An Economic Analysis of Coca Eradication Policy in Colombia

by

Rocio Moreno-Sanchez
David S. Kraybill
Stanley R. Thompson[1]

Department of Agricultural, Environmental, and Development Economics
The Ohio State University

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Abstract. We estimate an econometric model of coca production in Colombia. Our results indicate that coca eradication is an ineffective means of supply control as farmers compensate by cultivating the crop more extensively. The evidence further suggests that incentives to produce legal substitute crops may have greater supply-reducing potential than eradication.

Key words: coca production, coca eradication, drug control policy

[1] Graduate Assistant and Professors, respectively, in the Department of Agricultural, Environmental, and Development Economics at The Ohio State University. 2120 Fyffe Road, Columbus, OH 43210. Email: moreno.30@osu.edu

Introduction

Coca (*Erythroxylum coca)* is the main input in the manufacture of cocaine hydrochloride, an addictive, pscyhostimulant drug whose use is illegal today in most countries. Policies regarding production and use of coca and its derivatives are controversial. The controversy focuses primarily on whether drug-control policies are effective in achieving their stated objectives of reducing cocaine usage.

The Policy Setting

Cocaine is produced in four stages: cultivation of the coca plant and harvesting of the leaf, extraction of coca paste, transformation of the paste into cocaine base, and conversion of the base into cocaine (Riley, 1993). In the past, small-holding producers who grew coca sold the dried leaf after harvest. In recent years, some smallholders have begun to produce coca paste in an effort to generate additional value added.

Colombia, Peru, and Bolivia are host to more than 98% of the global land area planted in coca. In 2000, over 210,000 hectares of coca were cultivated in these three countries (UNDCP 2000). The coca production share of these three countries shifted dramatically over the period 1986-2000. During this period, the Colombian share increased from 12% to 75%, while the shares of the other two countries decreased from 75% to 18% for Peru and from 13% to 8% for Bolivia (UNDCP 1999, 2000). Global supply during the same period has remained almost constant with estimates of the growth ranging from -7.7% to 5.8% (UNDCP 1999, 2000).

By 2001, an estimated 163,000 hectares were planted in coca in Colombia, primarily in three departments, the largest political division in the country's system of governance (CGR, 2001). Putumayo, Guaviare, and Caqueta departments produce approximately 68% of Colombian coca leaf (DNE 2000). These isolated regions of the country have long received relatively little funding from the Colombian national government for infrastructure, technical assistance, education, and health services – limiting the range of feasible legal economic activities. In 1998, the index of poverty, measured in terms of unsatisfied basic needs (housing, health services, education, and infrastructure) for rural areas was estimated at 72% in Caqueta and 100% in Putumayo and Guaviare (DNP, 2002).

During the past decade, governments in the coca-producing countries and governments in cocaine-consuming countries have waged a “war on drugs,” allocating monies to control production and distribution through coca eradication, crop substitution, and interdiction (interception) of cocaine supply. In Colombia, the eradication of illegal crops has intensified in the last 10 years. From 459 hectares in 1991, the area eradicated annually in Colombia increased to 72,379 hectares in 2001 (DNE 2000, UNDCP 2000, CGR, 2001). Approximately US$113 million was spent on aerial spraying of coca in Colombia from 1994 to 2000. In 2000, the United States government approved a two-year budget of US$ 860 million in support of the national government’s Plan Colombia, whose main objective is to reduce drug production and trafficking. Of the US$860 million allocated to Colombia, US$ 642 million was designated specifically for efforts to reduce the supply of illegal crops. As a complement, US$ 440 million were approved for related activities in surrounding countries.

A number of reasons have been advanced for why coca acreage has increased in Colombia despite the intensification of counter-narcotic policies. Cocaine traffickers appear willing to increase the farm gate price to compensate farmers for policy-induced increases in production risk. They are able to do this because, though coca is the primary ingredient in the production of cocaine, the farm gate price is a small fraction of the retail price of cocaine in the consuming countries. Doubling or tripling the farm gate price can occur with a barely perceptible influence on the retail price in North America and Europe. Other reasons for the increase in coca supply in Colombia despite supply-control policies complement this hypothesis: low national and international prices for agricultural products, rising poverty rates in rural areas of Colombia, the virtual abandonment of some regions by the national government, inequality in land distribution, and the presence of left-wing guerillas and right-wing paramilitaries. Guerrilla and paramilitary groups, which profit from the drug trade, control the main coca-producing regions, and civil unrest has undoubtedly contributed to the expansion of coca acreage in Colombia (UNDCPa 2000).

Contrary to the widespread belief that the Colombian economy depends largely on the illegal drug trade, Steiner (1998) showed that drug revenues represent a small percentage of national income. Using official data and his own computations, Steiner (1998) found that income from the drug trade represents approximately 3 percent of Colombia's gross domestic product (GDP) and 25 percent of its exports.

Previous Research

There is a small body of economic research examining the market for illegal drugs. Demand studies have focused on factors affecting the consumption of illegal drugs by various population groups, the impact of consumption on worker performance, the effect of illegal drug use on labor market outcomes, substitution or complementarity among various illegal drugs, consumer expenditures on illegal drugs, the effect of drug-control spending on illegal drug use, and the effects of decriminalization of illegal-drug possession on prices and consumption (Saffer and Chaloupka 1998, MacDonald and Pudney 2000, Desimone 1998, Grossman and Chaloupka 1998, and Chaloupka, Grossman and Tauras, 1998).

Most of the supply studies of illegal drugs focus on the effectiveness of drug control policies. Fowler (1990) analyzed the effects of drug interdiction expenditures on illegal drug use. Gibson and Godoy (1993) analyzed alternatives to coca production in Bolivia using a computable general equilibrium model of the national economy. Riley (1993) assessed the impact of eradication, interdiction, and economic development strategies in Bolivia, Colombia and Peru using a dynamic economic model of the cocaine industry and source- country drug-control policies. They concluded that these policies could disrupt production for only short periods. Whynes (1991) used a simple game-theoretic approach to examine the feasibility of various supply-side policy options including taxation of coca production, crop substitution, eradication, and purchase of production by the government. He concluded that supply policies are ineffective as a means of drug control.

Kennedy, Reuter and Riley (1993), using a model of cocaine production in Bolivia, Colombia, and Peru, analyzed the determinants of the volume of cocaine trade, and simulated the effects of crop substitution, eradication, and other policies on cocaine production. One of the main conclusions was that strategies that seize and destroy even as much as 70% of cocaine production will have little impact on the market if cocaine traffickers can increase gross production to compensate for some percentage of the product being destroyed. The reason is that the increased cost of the higher gross production is low relative to the retail price of cocaine. They also conclude that crop substitution has a negligible impact on the world cocaine market because traffickers can easily exceed any economic profit coming from proposed substitution programs.

Rydell and Everingham (1994) examined the cost-effectiveness of both supply and demand control programs including source-country control, interdiction, domestic enforcement, and treatment of heavy users. They concluded that cutting back on supply control and expanding treatment of heavy users would make cocaine control policy more cost-effective.

Other studies have sought to identify specific economic, political, and social conditions that contribute to the emergence of illegal drug production. Morrison (1997) found that contributing factors include isolation, economic insecurity in rural areas, and lack of enforcement caused by corruption or insurgency. It is clear that these conditions are prevalent in Colombian coca-producing regions.

Focusing on Colombia, Uribe (2002) estimated the profitability of coca production for peasants in the three largest coca-producing departments. He found that the net income of peasant producers of coca ranged from US$1,629 to US$ 3,895 per year when the cost of family labor is not counted. If family labor is valued at local wage rates, net income is lower and can even be negative depending on the region, ranging from –US$1,485.91 to US$ 1,792.06.

Based on the existing literature, there is little reason to believe that supply control measures have been effective in reducing the production or trafficking of illegal drugs. No single drug policy instrument appears capable of permanently reducing output due to inherent characteristics of the cocaine industry: the availability of low-cost land and labor in politically unstable regions, and the ease of transporting the low-bulk and low-weight final product.

Analysis of Coca Cultivation

Most previous studies on the effectiveness of drug supply-control policies have used non-stochastic methods, such as market simulation models. Deterministic methods have been used in these studies primarily because the relatively small number of observations available on drug crop production limits the degrees of freedom available for econometric analysis. Crop estimates are available on only an annual basis. The number of observations increases, however, with each passing year. In this study, we utilize annual United Nations data on cocoa cultivation in Colombia over a 14-year period to estimate an econometric model of Colombian coca cultivation. We confront the problem inherent in small-sample econometric analysis by utilizing influence diagnostics (Belsley, Kuh, and Welch 1980) to determine the extent to which parameter estimates from our model are influenced by individual observations in the dataset.

Data. Due to the illegality of coca, available data on this crop are scarce. Although in recent years more sources of information have become available, not all of them are reliable. The lack of quantity and quality in data is a difficult problem to solve because “the boom” of coca production and its subsequent control in Andean countries started in the 1980s and neither national nor international institutions collected data before that period. When production of coca and consumption of cocaine reached alarming levels, national and international organizations began drug control programs and started to monitor the cultivated area and the volume of output in producer countries.

The data used in this study come from four sources: data on coca (area cultivated, area eradicated, and prices) were obtained from published reports of United Nations Office for Drug Control and Crime Prevention (UNDCP) and from the Colombian narcotics-control agency (Direccion Nacional de Estupefacientes). UNDCP reports are based on annual questionnaires completed by government agencies in the producer countries. Plantain price data were obtained from the Ministry of Agriculture of Colombia and the Food and Agriculture Organization of the United Nations (FAO).

The Basic Model. The decision to plant coca is assumed to be influenced by prices and alternative production opportunities in a manner similar to decisions regarding other farming activities. The area planted in coca is also assumed to respond to coca eradication policies in Colombia and to the area planted in other major coca-producing countries. Since coca is a perennial crop and the gestation period spans more than one growing season, we assume that the area planted responds to production conditions in the previous year.

Based on these assumptions, we specify the following econometric model of coca cultivation:

$$H_t = b_0 + b_1 P_{t-1} + b_2 PP_{t-1} + b_3 E_{t-1} + b_4 O_{t-1} + e_t$$

where H is the number of hectares of coca under cultivation in Colombia, P is the farm-gate price of coca, PP is the farm-gate price of plantain, E is the number of hectares of coca eradicated in Colombia, and O is the number of hectares of coca under cultivation in Bolivia and Peru. The error term is assumed to be normally distributed with zero mean and constant variance; that is, $\varepsilon \sim N(0,\sigma^2)$. The subscript t refers to the current year while t-1 refers to the previous year. The model was estimated using ordinary least squares (OLS).

It is assumed that coca farmers attempt to maximize profits, subject to various constraints. Therefore, own price of coca is hypothesized to have a positive effect on area planted in coca, while the price of plantain, a crop substitute, is expected to be negatively related to the number of hectares planted in coca. Coca eradication policy increases the production risk faced by farmers. Given the limited alternative economic opportunities in Colombia's coca-growing regions, it is expected that farmers respond to this increased risk by planting additional hectares of coca. Therefore, we hypothesize a positive relationship between cultivated area and eradicated area. Finally, the area planted in coca in other producing countries is hypothesized to be inversely related to the area cultivated in Colombia, as traffickers are assumed to quickly seek out new geographic sources of supply when production is reduced in old production areas.

Model 1. As shown in Table 1, all variables in the coca cultivation model are significant at the five-percent level, and the model explains a high proportion of the total variation in Colombian coca cultivation (adjusted $R^2 = 0.992$). All parameters have the expected signs. Consistent with our hypotheses, eradication appears to increase rather than reduce hectares planted in coca, and cutbacks in coca production in Bolivia and Peru result in the planting of more hectares of coca in Colombia.

The estimated parameters were used to compute elasticities at mean values of the variables. Coca cultivation is inelastic to own price ($\eta = 0.181$), as shown in Table 4. Low area-planted responsiveness to price could be due to the fact that coca is a perennial crop. Once it is planted, the coca bush continues to produce foliage each year with a minimum of maintenance, thus muting the responsiveness of production to price. The control that guerilla groups and paramilitaries exert over production and marketing decisions in coca-producing areas in Colombia probably further diminishes the effect of the farm gate price on coca cultivation.

The elasticity of coca cultivation with respect to hectares eradicated in Colombia indicates that producers increase the area cultivated in response to eradication efforts but less than proportionately ($\mu = 0.209$). Since coca is generally somewhat more profitable than other crops, producers apparently respond to the production risk imposed through supply control policies by increasing the area planted. Eradication seems to have an effect opposite to the one intended by policymakers.

The cross-price elasticity ($\varphi = -0.380$) indicates that coca cultivation decreases in response to increases in plantain price although less than proportionately. The area cultivated in Colombia is elastic ($\alpha = -1.124$) with respect to the area cultivated in Bolivia and Peru. Changes in the area cultivated in the other major producing countries, whether due to eradication efforts or other factors in those countries, appear to be more than offset by changes in the area cultivated in Colombia. This result is consistent with the argument of Youngers (2000) and others that coca eradication in the Andean region, while successful in reducing production in the Bolivia and Peru, has not reduced the total supply from the region.

Model 2. Because the coca bush is typically maintained over a number of years, we estimated an alternative model with a lagged dependent variable to examine whether accounting for plant-stock carryover affects our parameter estimates. Regression results are presented in Table 2. The coefficient of determination, which was high in the previous model, is now slightly higher. All signs remain the same and all parameter estimates are significant at the 10 percent level with the exception of area cultivated in Bolivia and Peru. Thus, when the perennial nature of the coca plant is taken into account, the conclusion that eradication is ineffective remains valid.

Dynamic multipliers, whose calculation is made possible by lagging the dependent variable, are presented in Table 4. For three of the four independent variables, the static elasticities from model 1 lie between the short-run and long-run dynamic multipliers for model 2.

Model 3. The data on hectares of coca eradicated exhibit a sharp increase in 1998 (see Figure 1). We therefore estimated a model, similar to model 1, but with a dummy variable included to determine the extent to which this one-year spike in eradication affects the parameter estimates. As show in Table 3, the estimated parameter of the dummy variable is statistically significant at the one percent level. The parameters of the other variables are all significant and the signs remain consistent with our hypotheses. The coefficient of determination (0.997) is slightly higher than in models 1 and 2. Static multipliers for model 3 are presented in Table 4.

Autoregression Diagnostics. Autoregression would violate the assumptions of the classical linear regression model, making OLS estimates inefficient. We analyzed the residuals of the estimated models to detect the possible presence of serial correlation. Given the error process

$$e_t = r e_{t-1} + m_t \qquad (t = 1, 2, ,\ldots),$$

we tested the null hypothesis, H_0: ρ = 0. The Durbin-Watson test, which is appropriate when there is no lagged dependent variable, was used for models 1 and 3. The Durbin-h test, appropriate when there is a lagged dependent, was used for model 2. The test statistics are reported in Table 1, 2, and 3. The null hypothesis was not rejected at the 10% level for all three models, indicating the absence of serial correlation.

Sample-Size Diagnostics. Given the small size of the dataset, we utilized an influence diagnostic test to determine the relative effects of each annual observation on the estimated parameters of the model (Belsley, Kuh, and Welch 1980). The DFBETA statistic indicates whether the change in the *jth* parameter as a consequence of dropping the observation for the *ith* year is significant. The hypothesis associated with this test is

$$H_0 : b_j^i = \hat{b}_j$$
$$H_1 : b_j^i \neq \hat{b}_j$$

where $\hat{b}_j$ is the *jth* estimated parameter when the whole sample is used, and b_j^i is the *jth* estimated parameter when the *ith* observation is dropped. The estimated DFBETA statistic indicates that none of the parameters changes significantly (α = 5%) when each observation is dropped one at a time with the exception of the parameter for eradicated area, which changes when the 1999 observation is dropped (see appendix). Though the magnitude of the effect of eradicated area on cultivated area changes when this year is omitted, the parameter is still statistically significant and the sign remains positive. Furthermore, it is only the 1999 observation that causes this parameter to change.

In summary, hypothesis H_0 is rejected for only one of the estimated betas and for one observation. It therefore seems reasonable to conclude that our findings regarding the determinants of coca cultivation in Colombia are not unduly influenced by the size of the sample.

Policy Implications and Conclusions

Our analysis indicates that the coca eradication policy of the Government of Colombia has not achieved its objective of reducing coca cultivation. Rather, cultivated area has increased as eradication efforts have intensified. Farmers appear to compensate for destruction of the crop by cultivating more extensively. The finding that the price of a key alternative crop, plantain, is negatively related to coca production suggests that the Colombia government could achieve its narcotic-control objectives more effectively by focusing on policies that increase farmers' net return coming from legal crops. Such policies might include assignment of secure property rights for land, provision of technical assistance and credit, mechanisms to improve marketing conditions for agricultural products, and infrastructure investments. Direct subsidies or lump sum transfers to farmers shifting from coca to other crops should be considered.

However, neither public nor private investments in rural areas may be feasible as long as the civil war in Colombia continues. While crop substitution programs in other countries have not proven to be a panacea as long as adverse socioeconomic and political conditions persist, our analysis suggests that crop substitution is nevertheless more likely to be effective than eradication.

Colombian coca cultivation is positively related to the price of coca. Reducing the demand for cocaine in consuming countries may lead to a lower farm-gate price for coca. Drug policy objectives of the U.S. and other cocaine-consuming countries could likely be achieved more effectively by focusing on demand control at home rather than on supply control efforts such as Plan Colombia.

Table 1. Coca Cultivation in Colombia, 1988-2001. Model With Lagged Independent Variables But No Lagged Dependent Variable.

Variable	Coefficient	Standard Error	t-statistic	Probability
Intercept	142560.2***	13054.85	10.920090	0.0000
P(-1)	11.40291**	4.772205	2.389442	0.0406
E(-1)	0.741728***	0.120588	6.150945	0.0002
PP(-1)	-32.56780**	12.34778	-2.637543	0.0270
O(-1)	-0.509218***	0.067404	-7.554730	0.0000
R-squared		0.991682		
Adjusted R-squared		0.987986		
F-statistic		268.2605		
Durbin-Watson statistic		2.148129		

***, **, and * indicate significance at 1, 5, and 10 percent levels.

Dependent Variable (period t):
H: Cultivated area in Colombia (ha)

Independent Variables (period t-1):
P: Farm-gate coca base price in Colombia (in constant 2000 US$)
E: Eradicated area in Colombia (ha)
PP: Farm-gate price of plantain in Colombia (in constant 2000 US$)
O: Cultivated area in Peru and Bolivia

Table 2. Coca Cultivation in Colombia, 1988-2001. Model With Lagged Dependent and Independent Variables.

Variable	Coefficient	Standard Error	t-statistic	Probability
Intercept	49565.8	32562.58	1.522169	0.1665
P(-1)	10.42816**	3.495908	2.982963	0.0175
E(-1)	0.577060***	0.103807	5.558992	0.0005
PP(-1)	-19.87081*	9.959068	-1.995248	0.0811
O(-1)	-0.147690	0.130660	-1.130344	0.2911
A(-1)	0.597419**	0.200047	2.986394	0.0174
R-squared		0.996067		
Adjusted R-squared		0.993609		
F-statistic		405.2129		
Durbin-h statistic		1.933000		

***, **, and * indicate significance at 1, 5, and 10 percent levels.

Table 3. Coca Cultivation in Colombia, 1988-2001. Model With Dummy Variable, Lagged Independent Variables, But No Lagged Dependent Variable.

Variable	Coefficient	Standard Error	t-statistic	Probability
Intercept	123312.0***	10508.0241	11.7350	0.0000
P(-1)	8.7326**	3.3304	2.6221	0.0310
E(-1)	0.9643***	0.1047	9.2063	0.0000
PP(-1)	-18.7477*	9.3080	-2.0141	0.0790
O(-1)	-0.4520***	0.0487	-9.2804	0.0000
Dummy	-16181.03***	4757.6321	-3.4011	0.0090
R-squared		0.997		
Adjusted R-squared		0.994		
F-statistic		468.902		
Durbin-Watson statistic		2.192185		

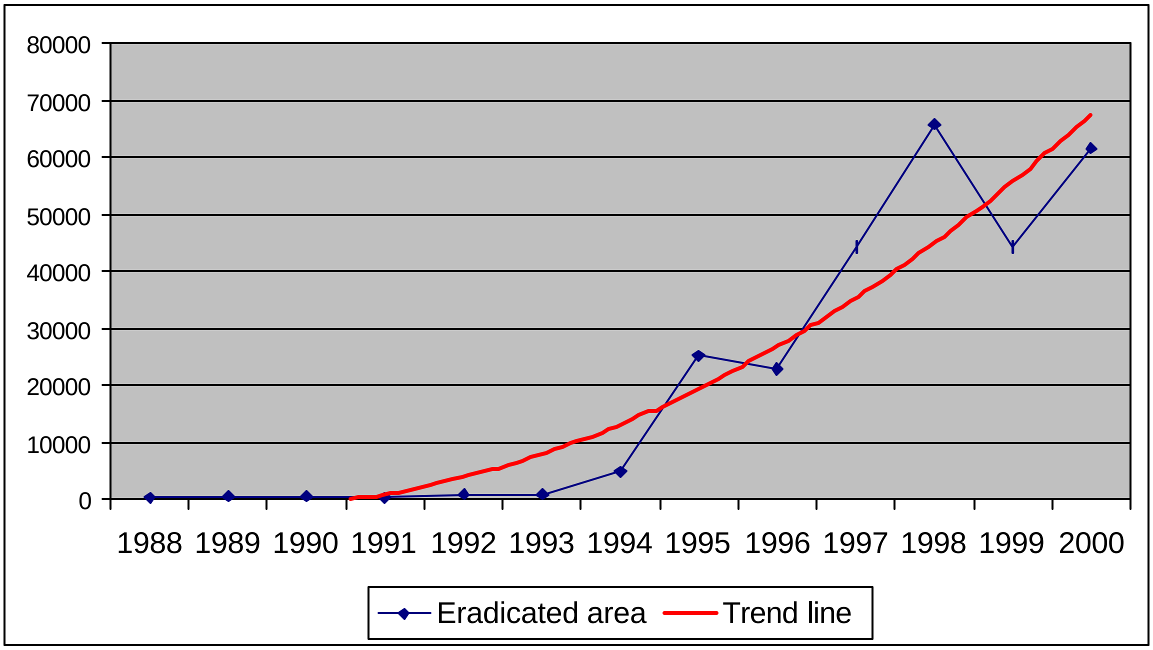
***, **, and * indicate significance at 1, 5, and 10 percent levels.

Table 4. Elasticities of Area Planted in Coca for Models 1, 2, and 3.

Variable	Model 1	Model 2*		Model 3
		Short run	Long run	
P	0.181	0.132	0.328	0.111
E	0.209	0.159	0.395	0.265
PP	-0.380	-0.210	-0.523	-0.198
O	-1.124	-0.294	-0.729	-0.899

* Model 2 is a lagged-dependent variable model; therefore, separate short-run and long-run elasticities are computed. A single elasticity is computed for each independent variable for models 1 and 3, which do not have a lagged dependent variable.

Figure 1. Area of Coca Eradicated in Colombia, 1988-2001



Appendix

Table A1. DFBETA Test Statistic

Year	Constant	Coca Farmgate Price	Eradicated Area	Plantain Price	Area Cultivated in Peru & Bolivia
1988	-1.0367	1.4293	0.6696	-0.1403	0.8283
1989	-0.0197	0.0149	0.0967	-0.1230	0.1026
1990	-0.0105	-0.1418	-0.0801	0.1692	-0.0359
1991	0.0086	-0.4692	-0.1469	0.4138	-0.1296
1992	-0.2341	0.2170	0.1978	0.0901	0.0481
1993	0.0723	-0.1392	-0.0560	-0.0210	0.0171
1994	-0.4382	0.0368	0.4366	0.1546	0.2753
1995	-0.0168	-0.3367	0.1211	0.0230	0.0891
1996	-0.2417	-0.1032	0.4615	-0.2636	0.5611
1997	-0.1417	-0.2020	-0.0658	0.4797	-0.1901
1998	-0.0499	-0.0293	0.0652	0.0438	0.0307
1999	2.1740	0.8251	-2.7217*	-1.6503	-1.2511
2000	0.1102	0.0257	-0.0809	-0.0243	-0.1114
2001	0.6329	0.2161	-0.1701	-0.1260	-0.7154

* Significant at 5% level.

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