COCAINE PRODUCTION AND THE PROVISION OF HOUSEHOLD SERVICES: EVIDENCE FROM COLOMBIAN COCA FARMERS

by

Maggie Jones

Submitted in partial fulfillment of the
requirements for the degree of
Master of Arts

at

Dalhousie University
Halifax, Nova Scotia
April 2012

DALHOUSIE UNIVERSITY

DEPARTMENT OF ECONOMICS

The undersigned hereby certify that they have read and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled "COCAINE PRODUCTION AND THE PROVISION OF HOUSEHOLD SERVICES: EVIDENCE FROM COLOMBIAN COCA FARMERS" by Maggie Jones in partial fulfillment of the requirements for the degree of Master of Arts.

Dated: April 30, 2012

Supervisors: ______________________________

____

Reader: ______________________________

DALHOUSIE UNIVERSITY

DATE: April 30, 2012

AUTHOR: Maggie Jones

TITLE: COCAINE PRODUCTION AND THE PROVISION OF HOUSEHOLD SERVICES: EVIDENCE FROM COLOMBIAN COCA FARMERS

DEPARTMENT OR SCHOOL: Department of Economics

DEGREE: M.A. CONVOCATION: October YEAR: 2012

Signature of Author

Table of Contents

List of Tables

List of Figures

Abstract

This paper analyzes how coca cultivation affects the provision of basic household services in Colombia. In particular, I examine how different levels of government responded to an exogenous upsurge in coca cultivation in 1995. I use data from Demographic Health Surveys to compare Colombian households' access to electricity (overseen by the federal government) and water (overseen by municipal governments) in coca growing areas relative to non-growing areas. I use both standard and generalized difference-in-differences models. My results indicate that after coca cultivation increased, electricity coverage increased by 7 percentage points more in coca growing departments than non-growing departments. In contrast, there were no differential trends in access to piped water between growing and non-growing departments.

Acknowledgements

I would like to thank all the faculty, staff and students of the Dalhousie Economics Department whom I have had the pleasure of meeting in the past two years. Specifically, a huge thank you to my supervisors and reader for all their help.

First, to Professor Daniel Rosenblum for his guidance and insight, both for the duration of my thesis and my time spent as a graduate student at Dalhousie. His encouragement played an integral role in completing this thesis and in my choice to pursue a career in economic research.

Thank you to Professor Mutlu Yuksel for his valuable comments, critiques and feedback. He, too, has been incredibly supportive of my academic endeavours and has pushed me to achieve my goals.

Many thanks to my reader, Professor Kuan Xu, who has been motivational and optimistic throughout my time spent in the graduate program. Additionally, thanks to Professor Andrea Giusto for his help translating Spanish documents, fixing LaTeX, and his general advice and encouragement.

Finally, thanks to my family, Kent Jones, Charlotte Jones, Cary Jones and Mike Němec, for their writing revisions and their endless support.

Chapter 1

Introduction

The Andean countries Bolivia, Peru and Colombia are notorious for the cultivation of coca leaves, and the refinement and trafficking of cocaine. Historically speaking, the coca leaf has played an integral role in Andean culture, with coca use dating as far back as 1800 B.C.. The coca plant was once used as a type of currency for native groups, and to this day it is still socially acceptable for peasants to use coca to barter for goods (Morales, 1990). Over the past 50 years an upsurge in the demand for cocaine in the developed world coupled with the globalization of trade routes has turned the drug industry into a fundamental part of the economies of Bolivia, Peru and Colombia. This has accelerated the commercialization of South American agriculture, facilitated regional economic integration, and aided the Andean economies to integrate into the global economic scene (Andreas & Youngers, 1989).

The World Drug Report (2011) estimates that the global market for cocaine in 2009 was worth approximately US $85 billion. While there is no doubt that the drug industry is highly profitable, there exists little empirical research that investigates the economic effects of cocaine production. Most studies that examine the role of cocaine production in the Andes are purely anecdotal and do not attempt to quantify the consequences of cocaine production. The purpose of this paper is to further this field of research by investigating the relationship between coca cultivation and the provision of basic household services in Colombia. I examine the provision of piped water and electricity, both of which are essential for the cultivation of coca.

Colombia's central state is infamous for its rampant corruption (see Wilkinson, 2011; S.B., 2011). Paramilitaries deliver votes to corrupt politicians and in return, politicians implement or promote policies that are favourable to the paramilitaries (Acemoglu, Robinson & Santos, 2008). These paramilitaries finance their initiatives from trafficking drugs (see Hristov, 2009), which leads me to hypothesize that the federal government may favour areas with high drug production.

I test this hypothesis by examining the effect of a 1995 drug eradication program that caused coca leaf production to shift from Peru to Colombia. The resultant increase in coca cultivation in Colombia provides a source of exogenous variation for coca cultivation. Using data from Demographic Health Surveys (DHS) between 1986 and 2010, I examine how the increased involvement in coca farming affected the allocation of household services in areas with high coca production relative to those without coca cultivation. Specifically, I investigate the change in households' access to electricity, which is controlled by the central state, and compare this to the change in access to piped water, which is controlled by municipal governments.[1]

The results of the analysis provide the first empirical investigation of how the allocation of household services may change in response to illegal drug production. The empirical findings suggest that Colombian coca growing regions benefited from the increased cultivation by receiving a greater increase in electricity coverage compared to non-growing regions. After 1995, the probability of a household having electricity increased by approximately seven percentage points more in growing areas than non growing areas. This suggests that the shift in coca cultivation incentivized the central state to increase infrastructure investment in drug producing areas of Colombia.

In contrast, the change in coca cultivation had no significant effect on the likelihood of a household gaining access to piped water. This indicates that municipal governments either did not have the same incentives to invest in coca growing regions, or they could not afford to increase investment, regardless.

The remainder of the study is outlined as follows. Chapter two provides a background of cocaine production in the Andes, followed by a survey of the existing literature on illegal drug production, access to household services, and development in Colombia. Chapter three describes the sample selection process and the dataset employed. Chapter four presents the econometric framework. Chapter five summarizes the results of the analysis and Chapter six provides the results of the robustness checks and falsification test. Chapter seven concludes with ideas for future research and a brief summary of the findings.

[1] Corruption does exist in municipal governments, however it is not as extreme as in the federal government. See section 2.2 for more information on corruption in Colombian politics.

Chapter 2

Background Information

2.1 Cocaine Production in the Andes

The coca leaf was first consumed by native populations in the Andes who would either chew the leaves or use them to make tea. Both mediums produce mild stimulant effects much like those of caffeine. Morales (1986) describes the use of coca leaves as "a traditional ecological interchange based on patterns of reciprocity between populations with subsistence agriculture (pg. 143)." It wasn't until the 1950s and 1960s that the cocaine industry became a commercial industry and until then coca did not represent a major social problem in the Andes (Morales, 1986).

The process of making cocaine involves several intermediate steps. Coca is grown in small peasant farms at approximately 600 to 2,000m above sea level in the jungles of Bolivia, Peru and Colombia. Coca smugglers travel to these remote areas to buy the leaves and transport them to coca-paste laboratories where the leaves are mixed with kerosene and sulphuric acid. The coca-paste is then dried, which forms cocaine hydrochloride (cocaine) and is subsequently transported internationally (Morales, 1986).

According to the World Drug Report (2011), profits are distributed unequally between those involved in the labor-intensive part of production (coca farmers) and those involved in the administrative side; in 2009, 99% of profits from the cocaine industry were collected by traffickers, while the remaining 1% were distributed amongst coca farmers in the Andean region. Morales (1986) comments on this phenomenon saying, "as in any social relations of production, those who contribute most in the creation of the commodity (cocaine) are less economically rewarded than those who market the end product in the underground industry (pg. 158)."

Prior to 1995, Peru and Bolivia cultivated most of the world's coca leaf (see Figure 2.1), while Colombia was responsible for refining coca paste to make cocaine. Colombia was also involved in the entrepreneurial and managerial aspects of the drug industry, with many large scale traffickers and cartels locating within Colombia (Andreas & Youngers, 1989; Feiling, 2010). After 1995, coca cultivation began to decline in Peru and rise steadily in Colombia. Colombia continued to produce significantly more coca leaf than both Peru and Bolivia until 2000 when coca cultivation began to decline in Colombia and rise once again in Peru and Bolivia.

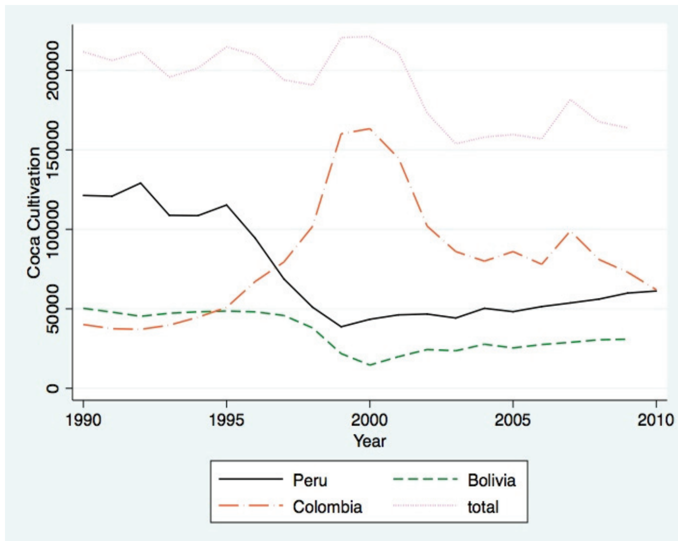


Figure 2.1: Cultivation (in hectares) of coca bush between 1990 and 2010. Data from 1986-1989 was excluded due to discrepancies in the data. Source: UNODC World Drug Report, 2010.

The decline in coca cultivation in Peru was a result of a drug eradication program implemented by the United States and Peruvian governments called the Air Bridge Denial (ABD) program. The ABD program was an attempt to stop cocaine production at its roots and targeted suspicious aircraft that were used for transporting coca-leaf and coca-paste from the jungles in Peru to the processing plants in Colombia (United States Government Accountability Office, 2005). The ABD program was implemented in the mid nineties in Peru but was later suspended due to the accidental shooting of a civilian aircraft. The program was re-implemented in Colombia in 2003. Additionally, in 2001 the Colombian government introduced Plan Colombia, a program designed to restore peace and reduce drug production (Mejía & Posada, 2008). Each of these initiatives may help to explain the fall in coca cultivation in Colombia between 2000 and 2005.

Evident in Figure 2.1, the ABD program was successful at reducing coca cultivation in Peru, but ultimately failed at eradicating cocaine production in the Andes, as reductions in Peruvian cultivation were offset by increases in Colombia. Consequently, total production remained constant through the end of the nineties. The increase in Colombian cultivation in 1995 provides a source of exogenous variation in coca cultivation. This is important for the empirical methodology of this paper in section 4.

2.2 Existing Economic Literature

There are few economic analyses that examine the overall impact of illegal drug production and development, and fewer that examine the relationship between cocaine production and development in the Andes. In both Afghanistan and Colombia the illegal drug trade has contributed to a phenomenon known as Dutch Disease (Martin & Symansky, 2004, Corchuelo & Steiner, 1999), wherein a country's exchange rate appreciates due to the repatriation of illegal capital from the drug industry. This hurts legal exports, which become more expensive relative to market alternatives.

Angrist & Kugler (2008) exploit the effects of the ABD program on coca production in Colombia. They look at the effect of higher coca prices and levels of coca cultivation in Colombia on changes in self-employment income, school enrolment, and violent death rates. They report that while households experienced an increase in income, violent deaths and self employment increased. Additionally, labour hours increased for teenage boys, indicating a slight increase in child labour due to the shift in coca cultivation.

Dammert (2008) also uses the ABD program to evaluate the effects of removing coca cultivation from Peru on child labour outcomes. In contrast to the findings by Angrist & Kugler (2008), she determined that after the ABD program was implemented, areas in Peru that experienced decreases in coca cultivation also experienced substantial increases in child labour, in the realm of 18% in 1997 and 40% in 2000. Most of the increased labour hours were due to increases in agricultural work on family-owned farms. This may be a result of lower yields from legal crops compared to those from coca plants, so families had to compensate for lost profits due to the removal of coca farming in Peru.

Arguably, the most considerable problem in the Andean region today is the ongoing violence between right wing paramilitaries and left wing guerrilla groups.[1] The cocaine industry has not caused the violence, but may play a substantial role in sustaining it, as many of these non-state armed actors finance their initiatives with money obtained from trafficking drugs. Colombian non-state armed actors are divided in to two groups. On the one hand, left wing guerrilla activists, such as the Revolutionary Armed Forces of Colombia (FARC), fight against what they believe is an oppressive government, whose interests do not include the wellbeing of all citizens. In *Colombia - Cocaine War* (2004), an anonymous FARC leader is quoted as saying:

> The state does not care if the people do not have enough food to eat, the state is only interested in collecting taxes. We have to protect the marginal core, the people who have no privileges, no protection, no housing or no food. They have no education, or no job and they live in misery.

On the other hand, right wing paramilitary groups, aided by the Colombian military, arose to protect wealthy land-owners and drug lords from the guerrilla groups (Marcy, 2010). Ironically, both groups are involved in narco-trafficking to finance their respective sides of the fight. Rangel (1998) estimates that the FARC derive one-third of their finances from drug trafficking. Likewise, after the defeat of two prominent Colombian drug cartels in the nineties (the Medellín and the Cali cartels), paramilitaries also moved into the cocaine market to finance their own operations (Marcy, 2010).

The violence between non-state armed actor groups in Colombia has substantial economic and social consequences. The ongoing civil conflict deters foreign investment, displaces hundreds of thousands of civilians, and draws large sums of aid money from other developed nations. Giedion & Steiner (1996) determine that the

---

[1] Colombia's history is plagued with violent episodes. A series of conquest wars occurred during the sixteenth and seventeenth centuries, when the Spanish were imposing their rule in Latin America. Revolts by slaves and intraclass contradictions caused numerous violent episodes throughout the eighteenth and nineteenth centuries. Between 1899 and 1902 Colombians experienced a lengthy bought of partisan violence, known as "The War of a Thousand Days," in which 100,000 people died. "La Violencia" occurred in the countryside from 1946 to 1966 between supporters of the Colombian Conservative and Liberal parties (Oquist, 1980). To present, violence has persisted between the many non-state armed actor groups in Colombia (see Bergquist, Peñaranda & Sánchez (2001) for an overview of violence between 1990 and 2000).

Colombian security situation is the greatest factor that affects investment decisions from foreigners.

Furthermore, Colombia is infamous for its political corruption (see Wilkinson, 2011, S.B., 2011). During the mid to late nineties, the Samper administration was accused of taking bribes from some of the largest drug cartels in Colombia.[2] Police officers, military personnel, then defence minister Fernando Botero, and even President Samper himself, were accused of accepting bribes worth millions of dollars. Political corruption did not end with Samper's presidential term; in the early 2000s, President Uribe's administration was rumoured to be in collaboration with paramilitary groups throughout Colombia.[3]

As a result of the ongoing corruption, Colombia consistently ranks poorly on the Corruption Perception Index (CPI). The CPI is measured on a scale of 0-10, where 0 equals absolute corruption and 10 equals no corruption. Colombia's CPI value was 3.44 in 1995 and had declined to 2.2 in 1998 at the end of President Samper's term. Over the next 8 years it saw an increase to 3.9 in 2006, but has been declining steadily since. According to Transparencia Colombia's national rankings, Índice de Transparencia Nacional (ITN), the Senate was the most corrupt institution in Colombia. The ITN is a corruption ranking on a scale of 0-100, 100 representing absolute transparency and no corruption, and 0 representing complete corruption. The Senate was given a ranking of 21.2, which was a full 29 points lower than the next most corrupt institution (Transparencia Colombia, 2009).

In contrast, municipality level corruption is not nearly as high as national level corruption. In fact, in a survey involving 22 nations in Latin America, Colombia's municipality level corruption was lower than most other countries; approximately 4% of Colombians reported that they had been victimized by the local government compared to around 40% in Haiti (Orces, 2009). However, municipal level corruption still exists and is problematic in many regions in Colombia. Transparencia Colombia's municipality rankings, Índice de Transparencia Municipal (ITM), suggest that many municipalities do suffer from corrupt politics, though even the most

[2]Ernesto Samper was president of Colombia between 1994 and 1998 and was heavily criticized (by the Clinton (US) administration, among others) for his involvement in narcotics corruption.

[3]Álvaro Uribe was president of Colombia between 2002 and 2010 and was also criticized for his involvement with paramilitary groups.

corrupt municipal governments are less corrupt than the Senate. The average ITM ranking for municipalities across Colombia is still approximately 38 points higher than the ranking of the Senate (Índice de Transparencia Municipal, 2009; Índice de Transparencia Nacional, 2009).

Acemoglu, Robinson & Santos (2008) develop a theoretical framework to explain the incentives of the central state in establishing a monopoly on violence in areas with paramilitary presence. Their models suggest that paramilitaries deliver votes to politicians whose policies are in line with those of the paramilitaries. The politicians that they help elect will possibly support policies that are preferential to paramilitaries. This theory is extended to an empirical analysis, which provides supporting evidence of the close connection between paramilitaries and the government in Colombia.

The relationship between the government and drug-financed paramilitaries suggests that the central state may have an incentive to invest in drug producing regions. I examine this hypothesis by comparing access to household services that are controlled by the federal government to those under municipal control and how access to these services changed in response to a shift in coca cultivation. Specifically, I look at the change in households' access to electricity after the ABD program caused coca cultivation to increase in Colombia. Electricity coverage is managed by the federal government in Colombia. I compare the change in access to electricity to the change in access to piped water, which is controlled by municipal governments.

2.3 Water, Electricity and Economic Development

Access to improved water systems and energy infrastructure are two keys to economic development (see Barnes & Floor, 1996; Jemelkova & Toman, 2003; World Health Organization, 2005). The United Nations Millennium Development Goals advocate increased access to safe drinking water and access to clean and renewable energy as tools for economic development. Improved access to water is beneficial to many economic sectors that rely heavily on water resources, like the agricultural sector, which is a prominent industry in many poor countries including Colombia (CIA World Factbook, 2012). Additionally, access to clean water reduces waterborne diseases like diarrhoeal disease and intestinal infections (World Health Organization, 2005).

Improving water infrastructure provides additional benefits to households by reducing the time spent traveling to the water source. This allows for increased time spent on leisure or productivity and removes a source of stress for many poor families (Devoto, F., Duflo, E., Dupas, P., Parienté, W., Pons, V., 2011). Devoto *et al.* (2011) find that households in Morocco that received access to piped water reported higher levels of happiness and social integration relative to households that did not benefit from access to piped water.

Likewise, access to electricity increases economic productivity; Jemelkova & Toman (2003) find that the influence of energy on development is particularly important for countries at lower levels of development. The World Energy Outlook (2010) classifies the lack of access to electricity as one of the most prominent indicators of household level poverty. It hinders economic and social development; thus, improving electricity infrastructure contributes greatly to the reduction of global poverty.

In a document released by the World Bank (2004) it was reported that between 1980 and 1995 Colombia invested approximately 2-3% of GDP per year in the infrastructure sectors, with this figure climbing to 4% in the mid nineties. The report indicates that Colombia has focused its infrastructure investments in the energy sector which underwent major reforms in the nineties. Similarily, figures in the document suggest that investment in water infrastructure is also higher than nearly all other Latin American countries involved in the study.[4]

The World Health Organization's Water and Sanitation Update (2012) reports that Latin America and the Caribbean have higher rates of access to piped water than the rest of the developing world, and has seen an increase of 13 percentage points in access to piped water between 1990 and 2010. The World Bank (2004) reports that Colombian households have higher access to basic household services than most other Latin American countries. Among those countries in the same income bracket, Colombia's water and sanitation coverage levels are 10-15 percentage points higher.

[4]The other countries involved include Venezuela, Mexico, Chile, Peru, Argentina and Brazil. The only other country that showed higher investment in water was Mexico.

However, the rural-urban divide remains problematic, with significant discrepancies in access to household services between urban and rural regions in Colombia. Access to electricity and proper sanitation is approximately 35-40 percentage points lower in rural areas than urban areas. In 2004 four million Colombians were still without access to safe water and sanitation services, and two million people were without electricity, most of whom were rural residents (World Bank, 2004).

Recently, nation-wide programs have been implemented to improve access to electricity in rural areas of Colombia. The Rural Electrification Fund (FAER) and the Non-Interconnected Zones Fund (FAZNI) focus on ameliorating access to electricity in populations within reach of the interconnected and non-interconnected areas. Unfortunately, water and sanitation coverage fall under the responsibilities of municipal governments; therefore, national programs aimed at improving public goods in rural areas are focused on access to electricity only (World Bank, 2004; Ley 142 de 1994 Nivel Nacional, 1994). For the purpose of this study, this allows me to compare the provision of federally controlled services to municipally controlled services and examine how the allocation of these services changes in response to coca cultivation.

Chapter 3

Data

3.1 Sample Selection

The analysis in this paper uses a binary representation of coca growth; departments within Colombia are classified as either non-growing or growing departments and coded as 0 or 1, respectively. While data on coca leaf production does exist from the United Nations Office of Drugs and Crime, the collection method for this data uses satellite imagery which does not pick up small growing areas. This may cause a bias in the amount of coca leaf reported. This is especially true in the last 10 years, when farmers have begun scattering small coca plots, which are less likely to be visible using the satellite images (Colombia: Monitoreo de Cultivas de Coca, 2011). These estimates of coca production are also incomparable to previous estimates, as the satellite imagery is more precise than the estimation techniques used in the 1990's (World Drug Report, 2011). This suggests that using a binary variable to classify coca producing regions is more accurate than using a continuous variable for quantity of coca leaf.

Colombia is divided into 32 political subdivisions called departments. Angrist and Kugler (2008) classify departments in 1994 as either growing or non-growing regions. They use criteria reported in Uribe (1997) and Perafán (1999) to make this distinction. They include nine departments listed in Uribe (1997) that had over 1,000 hectares under cultivation: Bolívar, Caquetá, Cauca, Guaviare, Meta, Nariño, Putumayo, Vaupés and Vichada. They also add five other departments that were listed as growing regions in Perafán (1999): Cesar, Magdalena, La Guajira, Norte de Santander and Guainía.

Angrist & Kugler (2008) verify that this group of 'growing' departments receives an increase in coca cultivation after the implementation of the ABD program in Peru. They regress the growth in coca cultivation between 1994 and 1999 on an indicator of growing status in 1994. Their results indicate that the increase in coca cultivation in regions classified as 'growing' greatly exceeds the increase in non-growing regions. They find that growing areas experience an increase in coca leaf production of approximately 7,500 more hectares than non-growing areas. Moreover, the intercept estimates in their regressions were not significantly different from 0, indicating that non-growing regions were not involved in coca cultivation between 1994 and 1999. This indicates that the ABD program affected growing regions, but had no effect on non-growing regions.

Following the framework proposed in Angrist & Kugler (2008), I group the aforementioned departments as 'growing regions'. However, I exclude Guainía, Vichada, Vaupés, Putumayo and Guaviare due to lack of data for all years of the study.[1] The non-growing regions consist of Antioquia, Atlantico, Bogota, Boyaca, Caldas, Chocó, Cundinamarca, Huila, Quindio, Risaralda, Santander, Sucre, Tolima and Valle de Cauca.[2] With the exclusions, the growing area includes 9 departments with 28,000 household respondents and the non-growing area includes 15 departments with 78,085 household respondents. Within the growing sample 35% of respondents lived in rural areas (10,009 households) compared with 24% of respondents (19,111 observations) in the non-growing sample.

3.2 Data Description

This paper examines changes in households' access to electricity and compares them to changes in access to water after the ABD program in Peru caused the majority of coca farming to shift to Colombia. The study focuses on Colombian households and uses Demographic Health Surveys (DHS) over the time period 1986 to 2010. These surveys are funded by the U.S. Agency for International Development and are implemented in over 90 countries worldwide. The surveys, conducted at the household level, are nationally representative and provide information on many health indicators and household characteristics. The first DHS study was conducted in 1984 and since then the surveys have progressed through six phases. Some variables have

[1]These departments were not recognized as departments until the 1991 Constitution of Colombia.

[2]The non-growing departments that were excluded due to lack of data availability include Casanare, San Andrés and Providencia, Arauca and Amazonas. These departments were also not recognized as departments until the Constitution of Colombia (1991).

remained constant through each phase, which has been particularly helpful for the analysis conducted in this study. The surveys I use include the years 1986, 1990, 1995, 2000, 2005 and 2010, and run through phases one to five. Phase six has not yet been introduced in Colombia.

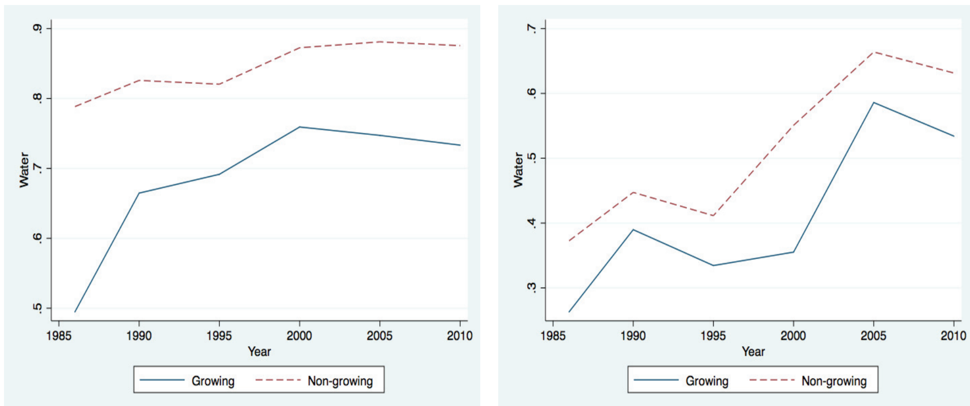
The variables of interest, 'electricity' and 'water', are both binary and are constructed from DHS questionnaire answers. For 'electricity', the DHS questionnaires ask whether or not the household has electricity, yes or no, and is coded as 1 or 0, respectively. The possible answers for water are more varied. The questionnaires ask for the source of household drinking water and the dummy variable for water is coded as a 1 if respondents receive piped water from a utility company or piped water from rural systems, and 0 otherwise. Thus, the variable 'water' measures whether or not respondents have access to any form of piped water.[3] By defining the variable 'water' this way, I am able to focus my analysis on water that is provided by the municipal government, as opposed to other sources.

Descriptive statistics are found in Table A.1 and Table A.2. Table A.1 presents statistics for the pooled sample (1986-2010) and for each individual year. In the 2005 and 2010 surveys some of the respondents were interviewed in 2004 and 2009. Accordingly, for the calculation of means and standard deviations in Table A.1 and A.2, 2004 responses are included with 2005 responses and 2009 with 2010. The descriptive statistics in each table are presented in three groups: all regions, only those in non-coca growing departments and those in coca growing departments. Coca farming is primarily a form of rural livelihood and therefore the shift in coca production might have been more likely to affect rural households than urban household. That being said, Table A.2 presents the same descriptive statistics excluding urban observations.

Both tables show an upward trend in household access to electricity and water over the 1986-2010 time period, with the trend being more extreme once urban observations are dropped. This indicates a focus on improving infrastructure and ameliorating household conditions in more rural areas of Colombia. Within the

[3] Other possible answers include public tab, open well with a sump pump, open well without a sump pump, river, stream, or spring, rain water, tanker trunk, water in drums or big cans, bottled water and "other".

pooled sample 94.76% of households had access to electricity, while 81.08% of respondents had access to water. These numbers decrease to 83.45% and 54.72%, respectively, when excluding urban observations.



(a) Including urban observations (b) Excluding urban observations

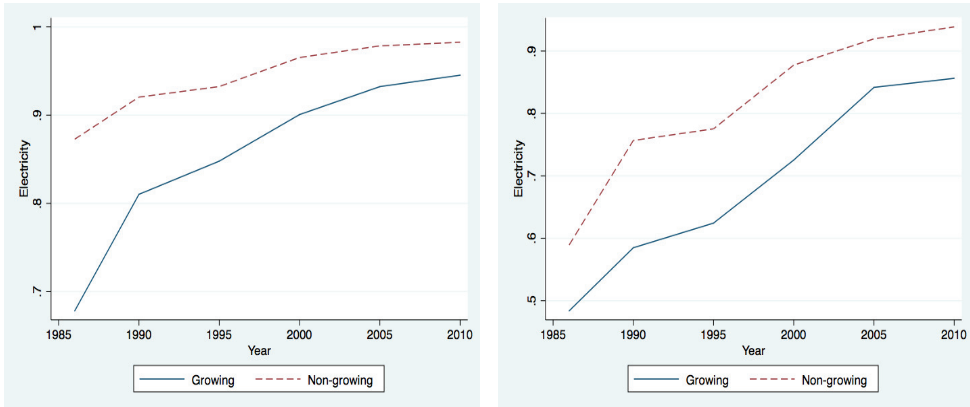
Figure 3.1: Mean of household access to piped water. Separated by growing and non-growing areas. Sample weights included for both figures. DHS 1986-2010 survey data used to calculate means.

Over the period of 1986 to 2010 access to electricity increased by 10.7% in non-growing areas and by 36.3% in growing areas. Similarly, access to water increased by 21.36% in non-growing areas and by 64.67% in growing areas. Table A.2, indicates similar results with electricity increasing by 54.53% in non-growing areas compared with 64.05% in growing areas and water increasing by 94.96% in non-growing areas and 119.77% in growing areas.

Figure 3.1 and Figure 3.2 show the trends in access to piped water and electricity over the years 1986 to 2010.[4] It is evident in the figures that after 1995 access to electricity increased more quickly in growing areas than non-growing areas. This trend is not as obvious for access to water.

Information on household size and whether or not a household has a car is also presented in each table. These two variables are used as household controls in the regressions in Chapter 4. Data on income was not readily available in the DHS datasets (for all years of the study), so these two variables represent controls for

[4]These figures include the sample weights provided by DHS. The figures without sample weights are very similar and are included in the appendix.



(a) Including urban observations

(b) Excluding urban observations

Figure 3.2: Mean of household access to electricity. Separated by growing and non-growing areas. Sample weights included for both figures. DHS 1986-2010 survey data used to calculate means.

wealth. Generally, household size decreases as income increases (see for example Fiegehen and Lansley, 1976), and given the low percentage of respondents who own a car or truck (only 8% in the pooled sample), ownership of a car or truck will also be used as a control for wealth. It should be noted that in the 2000 survey this variable was not collected.

The trend in percentage of rural households included in the interview varies substantially between 1986 and 1995, indicating that the sample may be more representative of the rural population between 2000 and 2010. Consequently, for all figures and regressions presented in this paper, I will be using the sample weights provided in the DHS datasets.

Chapter 4

Empirical Methodology

The framework used in this study looks at the prevalence of electricity and piped water in coca growing regions compared to non-growing regions, conditional on the implementation of the ABD program by the United States and Peruvian governments. The ABD program provides a source of exogenous variation in coca farming and can be used to form the basis of a natural experiment. The experiment follows two groups of observations: one group residing in Colombian departments that are unaffected by the change in coca farming (the control group), and another that would presumably be affected by a shift in coca production (the treatment group). In this case treatment refers to the effect of the ABD program. The estimation technique used is the difference-in-differences methodology which compares the change in access to electricity (or water) in growing areas before and after the ABD program to changes in access to electricity (or water) in non-growing areas before and after the ABD program.

Using access to electricity as an example, the change in access to electricity in growing areas is the expected value that a household residing in a growing area has access to electricity after the intervention less the expected value that a household residing in a growing area has access to electricity before the intervention. Formally, this can be expressed as $\mathbb{E}(Y = 1|T = 1, R = 1) - \mathbb{E}(Y = 1|T = 0, R = 1)$, where $Y = 1$ means a household has electricity (or water) and $Y = 0$ means that the household does not. Similarly, $T = 1$ is the time period after the implementation of the ABD program and $T = 0$ is the preceding time period. $R = 1$ represents a growing area and $R = 0$ is a non-growing area.

For the control (non-growing area) group, the difference can be expressed the same way, $\mathbb{E}(Y = 1|T = 1, R = 0) - \mathbb{E}(Y = 1|T = 0, R = 0)$. Then the difference-in-differences is the change between these two equations:

$$
\begin{aligned}
& [\mathbb{E}(Y=1|T=1,R=1)-\mathbb{E}(Y=1|T=0,R=1)] \\
- \;& [\mathbb{E}(Y=1|T=1,R=0)-\mathbb{E}(Y=1|T=0,R=0)] \qquad (4.1)
\end{aligned}
$$

This effect is captured by the difference-in-differences coefficient in the regression model. In this analysis the difference-in-differences coefficient represents the effect of being in a coca growing department after the 1995 shift in coca leaf production. As with all models in economics, one must make certain assumptions in order to correctly interpret the coefficient of interest. The fundamental assumption in the difference-in-differences methodology for this study is that in the absence of treatment the change in mean of the treatment group would be exactly equal to the change in mean of the control group. In other words, in the absence of the ABD program there would be no differential trends in access to water and electricity between growing and non-growing regions.

The basic model estimated in this study is the following:

$$Y_{i,j,t} = \beta_0 + \beta_1 coca_j + \beta_2 after_t + \beta_3 coca * after_{j,t} + X'_{i,j,t}\beta_4 + \mu_{i,j,t}, \qquad (4.2)$$

where $Y_{i,j,t}$ represents access to either water or electricity for household i in region j at time t. The variable $coca_j$ is a dummy variable for growing states and $after_t$ is a dummy variable for the time period after the ABD program was implemented. $X'_{i,j,t}$ is a control vector of household characteristics, including household size and whether or not the household owns a car. The difference-in-differences coefficient is the parameter on the interaction term $coca{*}after_{j,t}$, β_3, and it represents the average effect of receiving treatment. In order to account for possible changes between years and between regions, I implement the generalized difference-in-differences regression:

$$Y_{i,j,t} = \alpha_0 + \alpha_1 coca * after_{j,t} + \alpha_2 T_t + \alpha_3 R_j + X'_{i,j,t}\alpha_4 + \mu_{i,j,t} \qquad (4.3)$$

Here, T_t is a year dummy variable and replaces $after_t$ in Equation (2).[1] R_j is a

[1] t =1986, 1990, 1995, 2000, 2004, 2005, 2009, 2010

regional dummy variable which varies by department and replaces $coca_j$ in Equation (2). Again, $X'_{i,j,t}$ is a control vector and $coca * after_{j,t}$ is the difference-in-differences estimate. The inclusion of fixed effects controls for unobservable heterogeneity in the data. Regional fixed effects control for time invariant differences across regions, while time fixed effects control for regional differences that do not change over time.

The dependent variables in this analysis are both binary and thus running the model using the ordinary least squares estimation yields a linear probability model. As such, the coefficients of the model can be interpreted as percentage point increases (or decreases) in the probability that a household will have access to electricity or water.

Both equations were estimated with and without sample weights, as well as with and without urban observations. For the regressions that included urban observations I add a dummy variable for rural households. The results of the estimations including sample weights follow in Chapter 5.[2]

[2] Results without sample weights are very similar to those with sample weights. The results without weights will not be discussed in the text, but can be found in the appendix.

Chapter 5

Results

5.1 Access to Electricity

Table A.3 presents the estimation results for the probability of a household having access to electricity. This table examines the effect of the shift in coca cultivation on the allocation of household services managed by the federal government. All of the evidence provided from the regressions suggests that growing regions benefited from increased coca production by receiving increased access to electricity relative to non-growing states.

Column 1 of Table A.3 reports the results from Equation (2) without including a control for rural households. All standard errors are clustered by department. The difference-in-differences estimator (the coefficient on $coca * after$) is 0.070 and significant at the 5% level. This indicates that the probability of having access to electricity increased by approximately 7.0 percentage points more for households living in growing areas relative to non-growing areas after the implementation of the ABD program. In column 2 Equation (2) is re-estimated including a control for rural households. Adding the control for rural households decreases the magnitude of the parameter of interest slightly (to 0.069) and it remains significant at the 5% level.

In both column 1 and 2 the coefficients on *coca* and $after$ are significant at the 1% level and the estimates indicate that coca growing regions have less electricity availability than non-growing departments, but that electricity coverage increased in all regions after 1995. Similarly, in column 2, the effect of living in a rural household is significant at the 1% level and suggests that households in rural areas are less likely to have access to electricity. This is concurrent with the literature on rural households' access to electricity in Colombia (see section 2.2). The effect of living in a coca growing state is negative, which should be expected, as Table A.1 indicates that (on average) households in coca growing departments have less access to electricity. Finally, the estimates reflect the increasing trend (displayed in Figure 3.2) in access to electricity; the coefficient on $after$ is positive, with a magnitude of between 5.5 and 6.3 percentage points.

Column 3 displays the results from Equation (3) excluding a control for rural observations. The magnitude of the estimate for $coca * after$ in column 3 is higher than in column 1, revealing that the estimate in column 1 was downward biased due to the exclusion of region and year fixed effects. Again the estimate for $coca * after$ is statistically significant at the 5% level.

Column 4 also displays the estimation results for Equation (3) including a control for rural households. This does not change the magnitude of the results substantially. The difference-in-differences estimate in column 4 is significant at the 5% level and indicates that access to electricity increased by 7.2 percentage points more for households residing in growing areas relative to non-growing areas.

The next four columns re-estimate Equation (2) and (3) including controls for the number of members in each household and whether or not the household owns a car or truck. The inclusion of these controls does not produce different results from columns 1 through 4. The magnitude of the estimates for $coca * after$ remain between 7.2 and 7.7 percentage points and are all statistically significant. Furthermore, the coefficients on *household size* and *car/truck* are significant in all but one case. The effect of household size is negative and significant in all but the last column, reflecting a negative correlation between the number of people residing in a household and whether or not the household has access to electricity. This may be due to the tendency of poor families to have many children. The coefficient on *car/truck* is positive, indicating that wealthier families are more likely to have access to electricity.

The regression results for access to electricity indicate that households in coca growing regions benefited from the shift in coca cultivation by undergoing a more rapid expansion of their energy infrastructure than non-growing regions. On average, the likelihood of having access to electricity increased by approximately 7 percentage points more in households residing in growing regions relative to households in non-growing regions. These results are significant in all estimations and are robust to the inclusion of controls for household characteristics and whether households are located in rural or urban areas.

5.2 Access to Water

In order to determine whether or not the incentive to invest in high drug producing regions differs by government level, I look at the effect of the ABD program on water coverage, which is managed by municipal governments. Table A.4 reports the results of these regressions with standard errors clustered by department.

Columns 1, 2, 5 and 6 present the results of Equation (1) and columns 3, 4, 7 and 8 show the results for Equation (2). The magnitude of the parameter of interest, $coca * after$, is between 0.031 and 0.044, indicating that after the ABD program growing regions received an increase in access to piped water of between 3.1 and 4.4 percentage points higher than non-growing regions. However, in all estimations I find that the effect of being in a coca growing region after the implementation of the ABD program is not significantly different from zero. In most regressions the standard errors of the estimates for $coca * after$ are as large as the estimates themselves.

The results in Table A.4 are consistent when controlling for the number of household members, whether or not a household owns a car or truck and whether the household is in a rural or urban centre. In columns 5 and 6, household size is negatively correlated with access to piped water and this relationship holds with varying degrees of significance. Additionally, the effect of having a car or truck is positive and statistically significant. These results are less significant in columns 7 and 8. In column 2, 4, 6 and 8, the control for rural observations is statistically significant at the 1% level and demonstrates that households in rural areas are an average of 34 percentage points less likely to have access to piped water.

Given that nearly all other estimates are significant at the 1% level and reflect the expected direction of each variable (which is consistent with Table A.3), I conclude that the model is not misspecified, but merely reflects the fact that there were no differential trends in access to piped water between growing and non-growing regions. There are two possible reasons why access to electricity increased in response to the shift in coca cultivation, but access to piped water was unaffected.

First, since water coverage is monitored by the less corrupt municipal governments, then they may not have had the same incentives to invest in infrastructure in coca producing regions. Second, municipal governments may not be able to afford to invest in infrastructure even if they wanted to.

Chapter 6

Robustness Checks

6.1 Dropping Rural Observations

The first set of robustness checks I perform re-estimate Equation (2) and (3) excluding all urban observations from the dataset. This reduces the sample size from 106,085 to 28,874 observations. With such a small overall sample size, some departments have very few observations per year.[1] In 2005, Colombian departmental populations varied between approximately 35,000 and 7,000,000 (DANE, 2005) and approximately 26% of the population were living in rural areas (World Bank, 2011). The reduction in sample size means that it may not be a representative sample and consequently there may be severe biases in the results.

Table A.5 presents the results for access to electricity, with standard errors clustered by department reported in parentheses. Columns 1 and 3 show the results for Equation (2) and columns 2 and 4 display the results for Equation (3). The magnitude of the estimates are consistent with those in Table A.3. The results suggest that growing regions experienced an increase in access to electricity of between 6.5 and 7.5 percentage points more than non-growing regions. These results do not hold statistical significance below the 15% level.

The control variables in columns 3 and 4 are all statistically significant at the 1% level and are consistent with the results in Table A.3 and A.4. Increasing household size corresponds with a diminished access to electricity and increasing the likelihood of owning a car or truck increases the likelihood of having access to electricity. Likewise, the effect of residing in a coca growing state is negative, and the estimate for $after$ reflects the fact that access to electricity was increasing over the time period of the study.

[1] For example, in 1990, the sample sizes in each department varied between 15 and 102 observations. These samples may not be representative of the population means, and therefore it may be difficult to draw statistical inferences from the data.

When using water as the dependent variable, the difference-in-differences estimates have changed direction, however they are no longer significant, with p-values ranging between 0.80 and 0.89. This indicates virtually no effect of being in a coca growing department after the ABD program was implemented on access to piped water. These results are shown in Table A.6, with clustered standard errors in parentheses. The effect of being in a coca growing state remains negative and the effect of being in the time period after 1995 is positive, though only the estimates for $after$ hold statistical significance. The household controls (number of household members and whether or not the household owns a car or truck) remain significant at the 1% level and reflect the positive relationship between wealth and household services.

The results in Table A.5 and A.6 are consistent with those in A.3 and A.4. Electricity increased by approximately 7 percentage points more in growing areas relative to non-growing areas after the ABD program was implemented, and there were no differential trends in access to piped water.

6.2 Falsification Test

My final set of robustness checks includes a falsification test that evaluates the parallel trends assumption for interpreting the effect of the ABD program on access to electricity. It is not necessary to implement a falsification test for access to water, since the results from section 5.2 and 6.1 confirm that there are no differential trends in access to piped water over the time period of the study.

The falsification test uses a 'placebo' experiment for the pre-ABD cohort. I use data from 1986, 1990 and 1995: years that should not have been affected by the ABD program, and treat 1986 and 1990 as the 'before' period and 1995 as the 'after' period. The treatment (growing) and control (non-growing) groups remain the same. Similarly, the equations to estimate are Equation (2) and (3). To reiterate what was stated previously, the parallel trends assumption is important to interpret the changes in access to electricity as a result of the shift in coca cultivation. If the parallel trends assumption holds, then I should find no differential trends between the placebo 'before' and 'after' cohorts. Empirically, this is equivalent to finding that the coefficient on $coca * after$ is not significantly different from 0.

Table A.7 presents the results for the falsification test for access to electricity. In all columns the estimate for $coca * after$ is not significantly different from 0. Standard errors, which are clustered by departments, are larger than the actual estimates for $coca * after$. The estimates for rural areas are significant at the 1% level and reflect the inequality of public good provision between rural and urban areas. Likewise, the effect of living in a coca growing department is also negative, which is consistent with coca growing departments having a lower level of access to electricity relative to non-growing states. After the implementation of the ABD program, all households have a higher likelihood of receiving electricity and this result holds with statistical significance. Again, the control variables are consistent with those in Tables A.3 through A.6 and are significant at the 1% and 5% levels.

The results of the falsification test provide strong evidence that before 1995 the prevalence of electricity in growing and non-growing regions followed parallel upward trends. These findings are particularly important in determining that the increased access to electricity was a direct result of the ABD program initiatives.

Chapter 7

Concluding Remarks

7.1 Future Research

There is still a large gap in the literature dealing with illegal drug production and economic development. There is also a lack of research on the incentives that drug production creates for governments. This type of research is particularly important for countries like Bolivia, Peru and Colombia that rely heavily on the illegal drug industry. Depending on data availability, the ABD program could be used as a source of exogenous variation for coca cultivation to examine the effects of the drug industry on many other development outcomes. Following the framework outlined in this paper, one could examine access to schools and hospitals, social programs, and so forth. In evaluating these household level effects we will be able to understand how the illegal drug industry affects household behaviour and wellbeing.

Building on Angrist and Kugler (2008), and Acemoglu, Robinson and Santos (2008), a closer examination of the relationship between drug cartels and paramilitary activity may also be relevant, as this link may provide insight into the persistence of conflict and drug production in the Andean region. Angrist and Kugler (2008) graphically examine the trend in homicide rates in growing and non-growing areas and find that the trends in all areas increase after the ABD program was implemented. Homicide rates may be a an adequate proxy for paramilitary activity; however, Acemoglu, Robinson and Santons (2008) provide a measurement of paramilitary activity that may be more inclusive. They use an extensive database from Centro de Estudios sobre Desarrollo Económico (CEDE) which is a compilation of newspaper articles and police reports of many different types of violent acts. This database may be a more accurate representation of paramilitary activity in Colombia than homicide rates alone and could be used to examine the relationship between drug production and paramilitary persistence.

Finally, one can infer from the ABD program's failed attempts at eradicating cocaine that as long as demand for cocaine continues to exist, so will supply; if cocaine production is reduced in one country, the loss will be offset by increases in another country. This suggests a need for alternatives to the current drug eradication policies that are supply-side focussed. Another important field to examine would be the effectiveness of drug eradication policies. The fact that there is a link between the drug industry and the Colombian government's investment decisions indicates that foreign countries who finance the war-on-drugs in Colombia are working at cross purposes with the very same government who receives the funding. This not only affects countries involved in producing illegal drugs, but all countries that are involved in the debate over drug policy.[1]

7.2 Summary and Conclusion

This paper attempts to provide empirical estimates of the effects of drug production on access to household services. The cocaine industry is intertwined with many aspects of Andean culture and economy but little research has been conducted to empirically investigate its effects at the household level. This paper provides evidence suggesting that electricity availability in Colombian coca farming states increased (relative to non-growing states) after an exogenous shift in coca cultivation from Peru to Colombia.

I use the eradication efforts of the Air Bridge Denial Program, implemented by the Peruvian and United States governments in the mid nineties, as a source of exogenous variation for coca cultivation. I exploit this natural experiment by examining the change in access to electricity in growing and non-growing areas. I find that electricity coverage, which is provided by the federal government in Colombia, increased by a greater amount in coca growing departments relative to non-growing departments after the implementation of the ABD program. Specifically, access to electricity increased by 7 percentage points more in growing areas than non-growing areas.

I examine the issue further, by comparing access to electricity to access to water, which is controlled by municipal governments in Colombia. Municipal governments

[1]See the Global Commission on Drug Policy, www.globalcommissionondrugs.org, for more information on current drug policies.

do not have the same level of corruption as federal governments, and therefore may not have the same incentives to invest in drug producing areas, or may not have the money to invest in these areas.

I find that the ABD program had no impact on households' access to piped water. These results hold even after controlling for regional and year fixed effects, household size, whether or not households own a car or truck, and whether they live in an urban or rural centre.

I re-estimate the regressions for access to water and access to electricity, including only rural observations. These results provide the same conclusions and therefore I determine that the results are robust. Furthermore, I perform a falsification test to determine whether the parallel trends assumption holds. The parallel trends assumption is a fundamental assumption for drawing causal inferences from the regression results. As such, the falsification test is integral to providing evidence that the increases in electricity and water were a result of the shift in coca cultivation. The results of the falsification test indicate that before the implementation of the ABD program there were no differential trends in access to electricity between growing and non-growing departments.

While the results in this paper suggest that households received increases in access to electricity as a result of the shift in cultivation, I make no attempt to advocate that the Colombian drug industry is beneficial overall. Many other empirical analyses must be conducted (see section 7.1) in order to build a more thorough body of knowledge on this subject. Nevertheless, my findings provide a previously undocumented effect of cocaine production on the provision of federally controlled household services in Colombia.

Bibliography

[1] Acemoglu, D., Robinson, J., Santos, R. (2008). The Monopoly of Violence: Evidence from Colombia. *National Bureau of Economic Research,* Working Paper No. 15578.

[2] Andreas, P. & Youngers, C. (1989). U.S. Drug Policy and the Andean Cocaine Industry. *World Policy Journal, 6*(3), 529-562.

[3] Angirst, J. & Kugler, A (2008). Rural Windfall or a New Resource Curse? Coca, Income, and Civil Conflict in Colombia. *The Review of Economics and Statistics*, *XC*(2), 191-215.

[4] Anagou, G. (Producer), Avgeropoulos, Y. (Producer), Howe, J. (Photographer), Skoubri, A. (Producer) (2004, June 3). *Colombia - Cocaine War.* United Kingdom: Journeyman Pictures.

[5] B., S. (2011, July 29). Corruption in Colombia: Closer and Closer to the Top. *The Economist.* Retrieved from http://www.economist.com/blogs/americasview/2011/07/corruption-colombia

[6] Barnes, D. & Floor, Willem (1996). Rural Energy in Developing Countries: A Challenge for Economic Development. *Annual Review of Energy, 1996*(21), 497-530.

[7] Bergquist, C., Peñaranda, R., Sánchez, G. (2001). *Violence in Colombia 1990-2000: Waging War and Negotiating Peace.* Wilmington: Scholarly Resources Inc.

[8] CIA World Factbook (2012). *Colombia Fact Sheet.* Retrieved from https://www.cia.gov/library/publications/the-world-factbook/geos/co.html

[9] Corchuelo, A. & Steiner, R. (1999). Repercusiones económicas e institucionales del narcotráfico en Colombis. *Ensayos Sobre Política Cafetera, 1999*(15).

[10] Dammert, A. (2008). Child Labor and Schooling Response to Changes in Coca Production in Rural Peru. *Journal of Development Economics*, *86*(1), 164-180.

[11] Devoto, F., Duflo, E., Dupas, P., Parienté, W., Pons, V. (2011). Happiness on tap: Piped Water Adoption in Urban Morroco. *National Bureau of Economic Research,* Working Paper No. 16933.

[12] Feiling, T. (2009). *The Candy Machine: How Cocaine Took Over the World.* New York: Penguin Group (USA) Inc.

[13] Fiegehen, G. & Lansley, P. (1976). The Measurement of Poverty: A Note on Household Size and Income Units. *Journal of the Royal Statistical Society. Series A (General)*, *139*(4), 508-518.

[14] Giedion, U. & Steiner, R. (1995). Characteristics, Determinants and Effects of Foreign Direct Investment in Colombia. *Foreign Direct Investment in Latin America.*

[15] Global Commission on Drug Policy (2012). Retrieved from http://www.globalcommissionondrugs.org/

[16] Hristov, J. (2009). *Blood and Capital: The Paramilitarization of Colombia.* Ohio: Ohio University Press.

[17] International Energy Agency (2010). *World Energy Outlook Executive Summary.* Retrieved from http://www.iea.org/weo/2010.asp

[18] International Energy Agency & the Organization for Economic Co-Operation and Development (2010). *Energy Poverty: How to Make Modern Energy Access Universal?* Retrieved from http://www.iea.org/weo/docs/weo2010/weo2010_poverty.pdf

[19] Jemelkova, B. & Toman, M. (2003). Energy and Economic Development. *The Energy Journal, 24*(4), 93-112.

[20] El Congreso de Colombia (1994, July 11). *Ley 142 de 1994 Nivel Nacional.*

[21] Marcy, W. (2010). *The Politics of Cocaine.* Chicago: Lawrence Hill Books.

[22] Martin, E. & Symansky, S. (2006). Macroeconomic Impact of the Drug Economy and Counter-Narcotics Efforts. In *Afghanistan: Drug Industry and Counter Narcotics Policy* (pp. 25-45). The World Bank.

[23] Mejía, D. & Posada, C. (2008). Cocaine Production and Trafficking: What Do We Know? *The World Bank Development Research Group*, Working Paper No. 4618.

[24] Morales, E. (1986). Coca and Cocaine Economy and Social Change in the Andes of Peru. *Economic Development and Cultural Change*, *35*(1), 143-161.

[25] Morales, E. (1990). The Political Economy of Cocaine Production: An Analysis of the Peruvian Case. *Latin American Perspectives*, *17*(4), 91-109.

[26] Oquist, P. (1980). *Studies in Social Discontinuity.* New York: Academic Press Inc.

[27] Orces, D. (2009) Municipal Corruption Victimization. *Americas Barometer Insights, 2009*(22), 1-6.

[28] Perafan, C. (1999). *Impacto de Cultivos Ilicitos en Pueblos Indigenas: El Caso de Colombia.* Bogotá: Proyecto de Desarrollo Alternativo (PLANTE).

[29] Rangel, A. (1998). *Colombia: Guerra en el Fin de Siglo.* Bogotá: Tercer Mundo Editores - Universidad de los Andes.

[30] Schurr, S. (1984). Energy Use, Technological Change, and Productive Efficiency: An Economic-Historical Interpretation. *Anuual Review of Energy, 1984*(9), 409-425.

[31] Stockholm International Water Institute (2004). *Making Water a Part of Economic Development: The Economic Benefits of Improved Water Management and Services.* Retrieved from http://www.who.int/water_sanitation_health/waterandmacroeconomics/en /index.html

[32] Transparencia Colombia (2009). *Índice de Transparencia Nacional 2008-2009.* Retrieved from http://www.transparenciacolombia.org.co/INDICES/IndicedeTransparencia Nacional/tabid/105/language/es-ES/Default.aspx

[33] Transparencia Colombia (2009). *Índice de Transparencia Municipal 2008-2009.* Retrieved from http://www.transparenciacolombia.org.co/INDICES/IndicedeTransparencia Municipal/tabid/103/language/es-ES/Default.aspx

[34] Transparency International (1995-2011). *Corruption Perceptions Index.* Retrieved from http://www.transparency.org/policy_research/surveys_indices/cpi

[35] United Nations Office of Drugs and Crime (2007). *Colombia Coca Cultivation Survey 2006.* Retrieved from http://www.unodc.org/pdf/research/icmp/colombia_2006_en_web.pdf

[36] United Nations Office of Drugs and Crime (2011). *Colombia: Monitoreo de cultivas de coca 2010.* Retrieved from http://www.unodc.org/documents/crop-monitoring/Colombia/Colombia-cocasurvey2010_es.pdf

[37] United Nations Office of Drugs and Crime (2011). *2011 World Drug Report.* Retrieved from http://www.unodc.org/unodc/en/data-and-analysis/WDR-2011.html

[38] Uribe, S. (1997). Los Cultivos Ilicitos en Colombia. In F.E. Thoumi, *et al.,* (Ed.) *Drogas Ilicitas en Colombia: Su Impacto Economico, Politico y Social.* Bogotá: Ministerio de Justicia y del Derecho, Direccion Nacional de Estupefacientes.

[39] United States Government Accountability Office (2005). *Drug Control: Air Bridge Denial Program in Colombia Has Implemented New Safeguards, but Its Effect on Drug Trafficking Is Not Clear.* Retrieved from http://www.gao.gov/products/GAO-05-970

[40] Wilkinson, D. (2011, May 24). Death and Drugs in Colombia. *The New York Review of Books.* Retrieved from http://www.nybooks.com/articles/archives/2011/jun/23/death-and-drugs-colombia/?pagination=false

[41] World Bank (2004). *Colombia: Recent Economic Developments in Infrastructure (REDI).* Retrieved from http://www.worldbank.org/transport/transportresults/regions/lac/colombia-redi-exec-summ.pdf

[42] World Health Organization (2012). *Progress on Drinking Water and Sanitation: 2012 Update.* Retrieved from http://www.unicef.org/media/files/JMPreport2012.pdf

[43] World Health Organization & Unicef (2006). *Meeting the MDG Drinking Water and Sanitation Target: The Urban and Rural Challenge of the Decade.* Retrieved from http://www.who.int/water_sanitation_health/monitoring/jmpfinal.pdf

Appendix A

Tables from the text

Table A.1: Descriptive statistics including urban observations

Variable	Pooled 1986-2010	1986	1990	1995	2000	2005	2010
			Panel A: all regions				
electricity	0.948	0.838	0.939	0.915	0.951	0.956	0.962
	(0.222)	(0.369)	(0.240)	(0.280)	(0.215)	(0.206)	(0.192)
Water	0.811	0.640	0.877	0.794	0.846	0.818	0.808
	(0.392)	(0.480)	(0.329)	(0.405)	(0.361)	(0.386)	(0.394)
household size	4.29	5.59	4.78	4.58	4.36	4.30	3.96
	(2.24)	(2.99)	(2.34)	(2.31)	(2.21)	(2.22)	(2.02)
car/truck	0.104	0.121	0.137	0.115	.	0.084	0.109
	(0.305)	(0.327)	(0.344)	(0.319)	.	(0.278)	(0.311)
rural	0.273	0.333	0.145	0.299	0.281	0.293	0.265
	(0.445)	(0.472)	(0.352)	(0.458)	(0.450)	(0.455)	(0.441)
			Panel B: non-growing regions				
electricity	0.962	0.879	0.954	0.930	0.964	0.974	0.973
	(0.191)	(0.326)	(0.210)	(0.254)	(0.187)	(0.161)	(0.161)
water	0.845	0.695	0.906	0.821	0.867	0.857	0.844
	(0.362)	(0.460)	(0.292)	(0.383)	(0.340)	(0.350)	(0.363)
household size	4.20	5.53	4.66	4.48	4.28	4.20	3.86
	(2.18)	(2.90)	(2.27)	(2.24)	(2.17)	(2.14)	(1.95)
car/truck	0.111	0.136	0.146	0.121	.	0.087	0.117
	(0.315)	(0.343)	(0.353)	(0.326)	.	(0.282)	(0.321)
rural	0.245	0.270	0.120	0.280	0.266	0.267	0.234
	(0.430)	(0.444)	(0.325)	(0.449)	(0.442)	(0.424)	(0.439)
			Panel C: growing regions				
electricity	0.908	0.683	0.882	0.846	0.902	0.918	0.931
	(0.289)	(0.466)	(0.323)	(0.361)	(0.297)	(0.275)	(0.254)
water	0.717	0.436	0.769	0.678	0.762	0.736	0.717
	(0.450)	(0.496)	(0.421)	(0.467)	(0.426)	(0.441)	(0.450)
household size	4.52	5.82	5.21	5.03	4.67	4.51	4.20
	(2.38)	(3.30)	(2.54)	(2.53)	(2.35)	(2.36)	(2.16)
rar/truck	0.084	0.064	0.102	0.087	.	0.077	0.088
	(0.277)	(0.244)	(0.302)	(0.281)	.	(0.267)	(0.283)
rural	0.350	0.568	0.238	0.381	0.344	0.349	0.342
	(0.477)	(0.496)	(0.426)	(0.486)	(0.475)	(0.477)	(0.474)

Note: reported means with standard deviations in parenthesis. Source: DHS 1986-2010.

Table A.2: Descriptive statistics excluding urban observations

Variable	Pooled 1986-2010	1986	1990	1995	2000	2005	2010
Panel A: all regions							
electricity	83.45	55.77	67.82	73.68	84.14	87.16	87.79
	(0.372)	(0.497)	(0.467)	(0.440)	(0.365)	(0.335)	(0.327)
water	54.72	28.55	45.15	39.44	50.68	63.35	57.53
	(0.498)	(0.497)	(0.467)	(0.440)	(0.365)	(0.334)	(0.327)
household size	4.53	5.71	5.25	4.91	4.64	4.52	4.17
	(2.43)	(3.28)	(2.68)	(2.57)	(2.37)	(2.36)	(2.19)
car/truck	0.043	0.046	0.063	0.040	.	0.038	0.045
	(0.202)	(0.209)	(0.242)	(0.195)	.	(0.190)	(0.208)
Panel B: non-growing regions							
electricity	87.43	59.12	74.32	77.77	87.84	92.31	91.36
	(0.331)	(0.492)	(0.437)	(0.416)	(0.327)	(0.266)	(0.281)
water	58.32	31.60	50.07	42.90	54.95	68.06	61.29
	(0.493)	(0.465)	(0.500)	(0.495)	(0.498)	(0.466)	(0.487)
household size	4.45	5.64	5.10	4.77	4.61	4.43	4.07
	(2.36)	(3.16)	(2.61)	(2.48)	(2.36)	(2.29)	(2.10)
car/truck	0.043	0.051	0.070	0.044	.	0.038	0.50
	(0.202)	(0.220)	(0.256)	(0.204)	.	(0.191)	(0.217)
Panel C: growing regions							
electricity	75.84	49.69	55.53	60.74	72.81	78.88	81.52
	(0.428)	(0.497)	(0.555)	(0.607)	(0.728)	(0.789)	(0.815)
water	58.32	23.17	35.85	28.51	37.62	55.80	50.92
	(0.500)	(0.422)	(0.480)	(0.452)	(0.485)	(0.497)	(0.500)
household size	4.69	5.82	5.54	5.33	4.74	4.67	4.34
	(2.56)	(3.49)	(2.79)	(2.79)	(2.42)	(2.47)	(2.33)
car/truck	0.037	0.037	0.049	0.028	.	0.037	0.037
	(0.189)	(0.189)	(0.215)	(0.164)	.	(0.190)	(0.189)

Note: reported means with standard deviations in parenthesis. Source: DHS 1986-2010.

Table A.3: Difference-in-differences estimates for access to electricity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
coca*after	0.070**	0.069**	0.074**	0.072**	0.072**	0.072**	0.077**	0.076***
	(0.027)	(0.026)	(0.028)	(0.026)	(0.027)	(0.026)	(0.029)	(0.027)
coca	-0.114***	-0.093***			-0.110***	-0.092***		
	(0.032)	(0.024)			(0.032)	(0.024)		
after	0.063***	0.055***			0.062***	0.055***		
	(0.020)	(0.019)			(0.020)	(0.019)		
rural		-0.132***		-0.128***		-0.127***		-0.125***
		(0.014)		(0.014)		(0.014)		(0.013)
household size					-0.004***	-0.002***	-0.002**	-0.001
					(0.001)	(0.001)	(0.001)	(0.001)
has car/truck					0.041***	0.020***	0.033***	0.017***
					(0.009)	(0.006)	(0.009)	(0.005)
constant	0.916***	0.952***	0.851***	0.891***	0.929***	0.959***	0.861***	0.894***
	(0.024)	(0.016)	(0.030)	(0.028)	(0.023)	(0.017)	(0.031)	(0.029)
Observations	106062	106062	106062	106062	95137	95137	95137	95137
Adjusted R^2	0.035	0.112	0.069	0.132	0.044	0.114	0.073	0.133
F	28.30	45.10	.	.	21.11	32.29	.	.

Notes: standard errors in parentheses, clustered at the departmental level. Sample weights included in all regressions.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.4: Difference-in-differences estimates for access to water

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
coca*after	0.036	0.031	0.044	0.039	0.032	0.031	0.043	0.041
	(0.042)	(0.036)	(0.040)	(0.033)	(0.044)	(0.038)	(0.042)	(0.035)
coca	-0.172***	-0.113***			-0.165***	-0.113***		
	(0.055)	(0.039)			(0.054)	(0.040)		
after	0.062**	0.041**			0.056**	0.038**		
	(0.023)	(0.018)			(0.022)	(0.017)		
rural		-0.360***		-0.339***		-0.347***		-0.326***
		(0.023)		(0.020)		(0.024)		(0.022)
household size					-0.007***	-0.003*	-0.003	0.001
					(0.002)	(0.001)	(0.002)	(0.001)
has car/truck					0.061***	0.003	0.032*	-0.008
					(0.016)	(0.009)	(0.019)	(0.008)
constant	0.816***	0.914***	0.760***	0.866***	0.842***	0.923***	0.772***	0.858***
	(0.049)	(0.026)	(0.033)	(0.029)	(0.046)	(0.025)	(0.034)	(0.031)
Observations	106085	106085	106085	106085	95140	95140	95140	95140
Adjusted R^2	0.029	0.206	0.112	0.247	0.035	0.194	0.118	0.239
F	30.86	80.60	.	.	38.93	56.97	.	.

Notes: standard errors in parentheses, clustered at the departmental level. Sample weights included in all regressions.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.5: Difference-in-differences results for access to electricity without urban observations

	(1)	(2)	(3)	(4)
coca*after	0.068	0.065	0.072	0.075
	(0.053)	(0.052)	(0.052)	(0.052)
coca	-0.154***		-0.150***	
	(0.051)		(0.049)	
after	0.192***		0.193***	
	(0.038)		(0.042)	
household size			-0.007***	-0.003**
			(0.001)	(0.001)
has car/truck			0.113***	0.099***
			(0.014)	(0.014)
constant	0.731***	0.573***	0.761***	0.593***
	(0.040)	(0.050)	(0.043)	(0.056)
Observations	28868	28868	25797	25797
Adjusted R^2	0.075	0.123	0.090	0.132
F	45.47	.	61.95	.

Notes: standard errors in parentheses, clustered at the departmental level.
Sample weights included in all regressions.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.6: Difference-in-differences results for access to water without urban observations

	(1)	(2)	(3)	(4)
coca*after	-0.013	-0.009	-0.009	0.008
	(0.050)	(0.053)	(0.051)	(0.054)
coca	-0.080		-0.073	
	(0.064)		(0.063)	
after	0.218***		0.221***	
	(0.033)		(0.032)	
household size			-0.010***	-0.007***
			(0.003)	(0.002)
has car/truck			0.083***	0.075***
			(0.018)	(0.016)
constant	0.415***	0.378***	0.461***	0.423***
	(0.041)	(0.056)	(0.043)	(0.060)
Observations	28874	28874	25798	25798
Adjusted R^2	0.037	0.098	0.046	0.107
F	26.91	.	21.61	.

Notes: standard errors in parentheses, clustered at the departmental level.
Sample weights included in all regressions.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.7: Falsification test results for access to electricity

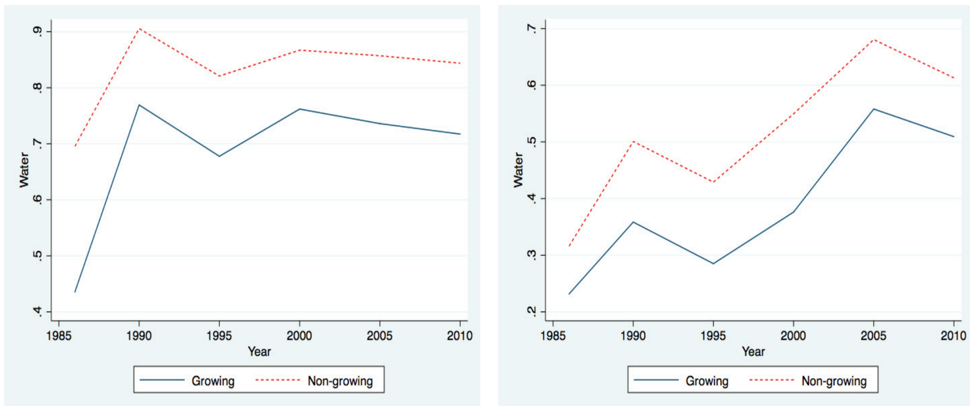
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
coca*after	0.057	0.034	0.045	0.024	0.057	0.035	0.046	0.025
	(0.060)	(0.056)	(0.059)	(0.056)	(0.059)	(0.056)	(0.059)	(0.056)
coca	-0.142***	-0.084**			-0.133***	-0.082**		
	(0.040)	(0.038)			(0.039)	(0.037)		
after	0.030**	0.032***			0.024*	0.030**		
	(0.012)	(0.011)			(0.012)	(0.011)		
rural		-0.286***		-0.273***		-0.280***		-0.270***
		(0.033)		(0.029)		(0.033)		(0.029)
household size					-0.007***	-0.003**	-0.003**	0.000
					(0.002)	(0.001)	(0.001)	(0.001)
has car/truck					0.103***	0.044**	0.072***	0.036**
					(0.024)	(0.018)	(0.024)	(0.013)
constant	0.902***	0.979***	0.870***	0.958***	0.924***	0.985***	0.881***	0.950***
	(0.027)	(0.009)	(0.020)	(0.019)	(0.028)	(0.012)	(0.023)	(0.023)
Observations	21786	21786	21786	21786	21756	21756	21756	21756
Adjusted R^2	0.027	0.206	0.116	0.249	0.042	0.209	0.123	0.250
F	11.19	57.77	.	.	28.06	42.28	.	.

Notes: standard errors in parentheses, clustered at the departmental level. Sample weights included in all regressions.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix B

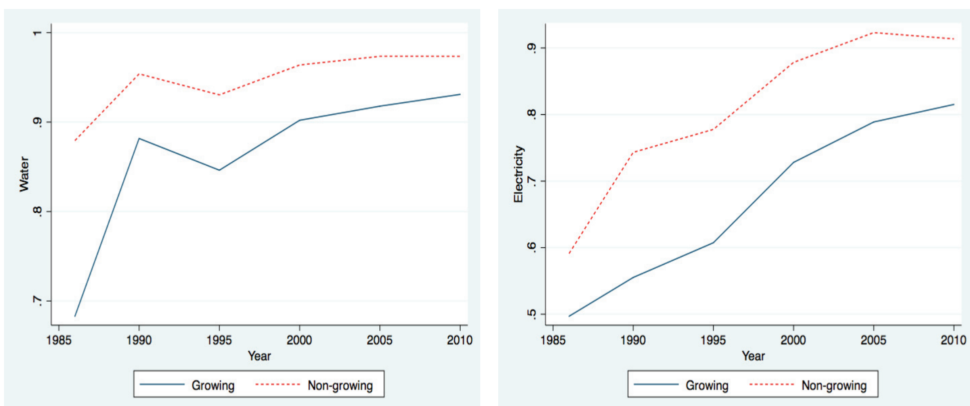
Figures without sample weights

The following figures correspond with Figure 3.1 and 3.2 from the text. They demonstrate the trends in access to electricity and water over the time period of the study without including the sample weights provided by DHS.



(a) Including urban observations (b) Excluding urban observations

Figure B.1: Mean of household access to piped water. Separated by growing and non-growing areas. DHS 1986-2010 survey data used to calculate means.



(a) Including urban observations (b) Excluding urban observations

Figure B.2: Mean of household access to electricity. Separated by growing and non-growing areas. DHS 1986-2010 survey data used to calculate means.

Appendix C

Results without sample weights

The following two tables present the results of Equation (2) and Equation (3) without including the sample weights provided by DHS. The results are concurrent with those in the text.

Table C.1: Difference-in-differences results for electricity (without sample weights)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
coca*after	0.054*	0.049*	0.055**	0.055**	0.053*	0.047*	0.057**	0.057**
	(0.027)	(0.026)	(0.025)	(0.025)	(0.028)	(0.027)	(0.026)	(0.026)
coca	-0.103***	-0.082***			-0.099***	-0.080***		
	(0.031)	(0.023)			(0.030)	(0.022)		
after	0.044**	0.048***			0.043**	0.048***		
	(0.017)	(0.015)			(0.018)	(0.016)		
rural		-0.152***		-0.145***		-0.149***		-0.143***
		(0.018)		(0.018)		(0.018)		(0.019)
household size					-0.004***	-0.002***	-0.002***	-0.001
					(0.001)	(0.001)	(0.001)	(0.001)
has car/truck					0.051***	0.025***	0.040***	0.021***
					(0.009)	(0.006)	(0.009)	(0.004)
constant	0.928***	0.962***	0.851***	0.897***	0.942***	0.969***	0.860***	0.899***
	(0.021)	(0.014)	(0.029)	(0.027)	(0.021)	(0.015)	(0.030)	(0.028)
Observations	106062	106062	106062	106062	95137	95137	95137	95137
Adjusted R^2	0.023	0.114	0.067	0.139	0.031	0.117	0.071	0.141
F	15.84	33.16	.	.	14.19	23.15	.	.

Notes: standard errors in parentheses, clustered at the departmental level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table C.2: Difference-in-differences results for water (without sample weights)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
coca*after	0.045	0.026	0.036	0.033	0.044	0.031	0.039	0.040
	(0.049)	(0.044)	(0.037)	(0.033)	(0.053)	(0.049)	(0.041)	(0.037)
coca	-0.168***	-0.115***			-0.163***	-0.120***		
	(0.051)	(0.037)			(0.051)	(0.039)		
after	0.030	0.039**			0.000	0.011		
	(0.022)	(0.016)			(0.025)	(0.019)		
rural		-0.353***		-0.328***		-0.337***		-0.313***
		(0.023)		(0.025)		(0.024)		(0.028)
household size					-0.008***	-0.004**	-0.003**	0.000
					(0.002)	(0.002)	(0.001)	(0.001)
has car/truck					0.065***	0.007	0.036***	-0.007
					(0.016)	(0.012)	(0.012)	(0.008)
constant	0.822***	0.901***	0.670***	0.779***	0.876***	0.937***	0.773***	0.858***
	(0.040)	(0.023)	(0.024)	(0.023)	(0.041)	(0.025)	(0.032)	(0.030)
Observations	106685	106685	106685	106685	95140	95140	95140	95140
Adjusted R^2	0.023	0.183	0.126	0.247	0.028	0.171	0.130	0.239
F	7.592	74.74	.	.	24.15	65.00	.	.

Notes: standard errors in parentheses, clustered at the departmental level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$