 2004), social norms (e.g. Glaeser et al. 1996; Calvo and Zenou, 2004, Garoupa, 2003) and legitimacy (e.g. Tyler, 1990; Tyran, 2002) also influence decisions to participate in illegal activities. For instance, the appearance and expansion of protestant groups, like the Pentecostal, Adventist, and Evangelical Churches, could have persuaded farmers to change their attitude towards others, and hence towards coca production. On the other hand, Thoumi (2000) argues that low levels of social capital and weak community and governmental institutions are responsible for the expansion of coca cultivation in Colombia. The regions where coca is cultivated have a recent history of colonization and low population density possibly implying weak social networks and hence weak mechanisms of social control. In addition, the presence of illicit armed groups in these areas may generate an attitude of resistance to legal institutions. Garcia, (2000) and Ortíz (2000) explain the expansion of coca cultivation as a result of the agricultural crisis. They argue that the low prices and high transport costs of legal products have forced farmers to cultivate coca in order to survive.

In this paper we explore the effects of economic and non-economic factors on coca cultivation both theoretically and empirically. We develop an extended version of the economic model of crime that includes both the effects of normative factors and those of lack of alternatives within the legal economy. The predictions of the model are tested using a unique data set of agricultural production for coca and non-coca farmers living in Putumayo, a region producing a sizable proportion of Colombia's coca. To our knowledge this is the first empirical study of coca cultivation decisions at the individual household level. Our analysis contributes to a better understanding of coca cultivation including key individual socioeconomic characteristics such as morality, social norms, legitimacy and lack of options.

The paper is organized as follows. Section two presents an extended version of the economic model of crime. Section three discusses the empirical measures used to capture the effect of economic and non-economic factors. The results and conclusions are presented in sections four and five, respectively.

2. A Model of coca cultivation

In our model, we focus on land allocation rather than labor allocation decisions that depend on the production technology. Therefore we consider the case of farmers who have access to land and capital (seeds, fertilizers, etc.). It is also assumed that soil quality is homogenous, which is consistent with the fact that coca plants are highly adaptable. According to the traditional portfolio model of crime (e.g. Becker, 1968; Ehrlich, 1973), a farmer holds *L* units of agricultural land and decides how much of that land to cultivate with coca, α, so as to maximize the value function,

$$V = (1-p)U(Y_g(\alpha)) + pU(Y_b(\alpha)) \tag{1}$$

Without loss of generality, we assume that the remaining land, L-α, is cultivated with a legal product. Since coca farming is an illegal activity that can be penalized by the authorities by eradication, two possible outcomes can arise; either the farmer has bad luck (b) and the coca plants are discovered and destroyed or he has good luck (g) and the coca crop remains unharmed.[1] The probability of coca plants being destroyed is p and is assumed to be exogenous as one single farmer has a negligible effect on the probability of eradication. A farmer's income in case of good and bad luck is respectively:

$$\begin{aligned} Y_g &= W + (1-\lambda(\alpha))(1-\gamma)\textstyle\prod_i(\alpha) + \prod_l(L-\alpha) - qt(\bar{a}-\alpha)^2 \\ Y_b &= W + (1-\lambda(\alpha))(1-\gamma)\textstyle\prod_i(\alpha) + \prod_l(L-\alpha) - qt(\bar{a}-\alpha)^2 - F(\alpha) \end{aligned} \tag{2}$$

Where *W* is the initial wealth, Π_i and Π_l is the profit from coca cultivation and the legal crop, respectively and *F* is the loss of income in the case of eradication. We assume non-increasing returns to scale on land and a loss of income *F* proportional to the amount of land cultivated with coca.[2] Other parameters (λ, γ, q, t and $\bar{a}$) refer to non-economic factors as explained below.

We consider that the profit generated by coca cultivation can have a lower utility value because of a sense of sinfulness or guilt at breaking one's own principles (e.g. Hausman and Mc Pherson, 1993; Frey 1997; Dawes and Messik, 2000;) or because of a sense of obligation about complying with the authorities (e.g. Easton, 1958; Tyler, 1990 and Tyran and Feld, 2002). In addition, we consider that legal norms may or may not be in accordance with an individual's own morality; however, the acceptance of authority may be high enough to support compliance (Tyler, 1990).

[1] The law dictates imprisonment and fines for production and transportation of drugs, but in practice this is very seldom used.

[2] $\frac{d\prod_i}{d\alpha} = \pi_i\ ; \frac{d\prod_l}{d(L-\alpha)} = \pi_l\ ; \frac{d^2\prod_i}{d\alpha^2} = \pi_i^{'} \le 0;\ \frac{d^2\prod_l}{d(L-\alpha)^2} = \pi_l^{'} \le 0; \frac{dF}{d\alpha} > 0; \frac{d^2F}{d\alpha^2} = 0$

Following Eisenhauer (2004) the profit from coca is weighted by $1-\lambda$, where λ is a personal subjective measure of sinfulness. For a moral individual, the sinfulness of engaging in the illegal activity is very high ($\lambda=1$), so he derives little or no utility from the income generated by illegal activity, while an amoral individual will feel no regret for his actions ($\lambda=0$). We consider that individuals feel bad about deviating away from moral precepts ($\lambda \geq 0$), but that the sense of guilt is not high enough to deter them from immoral action ($\lambda<1$); it is therefore tempting to engage in coca cultivation. We also assume that the feeling of wrong-doing increases at a constant rate with the amount of land that is cultivated with coca ($\lambda'_\alpha > 0$, $\lambda''_\alpha = 0$). Farmers who cultivate only one quarter of a hectare with coca may rationalize that they do it because they need to have a minimum income to buy food and hence do not feel too bad compared with those who cultivate more than they need to survive. Farmers who cultivate more than they need to survive may find it harder to justify their actions.[3]

Similarly, the profit from coca cultivation is weighted by a factor $1-\gamma$, where γ represents the sense of guilt that disobeying the authorities brings. A follower of the law experiences great guilt over breaking the law, $\gamma = 1$, while a protester feels no culpability, $\gamma = 0$. We rule out both the feeling of satisfaction from breaking the law ($\gamma \geq 0$) and consider that it is tempting to break the law ($\gamma \leq 1$). The sense of guilt from breaking the law is assumed to be constant for the amount of land cultivated, though this assumption can easily be relaxed.

Another motivation behind coca cultivation is the effect of social norms (e.g. Elster, 1989, Glaeser et al. 1996; Calvo and Zenou 2004; Garoupa, 1997, 2003). A social norm is an informal external pattern of behavior that is shared by other people and that is sustained by their approval or disapproval (Elster, 1989). The degree to which breaking a social norm has the ability to affect an individual's reputation, depends on the degree to which that individual feels identified with the group and with the norm (Akerlof, 1997).. Social norms discipline group members by condemning behavior that differs from what is socially accepted. In a pro-social environment, social norms protect against anti-social behavior, while in an environment full of anti-social

[3] An alternative approximation that includes the effect of behavioral norms and has the same implications as our model is presented in Sutinen and Kuperan (1999), Hatcher et al, (2000), Akpalu (2006).

behavior they could have the opposite effect.[4] The reputation cost from behaving differently can be captured by a function that depends on the probability that others observe individual behaviour, q, the weight that others have in the utility function, t, and the distance between individual and group behaviour. We use a quadratic function to capture the effect of disapproval for having a larger or a smaller amount of land with coca than the average, $\bar{a}$. It is assumed that others have imperfect observation of individual behaviour ($0<q<1$) and that farmers are not completely asocial ($t>0$).

Expected utility is the standard theory used to explain decisions affected by risk and uncertainty, but empirical evidence has documented patterns of choice that are inconsistent with this theory (see Starmer, 2000 for a discussion). Although there is much controversy about which alternative framework best captures observed patterns of choice, one framework that has gained increasing support is Cumulative Prospect Theory (Tversky and Kahneman, 1992). This framework captures three features that have been observed: i) outcomes are taken as gains and losses relative to a reference point. The utility function is concave for outcomes above the reference point while it is convex for outcomes below it; ii) losses appear larger than gains, so the utility function is steeper for losses than for similar gains (loss aversion); iii) the evaluation of risky outcomes involves a probability weighting function, p, that over-weights small probabilities and under-weights large probabilities. We adopt this theoretical framework not only because it offers a more sound representation of choices under risk, but also because it allows us to capture the effects of poverty or lack of options in legal agriculture. The impossibility of making a living from legal agriculture because of the marginality of the areas, the lack of infrastructure and high transport costs could be one reason why farmers cultivate coca. If the maximum income that farmers can obtain from cultivating all the agricultural land with coca, $Y_L = W + \Pi_l(L)$, is lower than the minimum subsistence income, Y_s, we consider that the farmer lacks options in legal agriculture. In our model, the minimum subsistence income, Y_s, is taken as a reference point to which the utility function is kinked. This implies that when the minimum subsistence income is covered, $Y_s<Y_b<Y_L<Y_g$, the utility function is concave and

[4] Social interaction reproduces anti-social behavior by learning effects from criminal peers (Opp, 1989; Calvo and Zenou, 2004; Glaeser, et.al, 1996), crowding-out of the legal system (Schrag and Schotchmer 1997), crowding-out of legal opportunities (Murphy, et Al., 1993: Haung et al., 2004), and social capital depreciation (Sah, 1991, Williams and Sickles, 2002, Mocan et al. 2005).

farmers are risk-averse and when the minimum subsistence income is not covered, $Y_b<Y_L<Y_g<Y_s$, the utility function is convex and farmers are risk-lovers.

The first order condition for the maximization problem implies that irrespective of whether farmers lack legal agriculture alternatives or not (whether the farmer is risk-loving or risk-averse) farmers cultivate coca if:[5]

$$(1-\lambda)(1-\gamma)\pi_i - \pi_l - 2qt(\alpha-\bar{a}) - \lambda'_\alpha(1-\gamma)\textstyle\prod_i(\alpha) - pf > 0 \qquad (3)$$

No coca would be cultivated and the farmer would specialize in the legal activities if the marginal profit from legal cultivation were higher than the marginal profit of coca net the moral cost of doing wrong, the guilt of disappointing authorities and the reputation cost, $(1-\lambda)(1-\gamma)\pi_i-2qt(\alpha-\bar{a})<\pi_l$. The farmer cultivates coca if the marginal profit net of the profit from the alternative production is larger than the expected marginal cost. In our model, the expected marginal cost is given by i) the expected cost of having the crops destroyed, pf, ii) the reputation cost, $2qt(\alpha-\bar{a})$ and iii) the cost of being more morally aware, $\lambda'_\alpha(1-\gamma)\Pi_i(\alpha)$. Note that when the social norm is to cultivate coca, $(\alpha-\bar{a})<0$, there is a reputation benefit from coca cultivation. When both coca and legal crops are cultivated, the optimal amount of land that is cultivated with coca is determined by the equity of the slope between the marginal rate of transformation between income in the lucky and unlucky outcomes, $\frac{dYg/d\alpha}{dYb/d\alpha}$ and the marginal rate of substitution between income in those states, $\left.\frac{dYg}{dYb}\right|_{dV=0}$

$$\frac{(1-\lambda)(1-\gamma)\pi_i - \pi_l - 2qt(\alpha-\bar{a}) - \lambda'_\alpha(1-\gamma)\prod_i(\alpha)}{(1-\lambda)(1-\gamma)\pi_i - \pi_l - 2qt(\alpha-\bar{a}) - \lambda'_\alpha(1-\gamma)\prod_i(\alpha) - f} = -\frac{p}{(1-p)}\frac{U'(Y_b)}{U'(Y_g)} \qquad (4)$$

Unless the marginal cost of being caught cultivating coca, f, is greater than the marginal incentives to enter into the illegal activity (i.e. the denominator of the left hand side of expression 4 is negative) complete specialization in coca cultivation occurs. To start cultivating, the expected marginal profit from coca cultivation has to be larger, equal or lower than the marginal profit in the illegal activity for a risk-averse, risk-neutral and risk-loving farmer, respectively.[6] Hence, a risk-loving farmer cultivates more units of

[5] Evaluating the first order condition at $\alpha=0$ where the marginal utility from cultivating coca is equal to the marginal utility of not cultivating coca, $U'(Y_g)=U'(Y_b)$.

[6] $(1-\lambda)(1-\gamma)\pi_i - 2qt(\alpha-\bar{a}) - \lambda'_\alpha(1-\gamma)\prod_i(\alpha) - pf \gtreqless \pi_l$ if $U'' \lesseqgtr \pi_l$

land with coca than a risk-neutral farmer and even more than a risk-averse farmer. A risk-loving farmer would specialize in coca cultivation if land has constant returns to scale and if the probability of eradication, the marginal cost of eradication and the marginal moral cost do not increase with α. In other, words, when the marginal incentive to cultivate is larger than the marginal cost, farmer specialize in coca cultivation.

As proved in the appendix A, the model predicts that increases in any of the four normative factors that we have considered (λ, γ, q or t), reduce the marginal incentive to cultivate coca irrespective of whether subsistence is covered or not. Similarly, increases in the expected cost of eradication (p *f*) discourage farmers from starting to cultivate coca irrespective of risk preferences. However, if the authorities offer alternatives to coca cultivation, the effect on the likelihood to cultivate is ambiguous. The opportunity cost of legal cultivation is increasing, thus farmers are less likely to engage in coca cultivation. However, higher returns on legal activities means that farmers are relatively richer, which is having the opposite effect. Similarly, increases in wealth or in land holdings have an undetermined effect on the likelihood of cultivating coca.

The predictions of the model when both coca and a legal crop are cultivated depend on risk preferences and whether subsistence is covered or not. Assuming decreasing absolute risk preferences, increase in normative factors, (λ, q, t), and in the expected cost of eradication (*pf*) decrease the marginal incentive to cultivate coca when subsistence is covered and thus reduce the amount of land that is cultivated.[7] However, the effect of the above factors is ambiguous when subsistence is under threat. On one hand, the marginal incentive to cultivate coca decreases so that farmers tend to cultivate less land with coca, but on the other hand as they are risk-lovers, they also tend to demand less in order to start cultivating it which has the opposite effect increasing the amount of land cultivated with coca. Moreover, since farmers are risk-lovers when subsistence is under threat, when the expected cost of eradication is higher, the amount of land that is cultivated with coca can increase. Increases in the opportunity cost of cultivating coca (π_l) have an ambiguous effect on the amount of land that is cultivated with coca when subsistence is covered but reduces coca cultivation when subsistence is

[7] When $a < \bar{a}$

under threat. Increases in the opportunity cost of cultivating coca (π_l) have an ambiguous effect independently on whether subsistence is under treat. Increases in wealth and land endowments increase the amount of land that is cultivated with coca when subsistence is covered but increases in wealth reduce the amount of land cultivated with coca while increases in the land endowments have an ambiguous effect when farmers are risk-loving.

Our model suggests that in addition to economic incentives, authorities can use non-economic instruments to discourage coca cultivation. For example, campaigns to increase awareness of the negative effects of coca cultivation are likely to affect moral resistance to coca cultivation. Similarly, the use of participative mechanisms and institutional transparency, may increase the support to the authorities and generate respect for the law.

3. Data

Putumayo in the South East of Colombia was selected as the locality for data collection because of its well-established tradition in coca production. Coca production was established in the region in the 1980's and by 2000 about one third of Colombia's coca-growing areas were located in Putumayo (DNE, 2005). In addition, this was the first region where eradication campaigns (destruction of coca plants through aerial spraying or manual pulling-up of plants) were implemented on a large scale. This was also one of the pioneer regions to benefit from alternative development projects aimed at making non-coca activities more profitable (DNE, 2005). In particular, in 2000 the government implemented Voluntary Agreements of Substitution (VAS) in which farmers agreed to destroy coca plants in exchange for funding (in kind) for a food security project.[8] Four municipalities were included in our study: Mocoa and Orito, where the number of hectares (ha) of coca per square kilometer of the total municipal area are low (0.08ha coca/Km^2 and 0.17ha coca/Km^2, respectively) and Puerto Asis and Valle del Guamuez where that ratio is higher (0.54ha coca/Km^2 and 1.82ha coca/Km^2, respectively). Three

[8] Other programs of voluntary substitution are the Forest Guarding Families Program in which farmers agreed to destroy coca plants in exchange for a three year monetary subsidy, paid monthly. Productive projects (e.g. palm hearts, flowers, vanilla and cattle raising), on the other hand, consist of subsidized credit for the establishment of a legal product plus technological advice and support in commercialization. Due to data limitations, we only analyze the impact of Voluntary Agreements of Substitution.

graduate researchers conducted the interviews, assisted by two to four trained enumerators from each municipality. Respondents were farmers who voluntarily participated in a meeting that was called by the local leader to talk to university researchers about coca farming and productive alternatives. To reduce the problem of validity of self-reported data due to the illegality of coca cultivation, participants in the survey were informed that it was an academic study and that we were interested in their opinions alone, therefore no names or addresses were asked. Participants were interviewed during the morning session and participated in what Harrison and List (2004) call a framed field experiment after a break for lunch. In total 293 households were interviewed for about one hour using a pre-tested questionnaire, but due to time limitations a shorter version of the interview was conducted in 38 cases. Using the Mann-Whitney test, no significant differences were found between the samples with the short and long questionnaires with respect to hectares with coca, education level, age or gender. The questionnaire included questions about i) productive activities on the individual's farm in 2003 and 2005, ii) coca production in the municipality in 2003 and 2005, iii) attitudinal questions on coca production and anti-drug policies, and iv) standard questions on socioeconomic characteristics (See appendix B). The questionnaire also included the Moral Judgment Test developed by Lind et al. (1985) and a risk experiment that followed the design of Binswanger (1980). We also included a hypothetical choice experiment on coca production to test for the effect of different levels and combinations of eradication and alternative development, but we do not analyze it in this study.

4. Results

Descriptive statistics

Table 1 presents the descriptive statistics for self-reported coca and non-coca farmers, as well as for the whole sample. We find that the self-reported proportion of coca farmers and the amount of land cultivated with coca decreased between 2003 and 2005. In addition, over this same period, the relative profit of coca compared with that of alternatives dropped,[9] the index of credit availability and market facility of coca compared with that of the alternatives decreases, and the number of hectares sprayed out

[9] The estimated median annual profit from coca and second best alternative are consistent with the estimated values in other studies (e.g. DNE, 2005; Rocha and Ramírez, (2006); and Uribe, 2005).

of the total number of hectares cultivated with coca in the municipality increases. These changes indicate that during this period economic incentives to cultivate coca decreased, offering a potential explanation for the reduction in areas cultivated with coca. Table 1 also reveals that there are significant differences in the socioeconomic characteristics of coca and non-coca farmers.

In order to capture the effect of morality on the decision to cultivate coca we used the Moral Judgment Test (Lind et. al., 1985). This test is based on the theory of social development (Kohlberg, 1969). According to this theory, the actions of individuals at the lowest level of moral development, pre-conventionalists, are motivated by individualistic and opportunistic behavior (e.g. avoidance of personal harm or obtaining personal satisfaction). At an intermediate level, the actions of conventionalists are motivated by y social concerns (e.g. what others would think or the desire to preserve social order). At the highest level of moral development, post-conventionalists justify their moral actions by higher objectives such as human rights and principles of conscience. As predicted by the cognitive theory of social psychology, we find that the level of moral development in coca farmers is on average lower than that of non-coca farmers although the difference is not significant at the 10% level using Mann Whitney test.[10]

Another measure of morality is religious belief. Though most of the farmers declared themselves to be Catholic (79%), the percentage of people that declared themselves to be Protestant was significantly higher for non-coca farmers than for coca farmers, and a significantly larger proportion of coca farmers declared themselves as not belonging to any religion than was the case with non-coca farmers. Some evidence of habituation on the coca-cultivation decision is found as the average number of years cultivating coca is significantly larger for coca farmers than for non-coca farmers.

Following the theory of procedural justice (Tyler, 1990), the guilt associated with disobeying the authorities was measured in terms of the degree of acceptance expressed by subjects in response to a series of statements about the authorities and the rule imposed by them. We captured five aspects of the authorities and their rule in our statements. These were: 1) agreement with the need of the prohibition on drugs; 2) agreement with the need to respect the prohibition; 3) participation in defining policies

[10] Aguirre (2002) studies criminal participation and moral development in Bogota, Colombia using Lind et al.'s (1985) Moral Judgment Test.

to control coca cultivation; 4) effectiveness of the policies against coca cultivation and 5) fairness in the implementation of the policies against coca cultivation. The level of obligation to comply is significantly higher in non-coca farmers than in coca farmers.
To capture the effect of social norms, we asked participants what proportion of the municipality's farmers they believed to have farmed coca in previous years. It is remarkable how close the average perceived proportion of coca farmers is to the sample's self reported percentage of coca farmers in both years. This is a good indication of the consistency of the self-reported information. However, since coca farmers may declare a higher proportion of coca farmers in order to justify their own behavior, this measure may be subject to endogeneity.

The effect of social norms is captured using the density of coca in the municipality in previous years (number of hectares with coca over total number of hectares in the municipality). To measure the probability that others observe individual behavior and the importance of the opinion of others in maintaining a sense of well-being we used participation in community organizations and the stated degree of trust. We find that the average degree of trust of non-coca farmers is not significantly different from that of coca farmers, but that on average, non-coca farmers participate more in community organizations. Using the Mann-Whitney test, we reject the null hypothesis of equal average participation of coca and non-coca farmers at 1% significance level.

Other significant differences between coca and non-coca farmers are observed in the characteristics of the head of the household. Coca farmers are significantly older, less educated and more risk-averse than non coca farmers. Although the difference is not significant, coca farmers also have less land than non-coca farmers.

Risk preferences were measured using Binswanger's (1980) risk experiment design whereby farmers compare five sets of lotteries in which the payment for lottery A was held constant at 1 million pesos with no risk while lottery B offered equal chances of receiving a payment above and below 1 million. The expected payment of lottery B increased in each choice set but so did the variance.[11] By finding the point at which farmers switch from option B to option A, it is possible to estimate the average

[11] 1 USD = 2,200 Colombia pesos in June, 2006

Table 1. Descriptive Statistics

Variable	Non-Coca farmers		Coca Farmers		Test Ho: Non-Coca=Coca	All Farmers	
	Mean	Std. Dev.	Mean	Std. Dev.		Mean	Std. Dev.
Coca Cultivation							
Dummy coca 2005	-	-	1	-		0.43	0.50
Dummy coca 2003	-	-	1	-		0.71	0.45
Hectares with coca 2005	-	-	1.41	1.29		0.61	1.10
Hectares with coca 2003	-	-	1.85	1.85		1.31	1.77
Proportion of farm land with coca 2005	-	-	0.29	0.30		0.12	0.24
Proportion of farm land with coca 2003	-	-	0.31	0.30		0.22	0.29
Economic Benefit							
Net annual income coca 2005 (Thousand COL 2005)	3818	3485	3212	3167	*	3507	3336
Net annual income coca 2003 (Thousand COL 2005)	5678	3545	5460	3767		5514	3707
Net annual income alternative 2005 (Thousand COL 2005)	1098	1267	842	1000	*	978	1157
Net annual income alternative 2003 (Thousand COL 2005)	839	1069	1006	1398		962	1319
Index of market conditions coca vs. alternative 2005	-0.69	1.34	-0.61	1.15		-0.65	1.25
Index of market conditions coca vs. alternative 2003	0.34	1.15	0.30	1.42		0.31	1.35
Eradication and Alternative Development							
Sprayed hectares over total hectares with coca 2002-2003	8.97	7.55	6.33	5.08		7.94	6.74
Sprayed hectares over hectares with coca 2000-2001	0.69	0.80	1.23	0.74	***	1.07	0.79
Dummy Voluntary Agreements of Coca Substitution	0.45	0.50	0.24	0.43	***	0.35	0.48
Morality, Social Norms and Legality							
Level of moral development	1.34	0.72	1.10	0.76	***	1.23	0.75
0 = Missing response for moral development	6.75		20.33		***	12.97	
1 = Pre-Conventionalist	60.74		53.66			57.68	
2 = Conventionalist	24.54		21.95			23.21	
3 = Post-Conventionalist	7.98		4.07			6.14	
Religion	1.10	0.48	0.97	0.40	**	1.04	0.45
0 = Percentage who do not belong to any Religion	6.79		9.76			8.25	
1 = Percentage Catholics	75.93		83.74			79.38	
2 = Percentage Protestants	17.28		6.50		***	12.37	

Continue…

Variable	Non-Coca farmers		Coca Farmers		Test Ho: Non-Coca=Coca	All Farmers	
	Mean	Std. Dev.	Mean	Std. Dev.		Mean	Std. Dev.
Number of years cultivating coca	5.15	5.77	7.52	5.50	***	6.15	5.75
Obligation to comply (Completely disagree=1. Completely agree=5)	3.69	0.69	3.19	0.82	***	3.48	0.79
Perceived proportion of coca farmers in 2005	0.37	0.23	0.61	0.25	***	0.47	0.27
Perceived proportion of coca farmers in 2003	0.70	0.24	0.82	0.19	**	0.79	0.21
Hectares with coca per square Km 2002-2003	0.42	0.34	0.92	0.39	***	0.63	0.44
Hectares with coca per square Km 2000-2001	3.11	3.54	6.49	4.94	**	5.50	4.82
Degree of trust (not at all=1 a lot=5)	3.09	1.29	2.89	1.20		3.01	1.25
Dummy participation in community organizations	0.63	0.48	0.50	0.50	*	0.57	0.50
Socioeconomic Characteristics							
Age	44.02	13.99	37.85	14.32	***	41.40	14.33
Dummy Female	0.34	0.48	0.36	0.48		0.35	0.48
Education Grade	1.47	0.86	1.75	0.90	**	1.59	0.88
0 = Percentage with no education	10.43		5.69			8.22	
1 = Percentage with basic education	46.01		39.02			43.15	
2 = Percentage with complete primary education	29.45		30.08			30.14	
3 = Percentage with more than primary education	14.11		25.20		**	18.46	
Risk aversion	3.77	3.58	3.14	3.67	*	3.44	3.62
0 = Percentage missing response for risk preference	15.95		23.58			20.48	
1 = Percentage risk-neutral to risk-loving	15.34		17.89			16.04	
2 = Percentage with slight to neutral risk preference	6.13		6.50			6.14	
3 = Percentage with moderate risk preference	7.98		10.57			9.22	
4 = Percentage with intermediate risk preference	7.98		4.07			6.14	
5 = Percentage with severe [strong?] risk preference	10.43		3.25		**	7.17	
6 = Percentage with extremely strong risk preference	36.20		34.15			34.81	
Transport cost (Thousand COL 2005)	2.56	2.20	2.99	2.53		2.74	2.34
Hectares per capita	1.05	1.24	0.78	1.12		0.92	1.20

The test of equal distribution is based on the Wilcoxon rank-sum test for continuous variables and the proportion test for fractions

*, ** and *** denote rejection of the null hypothesis with statistical significance at 10% 5% and 1% level respectively.

coefficient or partial risk aversion. More than half of the sample had high or extremely high levels of risk aversion.

When the maximum income attainable from cultivating all the available land with the most profitable legal product is lower than 93,000 pesos per person per month (the official poverty line) we say that an individual lacks options in the legal economy in order to survive. Using this definition, 45% of the farmers were classified as lacking options.

Econometric model

The coca-cultivation decision can be analyzed using an extended version of the Generalized Tobit Model. In the first step, farmers decide whether to cultivate coca or not, and then decide what amount of their land to cultivate with coca. A farmer cultivates coca (z=1) if the utility of cultivating it is larger than the utility of not cultivating it, ($V^*>0$).

$$z = \begin{cases} 1 & V^* = \beta_1 X_1 + \alpha D + \varepsilon_1 \geq 0 \\ 0 & \text{otherwise} \end{cases} \tag{5}$$

$(\varepsilon_1, \varepsilon_2) \sim N(0,0,\sigma^2,1,\rho)$ and X_1 is a vector of the economic and non-economic factors previously discussed, D is a binary variable that represents participation in programs of voluntary substitution (D=1). Participation in voluntary substitution programs depends on individual socioeconomic characteristics X_2.

$$D = \begin{cases} 1 & \text{If } D^* = \beta_2 X_2 + \varepsilon_2 > 0 \\ 0 & \text{otherwise} \end{cases} \tag{6}$$

However, since participation in programs of substitution is voluntary, unobserved characteristics that affect the decision to participate in the substitution program (ε_2) can be correlated with the unobserved characteristics that affect the decision to cultivate coca (ε_1), so the model will be subject to self-selection bias. We control for self-selection bias on coca-cultivation decisions by estimating a bivariate probit model that considers the effect of participation in a substitution program on the decision to cultivate coca (Equations 5 and 6). Conditional on cultivating coca, the amount of land cultivated with coca (α) is

$$\alpha = \begin{cases} \beta_3 X_3 + \varepsilon_3 & \text{If } z = 1 \\ 0 & \textit{otherwise} \end{cases} \qquad (7)$$

We estimate a linear regression model on the amount of land cultivated with coca conditional on a non-zero investment (Equation 7). Coca farming decisions for 2003 and 2005 were treated as independent of one another, so a pooled data set was used. To avoid scale effects, monetary related variables such as profits from coca and the best legal alternative as well as the number of hectares per household, were normalized using natural logarithms.

Econometric Results

Table 2 presents the predicted signs and estimated coefficients for the seemingly unrelated bivariate probit model for the coca-cultivation decision, and participation in agreements of voluntary substitution. The econometric results support the hypothesis of correlation between unobserved characteristics that affect the decision to cultivate coca, and that of participating in agreements of voluntary substitution at the 5% significance level. It is reasonable to think that all farmers face the same market incentives to enter into coca cultivation and that they are all aware of the high levels of profitability in coca cultivation compared with legal forms of production. Therefore, if farmers take different production decisions it must be because they face different opportunities, risks and needs. Econometric results confirm this hypothesis. Those farmers who had more opportunities and participated in VAS were less likely to cultivate coca while farmers that faced higher risks of having coca plants destroyed are significantly less likely to cultivate coca at 5% significance level and farmers with less land have fewer options to make a living from legal forms of production which significantly increases their likelihood of cultivating coca. This suggests that both strategies used by authorities in Colombia to control coca cultivation, i.e. both eradication and alternative development programs, have an effect on coca cultivation.

Interestingly, other non-economic factors can explain the decision about whether to cultivate coca or not, at least to some extent. First, being Protestant, rather than being Catholic, significantly decreases the likelihood of cultivating coca. One interpretation is that this might be the result of a change in attitude towards coca cultivation that has been introduced to the region by the Protestant Churches. This result suggests that authorities can change people's attitudes toward coca cultivation by providing them with information about the negative effect that coca has on the environment, the community, the family and other individuals. Publicity campaigns and educational programs seem to offer some options. Second, we find that farmers living in a municipality with more coca are more likely to cultivate. This result points at the importance on creating social resistance towards coca cultivation and suggest that authorities should use both local and national campaigns. Third, farmers who have a higher level of perceived obligation to comply with the law and the authorities are less likely to cultivate coca. This result indicates that institutional policies can complement alternative development and eradication programs. For example, the creation of participative spaces where farmers and authorities negotiate reducing coca cultivation is an option. Forest Guarding Families (see footnote 7) seem to be a promising option in this respect. However, the authorities will have to bargain over realistic offers if they are to ensure that the agreement will be lasting. The process of eliminating the cultivation of illicit crops has to be gradual in order to allow both farmers and authorities to adjust. Farmers will need to agree to lower levels of income and probably to returning to subsistence agriculture because it is simply not possible for the alternatives to compete in terms of profitability with coca cultivation. The authorities, on the other hand, should work on creating productive options that allow farmers to make a living. The creation of price premiums on labels such as "COCA FREE" could be an alternative. The gradual elimination of illicit crops could also make it possible to generate the social cohesion needed for the negotiation of community agreements on areas free of coca and to implement social control mechanisms. The authorities can gain the trust of the communities by increasing the coverage of the alternative development programs and the efficiency of their implementation.

Other socioeconomic characteristics of the head of a household such as age, gender, level of education, degree of risk aversion and distance from the market are not significant in explaining the decision to cultivate coca. Although not significant, the likelihood of cultivating coca does decrease with age and level of education, while it increases for female respondents, distance from the market and level of risk aversion. Although coca is more risky in terms of having the crops destroyed, legal production faces lower levels of credit availability, harder market conditions and more price variability than coca all of which could explain the positive sign on risk aversion.

Table 2. Seemingly unrelated bivariate probit

Dependent Variables		Coca cultivation Decision			Participation in Agreements of Substitution		
		n = 329			n = 329		
Independent Variables	**Predicted Signs**	**Coef.**		**Std. Err.**	**Coef.**		**Std. Err.**
Log profit coca.	-	-0.162		0.107			
Log profit alternative.	?	-0.025		0.084			
Index of credit availability and commercialization facility	-	0.078		0.075			
Sprayed ha/Total ha with coca in municipality	-	-0.037	**	0.017			
Dummy Atheists		-0.178		0.374	-0.005		0.329
Dummy Protestant		-0.950	***	0.326	-0.183		0.306
Years cultivating coca	+	0.025		0.017	-0.001		0.017
Moral development. Missing response=0; Pre-Conv=1; Conv=2; Post-Conv=3	-	-0.171		0.159	0.124		0.156
Obligation to comply. Completely disagree=1, completely agree=5	-	-0.482	***	0.155	-0.005		0.146
Degree of trust. Not at all=1, a lot=5	-	0.016		0.080	0.193	***	0.074
Dummy participation in community organizations.	-	-0.251		0.204	0.393	**	0.190
Ha with coca/Municipal area.	+	0.345	***	0.063			
Cost of transport (Thousand COL)		0.001		0.034	0.019		0.033
Log land per capita	?	-0.322	***	0.095	0.023		0.095
Age		-0.021		0.042	0.065		0.040
Squared age		0.000		0.000	0.000		0.000
Female		-0.157		0.207	0.268		0.183
Education (None=0,Basic=1, Primary=2, More=3		-0.150		0.414	1.171	***	0.393
Squared education grade		0.089		0.117	-0.233	**	0.109
Coefficient of risk aversion (missing response=0,lover=0.84 to extreme=8		0.015		0.028	-0.076	***	0.025
Dummy missing response level of moral development		1.385	**	0.614	0.700	*	0.402
Dummy missing response for risk aversion		-1.071		1.188			
Constant		4.263	***	1.436	-3.763	***	1.173
Dummy Orito					-1.105	***	0.251
Dummy Puerto Asis					-0.249		0.303
Dummy Valle del Guamuez					-1.295	***	0.351
Rho		-0.340		0.123			
Likelihood-ratio test of rho=0 chi2(1)		6.750		0.009			

*, ** and *** denote statistical significance at 10% 5% and 1% level respectively.

On the other hand, participation in agreements of voluntary substitution –VAS- is explained by the degree of trust in others and participation in community organizations reflecting the strategy that the program used to reach the beneficiaries. Similarly, there is a positive effect of age and education on participation in this program. The negative and significant effect of risk aversion on participation in VAS may reflect a perception among farmers that the substitution program was risky. Finally, farmers living in Orito and Valle are significantly less likely to participate in VAS compared with farmers from Mocoa, which indicates that substitution programs were directed to areas with better accessibility.

Our theoretical model predicts that the effect of economic and non-economic factors will differ according to whether farmers lack options in the legal economy or not. To test the predictions of the model, we run independent regressions for farmers in both groups. Table 3 presents the predicted signs from the theoretical model and the estimated coefficients of a linear regression model on hectares cultivated with coca for both groups. We find that irrespective of whether farmers lack options in the legal economy or not, those who have larger farms cultivated more hectares with coca. This could indicate that the high cost of production restricts smaller farmers from engaging in coca cultivation. We find some evidence for the effect of social norms on the decision to cultivate. Farmers who do not lack alternatives in the legal economy cultivate a larger amount of coca if they live in a municipality with higher levels of coca cultivation. For farmers who lack options in the legal economy, we find that participation in community organizations increases the amount of land that is cultivated with coca. These two effects may indicate a degree of social acceptance of coca cultivation in the area. It is also interesting to note that in the case of farmers who lack alternatives in the legal economy, the perception that there is a higher profit to be made from coca reduces the amount of coca that is cultivated. This could indicate that the coca-cultivation decisions depend on subsistence needs. As coca is more profitable, they can survive with only a few hectares given over to coca cultivation. More evidence for the positive correlation between lack of options and coca cultivation is provided by the positive correlation between the cost of traveling to market and coca cultivation. Other socioeconomic characteristics that are significant in explaining the amount of land cultivated with coca are age and the dummy for female respondents.

Table 3. Linear regression Model

Dependent variable hectares with coca	Do not lack options in the legal economy				Lack options in the legal economy			
	n=106				n=108			
Variables	**Predicted signs**	**Coef.**		**Std. Err.**	**Predicted signs**	**Coef.**		**Std. Err.**
Log profit coca	?	-0.107		0.209	?	-0.222	*	0.116
Log profit Alternative	?	0.135		0.198	?	0.070		0.111
Index of Credit Availability and Commercialization Facility		-0.100		0.130		0.133		0.084
Sprayed ha/Total ha with coca in municipality	-	0.032		0.045	+	-0.031		0.027
Dummy Atheists		-0.549		0.697		-0.565		0.390
Dummy Protestant		-0.505		0.911		0.004		0.572
Years cultivating coca	+	0.019		0.028	?	0.025		0.022
Moral development (Missing response=0; Pre-Conv=1; Conv=2; Post-Conv=3)	-	-0.218		0.295	?	-0.205		0.215
Obligation to comply (Completely disagree=1, Completely agree=5)	-	-0.015		0.234	?	0.093		0.136
Degree of trust (not at all=1, a lot=5)	-	0.222		0.134	?	0.089		0.096
Dummy participation in community organizations	-	-0.173		0.341	?	0.417	**	0.199
Ha with coca/Municipal area	+	0.091	**	0.044	?	0.017		0.024
Cost of transport (Thousand COL)		0.015		0.091		0.064	*	0.035
Log land per capita	+	0.557	**	0.228	?	0.326	**	0.149
Age		-0.030	*	0.017		-0.015	*	0.008
Female		-1.015	**	0.422		-0.183		0.199
Education (None=0,Basic=1, Primary=2, More=3		0.215		0.212		-0.113		0.140
Coefficient of risk aversion	-	0.010		0.046		0.018		0.028
Dummy missing response for moral development		-0.330		0.695		-0.170		0.419
Dummy missing response for risk aversion		dropped				0.446		0.825
Constant		1.909		2.699		3.000	**	1.153

*, ** and *** denote statistical significance at 10% 5% and 1% level respectively.

From a policy perspective, our results suggest that eradication and alternative development are effective in reducing the incentive to start cultivating coca but have a smaller role in affecting the amount of coca that is cultivated.

5. Conclusions

In this paper we explain the decision to cultivate coca and the amount of land that is cultivated both from a theoretical and empirical perspective. We develop a behavioral version of the economic model of crime to explain coca farming decisions.

Our model also considers situations in which farmers cannot make a living from legal activity. Coca is cultivated because it is more profitable than the legal alternatives, but also because this relative profit is tempting enough to compensate for the personal and social disapproval that coca cultivation generates. Therefore, higher moral standards or higher levels of social pressure reduce the likelihood of cultivating coca. This suggests that in addition to policies of eradication and alternative development, authorities can increase the population's awareness of the negative effects of coca cultivation in order to discourage the activity. Authorities can gain better support if policies are regarded as necessary and if the public recognize the efficiency, fairness and transparency in the policies. Increasing coverage of the existing programs and negotiating gradual reductions in areas can be some of the mechanism that authorities can use to gain public's trust. We find evidence that marginality and the impossibility of making a living out of legal activities is a strong factor behind coca cultivation. In this case, the emphasis of the policy should be towards increasing the profitability of legal agriculture by, for example, investing in infrastructure or offering minimum prices for legal products. Our model suggests that farmers reduce coca cultivation in response to both eradication and VAS.

Using self-reported information on an illicit activity such as coca cultivation may underestimate the dimensions of the problem of coca cultivation. However, our intention has been to unveil some of the factors that affect coca cultivation that cannot be studied with aggregated information. We consider that this study is a first step towards understanding the effect of motivational factors on coca cultivation and is meant to be indicative for alternative strategies that could be used by the authorities.

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Appendix A. Model

Coca is cultivated if: $Y = (1-p)U(Y_g) + pU(Y_b) - U(W + \prod_l(L)) > 0$. This implies the following partial effects on the decision of whether to cultivate coca or not.

$$\frac{\partial Y}{\partial \lambda} = ((1-p)U'(Y_g) + pU'(Y_b))(-(1-\gamma)\prod_{\mathrm{i}}) < 0 \tag{1.1}$$

$$\frac{\partial Y}{\partial \gamma} = ((1-p)U'(Y_g) + pU'(Y_b))(-(1-\lambda)\prod_{\mathrm{i}}) < 0 \tag{1.2}$$

$$\frac{\partial Y}{\partial q} = ((1-p)U'(Y_g) + pU'(Y_b))(-t(\overline{a}-\alpha)^2) < 0 \tag{1.3}$$

$$\frac{\partial Y}{\partial t} = ((1-p)U'(Y_g) + pU'(Y_b))(-q(\overline{a}-\alpha)^2) < 0 \tag{1.4}$$

$$\frac{\partial Y}{\partial p} = -U(Y_g) + U(Y_b) < 0 \tag{1.5}$$

$$\frac{\partial Y}{\partial f} = -pU'(Y_b)F_f < 0 \text{ if } \mathrm{F_f} > 0 \tag{1.6}$$

$$\frac{\partial Y}{\partial \pi_l} = ((1-p)U'(Y_g) + pU'(Y_b) - U'(Y_L))\prod_{l\pi l} = ? \tag{1.7}$$

$$\frac{\partial Y}{\partial \pi_i} = ((1-p)U'(Y_g) + pU'(Y_b))\prod_{i\pi i} > 0 \tag{1.8}$$

$$\frac{\partial Y}{\partial W} = (1-p)U'(Y_g) + pU'(Y_b) - U'(Y_L) = ? \tag{1.9}$$

$$\frac{\partial Y}{\partial L} = ((1-p)U'(Y_g) + pU'(Y_b) - U'(Y_l))(\pi_{lL}) = ? \tag{1.10}$$

When both coca and the legal product are cultivated, the first order condition for an interior solution implies:

$$\begin{aligned}\frac{\partial \mathrm{V}}{\partial \alpha_i} &= (1-p)U'(Y_g)((1-\lambda)(1-\gamma)\pi_i - \pi_l - 2qt(\alpha-\overline{a}) - \lambda'(1-\gamma)\prod_{\mathrm{i}}) + \\ &\quad pU'(Y_b)((1-\lambda)(1-\gamma)\pi_i - \pi_l - 2qt(\alpha-\overline{a}) - \lambda'(1-\gamma)\prod_{\mathrm{i}} - f) \\ &= A + B = 0\end{aligned} \tag{3.1}$$

Where:

$\frac{\partial \prod_k}{\partial \alpha} = \pi_k > 0$ for k = i,l $\quad \frac{\partial F}{\partial \alpha} = f > 0 \quad \frac{\partial U(Y_z)}{\partial \alpha} = U'(Y_z)$ for z = g, b

$$A = (1-p)U'(Y_g)((1-\lambda)(1-\gamma)\pi_i - \pi_l - 2qt(\alpha - \overline{a}) - \lambda'(1-\gamma)\prod_{\text{i}}) > 0$$

$$B = pU'(Y_b)((1-\lambda)(1-\gamma)\pi_i - \pi_l - 2qt(\alpha - \overline{a}) - \lambda'(1-\gamma)\prod_{\text{i}} - f) < 0$$

The second order condition for maximization implies:

$$\frac{\partial^2 V}{\partial \alpha^2} = (1-p)U''(Y_g)a^2 + pU''(Y_b)b^2 + (1-p)U'(Y_g)a' + pU'(Y_b)b' = \Delta < 0 \qquad (3.2)$$

Where,

$$a = ((1-\lambda)(1-\gamma)\pi_i - \pi_l - 2qt(\alpha - \overline{a}) - \lambda'(1-\gamma)\prod_{\text{i}}) > 0$$

$$b = ((1-\lambda)(1-\gamma)\pi_i - \pi_l - 2qt(\alpha - \overline{a}) - \lambda'(1-\gamma)\prod_{\text{i}} - f) < 0$$

$$\frac{da}{d\alpha} = a'; \frac{db}{d\alpha} = b';$$

Deriving equation (3) with respect to α and λ and solving we obtain:

$$\frac{\partial \alpha}{\partial \lambda} = \frac{1}{\Delta}\left[((1-p)U''(Y_g)a + pU''(Y_b)b)(1-\gamma)\prod_i + ((1-p)U'(Y_g) + pU'(Y_b))((1-\gamma)\pi_i + \lambda'_\lambda (1-\gamma)\prod_i)\right]$$

$$= \frac{1}{\Delta}\left[(1-\gamma)\prod_i (R(Y_g) - R(Y_b))B + ((1-p)U'(Y_g) + pU'(Y_b))((1-\gamma)\pi_i + \lambda'_\lambda (1-\gamma)\prod_i)\right]$$

where, $R(Y_z)$ is the coefficient of absolute risk aversion, $R(Y_z) = -\frac{U''(Y_z)}{U'(Y_z)}$. We assume that if subsistence is covered, U”<0 farmers have decreasing absolute risk aversion – DARA-, $R(Y_b) > R(Y_g) > 0$. If subsistence is under threat, we consider that U”>0 and assume decreasing absolute risk preferences – DARP- , $R(Y_b) < R(Y_g)$.<.0.

$$\frac{\partial \alpha}{\partial \lambda} \text{ is} \begin{cases} < 0 & \text{if U''} < 0; \text{DARA} \\ ? & \text{if U''} > 0; \text{DARP} \end{cases} \qquad (4.1)$$

Similarly, it is possible to show that

$$\frac{\partial \alpha}{\partial \gamma} = \frac{1}{\Delta}\left[(R(Y_g) - R(Y_b))B(1-\lambda)\prod_i + ((1-p)U'(Y_g) + pU'(Y_b))((1-\lambda)\pi_i - \lambda'\prod_i)\right]$$

$$\frac{\partial \alpha}{\partial \gamma} \text{ is} \begin{cases} ? & \text{if U''} < 0; \text{DARA} \\ ? & \text{if U''} > 0; \text{DARP} \end{cases} \qquad (4.2)$$

$$\frac{\partial\alpha}{\partial q} = \frac{1}{\Delta}\left[(R(Y_g) - R(Y_b))B(t(\overline{\alpha} - \alpha)^2) + ((1-p)U'(Y_g) + pU'(Y_b))2t(\alpha - \overline{a})\right]$$

$$\frac{\partial\alpha}{\partial q} \text{ is} \begin{cases} <0 & \text{if U''}<0;\text{DARA} \quad \overline{a}<\alpha \\ ? & \text{if U''}<0;\text{DARA} \quad \alpha<\overline{a} \\ ? & \text{if U''}>0;\text{DARP} \quad \overline{a}<\alpha \\ >0 & \text{if U''}>0;\text{DARP} \quad \alpha<\overline{a} \end{cases} \tag{4.3}$$

$$\frac{\partial\alpha}{\partial t} = \frac{1}{\Delta}\left[(R(Y_g) - R(Y_b))B(q(\overline{\alpha} - \alpha)^2) + ((1-p)U'(Y_g) + pU'(Y_b))2q(\alpha - \overline{a})\right]$$

$$\frac{\partial\alpha}{\partial t} \begin{cases} <0 & \text{if U''}<0;\text{DARA} \quad \overline{a}<\alpha \\ ? & \text{if U''}<0;\text{DARA} \quad \alpha<\overline{a} \\ ? & \text{if U''}>0;\text{DARP} \quad \overline{a}<\alpha \\ >0 & \text{if U''}>0;\text{DARP} \quad \alpha<\overline{a} \end{cases} \tag{4.4}$$

$$\frac{\partial\alpha}{\partial p} = \frac{-1}{\Delta}\left[-U'(Y_g)a + U'(Y_b)b\right] \; <0 \tag{4.5}$$

$$\frac{\partial\alpha}{\partial f} = \frac{1}{\Delta}\left[pU''(\text{Y}_{b.})\text{bF}_\text{f} + pU'(Y_b)\right] \text{ is } \begin{cases} <0 & \text{if U''}<0 \\ ? & \text{if U''}>0 \end{cases} \text{ for F}_\text{f}>0 \tag{4.6}$$

$$\frac{\partial\alpha}{\partial\pi_l} = \frac{1}{\Delta}\left[-(R(Y_g) - R(Y_b))B\prod\nolimits_{\pi l} + (1-p)U'(Y_g) + pU'(Y_b)\right]$$

$$\frac{\partial\alpha}{\partial\pi_l} \text{ is} \begin{cases} ? & \text{if U''}<0;\text{DARA} \\ <0 & \text{if U''}>0;\ \text{DARP} \end{cases} \text{ if } \prod\nolimits_{\pi l}>0 \tag{4.7}$$

$$\frac{\partial\alpha}{\partial\pi_i} = \frac{-1}{\Delta}\left[(R(Y_g) - R(Y_b))B(1-\lambda)(1-\gamma)\prod\nolimits_{i\pi_i} + ((1-p)U'(Y_g) + pU'(Y_b))((1-\lambda)(1-\gamma) - \lambda'(1-\gamma)\prod\nolimits_{i\pi_i}\right]$$

$$\frac{\partial\alpha}{\partial\pi_i} \text{ is} \begin{cases} ? \text{ if U''}<0;\text{DARA} \\ ? \text{ if U''}>0;\ \text{DARP} \end{cases} \text{ if } \prod\nolimits_{i\pi_i}>0 \tag{4.8}$$

$$\frac{\partial\alpha}{\partial W} = \frac{-1}{\Delta}\left[(R(Y_g) - R(Y_b))B\right] \text{is} \begin{cases} >0 \text{ if U''}<0;\text{DARA} \\ <0 \text{ if U''}>0;\text{DARP} \end{cases} \tag{4.9}$$

$$\frac{\partial\alpha}{\partial L} = \frac{-1}{\Delta}\left[(R(Y_g) - R(Y_b))B\prod\nolimits_{lL} - ((1-p)U'(Y_g) + pU'(Y_b))(\pi_{l,L})\right]$$

$$\frac{\partial \alpha}{\partial L} \text{ is} \begin{cases} >0 \ \text{ if U"} < 0; \text{DARA} \\ ? \quad \ \ \text{if U"} < 0; \text{DARP} \end{cases} \text{ when } \prod_{lL} > 0; \pi_{l,L} < 0 \qquad (4.10)$$

Appendix B. Survey

A choice experiment on coca cropping[12]

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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, since little is known about the effectiveness of policies targeting coca cultivation, this paper evaluates the efficiency of the two main ones: 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-economic factors that affect the coca cultivation decision. Social norms, legitimacy, and poverty are found to be affecting coca cultivation. The analysis concludes that it is more cost-efficient to spend money on increasing the risk of eradication than on alternative development, although any potential negative external effects of eradication are ignored.

Keywords: Illegal drugs, Choice experiment, Colombia.

JEL classification: G11, K42, Z12, Z13

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1. Introduction

Cocaine is the most commonly consumed illegal drug in the world after marijuana. Around 13 million people use it, and contrary to what many believe, cocaine consumption is a problem in both developed and developing countries (UNDCP, 2005). Cocaine production, on the other hand, is highly concentrated; more than 98% of the total cultivated area is located in Colombia, Peru, and Bolivia. In the 1980s, following three international conventions on narcotic drugs (UN, 1961, 1971, 1988) a campaign against transformation and trafficking of drugs was initiated in Colombia. Despite the successful dismantling of the two main Colombian drug cartels the Colombia cocaine production started a dramatic growth, from less than 10% of the total production areas in the early 1990's production increased to 74% in 2000. As a response, policies of eradication and alternative development were implemented to control coca cultivation. Eradication, or destruction, of coca plants by aerial spraying of herbicides or by pulling the plants manually aims at increasing the risk of cultivating coca. Alternative development, on the other hand, aims at increasing the profitability of legal crops by investing in infrastructure and providing subsidized credits and technological support. An astonishing 5.2 billion USD was spent on the war on drugs in Colombia between 1997 and 2005, but the production of cocaine nevertheless increased from 350 to 640 tons during the same period (ONDCP, 2006; UNDCP, 2006). Although the cost of anti-drug policies constitutes 1% of the Colombian GDP, surprisingly little is known about the effectiveness of the Colombian anti-drug policies. This paper contributes to the limited literature that evaluates the effectiveness of eradication and alternative development to control coca cultivation. To study economic and non-economic factors behind participation in the illegal coca production, we use unique household level data on Colombian farmers.

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 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.[14] 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 effect of economic and non-economic factors on coca cultivation. We use 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; Calvó-Armengol and Zenou, 2004; Garoupa, 2003 ; Frey, 1997; Elster, 1998), (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 the model, Section 3 the survey design, and Section 4 the econometric model. Section 5 reports the results, and Section 6 concludes the paper.

[14] 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.

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; Ehrlich, 1973; Allingham and Sandmo, 1972). Farmers decide how to allocate their land and labor 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. This loss is represented by the cost *F*.[15] Following the traditional models of crime, farmers will cultivate coca if the expected marginal profit from coca cultivation, Π^{Coca}, net of the opportunity cost of cultivating coca, $\Pi^{Alternative}$, is greater than the expected marginal cost of having the plants destroyed, *pF*. In addition, the models imply that the amount of land cultivated with coca depends not only on expected costs and benefits but also on a farmer's risk preferences.

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 (e.g., Frey and Torgler, 2004; Cohen, 1999; Andreoni *et al.*, 1998). To explain the departure from self-interested behavior in the rational choice models, the behavioral models of crime consider other non-economic factors affecting participation in illegal activity. For example, Elster (1989), Posner (1997) and Bowles and Gintis. (1998) propose that in addition to economic 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), Torgler (2002), and Sutinen and Kuperan (1999), 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 Frey, 2005; Feld and Tyran, 1990). People's compliance increases when they perceive the authorities and the law to

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

be fair, and when they participate in deciding the law. In summary, the supply function of coca, C, is

$$C = f(\Pi^{Coca}, \Pi^{Alternative}, p, F, S, M, L),$$

where S refers to social norms, M to morality, and L to legitimacy or acceptance of the authorities.

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 land holdings, profitability of coca and the best alternative, and perceptions of coca cultivation. In addition, to capture the effect of non-economic factors and individual socioeconomic characteristics, the survey included the Moral Judgment Test (Lind *et al.*, 1985), attitudinal questions on coca production and anti-drug policies, and a risk experiment. 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. 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 or buy land to establish coca crops. 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 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 ……

Each participant answered at most the nine choice sets described in Table 1. They combined three 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.

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

The profit of the best alternative was customized according to the actual situation for the farmer using 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.

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

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 "Not likely 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.

Table 3. Conversion table for 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)	-	Not likely at all (0)	Not too likely (2)
Not too likely (2)	Very Unlikely (1)	Not likely at all (0)	More or less likely (3)
More or less likely (3)	Not too likely (2)	Not likely at all (0)	Likely (4)
Likely (4)	More or less likely (3)	Not likely at all (0)	Very likely (5)
Very likely (5)	Likely (4)	Not likely at all (0)	-

Non-economic factors and socioeconomic characteristics

Following the behavioral models of crime, non-economic 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.

<u>Social norms</u>

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).

<u>Ethics/morality</u>

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:

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

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

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	7.500 – 3.615
2	1 000 000	800 000	2 400 000	3.615 – 1.189
3	1 000 000	600 000	3 000 000	1.189 – 0.506
4	1 000 000	200 000	3 800 000	0.506 – 0.168
5	1 000 000	0	4 000 000	0.168 – 0.000

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.[16] The expected indirect utility of coca cultivation for individual i in choice situation t is given by:

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

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:

[16] 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.

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

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:

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

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:

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

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:

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

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. Using the Mann-Whitney test, we cannot reject the null hypothesis of equal distribution of the relative profitability among municipalities at the 5% level, except for Puerto Asis with a significantly lower perceived relative profitability of the alternative than Valle. We cannot reject the null hypothesis of equal distribution of the relative profitability between coca and non-coca farmers at the 1% significance level using the Mann-Whitney test except for Mocoa, where non-coca farmers overestimate the 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 at the 5% level in Mocoa (2.75) and Orito (3.62) compared with Puerto Asis (4.29) and Valle del Guamuez (6.5). 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 have the same perceptions of the eradication risk. Using the Mann-Whitney test, we cannot reject the null hypothesis of equal distribution of the perceived risk between coca and non-coca farmers in each municipality at the 1% significance level.

Table 5. Descriptive statistics

Variable	Description	Mean	St Dev
Perceived risk of eradication in 2005	Risk of having crops destroyed. 1 = very unlikely, 5 = very likely.	3.883	1.457
Relative profitability of alternative in 2005	Profit best alternative / Profit coca.	0.470	0.899
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
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
Atheist	= 1 if respondent is atheist.	0.077	0.267
Protestant	= 1 if respondent is Protestant.	0.124	0.329
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
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 in the degree of relative risk aversion.	3.271	3.514
Inconsistent risk	Risk preference for prospect B and A changed more than once.	0.175	0.380
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

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.

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 at the 1% level were found in the level of moral development between coca and non-coca farmers using the proportion test. 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. 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 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-economic variables significantly affect the likelihood to cultivate coca.

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

	Random effects probit		Linear random effects	
Dependent variable	Dummy Coca		Ha 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	

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 associated with coca in terms of possibility to sell the product, price stability, and access to productive credits. 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 test

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 acting in an inconsistent manner. We estimated the model after removing inconsistent responses, and the results were similar. The absolute values of marginal effects for the risk and profit attributes are somewhat larger in the probit model and smaller in the linear model. The only important difference is that the marginal effect of the 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. Using the proportion test, we cannot reject the null hypothesis of equality between the actual and predicted proportions of farmers who cultivated coca in 2005, but we can reject the null hypothesis at the 1% significance level for 2003. Using the t-test, we also reject the null hypothesis of equal means of self-reported and predicted hectares with coca in 2003 and 2005. 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.

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	**Proportion of coca farmers** **P(crop)**		**Hectares with coca per farmer** **Ha Coca conditional on cultivating**	
	Self-reported (1)	**Predicted (2)**	**Self-reported (1)**	**Predicted (2)**
2005	0.430 (0.496)	0.401 (0.491)	1.319b (1.223)	1.870b (1.118)
2003	0.665a (0.473)	0.511a (0.501)	1.649c (1.343)	2.156c (1.170)

a: Significant differences at the 10% level using the proportion test. b, c: Significant differences at the 10% level using the t-test.

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 profits 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 great 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 spraying.

Compared with self-reported behavior in 2005, we find that increasing the risk of destroying the crops significantly does decrease the proportion of farmers who would cultivate coca but does not significantly decrease the number of hectares cultivated with coca. 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.

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)	0.55a (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)	0.51a (0.5)	0.31b (0.47)	3.45 (4.33)	2.14 (1.95)	1.52c (1.39)
Higher profitability of alternative than today	0.52 (0.5)	0.43 (0.5)	0.27b (0.44)	3.1 (3.66)	2.09 (2.29)	1.76c (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.

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 elasticity. Table 9 reports the elasticities of eradication and alternative development estimated from our econometric model. The risk level and relative profitability were evaluated at the 2005 mean and median values. In addition to the elasticities of the probability to crop and the conditional amount of coca, we report the elasticity for the unconditional amount of coca. The total marginal effect was calculated as:

$$\frac{\partial E[Ha_i]}{\partial x_i} = \frac{\partial P[Crop_i = 1]}{\partial x_i} E[Ha_i \mid Ha_i > 0] + \frac{\partial E[Ha_i \mid Ha_i > 0]}{\partial x_i} P[Crop_i = 1], \quad (6)$$

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

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

	Probability Crop Coca P(Crop)	**Hectares with Coca** Ha Coca conditional on cultivating	**Hectares total**
Risk of Eradication	-0.456 (0.050)	-0.464 (0.039)	-0.392 (0.029)
Profit Alternative	-0.074 (0.011)	-0.095 (0.023)	-0.105 (0.013)

After controlling for non-economic factors that affect the decision to cultivate coca and the number of hectares to be cultivated, we find that a 1% increase in the risk of having the crops destroyed decreases the total desired number of hectares by 0.39 percent. This elasticity is larger than the elasticity of the alternative crop profit (0.10), indicating that eradication is more effective than alternative development. However, from a policy perspective it is more 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.

Between 2003 and 2005, the average perceived risk of eradication increased by 32% (from 2.93 in 2003 to 3.88 in 2005). According to the estimated elasticity (0.39 percent), this change implies a decrease in the number of hectares with coca by 12.7%. During the same period, the government sprayed an additional 1,800 hectares in the sampled municipalities. Assuming that the increase in perceived risk is only due to the spraying, and considering that the estimated cost of spraying one hectare is 640 USD (Logan, 2006), the total cost of decreasing the number of hectares is 1.15 million USD Let us compare this cost with the cost of achieving the same reduction using alternative development. To achieve a 12.7% reduction in the total amount of hectares, the relative profit of the alternative must increase by 121.7%. That is, the profit per hectare per year from the alternative should increase by 320 USD (from 250 USD to 570 USD). Table 10 presents the estimated cost of alternative development depending on the number of hectares covered in the program. The decision on the number of hectares to target is a difficult issue. For example, should the government target the currently cultivated hectares (3,000 ha) or instead subsidize all agricultural land (270,000 ha)? In any case, it is only under rather restrictive assumptions that the subsidy would be more cost effective than increased spraying, as seen in Table 10.

Table 10. Cost of alternative development.

Number of hectares covered by the increase in profit from alternative product	Total cost in USD.
3,000	960,000
40,000	12,789,415
130,000	41,565,597
270,000	86,328,548

If the profit per hectare per year increases by 320 USD

Some warnings regarding this simplified analysis are relevant. We are comparing policies based only on financial cost, but if we consider the non-economic 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 effectiveness of 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-economic 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. While our econometric model gives an accurate estimative of the proportion of farmers who self-report cultivating coca, the predictions on the number of hectares are less accurate.

From a policy perspective, we found that the risk of eradication elasticity is higher than the relative profitability elasticity, suggesting that eradication is more effective than alternative development. From an efficiency point of view, taking the costs of the two policies into account, the difference between them is even stronger: spending the money on increased eradication risk is likely to have a larger effect on the amount of coca than spending the money on alternative development.

In our analysis, we have 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 and economic conditions. In addition, 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, although this task may be too demanding considering our low-educated sample. This study contributes to the limited body of literature evaluating anti-drug policies against coca cultivation and, despite its multiple limitations; we do consider it to be relevant for policy purposes.

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Carrots or sticks to reduce coca cultivation?

- A framed field experiment with farmers in Colombia [#]

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Abstract

We investigate the effect of different combinations of carrot and stick policies on coca investment among farmers in coca growing areas in Colombia by applying a public bad experiment that mimics coca cultivation. The experiment indicates that subjects are more responsive to changes in the relative profit of cattle farming than to changes in the probability of coca eradication. Moreover, we find evidence that behavior in the experiment is consistent with self-reported behavior, namely that in addition to economic incentives, social norms, religious beliefs and poverty also explained coca investments

Keywords: Coca; Colombia; Experiment; Public Bad.

JEL classification:, C93, D62, K42

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1. Introduction

The "War on Drugs" was initiated by the US president Richard Nixon who labeled drug abuse as "America's public enemy number one". In order to combat cocaine production a strong policy to reduce coca cultivation was introduced in Colombia, the world's leading producer of coca (the base for cocaine) (DNE, 2005). The policy against coca cultivation use two main strategies: (i) a stick policy whereby coca plants are eradicated by aerial fumigation as well as by pulling up plants manually (ii) a carrot policy that aims to increase the relative profit between non-coca agricultural activities and coca cultivation by implementing alternative development programs (e.g. investment in infrastructure, subsidized loans, technological advice).[17] Although one billion dollars has been spent annually on campaigns against coca cultivation, especially on aerial fumigation, little is known about the effects of eradication, alternative development programs or the motivational factors behind coca cultivation.

One of the problems encountered in the analysis of coca cultivation and the evaluation of how effective different policies against coca cultivation are, is the lack of data at the individual level. The few empirical studies that do exist have used data at the municipal level to investigate the effectiveness of different supply control measures on coca cultivation. The overall results from these studies show that alternative development programs have had a significant impact on reducing coca cultivation, but that aerial fumigation programs have not (e.g.; Carvajal, 2002; Moreno et al, 2003; Díaz and Sánchez, 2004; Moya, 2005 and Tabares and Rosales). However, revealed data does not provide information on behavior for policy levels that are outside the ranges that have been used historically. One alternative for obtaining individual information on coca investment decisions at different levels of alternative development (carrots) and eradication (sticks) is to use what Harrison and List (2004) classified as a framed field experiment. The basic idea of the framed field experiment is to impose a controlled environment in a situation that is not unnatural for participants. Using a framed experiment with subjects who are faced with cultivation decisions in real-life has the added benefit of allowing motivational factors behind coca investments to be included

[17] In recent years alternative development has also used voluntary agreements that consist of monetary subsidies in exchange for an undertaking not to cultivate coca (DNE, 2005).

in the analysis (e.g. morality, religious beliefs, poverty). We use complementary survey information to capture those factors.[18]

The objective of this paper is to investigate how the decision to invest in coca changes when the relative profit from the alternative development programs (carrot policies) and the probability of eradication (stick policies) varies using a framed field experiment that mimics real-life situations. The subjects of our study were farmers living in Putumayo, a region in Colombia with a long tradition of coca cultivation. We also use additional survey information in order to compare experimental and self-reported behavior and interpret the results in terms of policy implications.[19]

The use of experiments to capture compliance is not new, having mostly been applied to studying the effects of the severity and probability of punishment (e.g. Alm *et. al*. 1992a, 1992b, Anderson and Stafford, 2003; Trivedi *et al*., 2003, 2005, Cardenas *et al*., 2000) but disregarding the effects of positive and negative incentives. Our research contributes to the limited experimental literature on carrots and sticks, when both mechanisms are exogenous. For example Sefton *et al.* (2000) find that both rewards and sanctions increase cooperation in a public goods game but only sanctions are effective in sustaining cooperation. Sutter et al. (2006) find that endogenously chosen institutions, whether they imply positive or negative incentives, increase cooperation more than when they are exogenously imposed. However, none of the above papers consider mixing positive and negative incentives that are imposed exogenously. This paper also contributes to the literature on the relationship between behavior in the lab and in the field (e.g. Barr and Serneels, 2004; Cardenas and Ostrom, 2004; Carpenter and Seki, 2004; Levitt and List, 2007; Karlan, 2006: Potters and van Winder, 2000) by investigating the motivational factors behind coca investments in both settings.[20]

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[18] For example, Eckel and Grossman (1996) and Loewenstein (1999) argue that a non-neutral framing is needed in experiments where social context plays an important part in the problem under investigation . Moreover, in a sample with a low level of education, as in our case, a non-abstract description also has the benefit of making the task less complex.

[19] In our study, we focus on the mechanisms available for Colombian authorities to reduce coca cultivation by using exogenous institutions, and hence we do not consider the effect of endogenous mechanisms of social control (e.g. Ostrom et al., 1992; Fehr and Gächter, 2000). In addition, we do not consider the scenario of legalizing drugs as it is politically unfeasible.

[20] A growing body of literature that indicates that motivational factors as social norms (e.g. Glaeser et al., 1996; Akerlof, 1997; Calvó and Zenou, 2004, Garoupa 2003), morality (Eisenhauer, 2004, Sutinen and Kuperan 1999, Hatcher et al. 2000) and acceptance by the authorities (Tyler, 1990, Kuperan and Sutinen, 1998; Feld and Tyran, 2002) affect compliance with the law.

The rest of the paper is organized as follows. In section 2 we describe the main features of coca cultivation in the field and in section 3 we present our experimental design and predictions. Section 4 describes the procedure used and Section 5 presents our results. Finally, Section 6 concludes the paper.

2. The field context

The Department of Putumayo in southern Colombia is a region with one of the longest traditions of coca cultivation in the country to the extent that, in 2000, two fifths of Colombia's coca-growing areas were located there. Following a strong eradication campaign during 2002 and 2003, and also as the result of the establishment of Voluntary Agreements of Substitution, the number of coca-growing areas dropped. Even so, by 2005 one tenth of Columbia's coca-growing areas were still located in this department. Other agricultural activities in Putumayo are cattle farming and the cultivation of plantain, cassava and tropical fruits. Depending on the soil condition and technology applied, the monetary profit from investments in non-coca activities are approximately 20% to 85% of the profit from coca cultivation (Forero *et al.*, 2002). In the survey that we conducted parallel to the experiment, farmers stated an average profit of 1,402 USD per hectare of coca compared with an average profit of 391 USD for cattle farming in 2005, which implies a relative profit for cattle farming of 0.28. In contrast, the relative profit was 0.14 in 2003. This low relative profit reflects the rural location of Putumayo, where farmers have few possibilities to sell their products.

Following the 1961 "International Convention on Narcotics and Drugs", the cultivation, processing and trafficking of coca was prohibited in Colombia (UN, 1961). As a response to the increase in coca production during the 90s, the Colombian authorities approved the use of aerial spraying to destroy coca fields and more recently implemented the manual destruction of coca plants. Between 1999 and 2005 the number of sprayed hectares in Putumayo was 210,244 with 200,004 hectares being dedicated to coca- cultivation. Considering that in order to eradicate one hectare of coca it is necessary to spray 3 to 8 hectares to exterminate the plants completely, the probability of eradication is estimated to be between 13% and 35% (DNE, 2006).[21] While the law

[21] The probability of eradication is estimated as the number of hectares destroyed divided by the total number of hectares cultivated with coca. The number of destroyed hectares is estimated by dividing the

prescribes imprisonment for cultivating coca, this is rarely enforced since it is difficult to capture the owners of the fields, thus the supply control focuses on eradication.

Another characteristic of coca cultivation is that it generates negative externalities for the society. In addition to the health and social problems from coca and cocaine consumption *per se*, the pesticides and chemicals that are used in coca cultivation and the processing of coca leaves into cocaine contaminate the water and soil. In response to increased eradication and poor soil quality on old plots, coca farmers often relocate their coca plantations into forested areas where trees must be cut down which in turn often leads to erosion problems in the future. Another negative effect is caused by the spraying since the chemicals use to eradicate the coca often hit non -targeted areas such as non-coca crops, water sources and occasionally residential areas. In addition, in the backwash of coca cultivation, there is increased violence from disputes between armed groups over the control of coca intermediation. Moreover, the increased income due to coca cultivation has also led to a larger proportion of people carrying weapons, increased numbers of robberies that are sometimes fatal, as well as an increased level of alcohol consumption due to increased income. Perez et al. (2002) estimated that the average annual cost of illicit drugs in Colombia was about one billion dollars or the equivalent to 1% of the GDP.

3. Experimental design

In the experiment we used a framed public bad experiment in which we form random groups of five farmers. Each farmer is endowed with 10 tokens that represent the amount of land, labor and capital that are available to them to invest in agricultural activities and their task is to decide how many tokens to invest in coca cultivation and cattle farming respectively. The three key features of coca cultivation included in the public bad experiment are: (i) coca production is more profitable than cattle farming, (ii) there is a probability that the coca plants will be eradicated by the authorities, and (iii) coca production generates negative externalities (see the protocol used in the experiment in Appendix A).

In the experiment, each unit invested in coca cultivation yields a return of one, while investment in cattle farming gives a return of less than one, mimicking the fact

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number of sprayed hectares by the number of times that one hectare needs to be sprayed in order to be destroyed.

that investment in coca cultivation yields a higher profit than investments in cattle farming. Based on observations from real-life and likely future levels, we included the following three levels of relative profits between cattle farming and coca cultivation; 0.2, 0.44 and 0.68.

However, investment in coca cultivation is a risky decision since the plantation can be detected and subsequently eradicated. Since successful eradication is not certain, we introduce the probability of successful eradication. We applied the following three levels of successful eradication: 0%, 10% and 30%. These levels correspond to real life values. If coca plants are sprayed, farmers collect and process the leaves to sell them, but the coca plantation is lost, and the sprayed land cannot be used for any crops in the near future. For each unit invested in coca when eradication is successful, the resulting effect is a loss of income of 1.2 tokens in the experiment.[22] We keep the loss of income from eradication constant as the authorities can not usually do more harm than destroying the coca fields.

The third specific feature of coca cultivation is that it generates negative externalities such as environmental damage and social problems that affect everyone in the community.[23] These effects were included in the experimental design by making each unit of coca cultivation generated by any one member reduce the income by 0.17 for every person in the group including the one who made the investment.[24] To explain these effects to the subjects, we stated that these costs relate to the increased violence and environmental problems that arise from increased coca production. As we used three levels of probability for eradication and three levels of relative profit, each farmer participated in 9 one-shot experiments. The expected pay-off for subject *i* can then be expressed as

$$\pi_i = (1-p)\,(c_i + a(10-c_i) - 0.17\sum_{i=1}^{5} c_i) + p(c_i + a(10-c_i) - 0.17\sum_{i=1}^{5} c_i - 1.2c_i)\,,$$

where p is the probability of eradication, c_i is the amount invested in coca cultivation and a is the relative profit. The parameters included in the experiment ensure a social

[22] What we framed as a payment could also be phrased as a fine. The effect is the same, but to replicate reality in Colombia, it is better to use the wording payment.

[23] The best alternative, cattle farming, also has negative environmental impacts related with soil erosion and deforestation, but our main interest is to capture the effect of the illegality of coca.

[24] It would also be of interest to investigate the effect of different magnitudes of loss of income and negative externality, but we preferred to keep the design as simple as possible given that it is already rather complicated with 9 different decisions.

dilemma situation since the social cost related to the negative externality is 0.85 (0.17*5=0.85), which is larger than the private benefit (1-a), where a varies between 0.2 and 0.68. Differentiating with respect to c_i yields the first order condition for a risk-neutral individual who maximizes expected utility

$$\frac{d\pi_i}{dc_i} = (1-p)(1-a-0.17) + p(1-a-0.17-1.2) = 0.$$

Thus, it is expected that a subject who is a self-interested utility maximizer and who is risk-neutral will make a non-zero investment in coca if $1-a-0.17-1.2p > 0$. Table 1 summarizes the marginal profit from coca cultivation in all the nine treatments applied in the experiment, with the treatments being labeled *A* to *I*. As can be seen from the table, coca cultivation results in positive marginal benefits in all cases except treatment *I*. Thus a risk-neutral subject who maximizes the expected utility of the profit function given above will invest fully in coca cultivation in all cases except *I*, where nothing would be invested instead.

Table 1. Marginal incentives to cultivate coca.

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

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

To reduce the cognitive burden on the farmers, we provided them with pay-off tables based on the layout in Cardenas *et al.* (2000) (see appendix B). In the pay-off table, the columns indicate the total investment in coca made by a particular farmer him or herself while the rows show different levels of total investment in coca made by others. Thus, by making an assumption about other people's investments in coca as well as about that farmer's own investment, the monetary outcome in Colombian Pesos can be read directly from the pay-off table. Each experimental token was converted to 1,250 Colombian Pesos; in addition, participants received a show-up fee of 15,000 Colombian

Pesos to cover any losses that might arise from the experiment as well as to compensate them for their time.[25] A separate pay-off table was provided for each of the relative profits. In the situations where there is a probability of eradication, it was explained that a lottery would be used to determine whether eradication would take place, in which case their pay-off would be reduced by 1,500 Colombian Pesos for each token invested in coca compared with the figures shown in the pay-off table. The average earnings in the experiment were 19,227 pesos and the minimum and maximum earnings were 7,000 and 25,100 respectively compared with a daily wage of 15,000 Colombian Pesos.

There is extensive experimental evidence that a large proportion of subjects are conditional cooperators, i.e. they contribute if others contribute and vice versa (e.g. Sugden, 1984; Fehr *et al*. 1997; Fichbacher *et al*., 2001; Falk and Fischbaher, 2002; Falk *et al.*, 2004; Fischbacher and Gächter, 2006).[26] In order to analyze how much the cultivation decisions of others, affect the subject's own contribution, we elicited the subject's beliefs about how much others invested in coca cultivation. To motivate thoughtful thinking, we gave monetary rewards for correct guesses (e.g. Gächter and Renner, 2006; Sonnemans et al., 2001). Those who correctly guessed the amount invested by others received 1.6 tokens and those whose guesses were only one or two tokens wrong obtained 1.2 or 0.8 tokens respectively.

4. Experimental procedure

The experiment was conducted in four different municipalities in the Department of Putumayo; Orito, Mocoa, Valle del Guamuez and Puerto Asis in June 2006. The recruitment procedure was similar in all four municipalities, where the local leaders invited people of their community to a meeting with university researchers to discuss coca and alternative production. The meetings consisted of two sections; a morning session and an afternoon session both on the same day. During the morning session, the subjects were interviewed individually, while in the afternoon session we conducted the experiments. On average each interview lasted for one hour, while each experimental session lasted for approximately two hours.

[25] At the time of the experiment 1 USD was equal to 2,200 Colombian Pesos.

[26] Similarly, a tendency towards negative cooperation is found in e.g. Ostrom et al. (1992) and Fehr and Gächter (2000) where non-cooperators are punished despite the fact that there is a cost involved in the punishment.

The experimental session consisted of five stages. First, the instructions of the modified public bad experiment were read aloud to the subjects (see Appendix A), followed by several examples and individual exercises. To check for subjects' understanding of the experiment an enumerator accompanied them verifying that they understood their task. Then, the subjects simultaneously decided how much they wanted to invest in coca and how much they expected others to invest in each of the nine treatments, where the probability of eradication and relative profits varied as described above. In the third stage, we used a lottery, where each treatment had the same chance of being selected, to decide randomly which of the nine treatments would be paid by. If a treatment with a positive probability of eradication was selected, then a second lottery was used to determine if successful eradication took place. The outcomes from these two lotteries are common to everyone. This mimics the actual situation since both relative profits and successful eradication are normally the same for people living close to each other. Finally, all subjects were paid privately using checks made payable to them in the local store.[27] Afterwards, following similar procedures as applied by Cardenas and colleagues (e.g. Cardenas et al., 2000), there was a group discussion on the experiment and its similarity to real life.

The morning sessions consisted of individual interviews. The interviews were anonymous and in order to encourage honest answers we did not ask names, addresses or any other identifying information. To match survey and experimental information we used identification numbers with the date of birth or any other number that they could remember. The survey consisted of a battery of standard questions on socioeconomic characteristics and some specialized questions for our research relating to how much coca they cultivated in 2003 and 2005, risk preferences, moral development and legality, or acceptance of the authorities and the law.

Risk preferences were elicited by a hypothetical risk experiment based on the design in Binswanger (1980). In this design, subjects were asked to choose between a safe alternative and an alternative with two outcomes one of which had a lower pay-off than the safe alternative and the other a higher pay-off. The probability of selecting each of the outcomes was 50%. Each farmer was asked to make five such choices, where in each subsequent choice presented to them both the expected pay-off and its variance

[27] It would have been better to use cash, but for practical reasons we preferred to avoid carrying large amounts of cash.

increased in the risky alternative. The point at which the subject chose to switch from the risky to the safe alternative allowed us to calculate the degree of risk aversion, where we assumed a constant partial relative risk aversion utility function.

According to Colby and Kohlberg (1987), the individual level of moral development affects law compliance.[28] To determine the level of moral development, the Moral Judgment Test developed by Lind et al. (1985) was used. In the test, subjects have to select statements that best represent their views about the actions taken in two dilemmas; euthanasia and protection of workers rights. Based on the answers, the subjects can be divided into three levels of moral development; (i) pre-conventionalist (moral actions are motivated by the fear of punishment or by self-interest), (ii) conventionalist (motivated by the intention to please or help others or to fulfill social rules) and (iii) post-conventionalists (motivated by concepts of justice and rights or from universal principles).

According to Tyler's (1990) theory of procedural justice, legitimacy of the authorities plays a crucial role in legal compliance. The fairness of the law and the regulators of the law, the efficacy in which that law is enforced and the possibility of participating in decisions regarding its regulation have all been identified as factors that affect law compliance behavior.[29] To capture the effect of legality we constructed an index that captures the level of agreement with statements regarding respect towards the law, the fairness of authorities executing the law and participation of the community in defining substitution alternatives.

5. Results

In total, 293 farmers participated in the interviews while 164 of them also took part in one of the 13 organized experimental sessions. We test for attrition between the survey and the experiment using the proportion test and the Wilcoxon ranksum test. We cannot reject the null hypotheses of an equal proportion of coca farmers or of an equal number

[28] Empirical evidence supporting this theory is provided by Trivedi et al. (2003) and Kuperan and Sutinen (1998). Another study that reports a positive effect of morality is Offerman et al (1996).

[29] Participation in fixing regulations by voting or by communication has been identified as a factor that positively affect legal compliance (e.g. Cardenas et al., 2000; Cardenas 2004, 2005; Murphy and Cardenas., 2004; Ostrom et al., 1992; Tyran and Feld, 2002; Feld and Tyran, 2002). In addition, Fortin et al. (2003) and Trivedi et al. (2003) find that the fairness of the rule affects compliance while Nadler, (2005) concludes that the perceived injustice of authorities can also affect general compliance. Galbiati et al. (2005) find that imposing the obligation to comply affects the average level of contributions.

of hectares of coca cultivated at 5% significance level between those who only took part in the interview and those who took part in both the interview and the experiment using the proportion test and the Wilcoxon ranksum test respectively. Whether our sample is representative for the populations of farmers living in these areas is difficult to evaluate, but when compared with official statistics at the municipality level (DNE, 2006), the proportion of plots larger than 3 hectares in our sample (2.73%) is not significantly different at 5% level from the official reports (3.9%) using the proportion test.

5.1. Descriptive statistics

The descriptive statistics for the participants in the experiment are presented in Table 2. The second column presents the descriptive statistics for the overall population and the third and fourth columns present the same information but separated between coca and non-coca farmers, respectively. We test the null hypothesis of equal distribution of the variables between coca and non-coca farmers separately for each of the variables, where the significance levels are shown in the last column of the table. As presented in the last column of table 2, we reject the null hypothesis in some cases, most notably in education levels, years of coca cultivation, participation in community organizations and in statements about obligation to comply.

In Table 3 we present the summary statistics of investments in coca for the nine treatments used in the experiment. The rows represent the different relative profits of cattle farming compared with coca cultivation while the columns represent the different probabilities of eradication used in the experiment. We present the results separately for the average total investment in coca, the proportion of subjects with a non-zero investment in coca, and the average investment conditional on non-zero investment. Using the Wilcoxon sign rank test, we reject the null hypothesis that average investment in treatments A to H is equal to 10 tokens (the expected amount to be invested by a risk-neutral subject) at 1% significance level in separate tests. Similarly, we also reject the null hypothesis that subjects invested zero tokens in treatment *I*. The latter indicates that factors other than pure selfishness explain individual behavior.

Table 2. Descriptive statistics.

Variable	Overall mean n = 141		Non-Coca Farmers n = 81		Coca Farmers n = 60		Ho: no difference between coca and non-coca farmers
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	
Age	42.085	13.598	44.494	13.019	38.867	13.814	***
Dummy female	0.352	0.478	0.358	0.480	0.350	0.477	
Education grade (none=0,basic=1,primary=2, more=3)	1.556	0.836	1.383	0.795	1.783	0.839	***
Dummy missing risk aversion	0.148	0.355	0.136	0.343	0.167	0.373	
Dummy Moderate-Intermediate risk aversion	0.134	0.341	0.136	0.343	0.133	0.340	
Dummy Severe-Extreme Risk aversion	0.465	0.499	0.494	0.500	0.417	0.493	
Transport cost to market (Thousand COL)	2.641	2.213	2.494	2.045	2.850	2.423	
Farm hectares per capita	0.870	1.184	1.012	1.201	0.691	1.142	
Dummy Atheist	0.070	0.256	0.062	0.241	0.083	0.277	
Dummy Protestant	0.134	0.341	0.160	0.367	0.100	0.300	***
Years cultivating coca	5.718	5.222	4.654	4.796	7.083	5.462	***
Dummy missing moral development	0.120	0.325	0.049	0.217	0.217	0.412	***
Dummy Conventionalist	0.232	0.423	0.272	0.445	0.183	0.387	
Dummy Post-Conventionalist	0.035	0.184	0.012	0.110	0.067	0.250	*
Degree of trust (not at all=1, a lot=5)	2.951	1.286	3.049	1.324	2.817	1.233	
Dummy participation in community organizations	0.570	0.495	0.679	0.467	0.433	0.496	***
Obligation to comply (Compl disagree=1, Compl. Agree=5)	3.432	0.811	3.678	0.718	3.101	0.820	***

The test of equal distribution is based on Wilcoxon ranksum test for continuous variables and on the proportion test for binary variables.
*, ** and *** denote statistical significance at 10% 5% and 1% level respectively

As expected, the total number of tokens and the number of tokens invested conditional on non-zero investment decreases significantly as the probability of eradication increases as well as when the relative profit of cattle increases. This supports the hypothesis that people do react to economic incentives. Using the Wilcoxon sign rank test we reject the null hypothesis of equal distribution of total investments and conditional investment between pair wise treatments at 10% significance level.[30] The proportion of non-zero investments does not decrease significantly for small increases in the probability of eradication. Using the proportion test we cannot reject the null hypothesis of equal proportion of non-zero investments for pairs were the probability increases from 0 to 10% and from 10% to 30%. Only large increases in probability of eradication decrease significantly the proportion of non-zero investments. Using the proportion test we reject the null hypothesis at 10% level of equal proportion of coca investments for pairs were the probability of eradication increases from 0% to 30%). The proportion of non-zero investments decrease significantly at 10% level at high relative profit of the alternative (0.68) but not for medium relative profit (0.44) using the proportion test. As shown in Table 1, the paired treatments *C-E* and *F-H* provide the same economic incentive to cultivate coca, but the total investment and conditional investment is significantly smaller at 10% for treatments C and F compared with treatments E and H using the Wilcoxon sign-rank test. In other words, farmers react more to increases in relative profits than to increases in probability of eradication.

We asked subjects how much they believe that the others on average invested in coca cultivation and this summarized in Table 4. Using the Wilcoxon sign rank test, we cannot reject the null hypothesis of equality in own amount of investment and expected investment by others at 10% significance level in treatments *A* to *E*, suggesting that subjects are conditional cooperators. For treatments F to H, individuals overestimate the amount that others invest compared with their own investment.

[30] The only exception is treatment H and I where the conditional investment is not significantly different.

Table 3. Investment in coca cultivation (n=164).

Profit cattle/coca	Total Investment			Proportion of non-zero investments in coca			Conditional Investments in coca		
	Probability Eradication			Probability Eradication			Probability Eradication		
	0%	10%	30%	0%	10%	30%	0%	10%	30%
0.2	A = 4.17	B = 3.54	C = 3.11	A = 0.7	B = 0.66	C = 0.62	A = 5.97	B = 5.35	C = 5.02
0.44	D = 2.62	E = 2.13	F = 1.77	D = 0.64	E = 0.61	F = 0.54	D = 4.1	E = 3.47	F = 3.26
0.68	G = 1.48	H = 1.09	I= 0.95	G = 0.47	H = 0.44	I = 0.37	G = 3.15	H = 2.48	I = 2.59

Table 4. Expectation of others average investments in coca cultivation separated by treatments

Profit cattle/coca	All Farmers			Non-Coca Farmers N = 90			Coca Farmers N = 74		
	Probability Eradication			Probability Eradication			Probability Eradication		
	0%	10%	30%	0%	10%	30%	0%	10%	30%
0.2	A=3.59	B=2.93	C=2.88	A=2.98	B=2.55	C=2.59	A=4.26	B=3.32	C=3.19
0.44	D=2.64	E=2.05	F=1.94	D=2.21	E=1.64	F=1.64	D=3.10	E=2.51	F=2.26
0.68	G=1.42	H=1.18	I=0.97	G=1.15	H=0.90	I=0.64	G=1.75	H=1.47	I=1.33

5.2 Regression analysis

The descriptive analysis of Table 3 suggests us to estimate a Generalized Tobit Model for panel de data. Due to the limited number of observations this model did not converged so we apply a random effects model to correct for unobserved heterogeneity among decisions. A random effects probit model is applied to analyze the determinants of the binary decision on whether or not to invest in coca; while random effects generalized least squares (GLS) is used to analyze the amount invested in coca given a positive amount invested. In Table 5, we present the estimated elasticities evaluated at the relative profit and probability of eradication of 2005 (0.28 and 0.25, respectively) and at the mean values for the other variables. The values for the constant and the correlation coefficient of unobserved heterogeneity (rho) correspond to the estimated coefficients.

As shown at the bottom of Table 5, the estimated correlation coefficient of unobserved heterogeneity between decisions is large and significant which supports the use of random effects probit and GLS models. Both treatment variables in the experiment; relative profit (profit cattle/coca) and expected cost of eradication (probability of eradication times fine), have a significant and negative impact on the probability of cultivating and the conditional amount invested in coca. As shown in the last column of Table 5, the elasticity of conditional investment in coca is significantly higher for increases in relative profit than increases in expected cost suggesting that individuals respond more to carrots than to sticks.

Beside economic incentives, we find that normative factors affect investments in coca. Consistent with other experimental findings, individual behavior is positively correlated with the beliefs about others behavior indicating neighboring influence. Atheist and Protestants are less likely to invest in coca than Catholics, which in the case of Protestantism could be associated with an indoctrination effect that increases awareness of the negative effect of coca cultivation. Farmers who report to have more experience cultivating coca are more likely to invest, which could be indicating habituation effects on coca cultivation. Social capital, measured as trust and membership in organizations, has neither a significant effect on the decision to cultivate coca, nor on the amount cultivated.

Table 5. Elasticities on Random effects probit model (n=142) and GLS model (n=103).

Variables	Dummy if tokens invested in coca are greater than zero		Conditional investment in coca	
	Elasticity	**Std. Err.**	**Elasticity**	**Std. Err.**
Profit cattle/ coca	-0.189 ***	0.032	-0.334 ***	0.024
Probability of eradication * Fine	-0.122 ***	0.038	-0.067 ***	0.015
Expected investment of others	0.228 ***	0.035	0.243 ***	0.030
Dummy Atheist	-0.029 *	0.017	-0.010	0.011
Dummy Protestant	-0.041 *	0.024	-0.011	0.012
Years cultivating coca	0.120 **	0.061	0.025	0.045
Dummy missing moral development	0.051 **	0.025	0.027	0.019
Dummy Conventionalist	-0.006	0.034	0.016	0.020
Dummy Post-Conventionalist	0.082	0.107	-0.008	0.009
Degree of trust (not at all=1, a lot=5)	0.047	0.144	0.052	0.088
Dummy participation community organizations	-0.088	0.069	0.022	0.040
Obligation to comply (Abs Disagree =1, Abs Agree=5)	-0.168	0.267	-0.056	0.155
Age	-0.358 *	0.203	-0.238 *	0.127
Dummy female	0.053	0.044	0.020	0.031
Education grade (none=0,basic=1,primary=2, more=3)	0.265 **	0.128	-0.011	0.088
Dummy missing risk aversion	0.012	0.029	-0.006	0.020
Dummy Moderate-Intermediate risk aversion	-0.015	0.028	-0.016	0.016
Dummy Severe-Extreme Risk aversion	0.058	0.067	0.022	0.045
Transport cost to market (Thousand COL)	0.001	0.073	-0.093 *	0.050
Natural logarithm of hectares per capita	-0.098 **	0.044	-0.020	0.023
Constant	1.374	1.454	6.587 ***	1.260
Rho	0.802		0.408	

Note. *, ** and *** denote statistical significance at 10% 5% and 1% level respectively.
The values for the constant and rho correspond to the estimated coefficients

The probability of investment and the amount invested decrease significantly with age. After controlling for risk preferences and moral values, this behavior could be associated with a higher discount rate of the younger population. We also find that participants with a higher level of education were more likely to invest in coca. This could be an indication that it was easier for these subjects to understand the incentives to invest in coca that were offered by the experimental design. Subjects who have smaller areas of land are more likely to invest in coca. This could be associated with the difficulty of making a living from legal production given their low profitability. Contrary to our expectations, farmers living further away from markets, as indicated by the higher transport costs, invest less in coca.

5.3. Validity of the results.

A natural question for all experiments is how well the behavior in an experiment captures behavior in real-life. In order to make inferences from the experimental findings, we need to validate the behavior in the experiment. We test this by comparing behavior in the experiment of self-reported coca and non-coca farmers. The first column in Table 6, reports the total investment in coca, for coca and non-coca farmers. It is possible to see that coca farmers on average invest more in coca than non-coca farmers. In the nine treatments, we reject the null hypothesis of equality of the distributions of investments between coca and non-coca farmers at 10% significance level using a Wilcoxon rank-sum test. A more detailed analysis reveals that is possible to reject the null hypothesis of equal proportion of non-zero investments for coca and non-coca farmers at 10% significance level using the proportion test. But if we compare the investment from coca and non-coca farmers given that investment took place, i.e. the conditional investment in coca, as is presented in the last column of table 6, we find that it is not possible to reject the null hypothesis. So non-coca farmers are less likely to invest in coca but when they decide to invest they behave as if they were coca farmers. One possible explanation for this behavior is that most of those who are not cropping coca today did so a few years ago and would potentially cultivate coca again if the relative profits or risk of eradication were different. It could also be that the experiment does not replicate real life perfectly and leaves behind other important dimensions such

Table 6. Investment in coca cultivation separated by coca and non-coca farmers (coca farmers n=74; non-coca farmers n=90).

Profit cattle /coca	Group	Total investment in coca			Proportion of non-zero investments in coca			Conditional investment in coca		
		Probability of Eradication			Probability of Eradication			Probability of Eradication		
		0%	10%	30%	0%	10%	30%	0%	10%	30%
0.2	**Non-Coca Farmers**	3.50 *	3.08	2.66	0.61 ***	0.58 **	0.54 **	5.72	5.32	4.87
	Coca Farmers	4.92	4.04	3.55	0.80	0.76	0.70	6.17	5.34	5.08
0.44	**Non-Coca Farmers**	2.16 ***	1.67 **	1.36 **	0.56 **	0.52 **	0.43 ***	3.88	3.19	3.13
	Coca Farmers	3.09	2.64	2.23	0.73	0.72	0.67	4.21	3.68	3.30
0.68	**Non-Coca Farmers**	1.16 ***	0.72 ***	0.44 ***	0.37 ***	0.32 ***	0.23 ***	3.15	2.24	1.91 *
	Coca Farmers	1.82	1.50	1.54	0.59	0.58	0.53	3.07	2.58	2.92

The test for equal distribution of total investments and conditional investments between coca and non-coca farmers is based on Wilcoxon ranksum test, while the test for equal proportions are based on a two-sample test of proportions. *, ** and *** denote statistical significance at 10% 5% and 1% level respectively.

as the imposition of a restriction on coca cultivation – e.g. agreements of voluntary substitution. Interestingly, coca farmers believe that the proportion of farmers that would invest in coca is larger than non-coca farmers believe. But conditional on a non-zero investment, coca and non-coca farmers expect others to invest similar amounts in coca. (See table 4).

Another way to test for correspondence between behavior in real-life and an experiment is to compare the motivational factors that affect coca investment in both situations. Ibanez (2007) used self-reported data to investigate the determinants for the decision to cultivate coca and the amount of land cultivated with coca (see appendix C) We find that there is a positive correspondence between the factors that affect the decision on whether or not to invest in coca between the experiment and the real-life. In particular, we find that the density of coca cultivation in the municipality (an indicator of social norms), Protestantism and the area of farm land are significant factors when explaining the decision to invest in coca or not, both in the experiment and in the real life. We do not find a comparable good correspondence for the models that explain the amount invested.

A third way to validate the experimental data is to test the predictive power of the estimated models on self-reported behavior. If we assume that we can translate the experimental endowments of 10 tokens into hectares of land, we can compare experimental behavior and self-reported behavior in 2003 and 2005. We use the estimated parameters in the model reported in Table 5, to predict the proportion of non-zero investments and the fraction of invested endowment conditional on a non-zero investment. We take into account the fact that the relative profit of the alternative investment was about 0.14 in 2003 and 0.28 in 2005 and that the probability of eradication was around 15 and 30 percent, respectively. All other parameters are evaluated at their mean values. The first two columns in Table 7 present the self-reported and predicted proportions of non-zero investments and the third column presents the test comparing self-reported and predicted values. The next three columns present the corresponding values for the conditional investment in coca cultivation, where the Wilcoxon ranksum test is used. The upper part of the table presents the values for land-holders with fewer than 10 hectares (61% of participants in the experiment) and the lower part for all farmers.

Table 7. Predictions of the experiment.

Group	Year	Proportion of non-zero Investments			Conditional Proportion of endowment invested		
		Self-reported (Std. Err.)	**Predicted** (Std. Err.)	**Proportion-test** (P-value)	**Self-reported** (Std. Err.)	**Predicted** (Std. Err.)	**t-test** (P-value)
		A	**B**	**Ho: A=B**	**A**	**B**	**Ho: A=B**
Small Land holders	**2005**	0.468 (0.013)	0.624 (0.016)	-1. 300 (0.194)	0.399 (0.011)	0.440 (0.020)	-0.612 (0.542)
	2003	0.744 (0.011)	0.694 (0.019)	0.473 (0.636)	0.432 (0.009)	0.547 (0.021)	-1.772 (0.079)
All Farmers	**2005**	0.430 (0.010)	0.560 (0.016)	-1.159 (0.247)	0.288 (0.009)	0.426 (0.018)	-2.147 (0.034)
	2003	0.710 (0.009)	0.634 (0.018)	0.843 (0.399)	0.315 (0.007)	0.533 (0.019)	-3.390 (0.001)

The table shows that the model predicts the proportion of non-zero investments fairly well. Using the proportion test, it is not possible to reject the null hypothesis of equality in the proportion of non-zero investments between self-reported and predicted values at 10% significance level. The prediction ability of the model is lower for the conditional investment. Except for small farmers in 2005, we reject the null hypothesis of equality on self-reported and predicted conditional proportions of the endowments at 10% significance level using the t-test. It should be noted that in the experiment, we used a standardized unit of 10. In real-life however, the areas of land differ and although a farmer can own say 100 hectares, he/she would rarely maintain more than 3 hectares with coca. This is probably a strategy to reduce the risk of having the crops destroyed. According to discussions with farmers, labor requirements seem to limit the amount of land that is cultivated with coca. Our results suggest that the experimental setting that we used captures some aspects of self-reported behavior. This therefore allows us to use the experiment to analyze policy implications on policy levels, especially for households with under 10 hectares of land.

5.4. Partial equilibrium analysis of stick and carrot analysis

Based on the estimated model, we conduct a partial equilibrium analysis of the stick and carrot policy on the proportion of non-zero investments and the proportion of invested endowment. Figures 1, 2 and 3 present the predicted proportion of non-zero investments, the conditional investment and the total investment in coca at different levels of relative profit of cattle and probability of eradication. We focus only on small-land holders. Forecasting the results of the experiment across the range of possible relative prices and probabilities of eradication used in the experimental setting, it is interesting to note that the model predicts that not all farmers will cultivate coca and that not all land will be cultivated even when the relative profit and the probability of eradication are low. According to the predictions of the model, about 37% of the total endowment would be invested in coca when the economic incentives are extremely favorable to do so. The model also predicts that if the profit from cattle is high (68%) and the probability of eradication is high (30%) the proportion of the total endowment invested in coca will be lower than 10%. In addition, the model predicts that in the absence of alternatives - when the relative profit of cattle is too low - eradication will

Figure 1. Predicted probability

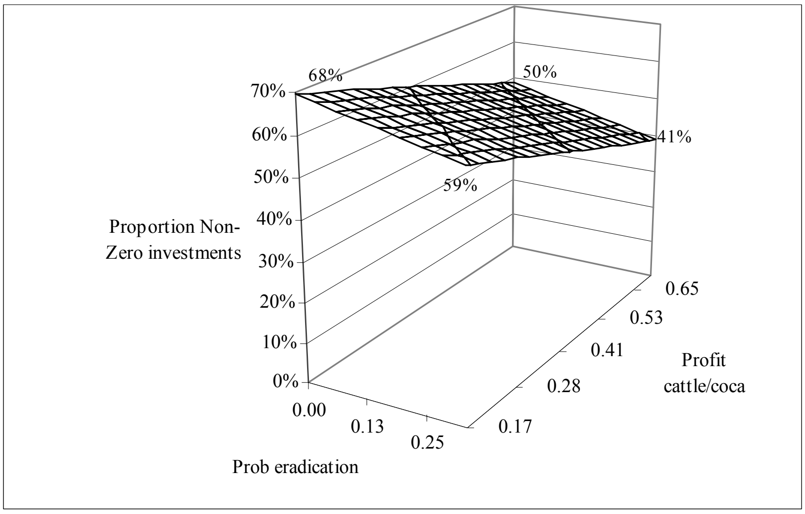


Figure 2. Predicted proportion of the endowment invested Conditional on a non-zero investment

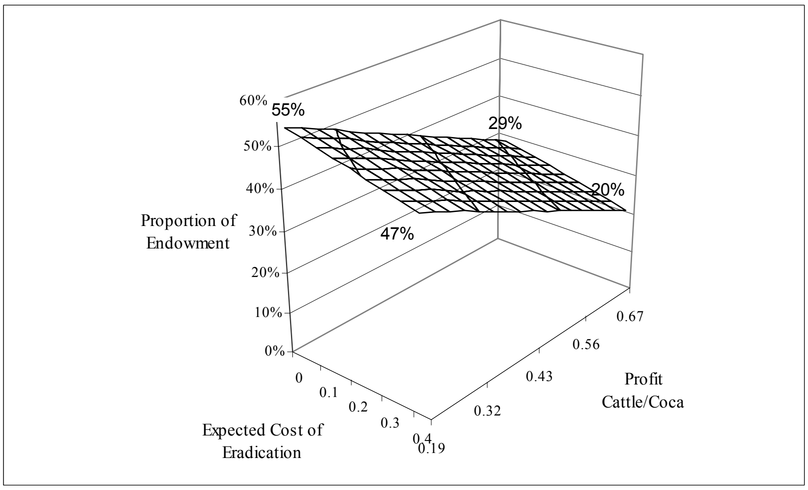
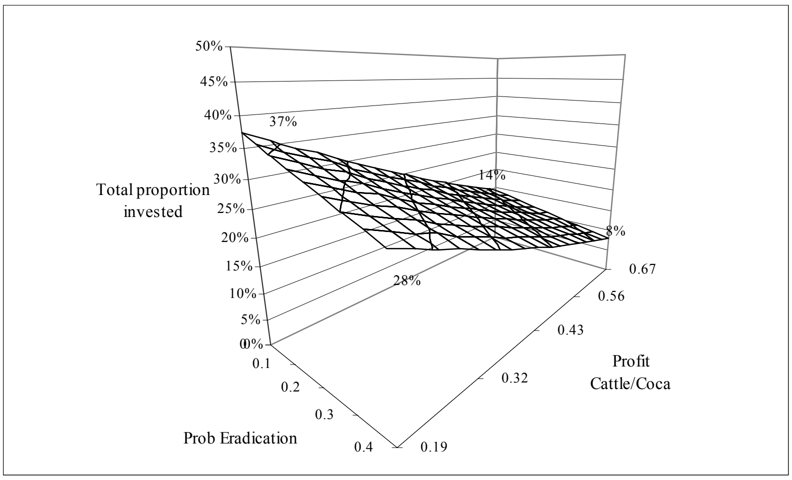


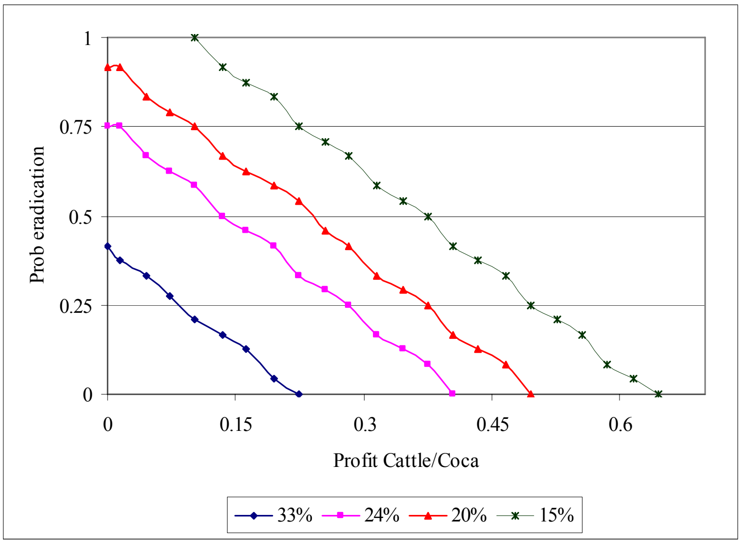
Figure 3. Total proportion of the endowment invested



not eliminate coca investments completely. The model predicts that more than half of the population would invest in coca and that the total investment would be 28% of the endowment. Similarly, at zero probability of eradication there will be positive investments even if profit from the alternative is high.–14% of the total endowment will be invested in coca if the relative profit of cattle is 68%. In summary we conclude that both carrots and sticks are needed to control coca cultivation.

It is important for the authorities to be able to evaluate the relative efficiency of different alternative development and eradication programs - carrots and sticks - in reducing coca cultivation. The optimal balance of carrots and sticks depends on the effectiveness of the eradication and alternative development program, but of course also on its cost. Figure 4 presents the combinations of relative profit and probability of eradication that keep constant total investments in coca. For example, both pairs of relative price and a probability of eradication (0.31 of 0.16) and (0.16, 0.45) imply that 24% of the total investments will be in coca. Increases in the probability as in the pair (0.31, 0.33) and (0.31, 0.7) decrease the total investment in coca to 20% and 15% respectively.

Figure 4. Combination of relative price and probability of eradication that maintain the total proportion of the investment constant.



When considering the question of cost, Logan (2006) estimated that spraying one hectare cost USD 626. But as we discussed before, in order to destroy one hectare completely, between three and eight hectares must actually be sprayed. Thus, the total cost of destroying one hectare is between 1,878 USD and 5,008 USD. In 2003, the government established a monetary subsidy by which households who agreed to keep their land free of coca received 1,524 USD yearly during three years compared with an average profit of 1,402 USD per hectare year of coca (Ibanez, 2007). On average, households that participated in the program in Putumayo agreed to keep 10 hectares free of coca, so the average cost of the subsidy per hectare year is 152 USD. In other words destroying one hectare by spraying is between 12 to 33 times more expensive than offering a monetary subsidy. However, the total cost of the eradication policy depends on the total number of hectares of coca that need to be sprayed and the total number of potential beneficiaries from the subsidy. If the number of hectares declared by potential beneficiaries of the subsidy is higher than the number of hectares that need to be sprayed, then spraying would be preferable to the alternative development.

6. Conclusions

Existing data on the amount of investment in coca under different regimes of carrot and stick policies in Colombia is limited to data at the municipal level based on revealed preferences. By using a framed field experiment, we mimic the decision that Colombian farmers in the department of Putumayo are faced with. Thus, our experimental approach allows us to investigate how farmers react to a wide range of different combinations of stick and carrot policies. In subsequent analyses, we compared the behavior in the experiment and in real-life, and the overall comparison suggests that experimental behavior is consistent with real-life coca cultivation. Our main results support earlier findings, based on municipal data, that changes in relative profit have more impact on reducing coca cultivation than changes in the probability of eradication do.

In terms of policy recommendations, our results suggest that both eradication and alternative development are needed to reduce coca cultivation. Although the cost of destroying one hectare is higher than the cost of the subsidy offered by the authorities, it may still be cost-effective to use eradication when the number of hectares to be subsidized is substantially higher than the number of hectares of coca to be eradicated. The current form of voluntary agreement to substitute coca with alternative development is a direct monetary pay-off. However, the longer-term strategy is to increase the relative profit more permanently by, for example, improving the infrastructure or undertaking policies that tackle the agricultural crisis in Colombia. Related to this is the issue of the effect of eradication on the income of farmers. If the two policies are expected to result in the same amount of coca cultivation, then the policy that has a higher level of eradication will cause a greater number of farmers to be below the poverty line because farmers loose their income if their coca fields are eradicated. Since many of the farmers are living close to or under the poverty line, it may explain why they respond to changes in relative profit more than they do to changes in eradication levels. Thus, a mix of policies resulting in the same amount of coca cultivated may have very different impacts on welfare, especially on those farmers who are below the poverty line. Our results suggests that a more systematic social welfare analysis of stick and carrot policies is needed in general, but also that the use of alternative development programs to increase the relative profits of non-coca activities seems to be a promising way of reducing coca cultivation.

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Appendix A

Instructions

Good afternoon and welcome to this workshop. Before we start we would like to thank you for your assistance. In this workshop you will have the opportunity to earn some money. The amount of money that you will earn depends on your own decisions as well as the decisions of others. This workshop is organized by Universidad de los Andes en Bogota. The results of this study will be used for academic purposes. Throughout the exercise we will not ask for your name, where you live or pose any other question that allows us to identify you or your family. The answers will not be presented individually.

How long is the exercise?

This workshop will take approximately two hours. You will be asked to make 9 different decisions. At a first glance they may seem to be similar, but they do, in fact, differ. Therefore it is important to think about each decision carefully.

What kinds of decision will you be asked to make?

We will randomly form groups of five people. You will not know to which group you belong either during or after the workshop. You will remain in the same group for all 9 decisions.

For each decision you will receive 10 tokens. These tokens are equivalent in real life to the land, the available hours of work and the money you have available to cultivate your crops. Your first task is to decide how many tokens you would like to invest in two agricultural products. Your second task is to guess how much the other four people in your group will invest in coca. Please consider what you would do in real life.

What are the characteristics of the investments?

The two agricultural products are coca and cattle raising. They have different returns. For each token you invest in coca you get 1250 pesos. For each token that you invest in cattle raising you will get 250 pesos. Cropping coca generates negative effects for the community such as increased levels of violence, environmental damage, increases in prices in the region, etc. Therefore for each token that you invest in coca, the incomes of you as well as the other members in your group will be reduced by 212.5 pesos. Similarly, for each token that others invest in coca, the incomes of you as well as the other members of your group, will be reduced by 212.5 pesos.

How is your payment calculated?

At the beginning of the workshop you will receive 15.000 pesos but depending upon your decisions and the decision of others in your group, you can earn more or less than that amount. Your payment can be lower than 15.000 pesos but even in the worst case you will earn a certain amount. In the workshop you have to take9 decisions but only one of these will be paid. Which decision is paid is selected randomly, so consider each decision carefully.

Let us look at an example.

As we explained before, for each token that you invest in cattle raising you obtain 250 pesos and for each token that you invest in coca you obtain 1250 pesos. {Write numbers on the blackboard}. Let us say that you, for example, have invested 7 tokens in coca and 3 tokens in cattle raising, while other people in your group have invested 27 tokens in coca. In this case, your earnings from coca are 7 tokens times 1.250 which is 8.550 pesos. The earnings from investing in cattle raising are 3 tokens times 250 pesos or 750 pesos. Due to the negative effect from coca of violence, environmental damage and increased prices, there is a reduction in earnings from coca investments. You invested 7 and the others 27 and in total this is 34 tokens. The reduction in tokens for investing in coca is thus 34 tokens times 212.5 pesos that is 7,225 pesos.

Investment in coca	7 x 1250	8.750
Investment in cattle raising	3 x 250	750
Reduction	-34 x 212,5	-7.225
In Pesos		2 275

To make this calculation easier, we have prepared a payment table that summarizes your earnings in pesos {show a poster with an enlarged pay-off table}. This table is called “Pay-off table”. Note that the top of the table indicates the return from coca and cattle raising. In the green table, for each token invested in cattle raising you receive 250 pesos. The columns indicate the number of tokens you invested in coca and cattle raising. The rows indicate the number of tokens that the others invested in coca and cattle raising. Continuing with our example, if you invested 7 tokens in coca {move along to column 7 using one hand} and 3 tokens in cattle raising and if the others invested 27 in coca {move down to row 27 with left hand side} and 13 tokens in cattle raising then your earning in pesos would be 2 275 {find intersection in the table}. Remember, what you do not invest in coca is automatically invested in cattle raising. In other words, the sum of your investment in coca and cattle raising is 10 tokens.

Let us look at another example. If you invest 4 tokens in coca and 6 tokens in cattle raising and the others invest 17 tokens in coca and 23 in cattle raising. In the table, four tokens invested by you {move with the right hand side to column 4} and 17 tokens invested by others {move with left hand side to row 17} imply a payment of 2.038 pesos. Do you have any question so far?

Correct guess

You can increase your earnings by correctly guessing how much the others have invested in coca. The closer your guess is to the investment of others the higher your reward will be. Do you think that the others will do the same as you did? Do you think they will invest more in coca? Do you think they will invest less?

Procedures

We start by sitting down in the room. Once you are seated in the assigned place you will receive your decision sheets and payment tables. Please write your birth date (year/month/day) and the last three digits of you I.D. number. This is your identification number. Once you have handed in your decision sheet we will put all the identification numbers in a bag and draw them to form groups of five people. You will not know who belongs to your group but in the nine decisions you will remain in the same group.

The decision sheet contains 9 choices/dilemmas/questions[?]. The first column of the decision sheet explains the particular characteristics of the case under consideration, in the second column you should write how many tokens you would like invest in coca. What you do not invest in coca is automatically invested in cattle raising. In the last column you should write how many tokens you expect the others will invest in coca. The others can, in total, invest anything between 0 and 40 tokens.

There are three payment tables. The green table indicates the payments when each token invested in cattle raising yields 250 pesos. The red table indicates the payments when each token invested in cattle raising yields 550 pesos and the blue table indicates the payments when each token invested in cattle raising yields 850 pesos. Once you have completed the first three decisions, we will explain the next 6 decisions and the procedure to be applied in the second half of the workshop. After the nine decisions have been completed we will select a letter from a bag to decide which decision is to be paid. The payment will be made in a coupon that can be exchanged in the super market.

Do you have any question so far?

Once we have started you should not talk to anyone in the room. Those who talk will be excluded from the workshop and the payments. If you have any question please raise your hand and one of us will come and answer your query.

{Distribute register sheet and form groups} We want to ask you to come to the front so that we canallocate places for you to sit in the room. {Allocate seats and hand in practice questions}

Practice questions

Before we begin with the investment decisions, you will make some hypothetical decisions. The idea is to make sure that we have managed to explain the experiment clearly to you. These decisions will not affect your payment.

1. If you obtain 1250 pesos for every token invested in coca and 250 pesos for each token invested in cattle raising:.
   How many tokens do you want to invest in coca? _________ tokens
   How many tokens do you think that the others will invest in coca? _________ tokens
   What would your payment be? _________ pesos

Once you have finished making your decisions, we will come and collect the first page of the form. Then we will determine whether eradication will happen or not by drawing balls from a bag. We will make one draw for each decision and the outcome of whether or not crop is being controlled by eradication will be the same for all of you. To ensure confidentiality, you will receive your payment in an envelope with your ID number when you leave.

Now we will explain the following six decisions.

Regulation and Control

Investment in coca is illegal and thus there is a risk that your investment will be detected. This will not necessarily be the case. To determine whether your crop is eradicated, we will draw a ball from a bag. If a green ball is selected then it is not. If a red ball is selected then it is eradicated. The proportion of red and green balls changes from case to case. In three cases the bag contains one red ball and 9 green balls and in the other three cases the bag contains 3 red balls and 7 green balls. If your crop is eradicated, you will lose 1500 pesos for each token invested in coca. But as in real life, eradication does not always occur.

Example

Let us consider the case where there are 9 green balls and 1 red ball . We put 9 green balls and one red ball in the bag. {Make demonstration}. If we continue with our first example in which you invested 7 tokens in coca and the others invested 27 tokens, and your income was 2 275 pesos, if there eradication took place your income would be reduced by 10 500 pesos. Why 10 500 pesos? You have invested 7 tokens and each token results in a cost of 1500 pesos so the total cost is 10 500 pesos. When there was no eradication your income was 2 275 but with eradication you must subtract10 500 which makes -8 225 pesos. If this decision is selected for payment, you would receive 4 500 pesos, that is 15 000 pesos minus 8 225pesos.

For the next six decisions we will follow the same procedure that we used before. First we will have some practice questions to make sure that our explanation is clear. Then you can complete the next six decisions. When you make your decisions you will have time to look at them again and make corrections. If you want to change a decision please mark a line over the decision so it is still possible to see the initial value and write down the new value. When you have finished, we will collect the decision sheets, select which alternative will be paid and determine whether eradication will take place or not by taking a ball from the bag. We will take one ball and the result will be applied to everyone in the group.

Practice questions

2. If you obtain 1250 pesos for every token invested in coca and 250 pesos for each token that you invest in cattle raising and if a red ball is selected meaning that eradication will take place. and you will need to pay 1500 pesos for each token invested in coca and if there are 9 green balls and one red ball.:.

   How many tokens do you want to invest in coca? _________ tokens

   How many tokens do you think that the others will invest in coca? _________ tokens

   What would your payment be if there is no eradication? _________ pesos

   What would your payment be if there is eradication ? _________ pesos

Decision Sheet

You have 10 tokens that you can invest in coca or in cattle raising. Your task is to decide how many tokens you would like to invest in coca and how much you expect others in your group will invest in coca. PLEASE USE THE TABLE TO STUDY THE OUTCOME OF DIFFERENT DECISIONS. **Please consider what you would do in real life.**

Decision Case		Your investment in Coca	Your investment in Cattle raising	Expected investment of others in coca
A.	1 token in coca gives 1250 pesos 1 token in cattle raising gives 250 pesos. 1 token in coca cost 212,5 to each person in the group.			
B.	1 token in coca gives 1250 pesos 1 token in cattle raising gives 550 pesos. 1 token in coca cost 212,5 to each person in the group.			
C.	1 token in coca gives 1250 pesos 1 token in cattle raising gives 850 pesos. 1 token in coca cost 212,5 to each person in the group.			
D.	1 token in coca gives 1250 pesos 1 token in cattle raising gives 250 pesos. 1 token in coca cost 212,5 to each person in the group. If a red ball is selected there is control. If this happens you have to pay 1500 pesos for each token in coca. There is one red ball and 9 green balls.			
E.	1 token in coca gives 1250 pesos 1 token in cattle raising gives 550 pesos. 1 token in coca cost 212,5 to each person in the group. If a red ball is selected there is control. If this happens you have to pay 1500 pesos for each token in coca. There is one red ball and 9 green balls.			
F.	1 token in coca gives 1250 pesos 1 token in cattle raising gives 850 pesos. 1 token in coca cost 212,5 to each person in the group. If a red ball is selected there is control. If this happens you have to pay 1500 pesos for each token in coca. There is one red ball and 9 green balls.			
G.	1 token in coca gives 1250 pesos 1 token in cattle raising gives 250 pesos. 1 token in coca cost 212,5 to each person in the group. If a red ball is selected there is control. If this happens you have to pay 1500 pesos for each token in coca. There are 3 red balls and 7 green balls.			
H.	1 token in coca gives 1250 pesos 1 token in cattle raising gives 550 pesos. 1 token in coca cost 212,5 to each person in the group. If a red ball is selected there is control. If this happens you have to pay 1500 pesos for each token in coca. There are 3 red balls and 7 green balls.			
I.	1 token in coca gives 1250 pesos 1 token in cattle raising gives 850 pesos. 1 token in coca cost 212,5 to each person in the group. If a red ball is selected there is control. If this happens you have to pay 1500 pesos for each token in coca. There are 3 red balls and 7 green balls.			

Appendix B

Each token invested in coca gives 1250 Pesos
Each token invested in cattle raising gives 250 Pesos

		Pay-off Table when there is no eradication										
		Your investment in Coca										
		0	1	2	3	4	5	6	7	8	9	10
Investment of others in coca	0	2500	3300	4100	4900	5700	6400	7200	8000	8800	9600	10400
	1	2300	3100	3900	4700	5400	6200	7000	7800	8600	9400	10200
	2	2100	2900	3700	4400	5200	6000	6800	7600	8400	9200	10000
	3	1900	2700	3400	4200	5000	5800	6600	7400	8200	9000	9700
	4	1700	2400	3200	4000	4800	5600	6400	7200	8000	8700	9500
	5	1400	2200	3000	3800	4600	5400	6200	7000	7700	8500	9300
	6	1200	2000	2800	3600	4400	5200	6000	6700	7500	8300	9100
	7	1000	1800	2600	3400	4200	5000	5700	6500	7300	8100	8900
	8	800	1600	2400	3200	4000	4700	5500	6300	7100	7900	8700
	9	600	1400	2200	3000	3700	4500	5300	6100	6900	7700	8500
	10	400	1200	2000	2700	3500	4300	5100	5900	6700	7500	8300
	11	200	1000	1700	2500	3300	4100	4900	5700	6500	7300	8000
	12	-100	700	1500	2300	3100	3900	4700	5500	6300	7000	7800
	13	-300	500	1300	2100	2900	3700	4500	5300	6000	6800	7600
	14	-500	300	1100	1900	2700	3500	4300	5000	5800	6600	7400
	15	-700	100	900	1700	2500	3300	4000	4800	5600	6400	7200
	16	-900	-100	700	1500	2300	3000	3800	4600	5400	6200	7000
	17	-1100	-300	500	1300	2000	2800	3600	4400	5200	6000	6800
	18	-1300	-500	300	1000	1800	2600	3400	4200	5000	5800	6600
	19	-1500	-800	0	800	1600	2400	3200	4000	4800	5600	6300
	20	-1800	-1000	-200	600	1400	2200	3000	3800	4600	5300	6100
	21	-2000	-1200	-400	400	1200	2000	2800	3600	4300	5100	5900
	22	-2200	-1400	-600	200	1000	1800	2600	3300	4100	4900	5700
	23	-2400	-1600	-800	0	800	1600	2300	3100	3900	4700	5500
	24	-2600	-1800	-1000	-200	500	1300	2100	2900	3700	4500	5300
	25	-2800	-2000	-1200	-500	300	1100	1900	2700	3500	4300	5100
	26	-3000	-2200	-1500	-700	100	900	1700	2500	3300	4100	4900
	27	-3200	-2500	-1700	-900	-100	700	1500	2300	3100	3900	4600
	28	-3500	-2700	-1900	-1100	-300	500	1300	2100	2900	3600	4400
	29	-3700	-2900	-2100	-1300	-500	300	1100	1900	2600	3400	4200
	30	-3900	-3100	-2300	-1500	-700	100	900	1600	2400	3200	4000
	31	-4100	-3300	-2500	-1700	-900	-200	600	1400	2200	3000	3800
	32	-4300	-3500	-2700	-1900	-1200	-400	400	1200	2000	2800	3600
	33	-4500	-3700	-2900	-2200	-1400	-600	200	1000	1800	2600	3400
	34	-4700	-3900	-3200	-2400	-1600	-800	0	800	1600	2400	3200
	35	-4900	-4200	-3400	-2600	-1800	-1000	-200	600	1400	2200	2900
	36	-5200	-4400	-3600	-2800	-2000	-1200	-400	400	1200	1900	2700
	37	-5400	-4600	-3800	-3000	-2200	-1400	-600	100	900	1700	2500
	38	-5600	-4800	-4000	-3200	-2400	-1600	-900	-100	700	1500	2300
	39	-5800	-5000	-4200	-3400	-2600	-1900	-1100	-300	500	1300	2100
	40	-6000	-5200	-4400	-3600	-2900	-2100	-1300	-500	300	1100	1900

Appendix C.

Coca cultivation decisions with self-reported data.

Variables	Decision to cultivate coca n=329		Proportion of land cultivated with coca n=214		
	Elasticity		Coef.		Std. Err.
Log profit coca	-0.349		0.008		0.008
Log profit alternative	-0.054		-0.004		0.011
Index of Market conditions	-0.005		-0.010		0.027
Sprayed ha/Total ha with coca in municipality	-0.066	***	0.001		0.014
Dummy Atheists	-0.003		0.057		0.038
Dummy Protestant	-0.029	***	0.082		0.224
Years cultivating coca	0.048		-0.003		0.006
Moral development (Missing=0; Pre-Conv=1; Conv=2; Post-Conv=3)	-0.052		0.020		0.018
Degree of trust (not at all=1, a lot=5)	0.040		0.010		0.009
Dummy participation in communitary organizations	-0.024		-0.006		0.027
Ha with coca/Municipal Area	0.264	***	0.001		0.003
Obligation to comply (Compl disagree=1, Compl. Agree=5)	-0.455	***	0.024		0.044
Age	-0.087		-0.008		0.007
Squared Age	0.065		0.000		0.000
Female	-0.011		-0.111	***	0.026
Education (None=0,Basic=1, Primary=2, More=3	0.047		-0.008		0.083
Squared Education Grade	0.038		0.009		0.014
Coefficient of relative risk aversion.	0.002		0.003		0.003
Cost of transport (Thousand COL)	0.004		0.004		0.005
Log Land per capita	-0.089	***	-0.152	**	0.067
Dummy missed stage moral development	0.034	**	0.064		0.134
Dummy missed risk aversion	-0.004		0.287		0.541
Dummy Participation Substitution Program -	-0.069	***	-0.063		0.166
Probability of non-zero investment			-0.063		

*, ** and *** denote statistical significance at 10% 5% and 1% level respectively.

Are cooperation preferences stable under endowment heterogeneity?*

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Abstract

In this paper we examine subjects' cooperation preferences when endowment is heterogeneous using a public goods experiment. Each subject takes part in several one-shot public goods experiments based on a modified design of Fischbacher *et al.* (2001). In each of the experiments, a subject is assigned to different endowment distributions. The results indicate that the dominant types of cooperative preference are positive conditional cooperation and free riding. Moreover, we find that subjects tend to be classified in the same type of cooperative preference independent of their endowments distribution.

Key words: Cooperation; Experiment; Inequality; Public goods.

JEL classification: C72 ; C91; H41.

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1. Introduction

Public goods experiments have consistently found that average contribution levels are higher than the zero prediction of standard economic theory (e.g. Ledyard, 1995; Zelmer, 2003). Different explanations have been proposed and tested in the laboratory to explain this deviation from standard economic theory.[32] Several experiments have shown that the most important explanation for non-zero contributions is probably positive conditional cooperative preferences, i.e. that individual contribution levels are positively correlated with the contribution levels by others. This finding is supported for example by Keser and van Winden (2000) who used data from public goods experiments. To be able to conduct a more detailed investigation of the factors that motivate subjects to contribute to the public good, Fischbacher *et al.* (2001) developed a public goods experiment that used a modified version of the strategy method. By asking subjects how much they would contribute to a public good and how much they would contribute conditional on the average contribution levels by others, more detailed information on subjects' behavior in a cooperative situation is elicited. Based on the conditional contribution levels, Fischbacher *et al.* (2001) and Fischbacher and Gächter (2006) report that about half of the subjects have positive conditional cooperation preferences, i.e. the more others contribute the more they will contribute themselves.

However, conditional cooperation preferences have predominantly been analyzed in situations where all subjects have the same endowment. There is, however, a growing literature focusing on the more realistic case where subjects have different endowments (e.g. Warr, 1983; Bergstrom et al., 1986; Aquino *et al.*, 1992; Chan *et al.*, 1996, 1997, 1999; Van Dijk and Wilke, 1994, 1995; Cardenas et al., 2002; Cardenas, 2003; Cherry *et al.*, 2005; Buckley and Croson, 2006; Anderson *et al.*, 2007; Visser, 2007; Kroll *et al.* forthcoming). However, the results are largely inconclusive about how inequality affects absolute and relative contributions to the public good.

Our analysis, however, differs from this line of research. Instead, the objective of this paper is to investigate the stability of cooperation preferences in situations with heterogeneity in endowments using the approach of Fischbacher *et al.* (2001). We

[32] For example, cooperation in public goods has been associated with trial and error learning (e.g. Palfrey and Prisbrey, 1997; Houser and Kurzban, 2002) and other types of social preference such as altruism, warm glow, fairness, reciprocity and inequality aversion (e.g. Andreoni, 1990, 1995; Brandts and Schram, 2001; Dufwenberg and Kirchsteiger, 2004, Fehr and Schmidt, 1999; Fehr and Gätcher, 2000; Bolton and Ockenfels, 2001).

investigate the stability of cooperation preferences at both aggregated and individual levels and evaluate the consistency of conditional and unconditional contributions.

The remainder of the paper is organized as follows. Section 2 describes the design of the public goods experiment. The following section presents the results and Section 4 concludes the paper.

2. Experimental design and procedures

We investigate subjects' cooperation preferences in a public good game where participants are randomly matched in a group of four subjects. Each subject is endowed with *e* tokens and is then asked to allocate this endowment between a group and a private account. Subject *i*'s pay-off in tokens is given by

$$\pi_i = e_i - c_i + 0.4\sum_{i=1}^{4} c_i \ ,$$

where *c* is the amount invested in the group account. Each token contributed to the public account yields a pay-off of 0.4 for each of the four group members while each token allocated in the private account yield a pay-off of 1. Following the design by Fischbacher *et al.* (2001), each subject makes both an unconditional and a conditional contribution decision. In the unconditional contribution decision, a subject is asked how much he/she would like to contribute to the public account. In the conditional contribution case, however, a subject is asked how much he/she would like to contribute to the public account given each possible average contribution (limited to average integer numbers) of the other members. In order to make each choice incentive compatible, the pay-off is determined in the following way. First, three subjects from the group are randomly selected and their unconditional contribution to the public account is recorded. Based on the average unconditional contribution of the three subjects, the contribution from the fourth subject is obtained.

We use three different distributions of endowment in our experiment; one with a homogenous endowment and two with heterogeneous endowments, but in all three cases we keep the total endowment fixed to 80 tokens to keep efficiency levels unaffected. In the homogenous case, each subject is endowed with 20 tokens. In the heterogeneous endowment cases, one distribution is symmetric with endowments of 12, 17, 23 and 28 tokens, while the other distribution is asymmetric with endowments of 12, 12, 12 and 44 tokens. Each subject is asked to make seven decisions corresponding to all possible endowments in the three distributions; one decision in the case of equal endowment (20), four in the case of symmetric heterogeneous distribution of endowments (12, 17, 23 and 28) and two in the case of asymmetric heterogeneous distribution of endowments (12 and 44). Each token earned in the experiment was equal to 1250 Colombian pesos, corresponding to 0.50 Euros at the time of the experiment.

The experiment was conducted in August 2006 at Pontificia Universidad Javeriana in Bogotá. Subjects were recruited from the university's undergraduate students, though no economics students participated. We conducted three sessions, two with 24 subjects and one with 16 subjects. After the subjects were seated at randomly assigned desk, the instructions for the experiments were handed out. The instructions were read aloud by the instructor and some examples were given. To test their comprehension of the instruction, follow-up questions were applied. Seven decision sheets, each one corresponding to one of the seven different positions in the three distributions, were then handed out to the subjects. The subjects were then instructed to complete the decision sheets in any order and that they could go back and change their decisions if they wished. After collecting the completed decision sheets, subjects were asked what their beliefs were about the contributions by others in each one of the seven cases. Following Gächter and Renner (2006), we monetarily rewarded subjects according to how close his/her belief about the total contributions of the others was to the actual total contribution of the other group members. They earned 2 tokens if the belief was +/- 1 token from the total group contribution. We then randomly selected one of the seven decisions for payment. The last stage of the experiment was a questionnaire with socio-economic questions for the subjects to complete. Once they had completed the experiment, subjects were paid privately in cash. The average payment was 34,461 Colombian pesos compared with a daily minimum wage of 14,500. Each session took about two hours including payments.

3. Experimental results

The focus of our analysis is on studying the stability of cooperative preferences among subjects when their endowment differ. First, we explain the method used to identify cooperation preferences and describe cooperation preferences. Then we investigate the stability of cooperative preferences at the aggregate level using a distribution test and comparing the patterns of cooperation across endowments. Third, we investigate the stability of cooperative behavior at the individual level. And finally, we evaluate the consistency between unconditional and conditional cooperation.

Cooperation Preferences

By using the information on conditional contribution levels, we classify the subjects into six broad categories of cooperation preferences, free-riding, unconditional cooperation, positive conditional cooperation, negative conditional cooperation, hump-shaped cooperation and other patterns. Free-riders are those subjects who contribute zero to the public good, irrespective of the contribution levels by others. Unconditional cooperation occurs when subjects contribute a constant *non-zero* contribution irrespective of the contribution levels by others. Positive conditional cooperation is when subjects meet both of the following two criteria. First, they show a monotonic increasing pattern of their own contributions in relation with the contributions by others. Second, there is a positive and significant Spearman rank correlation at 1% significance level between the conditional contribution and the contribution by others. Negative conditional cooperation is the opposite of positive conditional cooperation. The definition of hump-shaped cooperation preferences is when subjects demonstrate positive conditional cooperation up to a certain level of contribution by others, followed by a switch to negative conditional cooperation. Those subjects who cannot be classified in any of the above categories are classified as having another type of cooperation preferences.

In Table 1, we present the results from the classification of subjects' cooperation preferences in each of the seven endowments. The first column shows the classification of subjects when each of them has the same endowment. Slightly less than half of the subjects are classified as positive conditional co-operators and approximately 10% as free-riders. Our results for the fraction of positive conditional co-operators are similar to those of other studies, while the fraction of free-riders is substantially lower (e.g.

Fischbacher *et al.*, 2001, Fischbacher and Gächter, 2006; Kocher *et al.*, 2007).[33] Of the other three groups with pre-specified preference hump-shaped and negative conditional types are all slightly more common than the unconditional cooperation preference type. Finally, one quarter of the subjects are classified as having other preferences. The last six columns of Table 1 show the classifications for the other six endowments. A comparison of these six columns as well as with the classifications for the equal endowment show roughly equal proportions for each classification type. We conducted a chi-squared test to investigate the null hypothesis that there is no difference between the distributions of the proportion of types between two different endowments. We could not reject the null hypothesis in any of the 21 pair-wise comparisons at 5% significance level.

Table 1. Percentage of subjects by cooperation preference and treatment.

Types of behavior	Homo-geneous	Heterogeneous and symmetric				Heterogeneous and asymmetric	
	20	12	17	23	28	12	44
Free-riding	9.4	10.9	7.8	10.9	9.4	12.5	12.5
Unconditional cooperation	3.1	6.3	4.7	6.3	4.7	4.7	7.8
Positive conditional cooperation	43.8	40.6	46.9	42.2	48.4	42.2	48.4
Negative conditional cooperation	7.8	1.6	4.7	3.1	7.8	4.7	4.7
Hump-shaped	6.3	10.9	3.1	15.6	9.4	6.3	12.5
Other	29.7	29.7	32.8	21.9	20.3	29.7	14.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

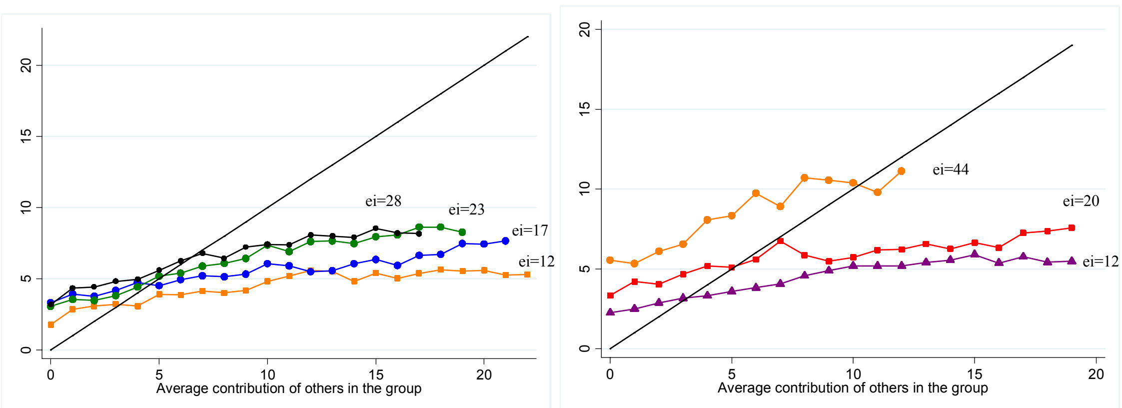
Conditional contribution levels

In the previous analysis we found that the distribution of types is stable over endowments at the aggregated level. In Figure 1, we present the mapping between the average absolute contribution of individual subjects (vertical axis) and the absolute average contribution of the other group members (horizontal axis) using the conditional contribution treatment for each of the seven different endowments. If the slope of the curve equals one, then we have a case of perfect positive conditional cooperation preferences, while a slope less than one implies a self-serving bias. The intercept of the curve represents the amount that would be contributed if the others were to contribute zero, which can be considered as a measure of altruism. In order to conduct a formal test for significant differences between the slopes and intercepts in conditional cooperation

[33] This behavior could also be related to a cultural difference in pro-social norms (e.g. Henrich *et al.*, 2005 and Cardenas and Carpenter, 2004).

and altruist levels, we estimate an econometric model. Each individual took 142 conditional decisions for the seven endowments. It is likely that the responses across decisions are correlated, which suggest that a random effect model should be estimated. Table 2 presents the results of regressing own conditional contributions on the average contributions by others, a dummy for each endowment level and an interaction term that allows different slopes across endowment levels. We take the homogenous endowment, 20, case as the reference point.[34] We find that the absolute contribution level increases with the level of contribution made by others. The slope of conditional contributions is significantly less than one reflecting some self-serving bias. On average, individuals contribute significantly more than zero to the public good which reflects a degree of altruism. The slope of the conditional contribution increases with relative endowment which means that when subjects are relatively rich, the more others contribute, the more they contribute themselves. Individuals with higher levels of endowment contribute more to the public good in an absolute sense than individuals with low levels of endowment, which is consistent with Buckley and Croson's (2006) model of altruism and with empirical findings in Cardenas et al. (2002) and Cherry et al. (2005). Individuals in the low endowment level contribute significantly less in absolute terms when they are in a more unequal endowment distribution.

Figure 1. Absolute average conditional contributions.



[34] We tried different specifications of the model all with the same basic message.

Table 2. Random effects model on conditional contributions.

Variables	Coefficient	Std. Error	95% Confidence Interval	
Average contribution by others	0.183 ***	0.021	0.141	0.224
Average contribution * Dummy for ei=12 ej=(17,23,28)	-0.048 *	0.027	-0.102	0.005
Average contribution * Dummy for ei=17 ej=(12,23,28)	-0.002	0.029	-0.058	0.055
Average contribution * Dummy for ei=23 ej=(12,17,28)	0.122 ***	0.031	0.061	0.183
Average contribution * Dummy for ei=28 ej=(12,17,23)	0.110 ***	0.034	0.043	0.177
Average contribution * Dummy for ei=12 ej=(12,12,44)	-0.030	0.027	-0.083	0.024
Average contribution * Dummy for ei=44 ej=(12,12,12)	0.317 ***	0.048	0.222	0.412
Intercept	4.088 ***	0.681	2.753	5.423
Dummy for ei=12 ej=(17,23,28)	-1.125 ***	0.340	-1.791	-0.460
Dummy for ei=17 ej=(12,23,28)	-0.429	0.346	-1.108	0.250
Dummy for ei=23 ej=(12,17,28)	-0.692 *	0.354	-1.386	0.002
Dummy for ei=28 ej=(12,17,23)	-0.036	0.363	-0.748	0.676
Dummy for ei=12 ej=(12,12,44)	-1.170 ***	0.340	-1.836	-0.505
Dummy for ei=44 ej=(12,12,12)	1.459 ***	0.395	0.685	2.234
Observations	9089			
Groups	64			

*, **, *** Denote statistical significance at 10%, 5% and 1% level, respectively.

An alternative analysis of the pattern of contributions is to look at the proportion of the endowment that was contributed (relative contribution). Figure 2 presents the relationship between the relative contributions of individual subjects (vertical axis) and the relative contribution of the other group members (horizontal axis) for the seven different endowments. The conditional contribution in relative terms shows a different pattern compared with the conditional contribution in absolute terms. Although we still find that the slope of the conditional contribution curve is positive, it is steeper for those with low levels of endowment compared with those with high levels of endowment. Those with low levels of endowment contribute a higher proportion of their endowment than those with higher levels of endowment. Table 3 presents the estimated coefficients from a random regression model with relative contribution as the dependent variable. The econometric results confirm the conclusions that we draw from the graphical analysis. Our results are consistent with empirical findings from Cherry et al. (2005) and Buckley and Croson, (2006), namely, that subjects appear to care about fairness in contributions in absolute terms but seem less concerned about the final outcome distribution.

Figure 2. Relative average conditional contributions.

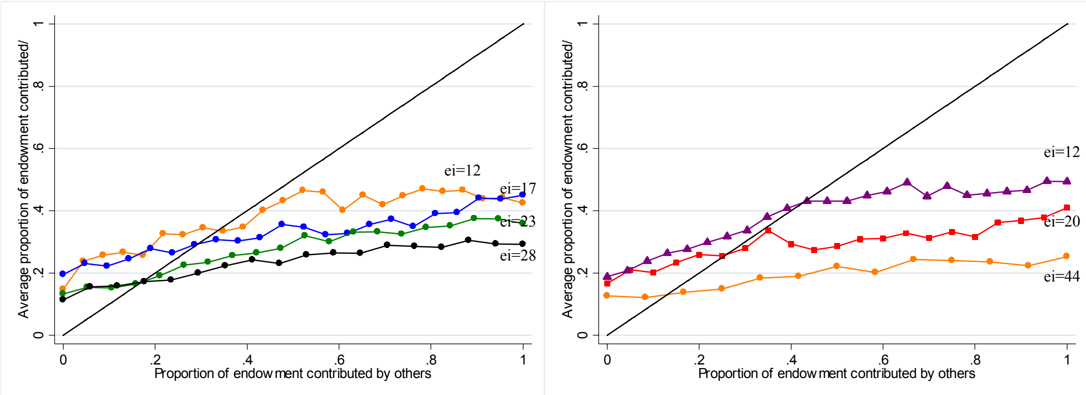


Table 3. Random effect model on relative contribution.
(Standard errors in parenthesis)

Variables	**Coefficient**	**Std. Error**	**95% Confidence Interval**	
Relative contribution by others	0.183 ***	0.020	0.143	0.223
Relative contribution * Dummy for ei=12 ej=(17,23,28)	0.075 ***	0.028	0.020	0.130
Relative contribution * Dummy for ei=17 ej=(12,23,28)	0.041	0.029	-0.015	0.097
Relative contribution * Dummy for ei=23 ej=(12,17,28)	0.069 **	0.029	0.012	0.126
Relative contribution * Dummy for ei=28 ej=(12,17,23)	-0.005	0.030	-0.064	0.054
Relative contribution * Dummy for ei=12 ej=(12,12,44)	0.111 ***	0.028	0.056	0.166
Relative contribution * Dummy for ei=44 ej=(12,12,12)	-0.046	0.032	-0.110	0.017
Intercept	0.204 ***	0.034	0.137	0.272
Dummy for ei=12 ej=(17,23,28)	0.043 ***	0.016	0.010	0.075
Dummy for ei=17 ej=(12,23,28)	0.011	0.017	-0.022	0.044
Dummy for ei=23 ej=(12,17,28)	-0.057 ***	0.017	-0.090	-0.023
Dummy for ei=28 ej=(12,17,23)	-0.060 ***	0.018	-0.094	-0.025
Dummy for ei=12 ej=(12,12,44)	0.039 **	0.016	0.007	0.071
Dummy for ei=44 ej=(12,12,12)	-0.078 ***	0.019	-0.116	-0.041
Observations	9089			
Groups	64			

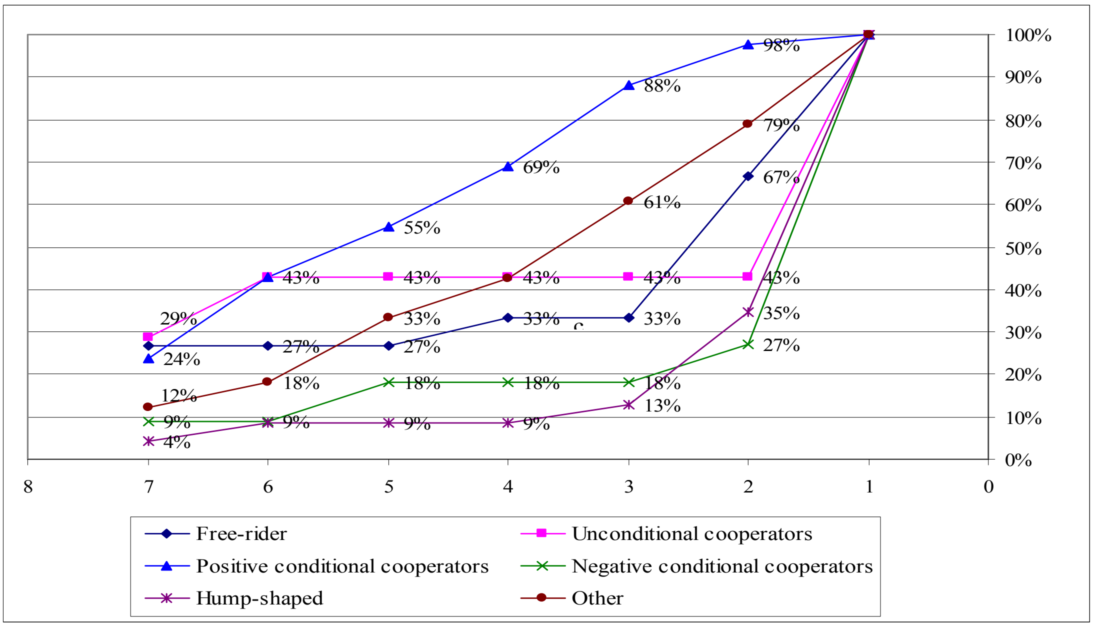
*, **, *** Denote statistical significance at 10%, 5% and 1% level, respectively.

Stability of cooperation preferences at the individual level.

We also test for the stability of types of cooperation preference at the individual level. We look at the number of decisions in which subjects had the same preferences. If subjects exhibit the same preferences in all seven of the decision cases, it suggests that there are stable "types" of preference. Figure 3 presents the cumulative frequency distribution of type stability in the treatments. The horizontal axis represents the number of decisions in which subjects were classified in the same preference type and on the vertical axis the proportion of subjects classified in this group.

The most stable types are conditional cooperation, free-riding and un-conditional cooperation. About one quarter of subjects that exhibit these types of cooperation preference did so consistently in all seven decisions. Positive conditional cooperation is the most stable cooperation preference and about 70% of those who exhibited it remained classified in this preference type for four or more decisions. In contrast only 30% of the free-riders did this. Negative conditional cooperation and hump-shaped preferences were the most un-stable preferences with only 18% and 9%, respectively, of the subjects remaining in the same classification for more than four decisions.

Figure 3. Stability of preferences at the individual level.



Comparison of contributions in the unconditional and the conditional case.

Besides asking the subjects for their conditional contribution at various levels of endowment, we also asked for their unconditional contribution and how much they expected others would contribute. Consistency between unconditional and conditional decisions implies that we observe similar patterns of behavior. Each person answer how much they would contribute unconditionally on 7 decisions, responses are likely to be correlated across decisions, which calls for a random effect model. Table 4 presents the estimated coefficients from a random effects model with unconditional contribution as the dependent variable. We take endowment 20 as a reference case.

Table 4. Random effect model on unconditional contribution.

Unconditional contribution	**Absolute Contribution**				**Relative Contribution**			
Variables	**Coefficient**	**Std. Error**	**95% Confidence Interval**		**Coefficient**	**Std. Error**	**95% Confidence Interval**	
Mean Expected Contribution by others	0.352 **	0.154	0.050	0.655	0.358 ***	0.117	0.128	0.588
Mean expected contribution * Dummy for ei=12 ej=(17,23,28)	-0.366 **	0.186	-0.730	-0.002	0.122	0.148	-0.168	0.413
Mean expected contribution * Dummy for ei=17 ej=(12,23,28)	-0.174	0.192	-0.551	0.204	-0.013	0.147	-0.301	0.276
Mean expected contribution * Dummy for ei=23 ej=(12,17,28)	-0.082	0.198	-0.471	0.306	-0.186	0.144	-0.469	0.097
Mean expected contribution * Dummy for ei=28 ej=(12,17,23)	0.201	0.206	-0.203	0.605	-0.199	0.142	-0.477	0.079
Mean expected contribution * Dummy for ei=12 ej=(12,12,44)	-0.369 **	0.182	-0.724	-0.013	-0.024	0.144	-0.306	0.258
Mean expected contribution * Dummy for ei=44 ej=(12,12,12)	0.763 ***	0.204	0.363	1.162	-0.158	0.137	-0.426	0.110
Intercept	4.137 ***	1.249	1.690	6.585	0.205 ***	0.049	0.109	0.301
Dummy for ei=12 ej=(17,23,28)	0.811	1.518	-2.165	3.786	0.040	0.057	-0.071	0.152
Dummy for ei=17 ej=(12,23,28)	0.881	1.498	-2.055	3.818	0.051	0.056	-0.059	0.160
Dummy for ei=23 ej=(12,17,28)	1.307	1.505	-1.642	4.256	0.049	0.056	-0.061	0.159
Dummy for ei=28 ej=(12,17,23)	1.181	1.535	-1.827	4.190	0.051	0.057	-0.062	0.163
Dummy for ei=12 ej=(12,12,44)	0.354	1.457	-2.503	3.210	0.056	0.054	-0.051	0.162
Dummy for ei=44 ej=(12,12,12)	2.090	1.418	-0.689	4.868	-0.012	0.056	-0.121	0.097

*, **, *** Denote statistical significance at 10%, 5% and 1% level, respectively.

The left hand side of the table presents the results for absolute contribution levels and the right hand side for relative contribution levels. We find that absolute unconditional contributions increase with average expected contributions by others. One again we observe self-serving bias as the slope of the conditional contribution curve is less than one. We find that individuals are willing to contribute positive amounts even if they expect others to contribute zero which indicates altruism. We find that the slope of the conditional contribution curve for absolute contributions is larger for higher levels of endowment compared with low levels of endowment. The level of altruism in absolute terms does not seem to increase with endowment. We find that the absolute and relative contributions are significantly different from zero which supports a degree of altruism.

The slope of the relative unconditional contributions increase with the relative expected contribution by others indicating that conditional cooperation is the dominant type of behavior. We find that about 20% of the endowment is invested when the expected contributions by others is zero, which support altruism. Not clear effects are found on the slope or in altruism with respect to endowment.

An alternative test for consistency is to compare conditional and unconditional cooperation. By asking subjects how much they expected others in their group to contribute, it is possible to compare the amount that they decided to contribute in the unconditional decision with the amount that they contributed in the conditional decision. Table 5 presents the proportion of answers in which conditional and unconditional contributions are equal. We also include the proportion of answers where the difference is only one or two tokens.

Overall, in 27% of the cases there was no difference between answers; in 55% of the cases the difference was 2 tokens or less. If we study the types separately, free-riders and unconditional co-operators are the most consistent between the unconditional and conditional treatments. One explanation of the difference between conditional and unconditional contribution levels may relate to the fact that the former is a "colder" approach than directly reporting unconditional contribution levels. There is an on going debate on this issue and the results are mixed as to whether or not there is a difference (e.g. Brandts and Charness, 2000; Brosig *et al.*, 2003).

Table 5. Proportion of answers where unconditional contribution is equal to conditional contribution.

	Equal	One token difference	Two tokens difference	More than two tokens difference	Total
All	27.35	13.90	13.45	45.29	100
Free-Riding	89.36	0.00	2.13	8.51	100
Unconditional Cooperation	56.52	4.35	4.35	34.78	100
Positive Conditional Cooperation	19.60	17.09	17.09	46.23	100
Negative Conditional Cooperation	13.64	9.09	9.09	68.18	100
Hump-shaped	14.63	14.63	17.07	53.66	100
Others	16.67	16.67	13.16	53.51	100

4. Conclusions

The effects of heterogeneous endowments on contribution levels in public goods experiments have recently received more and more attention in the literature. By combining the experimental design developed by Fischbacher *et al.* (2001) with heterogeneous endowments, we are able to analyze cooperation preferences under the more realistic case when endowments are heterogeneous within a group. We find that the most common cooperation preferences are positive conditional co-operators and free-riders in both the heterogeneous and homogenous cases. This result is in line with previous findings for homogenous endowments. In addition, we find evidence that cooperation preferences are stable over heterogeneous endowments. On average, individuals' contributions increase with the contributions by others, but they increase less than proportionally indicating the presence of a self-serving bias. We also find some evidence to support altruism as motivation behind cooperation since on average individuals are willing to cooperate even when contribution levels by others are zero. Moreover, we find evidence that higher endowments increase cooperation in absolute terms, but decrease it in relative terms. A large degree of internal consistency is found in the experiment.

Given that cooperative preferences are stable, the results imply that contribution levels are dependent on the distribution of cooperation preference types i.e. they are dependent on whether the free-riders or the positive conditional co-operators are on average richer or poorer within the society.

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Appendix A

Instructions

You are about to participate in an experiment on decision-making. If you follow these instructions carefully and make good decisions you could earn a considerable amount of money that will be paid to you at the end of this experiment in cash.

Throughout the entire experiment, communication of any kind is strictly prohibited. Communication between participants will lead to your exclusion from the experiment and the forfeit of all monetary earnings. If you have any questions, please raise your hand and a member of the research team will come to you and answer your question privately.

Your earnings in this experiment will be in "tokens." At the end of the experiment, tokens will be converted into Euros at the exchange rate of:

2 tokens = 1250 Pesos

Regardless of your decisions in the experiment, you will receive a show-up fee of 7500 Pesos.

You will also have to fill in a few questionnaires during the experiment. Some of the questions might seem a bit odd to you; but even so, please, answer them seriously. This is an international research project and we are bound to use the same set of questions in all locations. All your answers **remain confidential and anonymous**. We will use the experiment number tag that you have received on entering the room to identify you, and this will also be used to identify you when we pay you your income after the experiment.

All participants will bein groups of four. Nobody other than the people running the experiment will know who is in which group.

The Basic Decision

You will now learn how the experiment is conducted. First, we introduce the basic decision-making situation. Then, we ask you to answer control questions that will help you gain an understanding of the decision-making situation.

You will be a **member of a group of four people**. Groups will be assembled randomly. At the beginning of the experiment you will receive (on paper) **an number of tokens called an "endowment"**. Each of the four members of a group has to decide how to divide this endowment. You can put all, some or none of your tokens **into a group account**. Each token you do not deposit in the group account will automatically be transferred to your **private account**.

Different members of your group may have **different endowments**. You will see on your decision sheet (handed out later) how many tokens you are endowed with and how many tokens are in the endowments of the other members of your group.

Your income from the private account:

For each token you put into your private account, you will earn exactly one token. For example, if you have an endowment of 20 tokens and you put zero tokens into the group account (and therefore 20 tokens in the private account), then you will earn exactly 20 tokens from the private account. If instead you put 14 tokens into the group account (and therefore 6 tokens in the private account), then you receive an income of 6 tokens from the private account. *Nobody except you earns tokens from your private account.*

Your income from the group account:

Everybody receives the same income from the group account that is based on the total number of tokens paid into it by the group. This income is not affected by either the size of an indicual's endowment or by the amount that an individual puts into the group account. Your income from the group account, therefore will also be earned from the tokens that the other group members put into the group account, not just the tokens that you invest in it yourself. For each group member, the income from the group account will be determined as follows:

Income from the group account =
sum of all contributions to the group account x 0.4

For example, if the sum of all contributions to the group account is 60 tokens, you and all other group members will get an income of 60x0.4=24 tokens from the group account. If the four group members deposit a total of 10 tokens in the group account, then you and all others will receive an income of 10x0.4=4 tokens from the group account.

Your total income:

Your total income is the sum of the income from your private account and the income from the group account:

Income from your private account (= your endowment – your contribution to the group account)
+ Income from the group account (= 0.4 × sum of all contributions to the group account)
Total income

Before we finish reading the instructions we will ask you to answer the following control questions that help you to see whether you have understood everything correctly. If there are any questions or problems, please raise your hand. One of the people running the experiment will come to you and answer your questions privately.

Control Questions

Please answer the following control questions. Their purpose is to make you familiar with calculating the various incomes in tokens that you might arise from the decisions we ask you to make about allocating your endowments. *Please answer all questions and write down all calculations.*

1. Assume you have an endowment of 23 tokens and the three other group members have endowments of 12, 17, and 28 tokens each. Assume also that all group members (including yourself) put nothing into the group account.

   What is your total income? ____

   What are the incomes of the three other group members? ____, ____, and ____

2. Assume you have an endowment of 23 tokens and the three other group members have endowments of 12, 17, and 28 tokens each. Assume also that all group members (including yourself) put their entire endowment into the group account.

   What is your total income? ____

   What are the incomes of the three other group members?____, ____, and ____

3. Assume you have an endowment of 23 tokens. Assume also that the other group members collectively put a total of 30 tokens into the group account.

   a) What is your total income, if you, in addition to the 30 tokens of the other 3 group members, put 0 tokens into the group account?

      Your total income: ____

   b) What is your total income, if you, in addition to the 30 tokens of the other 3 group members, put 8 tokens into the group account?

      Your total income: ____

   c) What is your total income, if you, in addition to the 30 tokens of the other 3 group members, put 15 tokens into the group account?

      Your total income: ____

4. Assume you have an endowment of 23 tokens. You put 9 tokens into the group account.

a) What is your total income, if the other group members, in addition to your 9 tokens, put another 7 tokens into the group account?

   Your total income: ____

b) What is your total income, if the other group members, in addition to your 9 tokens, put another 12 tokens into the group account?

   Your total income: ____

c) What is your total income, if the other group members, in addition to your 9 tokens, put another 22 tokens into the group account?

   Your total income: ____

If you finish these questions before the others, we advise you to think about additional examples to familiarize yourself further with these types of decision-making situations.

The Experimental procedure

The experiment consists of decision-making situations like the one that we have just described. In the following we explain the procedure in detail.

As you know you have an endowment of tokens. You can put these tokens into a group account and the remaining tokens will automatically be deposited into your private account. Each member of your group may have a different number of tokens in his or her endowment.

Each group member has to make two types of decision. In the following instructions, we will refer to them as the "**unconditional contribution**" and the "**contribution table decision**."

- With the **unconditional contribution** to the group account, you decide how many of the tokens in your endowment to put into the group account. Write this amount behind *"Your unconditional contribution to the group account"* on the first page of your decision sheet. You must write down an **integer number** that **cannot be smaller than zero or larger than the total number of tokens that you have been given in your endowment.** The difference between your endowment and the amount you put into the group account is automatically the amount that will go into your private account.

- Your second task is to fill out a **contribution table** on page 2 of the decision sheet. In the contribution table you have to indicate how many tokens you would like to put into the group account for each possible average contribution of the other three group members (rounded up or down to the next integer number). What you actually contribute will depend on what the other group members actually contribute. This will become clear to you when you see the following contribution table example:

(Rounded) Average contribution of the other group members to the group account	Your contribution to the group account is
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	

The numbers in the left column are the possible (rounded) average contributions of the **other** group members. Assume for this example that the other group members have endowments of 12, 17 and 28 and can therefore contribute on average a maximum of 19 tokens (= (12+17+28)/3). Your actual contribution table might have a larger or smaller number of rows, depending on the sizes of endowment of the other group members (remember that different group members may have different sizes of endowment).

Using the column on the right, you simply have to write down how many tokens you would like to contribute to the group account for each possible average contribution of the others. You must make an entry in each field of the right column. For example, you must write down how many tokens you want to contribute to the group account if the others contribute on average 0 tokens to the group account; how many you contribute if the others contribute 1 or 2 or 3 tokens, etc. In each field, you must write down an integer a number that is neither smaller than zero and nor larger than the total number of tokens in your endowment. You can, of course, write down the same number in different fields.

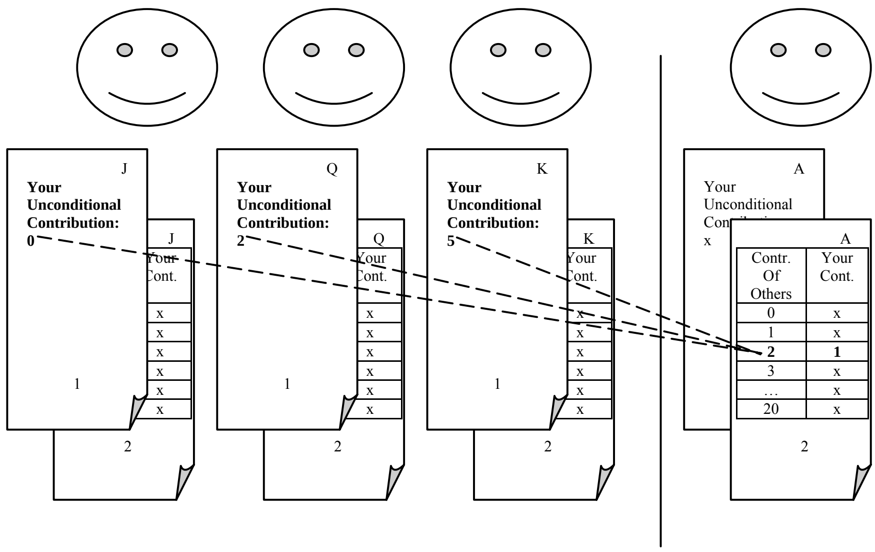
After all participants of the experiment have made their unconditional contribution decisions and have filled out their conditional contribution table, one member of each group will be selected randomly. Each person will receive payment for one decision only and this random selection mechanism is used to determine whether it is the unconditional contribution decision or the contribution table decision that is paid. For the randomly selected group member, only the contribution table will be income-relevant. For the other 3 group members that are not selected, the unconditional contribution decision will be the income-relevant decision. When you make your unconditional contribution and when you fill out the contribution table you do not know whether you will be selected randomly. Therefore you will have to think carefully about both types of decision because both could affect the amount that you earn. The following two examples should illustrate this:

Example 1: Assume that after you have handed in your decisions you have been selected by the random mechanism. This implies that your income-decision will be the contribution table. For the other 3 group members the unconditional contribution is the relevant decision. Assume they have made unconditional contributions of 0, 2, and 5 tokens. The rounded average contribution is therefore 2 (7/3 = 2.33).
If you have indicated in your contribution table that you will put one token into the group account if the others contribute 2 tokens on average, then the total contribution to the group account is 0+2+5+1=8. Thus all group members earn an income of 0.4x8=3.2 from the group account plus the respective incomes from their private accounts.
If you have indicated instead that you will contribute 19 tokens to the group account if the others contribute 2 on average, then the total contribution to the group account is 0+2+5+19=26. All group members earn an income of 0.4x26=10.4 tokens from the group account plus the respective incomes from their private accounts.

Example 2: Now assume that you have not been selected by the random mechanism, which means that for you and two other group members the unconditional contribution is the income-relevant decision. Assume further that your unconditional contribution to the group account is 16, and that those of the other two group members are 18 and 20 each. The average unconditional contribution of you and the other two is therefore 18 (=16+18+20)/3).
If the randomly selected group member indicates in the contribution table that he or she contributes one token to the group account when the other 3 group members contribute 18 on average, then the total contribution of the group to the group account is 16+18+20+1=55 tokens. All group members will therefore earn 0.4x55=22 tokens form the group account in addition to the respective incomes from their private accounts.
If the randomly selected group member instead indicated in the contribution table that he or she will contribute 19 tokens to the group account when the other 3 group members contribute 18 on average, then the total contribution of the group to the group account is 16+18+20+19=73 tokens. All group members will therefore earn 0.4x73=29.2 tokens from the group account in addition to the respective incomes from their private accounts.

The random selection of the participants will be implemented as follows. Each group member is assigned the name of a playing card (Jack, Queen, King or Ace) that can be seen on you're his or her decision sheet. **After** all of the participants have made their unconditional contribution and contribution table decisions, a randomly selected participant will draw one of four playing cards (Jack, Queen, King, Ace),. If the card that is drawn matches the card on your decision sheet, then your payment will be based on the contribution table on page 2 of your decision sheet. Otherwise, your payment will be for your unconditional contribution on page 1. Remember that you only know which decision your payment will be based on after you have submitted your decisions. Thus, you should fill out both pages carefully.

The following graph is a visual presentation of the situation from example 1. You are the person to the right, whose card is an Ace (A). An A was drawn in the random selection mechanism and therefore page 2 of the decision sheet is the relevant page for you, while page 1 is the relevant page for everybody else. While all group members had to fill out both pages completely (indicated by the letter "x") only the decisions in bold are relevant to the payoff.



Seven parallel decisions:

In the experiment, you are simultaneously **in nine groups** that are randomly assembled from the people in that room. Each consists of four members. You do not know and will never get to know the other group members, and they do not know and will never get to know that you were in their group. You have to fill out seven decision sheets ,each with an unconditional contribution on p. 1 and a conditional contribution on page 2. You do not have to fill out nine decision sheets because for three of the groups, you have exactly the same endowment so that we can take your values from one decision sheet only).

The **decision sheets do not have to be completed in any particular order**. In a minute we will hand out your decision sheets, and you can start with any one of them. You can also go back and make corrections on a sheet that you already filled out if you wish. When you have filled out all seven sheets, we will come and collect them from you. The **only difference** between the seven decisions sheets, i.e. the seven groups in which you are placed, is that **the distribution of endowments** within the group is different. So take a close look at the top of the sheets to discern this potentially important information. If you have any problems or questions at any time during the experiment, please raise your hand.

At the end of the experiment, your payment will be determined by randomly selecting one of the nine groups to which you belong. We will let one of you draw a lottery ticket at the end of the experiment out of a basket that contains nine tickets that are colored red, yellow, blue, green, black, white, orange, purple and pink (the names of the nine groups). The **number of tokens** that you earned in the group that selected in the draw will then be **converted into Euros and paid to you in cash.** The other eight groups do not result in cash payments. Since you do not know which group is going to be selected for the payoff, we advise you to think seriously about all your decisions because any one of them could influence your payoff. Therefore, please take your time in filling out the decision sheets.

Do you have any questions? Please raise your hand if you do and a member of the research team will come to you and answer your question privately.

Experiment ID:_____ Your card in your groups (Jack, Queen, King or Ace):___ Group Red

Decision Sheet

Page 1

Your endowment: 20 tokens

Endowment of player 2: 20 tokens
Endowment of player 3: 20 tokens
Endowment of player 4: 20 tokens

Your unconditional contribution to the group account: ______
(it must be an integer number not smaller than 0 and not larger than 20)

Page 2

Your conditional contribution to the group account (contribution table decision):

(Please enter in the cells of the right-hand column the number of tokens you want to contribute to the group account, given the average contributions of the other group members to the group account in the left column of the same row. As before, you must enter integer numbers.)

(Rounded) Average contribution of the other group members to the group account	Your contribution to the group account is
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	

How many tokens do you think others in your group have unconditionally contributed to the group account?

Earlier, you were asked to fill out 7 sheets with one unconditional contribution and a number of conditional contributions. Now we ask you to state what you believe the other participants in your groups have written down for their **unconditional** contribution.

Please record the number of tokens **you believe the other 3 players** in each of the 7 groups to have contributed unconditionally to the group account. In other words, what number do you think each of them wrote down on page 1? The range of possible contributions to the group account for each member varies from group to group. Please refer to the possible contribution amounts (found in parentheses) in the relevant cells of the [table on expected contributions. For example, each member in Group Red can contribute between 0 and 20 tokens; player 2 of group Yellow can contribute between 0 and 17 tokens, and so on.

Remember that one group will be selected randomly in order to determine the payments. You will **earn money from the allocation as described in the instruction** for the randomly selected group **AND** you can now earn more money **if your beliefs for the selected group are correct**. Suppose Group Green is selected randomly. You can then earn an additional 2 tokens for each of your beliefs that is **no more than one token larger or smaller than the actual contribution of a member of Group Green to the group account**. Suppose you guessed 10 tokens for player 2, 5 tokens for player 3 and 10 tokens for player 4, and the actual choices of the three players were 11, 4 and 5 tokens, respectively. Then you would earn an additional 4 tokens because your guesses for players 1 and 3 would have been close enough to the actual values. Note that players in your group will be assigned player numbers randomly so that you can refer to them easily.

Expected contributions to the group account

	Group Red	***Group Yellow***	***Group Blue***	***Group Green***	***Group Black***	***Groups White/Purple/Pink***	***Group Orange***
Your endowment	Endowment: 20	Endowment: 12	Endowment: 17	Endowment: 23	Endowment: 28	Endowment: 12	Endowment: 44
Player 2	Endowment: 20	Endowment: 17	Endowment: 12	Endowment: 12	Endowment: 12	Endowment: 12	Endowment: 12
	Expect.: ________ (0 – 20)	Expect.: ________ (0 – 17)	Expect.: ________ (0 – 12)	Expect.: ________ (0 – 12)	Expect.: ________ (0 – 12)	Expect.: ________ (0 – 12)	Expect.: ________ (0 – 12)
Player 3	Endowment: 20	Endowment: 23	Endowment: 23	Endowment: 17	Endowment: 17	Endowment: 12	Endowment: 12
	Expect.: ________ (0 – 20)	Expect.: ________ (0 – 23)	Expect.: ________ (0 – 23)	Expect.: ________ (0 – 17)	Expect.: ________ (0 – 17)	Expect.: ________ (0 – 12)	Expect.: ________ (0 – 12)
Player 4	Endowment: 20	Endowment: 28	Endowment: 28	Endowment: 28	Endowment: 23	Endowment: 44	Endowment: 12
	Expect.: ________ (0 – 20)	Expect.: ________ (0 – 28)	Expect.: ________ (0 – 28)	Expect.: ________ (0 – 28)	Expect.: ________ (0 – 23)	Expect.: ________ (0 – 44)	Expect.: ________ (0 – 12)