DOCUMENTO CEDE 2004-19
ISSN 1657-7191 (Edición Electrónica)
MARZO DE 2004

CEDE

A GEOGRAPHY OF ILLICIT CROPS (COCA LEAF) AND ARMED CONFLICT IN COLOMBIA*

ANA MARÍA DÍAZ**
FABIO SÁNCHEZ **

Abstract

Colombia is currently the world's largest producer of coca leaf and the principal producer of opium poppies in the Americas; the plants are the basic raw materials used to produce cocaine and heroin. This document will analyse the current relationship between these crops and illegal armed groups in Colombia, using the hypothesis that the geographical intensification of the conflict is the principal cause of expanding illicit crop production. This relationship was analysed using a theoretic model, in which an interaction between illegal armed activity and strategic territorial control lead to cocaine production. Spatial analysis techniques were then applied, especially spatial association indicators; and a clear spatial dynamic was observed, related to the two aspects mentioned above. Non parametric exercises were also carried out using matching estimators, to determine the effect illegal armed groups have on coca[1] crops, and also to analyse the efficiency of aerial eradication policies. The results suggest that a large percentage of coca production in Colombia is due to the effects of illegal armed activity. We therefore conclude that the expansion of illegal crop growing is a consequence of the expanding conflict. In contrast, coca crops can only be used to explain a small part of the armed conflict in Colombia. In addition, we found that crop eradication via aerial spraying has not been an efficient tool in the fight against coca production in the country.

JEL Classification: R12, R19, K14, C13, C19.

Key Words: Illicit crops, Coca, Armed Conflict, Eradication, Spatial Econometrics, Diffusion, Contagiousness, Matching Estimators, Probity, Propensity Scores, Nearest Neighbour, Kernel, Local Linear Regression.

---

* This version corresponds, in contents and form, to CEDE Document No 2004 - 18, originally written in spanish. Final version, Prepared for Crisis State Program, Development Research Centre, Development Studies Institute, London School of Economics. We would like thank: the valuable contribution of Carolina Mejía in the development of the technical model and Fernando Jaramiillo for his modelling advice; Mario Chacón for his excellent editing work; María Angélica Bautista who helped put together the bibliography; Martha Bottia as a Colciencias young researcher and María Paula Carvajal for their information gathering and processing activities, and who were co-authors of a previous version of this document; all those who attended the Fedesarrollo, CEDE, Departamento Nacional de Planeación, Destin (Bogota) and Lacea (México) seminars for their comments and suggestions; and Jean Paul Faguet for his critical read through of one version of this document. This research paper was financed by DESTIN-LSE, Colciencias and CEDE.
** anadiaz@uniandes.edu.co, fasanche@uniandes.edu.co, Research Centre for Economic Development, Economics Departament, Universidad de los Andes.

GEOGRAFÍA DE LOS CULTIVOS ILÍCITOS Y CONFLICTO ARMADO EN COLOMBIA

ANA MARIA DIAZ
FABIO SANCHEZ

Resumen

Colombia es actualmente el mayor productor de hoja de coca del mundo y de amapola de América, insumos básicos para la producción de cocaína y heroína. Este documento analiza la relación existente entre estos cultivos y los grupos armados ilegales en Colombia, bajo la hipótesis que la intensificación geográfica del conflicto es la causa principal de la expansión de los cultivos ilícitos. Para analizar esta relación se desarrolla un modelo teórico en el que la producción de coca es el resultado de la interacción de la actividad armada ilegal y el control territorial como estrategia de los grupos ilegales. Posteriormente se hace uso de las técnicas de análisis espacial, en particular los indicadores de asociación espacial, en los cuales se observa una clara dinámica espacial entre los dos fenómenos. De igual forma, se realizan ejercicios no paramétricos, con las técnicas de emparejamiento o matching estimators, con cuales se busca encontrar el efecto de la actividad de los grupos armados ilegales sobre los cultivos de coca, y por otra parte, se busca analizar la eficiencia de las políticas de la erradicación por aspersión. Los resultados sugieren que el efecto de la actividad armada ilegal en Colombia explica en un gran porcentaje la producción de hoja de coca en el país, por lo tanto se concluye que la expansión de los cultivos es una consecuencia de la expansión del conflicto. En contraste, los cultivos de coca explican solo una pequeña proporción del conflicto armado. Por otra parte, los ejercicios sobre la erradicación por aspersión exponen que esta no ha sido una herramienta eficiente para la lucha contra la producción de coca en el territorio nacional.

Clasificación JEL: R12, R19, K14, C13, C19.

Palabras Claves: Cultivos Ilícitos, Coca, Conflicto Armado, Erradicación, Econometría Espacial, Difusión, Contagio, Matching Estimators, Probit, Propensity Scores, Nearest Neighbor, Kernel, Local Linear Regression.

1. Introduction

Colombia has become the world's largest producer of coca leaf and the main producer of opium poppies in the Americas; these plants are the basic raw materials used to produce cocaine and heroin. The nineties were characterised by an expansion of coca growing in the order of 286% (cultivated hectares increased from 37,500 in 1992 to 144,807 in 2001). This expansion was accompanied by reduced cultivation in Peru and Bolivia. Various different social sciences have studied this phenomenon, most focusing on the causes and consequences, with little empirical or quantitative evidence. Evidence exists that coca and opium crops are closely linked to the finances of illegal armed groups, which is in line with recent literature regarding internal conflicts and civil wars. A lack of external funding leads the irregular groups towards an economic activity in which they have the competitive edge. In most cases, this activity is based on economic depredation or extortion—particularly of primary goods—via the selective or indiscriminate use of violence (Bannon and Collier, 2003). They are also, of course, involved in monetary extortion and kidnapping, in which the use of intense violence is employed.

The irregular groups' objective to dominate and control coca and opium poppy growing areas has lead to the intimidation of local communities, and the use of violence against them. However, coca and poppy crops are not a depredatory activity per se. There is a certain added value to their production; there is a market for the product, in which the irregular groups intervene, and they are the basic raw materials of psychoactive drugs. Nevertheless, geographical expansion goes beyond these economic factors. The illegal groups' strategic objectives regarding territorial control also play an important role here. In recent years the evidence has suggested a growing link between the expansion of illegal crops[2] and the activities of the armed groups, to the extent that profits from coca and poppy production, in addition to those generated by the production of psychoactive drugs, have become one of the main ways that these groups finance their activities. Therefore, this paper will analyse the above mentioned relationship, with the hypothesis that the geographical expansion and intensification of the conflict is the principal cause behind the expansion of illegal crops. To verify the hypothesis patterns of spatial diffusion and contagion between coca production and the activities of illegal armed groups were analysed using current spatial analysis techniques. A theoretic model of the illicit crops/conflict relationship was also developed to reach a better understanding of its dynamics and interrelations. Furthermore, in order to analyse the empirical causality relationship between illicit crops and the conflict, the level of illegal armed activity in coca growing areas in municipalities or regions was studied using the non-parametric method known as matching estimators.

[2] The cultivation of plants such as coca, opium poppies and marijuana, that are processed into natural psychoactive drugs. Coca grows in warm, humid zones with high rainfall, which are between 300 and 1,600m above sea level. Opium poppies, on the other hand, thrive in mountainous areas between 1,800 and 3,000m above sea level.

This paper is divided into six sections. The first is an analysis of coca trends in the Andean region, and how they have been interpreted by different authors. The second section offers a brief history of coca, and recent trends in the Andean region. The third is a description of coca trends in Colombia and regional dynamics over recent years, as well as a brief mention of the principal interpretations and hypotheses of the causes and consequences of illicit crop growing in Colombia. The fourth section develops the theoretic model and tries to explain the relationship between illegal crops and the conflict. The fifth section relates coca geography with that of the internal conflict in Colombia, by using spatial analysis techniques, in particular related to the clusters and dynamics of illicit crop diffusion. The sixth section offers an analysis of the effects of the armed conflict on the number of cultivated hectares and vice versa. Finally, we present our conclusions in the seventh section.

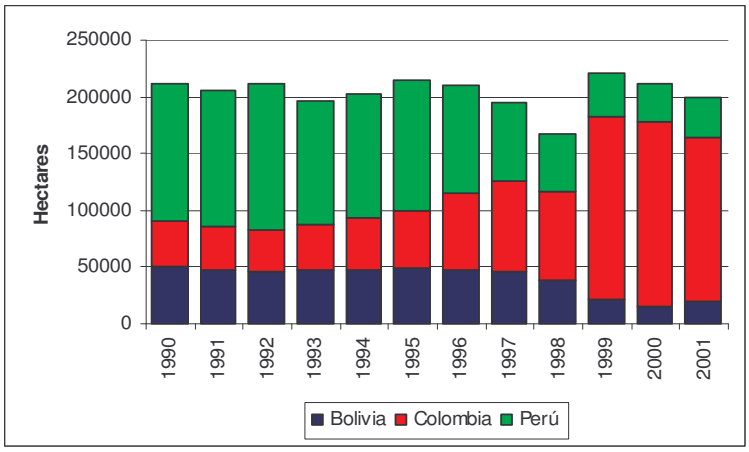
2. Interpreting Coca Trends in the Andean Region

Coca is native to the Andean Region (Bolivia, Peru and Colombia). Its cultivation and consumption (as leaf) has long been part of the traditions and customs of Andean peasant farmers, above all in Bolivia and Peru. In recent decades, specifically since international demand for drugs began to increase, this region has become the world's leading producer of coca; 200,000 hectares of coca are under cultivation in this part of the world. The cultivated area in these three countries was stable throughout the nineties. But in recent years the proportion of the total grown in each country has changed substantially. Colombia went from being an importer of coca base to being a net producer of coca leaf—from 19% of total regional cultivation in 1990 to 72% in 2001. Over the same period Peru's share fell from 57% to 17%, and Bolivia's from 25% to 10%.[3]

This relocation of coca production in the region (graph 1) was the result of successful eradication and interdiction efforts in Bolivia and Peru. Although these policies enjoyed domestic success, they did not have the same results at regional level. Reduced production in these two countries was compensated for by new crops in Colombia.

[3] In the international environment, it is believed that drug income is a fundamental part of development in the Andean countries (see Thoumi (2002) and Steiner (1997)). However, investigations based on rigorous calculations have shown that cocaine income is just 3.4% of Peruvian GDP, less than 5% of Bolivian GDP and around 5% of Colombian GDP. Today it is 3% of Colombian GDP, whilst in the first half of the 1980s it was 7% of GDP. This shows that other sectors exist in these countries that offer better economic growth perspectives than the coca business.

Graph 1. Coca Production in the Andean Region 1990-2001



Source: US State Department

Each country has used a different strategy to reduce the supply of coca. Bolivia favoured eradication, Peru placed greater importance on fighting trafficking (shutting down aerial and fluvial export routes and thus inspiring the abandonment of cultivated land), and Colombia has favoured chemical fumigation, eradication and crop substitution.

Although the Andean region is the principal world supplier of cocaine, it is also produced in parts of Africa, Asia, some areas of the USA (Hawaii), Guam and Latin America (Brazil, Ecuador, the Guyanas and Venezuela). Countries like Mexico and Cuba have become important global commercialisation centres. In the following sections we develop There follows a brief history of coca production in Bolivia, Peru and, specifically, Colombia.

2.1. Bolivia

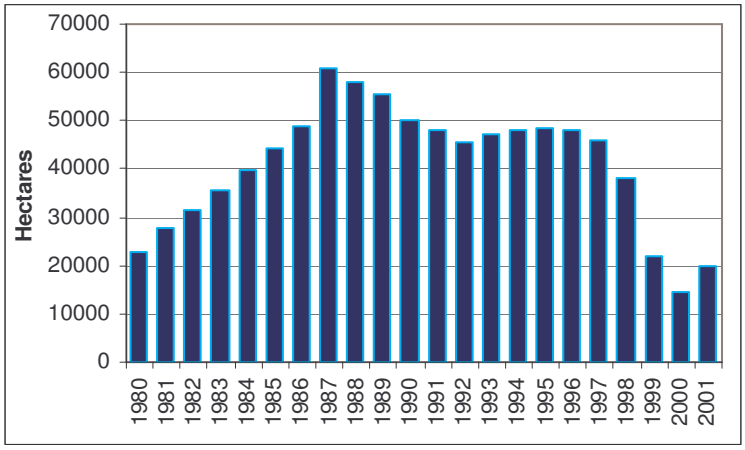
Between 1720 and 1950 Bolivian coca was grown mainly in the Yungas region, in the Department of La Paz. It was a legal activity and coca was a principal part of the Bolivian diet (Thoumi, 2002). During the 1950s, Chapare, in the Department of Cochabamba, began to overtake Yungas due to the productive advantages of this region[4], becoming the leading producer in the 1960s and 70s.

Until the end of the 1960s, the evolution of coca in Bolivia was fairly stable. However, high profits and sustained increases in international demand for coca, in addition to the Bolivian economic crisis in the 1980s and the closure of tin mines in 1985, led to a rise in illegal coca cultivation. An operational structure was consolidated during these years that facilitated the transition from the first phase of production to the cocaine business itself, although the final stage of production—the fabrication of cocaine hydrochloride—was controlled by the Colombian cartels (Rojas, 2002).

[4] These natural advantages are that coca can be produced without a need for terracing, and that plants may be harvested four times a year instead of three, as is the case in Yungas. Furthermore, Chapare coca contains more alkaloids than Yunga coca, and processing costs are therefore lower.

The coca situation in Bolivia today is very different to the sustained growth of the 1980s. In 1987 there were 60,000 hectares of coca being cultivated in Bolivia, which supplied a large proportion of international demand (graph 2). During subsequent years production remained stable at around 50,000 hectares. However, the effect of government programmes[5] designed to fight illicit production led to a fall in production that sharpened from 1997 when *Plan Dignidad*[6] (the Dignity Plan) came into force. The programme, supported by the US government, aimed to reduce supply to the minimum level needed to satisfy domestic demand for coca leaf. Since 1997 coca production in Bolivia has fallen significantly (graph 2); it currently makes a marginal contribution to the global market.

Graph 2. Coca production in Bolivia from 1980 to 2001



Source: US State Department

2.2. Peru

Coca has been grown in Peru for millennia; it has played a central role in Peruvian social customs[7] throughout the country's history. Initially, legal crops were established in the area known as *Ceja de la Selva* to satisfy a domestic demand for the product of around 1,000 cultivated hectares (Gonzáles, 1989). The poor state of the Peruvian economy in the 1950s (agricultural recession, population growth and a weakened mining sector) inspired the successive non-

[5] Law 1008 (1988), regulated production, distribution and commercialisation and offered alternative development sources. It also defined legal production zones. Amongst other programmes are the: "*Estrategia Nacional de Lucha contra el Narcotráfico*" (the National Drug War Strategy) and the "*Estrategia Nacional de Desarrollo Alternativo (Opción Cero)*" (National Alternative Development Strategy (Zero Option)), that focussed on offering monetary compensation for each hectare of coca eradicated, substituting illegal crops for legal alternatives, as well as eradication and interdiction.

[6] This plan is known as the "*Estrategia Boliviana de Lucha contra el Narcotráfico*" (Bolivian Drug War Strategy) and is based on four aspects: a) alternative development, b) prevention and rehabilitation, c) the eradication of illegal coca, and d) interdiction. International aid to the value of $952 million over five years was used by the Bolivian government to implement and continue the plan; $108 million (11%) were spent on eradicating coca crops, and $700 million (73%) on alternative development, which was based on the five commercially viable crops: banana, pineapple, oil palm, maracuya (a variety of passion fruit) and black pepper.

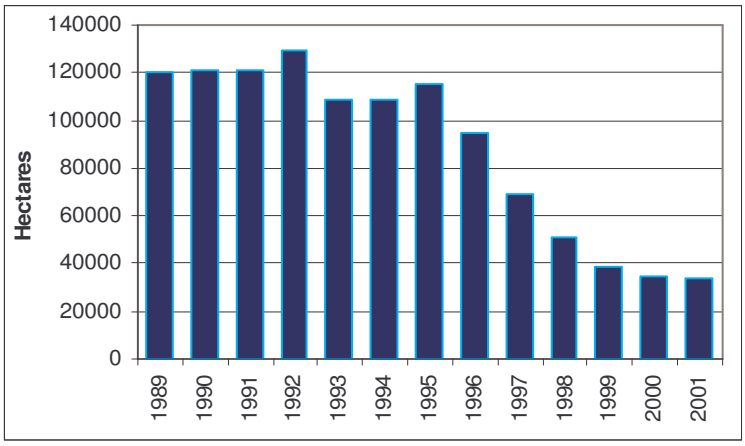
[7] Coca was considered by the Incas to be a "sacred leaf" and its consumption was limited to the governing and religious classes. Ritual use is still the principal motivation for chewing coca leaf in Peru.

structured colonization of the *Alto Huallaga* valley[8]. This region is ideal for coca cultivation due to its environmental and geographical characteristics, in addition to its proximity to Colombia and its poor access routes. These conditions, combined with growing international demand for drugs and an increase in drug-trafficking, led to the exponential growth of cultivated hectares of coca in Peru during the 1980s and 90s, which became known as the *boom de la coca*.

This increase in coca leaf production not only generated higher exports of coca paste to Colombia, it also became a source of financing for the guerrilla forces that established themselves in coca growing regions. (McClintock 1998). At the start of the 1980s, the *Sendero Luminoso and MRTA* guerrilla groups took control of the *Alto Huallaga* valley and began regulating prices; they became the intermediaries between peasant farmers and drug-traffickers (Obando, 1993).

Peru became the world's largest producer of coca—going from 18,000 cultivated hectares in 1969 to 129,000 in 1992. Coca growing also expanded to 16 new areas including the central jungle and valley of *Apurímac*. However, the evolution of coca growing in Peru appeared to have reached the end of its expansion. From the second half of the 1990s, production in Peru began to fall, reaching 34,000 hectares in 2001, as can be seen in graph 3.

Graph 3. Coca production in Peru 1989-2001



Source: US State Department

This accelerated reduction can be explained in terms of the successful policies designed to control production and commercialisation such as: eradication using toxic herbicides, aerial control (the destruction of the air lift with Colombia in 1995), the "*el gringo*" fungus and the defeat of the *Sendero Luminoso* guerrilla group. Currently, an internationally funded project called the *Programa de Desarrollo Alternativo de Prevención y Rehabilitación* (Programme for Alternative Development via Prevention and Rehabilitation) is in place in Peru. Its chief objective is to substitute illicit crops for legal agricultural systems.

[8] This valley straddles the north of the Department of Huanuco and the south of the Department of San Martín, 450 km north-east of Lima.

3. Coca Production in Colombia

3.1. A Brief History

During the 1960s Colombia became a producer and exporter of marijuana, which was grown in the *Sierra Nevada de Santa Marta* and the *Serranía del Perijá*[9]. However, the illegal industry's zenith was not to last due to manual eradication campaigns, confiscations of boats and planes, the destruction of equipment used to process narcotics and, principally, to the increased supply of Californian marijuana. Nowadays, marijuana is grown almost exclusively for domestic consumption. Although some exports to the USA have been detected, they are far lower than during the 1970s (Uribe 1997).

Towards the end of the 1970s and the start of the 1980s the *bonanza coquera* (coca bonanza) began. The traffickers began by importing coca base from Bolivia and Peru, and processed it into cocaine in Colombia for re exportation to the USA[10]. High profits enabled the business to rapidly become self-financing. At the same time, Colombia began to consolidate domestic coca production, and crops were established in areas far from the economic centres of the country (principally the Departments of Caquetá, Guaviare and Putumayo).

Colombia's increased participation in the global drug market led to the strengthening of drug trafficking and the consolidation of the industry (still using imported coca base from Peru and Bolivia). Large scale drug trafficking offered huge earnings and led to the formation of the Medellin, Cali and Caribbean Coast Cartels, who promoted the vertical integration of all stages of production; from growing the plants, supplying the precursors, processing, production and transport, to domestically and internationally commercialising the product via appropriate distribution networks. Equally, money laundering mechanisms and processes were created.

As the drug cartels consolidated their control, urban homicide rose (especially in Medellin and Cali) and the judicial system began to deteriorate (evidenced by rising impunity) (Sánchez and Núñez (2001), Gaviria (2001)). The cartels also began to openly challenge the State—via terrorist attacks and the selective assassination (or threatening) of political leaders—and to bribe and blackmail the different branches of politics. The Colombian State under different governments began to strengthen the national police and intelligence organisations, and, with the support of the US government, began to persecute the cartels. The Medellin and Cali cartels were the main targets from 1990 to 1996, by which time most of their leaders had been killed or jailed.

As the cartels got weaker, control of the cocaine business began to change hands. One part of the business passed into the hands of the second or third

[9] According to Ruiz (1979), marijuana cultivation could have reached 30,000 hectares.

[10] The process of converting coca leaf into cocaine is as follows: the leaves are mixed with a solution of kerosene and sodium carbonate, which extracts the alkaloid and produces what is known as **coca paste**. The paste is then treated with sulphuric acid and potassium permanganate to form **cocaine base**; finally the base is treated with ether and acetone to obtain high quality **cocaine hydrochloride**.

generation of cartels (*Norte del Valle, Costa, Medellín, Eje Cafetero*), and the much of the rest fell under the control of armed groups operating illegally (guerrillas and illegal self-defence groups). The production of coca and the sale of cocaine became one of the groups' principal sources of financing[11]. Drug trafficking has also become an important part of territorial control; it has the double function of offering the groups a social base (in terms of the labour force involved) and the income they need to escalate and expand their armed struggle.

At the end of the 1980s, opium poppies began to appear on high-plains and indigenous reserves between 2,200 and 2,800 meters above sea level[12]. According to Ramírez (1993) opium poppy growing zones are characterised by a low institutional presence, a lack of access roads and low coverage of State services. During the 1990s there was a dramatic rise in the number of hectares cultivated with opium poppies in the mountainous areas of the departments of Caquetá, Cauca, Huila, Tolima, Cesar, Cundinamarca and Boyacá.

Production of opium poppies has also risen alongside the guerrilla force's expansion (Echandía, 1999). And profits from the production and trafficking of opium poppies have also become a source of financing for the illegal armed groups.

3.2. Recent Trends

Colombia currently has the most problematic level of illicit crop growing in the Andean region. Over recent years, the country has gone from being a marginal contributor to being the major world producer of coca leaf, not forgetting cocaine production[13]. Between 1990 and 1994 it is estimated that around 40,000 hectares of coca were being cultivated in Colombia[14]. However, in the second half of the decade, this area increased considerably, from 50,000 hectares in 1995 to 166,000 in 2000 (although in recent years this figure has fallen). This growth was due to the destruction of the air lift between Bolivia, Peru and Colombia, reduced illicit production in Bolivia and Peru and enhanced demand for narcotics, all accompanied by the illegal groups' need for financing[15].

[11] Estimating the contribution of the drug trade to illegal groups' coffers is a complicated exercise. It is estimated that 34% of FARC income comes from this activity (Badel (1999), using Comité Interinstitucional de Lucha contra las Finanzas de la Subversión data). According to Carlos Castaño, commander in chief of the self-defence forces, 70% of this group's income comes from drug-trafficking.

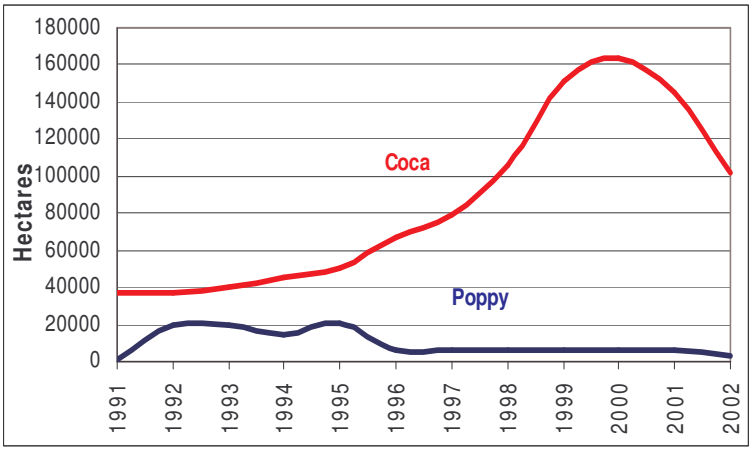
[12] In geographical terms, Colombia is extremely suitable for opium poppy cultivation. It has one of the largest tropical high-plains regions in the world, that goes from 1,800 to 3,200m above sea level (Ramirez, 1993)

[13] Around 80% of world annual cocaine production (estimated at 700 tons) is produced in Colombia.

[14] Satellite information from the US State Department and the UN, complemented by National Police Drug Squad data.
On the other hand, it is estimated that 60% of coca crops are on small landholdings of less than two hectares, managed by peasant farmers and indigenous people at subsistence level. The other 40% comes from industrial crops owned by drug traffickers.

[15] The growth of this activity in Colombia is due to its high levels of profitability, especially in the distribution stage, its low agro economic cost and the trans-national nature of the business

Graph 4. Production of coca leaf and opium poppies in Colombia 1991-2000



Source: Colombian National Police Force, Antinarcotics Division[16]

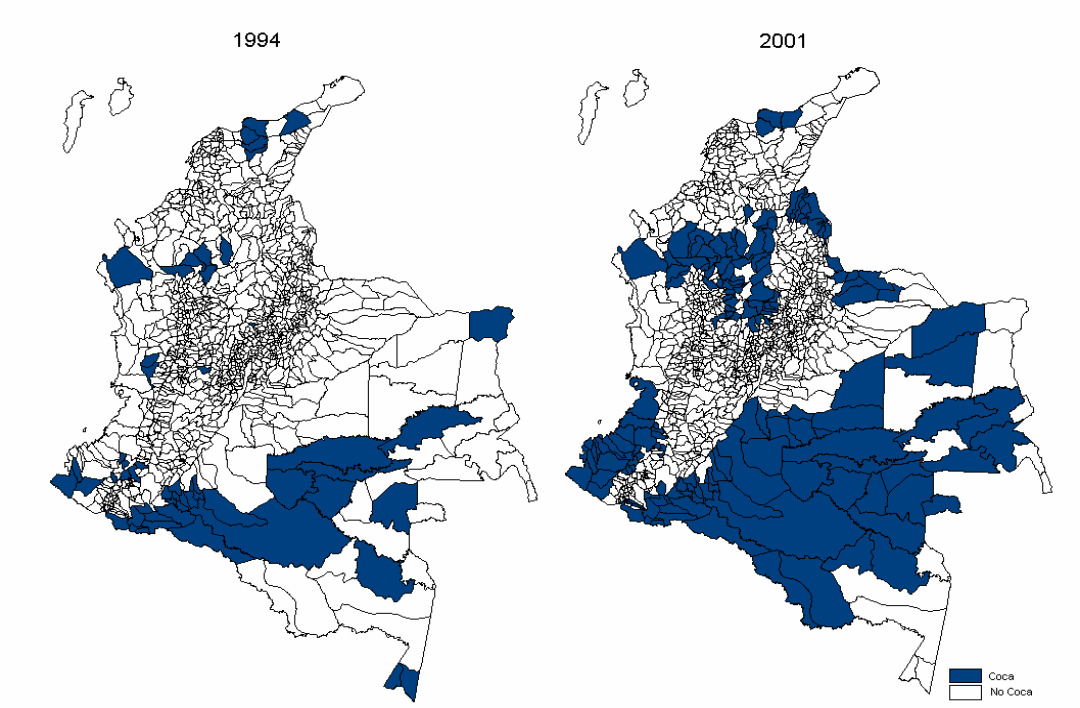
The geographic and spatial expansion of illicit crops has been massive, as can be seen in map 1. In 1994 these crops were only grown in a few departments and municipalities in the south of Colombia. Supported by the presence of illegal groups, they subsequently spread wildly throughout the south, south-east and south-west of the country, as well as in some important corridors such as *Magdalena Medio* (the middle Magdalena region). The three departments with the highest number of cultivated hectares were Putumayo (60,000), Guaviare (27,000) and Nariño (15,000).

From 2001 the number of cultivated hectares fell considerably, reaching 102,000 in 2002[17]. The most significant reductions were in Putumayo, Meta, Cauca and Caquetá, mainly due to aerial spraying. Furthermore, there has been a substantial amount of voluntary eradication in other departments, especially Bolívar, Meta, Cauca and Vichada.

[16] The opium poppy data comes from the second national aerial census of illicit poppy crops, October 2001. The 2002 data comes from the US anti-drugs tsar John Waltes, EL TIEMPO, May 13 2003, *"El 60% de la heroína que se consume en Estados Unidos proviene de Colombia"*.

[17] SIMCI data, *Sistema Integrado de Monitoreo de Cultivos Ilícitos* (Illicit Crop Monitoring Integral System), using satellite analysis methodology complemented by aerial information on areas with illegal crops. The reliability of the results is estimated to be +/- 90%.

Map 1. The evolution of coca crops in Colombia 1994-2001 (by municipality)



This drop in cultivation has been due to the three pronged approach of current anti-drugs policy: forced eradication, the systematic interdiction of the production chain and alternative development programmes. Aerial fumigation has been the most heavily used tool of the war on drugs since the end of the 70s, and its employment intensified from the mid-90s (see table 1). Between 1999 and 2001, more than 195,000 hectares were fumigated—48% of this total (more than 94,000 hectares) in 2001 alone. Alternative development programmes, designed to substitute the coca-cocaine cycle with legal agricultural initiatives, have become ever more important since the National Alternative Development Plan was created in 1994, and again with Plan Colombia[18].

Opium poppy cultivation has, on the other hand, remained stable at around 6,000 hectares. They are grown in cloud forests and high-plains—regions characterised by low State presence, isolation and a small population, e.g. Tolima, Cauca, Nariño, Cesar and Huila.

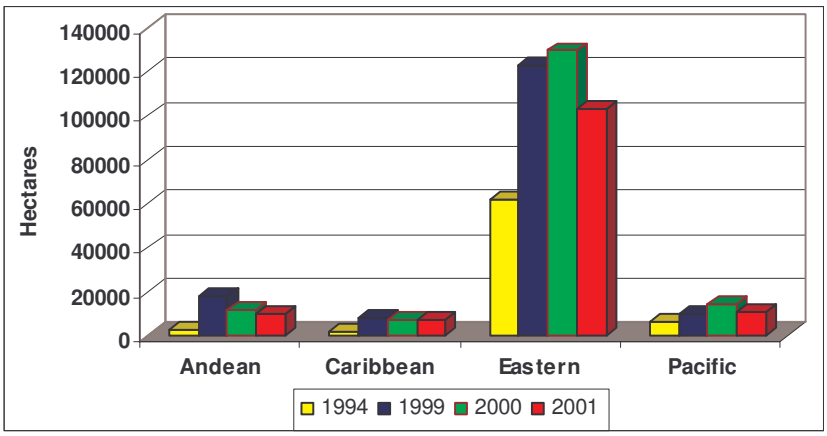
[18] By 2001, 54,551 families had benefited from this type of program (DNE).

3.3. Regional Aspects

Coca cultivation in Colombia has expanded in isolated areas of peasant colonisation, forest reserves, natural parks and indigenous reserves, all of which are characterised by poor agricultural and grazing land and precarious social conditions and infrastructure, and in which armed actors have played a determining role. These areas usually experience social (marginality and poverty), political (armed conflict) and economic (agricultural recession) conflicts.

78.6% of all coca production in Colombia is concentrated in the Orinoco and Amazon regions. These are areas with many forest reserves, enormous hydrological resources and the largest oil reserves in the country. Production in other areas is lower, but no less important; 8.3% in the Pacific region, 7.6% in the Andean region and 5.5% on the Caribbean coast.

Graph 4. Coca leaf production by region



Source: National Drugs Department, Authors' calculations

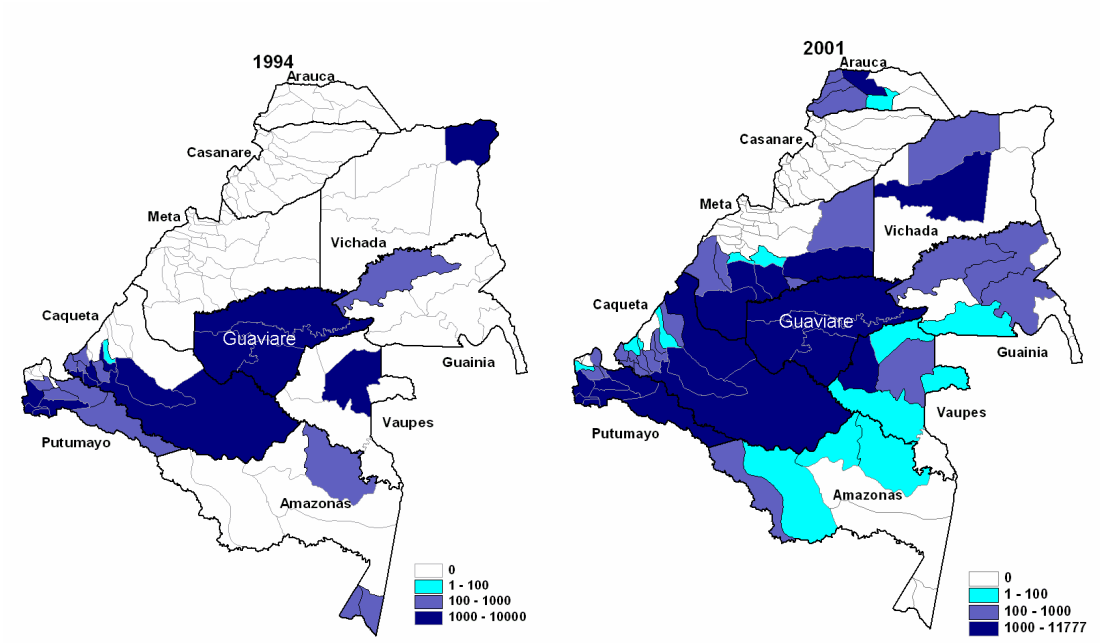
3.3.1. Orinoco and Amazon Region

The cultivation, processing and commercialisation of coca has become one of the main economic activities in the region. An average of 120,000 hectares were cultivated between 1999 and 2001, specifically in the Departments of Guaviare, Caquetá, Putumayo, Meta and Vichada. Of the 60,000 hectares under cultivation in 1994, 36.4% (22,445) were in Guaviare, 33.6% (20,704) in Caquetá and 23.59% (14,539) in Putumayo. The dynamics then changed and Putumayo became the principal producer of coca with 51% (66,000) of the total. Guaviare fell to third place with 14% (17,619) and then regained its crown in 2002 with 27,000 hectares. Production in the Department of Meta has gained importance, mainly in the Ariari region (see annexes, graph 1).

Coca production grew dramatically in Guaviare at the end of the 1970s. Colonization of this region began at the end of the 19th century (Molano, 1996) when timber extraction, rubber and the production of animal hides were the principal economic activities. By 1994, Guaviare was the largest producer of

coca in the country, and aerial fumigation with glifosato began. Production fell by almost 5,000 hectares between 1994 and 2000 (22,445 to 17,619)[19]. Some growers moved on to Putumayo, which became the principal producer of coca in Colombia in the mid-1990s, although coca had existed in the Department since the 1970s. Putumayo is on the border of Ecuador and Peru, which facilitates the transport of contraband, the drug trade, the importing of precursors and arms, and the mobilisation of the workforce from one side of the frontier to the other (Vargas, 2003). The presence and activities of armed groups have become a fundamental variable in the consolidation of Putumayo as the principal coca region in Colombia.

Map 2. The Evolution of Coca Crops in the Orinoco Region 1994-2001



During the 1970s, coca crops were established in deep, well protected jungle zones (Ramirez, 2001). During the eighties, production was somewhat unstable due to price fluctuations, plagues and eradication programmes. At the start of the 1990s, Bolivian and Peruvian varieties were introduced and cultivation expanded rapidly to 66,000 hectares (3.21% of the department's total surface area), spread over thirteen municipalities[20]. The municipalities with the highest levels of cultivation were Puerto Asís, Valle del Guamés (La Hormiga), Orito, Puerto Guzmán and Puerto Leguizamo, each with more than 3,000 cultivated hectares (see map 2).

[19] Guaviare was the country's largest producer of coca until 1994, when aerial spraying with glifosato began. In 2001, 24,000 hectares were under illegal cultivation in four municipalities: Miraflores (11,777), Calamar (4,966), El Retorno (4,231) and San José del Guaviare (3,089 ha). It has been estimated that growers in Guaviare pick an average of 825 kg of coca leaf per hectare per harvest—there are 5.7 harvests a year. Annual production in Guaviare is, therefore, 4.7 metric tons per hectare per year (wet weight) (DNE, 2001).

[20] It is estimated that producers in Putumayo pick an average of 975 kg of coca per harvest; there are 4 harvests per year. Total production in the department is thus estimated to be 3.9 metric tons (wet weight) per hectare per year (DNE2001).

In the same way as in Guaviare and Putumayo, coca crops in Caquetá increased from the mid-1970s. The department is now the second largest producer of coca in Colombia. In 2001 26,600 hectares were under cultivation in 15 of the department's 16 municipalities, the most important being: Cartagena del Chairá (13,551), Solano (4,005), San Vicente del Caguán (1,713), Solita (1,170) and Valparaíso (1,240). The remaining municipalities have less than 1,000 hectares under cultivation[21].

In the Departments of Meta and Vichada, coca production has also been of some importance. Various armed groups are present in these departments. Increased production began in the mid-90s, reaching 10,000 hectares in Meta and 8,000 in Vichada in 2001. In the Departments of Arauca and Casanare coca growing has been of little importance. They are however strategic transit areas for the precursors used in the manufacture of cocaine.

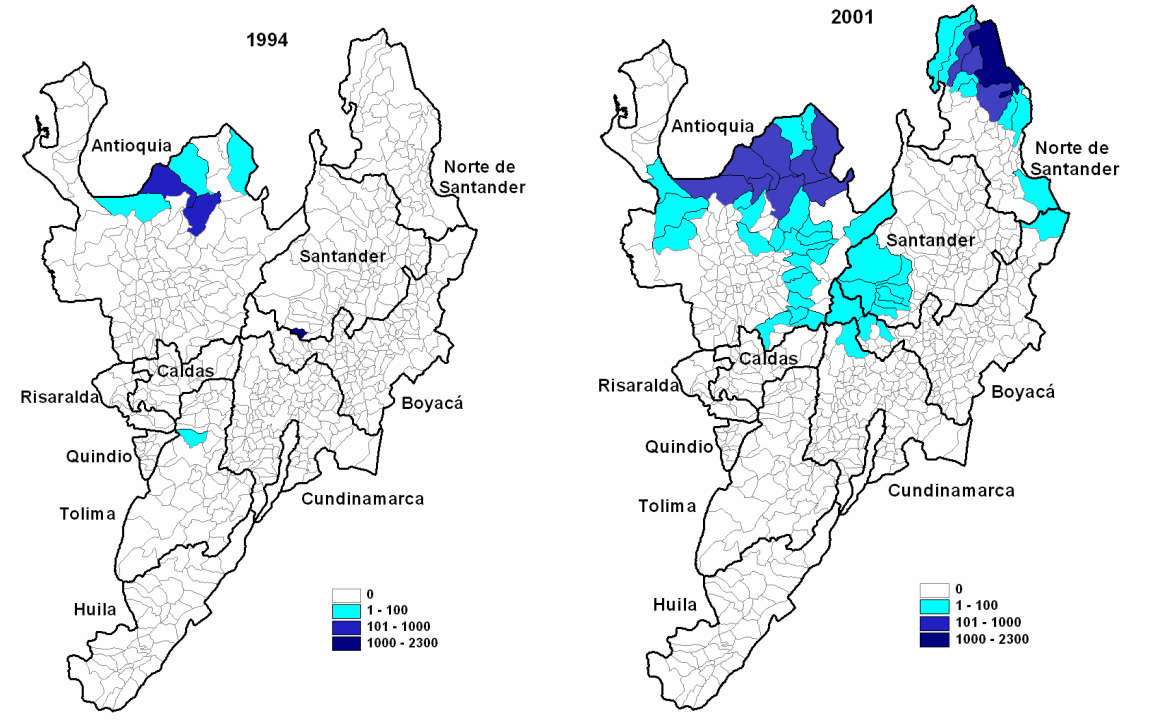
3.3.2. The Andean Region

Coca production in the Andean Region is concentrated in the departments of Norte de Santander (70% of total production between 1999 and 2001), Santander (25%) and Antioquia (19%). Santander is a mountainous department (see map 3) with an economy based around smallholdings[22]. It is also an important strategic transport corridor with the North of Colombia. All of the illegal armed groups are present in the department (FARC, ELN, AUC, EPL). The illegal groups are also present in Antioquia. In this department there have been high levels of migration towards the lowlands of Urabá, Bajo Cauca and Magdalena Medio, that have provided a ready workforce for the coca business, all in an environment of sustained guerrilla and paramilitary violence (Reyes, 1997).

[21] It is estimated that producers pick an average of 750 kg of coca per hectare per harvest; there are 5.4 harvests in the year. Thus the annual coca production in Caqueta is estimated to be 4.1 metric tons per hectare per year, DNE(2001)

[22] Apart from crude oil, coal, gold, marble and limestone are also produced.

Map 3. The Evolution of Coca Crops in the Andean Region 1994-2001



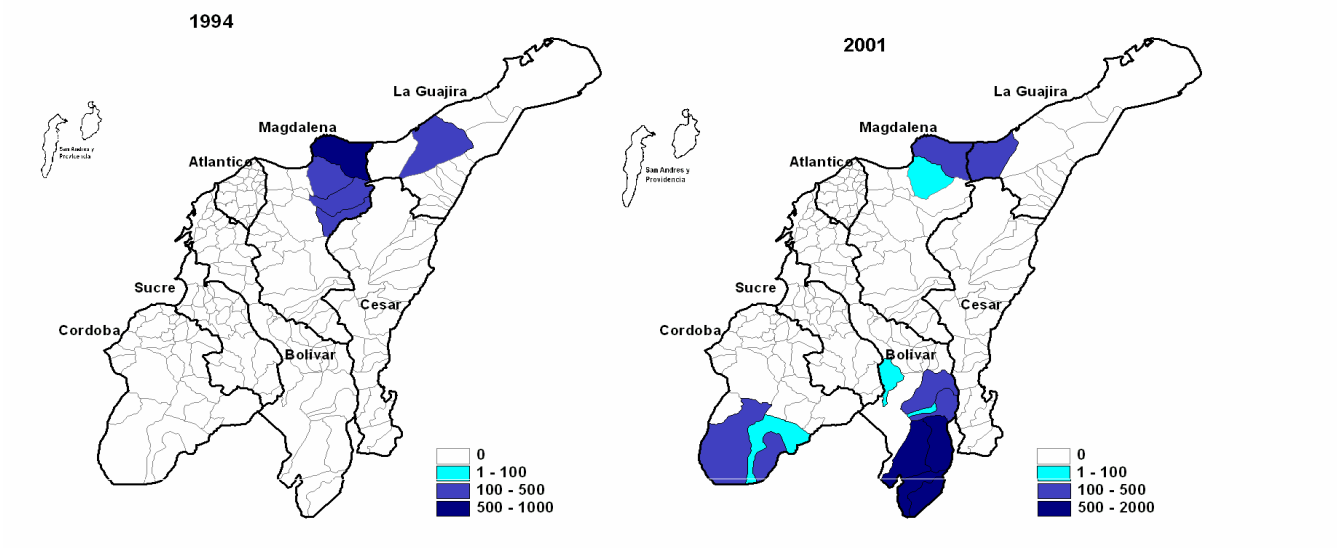
In the Department of Norte de Santander, 6,700 hectares of coca were cultivated in 2001 in 11 of the department's 39 municipalities. Santander, on the other hand, had 2,800 hectares of coca under cultivation in 24 of its 87 municipalities. Finally, in Antioquia 3,000 hectares were cultivated in 30 of its 124 municipalities.

3.3.3. The Caribbean Region

Approximately 5% of total production comes from the Caribbean region, concentrated in the Department of Bolívar (82%) and to a lesser extent in Magdalena (6,2%), Córdoba (9%) and Cesar (5%)[23]. Bolivar had 5,500 hectares under cultivation in 2000, spread over 10 of its 37 municipalities, mostly in the Magdalena Medio area of the south of the department. The municipalities where most coca growing is concentrated are Santa Rosa, Simití, San Pablo and Cantagallo, which are near the *Serranía de San Lucas* and are traditional guerrilla strongholds, due not only to gold mining in the area, which provides income, but also to the fact that that the zone is the headquarters of the ELN Central Command (COCE). Since 2000, paramilitary activity has increased in the area with the presence of the *Libertadores del Río Magdalena*, *Combatientes de la Serranía de San Lucas* and *Vencedores del Sur* fronts of the *Bloque Central Bolívar*.

[23] In these areas there exists a great inequality of land distribution, from large scale cattle ranches to small scale peasant farming that coexist alongside indigenous reserves such as *la Guajira*, *la Sierra Nevada de Santa Marta* and *San Andrés de Sotavento*.

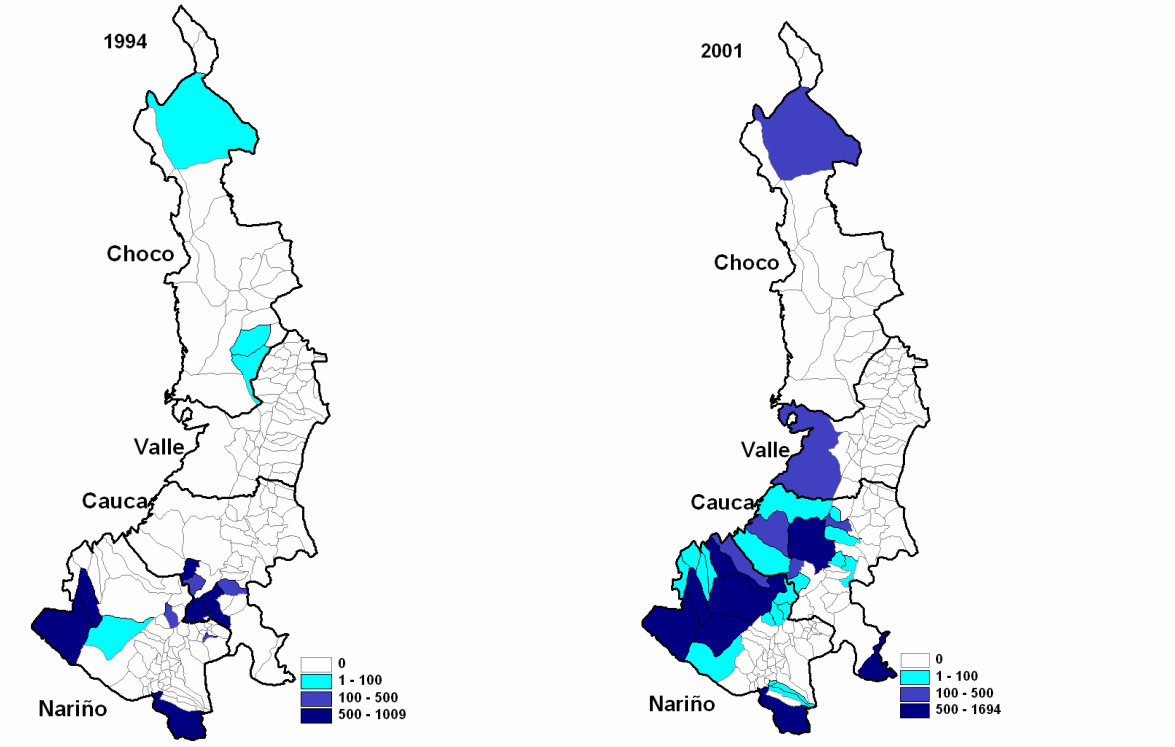
Map 4. The evolution of Coca Crops in the Caribbean Region 1994-2001



3.3.4. The Pacific Region

The Pacific region has many strategic advantages related to coca production, not least of which is the fact that it is the transit route for exports leaving via pacific coast ports. 7% of total coca production comes from this region, principally from the departments of Cauca and Nariño, and, to a lesser extent, Chocó and Valle.

Map 5. The Evolution of Coca Crops in the Pacific Region 1994-2001



3,190 hectares were under cultivation in 1994 in the department of Cauca. This figure had grown to 6,291 by 1999, but then fell to 2,900 in 2001. However, the number of municipalities in which coca is grown rose from 6 to 12 (out of 39) between 1994 and 2001.

Coca production in Nariño rose rapidly during the last decade, reaching a peak of 9,300 hectares in 2000. In 2001 this figure fell to 2,000 hectares. Similar to the case of Cauca, the geographical dissemination of coca in Nariño rose, from 6 to 19 (out of 62) municipalities.

3.4. Interpreting Coca Production in Colombia

Most explanations of the rising growth of coca production in Colombia point to socioeconomic factors such as poverty, marginality, the unequal distribution of wealth and income, economic recessions and weak, inadequate State intervention, amongst other aspects. The most recurring hypothesis to explain rising coca production in Colombia is that the illicit drug business is highly profitable, and that the zones in which it is most prevalent are economically precarious. According to Vargas (1999a), the coca business dates back to the end of the 1970s, when various organised groups formed in Miraflores and began to extract cocaine from coca leaves due to rising international demand for the drug and the high profitability of the business. Although there is little consensus as to why the business grew in Colombia, it is clear that the phenomenon began in the late 70s and that it was strengthened by the appearance of drug-trafficking organisations.

The initial hypotheses regarding the consolidation of illegal drug production in Colombia maintain that the main causes are adverse social and economic conditions, the absence of a strong State and the geographical characteristics of the country. Rocha (2000) argues that illicit crops began to be grown in non-modern regional economies where the traditional activities were agriculture and mining, that experienced an unequal distribution of land ownership and that were more vulnerable to relative price changes. Thus the production of illicit crops was concentrated in isolated peasant farming zones that were a long way from the economic centres of the country and were politically unstable (Rocha 1997, Rocha and Vivas, 1998 and Thoumi, 2002).

Similarly, Vargas (1994) found that illicit crops were most prevalent in regions with a total absence of State presence and high levels of violence, where guerrilla groups later arrived to “impose order” and support the peasant farmers. Vargas (1999a), argues that factors such as a weak State presence, armed illegal groups and the production and trafficking of illicit crops generate higher levels of violence in a region. The problem worsens as it spreads to neighbouring municipalities.

Thoumi (1994) states that Colombia was the perfect place for the establishment and consolidation of narcotics production due to the lack of State presence, the patronal system, the violent nature of society and the existing culture of illegal exports. The large number of Colombian immigrants in the USA facilitated the

development of distribution networks. However, Thoumi (2002) rejects the arguments related to poverty and inequality as the root cause of the illegal economy and denies the relationship between poverty and the cultivation of illicit crops.

Other hypotheses maintain that regional crises during the 1980s in the cotton, textiles, sugar and emerald markets drove the development of coca production. To these factors may be added the crisis of profitability and competitivity, the difficulties related to finance and the accumulation of capital, the limitations associated with obtaining advanced technology and a precarious commercial infrastructure (Betancourt and García ,1994).

Similarly, De Rementería (2001) states that the coca industry was established due to the unjust conditions of international commerce that Latin American countries have to face. Specifically, the author studies the appearance of illicit crops in terms of the adverse conditions created by an agricultural crisis. According to the author, the origins of the crisis are the subsidies that industrialised countries began to pay their farmers, which then generated competitive disadvantages for producers in developing countries. The response has been to minimise costs by extensively using land, amplifying the agricultural frontier or substituting production with natural drugs.

Mora et al (1986) state that colonisation and coca crops do not generate permanent social riches in an area; on the contrary, they generate resource and labour exploitation. Tovar (1993) considers that coca has become an alternative source of capital in marginal communities that want to better their conditions and overcome the exclusion they have suffered at the hands of the traditional dominant classes.

The investigations mentioned show some of the diverse hypotheses regarding the origin, causes and consequences of illicit drug production in Colombia; most of them are based on much qualitative but little quantitative evidence. However, no investigation has been carried out about the spatial dynamics of illicit crops and their relationship with illegal armed groups. Thus, the purpose of this investigation is to offer empirical evidence to show that the intensification of the Colombian armed conflict has been the main cause behind the expansion of illicit crops in Colombia.

4. Rebellion: Financing Armed Conflict

4.1. Recent Literature on Financing Armed Conflict

Internal armed conflicts may be defined as the confrontation between State forces and organised armed groups (whether they be rebels or insurgents, etc.) that are fighting for a determined political, ideological or economic end, including, in some cases, the subversion of a pre-established social order. It should be noted that although social, political, economic and international conditions may be the cause of confrontation, they are often not in themselves enough to generate armed conflict. One of the most important factors related to

the growth, development and consolidation of a rebel group is its financial viability[24]; this is its guarantee of survival, and allows the group to scale up its armed activities. The financial viability of rebels or insurgents, and more specifically the depredation of productive activities in the zone in which they operate, have become the subject of economic analysis. In recent literature, insurgents are seen as political agents[25] whose final objective is to maximise their own benefits via the depredation of productive economic activities, whether they be legal or not.

Hirshleifer (1990) states that a conflict depends on the level of profitability of depredation—each group of contenders invests its efforts (militants, arms, munitions, etc.) with the hope of winning a share of the bounty. Thus, the result of the conflict depends on the rebel group's ability to transform its resources into an offensive capacity in different geographical conditions and human contexts. If both contenders enjoy an increase in their wealth, the richest of the two will advance, and smaller contenders will become non-viable or will become dominated by the bigger players over time.

Similarly, Grossman (1991,1994) developed general equilibrium models to analyse insurrection and revolutionary movements, in which rebellion is a non-productive activity that competes with productive activities for society's scarce resources. In the models there are two main agents: the government and peasant families[26]. The result of the confrontation depends on the technologies of insurrection, production and repression. In the case that insurrection is successful, the peasants' bounty will be the government's resources and clients.

Equally, Collier and Hoeffler (1998, 2001) and Collier (2000), believe that civil wars arise only if there are financially viable organisations, and that the circumstances under which they exist are genuinely exceptional. There is, therefore, a wide gap between popular perceptions of the causes of conflict and the results of recent economic analyses. Popular perception sees rebellion as a social movement motivated by extreme discontent. In reality it matters little whether the rebels are motivated by greed, by a desire for power or due to their discontent, which is why the feasibility of depredation is a cause of conflict.

However, one must remember that the end result of depredation is different between rebel groups and criminal organisations. According to Restrepo (2001) an organisation in conflict reinvests all its resources in the armed struggle, that is, it increases its military apparatus and the offensive use of violence[27]. Criminal organisations, on the other hand, look towards increasing profits. In this context, Gutiérrez (2003) states that Collier and Hoefler's "greedy war" hypothesis may not be strictly applied to the Colombian case. In spite of the fact

[24]It is important to note that financial viability is a necessary, but not the only, factor in the generation of a conflict situation.
[25] In some cases, rebels are seen as an extreme manifestation of organised crime.
[26] The government hopes to maximise income from its clients, and thus taxes land and productive activities and employs soldiers to dissuade or repress insurrection. For their part, peasant families respond to government policies by assigning time to production, militancy or insurrection.
[27] This is not to say that top officials are not remunerated, that hierarchy does not determine the level of remuneration, nor that there is no personal enrichment, on whatever side, due to the conflict.

that economic incentives for combatants are precarious, there is a degree of individual motivation to fight that the "greedy war" theory cannot explain. In addition, this hypothesis does not contemplate possible interrelations between the different groups and social organisations.

The Colombian armed conflict began in the 1960s and, after a long period in hibernation during which its growth was precarious and limited to a few rural areas, especially colonisation zones at the frontiers of agricultural expansion, the rebel groups (FARC, ELN and illegal self-defence forces specifically) began a process of accelerated growth in the 1980s. This numerical growth and territorial expansion, as well as a significant increase in their capacity for military action, was linked to their new economic prosperity (Rangel, 2001). This prosperity came from the exploitation of legal and illegal exports, without directly participating in them and thus without incurring the direct costs of military activity (Salazar y Castillo 2001).

The depredation of productive activities by armed groups in Colombia has taken place through three stages according to Rangel (2000): predatory, parasitic and symbiotic. The predatory stage is when the groups have very weak links with the population and, therefore, their activities require minimum exposure and produce one-off benefits (activities such as territorial piracy, bank robberies, random kidnappings, occasional extortion, amongst others). The parasitic phase begins following long-term social infiltration and includes activities such as protection based extortion, amongst others. Finally, there is the symbiotic stage in which the guerrilla economy becomes an integral part of the regional economy and the distinction between legal and illegal activities becomes blurred.

The principal sources of financing for illegal armed groups, in whichever stage, have traditionally been extortion, different types of robbery, kidnapping, scams, piracy, the theft of municipal fiscal resources and, recently, drug-trafficking; the latter having become a principal source of financing[28]. In fact, the guerrillas' role in the drug trade was initially *el gramaje* (a by weight tax on the production of coca leaf or coca base of between 10% and 15%) charged to peasant farmers, and the taxes levied on the laboratories, runways and river ports used by drug-traffickers, in exchange for guaranteeing their security. During the 1990s, guerrilla participation grew considerably; they established their own system of production, transport and commercialisation of both precursors and the final product (La Rotta, 1996; Vargas, 2003). The way in which the guerrillas control and regulate the coca business in Colombia is a classic example of the symbiotic relationship between insurgency and the regional economy, and, in some areas, the distinction between what is legal and what is not has all but disappeared.

Similarly, the illegal self-defence groups grew and developed between 1982 and 1994, to offer security to the population in the face of guerrilla actions and to

[28] Vargas (1999a) analysed guerrillas finances over the period 1991-1996 and concluded that 44.4% came from drug-trafficking; 27.4% from extortion and robbery; 21.9% from kidnapping, and 6.3% from municipal funds (Quoted in Thoumi, 2002).

protect land ownership[29]. In 1994 the first paramilitary summit was held with the objective of unifying the command structure, concentrating operations and expanding the movement throughout the country. This strategy was consolidated by offensive action, and in the mid-1990s, the exponential growth of violent paramilitary activity began. This growth happened alongside a growth in their sources of financing, which until then had been based on the payment of obligatory fees for their security services, donations from large-scale landowners and the middle classes and, finally, their links with the drug-trade.

In recent years, guerrilla (FARC and ELN) and paramilitary links with the production, processing and commercialisation of illegal drugs have become ever stronger (Echandía, 1999). A struggle has evolved for the control of strategic zones, related as much to finances as to the armed struggle itself[30]. The money that comes from these sources of financing is reinvested in strengthening the war machine. Although this does not allow us to establish a direct link between illicit crops and violence, it does show the enormous importance of this activity to guerrilla finances and the drug-trade. Bottía (2003) stated that the FARC are dedicated to expanding their sphere of influence to include the municipalities that guarantee their continued financing. Sánchez *et al* (2003) conclude that drug-trafficking is a crime that is closely linked to the expansion of illegal armed groups, that is, that the increase in illegal crops is the result of these groups' expansion.

Although great advances have been made in terms of analysing the relationship between armed groups and coca production in Colombia, no analysis has yet been made into the dynamics of illegal crop expansion and its relationship with the armed conflict. Below we present a theoretical model that explains this relationship.

4.2. A Theoretical Model of the Relationship Between Coca and the Conflict

4.2.1. The Model

This section aims to develop a theoretic model to explain the relationship between coca production and the armed conflict. It begins with the assumption that illegal armed groups have the fundamental objective of winning territorial control— the mechanism they use to weaken the State or rival groups, generate income and consolidate a social support base (González et al, 2002). This model aims to establish the inter-temporal decision relationship between the territorial control enjoyed by an armed group and the recruitment of the forces it

[29] In Colombia, the organisation of armed civilian groups by the State or local leaders began in the 19th century. The practice effectively ended around the 1940s and 50s, when the armed groups were formed that contributed to the period known as "La Violencia". In 1965, decree 3398 defined the defence of the nation as "the organisation provision and employment of all the inhabitants and resources of the country, in peacetime, to guarantee national independence and institutional stability" and gave temporary powers to the Ministry of Defence to arm civilians. The decree was incorporated into law 48, 1968.

[30] Thoumi (2002) states that fighting between the guerrillas and paramilitaries for control of areas such as Urabá, is an indication of both groups' need to control strategic drug-trafficking routes, which are also used to import arms and precursors.

needs to expand its military actions. Illicit crops will be the result of this inter-temporal relationship, with the contextual parameters of fumigation policies and the State's military activities. A dynamic optimisation model was developed according to the basic model developed by Ramsey.

It begins with the following homogeneous function of degree coca production (that is, constant returns to scale):

$$C_t = \frac{1}{1+\beta} Af(\gamma Z_t, N_t - G_t) \quad (1)$$

Where:

C_t= coca production during period t.
Z_t= the territorial control the armed group enjoys in the region.
N_t= the population in the area controlled by the armed group.
G_t= the number of active guerrilla fighters.
λ = the area (%) dedicated to coca production.
β = the level of eradication practised by the authorities.
A= the production factor.

Equation 1 in per capita terms[31] (lower case letters):

$$c_t = \frac{1}{1+\beta} Af(\gamma z_t, 1 - g_t) \quad (2)$$

Equally, the group has to confront the following budgetary restriction at each moment of time:

$$C_t = w_n(N_t - G_t) + w_g G_t + P_z Z_t + \frac{\partial G_t}{\partial t} w_g \quad (3)$$

Where:

w_n= the salary earned by the population involved in coca production.
w_g= the salaries and equipment costs of active guerrilla fighters
P_z= the cost of maintaining territorial control

Equation 3 implies that the income obtained from coca production is spent on coca workers' salaries, maintaining troops, maintaining territorial control and recruiting new members.

Once again, in per capita terms:

$$c_t = w_n(1 - g_t) + w_g g_t + P_z z_t + \frac{\partial g_t}{\partial t} w_g + w_g n g_t \quad (4)$$

[31] It is assumed that function *f* is strictly concave and that it satisfies the conditions of Inada: $f(0) = 0$, $f'(0) = \infty$ y $f'(\infty) = 0$.

Where *n*, represents the population growth rate in the region.

The preferences of the armed group over time can be represented by using the integer of instant utility:

$$u_o = \int_0^{\infty} m(z_t) e^{-\theta t} dt \quad (5)$$

Which implies that immediate utility depend positively on the territorial control that the group enjoys in the region, z_t, where θ represents the armed groups' inter-temporal discount rate. Furthermore:

$$m'(z_t) \geq 0, \quad m''(z_t) \leq 0 \quad \text{and} \quad \theta > 0$$

Thus, the armed groups problem of maximisation is:

$$\text{Max } u_o = \int_0^{\infty} m(z_t) e^{-\theta t} dt$$

s.t.

$$\frac{\partial g_t}{\partial t} = \frac{\frac{1}{1+\beta} Af(\gamma z_t, 1-g_t) - w_n(1-g_t) - w_g g_t - w_g n g_t - P_z z_t}{w_g}$$

Where the control variable is z_t and the state variable is g_t. This means that the armed group must find an optimum path to territorial control that allows it to maximise utility, subject to inter-temporal restrictions. The optimum path to territorial control determines the optimum number of guerrilla troops and coca production during each period.

Thus, the Hamiltonian is:

$$H = e^{-\theta t} m(z_t) + \mu_t \left\{ \frac{\frac{1}{1+\beta} Af(\gamma z_t, 1-g_t) - w_n(1-g_t) - w_g g_t - w_g n g_t - P_z z_t}{w_g} \right\}$$

Given that $\mu_t = \lambda_t e^{-\theta t}$

Therefore, the first order conditions for the Hamiltonian and the transversal conditions are, respectively:

(1) $$\frac{\delta H}{\delta z_t} = e^{-\theta t}\left\{ m'(z_t) + \lambda_t \left[\frac{\gamma \frac{1}{1+\beta} A f_z(\gamma z_t, 1-g_t) - P_z}{w_g} \right] \right\} = 0$$

(2) $$\frac{\delta H}{\delta g_t} = \lambda_t e^{-\theta t}\left\{ \frac{-\frac{1}{1+\beta} A f_{1-g_t}(\gamma z_t, 1-g_t) + w_n - w_g - w_g n}{w_g} \right\} = -\dot{\mu}$$

$$\lim_{t\to\infty} g_t \mu_t = 0$$

Having derived the first order conditions and with some algebra, we found the dynamic equations for control variable z_t, and for state variable g_t.

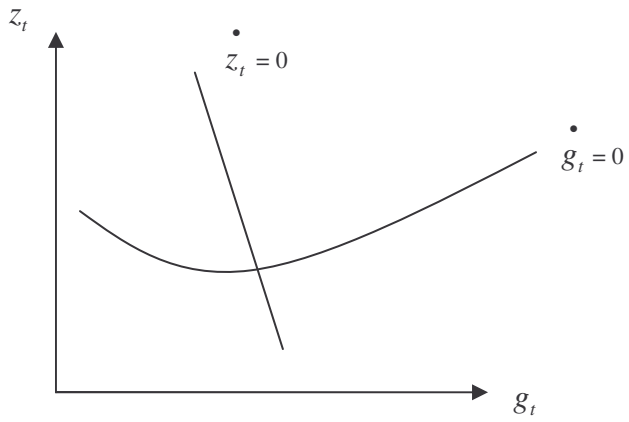
$$\dot{z}_t = \frac{w_g \theta + \frac{1}{1+\beta} A f_{1-g_t}(\gamma z_t, 1-g_t) - w_n + w_g + w_g n}{w_g \left\{ \frac{m_{z_t, z_t}(z_t)}{m_{z_t}(z_t)} - \frac{\gamma \frac{1}{1+\beta} A f_{z_t, z_t}(\gamma z_t, 1-g_t)}{\gamma \frac{1}{1+\beta} A f_{z_t}(\gamma z_t, 1-g_t) - P_z} \right\}} \quad (6)$$

$$\dot{g}_t = \frac{\frac{1}{1+\beta} A f(\gamma z_t, 1-g_t) - w_n(1-g_t) - w_g g_t - w_g n g_t - P_z z_t}{w_g} \quad (7)$$

In a stationary state, $\dot{z}_t = \dot{g}_t = 0$. The phase diagram, in plane (z_t, g_t) allows us to determine the equilibrium dynamics (z_t^*,g_t^*), and establish whether it is stable[32].

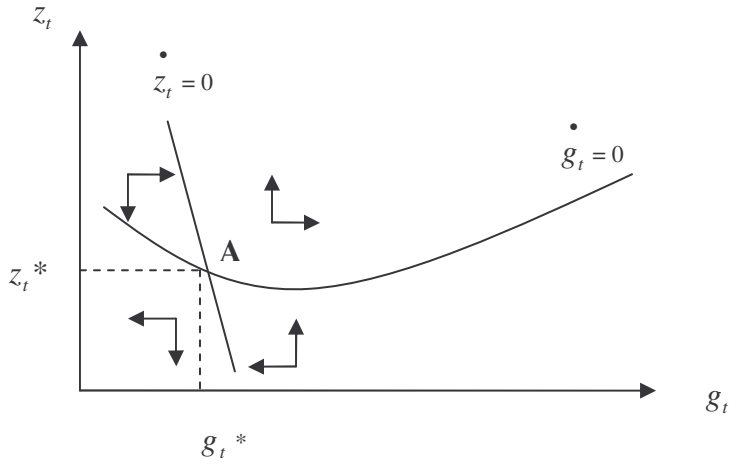
The phase diagram and the curves $\dot{z}_t = \dot{g}_t = 0$ are presented in the graph below:

[32] To determine the stationary state curves, we assumed a Cobb-Douglas production function, and plausible values were given to the different parameters used in the model.



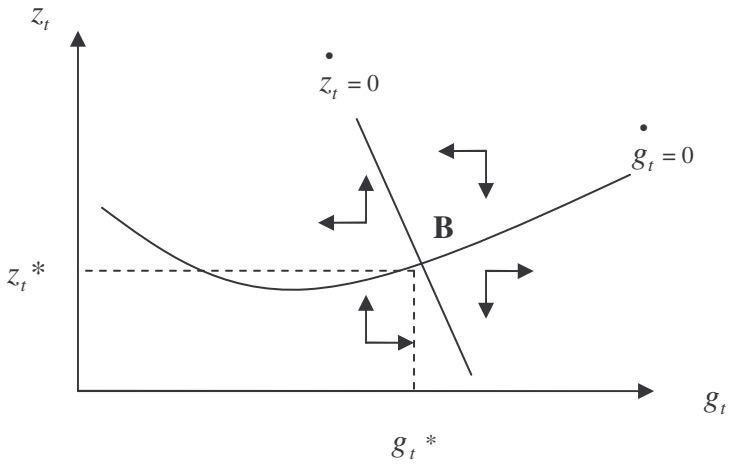
The different signs are due to the result of three plausible equilibriums, which depend on the sign of the following derivatives $\frac{\delta z_t}{\delta g_t} < 0$ in $\dot{g}$, $\frac{\delta \dot{g}_t}{\delta z_t}$ and $\frac{\delta \dot{z}_t}{\delta g_t}$, and also on whether the curve $\dot{z}_t$ =0 cuts the curve $\dot{g}_t$ =0 before or after its point of inflection.

Case 1



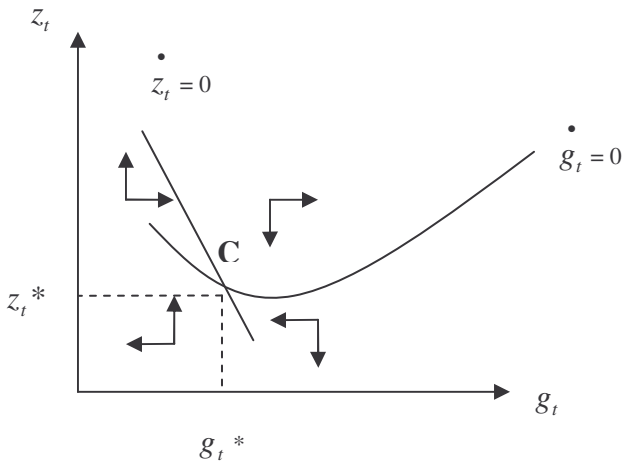
In case 1, equilibrium is established at point **A** under the assumption that $\frac{\delta z_t}{\delta g_t} < 0$ in $\dot{g}$, $\frac{\delta \dot{g}_t}{\delta z_t} > 0$, and $\frac{\delta \dot{z}_t}{\delta g_t} > 0$. As can be seen, the resulting equilibrium is a saddle point.

Case 2



In case 2, equilibrium is reached at point B, with the assumption that $\frac{\delta z_t}{\delta g_t} > 0$ in $\dot{g}$, $\frac{\delta \dot{g}_t}{\delta z_t}$ <0, and $\frac{\delta \dot{z}_t}{\delta g_t}$ <0. Similar to case A, the resulting equilibrium is also a saddle point.

Case 3



In case 3, equilibrium is reached at point C, with the assumption that $\frac{\delta z_t}{\delta g_t} < 0$ in $\dot{g}$, $\frac{\delta \dot{g}_t}{\delta z_t}$ > 0, and $\frac{\delta \dot{z}_t}{\delta g_t}$ < 0. The resulting equilibrium is stable.

4.2.2. Comparative Statistics

In this section we aim to establish the impact of eradication efforts β carried out by the authorities, and the cost of controlling the territory, P_z, on the previously mentioned equilibriums.

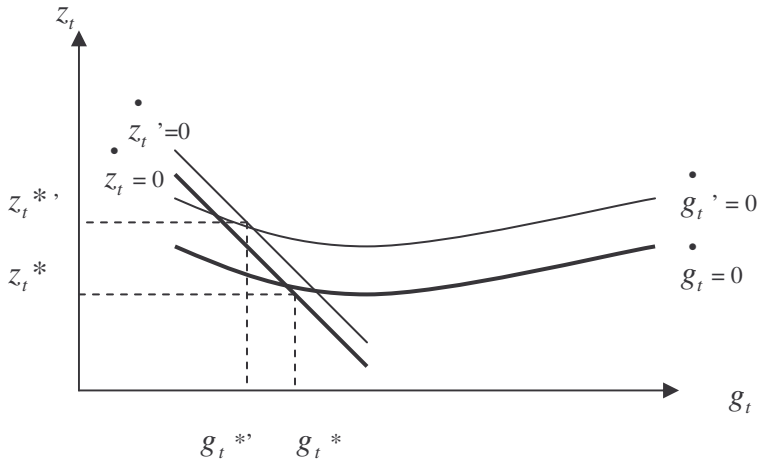
Changes in eradication initiatives β

The dynamic equations $\dot{z}_t = 0$ and $\dot{g}_t = 0$ are totally derived, to obtain the signs of $\frac{\delta \dot{z}_t}{\delta \beta}$ and $\frac{\delta \dot{g}_t}{\delta \beta}$:

$$\frac{\delta \dot{z}_t}{\delta \beta} = \frac{\frac{1}{1+\beta} A f_{1-g_t}(\gamma z_t, 1-g_t)}{\gamma \frac{1}{1+\beta} A f_{1-g_t, z_t}(\lambda z_t, 1-g_t)} > 0 \quad (8)$$

$$\frac{\delta \dot{g}_t}{\delta \beta} = \frac{\frac{1}{(1+\beta)^2} A f(\gamma z_t, 1-g_t)}{w_n - w_g - w_g n - \frac{1}{1+\beta} A f_{1-g_t}(\lambda z_t, 1-g_t)} > 0 \quad (9)$$

The following graph shows the shifts of curves $\dot{z}_t = 0$ y $\dot{g}_t = 0$ and reflects changes in eradication efforts that determine the new levels of equilibrium for z and g.



The results of the comparative statistics show that in the face of changes to eradication efforts, the illegal armed groups choose to consolidate their

territorial presence, and sacrifice recruitment efforts. Thus, when faced with an increase in eradication efforts, territorial control increases and the number of fighters in the organisation falls (see the two cases mentioned in the appendix).

To evaluate the impact of a change in β on coca production we started from the base of equation (1) that, once the optimum levels of z_t^* and g_t^* have been found, can be expressed thus:

$$c_t = \frac{1}{1+\beta} Af(\gamma z_t^*, 1-g_t^*) \quad (1)'$$

Therefore:

$$\frac{\delta c_t}{\delta \beta} = -\frac{1}{(1+\beta)^2} Af(\gamma z_t^*, 1-g_t^*) + \frac{1}{1+\beta} A\left\{ f_{z_t}(\gamma z_t^*, 1-g_t^*) \frac{\delta z_t^*}{\delta \beta} + f_{g_t}(\gamma z_t^*, 1-g_t^*) \frac{\delta g_t^*}{\delta \beta} \right\} \quad (11)$$

It can be seen that the first term of this expression is always negative, whilst the second depends on the signs and magnitude of $\frac{\delta z_t^*}{\delta \beta}$ and $\frac{\delta g_t^*}{\delta \beta}$. The total effect is, therefore, ambiguous. If the second term is positive, and lower than the first, coca production falls as a result of the increased probability of eradication. However, if the second term is positive and larger than the first, it is possible that coca production rises in spite of increased eradication efforts[33].

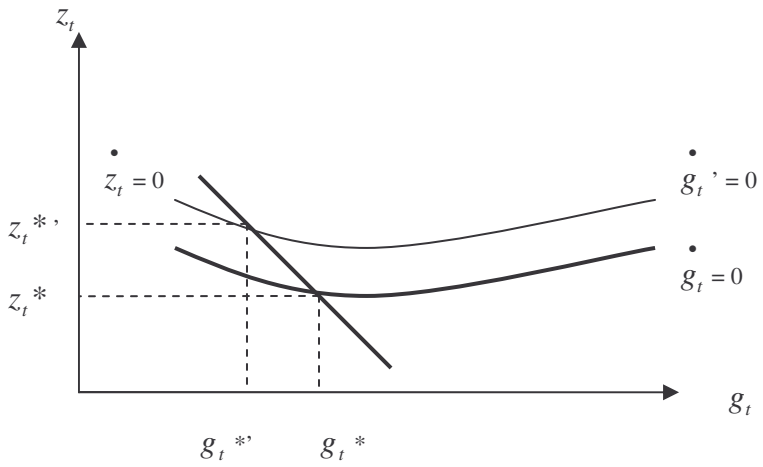
Changes in the price or cost of territorial control P_z

According to the equations, curve $\dot{z}_t = 0$ is not affected by a change in the cost of territorial control in a region P_z, whilst the effect or shift of curve $\dot{g}_t = 0$ following a change in P_z results in:

$$\frac{\delta \dot{g}_t}{\delta P_z} = \frac{z_t}{w_n - w_g - w_g n - \frac{1}{1+\beta} Af_{1-g_t}(\lambda z_t, 1-g_t)} > 0 \quad (12)$$

Thus the new equilibriums are:

[33] The simulations used a Cobb-Douglas production function and reasonable parameters, and always showed a reduction in coca production following increased eradication efforts.



As can be seen in the graph, if the cost of maintaining territorial control, P_z, rises, greater efforts are made towards consolidating control, to the detriment of the number of combatants (see the other two cases in the annexes).

In terms of the effect of the increased cost of territorial control on coca production we find that:

$$\frac{\delta c_t}{\delta P_z} = \frac{1}{1+\beta} A\left\{ f_{z_t}(\gamma z_t^*, 1-g_t^*)\frac{\delta z_t^*}{\delta P_z} + f_{g_t}(\gamma z_t^*, 1-g_t^*)\frac{\delta g_t^*}{\delta P_z} \right\} \quad (13)$$

Once again, the results are ambiguous and depend on the signs and magnitudes of $\frac{\delta z_t^*}{\delta P_z}$ and $\frac{\delta g_t^*}{\delta P_z}$.

5. Coca and Armed Conflict in Colombia

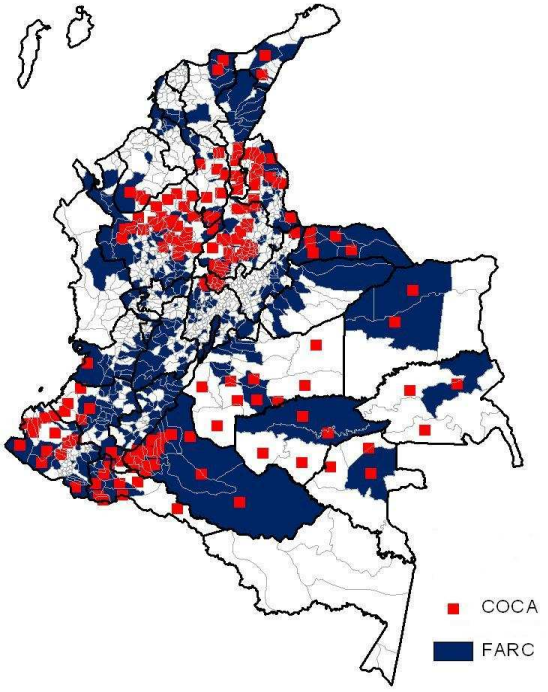
5.1. The Geography of the Armed Conflict and its Relationship with Coca

At the start of the 1980s, guerrilla and paramilitary activity was limited to a few rural areas, especially colonization zones at the frontier of agricultural expansion. However, the map of the conflict has changed considerably since the 1990s. The armed conflict has extended to include almost all national territory (González et al, 2002), and has been linked to the search for strategic zones of financing and armed conflict.

Since the mid-90s, FARC strategy has included the harassment of the civilian population, confrontations with the Colombian army, as well as the desire to strengthen its control of different regions. Thus, this guerrilla group's military actions have been focussed towards territorial control, not just of colonisation zones and areas of illicit crops, but also of economically rich regions, all in the context of its strategy of confronting the State (González et al, 2002). This guerrilla group has, therefore, changed its condition from being a rural guerrilla force, with an influence only in periphery zones, to becoming a force in urban centres that are integrated to the nucleus of domestic production[34].

Most areas in which the FARC are active are also illicit crop growing areas, as can be seen in map 6. This is the result, in terms of our hypothesis, of the expansion of the conflict. The *Bloque Sur*'s zone of influence covers the departments of Caquetá and Putumayo, which are the two areas with the highest levels of coca production (Vicepresidencia de la República, 2002).

Map 6. FARC Activity and the Presence of Coca Crops in Colombia



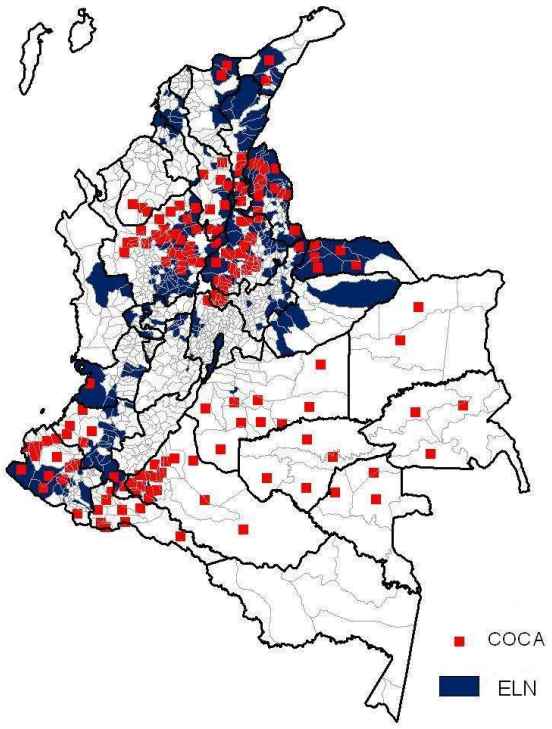
During the 1990s, the *Ejército de Liberación Nacional* (ELN) also began a territorial expansion process concentrated in the north of Colombia, with 5 fronts, the most important of which is the *Nororiental* that operates in the department of Santander. The other fronts operate in southern Bolivar (Serranía

[34] The FARC now has 23,000 fighters divided into 62 fronts that operate throughout the country. The fronts form part of the 5 blocks: the *bloque Caribe*, that operates on the Atlantic coast, the *bloque Central* that operates in Tolima, Huila and Cundinamarca, the *bloque Sur*, that operates in Nariño, Putumayo and Caquetá, the *bloque Oriental* that operates in Meta, Vichada and Guaviare and the *bloque Jóse María Córdoba* that operates in Urabá and Antioquia.

de San Lucas), Antioquia, Cauca and the south of Huila. The ELN is also beginning to operate in Tolima and Cundinamarca. The group has 41 fronts and a total of about 5,000 combatants.

This group's territorial expansion is concentrated in zones rich in natural resources: oil, coal, gold and emeralds. As in the case of the FARC, this expansion strategy is linked to the search for sources of financing, the most important of which is the exploitation of extractive economic activities[35]. The ELN's relationship with drug production is most important in the *Bloque Norte*, specifically in southern Bolívar, a strategic coca production zone in the Caribbean region.

Map 7. ELN Activity and the Presence of Coca Crops in Colombia

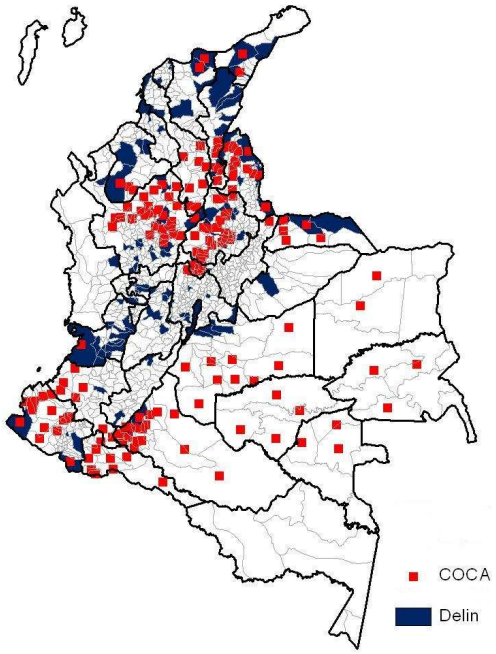


The illegal self-defence groups have also enjoyed sustained growth since the mid-90s. They went from 850 members in 1992 to 8,150 in 2000, which allowed them to consolidate their power, especially in northwest Colombia (Antioquia, Córdoba, Sucre, Bolívar, and even Norte de Santander) and to advance on towards the south and east of Colombia[36]. The self-defence groups obtain their finances principally from coca cultivation and drug-trafficking, although they also obtain income from extorting agricultural and cattle farmers. They also use a system of extortion in coca and opium poppy growing regions under their

[35] It has been estimated that around 66% of ELN income comes from extortion, followed by kidnapping (28%), and drug trafficking (6%) (Vicepresidencia de la República, 2002).
[36] According to González et al (2002) Urabá, northern Antioquia, Bajo Cauca Antioqueño, Magdalena Medio, southern Bolivar, Cesar and Catatumbo are an east-west corridor that has become the centre of confrontations between armed groups, especially the paramilitary and FARC, that have lead to the ELN's military and territorial recession.

control, namely southern Bolívar, the Catatumbo Valley, Meta, Guaviare, Caquetá and Putumayo, where the self-defence forces charge security quotas to coca growing peasant farmers (Ministerio de Defensa, 2000).

Map 8. Paramilitary Activity and the Presence of Coca Crops



5.2. The Spatial Relationship Between the Armed Conflict and Coca Crops

Although the direct relationship between illicit crops and the armed conflict has been extensively studied, the patterns of the relationship and spatial diffusion between these two activities has not been studied at all. In this section we will analyse these cluster patterns and the overspill of coca growing into neighbouring municipalities. We will also examine the characteristics of the dynamic relationship between the activities of illegal armed actors and coca production in Colombia, using spatial analysis techniques[37].

5.2.1. Spatial Indicators Of The Armed Conflict And Coca Crops

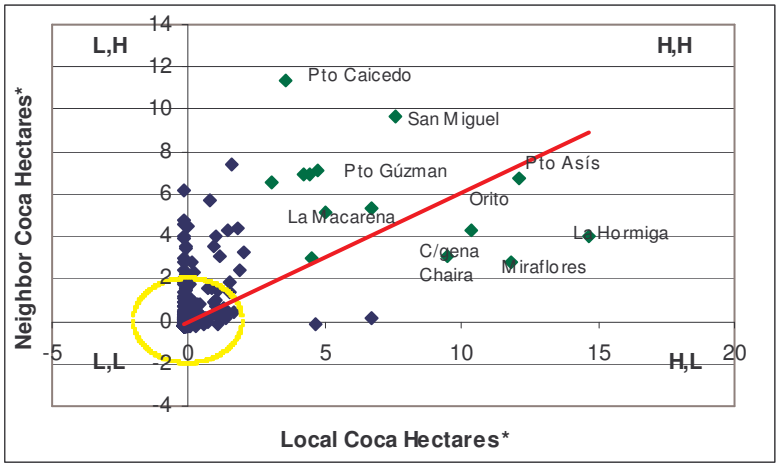
In this section we will present a set of indicators that relate coca crops (hectares under cultivation at municipal level) to the armed conflict (attacks on municipalities by illegal armed actors), in order to determine the spatial association patterns that exist between the entities under investigation. The behaviour of the variables in a geographic unit and in their neighbouring

[37] Specifically, Local Spatial Association Indicators (LISA) were used, according to Cohen and Tita's methodology (1999) used to analyse violent behaviour in Pittsburg, Pennsylvania.

geographic unit were examined[38] in an Euclidian plane where each point expresses the relationship between the two standardised variables[39]. This plane is divided into four quadrants. The X-axis contains the local municipality variables and the Y-axis the neighbouring ones. Thus, the first quadrant contains the high local and neighbouring variable points (quadrant H,H), in the second quadrant we find low local variables and high neighbouring ones (L,H), in the third quadrant both local and neighbouring variables are low (L,L) and in the fourth, local variables are high and neighbouring ones are low (H,L). In addition, the points in quadrant *(H,H)* outside the circle of standard deviations are groups of municipalities or clusters of municipalities (regions) where coca growing is well above average.

Graph 5 shows the current relationship between cultivated hectares in each municipality and those of its neighbours[40]. A clear spatial association is evident. The average spatial correlation coefficient for the period 1999-2001 is 0.60. This implies that the presence of illicit crops in Colombia has a high spatial dependence, that is, the number of hectares under cultivation in one region depends on the situation in neighbouring regions. In addition, the points outside the two standard deviations are critical point or hot-spots. Amongst these are 7 of Putumayo's 13 municipalities (Puerto Asís, Puerto Caicedo, San Miguel, La Hormiga, Orito, amongst others); Miraflores and San José in Guaviare; Cartagena del Chairá, Solano and San Vicente in Caquetá, and La Macarena in Meta.

Graph 5. Local And Neighbouring Coca Production, (standardised average 1999-2001)



Source: Authors calculations. * The hectares have been standardised

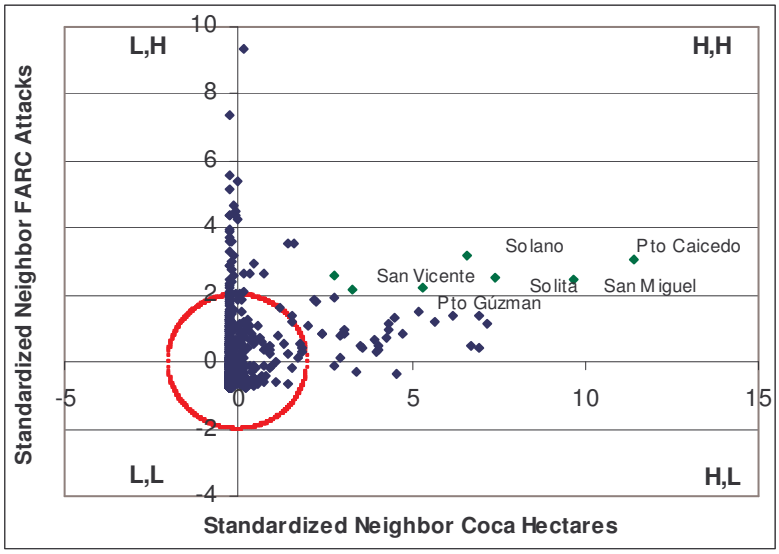
The relationship between neighbouring presence of illegal armed groups and neighbouring coca crops is presented in graphs 6 to 8. It is evident that there is a grouping pattern amongst these variables, especially relevant to the FARC. In

[38] The criteria of neighbouring areas was obtained using a spatial contiguous matrix for 1,062 municipalities. It is a square matrix Wij, where each of the elements i and j are the inverse distance between the points i and j, and the furthest units have the lowest values. See Moreno and Vayas (2001).
[39] Standardised means (Xi-Xmed)/DST, where Xi is the observation value i of the variable X, Xmed is the medium of X, and DST is the standard deviation of X.
[40] The average number of cultivated hectares in neighbouring areas is the sum of cultivated hectares in the other municipalities, adjusted by the the inverse distance between the local municipality and the others.

those regions where there is a high number of cultivated hectares (standardised) there is also high presence of armed actors; municipalities with a low presence of illegal groups also have fewer cultivated hectares of coca. In all cases there are hot spots with a high presence of armed actors and also a large number of cultivated hectares dedicated to coca production.

The positive correlation between regional coca crops and the regional activities of the FARC is shown in graph 6. The critical points are all those outside the red circle. However, those of interest are those in which the two activities are well above the average (more than two standard deviations)—the municipalities of Puerto Caicedo, San Miguel, San Francisco and Puerto Guzmán in Putumayo; and Solita, Solano and San Vicente del Cagúan in Caquetá.

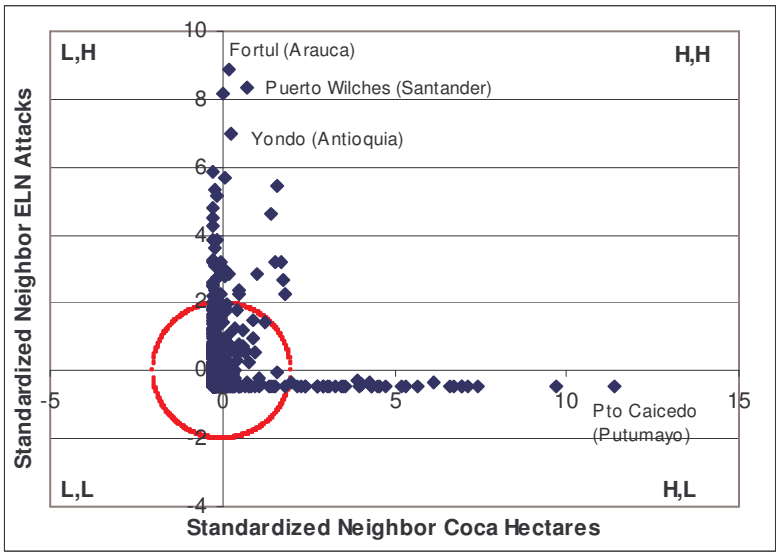
Graph 6. Regional Coca Production and Farc Activity, (standardised average 1999-2001)



Source: Authors' calculations.

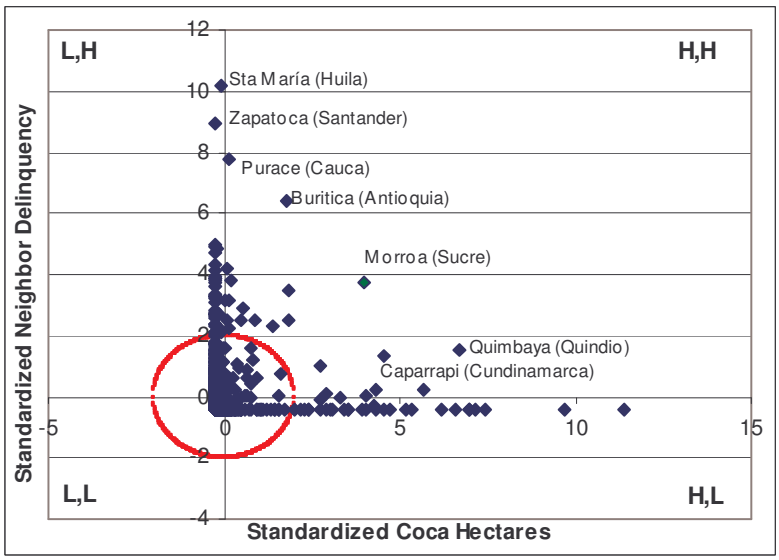
In contrast, the correlation between regional coca crops and ELN activity is not so high, as can be seen in graph 7, and there are no critical points in which the relationship between these two variables is neuralgic. However, there are some municipalities in which the presence of each of these variables is high, as is the cases in Fortul (Arauca), Puerto Wilches (Santander) and Yondó (Antioquia), which have a high level of ELN activity. In contrast, Puerto Caicedo (Putumayo) had a high number of average cultivated hectares of coca between 1999 and 2001.

Graph 7. Regional Coca Production and EIN Activity in Neighbouring Areas, (standardised average 1999-2001)



Graph 8 shows the positive relationship between cultivated hectares and regional paramilitary activity. It can be seen that one of the critical points where high levels of paramilitary activity accompany a large number of cultivated hectares is the municipality of Morroa in the department of Sucre. The other points indicate a high level of one or other of the two activities.

Graph 8. Regional Coca Production and The Regional Paramilitary Activity (standardised average 1999-2001)



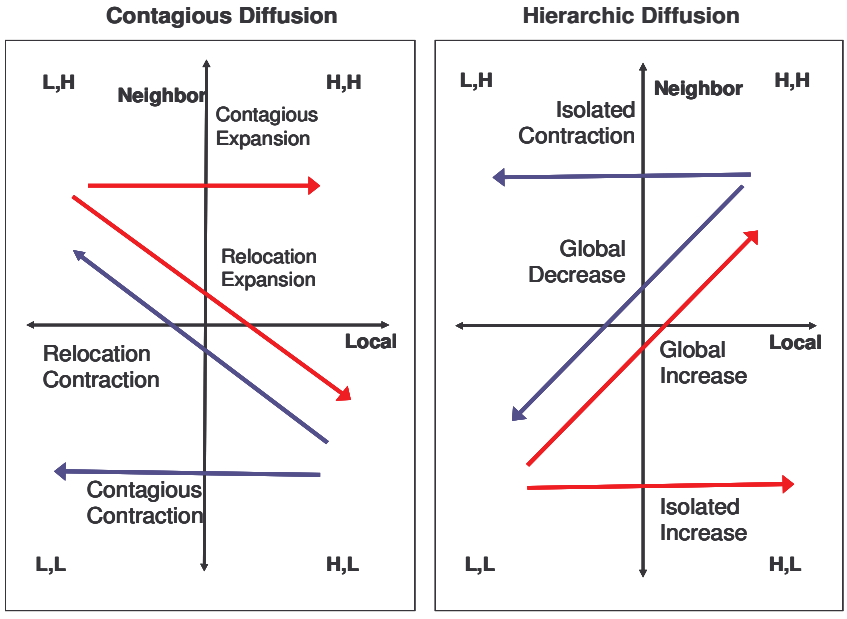
5.2.2. The Diffusion and Spatial Dynamics of Illicit Crops and the Armed Conflict

The spatial diffusion of illicit crops is shown in two different ways: contagious diffusion and hierarchic diffusion. Contagious diffusion, as its name suggests, is

where one region infects its neighbour with coca production. This type of diffusion can, in turn, be classified in two different ways: ***relocation***—coca crops move to neighbouring areas and production ends in the local municipality due to eradication or other factors—and ***expansive diffusion***—the presence of coca spreads from the municipality towards contiguous spatial units, but production continues in the local municipality. Hierarchic diffusion, in turn, occurs without spatial contact, that is, by imitation or innovation (Cohen and Tita, 1999). For example, illegal armed groups from other regions see the profitability of the business and the low costs, and decide to begin cultivation, thus increasing the presence of coca in other regions. When analysing diffusion dynamics, it is necessary to study the changes in cultivated hectares in local and neighbouring municipalities, and to relate this to the changing activities of armed groups in local and neighbouring municipalities.

The diffusion process is clearly seen in a Cartesian plane (graph 9). There are two types of contagious diffusion: a) expansion between neighbours, when few cultivated hectares in the local municipality and many in the neighbouring one become many in the local municipality and few in the neighbour, and a set of neighbours goes from quadrant *(L,H)* to *(H,H)*. The opposite may also occur when a group of municipalities goes from *(H,L)* to *(L,L);* b) relocation between neighbours, when cultivated hectares go from low in the local area and high in the neighbour to high in the local area and few in the neighbour; in this case, a set of municipalities goes from quadrant *(L,H)* to *(H,L)*. The opposite may also occur when a group of municipalities goes from *(H,L) to (L,H).*

Graph 9. The Dynamics of Spatial Diffusion

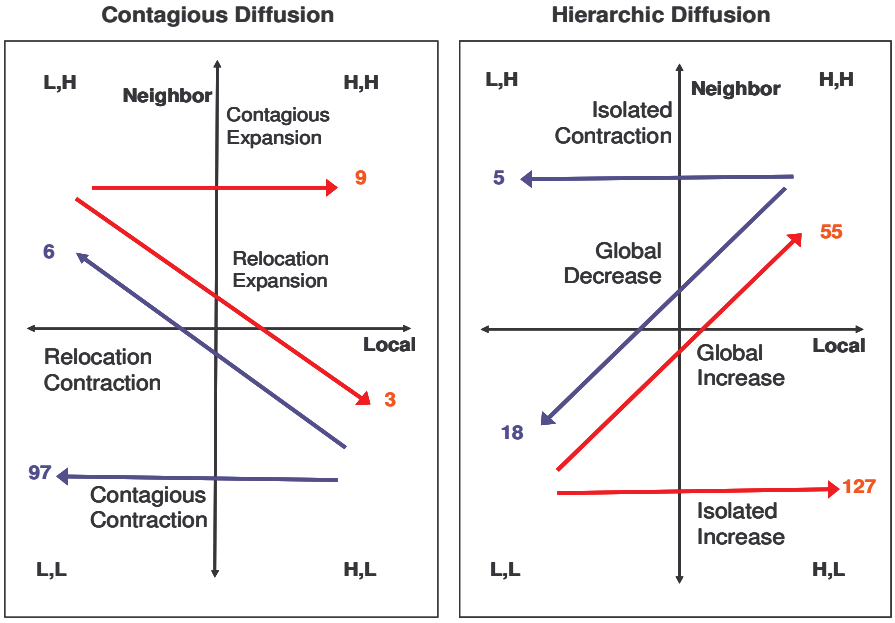


The dynamics of hierarchic diffusion may be classified thus (graph 9): a) Isolated rise or fall, presented when cultivated hectares rise (fall) in the local municipality without those of the neighbouring area being high (low). Local municipalities go from quadrant (L,L) to (H, L) in the case of a rise, and from quadrant (H,H) to (L,H) in the case of a fall; b) global rise or fall, presented when both the local and neighbouring municipality go from having few cultivated

hectares to having many, or from many to few. In the first case they go from quadrant (L,L) to (H,H) and in the second from (H,H) to (L,L).

In graph 10 the diffusion processes between municipal coca crops and their neighbours is presented for the period 1994 and 1999-2001 (average hectares[41]). 12 municipalities presented contagious diffusion—expansion and relocation—and 103 contracted. 182 municipalities experienced growing hierarchic diffusion, whilst 23 fell. Thus, the diffusion of coca production is more due to hierarchic diffusion, in which dissemination responds more to innovation or imitation; this is exactly what is expected when the diffusion of crops is the result of illegal groups expanding their activities.

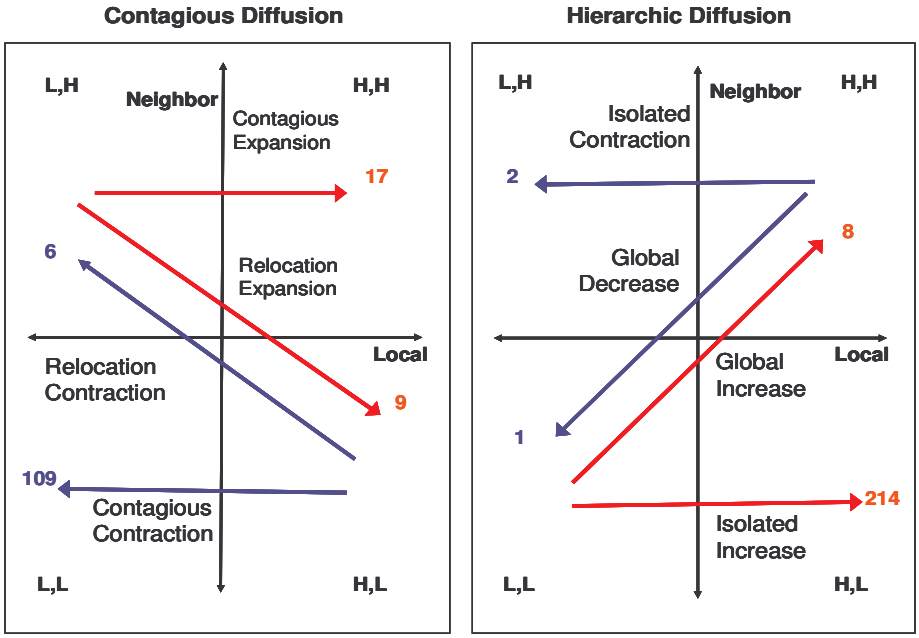
Graph 10. Spatial Diffusion of Local and Neighbouring Coca Crops 1994/1999-2001



Graph 11 shows the results for regional coca crops and regional FARC activity, and allows one to see the way in which FARC regional expansion corresponds to regional rises in coca crops. The exercise shows that between 1999 and 2001, compared with 1994, 26 groups of municipalities experimented contagious diffusion—expansion or relocation—and that 115 groups experienced falling contagious diffusion or relocation. In turn, growing hierarchic diffusion was evident in 222 groups of municipalities, whilst falling hierarchic diffusion was evident in 3 groups of municipalities. These results imply that regional rises in abundant coca crops were preceded by a high previous regional presence of the FARC.

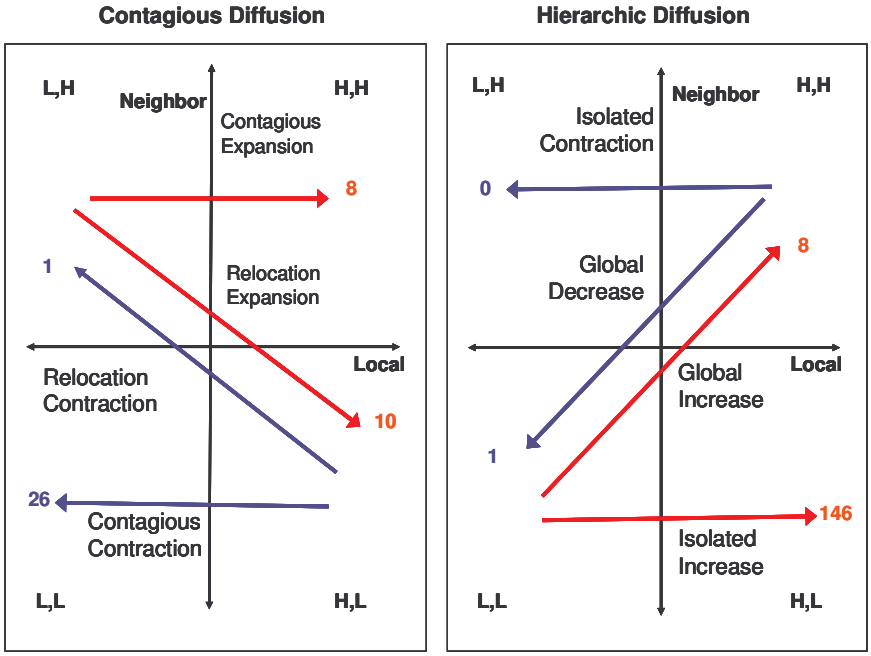
[41] This period was chosen because it is the current information about cultivated hectares of coca in Colombian municipalities.

Graph 11. Spatial Regional Diffusion of Coca And FARC Regional Presence 1994/2001



The relationship between regional coca crops and ELN activity in neighbouring areas is shown in graph 12. It can be seen that 18 groups of municipalities presented growing contagious diffusion or relocation, whilst 27 groups experimented falling contagious diffusion or relocation. In turn, 154 groups of neighbouring municipalities presented rising hierarchic diffusion, whilst 1 showed falling hierarchic diffusion.

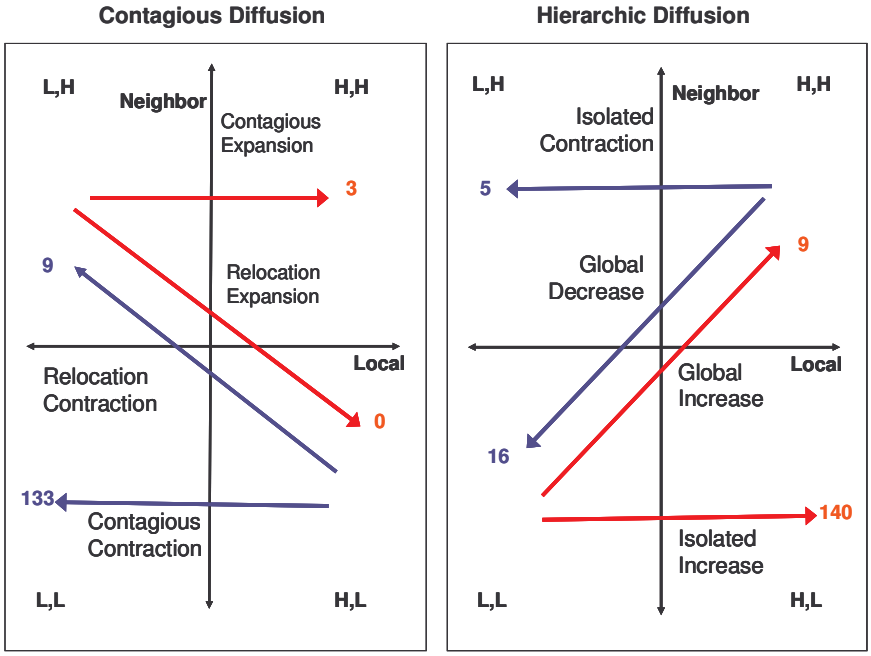
Graph 12. Spatial Diffusion of Regional and Coca Regional ELN 1994/1999-2001



Graph 13 shows the same diagram related to illegal self-defence groups. The results show that 3 municipalities experienced growing contagious diffusion and

140 growing hierarchic diffusion. In turn, 142 municipalities experimented falling contagious diffusion and 21 falling hierarchic diffusion.

Graph 13. Spatial Diffusion of Regional Coca and Regional Self-defence Groups 1994/1999-2001



5.3. Eradication of Coca in Colombia

5.3.1. The History and Policies of Eradication

The drug problem in Colombia was originally based on converting coca paste into cocaine, and then commercialising the drug. Anti drug-trafficking legislation reflected this structure. The legal framework was then amplified and an anti-drug jurisdiction was created, of a similar nature to international legislation.

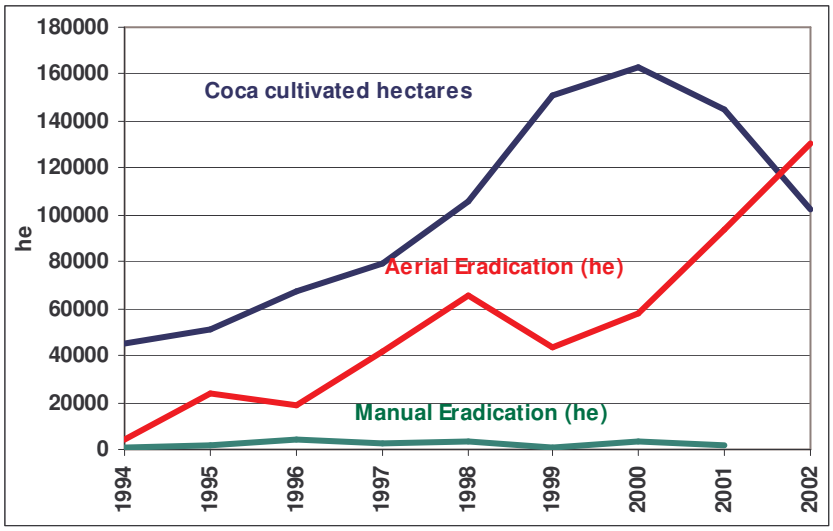
In 1976 the National Drugs Council (CNE) was created to create policies, plans and programmes designed to combat the production, trafficking and consumption of psychotropic substances[42]. Furthermore, from 1986 the legal framework began to grow and the cultivation of illicit crops was made a crime related to drug-trafficking. At the same time, eradication efforts began. Law 30 of 1986 enabled the CNE to become the Special Administrative Unit in charge of developing and adopting government policies related to the prevention, rehabilitation and repression of illicit crops in Colombia.

During the 1990s, the production of illicit crops rose considerably, reflecting the insufficient efforts of the drug war, and the need to modify it. Priority was given to mechanic or manual destruction (plant by plant), aerial or manual spraying, burning and the use of biological means.

[42] The National Drugs Council is made up of the Ministries of Justice, Defence, Education, Health and Foreign Affairs, the National Drugs Director, the General Procurator, the Administrative Security Director, the National Police Force Director and the General Attorney.

The most intensely used of all these methods has been aerial fumigation; it had already been used at the end of the 1970s to reduce marihuana crops in the *Sierra Nevada de Santa Marta* and the *Serranía del Perijá*. Gaviria's government (1990-1994) approved the aerial spraying of coca with glifosato (and of opium poppies in the departments of Cauca, Tolima and Huila). However, it was not until Samper became President in 1994 that aerial spraying of coca and marihuana crops was extended throughout most of Colombia, especially the south of the country. Aerial fumigation has been considerably intensified in recent years under Plan Colombia[43]. 130,000 hectares were fumigated in 2002, as can be seen in graph 14.

Graph 14. The Eradication of Coca Crops: 1994-2002



Source: National Drugs Office[44].

Aerial eradication initially focussed on the department of Guaviare (see table 1), and to a lesser extend on Putumayo, Caquetá and Meta. However, since 2002 coverage has increased considerably to cover 12 departments. The new epicentre of fumigation is Putumayo, the country's principal producer of coca. In 2001, 32,000 hectares were fumigated in Putumayo, 17,000 in Caquetá and 7,000 in Guaviare—around 60% of all coca production in the country.

In addition, alternative development programmes have been designed that offer incentives for substituting illicit crops for economically sustainable activities. The PLANTE presidential programme and Plan Colombia have led to the eradication of between 1,000 and 3,000 hectares, and have benefited 54,551 families.

The efficacy of policies designed to combat illicit crops has been heavily questioned. Vargas (1994, 1999b) argues that the war on drugs has been a failure because it is based on erroneous market hypotheses: "those fighting

[43] Plan Colombia was designed by the Colombian government and is internationally financed. It was ratified in 2000 by President Clinton of the USA and President Pastrana of Colombia. The plan has four principal components: 1. economic and social recovery, 2. an end to the armed conflict, 3. the strengthening of institutions and social development, and 4. an anti-drugs strategy. $1.6bn have been donated to the plan, of which $81m are destined to alternative development, whilst $663.5m have been used to equip the police and army for the war on drugs.

[44] The figures for manual eradication in 2002 are still not available

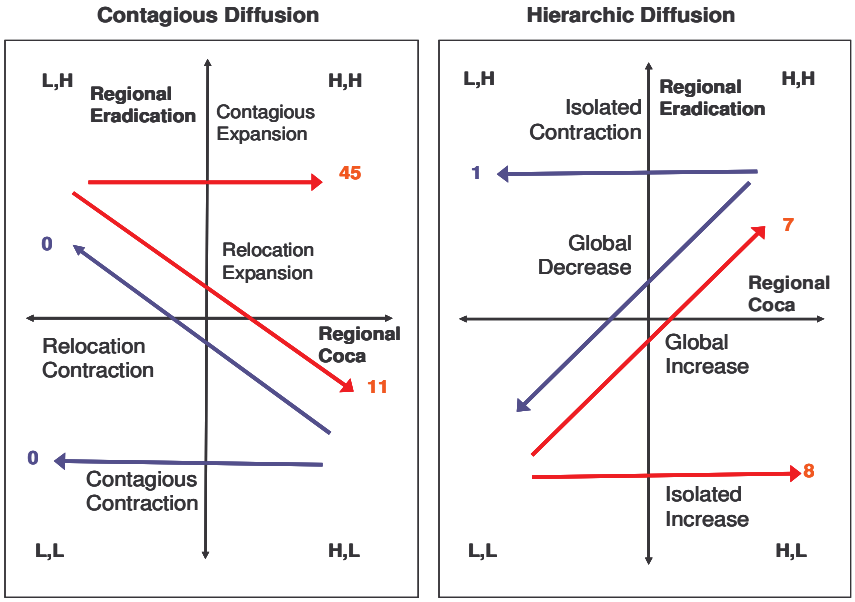
drug-trafficking appear to have ignored the paradox generated by high profits; however effective measures are in the short-term, the incentive to increase production in the long term is greater. If the coca supply is limited, prices rise and this in itself is an incentive for more producers to become involved in the business". According to Uprimmy (1995), "Effective repression in one region simply displaces production and trafficking to another zone, as long as demand remains dynamic, due to the simple nature of the means of production and the extensive geographical possibilities".

Regarding alternative development, Thoumi (2002) believes that this type of project runs into problems, not only because it is difficult to find legal alternatives that generate an income comparable to that generated by coca, but also because the incentives can actually make people more likely to begin growing coca or expand existing crops, to become eligible for State help. Thus, if a reduction in the number of hectares cultivated with coca is what is desired, alternative development may not be the most efficient strategy. However, Rementería (2001) sustains that alternative development may be advantageous to poor peasant farmers, due to the agricultural recession, and could become a non-violent option to control illicit cultivation. However, it is not enough just to reduce illicit cultivation, which responds to other factors that are not included in this type of programme.

5.3.2. The Diffusion and Dynamics of Illicit Crops and Eradication

Similar to the analysis of the diffusion of illicit crops and the armed conflict, exercises designed to find the spatial association indicators were carried out. In graph 15 the spatial diffusion pattern between regional coca production and coca eradication between 1999 and 2001 is presented. 23 municipalities experienced growing contagious diffusion and 4 presented growing hierarchic diffusion. Additionally, 2 municipalities showed falling contagious diffusion and none experienced falling hierarchic diffusion.

Graph 15. Coca Eradication, 1994-2002



The graph shows that between 1994 and 2001, coca expanded from regions with high levels of eradication and low levels of coca, to regions with high levels of both eradication and coca, or low levels of eradication and high levels of coca. This graph implies that eradication policies have resulted in the increased "infection" of neighbouring municipalities. The left plane contrasts the right plane; in fact, the latter shows almost non-existent levels of hierarchic diffusion.

6. Econometric Evidence

6.1. Hypothesis

In section four's theoretical model, a relationship was shown between the conflict, territorial expansion of the armed groups and coca cultivation. This relationship is presented in equation (1):

$$c^*_t = \frac{1}{1+\beta} Af(\gamma z_t^*, 1 - g_t^*) \quad (1)'$$

Where c_t^*, z_t^*, and g_t^* represent the optimum values per capita for hectares under cultivation, territorial control and the number of combatants. The equations for $\dot{z}_t = \dot{g}_t = 0$, presented in section 4, allow us to determine that the optimum values for z_t^* y g_t^* can be expressed as follows:

$$z_t^* = z_{t^*}(\theta, \beta, W_g, W_n, n, P_z), \quad (14)$$

and

$$g_t^* = g_{t^*}(\beta, W_g, W_n, n, P_z) \quad (15)$$

Equations (14) and (15) show that the optimum values for territorial control and the number of active combatants (expansion of the conflict) are based on a set of exogenous variables such as labour income in the region, the combatants' "wage", fumigation and the cost of territorial control. The model shows that coca cultivation depends on territorial control and the number of combatants in the armed groups (or their activities). That is, there is a strong relationship between the presence and expansion of illicit crops and the presence and expansion of illegal armed groups. The previous section showed how this relationship forms via interaction between the spatial diffusion of illicit crops and the spatial diffusion of the conflict. The following subsection quantifies the magnitude of the relationship between the conflict and illicit crops using matching estimators, which allow us to correct any endogenous problems in the relationship.

6.2. Matching Estimators

To determine the effect of armed groups' activities on coca cultivation, an econometric model could be used in which the dependant variable is the number of cultivated hectares and the independent variable is armed activity. It could also be controlled by proxy variables or could include the exogenous variables in equations (14) and (15) (poverty, inequality, and geographical,

judicial and anti-drug activity variables, etc.)[45], as is shown in the equation below:

$$Coca_{i,t} = \alpha_1 + \alpha_2 G_{i,t} + \alpha_3 GEO_{i,t} + \alpha_5 J_{i,t} + \alpha_6 AE_{i,t} + \alpha_8 S_{i,t} + \varepsilon_{i,t} \qquad (16)$$

Where $Coca_{i,t}$ is the variable indicating the presence of illicit crops in municipality *i* in year *t*, *G* is the matrix that contains information related to the presence of each of the armed groups in municipality *i* at moment *t*, *GEO* is the matrix of geographical a spatial characteristics, *J* is a vector containing information related to judicial efficiency (a proxy of P_z), *AE* is a vector containing information related to productive activities and wealth in each of the municipalities and *S* is a matrix containing the socioeconomic characteristics of each municipality, such as GINI, NBI, level of education, amongst others (proxies of W_g and W_n).

However, various errors are evident in this exercise; the estimates of the parameters could be biased, have erroneous significance levels and could therefore lead to incorrect conclusions. In the first place, there could be endogenity between the presence of coca crops and illegal armed activity—illegal armed actions could, in turn, depend on illegal productive activities. In the second place, the armed groups' actions are a decision variable, that depends on variables *GEO, J, AE* and *S*, leading us to commit the error known as selection bias (see Heckman (1977); Heckman *et al.* (1998); Todd (1999)). In fact, the theoretical model shows how an "optimal" armed conflict (expressed as the number of men and women in arms or their activities) depends on variables *GEO, J, AE* and *S*, which gives theoretic credence to the hypothesis proposed here.

To overcome the endogenous inconveniences, and to ensure that the empirical estimates reflect the theoretic model, a non-parametric method was used that enabled us to analyse the existing relationship between coca crops, illegal armed groups (FARC, ELN and illegal self-defence groups) and aerial spraying. The methodology used was that of matching estimators, which enabled us to answer the following question: What would be the value of cultivated hectares of coca in a municipality with illegal armed group presence if these groups had not been present? The answer will show the effect of the armed conflict (expressed via the activity of these groups) on the number of hectares cultivated with coca in a municipality. The problem with this type of analysis is that it is impossible to observe the same municipality, at the same moment in time, with and without the activity of an armed group, and then to compare the number of hectares cultivated in each scenario. The fact that one of the events is not physically observable means that a simulation has to be carried out.

In other words, if $Coca_1$ and $Coca_2$ represent the number of cultivated hectares of coca in municipalities with and without the presence of armed actors

[45] In fact, probabilistic econometric exercises were carried out (Spatial Probit) to try and find the determinants of illegal activity in Colombian municipalities, using spatial econometric tools. However, the results, although satisfactory, presented problems related to endogenity and multicolinearity, which is why the models were calculated using the methodology proposed here.

respectively, what we need to know is: How many cultivated hectares would there be in municipalities with the presence of illegal armed groups ($Coca_1 | Z$, $A_i=1$), if those armed groups were not present ($Coca_2 | Z$, $A_i=0$)? The difference between these two values, ($Coca_1 | Z$, $A_i=1$) - ($Coca_2 | Z$, $A_i=0$), is the effect of illegal armed group presence on cultivated hectares of coca. However, ($Coca_2 | Z$, $A_i=0$) is non-observable. It is, therefore, necessary to simulate it via a secondary estimate of variable A (the activities of illegal armed groups). This simulation will permit a comparison of the number of hectares in each municipality with illegal armed activity, with those of municipalities without illegal armed activity but with a similar probability of experiencing the presence of an armed group. In other words, each municipality with armed group presence should be paired (compared) with the most similar municipality that does not present any illegal armed activity.

The first step is to determine the probability that an armed group will begin activities in a given municipality by using binary, probit or logit selection models, which have explanatory variables that are similar or proxy to the equation's exogenous variables (15), as well as other controls (persistence and diffusion variables of the group's activities in the municipalities—temporary and spatial lags[46] of the dependant variable—as well as, geographical, judicial, economic and social factors). These regressions will serve to estimate the prior probability. For example, if a probability model is constructed for FARC activity in Colombian municipalities, the probability of this group's entering a municipality may be estimated, given the characteristics of all other municipalities. This probability will be enough to carry out the matching exercise. The probability of an armed group beginning activities could be high or low, independent of whether or not they had been active in the area before. We used the equation below to calculate this probability:

$$\Pr(A_i = 1 | Z) = f(\omega Z_j) \qquad (17)$$

Using the probabilities that result from the probit models, municipalities may be paired via a matching estimator. This procedure consists of generating a control group that allows us to compare the effect of intervention on a municipality (in this case, illegal armed activity) with municipalities that have an equal probability of intervention, although they did not actually experience it. Various types of matching estimators may be used: simple average nearest neighbour , kernel or local linear regression.

The simple average nearest neighbour estimator allows a comparison of each municipality with armed activity with those that have the closest mathematical probability of some kind of attack, but which have not yet experienced it. By using the values calculated for ω, a probability estimate of illegal armed activity can be made for each municipality (propensity score). The differences between each municipality with illegal armed activity and each municipality without it can then be calculated to form a distance vector that should be ordered from the lowest to the highest. The number of cultivated hectares in each municipality

[46] These are spatial Probit models. The spatial variables are presented in the spatial contiguity matrix (see footnote, p.32), which solves the spatial autocorrelation problem. (See Moreno and Vayá 2000)

should then be compared with the N closest municipalities in terms of probability, but that do not have illegal armed activity. This investigation used 1, 3, 5, 7, 10 and 20 neighbours. Thus, for these N municipalities, the number of cultivated hectares of coca should be calculated as follows:

$$Coca_{m,k} = \sum_{j=1}^{N} \frac{Coca_j}{N} \qquad (18)$$

Equation (18) simulates the number of hectares of coca municipality *k* would have had if it were a municipality without illegal armed activity. Therefore, ($Coca_i$- $Coca_{m,k}$) is the effect of illegal armed activity on the number of cultivated hectares. The simulation should be carried out for all municipalities with illegal armed activity, in order to find the average difference, called the average treatment effect on the treated (ATT):

$$ATT = \sum_{k=1}^{N} \frac{(Coca_k - Coca_{m,k})}{N_t} \qquad (19)$$

Where N_t are municipalities with illegal armed activity. The ATT value is the effect of armed activity or the conflict on the number of cultivated hectares of coca.

The kernel estimator methodology is similar to that of the simple average nearest neighbour, but a 1/x weighting is assigned to all observations in the comparison group. All municipalities with guerrilla presence are paired with weighed averages of all the controls, using weighs that are inversely proportional to the distance between the propensity scores of the treated and the control group. This means that the weighting is selected to ensure that the closest observations (in terms of distance |P(Xi) - P(Xj)|) are given greater weighs. This weighting is reached via a kernel function that requires the choice of a bandwidth; this is equivalent to choosing the number of neighbours in the case of the simple average nearest neighbour (Tood, 1999).

Finally, the lineal local regression estimators are based on a non parametric regression technique in which for each propensity score a weighed least square regression for Coca is estimated on a constant term and on the difference in probabilities between the treated and the controls, in those municipalities with illegal armed activity. We use the data in which the difference is zero, and the parameter of the constant will be the estimated difference (Tood, 1999).

Once the estimators for whichever of these methodologies have been calculated, one must verify their reliability. As the techniques used are not parametric, a method should be used that allows us to obtain almost real solutions using random data. The procedure most often used in these cases is bootstrapping—taking samples from the original sample B that allow one to obtain the difference for each of the models. The prediction error is then quantified, and the average of all these errors is the estimate of the prediction standard error.

This methodology may also be used to evaluate the effect of illicit crops on rebel and paramilitary activity, allowing us to examine the hypothesis that coca crops explain the conflict. To do this, we tried to determine armed group activity in municipalities with coca crops if these coca crops had not existed. Therefore, the treatment variable is the presence of coca in all the municipalities, and the outcome variable is illegal armed activity measured as the activity of the groups (attacks or per capita attacks).

6.3. Data

The econometric exercises used different variables for 1,062 Colombian municipalities in 1994 and 1999-2001. As stated above, econometric exercises were carried out on binary variables to find the probability of illegal armed activity (FARC, ELN and illegal self-defence groups). The available information was the number and type of activity or attack, by municipality and by group. This information was processed and a value of 1 was given if there was activity[47] and 0 if there was not.

The variables related to the presence of armed activity were divided into five groups: illegal armed groups activities, geographical, infrastructure, justice and eradication activities, economic activity and social conditions. Armed conflict variables include the dependent variables lagged temporally and spatially, as well as the activity of other armed groups in the municipality. These variables affect P_z (if the group is the same P_z falls, and if it is a different group P_z rises). The geographical characteristics include altitude, land aptitude, erosion, the presence of water[48], and the distance to the most important markets and the departmental capital, all of which are linked to the cost of territorial control P_z in equation (15). Infrastructure includes municipal roads and phone lines. The proxy variables for economic activity are dummy variables related to the presence of extractive economies such as oil, coal, emeralds and gold, as well as cattle farming, all of which are variables related to coca workers' incomes W_n and those of combatants W_g. The effort of the State is expressed as judicial efficiency and its effect on P_z, and coca eradication β. Finally, social conditions are summarized as the Unsatisfied Basic Needs Index (NBI) and the Gini coefficient (rural land concentration), both of which affect W_n and W_g.

6.4. Results

This section presents the results on the differences between cultivated hectares of coca in 2000 in municipalities with and without the presence of illegal armed activity, for all Colombian municipalities and then by region. Initially the

[47] Included actions are: extortive terrorist acts, armed confrontation, attacks on installations, planes, urban and rural areas, ambushes, harassment, confrontations, terrestrial piracy and massacres.

[48] All this information is from the Instituto Geográfico Agustín Codazzi. Altitude is measured as metres above sea level, aptitude and erosion are divided by range. Soil aptitude goes from 1 to 8, 1 being the most fertile and 8 the least. Erosion goes from 0 to 5, 0 representing no erosion and 5 severe erosion. A weighed average was then calculated for soil erosion and aptitude (see Sánchez and Nuñez, 1999).

determinants of guerrilla and paramilitary activity were calculated for the whole of the national territory and then by geographical region (Orinoco and Amazon, Andean, Caribbean and Pacific). Propensity scores were estimated using the spatial probit methodology. In general, the models accurately predicted the effect of the independent variables on the probability of an attack by an illegal armed group.

Once all the propensity scores had been calculated, the number of cultivated hectares in municipalities with illegal armed activity were compared with the control group of municipalities without this type of activity, but which have a close probability of having it. Simple average nearest neighbour, kernel and local lineal regression methodologies were used, each of which produced very similar results.

The same procedure was used to determine the effect of illicit crops on armed activity. In order to analyse the efficacy of eradication policies, the same methodology was used to compare municipalities where eradication had taken place with those where it had not (although coca was being grown). A similar level of probability was found.

6.4.1. The Differences Between Cultivated Hectares of Coca as a Consequence of Illegal Armed Activity.

6.4.1.1. Armed Actors

The variables that determine the national and regional activities of the armed groups[49] (see table A2 in the annexes) are divided into five groups: historical persistence and neighbouring activity, justice and drug trafficking, economic and social, geographic, and infrastructure. In general, all the models present a good fit value and the variables have the expected signs. Historical persistence, geography and infrastructure positively affect armed activity, whilst judicial efficiency dissuades armed activities and thus has a negative coefficient.

However, our interest is in determining the effect of armed activity on coca production in Colombia. By using matching estimators, the results shown in table 1 were obtained. In 2000, armed activity by at least one of the armed groups was present in 507 municipalities, and the difference between the average number of hectares in these municipalities and the control group is positive and significant. For example, according to the simple average nearest neighbour methodology, the average difference was 166.5 hectares. If this figure is multiplied by the 507 municipalities mentioned above, the total is 84,430 hectares—which means that about 50% of the total number of cultivated hectares in Colombia in 2000 was due to the presence of illegal armed activity.

When the exercises were carried out at a regional level, the differences rose significantly, due to the fact that the variables that explain illegal armed activity and the coefficients obtained were different for each region. In Orinoco and Amazon, an average of 1,064 hectares were cultivated in the 59 municipalities

[49] In this case a dummy variable of 1 was used if a municipality i presented illegal armed activity (FARC, ELN or illegal Self-defence groups) and of 0 if it did not.

with the presence of one of the armed groups; in the control groups the figure was 203.03 (using the average nearest neighbour estimator and local lineal regression). The number of cultivated hectares that can be attributed to the presence of armed actors is, therefore, 1,400 hectares. If this difference is multiplied by the number of municipalities in which there was illegal armed activity (59), it can be seen that approximately 60% of all cultivated hectares in 2000 in this region was due to the presence of armed activity. The number of cultivated hectares originating from the conflict in Orinoco and Amazon represent 47% of all coca cultivated in Colombia that year.

Table 1. The Difference Between the Number of Cultivated Hectares of Coca in Municipalities with Illegal Armed Activity and the Control Group[50]

Methodology	Difference	Standard Error	Average Treated	Average Controlled	T	NT	N	Difference*No treated
Nation Total								
NN	**166.53**	57.62 ***	231.66	65.13				84431
KERNEL	**129.16**	57.23 **	231.66	102.51	507	555	1062	65483
LLR	**126.58**	65.43	231.66	105.08				64178
Orinoquía and Amazonía								
NN	**1401.37**	530.98 ***	1604.41	203.03				82681
KERNEL	**1166.57**	314.67 ***	1604.41	437.84	59	55	114	68828
LLR	**1401.37**	729.20	1604.41	203.03				82681
Andean								
NN	**25.01**	10.90 **	30.72	5.71				7502
KERNEL	**16.17**	12.35	30.72	14.55	300	315	615	4852
LLR	**12.50**	14.47	30.72	18.22				3749
Caribbean								
NN	**64.06**	29.88 **	64.97	0.91				4484
KERNEL	**38.34**	53.69	64.97	26.63	70	101	171	2684
LLR	**50.43**	61.30	64.97	14.54				3530
Pacific								
NN	**116.16**	46.48 **	116.89	0.72				9177
KERNEL	**95.56**	37.46 **	116.89	21.33	79	84	163	7549
LLR	**109.36**	101.08	116.89	7.53				8639

*** Significantly different from zero at 99% confidence
** Significantly different from zero at 95% confidence
* Significantly different from zero at 90% confidence

The difference in other regions is not as great as in the south of the country, although it is still significant. In the Andean region, the highest difference was 25.01, which represents 7,500 hectares in the 300 municipalities with illegal armed activity (60% of all coca cultivated in the region). Similarly, in the Caribbean region the average difference was 64.06 hectares, which when multiplied by the number of municipalities with illegal armed activity (70) gives a total of 4,500 hectares (65% of all coca grown in the region in 2000). Finally, in the Pacific region the average difference is 116.16, which when multiplied by the number of municipalities with illegal armed activity gives a total of 9,176 hectares (64% of the region's total).

6.4.1.2. FARC

To determine the effect of FARC activities on coca crops, spatial probit models were estimated for municipalities and regions for 2000. The results, presented in table A3, indicate that FARC activity in Colombian municipalities and regions generates dependence and contagious diffusion. Dependence refers to the historical presence of the FARC; contagious diffusion refers to the effect of

[50] Difference refers to the average treatment effect on the treated, the standard error is the error obtained by bootstrapping, the treated average is the average number of hectares in municipalities with illegal armed activity, the control average is the average number of cultivated hectares once the observed variables have been taken into account, *T* is the number of treated municipalities (in this case the number of municipalities with illegal armed activity), *NT* is the number of non treated, and *N* is the total number of municipalities in the sample.

FARC activities in neighbouring areas. Other variables affecting FARC activity are justice, distance to the most important markets (Bogotá. Medellín, Cali and Barranquilla), the presence of mining activities and inequalities in land ownership.

The results of the matching estimators show that the average difference in 2000 between municipalities with (350) and without (712) FARC presence was, in the highest case, 219 hectares, which is highly significant. If this value is multiplied by the number of municipalities with FARC presence, the total is 76,650 hectares, or 47% of the national total.

Table 2. The Difference Between the Number of Cultivated Hectares of Coca in Municipalities with FARC Activity and the Control Group

Methodology	Difference	Standard Error	Average Treated	Average Controlled	T	NT	N	Difference*No treated
Nation Total								
NN	**218.99**	109.75 **	326.01	107.02				76647
KERNEL	**192.79**	94.04 **	326.01	133.23	350	712	1062	67476
LLR	**196.20**	96.57 **	326.01	129.81				68672
Orinoquía and Amazonía								
NN	**1624.88**	618.39 ***	1911.87	286.99				79619
KERNEL	**1285.15**	593.60 **	1911.87	626.73	49	55	104	62972
LLR	**1624.88**	936.53 *	1911.87	286.99				79619
Andean								
NN	**28.46**	18.09	37.69	9.23				5350
KERNEL	**23.78**	19.42	37.69	13.91	188	427	615	4471
LLR	**21.22**	16.18	37.69	16.47				3990
Caribbean								
NN	**72.86**	18.53 ***	74.26	1.40				3133
KERNEL	**50.35**	20.26 **	74.26	23.90	43	128	171	2165
LLR	**63.76**	54.29	74.26	10.49				2742
Pacific								
NN	**121.03**	14.07 ***	152.76	31.73				7262
KERNEL	**104.11**	40.12 ***	152.76	48.65	60	103	163	6246
LLR	**121.00**	81.05	152.76	31.76				7260

*** Significantly different from zero at 99% confidence
** Significantly different from zero at 95% confidence
* Significantly different from zero at 90% confidence

Once again, the regional results are more convincing. In Orinoco and Amazon, the resulting difference using matching estimators was of 1,625 hectares. Taking into account the fact that 49 municipalities experienced illegal FARC activity in 2000, the total value is 79,619 hectares, or 61% of the regional total.

In the Caribbean and Pacific regions, FARC presence accounts for a difference of 72.86 and 121.03 respectively. However, in the Andean region FARC presence in 188 out of a total of 615 municipalities is not significant enough to explain coca production in the region.

6.4.1.3. ELN

Table A4 shows that the probability of ELN activity in Colombian municipalities in 2000 depended principally on spatial dynamics and the persistence and activities of other armed groups in the regions. The effect of the socioeconomic variables is not significant enough to explain the activities of this guerrilla group.

The effect of ELN activity on coca production is not important nor significant, as can be seen in table A4. In fact, in some cases the difference is negative, although not significant. This implies that coca production in Colombia, as a whole, is not connected to ELN activity.

Table 3. The Difference Between the Number of Cultivated Hectares of coca in Municipalities with ELN Activity and the Control Group

Methodology	Difference	Standard Error	Average Treated	Average Controlled	T	NT	N	Difference*No treated
Nation Total								
NN	**37.10**	59.19	49.23	12.13				8867
KERNEL	**-29.50**	33.84	49.23	78.73	239	823	1062	-7050
LLR	**-34.74**	39.74	49.23	83.97				-8302
Andean								
NN	**46.33**	18.62 **	60.56	14.23				6671
KERNEL	**39.53**	19.84 **	60.56	21.03	144	471	615	5692
LLR	**36.13**	29.48	60.56	24.43				5203
Caribbean								
NN	**-38.10**	73.55	76.02	114.12				-1638
KERNEL	**-36.57**	60.49	76.02	112.60	43	128	171	-1573
LLR	**-117.50**	140.49	76.02	193.52				-5052
Pacific								
NN	**28.83**	116.86	99.17	70.34				1182
KERNEL	**-24.44**	202.42	99.17	123.61	41	122	163	-1002
LLR	**19.67**	324.80	99.17	79.50				807

*** Significantly different from zero at 99% confidence
** Significantly different from zero at 95% confidence
* Significantly different from zero at 90% confidence

At regional level, the presence of this group is a determining factor of coca production in the Andean region. The difference between municipalities with and without ELN activity is 46.33. This generates a total of 6,671 hectares in 2000 (57% of the region's total), specifically in Antioquia, Santander and Norte de Santander[51].

6.4.1.4. Illegal Self-Defence Groups

Probability models were designed to determine the effect of a paramilitary presence (at a national and regional level) on coca crops. Orinoco and Amazon were excluded as only 8 of their 114 municipalities have paramilitary presence. The probability of paramilitary presence is positively linked to the presence of

[51] The results for the other regions were unsatisfactory—in Orinoco and Amazon only 12 out of 114 municipalities showed ELN activity.

this group in neighbouring areas, to the previous presence of another armed group in the area, to the presence of coal and oil, to the presence of cattle farming and to drug-trafficking. Judicial efficiency and aerial spraying have a dissuasive effect on this armed group's activities. In the regions, the most important variables are spatial dynamics and the previous presence of one of the other armed groups (see table A5).

At national level, the difference between municipalities with a paramilitary presence and those without was positive but not significant. However, in the Andean, Caribbean and Pacific regions the difference was important and significant. In the Andean region, the average number of cultivated hectares in the 97 municipalities with a paramilitary presence was 136.3 (in the control group the value was between 16.93 and 90.84 depending on the methodology). The average nearest neighbour estimator generates an average difference of 119.4, which corresponds to a total of 11,581 hectares, or 98% of the regional total in 2000 (principally in Santander, Norte de Santander and Antioquia). The difference generated by the LLR estimator falls to almost a third of the previous result, which means that just 30% coca production in the Andean region is due to the presence of paramilitary activity.

In 2000, paramilitary groups were active in 53 municipalities in the Caribbean region, mainly in Cesar (14), Bolívar (12) and Magdalena (12). The average difference was positive and significant in all cases (between 44.61 and 74.84 hectares). Paramilitary activity, therefore, generated close to 45% of the cultivated hectares in the region in 2000.

Table 4. The Difference Between the Number of Cultivated Hectares of Coca in Municipalities with Paramilitary Activity and the Control Group

Methodology	Difference	Standard Error	Average Treated	Average Controlled	T	NT	N	Difference*No treated
Nation Total								
NN	**123.91**	168.24	128.30	4.39				23419
KERNEL	**45.75**	165.45	128.30	82.55	189	873	1062	8646
LLR	**48.66**	99.03	128.30	79.64				9197
Andean								
NN	**119.40**	57.20 **	136.33	16.93				11581
KERNEL	**53.32**	31.40 *	136.33	83.01	97	518	615	5172
LLR	**45.49**	29.35	136.33	90.84				4413
Caribbean								
NN	**74.84**	42.01 *	126.06	51.22				3966
KERNEL	**44.61**	13.54 ***	126.06	81.45	53	118	171	2364
LLR	**51.07**	26.34 *	126.06	74.99				2706
Pacific								
NN	**126.31**	58.49 **	143.15	16.84				3284
KERNEL	**-106.59**	126.67	143.15	249.74	26	137	163	-2771
LLR	**-132.24**	243.38	143.15	275.39				-3438

*** Significantly different from zero at 99% confidence
** Significantly different from zero at 95% confidence
* Significantly different from zero at 90% confidence

In the Pacific region in 2000, paramilitary forces carried out attacks in 26 municipalities, mainly in Cauca (11 municipalities) and Valle del Cauca (11). Average coca production in these municipalities was 143.15 hectares, which compared to the control group, and using the average nearest neighbour methodology, was equal to 126.31. If we multiply this value by the number of municipalities in which there was paramilitary presence, we can see that this group accounts for 26% of production. Using Kernel and LLR estimators gives negative but not significant results.

6.4.2. Differences in Armed Activity as a Consequence of Illicit Crop Production.

This section presents the results of econometric exercises designed to find the effect of illicit crops on the activities of the armed groups. The treatment variable is the presence of illicit crops in a municipality. In 2000, the probability of a coca presence was determined by the socioeconomic characteristics of the region: poverty, inequality in land distribution, educational coverage, and by geographical variables: surface area, distance to the departmental capital, altitude, precipitation, erosion, soil and rivers (see table A6). Probit models were used to estimate national and regional coca presence. The outcome variable is the presence of illegal armed activity (a value of 1 is assigned if a municipality has experienced at least one attack or action by an illegal armed group, and of 0 if not). The same analysis was made for each one of the illegal armed groups (FARC, ELN and illegal Self-Defence groups) and by region.

6.4.2.1. FARC

In 2000, coca was being grown in 175 Colombian municipalities. By using matching estimators, we were able to ascertain that there is a positive and significant difference between municipalities with FARC presence and the control group[52]. The results show that approximately 47% of municipalities in which coca is grown also have FARC presence (in the control group armed activity is 28%) (table 6). This 20% difference can be explained by the presence of coca. In the Orinoco and Amazon region the difference is even larger at 40%. The difference is not significant in the other regions.

[52] This variable is the presence of illegal armed activity, and is given a value of 1 if there is activity and 0 if there is not.

Table 6. The Differences Between FARC Presence in Municipalities with Coca Crops and the Control Group

Methodology	Difference	Standard Error			Average Treated	Average Controlled	T	NT	N
	(1)	ES	T	P-value	(3)	(4)	(5)	(6)	(7)
Nation Total									
NN	**0.19**	0.05	3.508	0.000 ***	0.47	0.28			
KERNEL	**0.18**	0.05	4.070	0.000 ***	0.47	0.28	175	887	1062
LLR	**0.20**	0.04	5.262	0.000 ***	0.47	0.27			
Orinoquía and Amazonía									
NN	**0.40**	0.14	2.868	0.004 ***	0.70	0.30			
KERNEL	**0.37**	0.15	2.407	0.016 **	0.70	0.33	73	542	615
LLR	**0.06**	0.30	0.187	0.852	0.70	0.65			
Andean									
NN	**-0.16**	0.11	-1.533	0.126	0.33	0.49			
KERNEL	**-0.16**	0.10	-1.564	0.118	0.33	0.49	25	146	171
LLR	**-0.09**	0.07	-1.282	0.200	0.33	0.41			
Caribbean									
NN	**0.28**	0.27	1.046	0.296	0.44	0.16			
KERNEL	**0.26**	0.20	1.274	0.203	0.44	0.19	24	139	163
LLR	**0.31**	0.25	1.228	0.220	0.44	0.13			
Pacific									
NN	**0.26**	0.15	1.681	0.093 *	0.38	0.12			
KERNEL	**0.22**	0.14	1.535	0.125	0.38	0.15	54	60	114
LLR	**0.23**	0.18	1.251	0.211	0.38	0.15			

*** Significantly different from zero at 99% confidence
** Significantly different from zero at 95% confidence
* Significantly different from zero at 90% confidence

In addition, exercises were carried out to determine the effect of illegal crops on the number of FARC attacks. The results for 2000 can be observed in table A6. Municipalities with coca crops experienced an average of 4.2 attacks per year, whilst the value for the control group was 1.3. This difference can be explained by the presence of coca[53]. The difference is also significant in the case of per capita attacks. In Orinoco and Amazon the average number of FARC attacks per year in municipalities with coca crops is 6.9, whilst in the control group it is 1.5. This difference can be explained by the presence of coca, and is significant. The differences persist in the other regions, and are significant in the majority of cases, although lower than in Orinoco and Amazon.

6.4.2.2. ELN

ELN activity in municipalities with coca crops is 22% higher than in municipalities with no coca. In the control group ELN activity is 14%, and in the municipalities with coca it is 36%.

[53] The effect of coca on FARC activity is as follows: In 2000 there were around 1,940 FARC attacks, and coca explains 504 of them (2.87 attacks*175 municipalities with coca). Thus, coca was responsible for close to 26% of FARC activity that year.

Table 7. The Differences Between the ELN Presence in Municipalities with Coca Crops and the Control Group.

Methodology	Difference	Standard Error			Average Treated	Average Controlled	T	NT	N
	(1)	ES	T	P-value	(3)	(4)	(5)	(6)	(7)
Total National									
NN	**0.22**	0.04	5.331	0.000 ***	0.36	0.14			
KERNEL	**0.23**	0.04	5.778	0.000 ***	0.36	0.13	175	887	1062
LLR	**0.22**	0.05	4.898	0.000 ***	0.36	0.14			
Orinoquía and Amazonía									
NN	**0.09**	0.07	1.300	0.194	0.11	0.02			
KERNEL	**0.09**	0.04	2.072	0.038 **	0.11	0.02	73	542	615
LLR	**0.06**	0.06	0.924	0.356	0.11	0.06			
Andean									
NN	**0.36**	0.08	4.658	0.000 ***	0.52	0.16			
KERNEL	**0.35**	0.07	5.012	0.000 ***	0.52	0.17	25	146	171
LLR	**0.36**	0.07	4.955	0.000 ***	0.52	0.16			
Caribbean									
NN	**0.41**	0.14	2.886	0.004 ***	0.56	0.15			
KERNEL	**0.44**	0.19	2.338	0.020 **	0.56	0.12	24	139	163
LLR	**0.37**	0.17	2.189	0.029 **	0.56	0.19			
Pacific									
NN	**0.13**	0.29	0.424	0.671	0.25	0.13			
KERNEL	**0.11**	0.12	0.901	0.368	0.25	0.14	60	54	114
LLR	**0.10**	0.19	0.540	0.589	0.25	0.15			

*** Significantly different from zero at 99% confidence
** Significantly different from zero at 95% confidence
* Significantly different from zero at 90% confidence

The presence of coca has a significant effect on ELN activities in the Andean region. 36% of municipalities with coca also experienced ELN activity, versus 16% in the control group. The same is true in the Caribbean region, where 56% of municipalities with coca crops also have ELN activity, against 16% in the control group. In the Pacific region the difference is not significant.

Regarding attacks (table A7), municipalities with coca crops experienced an average of 2.4 ELN attacks per year, against 0.60 in the control group. This difference is statistically significant and is confirmed under all of the pairing methods. In the Andean region, municipalities with coca crops experienced 3.1 attacks, against 0.8 in the control group. In the Orinoco and Amazon, Caribbean and Pacific regions, the differences are not significant.

6.4.2.3. Illegal Self-Defence Groups

In the case of the paramilitary, the percentage of municipalities with this group's presence in municipalities with coca crops is 39%, versus 10% in the control group. This difference is significant. The same is true in Orinoco and Amazon, where 19% of municipalities with coca production also have paramilitary presence, against 0% in the control group. In the Andean region the difference is 36% and is positive and significant. Finally, although a positive difference is also evident in the Pacific and Caribbean regions, it is not significant.

Table 8. The Differences Between Paramilitary Presence in Municipalities with Coca Crops and the Control Group.

Methodology	Difference	Standard Error			Average Treated	Average Controlled	T	NT	N
	(1)	ES	T	P-value	(3)	(4)	(5)	(6)	(7)
Total National									
NN	**0.31**	0.09	3.372	0.001 ***	0.39	0.08			
KERNEL	**0.29**	0.10	2.933	0.003 ***	0.39	0.10	175	887	1062
LLR	**0.29**	0.09	3.421	0.001 ***	0.39	0.10			
Orinoquía and Amazonía									
NN	**0.19**	0.11	1.680	0.093 *	0.19	0.00			
KERNEL	**0.16**	0.09	1.817	0.070 *	0.19	0.03	73	542	615
LLR	**0.19**	0.19	0.990	0.322	0.19	0.00			
Andean									
NN	**0.36**	0.14	2.619	0.009 ***	0.45	0.09			
KERNEL	**0.28**	0.16	1.731	0.084 *	0.45	0.17	25	146	171
LLR	**0.33**	0.15	2.170	0.030 **	0.45	0.13			
Caribbean									
NN	**0.40**	0.26	1.548	0.122	0.64	0.24			
KERNEL	**0.41**	0.29	1.391	0.164	0.64	0.23	24	139	163
LLR	**0.49**	0.54	0.898	0.369	0.64	0.15			
Pacific									
NN	**0.38**	0.22	1.709	0.088 *	0.38	0.00			
KERNEL	**0.31**	0.26	1.216	0.224	0.38	0.06	54	60	114
LLR	**0.38**	0.27	1.377	0.169	0.38	0.00			

*** Significantly different from zero at 99% confidence
** Significantly different from zero at 95% confidence
* Significantly different from zero at 90% confidence

In terms of the number of attacks (table A8), the average over the whole country is 0.19 in municipalities with coca crops and 0.1 in the control group. This difference Is significant. In the Andean region there is a significant difference between the treated group (0.19 attacks on average) and the control group (0.13 attacks on average). In the Pacific region the difference is also significant at 0.14 (0.20 in municipalities with coca and 0.06 in the control group). The differences in the Caribbean and Orinoco regions are not significant.

6.4.3. Eradication.

Matching estimators were used to analyse the effect of anti-drug policies in Colombia—specifically related to eradication via aerial spraying—and to answer the following question: How many hectares would have been cultivated in a municipality where aerial spraying has been used if the municipality had not experienced eradication? The answer indicates the effect of eradication on the number of cultivated hectares of coca in Colombia. The theoretic model presented in section 4 shows that eradication reduces the conflict, although its effects on production are undetermined. The aim of fumigation is to dissuade peasant farmers from cultivating coca by increasing the cost of installing and maintaining crops. However, if fumigation is foreseen, the farmers can over sow or move their crops to other parts of the same municipality, and production may increase in spite of fumigation.

To determine the effects of fumigation, probability models were estimated for the presence or not of municipal fumigation for all municipalities with coca production during the 1999-2001 period. The exercise was also carried out by region[54]. The explicative variables are eradication in neighbouring areas (spatial dynamics), armed activity, justice, drug-trafficking, and economic, social, geographical and infrastructure variables (see table A10). These models generated the propensity scores needed to carry out the pairing.

Between 1999 and 2001, a total of 188,000 hectares in 120 of the 412 municipalities with illegal production were fumigated, primordially in Caquetá (31), Putumayo (19), Guaviare (12), Meta (12) and Nariño (11). The results show a positive difference. By multiplying the difference by the total number of municipalities where spraying was carried out, and subtracting the number of hectares eradicated, a positive result of around 24,000 hectares is generated. Therefore, it may be concluded that eradication policies were not successful in the 1999-2001 period.

However, looking at the results by region it can be observed that this lack of success was due to Orinoco and Amazon, which was the region with the highest level of coca production. In fact, the results show that fumigation in this region lead to an increase of more than 60,000 hectares. Conversely, in the Andean and Pacific regions, although the differences are positive, the net effect on cultivated hectares is negative, and thus eradication by fumigation was successful in these regions.

Table 9. The Difference Between the Number of Cultivated Hectares of Coca in Municipalities with Eradication by Spraying and the Control Group.

Methodology	Difference	Standard Error	Average Treated	Average Controlled	T	NT	N	Difference * Treated (1)	Eradicated Hectares (2)	Net Effect (1-2)
Total National										
NN	**1774.46**	275.80 ***	2428.36	653.90				212935	188153	24782
KERNEL	**1771.92**	303.71 ***	2428.36	656.44	120	292	412	212631	188153	24477
LLR	**1528.78**	429.66 ***	2428.36	899.58				183453	188153	-4700
Orinoquía and Amazonía										
NN	**2687.75**	352.01 ***	3467.50	779.75				198894	130774	68120
KERNEL	**2644.74**	505.82 ***	3467.50	822.76	74	65	139	195711	130774	64937
LLR	**2519.41**	1094.02 **	3467.50	948.09				186436	130774	55662
Andean										
NN	**357.10**	144.01 **	535.72	178.62				7856	25137	-17281
KERNEL	**317.32**	177.12 *	535.72	218.40	22	125	147	6981	25137	-18156
LLR	**389.68**	270.94	535.72	146.04				8573	25137	-16564
Pacific										
NN	**692.34**	145.27 ***	1038.58	346.24				11770	20336	-8566
KERNEL	**730.15**	194.65 ***	1038.58	308.43	17	51	68	12413	20336	-7924
LLR	**558.53**	426.14	1038.58	480.05				9495	20336	-10841

*** Significantly different from zero at 99% confidence
** Significantly different from zero at 95% confidence
* Significantly different from zero at 90% confidence

[54] It is important to note that the sample was restricted to municipalities that had coca crops in 1999.

7. Conclusions

Over the last two decades, Colombia has experienced sustained growth in coca production. From the mid-1980s, this tendency sharpened following a re-composition of cultivated hectares in the Andean region. Colombia thus became the region's largest producer of coca leaf, ahead of the two biggest coca producers in the world (Peru and Bolivia). Colombia's rising participation in the world drug market was accompanied by the strengthening of drug-trafficking and the consolidation of the industry—initially by the Medellin, Cali and Costa cartels. However, the cartels were weakened during the 1990s and control of illicit drug production passed onto the hands of illegal armed groups; this became one of their main sources of financing and allowed them to scale up their armed activities and increase their troop numbers towards the end of the decade.

The analysis of spatial patterns such as the diffusion of coca production amongst Colombian municipalities and illegal armed activity shows the existence of a strong spatial relationship between coca production, illegal armed activity and illegal productive activity, both at local level and in groups of neighbouring municipalities, that is preceded by the activities of the illegal armed groups. In addition, to ascertain the relationship of cause and effect between coca crops and the Colombian armed conflict, a non-parametric methodology known as matching estimators was used. This allowed us to establish the effect of illegal armed activity on coca production, and vice versa, by comparing municipalities with the same characteristics. The results show that the presence of illicit crops is closely linked to the presence of armed activity, as much in the case of the guerrillas as in that of the paramilitary. This definitively shows that one of driving factors behind the expansion of the coca economy is the Colombian armed conflict. Around 70% of coca crops in 2000 were the result of the armed conflict. This shows that coca, rather than being the illegal armed groups' "gasoline", is in fact the result of financial needs that increase *pari passu* with the spatial scaling up and expansion of the conflict. These results are true both at a national and regional level.

However, the conclusions are different depending on the armed group. FARC activity is closely linked to the greater part of national and regional coca production, especially in the east of the country. However, although the effect of ELN and paramilitary activity on coca production is positive, it is not significant throughout Colombia. A regional analysis shows that the activity of these groups does lead to higher production of illicit crops. In the case of the ELN, the positive effect is in the Andean region. Paramilitary presence increases production in the Andean, Caribbean and Pacific regions. These are areas in which the illegal armed groups' activities and territorial control have expanded, and are also strategic points in the armed conflict.

When determining if there was double causality between coca production and armed guerrilla activity, we found that coca explains part of the armed groups' activities. Municipalities with coca crops have the highest presence of illegal armed groups and the highest number of attacks. However, coca explains between 20% and 25% of FARC activity, and even less for the other groups,

although there are regional differences. This implies that illicit crops only make up part of the “gasoline” of the conflict.

These results confirm the hypotheses related to the economic theory of conflict (Collier 2001), which sustains that it is of no importance whether rebels are motivated by greed, a desire for power or discontent; what is important, however, is that rebellion be financially viable via illegal activities or depredation. Coca expansion in Colombia is the result of the conflict, in as much as it has made it financially viable. However, in contrast to natural resources or raw materials, where supply is fixed, coca supply depends on the strategic and territorial objectives of the armed groups, the scaling up of the conflict and State policies related to controlling production. In addition, the investigation showed that the strategy of financing the conflict with the proceeds of drug production can be explained by the armed groups’ territorial and strategic objectives. This implies that the economic theory of conflict should be complemented by studies that analyse the dynamics of internal conflicts or civil wars, at a national or regional level, to better understand the financial strategies, economic motivations and objectives of irregular forces.

The war on illicit crops has used a three pronged approach: manual eradication, crop substitution and eradication via chemical spraying (the most used method being aerial spraying, which has intensified in the south of the country since the mid-1990s). To analyse the efficiency of this policy, the same methodology was used as that used to study the effect of armed actors on coca production. We found that rather than reducing coca cultivation, the fumigation policies that were carried out between 1999 and 2001 caused it to rise, especially in the Orinoco and Amazon region. The opposite was true in the Pacific and Andean regions.

8. Bibliography

Betancourt, Darío and García, Martha L (1994). *Contrabandistas, marimberos y mafiosos: historia social de la mafia colombiana (1965 – 1992).* Bogotá, Tercer Mundo.

Bannon, Ian and Paul, Collier (2003) "Natural Resources and Conflict: What We Can do" In Bannon, Ian and Paul, Collier (Editores) *Natural Resources and Violent Conflict*, The World Bank, Washington, D.C.

Bottía, Martha (2003). *La presencia y expansión municipal de las FARC: Es avaricia y contagio, más que ausencia estatal*. Bogotá, Documento CEDE 2003-03.

Cohen, Jacqueline and Tita, George (1999). "Difussion in Homicide Exploring a General Method for Detecting Spatial Diffusion Processes". *Journal of Quantitative Criminology,* Vol 15, No.4, pp 451-494.

Collier, Paul (2000) "Economic Causes of Civil Conflicts and their Implications for Policy", World Bank, Working Paper, June.

_____, Paul and Hoeffler, Anne (1998). "On Economic Causes of Civil War", Oxford Economic Papers 50, pp 563-573.

_____, Paul and Hoeffler, Anne (2001). "Greed and Grievance in Civil War", Working Paper, World Bank, CSAE WPS/2002-01.

De Rementería, Ibán (2001). *La guerra de las drogas: Cultivos ilícitos y desarrollo alternativo*. Bogotá, Editorial Planeta Colombiana SA.

Dirección Nacional de Estupefacientes (2001). La Lucha de Colombia contra las Drogas Ilícitas: Acciones y Resultados 2001.Bogotá, Ministerio de Justicia y Derecho.

Echandía, Camilo (1999). *El conflicto Armado y las Manifestaciones de Violencia en las Regiones de Colombia.* Bogotá, Presidencia de la República de Colombia Oficina del Alto Comisionado para la Paz Observatorio de Violencia.

Gaviria, Alejandro (2001). "Rendimientos Crecientes y la Evolución del Crimen Violento: el Caso Colombiano" en *Economía, Crimen y Conflicto*, Bogotá, Universidad Nacional de Colombia.

Gonzáles, José E (1989). *Perú: Sendero Luminoso en el Valle de la Coca* en Coca, Cocaína y Narcotráfico. Laberinto en los Andes.

González, Fernán, Ingrid Bolívar y Teófilo Vázquez (2002). *Violencia Política en Colombia*. *De la nación fragmentada a la construcción del Estado*. Bogotá, CINEP

Grossman, Herschel (1991). "A General Equilibrium Model of Insurrections". *The American Economic Review*, 81(4), pp 912-921.

_____, Herschel (1994). "Kleptocracy and Revolutions", Oxford Economic Paper, 51, pp 267-283.

Gutiérrez, Francisco (2003) "Criminal Rebels? A Discussion on War and Criminality from the Colombian Experience "Crisis State Program Working Paper, No. 17, London School of Economics.

Heckman, James (1977). "Sample Selection Bias as a Specification Error (With an application to the Estimation of Labor Supply Functions)"

_____, James, Hidehiko Ichmura, Jeffrey Smith and Petra Todd (1998). "Characterizing Selection Bias Using Experimental Data", Econometrica, 66(5), 1017-1098.

Hirshleifer, Jack (1990). "The Technology of Conflict as an Economic Activity" UCLA, Working Paper 491.

La Rotta, Jesús E (1996). Las finanzas de la Subversión Colombiana: una forma de explotar la nación. Bogotá, Alianza Editorial Colombiana.

McClintock, Cynthya (1998), "The war on Drugs: the Peruvian Case" in *Journal of Interamerican Studies and World Affairs.* No 30.

Ministerio de Defensa Nacional (2000), "Los Grupos Ilegales de Autodefensa en Colombia". Documento de Estudio. www.mindefensa.gov.co

Molano, Alfredo (1999). *Selva adentro: Una historia oral de la colonización del Guaviare*. Bogotá, El Ancora Editores.

Mora, Leonidas, Jaime Jaramillo and Fernando Cubides (1986). Colonización Coca y Guerilla, Bogotá, Alianza Editores Colombiana.

Moreno, Rosina and Vayá, Esther (2000). *Técnicas econométricas para el tratamiento de datos espaciales: La econometría espacial*. Barcelona, Edicions de la Universitat de Barcelona.

Obando, Enrique (1993). "El narcotráfico en el Perú: una aproximación histórica" en *Análisis Internacional,* No. 2, abril-junio.

Ramírez, María Constanza (1993). “El Cultivo de Amapola en Colombia” en *Consulta Técnica Internacional sobre el Cultivo Ilícito de Amapola en Latinoamérica.* Bogotá, Ministerio de Justicia, UNDCP.

Ramírez, María Clemencia (2001). *Entre el Estado y la guerrilla: Identidad y ciudadanía en el movimiento de los camerinos cocaleros del Putumayo.* Bogotá, Instituto Colombiano de Antropología e Historia.

Rangel, Alfredo (2000). *Colombia: Guerra en el fin de siglo.* Bogotá, Editorial Tercer Mundo SA.

_____, Alfredo (2001). *Guerra Insurgente: conflicto es Malasia, Perú, Filipina, El Salvador y Colombia*. Bogota. Editorial Intermedio

Restrepo, Jorge Alberto (2001). “Análisis económico de conflictos internos” . Documento preparado para la fundación ideas para la paz.

Reyes, Alejandro (1997). “Compra de tierras por narcotraficantes” en *Drogas ilícitas en Colombia: Su impacto económico, político y social*, Bogotá, Planeta Colombia Editorial.

Rocha, Ricardo (1997). “Aspectos económicos de las drogas ilegales” en *Drogas ilícitas en Colombia: Su impacto económico, político y social*, Bogotá, Planeta Colombia Editorial.

Rocha, Ricardo (2000). “*La economía colombiana tras 25 años de narcotráfico*”, Bogotá, Siglo del Hombre Editores.

Rocha, Ricardo and Alejandro Vivas 1998, “Crecimiento regional en Colombia: ¿Persiste la desigualdad?”, in Revista de economía del Rosario, vol. 1, núm.1, enero de 1998, pp. 67-108.

Rojas, Fernando (2002). “La Economía de la Coca”, Instituto de Investigación Socio-Económicas, Universidad Católica Boliviana, La Paz, Bolivia

Ruiz, Hernando (1979). “Implicaciones sociales y económicas de la producción de marihuana”, en *Marihuana: legalización o represión*, Bogotá, ANIF.

Sánchez, Fabio, Díaz, Ana María and Formisano, Michel (2003). Conflicto, violencia y actividad criminal en Colombia: un análisis espacial. Bogotá, Documentos CEDE 2003-05.

Sánchez, Fabio and Nuñez, Jairo (2000). “Determinantes del Crimen Violento en un país altamente violento: el caso de Colombia” in *Economía, Crimen y Conflicto,* Bogotá, Universidad Nacional de Colombia.

Salazar, Boris and Castillo, María del Pilar (2001). *La Hora de los Dinosaurios: conflicto y depredación en Colombia*. Bogotá, Fondo Editorial CEREC.

Steiner, Roberto (1997), *Los Dólares del Narcotráfico*. Cuadernos de Fedesarrollo, No. 2. Editorial Tercer Mundo.

Thoumi, Francisco E. (1994). *Economía política y narcotráfico.* Bogotá: Tercer Mundo

_____, Francisco E. (2002). *El Imperio de la Droga: Narcotráfico, economía y sociedad en Los Andes*. Bogotá, Editorial Planeta Colombiana SA.

Tovar, Hermes (1999). Colombia: droga, economía, guerra y paz. Bogotá, Planeta Colombiana Editorial.

Todd, Petra (1999). A Practical Guide to Implementing Matching Estimators. Mimeo

Trujillo, Edgar and Martha Badel (1998). Los costos económicos de la criminalidad y la violencia en Colombia: 1991-1996. Archivos Macroeconomía, DNP, marzo de 1998.

Uprimmy, Rodrigo (1995). "Narcotráfico, régimen político, violencia y derechos humanos en Colombia" in Ricardo Vargas (comp.), Drogas, poder y región, Bogotá, CINEP.

Uribe, Sergio (1997). "Los cultivos ilícitos en Colombia" in *Drogas ilícitas en Colombia: Su impacto económico, político y social*, Bogotá, Planeta Colombia Editorial.

Vargas, Ricardo a (1994), "La bonanza de la marimba empezó aquí" in *La Verdad del '93: paz, derechos humanos y violencia,* Bogotá: CINEP.

_____, Ricardo (1999a). *Drogas, mascaras y juegos.* Bogotá, Editorial Tercer Mundo SA.

_____, Ricardo (1999b). *Fumigación y conflicto: Políticas antidrogas y deslegitimación del Estado en Colombia*. Bogotá, Editorial Tercer Mundo SA

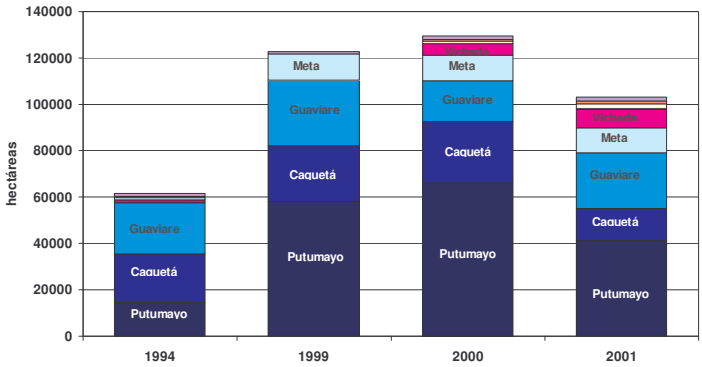
_____, Ricardo (2003). *Drogas, Conflicto Armado y Desarrollo Alternativo*. Bogotá, Gente Nueva Editorial.

Vicepresidencia de la República de Colombia (2002). Colombia, Conflicto Armado, Regiones, Derechos Humanos, DIH 1998-2002, Bogotá.

9. Annexes

9.1. Graphs

Graph A1. The distribution of coca production in the Orinoco and Amazon regions.



9.2. Tables

Table A1. Aerial spraying of coca by department, 1994-2001(hectares).

Departament	1994	1995	1996	1997	1998	1999	2000	2001
Antioquia			684				4434	183
Bolivar								11398
Boyaca							221	
Caqueta			537	4370	18433	15656	9508	15647
Cauca						2713	3378	1917
Cordoba			349				1826	
Cundinamarca							44	
Guaviare	3142	21394	14425	30192	37081	17376	8450	7236
Meta	729	2471	2524	6725	5920	2296	1136	4115
Nariño							6349	8366
Norte de Santander							9799	10308
Putumayo				574	3949	4980	12645	32784
Santander							283	
Vaupes					349			
Vichada		50			297	91		2199
Total	**3871**	**23915**	**18519**	**41861**	**66029**	**43111**	**58074**	**94153**

Source: Environmental Audit: Illicit Crop Programme

Table A2. Determinants of illegal activities 2000.

Dependent Variable	**Armed Groups 2000**				
Region	**Nation Total**	**Orinoquía y Amazonía**	**Andean**	**Caribbean**	**Pacífica**
Variables	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Constant	-3.411 ***	-0.203	-3.915 ***	-5.358 ***	-5.352 ***
Armed Groups					
Illegal Armed Group Activity 1999	0.826 ***	0.841 ***	0.824 ***	1.036 ***	1.008 ***
Illegal Armed Group Activity 1998	0.364 ***		0.290 **	0.494 *	0.809 ***
Illegal Armed Group Activity 1997	0.432 ***		0.437 ***	0.812 ***	0.111
Justice and Drug Trafficking					
Justice Efficiency 1999	-0.805 ***		-0.588 *	4.509 **	-0.894
Social and Economic					
Gold Production	0.357 ***		0.370 **	-0.461	1.026 ***
Cattle Activity	0.018		0.128	-0.249	0.666 **
Index of Basic Unsatisfied Needs 2000	0.002		0.012 ***	0.013	-0.011 *
Gini of Private Property 1999		-2.730 ***			
Educational Coverage		-3.064 ***			
Geographical Variables					
Altitude	0.180 ***		0.179 ***	0.149	0.240 ***
Distance to the four Principal Markets	0.001 ***	-0.002	0.001	0.001	0.004 ***
Infrastructure Variables					
Roads	0.081 ***		0.132 ***	0.101	0.131
Phones Lines	0.039 **	0.087 *	0.006	0.038	0.057
Estimation Method:	**PROBIT**	**PROBIT**	**PROBIT**	**PROBIT**	**PROBIT**
No Observations	1062	114	615	171	163
Pseudo R2	0.241	0.296	0.2376	0.3258	0.3897
loglikelihood	-557.25652	-55.57793	-324.85	-78.001	-68.9101

Table A3. Determinants of FARC Activity in 2000

Dependent Variable= FARC 2000					
Region	**Nation Total**	**Orinoquía and Amazonía**	**Andean**	**Caribbean**	**Pacífic**
Variables	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Constant	-2.434 ***	-2.408 **	-2.344 **	-2.960 ***	7.227
Spatial Dynamic					
FARC's neighbor activity in 2000	0.059 ***	2.322 ***	0.877 ***	1.611 ***	0.874 *
Armed Groups					
FARC's activity 1999	0.822 ***	1.212 ***	0.655 ***	0.215	0.965 ***
FARC's activity 1998	0.429 ***	0.418	0.350 **	1.046 ***	0.468
FARC's activity 1997	0.524 ***		0.577 ***		
Interaction between FARC and Self-Defense Groups 1999		0.324			
ELN's activity 1999 (Dummy)				0.364	0.170
Self Defense Groups activity 1999 (Dummy)				0.703 ***	0.350
Justice and Drug Trafficking					
Justice Efficiency 1999	-0.710 **				
Justice Efficiency against Drug Trafficking 2000		-2.370			
Aerial Eradication 1999	0.000	0.946 **			
Social and Economic					
Coal Production	0.352 **		0.330 *		
Oil Production	-0.176				
Participation in the nation current income (per cápita)					-1.038 **
Index of Basic Unsatisfied Needs 2000	0.002				
Gini of Private Property 2000	1.301 **	1.835 *	1.786 **		3.368 **
Gini of Private Property 2001 (neighbors)	-2.233 ***		-2.348 **		
Educational Coverage	-0.507		-1.905 ***		
Geographical Variables					
Altitude	0.108 ***		0.090	-0.036	
Distance to the Capital	-0.001	-0.002			
Distance to the four Principal Markets	0.001 **	0.000			0.002 *
Infrastructure Variables					
Roads	0.124 ***		0.160 ***	0.112	
Phones Lines					
Estimation Method:	**PROBIT**	**PROBIT**	**PROBIT**	**PTOBIT**	**PROBIT**
No Observations	1062	104	615	171	163
Pseudo R2	0.247	0.4248	0.2193	0.3799	0.3676
loglikelihood	-506.9	-41.3674	-295.5755	-59.79868	-67.8223

Table A4. Determinants of ELN activity 2000

Dependent Variable= FARC 2000	**ELN 2000**	**ELN 2000**	**ELN 2000**	**ELN 2000**
Region	**Nation Total**	**Andean**	**Caribbean**	**Pacífic**
Variables	Coefficient	Coefficient	Coefficient	Coefficient
Constant	-4.740 ***	-4.021 ***	-6.704 ***	-5.835 ***
Spatial Dynamic				
ELN's neighbor activity in 2000	1.772 ***	2.516 ***	0.615	0.942
Armed Actors				
ELN's activity 1999 (dummy)	0.591 ***	0.524 **	0.885 **	0.842 *
ELN's activity 1998 (dummy)	0.321 **	0.410 **	1.131 ***	0.799 **
ELN's activity 1997 (dummy)	0.668 ***			
FARC's activity 1999 (dummy)	0.267 **	0.312 **		
FARC's activity 1998 (dummy)	-0.080			
Self Defense Groups activity 1999 (Dummy)	0.583 ***	0.574 ***	0.719 **	0.926 ***
Justice and Drug Trafficking				
Justice Efficiency 1999	0.016			
Justice Efficiency against Drug Trafficking 1999			3.292	
Drug Trafficking Income			-0.526	
Social and Economic				
Coal Production	0.104			1.777
Oil Production	-0.146			
Gold Production	0.150			
Cattle Activity				0.491
Index of Basic Unsatisfied Needs 2000	0.002			0.025 ***
Gini of Private Property 2000	0.862	1.085		
Geographical Variables				
Altitude	0.143 ***	0.174 **	0.348 ***	0.000 ***
Distance to the Capital	0.000		0.002 *	
Distance to the four Principal Markets	0.001		0.006 **	
Infrastructure Variables				
Roads	0.107 ***	0.003 **		0.190 *
Estimation Method:	**PROBIT**	**PROBIT**	**PROBIT**	**PROBIT**
No Observations	1062	615	171	163
Pseudo R2	0.3934	0.4019	0.377	0.3811
loglikelihood	-343.5108	-200.201	-60.079	-56.8944

Table A5. Determinants of paramilitary activity 2000

Dependent Variable	**Autodefensas 2000**	**Autodefensas 2000**	**Autodefensas 2000**	**Autodefensas 2000**
Region	**Nation Total**	**Andean**	**Caribbean**	**Pacífic**
Variables	Coefficient	Coefficient	Coefficient	Coefficient
Constant	-1.891 **	-2.817 ***	-2.806 **	-1.276 **
Spatial Dynamic				
Illegal Self Defense Groups 2000 (neighbors)	0.799 **	0.947 *		
Armed Groups				
Illegal Self Defense Group's activity 1999 (dummy)	-0.018	0.445 **	0.176 **	0.374 **
Illegal Self Defense Group's activity 1998 (dummy)	0.443 ***	0.448 **		
Illegal Self Defense Group's activity 1997 (dummy)	0.273 **			
Self Defense Group - FARC interaction 1999	0.357 *			
Self Defense Group - ELN interaction 2000	0.554 ***			
FARC's activity 1999 (dummy)		0.124 **	0.449 **	0.169 **
Actividad del ELN 1999 (Dummie)				1.083 **
Justice and Drug Trafficking				
Justice Efficiency 1999	-0.897 *	-1.700 **		7.230 **
Social and Economic				
Index of Basic Unsatisfied Needs 2000	-0.016 ***	-0.013 **	-0.028 **	
Gini of Private Property 1999			-3.346 **	
Geographical Variables				
Altitude	-0.090 *			
Distance to the Capital	-0.001			-0.004 **
Distance to the four Principal Markets	0.001			-0.006 **
Infrastructure Variables				
Roads	0.110 **	0.153 **	0.386 **	
Phones Lines	0.069 ***	0.053 *	0.107 **	0.156 **
Estimation Method:	**PROBIT**	**PROBIT**	**PROBIT**	**PROBIT**
No Observations	1062	615	171	163
Pseudo R2	0.2815	0.2159	0.4457	0.4211
loglikelihood	-269.1407	-155.89	-42.2587	-37.3428

Table A6. Determinants of the Ilicit Crops 2000

	Total National	**Orinoquía y Amazon**	**Andiean**	**Caribean**	**Pacific**
Constant	-2.024***	-5.419	-4.875***	7.029**	-5.582*
Social and Economics					
Index of Basic Unsatisfied Needs 2000	0.141***	0.039***	0.130**	-0.006	0.146
Gini of private property 2000	-2.203***	-1.970**	-1.505**	-2.352	-2.278
Education	-1.083**	-0.415	-2.040**	2.237	-1.396
Geographical Variables					
Altitude	-0.0003***	-0.002**	-0.006	-0.001*	0.009
Distance to the capital	0.001***	-0.008	-0.001	0.002*	0.005***
Distance to the tour Principal Markerts	-0.0001	-0.002	0.003*	-0.011*	0.004*
Precipitation	-0.0003	-0.001**	0.007	0.003	-0.005**
Water disponibility index	0.0005***	0.001**	0.008***	-0.007*	0.009
Erosion	0.2443***	0.153***	0.373***	0.191	-0.012
Soil aptitude Index	-0.0791	-0.029	-0.102	-0.339*	0.135
Infraestructure variables					
Roads	-0.002	-0.002	0.004	-0.005*	-5.582*
Estimation Method:	**PROBIT**	**PROBIT**	**PROBIT**	**PROBIT**	**PROBIT**
No de Observations	1062	114	615	171	163
Pseudo R2	0.243	0.4694	0.3041	0.4215	0.5242
loglikelihood	-359.7555	-41.84	-155.92	-41.1572	-32.41

Table A7. Differences in FARC activity (number of attacks) as the result of illicit drug production in 2000

	Total National	Orinoquía y Amazon	Andiean	Caribean	Pacific
Constant	-2.024***	-5.419	-4.875***	7.029**	-5.582*
Social and Economics					
Index of Basic Unsatisfied Needs 2000	0.141***	0.039***	0.130**	-0.006	0.146
Gini of private property 2000	-2.203***	-1.970**	-1.505**	-2.352	-2.278
Education	-1.083**	-0.415	-2.040**	2.237	-1.396
Geographical Variables					
Altitude	-0.0003***	-0.002**	-0.006	-0.001*	0.009
Distance to the capital	0.001***	-0.008	-0.001	0.002*	0.005***
Distance to the tour Principal Markerts	-0.0001	-0.002	0.003*	-0.011*	0.004*
Precipitation	-0.0003	-0.001**	0.007	0.003	-0.005**
Water disponibility index	0.0005***	0.001**	0.008***	-0.007*	0.009
Erosion	0.2443***	0.153***	0.373***	0.191	-0.012
Soil aptitude Index	-0.0791	-0.029	-0.102	-0.339*	0.135
Infraestructure variables					
Roads	-0.002	-0.002	0.004	-0.005*	-5.582*
Estimation Method:	**PROBIT**	**PROBIT**	**PROBIT**	**PROBIT**	**PROBIT**
No de Observations	1062	114	615	171	163
Pseudo R2	0.243	0.4694	0.3041	0.4215	0.5242
loglikelihood	-359.7555	-41.84	-155.92	-41.1572	-32.41

Table A8. Differences in ELN activity (number of attacks) as the result of illicit drug production in 2000

Methodology	Difference	Standard Error			Average Treated	Average Controls	T	NT	N
	(1)	ES	T	P-value	(3)	(4)	(5)	(6)	(7)
Total National									
NN	**1.78**	0.49	3.655	0.000***	2.42	0.63			
KERNEL	**1.91**	0.49	3.872	0.000***	2.42	0.51	175	887	1062
LLR	**1.85**	0.47	3.956	0.000***	2.42	0.56			
Orinoquía y Amazon									
NN	**1.50**	0.88	1.713	0.087***	1.69	0.18			
KERNEL	**2.14**	1.92	1.117	0.264	1.69	-0.45	54	60	114
LLR	**1.37**	1.13	1.211	0.226	1.69	0.31			
Andean									
NN	**2.23**	0.86	2.589	0.010***	3.08	0.85			
KERNEL	**2.22**	0.84	2.631	0.009***	3.08	0.87	73	542	615
LLR	**2.14**	0.96	2.235	0.026**	3.08	0.94			
Caribbean									
NN	**2.14**	1.54	1.393	0.164	3.24	1.10			
KERNEL	**2.54**	2.92	0.868	0.358	3.24	0.70	25	146	171
LLR	**1.70**	2.56	0.663	0.508	3.24	1.54			
Pacific									
NN	**0.72**	0.84	0.851	0.395	1.21	0.49			
KERNEL	**0.76**	1.54	0.494	0.621	1.21	0.45	24	139	163
LLR	**0.64**	1.34	0.481	0.631	1.21	0.56			

*** Significant at 99%
** Significant at 95%
* Significant at 90%

Table A9. Differences in delinquent activity (number of attacks) as the result of illicit drug production 1999-2003

Methodology	Difference	Standard Error			Average Treated	Average Control	T	NT	N
	(1)	SE	T	P-value	(3)	(4)	(5)	(6)	(7)
Total National									
NN	**0.09**	0.02	3.679	0.000***	0.19	0.10			
KERNEL	**0.08**	0.02	3.715	0.000***	0.19	0.11	175	887	1062
LLR	**0.07**	0.02	4.200	0.000***	0.19	0.11			
Orinoquía y Amazon									
NN	**0.03**	0.06	0.453	0.651	0.13	0.10			
KERNEL	**0.02**	0.05	0.428	0.669	0.13	0.11	54	60	114
LLR	**0.02**	0.08	0.273	0.785	0.13	0.11			
Andean									
NN	**0.06**	0.03	1.847	0.065*	0.19	0.13			
KERNEL	**0.06**	0.03	1.945	0.052*	0.19	0.13	73	542	615
LLR	**0.07**	0.04	1.719	0.086*	0.19	0.13			
Caribbean									
NN	**-0.12**	0.13	-0.939	0.348	0.32	0.44			
KERNEL	**-0.01**	0.13	-0.075	0.940	0.32	0.33	25	146	171
LLR	**-0.13**	0.20	-0.655	0.513	0.32	0.45			
Pacific									
NN	**0.14**	0.05	2.748	0.006***	0.20	0.06			
KERNEL	**0.14**	0.05	2.800	0.005***	0.20	0.06	24	139	163
LLR	**0.14**	0.04	3.316	0.001***	0.20	0.06			

*** Significant at 99%

** Significant at 95%

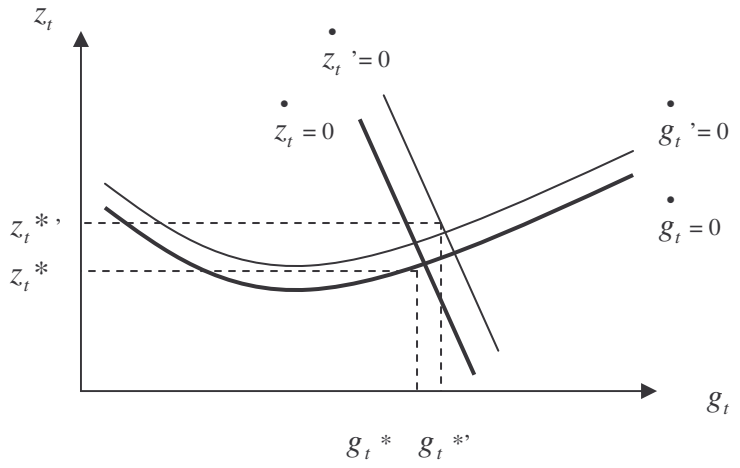
* Significant at 90%

Table A10. Determinants of Aerial Erradication 1999-2001

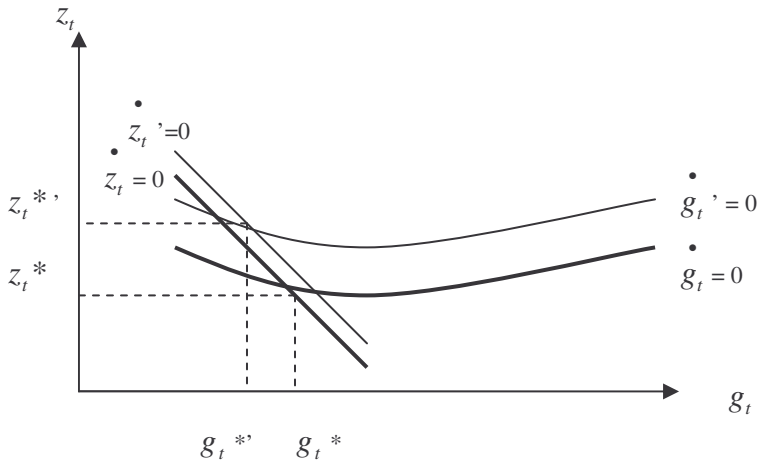
Dependent Variable	**Eradication 1999-2001**	**Eradication 1999-2001**	**Eradication 1999-2001**	**Eradication 1999-2001**	**Eradication 1999-2001**
Region	**Nation Total**	**Nation Total**	**Orinoquía and Amazonía**	**Andean**	**Pacific**
Variables	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Constant	-1.726 *	-2.280 ***	0.287 ***	1.091 ***	-5.071 ***
Spatial Dynamic					
Aerial Eradication (neighbors)	4.333 ***	0.001 ***	0.001 ***	0.001 ***	
Actores Armados					
FARC's activity 1997-1999			0.058 ***	-0.299 ***	0.83 ***
ELN's activity 1997-2000				-0.015 ***	-1.547 ***
Illegal Self Defense Group's activity 1997-1999			0.534 ***	0.335 ***	
Justice and Drug Trafficking					
Aerial Eradication 1999 / 1998-2000	1.117	0.866 ***	0.941 ***	0.068 ***	2.509 ***
Aerial Eradication 1997-1999		0.740 ***	0.725 ***		
Social and Economic					
Index of Basic Unsatisfied Needs 1998-2000	0.018 **	0.007 ***	0.000 ***	0.004 ***	
Gini of Private Property 1998-2000			-0.348 ***	-2.611 ***	
Educational Coverage	-2.570 **				
Geographical Variables					
Soil Aptitude	-0.250 **				
Height (mt above the sea level)		-0.051 ***	-0.182 ***	-0.104 ***	
Erosion		0.123 ***			
Distance to the Capital		0.000 ***	0.001 ***	0.001 ***	
Distance to the four Principal Markets		0.000 ***	-0.001 ***	-0.002 ***	0.008 ***
Infrastructure Variables					
Roads		0.065 ***			
Phones Lines	0.095 *	-0.011 ***			
Estimation Method:	**PROBIT**	**PROBIT**	**PROBIT**	**PROBIT**	**PROBIT**
No Observations	173	412	139	147	68
Pseudo R2	0.503	0.3352	0.4139	0.12	0.4028
loglikelihood	-84.74	-165.24406	-56.299	-54.6	-22.834

9.3. Theoretic Model

Case 3. Changing the probability of eradication

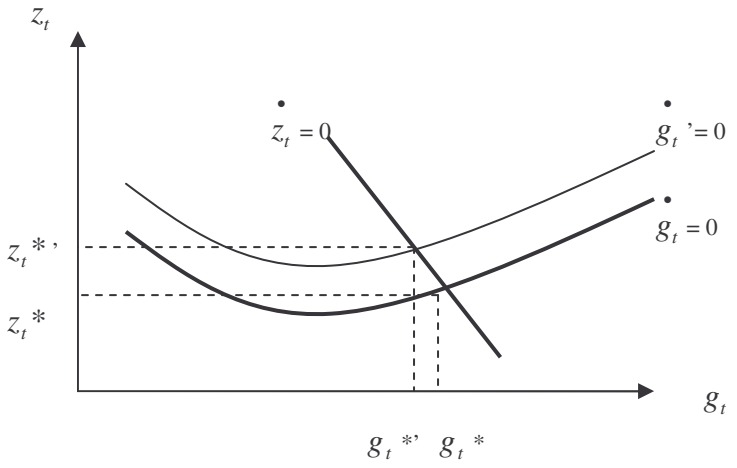


In contrast to the previous case: an increased probability of eradication leads to increased levels of territorial control and guerrilla numbers.

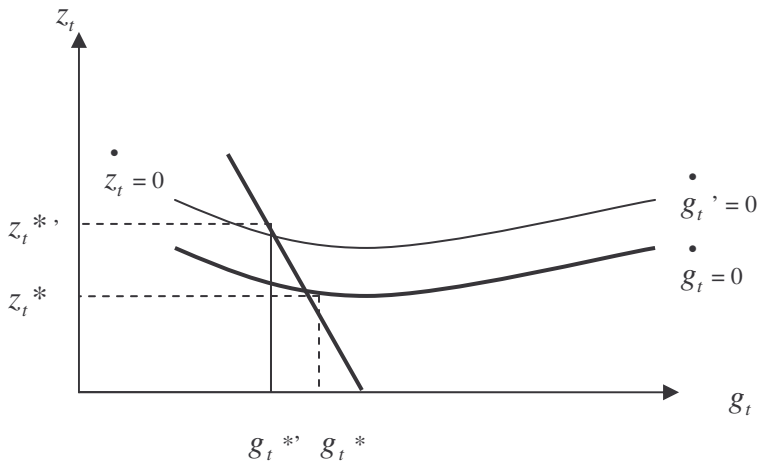


Similar to the first case, increased probability of eradication leads to increased levels of territorial control and fewer guerrillas.

Case 4. Changes in the costs of territorial control



The rising cost of territorial control leads to more territorial control and to a reduction in the number of active guerrillas.



The rising cost of territorial control leads to more territorial control and to a reduction in the number of active guerrillas.