Essays on the Economics of the Colombian Armed Conflict and Violence

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Declaration

I, Jaime Augusto Milllán Quijano, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in this thesis.

Jaime Augusto Millán Quijano

Abstract

This thesis uses microeconometric methods to study the armed conflict in Colombia.

Chapter 2 uses geographical and temporal variation in potential drug trafficking networks to instrument for the prevalence of violent crime in different regions of Colombia. Using changes in the prices of different international cocaine markets I identify exogenous changes in violence at municipality level. I exploit the comparative advantage that different regions in Colombia have when they are serving either the cocaine market in the US or Europe. My results suggest that homicide rates increase according to the comparative advantage each municipality has in the drug trade. However, I do not find strong evidence of the influence of drug trade over the placement and actions of left wing guerrillas or right wing paramilitary groups.

Thereafter, chapter 3 uses the exogenous variation from drug trafficking to analyse the effect of homicides on the prevalence of early motherhood. My results suggest the one standard deviation increase in the homicide rate induces 2.65 p.p. increase in the probability of early motherhood.

Chapter 4 proposes a microeconomic framework to describe the features of an optimal reintegration contract. In my model, a Principal (government) collects taxes from the community in order to fund a reintegration contract with the Agents (illegal soldiers). This contract involves a set of threats and benefits. The shape of such threats and benefits depends on the relative productivity of the security technology and the level of absorption of the labour markets.

Last chapter concludes.

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Nomenclature and Definitions

ACR	Alta Consejeria para la Reintegración (Office of the High Commissioner of Peace)
ADO	Movimiento de Autodefensa Obrera (Workers Self-Defence Movement). Colombian former guerrilla group.
AUC	Autodefensa Unidas de Colombia (United Self-Defence Forces of Colombia). Colombian paramilitary group.
CC	Civil Community
CEDE	Centro de Estudios sobre Desarrollo Económico, Los Andes University
CERAC	Centro de Recursos para el Análisis de Conflictos (Conflict Analysis Resource Center)
CRP	Colombian Reintegration Programme
DANE	Departamento Administrativo Nacional de Estadística (National Statitics Bureau)
DDR	Disarmament, Demobilization and Reintegration
Demobilization	refers to the process by which parties to a conflict begin to disband their military structures and combatants begin the transformation into civilian life. It generally entails registration of former combatants; some kind of assistance to enable them to meet their immediate basic needs; discharge, and transportation to their home communities. It may be followed by recruitment into a new, unified military force. From Annan (2000)
DHS	Demographic and Health Survey. http://legacy.measuredhs.com/start.cfm

Disarmament	is the collection of small arms and light and heavy weapons within a conflict zone. It frequently entails the assembly and cantonment of combatants; it should also comprise the development of arms management programmes, including their safe storage and their final disposition, which may entail their destruction. Demining may also be part of this process. From Annan (2000)
DNE	Dirección Nacional de Estupefacientes (National Anti-Narcotics Bureau)
DNP	Departamento Nacional de Planeación (National Planning Bureau)
DRC	Government of the Democratic Republic of Congo
EPL	Ejército Popular de Liberación (Popular Liberation Army). Colombian former guerrilla group.
FARC	Fuerza Armadas Revolocionarias de Colombia (Colombian Revolutionary Armed Forces). Colombain guerrila group.
IAG	Illegal Armed Group
IDDRS	Integrated DDR Standards
IGAC	Instituto Geográfico Agustín Codazzi. The Colombian National Geographic Office
IS	Illegal Soldier - Combatant
M-19	Movimiento 19 de Abril (19th of April Movement). Colombian former guerrilla group.
MDRP	Multi-Country Demobilization and Reintegration Programme
ODC	Observatorio de Drogas de Colombia (Colombian Illegal Drug Observatory)
OSAA	United Nations, Office of the Special Adviser on Africa
PRSE	Política Nacional de Reintegración Social y Económica para Personas y Grupos Armados Ilegales (National Policy for the Social and Economics Reintegration of Illegal Armed Groups). See COMPES 3554 - DNP (2008).

Reintegration	refers to the process which allows ex-combatants and their families to adapt, economically and socially, to productive civilian life. It generally entails the provision of a package of cash or in-kind compensation, training, and job- and income-generating projects. These measures frequently depend for their effectiveness upon other, broader undertakings, such as assistance to returning refugees and internally displaced persons; economic development at the community and national level; infrastructure rehabilitation; truth and reconciliation efforts; and institutional reform. Enhancement of local capacity is often crucial for the long-term success of reintegration. From Annan (2000)
RP	Reintegration Programme
SIG-OT	Sistema de Información Geográfica para la Planeación y el Ordenamiento Territorial (Geographic Information System for Territorial Planning).
SIMCI	Sistema Integrado de Monitoreo de Cultivos Ilícitos (Illicti Crops Monitoring Integrated System)
TFR	Teenage Fertility Rate or Adolescent fertility rate is the number of births per 1,000 women ages 15-19.
UN	United Nations
UNUDC	United Nations Office on Drugs and Crime

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To all of you, thank you.

Chapter 1

Introduction

Colombia has suffered a violent conflict for more than 50 years. Some authors argue that the conflict began with *"La Violencia"*, a civil war between the two most important political parties in the 1950s. Since then, guerrillas, paramilitaries, drug lords and many other armed agents have changed the violent scenario of Colombia.

For this reason, the study of the dynamics of the violent processes and their impact on the economic institutions have called the attention of many researches. However, the characteristics of the conflict impose many challenges especially when attempting to quantify the effects. This thesis aims to contribute to the analysis of the cost of armed conflict using different microeconometric methods.

Chapter 2 uses the internal potential cocaine trafficking to estimate exogenous changes in violent crime rates at municipality level in Colombia. Firstly, I build the network of internal cocaine trafficking linking the municipalities with potential coca fields with the municipalities on the Colombian borders using the system of primary and secondary roads. Secondly, I divide the network according to the frontier where each route finishes. The division allows me to distinguish four different trafficking clusters: Pacific coast, Atlantic coast, the northern border with Venezuela and the southern border with Venezuela.

The later division give us geographical variation on the comparative advantage that some municipalities have on the cocaine supply to different international markets. For that reason, I use a reduce form approach that uses the interaction of the wholesale price of cocaine in the American and European markets, and the potential trafficking network in order to find exogenous variation on crime over different regions in Colombia. Identification relies on the following statement:

Drug dealers react to the relative profits they could get in the international markets. Thus, an increase in the cocaine price at one market (keeping the price in the other market constant) should increase the level of violence on the municipalities strategically placed to supply that market. The violence that results from this international price variation is orthogonal to the characteristics of the local economic agents, for instance households or firms.

The main arguments to support my identification are the following: (1) Mejia and Rico (2010) showed that 70% of the added value of the coca market in Colombia is due to traffic. (2) According to Fiorentini and Peltzman (1996), Kugler et al. (2005) and Restrepo (2009) violence is used to enforce contracts in illegal markets. If trafficking of cocaine is illegal one would expect that the control of trafficking would result in violence from drug dealers seeking higher profits. Chimeli and Soares (2010) found that violence increases in some regions in the Brazilian Amazon when the traffic of Mahogany became an illegal activity. (3) Finally, I control for the price of cocaine in the cities of Colombia to account for possible supply shocks that may affect the final price.

As expected, my results suggest that homicide rates increase in the Pacific, Atlantic and North-Venezuelan borders when the wholesale price of cocaine increases in the United States. Meanwhile, the homicide rate increases in the South-Venezuelan border when the price of cocaine increases in Europe. After analysing the fitness of my estimations I found a clear exogenous variation that allow us to analyse the impact of homicides over different municipality outcomes in the future.

Moreover, I found evidence that guerrilla groups seek the benefits from the profits of cocaine traffic. On the one hand, I found that the FARC increase its presence in the eastern part of the country when the price of cocaine increases in Europe. On the other hand, the ELN moves either to the Pacific and North-Venezuelan border when the price in the United States increases, or to the South-Venezuelan border when the price in Europe increases. Nevertheless, potential drug trafficking is not as good predictor of guerrilla movements as it is of the homicide rates at municipality level.

Chapter 3 investigates whether armed violence affects the incentives of young women regarding the timing of their first pregnancies. The hypothesis is that violent crimes change the cost-benefit function of postponing motherhood. In order to test this hypothesis, I initially set up a theoretical framework following the work of Kearney and Levine (2011) in order to describe the channels in which violence could affect women pregnancy decisions. Afterwards, using the Colombian Demography and Health Survey (DHS), I estimate a discrete duration model to quantify the effect of the homicide rate on the probability of woman to be pregnant for the first time when she is younger than 19 years old. For the estimations I use the results of the previous chapter as a source of exogenous variation in the municipality level homicide rate.

My results suggest that an increase of one standard deviation in the municipality homicide rate increases by 2.65 p.p. the probability that a woman gets pregnant before the age of 19 . Moreover, the effect is stronger for women from 15 to 19. The latest result suggest that homicides affect the decision of women when they are finishing high school. They may be analysing their choices of further education, work or starting a family. Furthermore, given the strong distributional assumptions for the duration model, I check different functional forms for the hazard function and the control function to prove that the results are not driven by the initial distributional assumptions. My results hold over different specifications. What is more, I found evidence of non-linearity in the control function.

Chapter 4 is marginally different to the previous two. I develop a Principal-Agent model to understand the shape of an optimal reintegration contract. I pay particular attention to the influence of the informational asymmetries on the model outcomes. Firstly, I set up a game between one principal (government) and one agent (excombatant) following the literature on optimal welfare such as Shavell and Weiss (1979). The Principal chooses optimally the benefit and security scheme in order to incentivise the Agent to leave his/her illegal armed group - IAG - and look for a job in the legal market. I show how the benefit shape will depend on the relative productivity of the security technology and the way that labour markets prize the job searching.

Afterwards, I extend the model introducing heterogeneity in the agents preferences for war. I assume that combatants who gain more utility from war will be able to impose more significant damages to the community as well. What is more, I model the role of the tax payer who will decide the size of the Principal's budget constraint. In this model the monotonicity assumption on the agents utility and the way that security reduces the utility of criminal activities allows the Principal to find a *turning combatant.* This *turning combatant* will be indifferent between demobilisation or staying at war. Then, any combatant with less war preferences than the *turning combatant* will join the reintegration programme. Those remaining will stay at the IAG.

This later chapter aims to fill a gap in the economic analysis of the Demobilisation, Disarmament and Reintegration - DDR - programmes. These programmes have dominated the policy agenda in countries that have suffered internal violent confrontations. However, there is no technical analysis of the economic implications of these programmes.

Last chapter discuss the findings and implications of this dissertation.

Chapter 2

Internal Cocaine Trafficking and Violence in Colombia

2.1 Introduction[1]

There is increasing interest to understand the forces and mechanisms by which war, crime and conflict affect economic institutions. However, the analysis of internal conflicts usually deals with large heterogeneity in terms of causes, participants, characteristics and consequences. For example, Collier and Hoeffler (1998) analyse the way that different institutions could be the cause of civil war. What is more, Collier et al. (2001) analyses the factors that could determine durations of the confrontations.

Besides, according to the data from Gleditsch et al. (2002)[2] internal confrontation last from less than a year to 50 years or more. Despite the majority of conflicts finished before the first 2 years of their onset, around 20% of confrontations lasted more than 20 years. Long-lasting conflicts could modify the internal structure of markets, institutions and household decision process.

Apart from the different causes and characteristics, more analytical problems arise due to the multiple dimension of violence and conflict affecting economic agents and institutions. Soares (2013) reviews the different welfare implications

[1]I want to thank Daniel Mejía and participants of the 3rd AL CAPONE meeting and the 7th ISSDP meeting for their valuable comments and feedback. Special thanks to Fabio Sanchez from CEDE (Los Andes University, Bogotá Colombia) who provided me the violence data. Finally I want to thank Carolina Restrepo for her exceptional help in data organisation.

[2]Some descriptive statistics of the durations of internal conflicts can be seen at table 2.9 in the appendix of this chapter.

of conflict and violence. The author categorises the possible consequences as follows: firstly, there are direct losses as greater insecurity causes lifespan reductions and behavioural changes. Secondly, there is a social cost in the destruction of goods, public and private investment in security, and the cost of justice and imprisonment. Finally, crime can be the cause of productivity reductions or less investment as a response to shorter lifespans.

Each conflict scenario implies different challenges when researchers seek to identify the economic effects of violence. Mainly, when researchers look for exogenous violent shocks. This work aims to contribute with a new strategy to find exogenous changes in violent crime.

In some cases, when the causes and characteristics of the violent process is clear, it is usually possible to identify how this violence affects economic agents. Some authors used specific time/location violent shocks to identify effect of conflict on household decisions, particularly education, marriage and fertility. Among others Jayaraman et al. (2009); Khlat et al. (1997); Schindler and Brück (2011); Valente (2011); Shemyakina (2009); Abramitzky et al. (2010) use different civil war events in different environments to identify causal effects.

Nevertheless, there are not to many cases where identification of causality is clear. It that sense, many other authors deal with more difficult frameworks when they want to find clear exogenous violent shocks in order to analyse the effects on the economy agents. This work follows the line of Dube and Vargas (2013) who asses the effect of international commodity shocks over the violence in Colombia, where the internal conflict has been ongoing for over 60 years.

The Colombian conflict is unique not only for its duration. It combines as well different armed actors with different roles in history. Firstly, left wing guerrillas and right wing paramilitary armies have been fighting each other and fighting the state at a local and central level. Secondly, cropping, production and trafficking of cocaine created another violent force in the country since the war against big cartels in the 80's and beginning of the 90's. Afterwards, the cocaine violence turned into war amongst small criminal organisations over the profits of the illegal drugs. Sánchez et al. (2003) present a very detailed review of how the role of different agents evolved during this conflict. In total, from 1964 to 2013 Colombia registered 756197 homicides. The number of violent kills is similar to the total population of Krakow (Poland) or Leeds (UK).

It is straight forward to claim that cocaine markets are part of the causes of the violence in Colombia. This is clear base on the important role that the country plays in the international war on drugs (by 2000 the country represented 70% of the total worldwide supply of cocaine). Most previous analyses have focused in the relationship between production of cocaine and violence (see for example Díaz and Sánchez (2004) and Angrist and Kugler (2008)). However, I claim that the internal trafficking of cocaine, as opposed to production, is the main factor in explaining the progression of violence in Colombia. The following reasons support my argument.

First, Mejia and Rico (2010) showed that the proportion of the total profits of he cocaine market that goes to traffickers is at least 4 times the proportion that goes to the coca leaf farmers and producers. This means that there are more incentives to exert violence in order to control the traffic than incentives to control the fields. Secondly, Dávalos et al. (2011) showed that environmental variables, such as weather and rain do not explain the probability of cropping cocaine in a municipality in Colombia. According to the authors, the main factors to explain the existence of coca fields are related with economic institutions. Finally, the link between illegal business and crime comes from the incapacity of the different parts to enforce contracts without the use of violence. This idea was developed by Fiorentini and Peltzman (1996) following the model of crime proposed by Becker et al. (1960); Becker (1968).

Therefore, the main purpose of this chapter is to show how drug traffickers adjust their decisions according to changes in the relative expected profits in international markets. Further, their use of the road networks varies in time. Assuming that violence is used in order to gain control over the possible traffic routes, changes in the optimal use of the network would create exogenous changes in the violent forces over different regions over time. In order to be able to capture this time-region variation, I construct the network that links producing municipalities with the municipalities at the national border where the cocaine is finally sent to international consumers.

My strategy follows closely the ideas of Dube and Vargas (2013). The interest in internal illegal traffic parallels to the works of Dell (2011) and Robles et al. (2013) who analyse drug traffic in Mexico. Nevertheless, one of the main novelties of my work is that I exploit the comparative advantage that each municipality has when serving each international market. This allows me to estimate different violent reactions in different regions when different international prices change.

This chapter is organised as follows. After this introduction, section 2.2 presents a review of the main features of the international cocaine market and the participation of Colombia in this market. Section 2.3 develops the estimation strategy describing the construction of the networks of drug trafficking throughout Colombia. Following the estimation strategy I describe the data in section 2.4. Afterwards, I present the results of the impact of drug trafficking on homicides and the actions of illegal armed groups. Finally, section 2.6 concludes.

2.2 The Cocaine Market

This section describes the main features of the cocaine markets around the world with particular emphasis on Colombian's role in cocaine markets. I describe production, consumption, trafficking and the efforts of the so called "war on drugs". This section also presents a review of the literature that explains the link between the illegal cocaine market and violence.

The market for cocaine includes different agents and stages; from the fields in the producing countries, to the final consumers within the consumer countries. During the 1980's and early 1990's the entire Colombian market was controlled by a small number of powerful mafias. However, the main groups were destroyed, the market divided into many smaller groups who compete in each stage of the chain (Echandia (2013)).

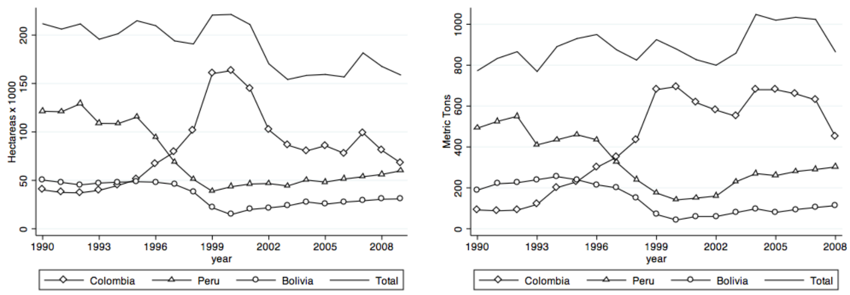
According to different studies from the United Nations Office on Drugs and Crime UNODC (2011) 7 stages are identified from the Andean production to the American streets. Firstly, farmers sell coca leaves to local laboratories who produce coca base. Then, cocaine is sold to local traffickers who aim to take the coca base to ports. At the ports, cocaine is bought by transnational traffickers. These traffickers ship the cocaine to traffickers in Mexico and sometimes in the Caribbean. The latter groups smuggle the cocaine across the US border, where it is sold to wholesalers. This wholesalers sell the product to local mid-level dealers who finally sell cocaine to street dealers in US cities.

According to UNODC statistics only 1.5% of the revenues go to Andean farmers. 98% of revenues are received by local and international traffickers. The European market structure is similar, although international traffic is principally carried out by groups operating in West African countries and Spain. This section will describe each part of the market from production to consumption.

Firstly, the conditions needed to grow coca bushes are found in three South American countries: Bolivia, Colombia and Peru. These countries produce virtually all the world's cocaine. Figure 2.1 shows the evolution of the coca fields and the potential cocaine production in each country. As we can see in panel a, Colombian cropping was increasing from 1990 to 2000. This replaced the cropping in Bolivia and Peru, keeping the total world area of fields at around 200 thousand hectares. By 2000, Colombia accounted for 73% of the total coca crops. After 2000 the area of coca bushes in Colombia fell to around 50%, and increased in Peru and Bolivia. Panel b shows similar cocaine production trends before 2001, although the production does not fall as much as the cropping. This difference could be driven by technological developments to make crops and production more efficient.

Figure 2.1: Andean Production of Coca and Cocaine by Country (1990 - 2009)

(a) Hectares of Coca Leaves Fields (b) Potential Cocaine Production



Source: World Drug Report - UNODC. Coca leave crops are estimating after eradication programmes. See UNODC (2010)

There have also been significant changes in consumption of cocaine over the same period. According to **?** consumption of cocaine was not considered a major problem in Europe in 1997. Only 3% of the treated patients for drug abuse were cocaine users. In contrast, in North America 40% of drug abuse was cocaine related. Since 1998, the consumption in the EU increased while it declined in the US. Therefore while in 1998 the difference in consumption between the two regions was around 200 metric tons, by 2009 the quantities consumed in EU were only 34 metric tons less than the consumption in the US.

Panel a in Figure 2.2 shows the total amount potentially consumed in Europe and the US[3]. According to UNODC estimations, by 2008 the total number of cocaine consumers in the world was around 15.9 millions with 6.2 and 4.1 in North America and EU[4] respectively. This two regions represent 65% of the world consumers. Panel b show the estimated number of consumers in the world. While

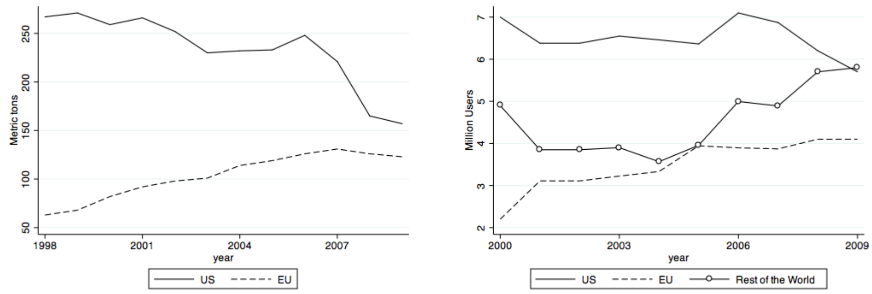
[3]There are no statistics about the exact consumption of cocaine. Thus, estimations are based on potential production, seizures and consumptions surveys.

[4]From the UNODC studies the European regions includes the 27 countries of the European Union (EU) and the four countries of the European Free Trade Association (EFTA).

the US market seems stable, and only showed a decrease after 2006, the other markets in the world have increased since 2002. Consequently, by 2009 Europe, the US and the rest of the world[5] share equally the world cocaine market.

Figure 2.2: Consumption of Cocaine in Europe and United States

(a) Cocaine consumption (b) Cocaine consumers



Source: World Drug Report – UNODC

It is important to point out the great decline in US consumption since 2006. From 2006 to 2007 the amount of cocaine consumed in the US fell 10%. This trend continued until 2009. The result is a 32% decrease from 2006 to 2009. This signifies a decrease of more than 1 million consumers in the US. As I will show later, this decrease is accompanied by an increase price of cocaine (wholesale and street markets). Nevertheless, the fall in consumption does not stem from a dramatic fall in production or very strong increases in consumption in other regions.

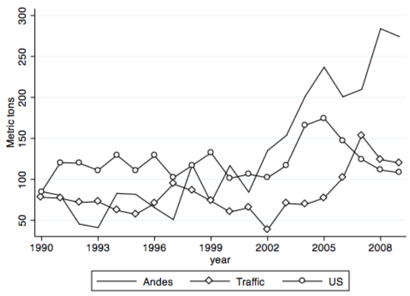
As we can see in figure 2.3, there is an increase in the amount of cocaine seized from 2000 in the origin countries. What is more, from 2005 to 2007 the seizures en route to the American market show a sharp increase. However, the amounts seized in the final markets (US and EU), decreased after 2005.

After analysing the supply, traffic and demand of cocaine, I describe the evolution of prices in consumer regions. Panel a of figure 2.4 shows the continuous fall of wholesale prices in Europe and United States from 1990 to 1999. This fall, according to **?**, was due to the changes in the composition of the supply and traffic after the disintegration of the Colombian cartels. After the new scheme in the production and traffic, prices were stable in Europe. However, the United States price continued falling until 2006. By 2006 we observe the biggest gap between EU and US, when the difference was 17USD. However, following the drop in the

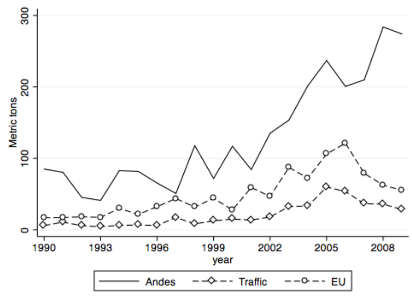
[5]Rest of the world adds up the consumption of Eastern Europe, Pacific countries, South America and Africa.

Figure 2.3: Cocaine seizures by international market

(a) From Andes to US



(b) From Andes to EU

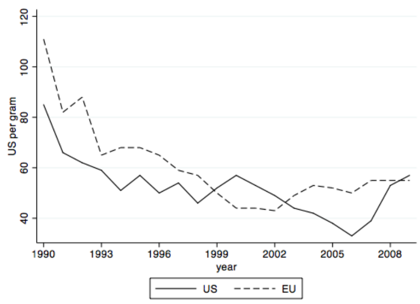


Source: World Drug Report – UNODC. Andes includes Colombia and Peru. Traffic to US adds Mexico, Central America and Caribbean countries. Via to EU adds Venezuela and West Africa

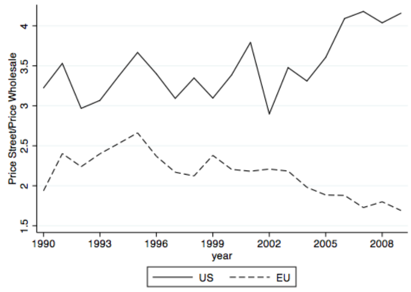
US consumption rates, the price in the United States sharply increased until 2009, when it finally reached the European price.

Figure 2.4: Wholesale price and street price mark up of cocaine in Europe and United States

(a) Cocaine wholesale price



(b) Street price mark up – $\frac{Street\ Price}{Wholesale\ Price}$

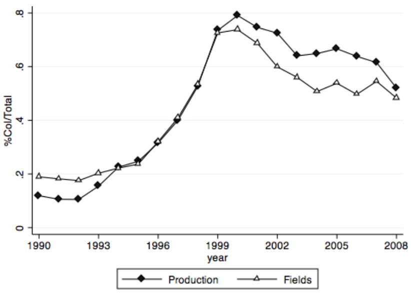


Source: World Drug Report – UNODC. Prices in current USD of 2009. Prices are purity corrected.

Panel b shows the mark up – $mk_i = \frac{Street\ Price_i}{Wholesale\ Price}$ – inside each of the consumer areas. The trends show differences from one another. The European market does not have much volatility and only showed a slightly increase in the early 90's followed by a constant but slow decrease. The American market shows a volatile mark up, increasing from 2002 onwards. It is important to point out the difference in levels: the American market has, on average, a mark up of 3.5 USD while the mean European mark up mean is 2.1 USD. Furthermore, in 2009, when both wholesale prices were equal, the mark up difference is 2.4 USD (4.2 in US and 1.7 in EU). This can be an indicator of greater market power for the transnational traffickers going to Europe.

In the last part of this section I describe the role and dynamics of the cocaine market in Colombia. I focus in the cropping, production and internal trafficking. As I have already shown in figure 2.1, since 1997 Colombia has been the main supplier of cocaine in the world. Figure 2.5 shows clearly the increase in Colombian participation in either cropping and production that reached almost 80% of the share in 2000. Importantly, after 1999 the share of Colombian production was larger than the share in cropping. This suggest that improved productivity may be a response to the increased pressure on crop eradication, which I will describe next.

Figure 2.5: Colombian share in the cocaine production

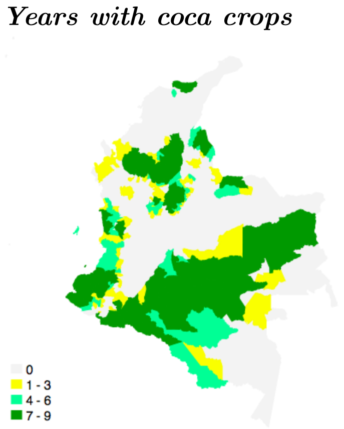


Source: World Drug Report – UNODC. Eradication's includes manual and aerial

The total production and cropping is not the only change over this period of time. Following the reports from the Coca Monitoring System (SIMCI), we can observe that cocaine fields have been moved around different regions of Colombia. Figure 2.6 shows the prevalence of the coca crops from 2001. The map shows, in different colours, the number of years that a municipality has more than 20% of its area for the use of coca cropping. Then, in dark green we find the areas with coca fields for more than 7 years. The table attached to the map marks changes in the cropping strategy. In 2001 Colombia had fewer municipalities with large areas cultivated – 130 hectares on average which represented 63% of the area of each municipality. By 2009, there were more municipalities involve but with smaller fields – 61 hectares on average.

Even though Colombian's main role in the cocaine market is cropping and production, Mejia and Rico (2010) show that they represent no more than 30% of the internal added value chain. However, internal traffic accounts for almost 70% of the added value of the market of cocaine. This feature is part of my identification strategy that will explain in more detail later in this chapter. To summarise, the authors calculations showed that by 2008 the cocaine industry represents 2.3% of the Colombian GDP. This number is lower than previous estimations of 4% to 5% from 1982 to 1998 – see Steiner (1998).

Figure 2.6: Coca crops prevalence (2001 - 2009)



Year	Municipalities with coca fields	Hectares cultivated *(average)*	% of area cultivated *(average)*
2001	164	129.06	0.63
2002	168	90.97	0.33
2003	185	76.94	0.34
2004	190	71.61	0.36
2005	190	76.43	0.36
2006	199	69.40	0.36
2007	190	86.52	0.51
2008	206	72.15	0.45
2009	217	60.63	0.38

Source: SIMCI – UNODC. Author calculations.

Since this chapter focuses on the effect of internal cocaine trafficking, the last part of this section describes some features of its structure. I use the analysis of Mejia and Rico (2010). The authors point out that different structures depend on the level of participation of the illegal armies – either left wing guerrillas or paramilitary armies – who are usually the owners of the crops. In some cases illegal armies sell directly from the laboratory transferring the traffic risk to the buyer who is usually a national trafficker. In other cases, illegal groups share the risk with traffickers. According to the authors, this has been the most common approach used by FARC when they sell the cocaine to the American market via the Pacific and Central America.

Another recent change in the market structure is the relationship between different illegal armed groups. Previously, paramilitary and guerrillas fought for the control of production and traffic. However, currently the new criminal organisations and traffickers enter into business with the main illegal armies without taking into account their political orientation. What is more, in some regions former paramilitaries and guerrillas have joined forces to control cocaine trafficking (see Echandia (2013)).

This section described the main features of production and consumption of cocaine and the role of Colombia in the market. However, the evolution of international and internal trafficking will be described in more detail in the later sections. Trafficking is indeed the key feature of the market that I am exploiting in order to estimate exogenous variation in the violence in Colombia at the municipality level.

2.3 Estimation Strategy

This chapter claims that in Colombia violent crime is more prevalent along the routes used for drug trafficking. Moreover, the routes used by drug traffickers vary over time depending on which international market they are willing to supply. In this section I will argue that traffickers behaviour provides us with exogenous variation in the level of violence in different areas.

This work analyses the effect of internal cocaine trafficking instead of the effect of cropping and production on violence which is the major strategy. Previous analysis in Colombia, for example Angrist and Kugler (2008); Díaz and Sánchez (2004) have focused on the effect of coca cropping and production on violence.

Therefore, identification relies on the following statements: Drug traffickers adjust their decisions according to changes in the relative expected profits they could get in international markets. Thus, violence within a municipality will vary depending on the competitive advantage it has on different international markets.

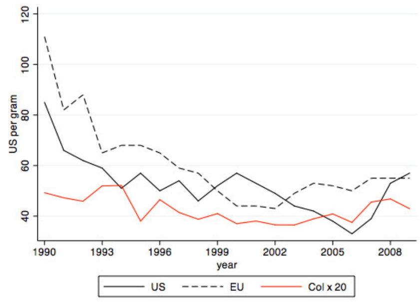
My identification strategy follows the ideas of Dube and Vargas (2013) who used commodity price shocks and their effect on local legal and illegal economies to assess regional variations of violence. The idea to use the illegal drug market traffic is also similar to Dell (2011) and Robles et al. (2013) analysis in Mexico. However, while Robles et al. (2013) uses cocaine supply shocks to instrument violence in Mexico through which cocaine is trafficked to US, I use demand shocks to instrument violence in Colombia. This work is significant because Colombia is the most important producing country.

As I argued above, my analysis is supported by Mejia and Rico (2010) who showed that 70% of the added value of the coca market in Colombia is due to traffic. What is more, Dávalos et al. (2008, 2011) claim that environmental variables are not the main driving forces of coca farming. They found that the presence of coca is explained mainly by the low presence of the central government institutions. Additionally, according to Fiorentini and Peltzman (1996) and Restrepo (2009) violence is used to enforce contracts in illegal markets. If trafficking and production are both illegal, one would expect that the control of trafficking would imply more violence from groups that seek higher profits. Likewise, Chimeli and Soares (2010) give evidence of the causal effect of illegality over violence in the control of the Mahogany market in the Amazon.

Given that Colombia is the main producer of cocaine, one can expect that Colombian drug dealers may be able to change the price in the international markets. The latest claim will affect identification. Nevertheless, Echandia (2013) showed that in Colombia drug dealers compete in regional oligopoly markets and this reduces their power to set prices. Furthermore, UNODC (2011) explains that the revenues of Colombian drug dealers are less than one third of the revenues of international traffickers. This implies that Colombians may not have monopsony power.

However, in order to account for common supply shocks I control for the price of cocaine in the cities of Colombia. My hypothesis is that this price may work as a reservation price for Colombian drug dealers and will pick up the common supply shocks that may affect all prices. Figure 2.7 shows the evolution of the wholesale prices of cocaine in the consuming regions (US and EU) and the price of cocaine in Colombian cities.

Figure 2.7: Wholesale price of cocaine in Consuming regions and price of cocaine in Colombia



Source: World Drug Report – UNODC. Anti-narcotics Unit – Colombian National Police.

This section has two parts. Firstly, I explain how I construct the potential cocaine traffic network using the roads of Colombia. Secondly, I explain how, using my network and the international prices of cocaine, I can identify different profiles of violence according to the comparative advantage in trafficking of each municipality.

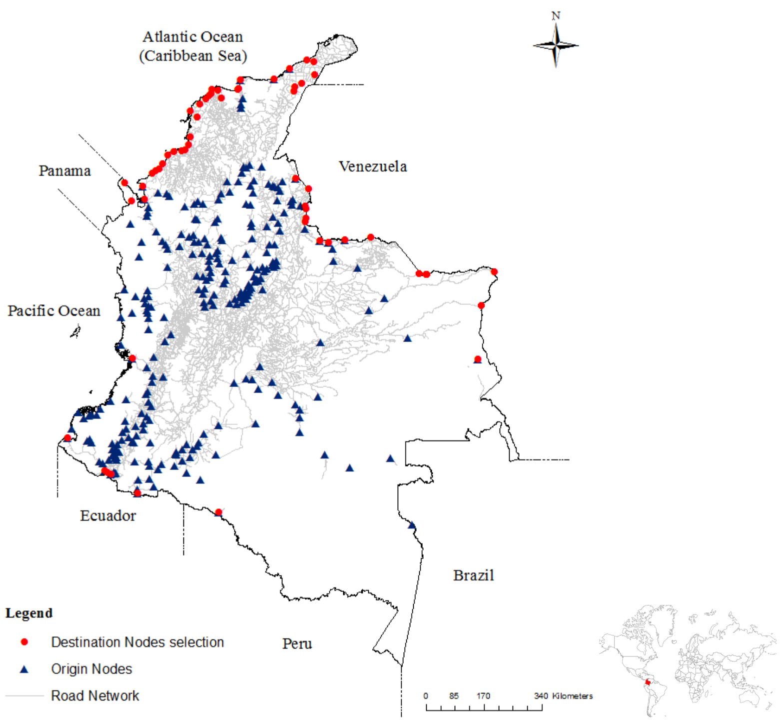
2.3.1 Building the internal cocaine traffic network

The simplest way to understand the network of potential internal cocaine trafficking for the proposes of this work is the following: I want to find the way that the cocaine produced in some areas of Colombia reach the border of the country to be shipped to the international markets. The network $N(O, V, D)$ is defined by the set of origin nodes $O = \{o_1, \ldots, o_{\bar{O}}\}$ which are the municipalities with coca bush fields. $V = \{v_1, \ldots, v_{\bar{V}}\}$ is the set of intermediate transit points which will be the municipalities crossed by the roads used to transport the cocaine. $D = \{d_1, \ldots, d_{\bar{D}}\}$ is the set of ports to international markets at the Colombian border[6].

Then, I define a route z as the triple from an origin , o, some intermediate points (edges) , v, and a final port , d. Thus $z = (o, v, d)$. In other words, a cocaine trafficking route is the way in which a drug dealer takes cocaine from a producing municipality to a municipality on the border using the road network. At the border, the dealer sells the cocaine to an international trafficker.

In order to construct the network I use the following data. Firstly, the set O of origin nodes contains the municipalities which had coca bushes at some point from 2001 to 2009. This information is based on the yearly report on coca crops by UNODC (2010). Secondly, the set of destination nodes – D – includes the municipalities at the Colombian border that have road access. Finally, to build up the set V of intermediate points, I use information from the network of primary and secondary roads in 2005 from the Minister of Transport and the SIG-OT in Colombia. Figure 2.8 shows the spacial distribution of the origin nodes, destination nodes and road networks.

Figure 2.8: Colombian Internal Cocaine Traffic Network



[6] $\bar{O}$, $\bar{V}$, $\bar{D}$ are the total number of origins, intermediate nodes and destinations respectively.

To construct the set of feasible routes for cocaine trafficking I look for the shortest route to link each origin o with each destination d following a predeterminate rule of transit. Initially I use two different rules. The first rule prioritises to the primary road network over the secondary road network. The second assumes the reverse. I define N to be the full set of feasible routes for cocaine trafficking.

Table 2.1 summarises the main features of the set N. I found 11453 routes from 224 origins to 47 destinations. The average length of each route is 1556 km. This is similar to the distance between Boston and Chicago in the US, or Madrid and Milan in Europe. The length of the routes vary from 36 to 4065 km. The latter is approximately the same distance as Tampa to Los Angeles or Lisbon to Kiev. The routes mainly follow secondary roads. On average, only 36% of each route uses primary roads. This feature was expected given that the origin nodes are usually in areas with low development and poor infrastructure.

The lower panel of table 2.1 shows characteristics of the set of routes which link each origin with the closest destination. The average length of this set is 504 km (around the same distance from San Diego to Las Vegas, or Paris to Geneva). It is important to point out that the median length of the shortest route set is 508 km. This means that for half of the cocaine producing municipalities traffickers need to be on the road for at least 500 km. What is more, 90% of the origin nodes have a minimum distance route shorter than 940 km.

Table 2.1: Cocaine Traffic Network – Descriptive Statistics

Main Features				
Origin Nodes	224			
End Nodes	47			
Total Routes	11453			
Statistics	***Mean***	***S. D.***	***Min***	***Max***
Total Length (Km)	1556.3	820.9	35.6	4065.1
Main Road Proportion	0.36	0.12	0	0.94
Number of Departments	5.31	2.95	1	15
Shortest route distribution	***Mean***	***S. D.***	***Min***	***Max***
Total Length (Km)	540.8	376.6	35.6	1641.5
	Percentile	*Length (Km)*		
	10%	126.5		
	50%	508.9		
	90%	940.83		

This set only include routes using the road network. It doesn't include routes finishing in the border with Ecuador because I assume this is an entry border and not an exit of cocaine. There are no routes reaching the borders with Brazil and Peru.

Nevertheless, this network will only explain the traffic travelling along roads. This excludes the use of rivers and trafficking via international or small private airports to fly directly from Colombia to other countries. Despite this limitation the validity of my analysis is supported by the following facts: After the fall of the big drug cartels at the beginning of the 90's the reduction in air traffic reduce gave more importance to road traffic that sought out access to sea ports in order to reach international markets.

According to reports of Colombian Illegal Drugs Observatory – ODC, by 2009, 54% of the cocaine seized in Colombia was at sea, 24% was on country roads. Only 3% was seized at airports (DNE (2002, 2010)). What is more, the number of detected illegal air routes drop from 639 to 88 between 1990 to 2006. Finally, information from the National Anti-Narcotics Bureau (DNE) also shows that the number of airplanes confiscated dropped from 33 to 22 (with a peak of 93 in 1998). The number of vehicles confiscated increased from 311 to 1233 (the largest number of vehicles confiscated in a given year was 1987 in 2003).

The analysis did not find ways to reach the borders with Panama, Peru and Brazil. Moreover, I exclude the routes that finish at the border with Ecuador because I assume that this border is an entry for coca leaves or other inputs for production rather than an exit of cocaine to international markets. I also assume that taking the cocaine to the Colombian Pacific coast directly strongly dominates the strategy of taking the cocaine to Ecuador to go to the Ecuadorian Pacific coast afterwards.

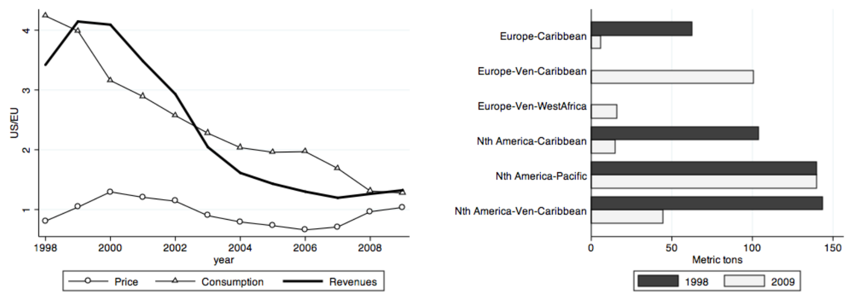
2.3.2 Estimating the effects of cocaine trafficking on violence

In this work identification relies on the following statement: Drug dealers react to changes on the relative profits that they could gain in different international markets. As described in section 2.2, there are two main international cocaine consuming regions, US and EU. Cocaine going to the US can be transported either via the Pacific Ocean or the Caribbean sea, whereas the cocaine destined for Europe is transported via the Caribbean or through Venezuela across the Atlantic or West Africa.

As a result, certain municipalities in Colombia are better situated than others to serve each of these markets. Therefore, as demand of cocaine declined in the United States and grew in Europe during the 2000's (as shown in the panel a of figure 2.9), the amount of cocaine transported along different international routes has also changed (panel b of the same figure). I claim that the amount of cocaine moved through some municipalities would has also changed. This, I argue, give us an exogenous source of variation for the levels of violence.

Figure 2.9: Relative Revenues (US/EU) and International Cocaine Traffic Flows (1998-2009)

(a) Relative Revenue (b) International Traffic Flows



Source: World Drug Report – UNODC. The information of traffic come from Map 22 and 23 page 122 WDR 2011 UNODC (2011). NA = North America (US, Mexico and Canada) and EU = European Union + EFTA countries.

Given the evidence presented in figures 2.4 and 2.2, we would expect violence to be focused on the routes to the US using the Pacific and the Caribe in the 1990's, while, in the 2000's we should expect that the optimal trafficking of cocaine would move to the border with Venezuela as demand in Europe increases. Then, violence would shift to a different set of municipalities.

Consequently, this thesis exploits the time variation in cocaine prices in consumer countries, and the effects on the location of the cocaine traffickers within Colombia, to identify the effect on the levels of violence. In order to link the internal traffic network with international market behaviour I cluster the routes by the border where each route finishes. Thus, I declare F to be the set of frontiers where each route will belong to one $f \in F =${Atlantic, Venezuela North, Venezuela South, Pacific}[7].

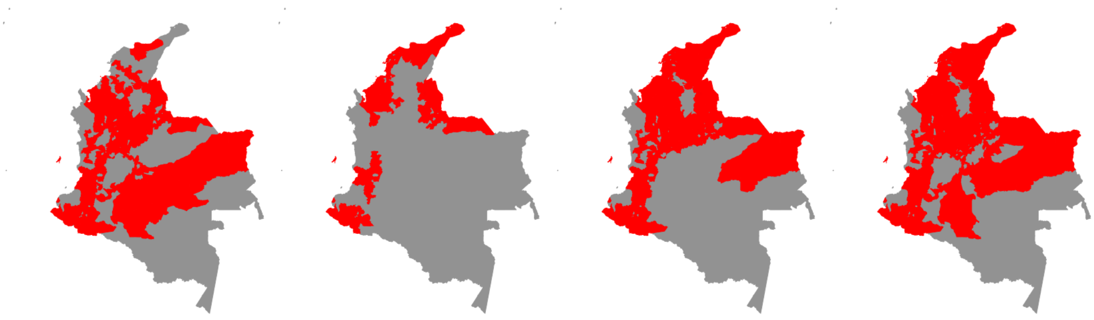
Moreover, the complete potential trafficking network just described contains some routes which are potentially implausible due to their length. In the estimations I restrict the network to including only reasonably long routes. As shown in figure

[7] Venezuela North includes the department of Guajira, Cesar, Norte de Santander and Boyacá. Venezuela South Arauca, Vichada and Guanía. What is more, there are no routes leaving the country through Brazil and Peru. I do is not use the border with Ecuador because this frontier could be more an entering point of coca coming from Bolivia and Peru but not an exit to the American market. In other words, going directly to the Pacific strongly dominates the strategy of leaving to Ecuador to reach the Pacific ocean afterwards.

2.10 the set of municipalities varies according to the definition of plausible routes.

Figure 2.10: Municipalities in the Internal Cocaine Traffic by the Maximum Length of the route.

(a) Minimum Length (b) $Length \leq 500km$ (c) $Length \leq 1000km$ (d) $Length \leq 1500km$



(499) (379) (633) (760)

Author calculations. †Municipalities part of each trafficking network in parentheses

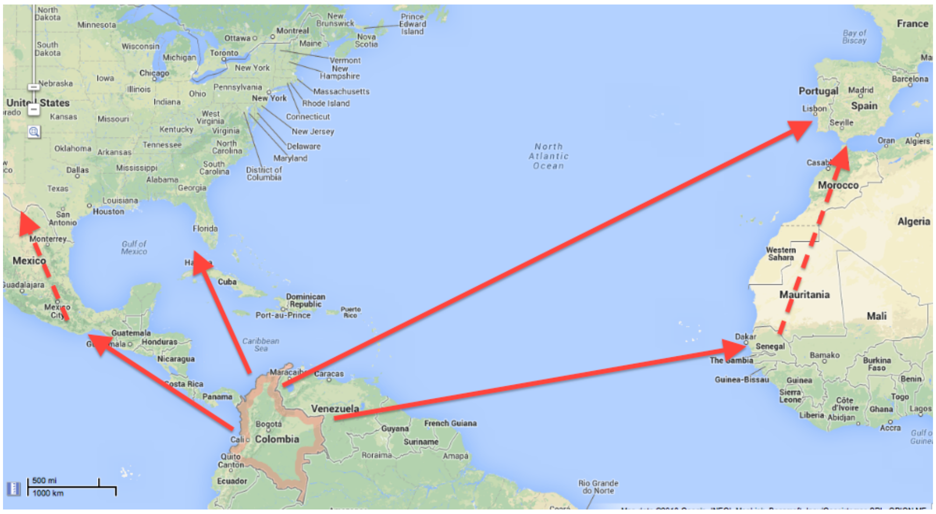
One can analyse the effect of drug traffic assuming that drug dealers minimise the cost of transport. Therefore, from each municipality with coca fields traffickers will only use the route with the minimum length. This is the strategy was previously used by Dell (2011). Alternatively, we can assume that drug traffickers never use routes longer than 500 km, 1000 km or 1500 km in order to minimise the time spent on the roads, which means time at risk.

Once I fixed the maximum length of the routes and clustered them by border of exit, identification relies on the fact that different exits (frontiers) have comparative advantage in regards to different international markets. Determining which market is served by each cluster is difficult. However there are two cases where this link is clearer" the Pacific coast and the southern border with Venezuela. On the one hand, if a trafficker sells his cocaine on the Pacific coast, the final destination of that parcel will almost certain be the US market. On the other hand, if this cocaine exists Colombia through the southern frontier with Venezuela, the final destination is most likely Europe. The map on figure 2.11 shows the main international trafficking routes.

UNODC (2012) reports that, between 2006 and 2008, 51% of the cocaine in Europe came from Venezuela while only 11% came from the Caribbean. The studies also suggest that around 67% of the cocaine in the US came from Mexican cartels who buy it in the Andean countries.

Following the identification statement, I define Vio_{mt} to be the measure of viol-

Figure 2.11: International cocaine trafficking routes



Map from Google Maps. The routes were drawn base on UNODC (2011)

ence on municipality m at period t. Furthermore, the dummy variable D_{mf} will be equal to 1 if the municipality m belongs to a route that finishes at frontier $f \in F$ and zero otherwise. What is more, $P_{\iota t}$ is the wholesale price of cocaine at market $\iota \in M = \{US, EU\}$. It is important to remember that in order to account for supply shocks that affect the final prices I subtract the price of cocaine in Colombia from each international price. I define $P_{\iota t} = p_{\iota t} - p_{COL,t}$ where $\iota \in M = \{US, EU\}$. Equation 2.1 summarises my first approach.

$$Vio_{mt} = \sum_f \beta_f D_{mf} + \sum_\iota \sum_f \beta_{\iota f} P_{\iota t} D_{mf} + \rho X_{mt} + M + T + \mu_{mt} \tag{2.1}$$

In this case, Vio_{mt} is a linear function on each cluster dummy D_{mf}, the interaction of each cluster and each international price $P_{\iota t}$, some municipality controls X_{mt}, municipality fixed effects M, year fixed effects T and error term μ_{mt}. Therefore, $\beta_{\iota f}$ will capture the effect of the price of international market ι over the municipalities involve in the cocaine trafficking that finishes on frontier f. Then, if $\beta_{\iota f} > 0$ the municipalities in cluster f are part of the trafficking of cocaine to the international market ι. Contrarily, $\beta_{\iota f} \leq 0$ if cluster f has comparative advantage to the other market. Table 2.2 summarises the expected sign of each $\beta_{\iota f}$.

So far each $\beta_{\iota f}$ will capture the average reaction of each cluster to each international price. However, inside each cluster there is heterogeneity in terms of the competitive advantages of each municipality. In order to capture this heterogeneity, I estimate the effect of the length of each trafficking route on the violence at municipality level.

Table 2.2: Expected direction of the violent reaction after an increase in the international price of cocaine in each consuming region

	Trafficking cluster			
International Price	Pacific	Atlantic	Venezuela - North	Venezuela - South
US	+	?	?	-
EU	-	?	?	+

I have already argued that drug traffickers prefer shorter routes in order to minimise the risk of interception. Therefore, in addition to the restriction I use over the maximum length of the routes in the network, I define $\pi_{mf} = g\left(\bar{L}_{mf}\right)$ to be a function of the average length of the routes that cross over the municipality m and go to frontier f. If π_{mf} is a proxy of the profitability of each municipality m in the cluster f, we could assume that $\frac{\partial \pi_{mf}}{\partial \bar{L}_{mf}} < 0$. The function I use in this analysis will be $\pi_{mf} = \frac{1}{exp\left(\bar{L}_{mf}\right)}$ where $\bar{L}_{mf}$ is the average length of the routes that go over municipality m to frontier f. Thus, equation 2.1 can be complemented in the following way.

$$Vio_{mt} = \sum_{f} \beta_f D_{mf} + \sum_{\iota} \sum_{f} \{\beta_{\iota f} P_{\iota t} D_{mf} + \delta_{\iota f} P_{\iota t} \pi_{mf}\} + \rho X_{mt} + \iota + t + \mu_{mt} \quad (2.2)$$

Where $\delta_{\iota f}$ will capture the marginal effect of the competitive advantage that shorter routes have for cocaine trafficking. I expect that $\delta_{\iota f} > 0$ if the cluster f supply to the market ι.

Once I define the violence indicator and the maximum length of the routes in the traffic network, the latest reduced form analysis captures different violent profiles as responses to different reactions to the international price of cocaine at consumer markets. Then, when researchers want to evaluate the impact of violence over household behaviour, my instrument provides exogenous changes in violence orthogonal to the characteristics of the households in the analysis.

2.4 The Data

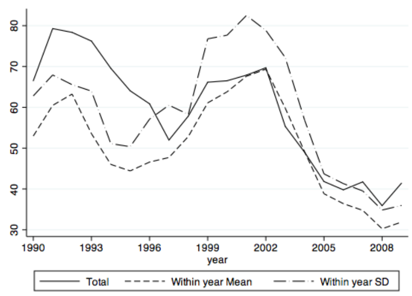
In this section I describe the data I use to estimate the effect of cocaine trafficking on violence. The most important right hand side variable is the potential cocaine trafficking. In the last section I already explained how I did build up the potential cocaine trafficking network and the data I used.

However, I have not defined the variables of analysis on the left hand side. This work would focus the analysis in the impact of potential internal cocaine traffic on homicides at municipality level, and the location and actions of the illegal armed groups. Table 2.10 in the appendix 2.A lists the data I use in my estimations. I already describe the key variables in terms of international cocaine markets and the internal cocaine traffic. Therefore, in this section I focus on describing the variables of violence.

My analysis begins with a model of potential cocaine trafficking and homicides. Homicides are the most prevalent violent crime. Firstly, figure 2.12 shows the yearly evolution of the homicide rate in Colombia[8]. As we can observe in this figure, the homicide rate moves from 80 to 40 with an average of 50 (see table 2.3).

At the beginning of the 1990's the Colombian homicide rate was at it largest value of 80 when the country was at war with the big drug cartels. Afterwards, the rate felt almost 30 points from 1991 to 1995. From 1996 to 2003 the violence increases again to reach a new high by 2002: 69.6 homicides per 100000 habitants. This increase is consequence of the war that involve left wing guerrillas, right wing paramilitary armies and State forces. There were 28603 homicides in Colombia in 2002 (see Sánchez et al. (2003)). After 2003 the violence in Colombia shows a sharp reduction to reach a minimum rate of 35 by 2008. The latest effect has been the result of multiple policies including strong military investment (with funds from the US government) and a peace process with the paramilitary armies (Mejia and Restrepo (2008)).

Figure 2.12: Homicide Rate Statistics (1990 - 2009)



Notes: Vital statistics – DANE. Author calculations †Homicide data source: rate is measure as homicides per 100000 habitants. The sample includes 1014 municipalities.

Figure 2.12 also includes the average and the standard deviation of the muni-

[8] All the violent rates and the count of the event per 100000 habitants. $vioRate = \frac{vio}{population}1000000$

cipality homicide rate for each year of analysis. As we can see the within year average of the municipality homicide rate was smaller than the national rate before 2003, especially before 1996. This fact shows that the homicides were focused in the main cities while the rates in smaller were smaller. The reduction of this gap shows a geographical change in violence, where homicides moved from the cities to small towns in the countryside. Finally, the within year standard deviation shows similar trends to the mean. The period with larger variation among municipalities was from 1998 to 2003.

It is important to point out that Colombian average homicide rate is considerably larger than the rates in developed countries. The United Kingdom and United State currently have a homicide rate of 1 and 5 respectively. Even after 2005 when rates decreased, the value of the Colombian homicide rate was still larger than the Mexican rate, which for example in 2011 was of 23 homicides per 100000 habitants.

Table 2.3 complements the descriptive analysis and shows the main statistics of the homicide rates by gender and age. The maximum homicide rate is for adults – 15 to 44. The homicide rate for this age group is 88 while in the rate of the younger population is never larger than 3. Another important feature of the homicides is the significant gap between male and female homicides. The average male rate is 90.54 while the female rate is 8.67. The final part of table 2.3 shows how on average 90% of the homicides in the Colombian municipalities are men.

Moreover, figure 2.13 shows the geographic features of the homicide rate. This analysis help us to identify the hot-spots base on the intensity of conflict and its variability. This is the key feature I exploit using the reactions of different areas to the changes in international cocaine prices. As we can see, the violence spread in a heterogeneous way over the country resulting in more intense conflict over the south east and north west areas. The border with Venezuela shows as well high violence on some towns. Panel b shows the within municipality standard deviation. The highest variation is in some municipalities in the north west in the region of Antioquia, where the Medellín cartel used to have control. What is more, the south east of the country, where the left wing guerrillas have more power, shows a very high standard deviation.

The second set of violent variables for the analysis is related with the presence and actions of the Illegal Armed Groups – IAG. Figure 2.14 shows the proportion of Colombian municipalities with activity of one of the main illegal groups: The 2 largest left wing guerrillas FARC and ELN, and the union of right wing

Table 2.3: Homicide rates descriptive statistics (1990 - 2009)†

	Full Sample			
	mean	**sd**	**min**	**max**
Total homicide rate	50.34	61.57	0	1036
4 y.o. or less	1.82	13.19	0	549
5 to 14 y.o.	2.66	12.21	0	362
15 to 44 y.o.	88.07	113.47	0	2576
45 to 64 y.o.	56.83	93.87	0	1613
65 y.o. or older	26.40	76.64	0	1681
within municipality s.d. (Total)	34.97	30.04	0	283
Male homicide rate	90.54	111.01	0	1851
4 y.o. or less	1.90	17.89	0	645
5 to 14 y.o.	3.41	18.30	0	685
15 to 44 y.o.	160.46	207.43	0	4802
45 to 64 y.o.	101.25	169.43	0	3409
65 y.o. or older	45.10	135.48	0	2606
within municipality s.d. (Total)	63.52	53.37	0	491
Female homicide rate	8.67	17.89	0	288
4 y.o. or less	1.71	18.52	0	1149
5 to 14 y.o.	1.88	13.95	0	552
15 to 44 y.o.	13.32	31.91	0	619
45 to 64 y.o.	10.32	43.99	0	1000
65 y.o. or older	7.58	58.15	0	2857
within municipality s.d. (Total)	12.29	10.65	0	104
Male homicide proportion - $\frac{male\ homicides}{total\ homicides}$				
Total	0.91	0.16	0	1
4 y.o. or less	0.55	0.47	0	1
5 to 14 y.o.	0.67	0.43	0	1
15 to 44 y.o.	0.92	0.16	0	1
45 to 64 y.o.	0.91	0.22	0	1
65 y.o. or older	0.86	0.31	0	1

Notes: Vital statistics – DANE. Author calculations †Homicide data source: rate is measure as homicides per 100000 habitants. The sample includes 1014 municipalities.

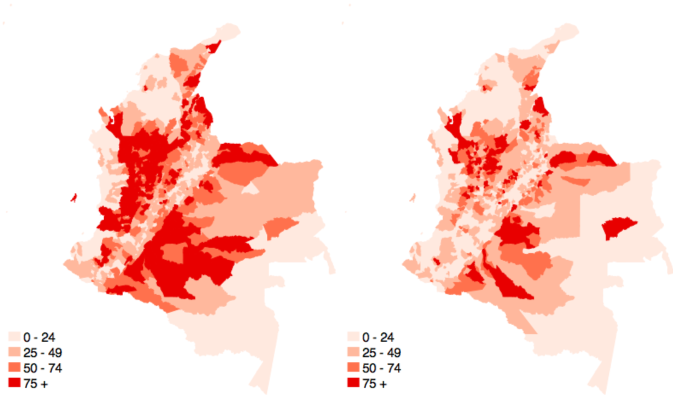
paramilitary armies AUC.

As we can see, FARC is the group with the largest presence around the country. In 2002, they were in 42% of the Colombian municipalities. After 2002, the war against the government and other illegal groups reduced their presence to only 15% of the municipalities by 2008. Meanwhile, the second guerrilla group – ELN – was in 10% of the Colombian towns until 1999. Thus they were similar to FARC at that time. After 2002 ELN reduced their actions year by year, such that in 2008, they were active in only 4% of the municipalities.

The AUC increased their actions sharply from 1997 to 2005 while combating

Figure 2.13: Within municipality homicide rate mean and standard deviation.

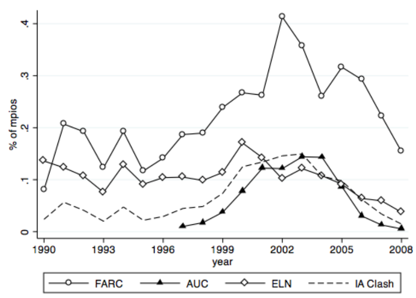
(a) Mean (b) Standard Deviation



Source: DANE – Vital Statistics (Deaths report). Homicide rate = homicides per 100000 habitants. Within municipality statistics are the mean and standard deviation of each municipality from 1990 to 2009. The overall mean is 50.33 and the standard deviation is 61.56897.

guerrilla groups. The clash trend is linked with the expansion of the paramilitary armies. After 2005, following a peace process, the AUC functioned in less municipalities. By 2008, they were present in only 5% of municipalities.

Figure 2.14: Presence of the Illegal Armies in Colombia (% of municipalities)



Source: CEDE and Human Rights Observatory – Vice-Presidency of Colombia, author calculations. Each cell indicates the % of municipalities where a group have at least one illegal action reported. A municipality with clash is defined as a municipality where there were reports of actions of 2 or more groups.

Table 2.4 summarises the evolution of the different actions of the illegal groups. Terrorist attacks are the actions used in more municipalities – 17% over the period 1998 to 2009. The highest use was in 2002 where 28% of the Colombian municipalities reported a terrorist attack. Harassment is the second action with 11% mean. The actions targeting military forces, like ambushes and attacking military bases, have an average of 5% with a maximum of 7% in 2002.

Finally, my estimations will control for year and municipality level fixed effects and some municipality level variables. These are described on table 2.11 in appendix 2.A.

Table 2.4: Illegal Armies presence and actions

	Terrorist attacks	Ambush	Attack to military base	Harassment	Land piracy	Illegal army actions
Overall statistics						
mean	0.17	0.05	0.04	0.11	0.10	0.29
sd	0.38	0.22	0.18	0.31	0.30	0.45
Yearly %						
1998	0.18	0.05	0.01	0.12	0.08	0.29
1999	0.15	0.04	0.03	0.12	0.14	0.32
2000	0.20	0.04	0.06	0.11	0.14	0.36
2001	0.17	0.04	0.04	0.12	0.17	0.34
2002	0.28	0.06	0.04	0.15	0.18	0.42
2003	0.23	0.07	0.07	0.17	0.16	0.41
2004	0.16	0.08	0.05	0.13	0.11	0.30
2005	0.19	0.07	0.06	0.10	0.12	0.29
2006	0.22	0.05	0.03	0.11	0.07	0.28
2007	0.13	0.03	0.01	0.08	0.02	0.19
2008	0.10	0.02	0.01	0.05	0.02	0.14
2009	0.07	0.03	0.01	0.04	0.00	0.11

Source: Human Rights Observatory – Vice-Presidency of Colombia, author calculations. Each cell indicates the % of with at least one action reported.

2.5 Results

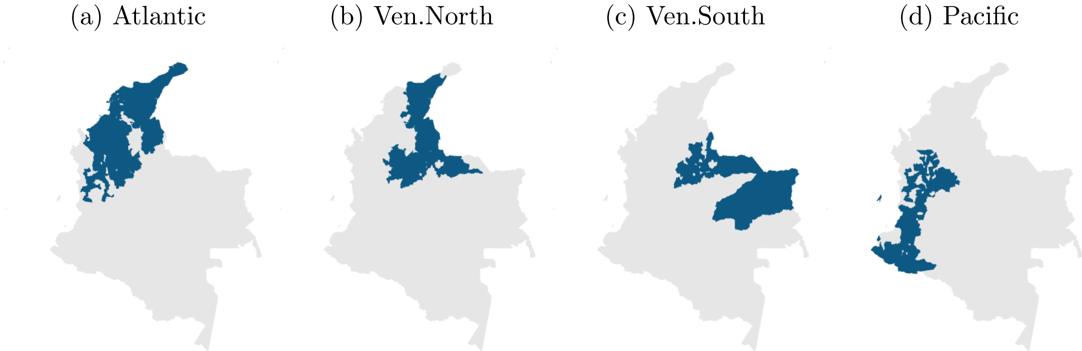
Before showing the results of my estimations, I still need to set the maximum length restriction to the cocaine trafficking network. Following previous works I could have assumed that a profit maximising drug dealer would use the shortest route to ship his cocaine parcel. In that case, the optimal network would be such that I use only the shortest route from each cropping municipality (figure 2.10.a). However, this would reduce the trafficking network to only one route from each origin node. This means that each route would be easily traceable by the police and other drug dealers. Using an unique route does not seem to be optimal from the point of view of a trafficker. For that reason I do not use this network.

From table 2.1 and figure 2.10 I could support the choice of the maximum length of 1000 km for my analysis. Firstly, figure 2.10.b shows how using only routes shorter than 500km creates a clear division between each of the frontier clusters. However, I will be using only the network from 50% of the possible origin municipalities. Secondly, when I include all the cropping areas (using 1500 km as the maximum length of the routes), each frontier cluster includes municipalities far away from each other. What is more, there are large regions where the clusters overlap each other. Then, my estimation strategy would not clearly identify the average reaction to international prices within cluster comparative advantages in trafficking.

Nevertheless, when I set the maximum distance to 1000 km, I include 90% of the origin municipalities and I keep a clear division between the different trafficking regions. The resulting clusters are shown on the figure 2.15.

Figure 2.15: Municipalities in the Drug Traffic Network by Cluster

Only using routes shorter than 1000km



2.5.1 The effect of drug trafficking on homicides

Once I set up the cocaine trafficking network I estimate equations 2.1 and 2.2. I standardise the homicide rate in order to simplify the comparability of models and make the reading and interpretation of my results easier.

When I estimate equation 2.1 the coefficients in table 2.5 have the expected direction. On the one hand, the municipalities in the Pacific cluster are oriented to the US market and homicide rates increase when the price of cocaine in United States increases. On the other hand, the violence increases in region at the south frontier with Venezuela when the price of cocaine increases in Europe or decreases in the United States; the latter could be understand as a substitution effect. Additionally, the clusters of Atlantic and the northern border with Venezuela seem to be oriented to the US market because they increase their violent rates when the United States market increases its profitability relative to the European market.

Finally, there is evidence of substitution effects over the border with Venezuela. When the price of cocaine increases in the United States the homicide rates rises in the municipalities involved in the trafficking towards the northern part of the border with Venezuela and lowers in the municipalities involved in the trafficking towards the southern part. When the price that increases is the one in the European market the opposite happens. There may be some drug traffickers that move between the north and the south of that border depending on where they expect to get higher revenues.

In the second model – table 2.5 – my estimation includes the clusters that only serve one market (Pacific and Venezuela South). As we can see, the statistical significance and signs do not change, what is more, the joint significance F test over the trafficking variables increases from 10.28 to 20.77.

Table 2.5: OLS of Potential Cocaine Trafficking Network on municipality homicide rate

D_f	P_ι US	P_ι EU	P_ι US	P_ι EU
	Model 1		***Model 2***	
Pacific	0.734***	-0.022	0.751***	
	(0.126)	(0.183)	(0.129)	
Atlantic	0.343***	-0.031		
	(0.116)	(0.158)		
Ven. South	-0.228**	0.499***		
	(0.112)	(0.157)		
Ven. North	0.330**	-0.372*		0.237***
	(0.138)	(0.217)		(0.091)
F_{TEST}	10.28		20.77	
R^2	0.50		0.50	
Mpios	1122		1122	
N	21395		21395	

Standard errors clustered by municipality in parentheses (1122 mpios). The cocaine network includes only the routes shorter than 1000 kilometres ($L_R \leq 1000km$). All regressions follow equation 2.1 including year fixed effect, municipality fixed effects, GDP per capita at departmental level, logarithm of the population and a dummy if the municipality have coca crops at some point between 1990 - 2009 and its interaction with the international prices of cocaine, a dummy for the presidential periods of Alvaro Uribe Vela in Colombia and Hugo Chávez in Venezuela, a dummy variable if the municipality belongs to the CCT programme Familias en Acción. The dependent variable is standardised - Mean = 50.34 and Standard deviation = 61.57. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Likewise, table 2.6 show the results of the estimation of the model in equation 2.2. The effect is weighted using a function of the average length of the routes that go through each municipality to check if within the cluster municipality competitiveness will increase the violent reaction[9]. For that reason, in this case I only interact the profit function with the price I assume each cluster is supplying to. In section 2.3, I set the Pacific cluster to supply to the US market, and the cluster Venezuela south as the main exit to the European market. After

[9]Is good to remember that I am using and inverse exponential function of the form $\pi_{mf} = \frac{1}{exp(\bar{L}_{mf})}$ where $\bar{L}_{mf}$ is the average length of the routes that go over municipality m to frontier f.

establishing the initial results from table 2.5, I fix both Atlantic and Venezuela North as US oriented clusters. For this reason, I do not interact the profit function of Pacific, Atlantic and Venezuela North with the price of cocaine in Europe. Additionally, I do not interact the price of the cocaine in the US with the profit function of the Venezuela South cluster.

Table 2.6 shows the results of estimation equation 2.2. The upper panel shows the results of the interaction of each trafficking cluster dummy and the international prices as I have already shown in table 2.5. The lower panel shows the interaction of the price and the profit proxy I describe in section 2.3.

Table 2.6: OLS of Potential Cocaine Trafficking Network on municipality homicide rate – extended model

		P_ι			
		US	EU	US	EU
		Model 1		***Model 2***	
D_f	Pacific	0.592***	-0.033	0.585***	
		(0.132)	(0.183)	(0.128)	
	Atlantic	0.234*	-0.025		
		(0.121)	(0.159)		
	Ven. South	-0.252**	0.384**		0.117
		(0.114)	(0.152)		(0.107)
	Ven. North	0.304**	-0.443*		
		(0.150)	(0.227)		
$D_f\pi_f$	Pacific	1.542***		1.665***	
		(0.358)		(0.349)	
	Atlantic	0.033			
		(0.332)			
	Ven. South		0.662**		0.486
			(0.334)		(0.304)
	Ven. North	0.434			
		(0.721)			
F_{TEST}		9.17		16.65	
R^2		0.50		0.49	
Mpios		1122		1122	
N		21395		21395	

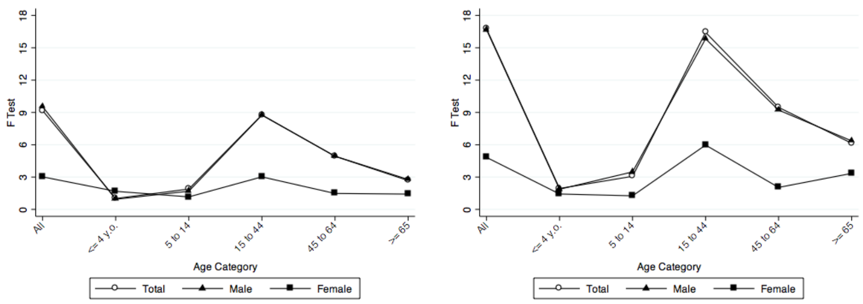
Standard errors clustered by municipality in parentheses (1122 mpios). The cocaine network includes only the routes shorter than 1000 kilometres ($L_R \leq 1000km$). All regressions follow equation 2.1 including year fixed effect, municipality fixed effects, GDP per capita at departmental level, logarithm of the population and a dummy if the municipality have coca crops at some point between 1990 - 2009 and its interaction with the international prices of cocaine, a dummy for the presidential periods of Alvaro Uribe Vela in Colombia and Hugo Chávez in Venezuela, a dummy variable if the municipality belongs to the CCT programme Familias en Acción. The dependent variable is standardised – Mean = 50.34 and Standard deviation = 61.57. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

My results suggest that homicide rates in the Pacific have an extra reaction to an increase in cocaine prices in the United States when the municipalities are part of shorter routes. As I explain above municipalities with shorter routes could be more profitable in terms of trafficking. An increase in the price will have a stronger effect on more profitable municipalities. I find similar effects for the municipalities in the south border with Venezuela when the price of cocaine in Europe is the one who increases. For the other clusters, the distance does not seem to be a significant variable for the drug dealers' optimal choices. As we can see, the F test over my traffic variables are around 10. This confirms that drug trafficking on roads is indeed an important factor of violence in Colombia.

Thus, I have only analysed the effect of drug traffic on the municipality homicides. However, the data allows us to study whether the violence caused by drug traffic targets specific populations. I estimate equation 2.2 for the different homicide rates using all the traffic clusters, using only Pacific and Venezuela South as I did before. We can see in tables 2.12, 2.13 and 2.14 on appendix 2.A that the coefficient structure does not change notably between specifications. Although, as I compile on figure 2.16, the joint significance test varies with age and gender. From both panels I conclude that drug traffic explains the male homicides much better than female deaths. What is more, the model fits the best for adults between 14 and 45 years old, while traffic seems not to have explicative power over child homicides or homicides of persons older than 45 years. As we saw before, 91% of the homicides are male, which explains why the potential cocaine trafficking has such a poor explicative power over female homicides.

Figure 2.16: Join significance test of Cocaine Trafficking Network on municipality homicide rate by age and gender

(a) Model 1 (b) Model 2



Standard errors clustered by municipality in parentheses (1122 mpios). The cocaine network includes only the routes shorter than 1000 kilometres ($L_R \leq 1000km$). All regressions follow equation 2.1 including year fixed effect, municipality fixed effects, GDP per capita at departmental level, logarithm of the population and a dummy if the municipality have coca crops at some point between 1990 - 2009 and its interaction with the international prices of cocaine, a dummy for the presidential periods of Alvaro Uribe Vela in Colombia and Hugo Chávez in Venezuela, a dummy variable if the municipality belongs to the CCT programme Familias en Acción. The dependent variable is standardised. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

2.5.2 The effect of drug trafficking on the actions of Illegal Armed Groups

The latest section focused on the analysis of cocaine traffic on homicides. Now I turn to study the effect of cocaine traffic on the behaviour of the Illegal Armed Groups – IAG – in Colombia. As shown by Mejia and Rico (2010), the IAG are part of the country's cocaine business. As I have shown previously, I want to know if guerrillas and paramilitary armies move and attack different municipalities to pursue the rents of drug markets. For this reason, I use the same strategy over dummy variables which are equal to 1 if a municipality reports actions by a certain group. What is more, I estimate the effect of traffic on different actions of illegal armed groups such as terrorist attacks (to population) or attacks to military bases.

I estimate equation 2.2 for a set of variables related with the activity of the illegal armed groups. Table 2.7 shows the joint significance test for the variables of interest[10]. Unfortunately, my estimations do not fit as well as they did when the violence indicator was the homicide rate. However, the model seems to explain part of the positioning of guerrillas and the terrorist attacks. As we can see in table 2.15 (appendix 2.A), the probability that a municipality has an action from the ELN increases in the Pacific, Atlantic and Venezuela North clusters when the price in the US increases. Similarly, the ELN presence increases in Venezuela South if the European price increases. The length of the routes in each cluster does not seem to be important for the location of this guerrilla group.

Table 2.8 shows the results of the estimations of my first specification. As we can see in the first column the presence of ELN follows the model I explain before and the results I found for the homicide rates. In this case, the joint significance test increases to 7.79 which is not very far away from the critical value of 10. However, leaving only the clusters of Pacific and the southern border with Venezuela reduces the explicative power of the model. This was an expected result because the main area of influence of ELN is the north border with Venezuela, a region called Catatumbo.

In the case of FARC, the last column of table 2.8 suggests very interesting behaviour. As we can see the presence of FARC reduces in the Pacific when the price of the cocaine in the United States rises. As I explain before, guerrilla armies choose the level of participation in traffic, therefore, if the FARC groups

[10] $\sum_\iota \sum_f \{\beta_{\iota f} P_{\iota t} D_{mf} + \delta_{\iota f} P_{\iota t} \pi_{mf}\}$

Table 2.7: Join significance test of Potential Cocaine Trafficking Network on the presence of different illegal armies and different actions.

Dependent variable		**F test**
Presence (1990 – 2008)	FARC	3.51
	ELN	5.22
	AUC*	2.44
	Clash	3.23
Actions (1998 - 2008)	Terrorist attack	4.09
	Ambush	1.46
	Attack to military base	2.83
	Harassment	2.18
	Land piracy	3.42
	Illegal army action (any)	5.03

Standard errors clustered by municipality in parentheses. The cocaine network includes only the routes shorter than 1000 kilometres ($L_R \leq 1000km$). All regressions follow equation 2.2 including year fixed effect, municipality fixed effects, GDP per capita, logarithm of the population and a dummy if the municipality have coca crops at some point between 1990 - 2009.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
*There is no information for the AUC before 1997.

in the Pacific region decide to share the risk and do not get involve in the traffic when the price of cocaine increases, the trafficker will gain more power over the territory and move the guerrilla armies out.

Conversely, at the border with the south of Venezuela, FARC have historically been more powerful and therefore have more control over the illegal activities, including cocaine traffic. Thus, their participation in the internal traffic will be larger than in the Pacific, allowing them to gain the benefits of price increases in the European wholesale cocaine market.

Finally, when analysing the actions of illegal groups it is important to point out from table 2.7 that cocaine prices seem to explain part of the terrorist attacks but have no power to explain actions that imply army strategy and confrontations like ambushes, harassments or base attacks. The results on terrorism seem to follow the same behaviour of the FARC presence which is rational given the importance of this guerrilla group in Colombia. Nevertheless, the F test still very small.

2.6 Conclusions and policy implications

This work aims to contribute to the analysis of the economic consequences and cost of violent crime, armed conflict and war. The main contribution of this chapter is the use of international cocaine prices and internal potential cocaine trafficking network to find exogenous violent shocks at municipality level. I ana-

Table 2.8: Potential Drug Trafficking on the Probability of the Presence of Guerrillas (linear probability model)

			ELN		FARC	
	P_ι	D_f	model 1	model 2	model 1	model 2
$P_\iota D_f$	US	Pacific	0.117**	-0.001	-0.128**	-0.131***
			(0.046)	(0.032)	(0.059)	(0.044)
		Atlantic	0.088**		0.019	
			(0.037)		(0.042)	
		Ven.South	-0.092*		0.095	
			(0.051)		(0.059)	
		Ven.North	0.225***		-0.013	
			(0.052)		(0.057)	
	EU	Pacific	-0.154***		-0.002	
			(0.045)		(0.051)	
		Atlantic	0.008		0.042	
			(0.039)		(0.042)	
		Ven.South	0.127***	0.100***	0.084	0.136***
			(0.049)	(0.031)	(0.055)	(0.036)
		Ven.North	-0.081		0.025	
			(0.062)		(0.053)	
F_{TEST}			7.79	5.34	4.14	12.78
R^2			0.39	0.39	0.39	0.39
Mean %			0.10	0.10	0.22	0.22
Mpios			1096	1096	1096	1096
N			20180	20180	20180	20180

Standard errors clustered by municipality in parentheses. The cocaine network includes only the routes shorter than 1000 kilometres ($L_R \leq 1000km$). All regressions follow equation 2.2 including year fixed effect, municipality fixed effects, GDP per capita, logarithm of the population and a dummy if the municipality have coca crops at some point between 1990 - 2009.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

lyse the case of violent conflict in Colombia where internal war and illegal drug production and traffic have been part of the country's history for at least 60 years.

My identification relies on the following statement: Drug traffickers adjust their decisions according to changes in the relative expected profits they could get in international markets. Then, changes in the relative profits from cocaine induce different time/space changes in violence. For this reason we observe that violence changes accordingly to the municipality comparative advantage in the drug trade.

I construct a network with more than eleven thousand possibilities for taking cocaine from the producing municipalities to the national borders in order to ship the cocaine to the US or European markets. Afterwards, I restrict the network according to the maximum length of the routes and cluster different municipalities in four trafficking groups – Atlantic, Venezuela North, Venezuela South and Pacific. I argue that violence in each cluster rises when the price of cocaine in the market being supplied increases. The clearest effect is in the Pacific region, which serves the US market and Venezuela South which serves the European Market.

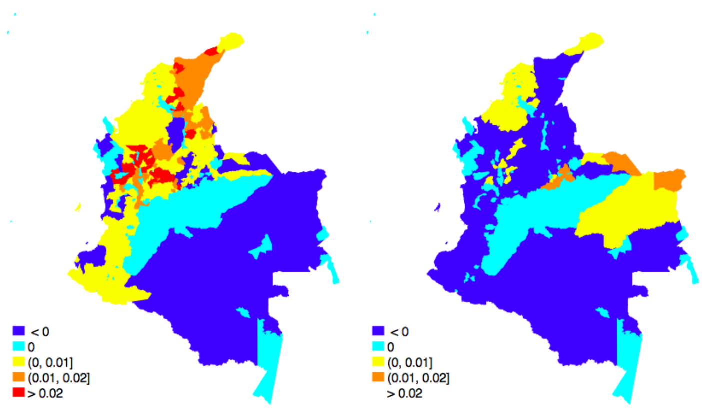
Given that Colombia was the main producer during the period of analysis (1990 - 2009), I use the price of cocaine in the cities of Colombia to capture the effect of supply shocks in Colombia that may affect the price in the consumer regions.

On the one hand, my reduced form estimation shows that when the cocaine price in the Unites States increases the homicide rate increases in the municipalities that are part of the clusters of Pacific, Atlantic and Venezuela North. On the other hand, homicides increase in the municipalities involved in trafficking through the Southern Venezuelan border when the price of cocaine increases in Europe. The latest conclusions hold when I weight each municipality according to the average length of the trafficking routes that cross each municipality.

Using the latest analysis I identify the regions which are more sensitive to changes in the international cocaine prices. Figure 2.17 shows the estimated reaction to each municipality in Colombia when the price of cocaine increases in the US or EU. The region that responds more to the US cocaine market is the Northern coast of the country and the traffic over Antioquia, which used to be the headquarters of the must important coca cartel, the "Medellín Cartel". Moreover, when the price of cocaine in Europe increases keeping the US price constant, violence is expected to rise the most in the Eastern corner of the frontier with Venezuela.

Figure 2.17: Estimated change in homicide rate by 1 dollar increase in the cocaine price by international market.

(a) + 1 USD in US price (b) + 1 USD in EU price



Finally, I extend my analysis to the behaviour of illegal armies. I show that guerrillas seem to respond more to the cocaine market. My strategy was not explicative of the presence of the paramilitary armies (AUC). Furthermore, according to my estimations, the ELN follows closely the rents from controlling the cocaine routes and the probability of ELN presence increases in the Pacific, Atlantic and Venezuela North traffic clusters when the price in the US increase. What is more, ELN increases their presence in the Venezuela South cluster when the returns in the european market rises. Although, FARC guerrillas follow the cocaine trafficking on the cluster of Southern border with Venezuela. They seem to not get directly involved in the traffic of the Pacific to North America.

My strategy and results can be use now to analyse the cost of criminal violence over municipality institutions and households behaviour. The changes in violence are driven by drug lords who seek different international profits and choose violence without taking into account household composition and characteristics. Consequently, I now open a window to analyse different consequences of violent crime. In the following chapter I use my strategy to study the effect of homicides on teenage fertility.

Appendix 2.A Support tables

Table 2.9: Duration of Internal Conflicts 1946 - 2001

Type	**N**	**mean**	**sd**	**min**	**max**	$\% (T < 2y)$	$\% (T \geq 20y)$
Internal Minor Conflict	80	7.25	10.4	0	10	46.2	11.2
Internal Intermediate Conflict	37	11.37	13.9	0	47	29.6	21.6
Internal War	51	11.33	15.5	0	55	35.2	19.6

Source: Data from Gleditsch et al. (2002). Author's calculations

Table 2.10: Main Data Sources

Group	**Data description**	**Period**	**Source**
Violence	Homicides at municipality level	1990 - 2009	CEDE – Human Rights Observatory – Vice-presidency of Colombia
		1990 - 2009	DANE - Vital statistics - Deaths Reports
	Illegal Armed Groups actions	1990 - 2009	CEDE- Human Rights Observatory - Vice-presidency of Colombia
		1988 - 2010	CERAC
	Terrorist actions	1998 - 2009	Human Rights Observatory - Vice-presidency of Colombia
Cocaine traffic	Colombian Road Network	2005	Minister of Transport - IGAC - SIG-OT
	Wholesale cocaine price - Europe and United States	1990 - 2010	UNODC - World Market Reports
	Coca crops in Colombia	2001 - 2010	UNODC - SIMCI
Support data	Population	1990 - 2009	DANE: Population estimates
	GDP per capita (By department)	1990 - 2009	DANE
	Municipalities in Familias en Acción	2002 - 2009	Acción Social - Econometría S.A.

Table 2.11: Municipality data descriptive statistics

	mean	**sd**	**min**	**max**
Municipality Controls				
Population - Logarithm	9.54	1.06	5	16
GDP per capita*	4633.19	3812.02	311	28966
With Coca fields (%)‡	0.25	0.43	0	1
Familias en Acción (%)$^{\circ}$	0.19	0.39	0	1

Notes: Author calculations

*GDP in thousands of pesos (COP) per year.

‡% of municipalities who have coca fields at some point from 2001 to 2009

$^{\circ}$% of municipalities with the CCT programme Familias en Accíon. The programme star in 2002 and increase its presence until 2007.

Table 2.12: OLS of Potential Cocaine Traffic Network on municipality homicide rate by age category - extended model

			Model 1						Model 2					
	P_ι	D_f	Total	less than 4 y.o.	5 to 14	15 to 44	45 to 64	64 or older	Total	less than 4 y.o.	5 to 14	15 to 44	45 to 64	64 or older
$P_\iota D_f$	US	Pacific	0.592***	-0.116	0.116	0.573***	0.426***	0.270**	0.585***	-0.122	0.224**	0.589***	0.376***	0.438***
			(0.132)	(0.143)	(0.136)	(0.132)	(0.118)	(0.133)	(0.128)	(0.103)	(0.108)	(0.135)	(0.092)	(0.089)
		Atlantic	0.234*	0.133	0.031	0.195*	0.179	0.163						
			(0.121)	(0.091)	(0.107)	(0.111)	(0.117)	(0.116)						
		Ven.South	-0.252**	0.131	-0.073	-0.321***	-0.216*	0.048						
			(0.114)	(0.157)	(0.175)	(0.118)	(0.124)	(0.146)						
		Ven.North	0.304**	-0.078	0.260	0.317**	0.188	0.157						
			(0.150)	(0.166)	(0.163)	(0.156)	(0.143)	(0.149)						
	EU	Pacific	-0.033	0.048	0.124	-0.003	-0.088	0.233						
			(0.183)	(0.088)	(0.135)	(0.174)	(0.154)	(0.160)						
		Atlantic	-0.025	-0.076	-0.022	0.047	-0.218	-0.103						
			(0.159)	(0.079)	(0.121)	(0.139)	(0.141)	(0.137)						
		Ven.South	0.384**	-0.112	0.052	0.442***	0.193	0.109	0.117	-0.012	-0.077	0.124	0.067	0.087
			(0.152)	(0.176)	(0.194)	(0.149)	(0.169)	(0.169)	(0.107)	(0.150)	(0.110)	(0.106)	(0.134)	(0.121)
		Ven.North	-0.443*	0.106	-0.307	-0.443**	-0.214	-0.149						
			(0.227)	(0.134)	(0.194)	(0.217)	(0.203)	(0.171)						
$P_\iota D_f \pi_f$	US	Pacific	1.542***	0.457*	0.656	1.507***	0.891***	-0.314	1.665***	0.590**	0.635	1.641***	0.888***	-0.266
			(0.358)	(0.255)	(0.403)	(0.362)	(0.343)	(0.319)	(0.349)	(0.265)	(0.401)	(0.351)	(0.329)	(0.312)
		Atlantic	0.033	-0.655	0.399	0.014	0.061	0.176						
			(0.332)	(0.434)	(0.379)	(0.343)	(0.330)	(0.271)						
		Ven.North	0.434	-0.452	-0.475	0.535	0.091	-0.003						
			(0.721)	(0.283)	(0.365)	(0.743)	(0.563)	(0.713)						
	EU	Ven.South	0.662**	-0.354	0.447*	0.645*	0.830*	0.076	0.486	-0.350	0.398*	0.472	0.754*	0.058
			(0.334)	(0.338)	(0.236)	(0.331)	(0.483)	(0.272)	(0.304)	(0.313)	(0.221)	(0.303)	(0.445)	(0.254)
F_{TEST}			9.17	1.01	1.89	8.77	4.93	2.68	16.65	1.94	3.07	16.43	9.47	6.14
R^2			0.50	0.05	0.08	0.47	0.28	0.13	0.49	0.05	0.08	0.47	0.28	0.13
HomMean			50.34	1.82	2.66	88.07	56.83	26.40	50.34	1.82	2.66	88.07	56.83	26.40
HomSD			61.57	13.19	12.21	113.47	93.87	76.64	61.57	13.19	12.21	113.47	93.87	76.64
Mpios			1122	1122	1122	1122	1122	1122	1122	1122	1122	1122	1122	1122
N			21395	21395	21395	21395	21395	21395	21395	21395	21395	21395	21395	21395

Standard errors clustered by municipality in parentheses (1122 mpios). The cocaine network includes only the routes shorter than 1000 kilometres ($L_R \leq 1000km$). All regressions follow equation 2.1 including year fixed effect, municipality fixed effects, GDP per capita at departmental level, logarithm of the population and a dummy if the municipality have coca crops at some point between 1990 - 2009 and its interaction with the international prices of cocaine, a dummy for the presidential periods of Alvaro Uribe Vela in Colombia and Hugo Chávez in Venezuela, a dummy variable if the municipality belongs to the CCT programme Familias en Acción. The dependent variable is standardised. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 2.13: OLS of Potential Cocaine Traffic Network on municipality male homicide rate by age category - extended model

			Model 1						Model 2					
	P_ι	D_f	Total	less than 4 y.o.	5 to 14	15 to 44	45 to 64	64 or older	Total	less than 4 y.o.	5 to 14	15 to 44	45 to 64	64 or older
$P_\iota D_f$	US	Pacific	0.598***	-0.075	0.102	0.565***	0.456***	0.281**	0.600***	-0.120	0.163	0.589***	0.417***	0.402***
			(0.127)	(0.190)	(0.141)	(0.127)	(0.117)	(0.125)	(0.132)	(0.130)	(0.105)	(0.138)	(0.097)	(0.090)
		Atlantic	0.234**	0.130	0.002	0.190*	0.192*	0.171						
			(0.117)	(0.099)	(0.098)	(0.107)	(0.116)	(0.117)						
		Ven.South	-0.265**	-0.174	0.009	-0.319***	-0.241**	0.019						
			(0.113)	(0.235)	(0.145)	(0.115)	(0.118)	(0.146)						
		Ven.North	0.272*	0.164	0.142	0.275*	0.147	0.226						
			(0.144)	(0.149)	(0.115)	(0.147)	(0.138)	(0.152)						
	EU	Pacific	-0.017	-0.015	0.073	0.013	-0.074	0.175						
			(0.174)	(0.111)	(0.141)	(0.164)	(0.150)	(0.152)						
		Atlantic	-0.004	-0.055	-0.016	0.060	-0.218	-0.103						
			(0.153)	(0.095)	(0.105)	(0.134)	(0.137)	(0.138)						
		Ven.South	0.378**	-0.154	-0.041	0.439***	0.175	0.150	0.114	-0.227	-0.067	0.135	0.049	0.124
			(0.149)	(0.182)	(0.159)	(0.146)	(0.167)	(0.162)	(0.109)	(0.144)	(0.093)	(0.108)	(0.140)	(0.122)
		Ven.North	-0.384*	-0.039	-0.120	-0.382*	-0.150	-0.166						
			(0.209)	(0.142)	(0.131)	(0.197)	(0.193)	(0.171)						
$P_\iota D_f \pi_f$	US	Pacific	1.639***	0.440	1.013***	1.547***	0.905**	-0.119	1.778***	0.572**	0.992***	1.690***	0.917***	-0.058
			(0.370)	(0.284)	(0.338)	(0.371)	(0.356)	(0.334)	(0.362)	(0.286)	(0.336)	(0.360)	(0.343)	(0.322)
		Atlantic	-0.025	-0.562	0.277	-0.046	0.006	0.159						
			(0.339)	(0.516)	(0.343)	(0.347)	(0.351)	(0.279)						
		Ven.North	0.516	-0.278	-0.499	0.623	0.034	-0.128						
			(0.758)	(0.319)	(0.339)	(0.775)	(0.564)	(0.718)						
	EU	Ven.South	0.639*	0.159	0.319	0.585*	0.757	0.308	0.483	0.160	0.336	0.428	0.707	0.307
			(0.345)	(0.334)	(0.251)	(0.332)	(0.504)	(0.280)	(0.314)	(0.308)	(0.245)	(0.305)	(0.467)	(0.263)
F_{TEST}			9.54	0.94	1.69	8.75	4.94	2.78	16.67	1.78	3.48	15.83	9.22	6.36
R^2			0.50	0.05	0.08	0.47	0.27	0.12	0.50	0.05	0.08	0.47	0.27	0.12
HomMean			90.54	1.90	3.41	160.46	101.25	45.10	90.54	1.90	3.41	160.46	101.25	45.10
HomSD			111.01	17.89	18.30	207.43	169.43	135.48	111.01	17.89	18.30	207.43	169.43	135.48
Mpios			1122	1122	1122	1122	1122	1121	1122	1122	1122	1122	1122	1121
N			21395	21395	21395	21395	21395	21390	21395	21395	21395	21395	21395	21390

Standard errors clustered by municipality in parentheses (1122 mpios). The cocaine network includes only the routes shorter than 1000 kilometres ($L_R \leq 1000km$). All regressions follow equation 2.1 including year fixed effect, municipality fixed effects, GDP per capita at departmental level, logarithm of the population and a dummy if the municipality have coca crops at some point between 1990 - 2009 and its interaction with the international prices of cocaine, a dummy for the presidential periods of Alvaro Uribe Vela in Colombia and Hugo Chávez in Venezuela, a dummy variable if the municipality belongs to the CCT programme Familias en Acción. The dependent variable is standardised. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 2.14: OLS of Potential Cocaine Traffic Network on municipality female homicide rate by age category - extended model

			Model 1						Model 2					
	P_ι	D_f	Total	less than 4 y.o.	5 to 14	15 to 44	45 to 64	64 or older	Total	less than 4 y.o.	5 to 14	15 to 44	45 to 64	64 or older
$P_\iota D_f$	US	Pacific	0.305*	-0.096	0.063	0.361**	0.056	0.060	0.322***	-0.058	0.181	0.333***	0.019	0.235***
			(0.158)	(0.094)	(0.134)	(0.156)	(0.148)	(0.117)	(0.098)	(0.077)	(0.113)	(0.095)	(0.093)	(0.084)
		Atlantic	0.140	0.064	0.063	0.178	-0.044	-0.006						
			(0.124)	(0.084)	(0.119)	(0.126)	(0.093)	(0.094)						
		Ven.South	-0.064	0.375*	-0.131	-0.155	-0.021	0.054						
			(0.182)	(0.226)	(0.241)	(0.191)	(0.158)	(0.131)						
		Ven.North	0.407**	-0.290	0.271	0.441**	0.254*	-0.041						
			(0.195)	(0.229)	(0.245)	(0.207)	(0.148)	(0.119)						
	EU	Pacific	0.001	0.081	0.133	-0.068	-0.050	0.245*						
			(0.209)	(0.084)	(0.128)	(0.207)	(0.143)	(0.132)						
		Atlantic	-0.152	-0.057	-0.022	-0.121	-0.094	-0.011						
			(0.151)	(0.064)	(0.140)	(0.149)	(0.118)	(0.102)						
		Ven.South	0.243	-0.048	0.142	0.283	0.129	-0.077	0.057	0.168	-0.046	0.045	0.060	-0.069
			(0.212)	(0.250)	(0.261)	(0.218)	(0.151)	(0.154)	(0.125)	(0.196)	(0.137)	(0.134)	(0.112)	(0.108)
		Ven.North	-0.625**	0.172	-0.380	-0.637**	-0.363*	0.019						
			(0.298)	(0.125)	(0.287)	(0.301)	(0.187)	(0.116)						
$P_\iota D_f \pi_f$	US	Pacific	0.424	0.260	-0.221	0.557	0.386	-0.514*	0.408	0.314	-0.224	0.582*	0.288	-0.526*
			(0.317)	(0.235)	(0.517)	(0.341)	(0.313)	(0.295)	(0.309)	(0.243)	(0.503)	(0.330)	(0.301)	(0.288)
		Atlantic	0.301	-0.369	0.334	0.287	0.165	0.041						
			(0.290)	(0.250)	(0.354)	(0.308)	(0.255)	(0.180)						
		Ven.North	-0.333	-0.308	-0.168	-0.270	0.030	0.085						
			(0.412)	(0.271)	(0.365)	(0.440)	(0.364)	(0.321)						
	EU	Ven.South	0.576**	-0.463*	0.376*	0.698**	0.655**	-0.519	0.359	-0.477*	0.269	0.485*	0.519*	-0.519
			(0.289)	(0.266)	(0.207)	(0.312)	(0.313)	(0.389)	(0.259)	(0.280)	(0.185)	(0.289)	(0.288)	(0.378)
F_{TEST}			3.02	1.68	1.16	3.02	1.48	1.42	4.83	1.43	1.26	5.97	2.04	3.34
R^2			0.22	0.06	0.06	0.19	0.09	0.06	0.22	0.06	0.06	0.19	0.09	0.06
HomMean			8.67	1.71	1.88	13.32	10.32	7.58	8.67	1.71	1.88	13.32	10.32	7.58
HomSD			17.89	18.52	13.95	31.91	43.99	58.15	17.89	18.52	13.95	31.91	43.99	58.15
Mpios			1122	1122	1122	1122	1122	1122	1122	1122	1122	1122	1122	1122
N			21395	21395	21395	21395	21395	21395	21395	21395	21395	21395	21395	21395

Standard errors clustered by municipality in parentheses (1122 mpios). The cocaine network includes only the routes shorter than 1000 kilometres ($L_R \leq 1000km$). All regressions follow equation 2.1 including year fixed effect, municipality fixed effects, GDP per capita at departmental level, logarithm of the population and a dummy if the municipality have coca crops at some point between 1990 - 2009 and its interaction with the international prices of cocaine, a dummy for the presidential periods of Alvaro Uribe Vela in Colombia and Hugo Chávez in Venezuela, a dummy variable if the municipality belongs to the CCT programme Familias en Acción. The dependent variable is standardised. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 2.15: Drug traffic on different actions and presence of illegal armies - model 1

			Illegal Armies Presence				Illegal Armies Actions					
	P_ι	D_f	FARC	ELN	AUC	Clash	Terrorism	Ambush	Attack to military base	Harassment	Land piracy	Illegal army actions
$P_\iota D_f$	US	Pacific	-0.154**	0.111**	-0.004	0.029	0.075	0.038	-0.038	-0.075	0.174	0.029
			(0.062)	(0.048)	(0.025)	(0.034)	(0.223)	(0.055)	(0.123)	(0.097)	(0.112)	(0.123)
		Atlantic	-0.004	0.088**	0.074***	0.046	0.082	0.081	0.111	0.087	0.089	0.145*
			(0.045)	(0.039)	(0.023)	(0.028)	(0.119)	(0.061)	(0.072)	(0.075)	(0.087)	(0.083)
		Ven.South	0.096	-0.102*	-0.007	-0.000	0.207	-0.279	-0.098	0.242	-0.321**	0.057
			(0.060)	(0.053)	(0.027)	(0.034)	(0.227)	(0.219)	(0.177)	(0.173)	(0.150)	(0.205)
		Ven.North	-0.030	0.242***	0.024	0.034	-0.091	0.034	0.122	-0.108	0.816***	0.121
			(0.064)	(0.061)	(0.031)	(0.040)	(0.262)	(0.146)	(0.120)	(0.128)	(0.168)	(0.171)
	EU	Pacific	-0.005	-0.156***	0.001	-0.074**	0.293	0.120	0.074	0.151	0.074	0.254
			(0.051)	(0.045)	(0.027)	(0.035)	(0.340)	(0.180)	(0.169)	(0.138)	(0.406)	(0.222)
		Atlantic	0.044	0.009	-0.076***	-0.049	0.016	-0.318**	0.380***	0.166	0.124	0.144
			(0.042)	(0.039)	(0.028)	(0.031)	(0.265)	(0.159)	(0.135)	(0.142)	(0.466)	(0.225)
		Ven.South	0.053	0.109**	0.098***	0.063*	1.550***	0.651	0.472	-0.146	0.689	0.951***
			(0.057)	(0.047)	(0.034)	(0.036)	(0.443)	(0.501)	(0.441)	(0.378)	(0.452)	(0.367)
		Ven.North	0.006	-0.092	-0.077*	-0.084*	-0.668	0.579*	0.165	-0.308	-0.577	-0.399
			(0.056)	(0.065)	(0.042)	(0.046)	(0.445)	(0.334)	(0.316)	(0.281)	(0.472)	(0.350)
$P_\iota D_f \pi_f$	US	Pacific	0.282*	0.048	0.079	0.303***	1.643**	0.324	0.359*	0.353	0.301	1.057***
			(0.147)	(0.103)	(0.075)	(0.092)	(0.686)	(0.209)	(0.197)	(0.255)	(0.312)	(0.381)
		Atlantic	0.013	0.023	-0.070	0.121	-1.962	-0.304	-0.006	0.269	-0.139	-0.765
			(0.159)	(0.117)	(0.056)	(0.074)	(1.983)	(0.227)	(0.111)	(0.393)	(0.352)	(0.646)
		Ven.North	0.196	-0.169	0.066	0.044	1.454	-0.242	-0.249	0.900	-1.712***	0.551
			(0.228)	(0.259)	(0.085)	(0.177)	(1.078)	(0.398)	(0.260)	(0.694)	(0.538)	(0.762)
	EU	Ven.South	0.181	0.104	0.005	0.126	-0.014	-1.501	-0.026	3.758**	-0.269	1.496
			(0.119)	(0.106)	(0.072)	(0.088)	(1.277)	(1.011)	(0.870)	(1.807)	(1.085)	(1.389)
F_{TEST}			3.51	5.22	2.44	3.23	4.09	1.46	2.83	2.18	3.43	5.03
R^2			0.39		0.21	0.32	0.41	0.25	0.20	0.33	0.31	0.43
Mean %			0.22	0.10	0.04	0.07	0.17	0.05	0.04	0.11	0.10	0.29
Mpios			1096	1096	1096	1096	1120	1120	1120	1120	1120	1120
N			20180	20180	20180	20180	13142	13142	13142	13142	13142	13142

Standard errors clustered by municipality in parentheses (1122 mpios). The cocaine network includes only the routes shorter than 1000 kilometres ($L_R \leq 1000km$). All regressions follow equation 2.1 including year fixed effect, municipality fixed effects, GDP per capita at departmental level, logarithm of the population and a dummy if the municipality have coca crops at some point between 1990 - 2009 and its interaction with the international prices of cocaine, a dummy for the presidential periods of Alvaro Uribe Vela in Colombia and Hugo Chávez in Venezuela, a dummy variable if the municipality belongs to the CCT programme Familias en Acción. The dependent variable is standardised. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Chapter 3

Drugs, Guns and Early Motherhood in Colombia

3.1 Introduction

> *"I was 15 when I became a widow, ... Hi died on my legs. In my heart he left me a great sadness and a reminder I will never forget, which is my son." Cielo (17 years old)*[1]

Cielo is one of the main characters of La Sierra - (Dalton et al. (2005)), a documentary about 3 young who lived in the neighbourhood of La Sierra (Medellín, Colombia) during the conflict between extreme right-wing paramilitary forces (AUC) and extreme left-wing guerrillas (FARC). Cielo, who was 17 at the time of the documentary was already the mother of a 2 year old baby. But she is only one of many teenage girls who are already mothers living through the war in that neighbourhood La Sierra.

Colombia is no stranger to the global interest in understating the causes and consequences of teenage pregnancy. Despite the 17% drop of the worldwide Teenage Fertility Rate (*TFR*) from 2002 to 2011 (table 3.1) the problem of early motherhood is still very important in the public agendas of almost every country. For example, even after falling 34%, the TFR in low income countries (91.8 babies born from 1000 women from 15 to 19 years old) are still 1.7 times the world average and 3.5 times the rate in the OECD countries.

Even though the problem of teenage pregnancy is higher in poor and developing

[1]Translation from Dalton et al. (2005)

countries, some high income countries also suffer from the increase in the TFR rates inside their own population. For instance, against the worldwide decreasing tendency countries like Spain and the United Kingdom showed increases of 18% and 4% in the TFR from 2002 to 2011.[2] .

Table 3.1: Teenage Fertility Rates 2002 - 2011

	2002	2011	%Change
World	64.72	52.67	-17%
Low Income Countries	120.23	91.81	-24%
Middle Income Countries	60.35	50.21	-17%
OECD Countries	31.76	25.76	-19%

Source: UN Population Division, World Population Prospects. Teenage Pregnancy Rate (TFR) is the number of births per 1,000 women ages 15-19.

There is indeed extensive literature that analyses the causes of early childbearing and the cost to mothers, fathers and the children. Theoretical analyses of the timing of motherhood build on the initial idea of Becker et al. (1960) and the later developments of Blackburn et al. (1993). On the one hand, the timing of motherhood is a function of relative wages and the human capital accumulation of women. On the other hand, it has been shown that young mothers face reductions in the accumulation of human capital, labor opportunities, income and their own health. (Klepinger et al. (1999); Miller (2011); Fletcher (2011); Buckles (2008)). Furthermore, the outcomes in education, health and labor opportunities for the offspring of young mothers decrease significantly as well (Klepinger et al. (1999); Miller (2009, 2011); Buckles (2008); Chevalier and Viitanen (2003); Francesconi (2008)).

As I described in the previous chapter, many authors have analysed the cost and consequences of civil war, armed conflict and crime on economic agents. Furthermore, every single work is challenged by unique problems, depending on the causes and characteristics of the conflict.

This chapter contributes to both fields by analysing the indirect cost of conflict and the causes of early motherhood. This work builds up on the puzzle propose by Flórez et al. (2004) when they analysed the behaviour of teenage fertility in Colombia. The authors said:

> *"The increasing tendency in the teenage fertility rate was not expected given the positive changes in socioeconomic factors at individual level*

[2]According the UN the TFR grows in Spain from 9.4 to 11.1 and from 28.6 to 29.7 in the United Kingdom between 2000 and 2011.

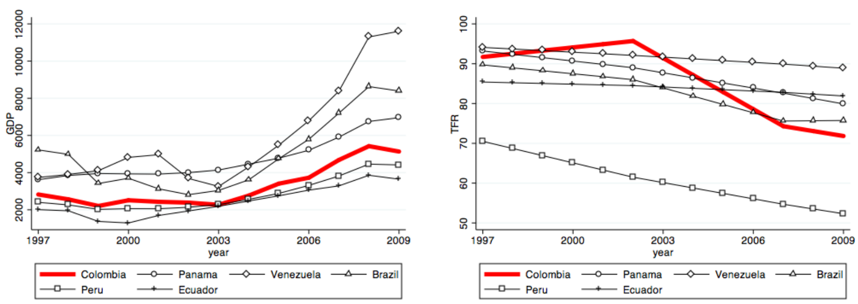
(education, labor participation) and in the context (urbanisation, ...'[3]

Furthermore, supporting the latest statement figure 3.1 compares the GDP per capita and the TFR of Colombia and its surrounding countries.[4] As we can see in the panel *a*, the behaviour of Colombia's GDP does not differ significantly from the evolution of the GDP per capita region from 1997 to 2009. However, the fertility rate of Colombia is the only one in the region with a positive slope before 2002 and a sharp decline afterwards (panel *b* on the same figure).

As Flórez argues, the increase in babies born to adolescent mothers was not expected and therefore Colombia should have seen a reduction in the levels of teenage fertility as the other countries in the region. However, unlike the other countries of the region, the homicide rate in Colombia was about 3 times greater in 2002. Figure 3.2 shows the homicide rates of the same countries in the analysis of figure 3.1. In this case, Colombia shows a very different profile in terms of violence and security.

Figure 3.1: Teenage Fertility Rate and GDP per capita
Colombia and some countries in Latin America and Caribbean 1997 - 2009

(a) GDP per capita (b) Teenage Fertility Rate



Source: World Bank national accounts data, and OECD National Accounts data files. GDP per capita (current US$)
LA is for Latin America and the Caribbean developing countries

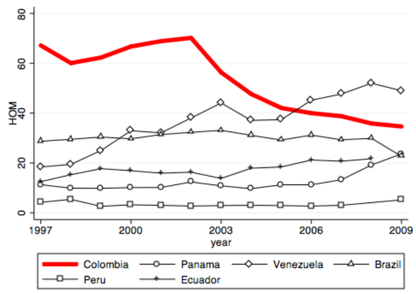
Source: UN Population Division, World Population Prospects. Teenage Pregnancy Rate (TFR) is the number of births per 1,000 women ages 15-19.
LA is for Latin America and the Caribbean developing countries

Subsequently, this chapter claims that violent conflict explains part of the increases of the rate of teenage fertility in Colombia. Specifically, I argue that when the household is exposed to increases in local violence, the cost-benefit relationship of postponing motherhood changes. In fact the incentives to be a young mother increase. Firstly, armed violence reduces the incentives to invest in

[3]Flórez et al. (2004) *Page 10.* This is my translation from the following quote in Spanish. "*La tendencia creciente en la fecundidad adolescente en el país no era esperada dado los cambios positivos que observamos en algunos determinantes socioeconómicos al nivel individual (educación, participación laboral) y contextual (urbanización ...*"

[4]Colombia has borders with Panama, Venezuela, Brazil, Peru and Ecuador.

Figure 3.2: Homicides per 100.000 habitants
Colombia and some countries in Latin America and Caribbean 1997 - 2009



Source: UN Office on Drugs and Crime's International Homicide Statistics database. Homicide rate (HOM) is Intentional homicides per 100,000 people

education. This reduces the expected prize of postponing motherhood. Secondly, since violence affects men more than women (for instance recruitment in IAG and gangs and homicides), changes in the sex ratios reducing the expected gains in the marriage markets. I discuss these two mechanisms later in this chapter.

Similar analyses are found in the literature on household welfare and armed conflict. The papers from Abramitzky et al. (2010), Shemyakina (2009) and Valente (2011) have found interesting relationships between violence of the civil war and marriage markets and fertility decisions. These authors take advantage of sharp, localised increases in violence to identify the effects of conflict over households.

However, such sharp increases are not present in the Colombian case of long-lasting, changing conflict. Thus, in this chapter I use the strategy proposed in chapter 2. I use the network of potential internal cocaine trafficking as an instrument to identify the causal effect of armed violence over changes in the teenage fertility profiles at municipality level in Colombia.

Identification relies on the following statement: Drug traffickers adjust their decisions according to changes in the relative expected profits they could get in international markets. Then, changes in the relative international profits from cocaine induce different time/space variations in violence according to the municipality competitive advantage for drug traffic. Further, Colombian drug dealers compete in regional oligopoly markets and have no power to set prices at international markets (Echandia (2013); Kugler et al. (2005)). Thus, changes in violence due to changes in the potential cocaine trafficking are orthogonal to the household characteristics and to the underline pregnancy profiles of young women.

Consequently, this chapter develops a simple theoretical framework to show how homicides could affect the cost-benefit function of postponing motherhood. I use a discrete duration model in order to estimate the effect of municipality homicide rates on the pregnancy hazard function of adolescent women. My estimations use a control function approach using internal drug traffic as an instrument of municipality homicides.

My results suggest that after accounting for endogeneity, one standard deviation increase in the municipality homicide rate increases the probability of a woman to become pregnant for the first time before 19 years old by 2.65 p.p. with a 95% confidence interval from 0.07 to 5.23. What is more, an increase in violence increases the probability of early marriage but reduces the probability of early sexual intercourse and having a second baby before 19 years old. The latest results suggest that early pregnancy and marriage is being use by teenage women as an insurance strategy when they foreseen a reduction in the future utility due to an increase in local violence.

Hence, this chapter has the following structure. Firstly, section 3.2 describes the theoretical framework that establishes a base for my estimations. Secondly, section 3.3 explains my estimation strategy and describes the conditions to assure identification. Thirdly, section 3.4 describes the data I use. Fourth, in the next section I show and discuss the results of my estimations. Finally, I conclude.

3.2 A model of pregnancy and violence

In this section I develop a model of women's fertility choice as the framework to understand the way in which the local violence could affect the probability of becoming a young mother.

Before setting up the model, I discuss its constraints. Firstly, this model focuses only on the decision of first pregnancy. Thus, I do not analyse related decisions such as the time of marriage or number of children. Secondly, this model only takes into account the woman's decision and ignores male decision functions and matching equilibriums. The main reason for imposing such a restriction to the model is the lack data for men available for our estimations.

The model builds up on the work of Kearney and Levine (2011), where the decision of postponing motherhood is driven by the subjective probability of success. I complement their model while making explicit the role of the marriage market and the effect of violence on such a market.

3.2.1 The environment

A woman i has a *attractiveness endowment* μ_i and lives over 2 periods $t = \{0, 1\}$ which represent teenage and adulthood years. The discount factor is β. μ_i represents the set of her personal characteristics that are valuable to men[5]. What is more, if she is single and has no children, each period she receives a random couple x_j from the set of men Ω. I define $G_i(x_j) = G(x_j \mid \mu_i) = P(x \leq x_j \mid \mu_i)$ to be the cumulative probability distribution that a woman i enters into a couple with characteristics x_j from set Ω. $g_i(x_j)$ is the corresponding density probability distribution.

In each period – t – women gain utility from consumption $u(c_t)$, where u is an increasing and concave function. At $t = 0$ every woman has consumption c_0 with probability 1. At $t = 1$ women can have either high or low consumption. Then, $c_1 = \bar{c}_1$ with probability q and $c_1 = \underline{c}_1$ with probability $1 - q$ where $\bar{c}_1 > \underline{c}_1$. Following Kearney and Levine (2011), q is the subjective probability of getting high consumption $\bar{c}_1$ (economic success). That probability depends on each woman's decision at $t = 0$. If she decides to become a young mother, her subjective probability of success is q^e. While q^d is her probability of getting high consumption if she decides to delay motherhood until $t = 1$. As Kearney and Levine (2011), this paper assumes that $q^e < q^d$.

Moreover, motherhood gives utility $v_i(x_j) = \alpha_i + b_i d_{ij}$ where α_i is the direct utility of being a mother and $b_i d_{ij}$ is the utility she gets from the *attractiveness surplus* $d_{ij} = (x_j - \mu_i)$. It is important to point out that women will not accept any offer and will prefer motherhood only if $v_i(x_j) \geq 0$. For offers such that $v_i(x_j) < 0$, the preferred option is to stay single and childless. In addition, baby care has a fixed cost κ units of consumption. Finally, the mother will gain utility Ψ_x when her offspring has grown up.

As follows, the lifetime expected utility of becoming a mother at period 0 when she gets couple x is:

$$U_x^e = u_0^e(x) + \beta V_x^e \tag{3.1}$$

Where, $u_0^e(x) = u(c_0 - \kappa) + v_i(x)$ is the immediate utility in period 0 meanwhile $V_x^e = q^e u(\bar{c}_1) + (1 - q^e) u(\underline{c}_1) + \Psi_x$ is her expected utility in period 1. If she decides to postpone motherhood, her lifetime expected utility would be:

[5]for example education, income, race, physical characteristics

$$U^d = u_0^d + \beta V^d \tag{3.2}$$

Where $u_0^d = u\left(c_0\right)$ and $V^d = q^d\left[\left(1 - G_{\underline{x}}\right)\left(u\left(\bar{c}_1 - \kappa\right) + v\left(\hat{x}\right) + \Psi_{\hat{x}}\right) + G_{\underline{x}} u\left(\bar{c}_1\right)\right] + \left(1 - q^d\right)\left[\left(1 - G_{\underline{x}}\right)\left(u\left(\underline{c}_1 - \kappa\right) + v\left(\hat{x}\right) + \Psi_{\hat{x}}\right) + G_{\underline{x}} u\left(\underline{c}_1\right)\right]$. Moreover, $G_{\underline{x}} = G_i\left(\underline{x}\right)$ is the probability of getting an offer lower than $\underline{x}$ which is the minimum offer that a woman would accept. Furthermore, $\hat{x} = \int_{\underline{x}} z g\left(z\right) dz$ is the expected value of the offer she could receive in period 1.

3.2.2 The turning offer $\tilde{x}$ and the pregnancy decision

Assuming that women are risk neutral - $u' = 1$ - for a given offer x a woman chooses to be a mother at $t = 0$ if $U_x^e \geq U^d$ when:

$$\left(v\left(x\right) - \kappa + \beta\Psi_x\right) - \beta\left(1 - G_{\underline{x}}\right)\left(v\left(\hat{x}\right) - \kappa + \Psi_{\hat{x}}\right) \geq \beta\Delta q\Delta c \tag{3.3}$$

Equation 3.3 shows the cost-benefit relationship of becoming a young mother. On the left hand side we describe the benefits of early motherhood. Benefits come from the gain of expected life time utility of being a mother. Importantly, women will never be mothers with probability $G_{\underline{x}}$. The right hand side $\Delta q\Delta c = \left(q^e - q^d\right)\left(\bar{c}_1 - \underline{c}_1\right)$ is the gain in subjective consumption due to postponing motherhood, which represent the opportunity cost of early childbearing. If women believe that the gains of motherhood are larger than the subjective loss in consumption they will prefer to be mothers when young, rather than wait until adulthood.

In order to explain the effect of violence on women's pregnancy decisions I define the *turning offer* $\tilde{x}$ as the couple such that $U_{\tilde{x}}^e = U^d$:

$$\tilde{x} = \frac{1}{b}\left[\beta\left(\Lambda_{\underline{x}} v\left(\hat{x}\right) + \Delta q\Delta c + \left(\Lambda_{\underline{x}}\Psi_{\hat{x}} - \Psi_{\tilde{x}}\right)\right) - \left(\alpha - b\mu - \left(1 - \beta\Lambda_{\underline{x}}\right)\kappa\right)\right] \tag{3.4}$$

Where $\Lambda_{\underline{x}} = 1 - G_{\underline{x}}$ is the probability of getting an offer that she will accept in period 1. Hence, at $t = 0$ a woman i will decide to be a teenage mother if she gets a couple $x \geq \tilde{x}$. Thus, if G rules the distribution of x the probability that a woman i chooses early motherhood is:

$$P\,(\text{young mother=1}) = P\,(x > \tilde{x} \mid \mu_i) = 1 - G_i\,(\tilde{x}) \tag{3.5}$$

Hence $\frac{\partial P(\text{young mother=1})}{\partial \tilde{x}} = -g_i\,(\tilde{x}) \leq 0$. Then, we can analyse the effect of different variables over the pregnancy decision using equations 3.4 and 3.5. Nevertheless, it is important to describe the variables that affect $\tilde{x}$.

The first part of equation 3.4 – $\Lambda_{\underline{x}} v\,(\hat{x})$ – is the expected value of the expected couple she could get in period 1. In other words, the first part represents the auction value of the option to delay. The second part of the equation – $\Delta q \Delta c$ – represents the opportunity cost of not waiting, due to the expected forgone consumption in the future. Thereafter, $(\Lambda_{\underline{x}} \Psi_{\hat{x}} - \Psi_{\tilde{x}})$ is the gain on the future returns from offspring, due to postpone motherhood. Following Miller (2009), offspring from teenage mothers invest less in human capital. Thus, their returns in the future may be lower, such that $(\Lambda_{\underline{x}} \Psi_{\hat{x}} - \Psi_{\tilde{x}}) \geq 0$. Finally, $(\alpha - b\mu + (1 - \beta \Lambda_{\underline{x}})\,\kappa)$ represents the possible forgone utility if the woman never married. These results are according to the findings of Blackburn et al. (1993), Cigno and Ermisch (1989), Ermisch and Pevalin (2004) and Ermisch and Pevalin (2004).

3.2.3 How does conflict affect women's decision?

Following the analysis, we use equations 3.4 and 3.5 to understand the possible mechanisms in which the violence affects the probability of being a mother when young. It is important to point out that this chapter does not analyse the use of gender and sexual violence in conflict. Previous works such as Lara (2008) and Pinzón-Paz (2009) studied already the use and the consequences of gender violence in the Colombian conflict[6].

I begin my analysis declaring Vio_i the level of conflict violence that a woman i is exposed to. Then, rewriting equation 3.5 as $h_i = P\,(\text{young mother =1} \mid \tilde{x}_i)$ $= 1 - G_i\,(\tilde{x}_i)$, where h_i is the probability that woman i become a mother when young (period 0 in the model). Therefore, the influence of violence in the decision of woman i can be written as $\frac{\partial h_i}{\partial Vio_i} = -g_i\,(\tilde{x}_i)\,\frac{\partial \tilde{x}_i}{\partial Vio_i}$. Given that $g_i\,(\tilde{x}_i) > 0$, the analysis simplifies to the analysis of $\frac{\partial \tilde{x}_i}{\partial Vio_i}$ from equation 3.4.

As I claim in the introduction, violent crime affects the expectations of young women regarding their future outcomes in the marriage and labor markets. Ac-

[6]One can argue that more homicides are correlated with more sexual and gender violence. I did not find evidence of this correlation. The main reason may be the quality of the data in sexual and gender violence and the high levels of not reporting.

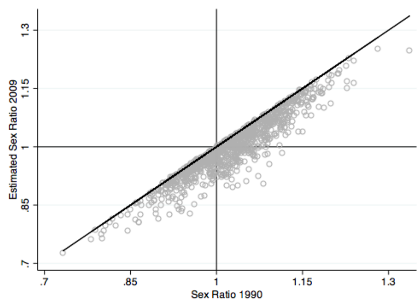
cording to the model, I capture the expectations on marriage via $\Lambda_{\underline{x}} v(\hat{x})$ and the expectations in the labor market using $\Delta q \Delta c$.

Firstly, when men are targeted by armed violence, women's decisions are affected as well. I asses this channel through changes in the c.d.f. G, specially through changes in the sex ratio - $sr = \frac{men}{women}$, via recruitment of soldiers and killings.

According to a survey of former soldiers from illegal armed groups in Colombia (DNP (2008)), 91% of the excombatants were men. Almost 70% of these men have only primary education or less. Pinto et al. (2002) show that 82% of the former members of the illegal armed groups joined the group when they were 10 to 17 years old. In addition, as I emphasise above, homicides are more prevalent in men than women. Table 2.3 in chapter 2 shows how 91% of the total homicides are men, while only 10% were women casualties. Therefore, I contend that decreases in sex ratio could affect the decision of motherhood in the following ways.

Firstly, when the sex ratio falls (less men) the final probability of find a couple decreases - $\frac{\partial \Lambda_{\underline{x}}}{\partial Vio} < 0$. Figure 3.3, shows the variability in the change in the sex ratios in Colombia as a result of the homicides in each municipality. It is important to point out that no municipality shows a positive change in the sex ratio. The changes in the ratio are within a range from 0 to -16.6%, showing large heterogeneity in the effect over different regions of the country.

Figure 3.3: Estimated change in the adult sex ratio due to homicides rates from 1990 to 2009 (individuals from 15 to 44 years old).



The second effect might be related to the expected quality of the future offer - $\hat{x}$. When the sex ratio decreases, each woman has less bargaining power and the expected quality of the offer decreases (men could choose better partners). What is more, losing bargaining power reduces the capability of the woman to have autonomy over her own fertility choices. Men, in times of conflict, aim to have a child in order to build a memory or legacy, after their death. Then, $\frac{\partial \hat{x}}{\partial Vio} < 0$. This result follows Abramitzky et al. (2010) and Chiappori et al. (2002).

In addition, one can assume that violent conflict reduces the expectations of future economic success. Soares (2005, 2013) and Lorentzen et al. (2008) argue that armed conflict increases future uncertainty, and thereby reduces investment in activities like education. One can also argue that the feeling of despair, as opposed to hope, increases when violence increases around a household. What is more, Rodríguez and Sánchez (2009) show that high school drop out rates increase when violence increase in Colombia. Therefore, we could expect that $\frac{\partial \Delta q_i \Delta c_i}{\partial Vio_i} < 0$

Table 3.2 shows that violence also affects parental expectations about the benefits of education. Using data from the evaluation of the social welfare programme Red Juntos[7], the table shows that in municipalities where the mean and the standard deviation of the homicide rate is higher, parents have lower expectations about the income of their offspring if he finishes high school or university education. If parents expectations are lower, one can expect that youth living in violent environments do not recognise an expected return from investing in education. Therefore, the cost of being young parents reduces.

Table 3.2: Effect of homicides on parental expectations about offspring's future income, conditional on education

Violence1990 - 2009	Expected income conditional on working		
	High School	University	Difference
S.D.	-0.047	-0.370***	-0.184
	(0.078)	(0.108)	(0.141)
Mean	-0.031	-0.246***	-0.122
	(0.052)	(0.072)	(0.094)
N	1258	1055	1055

Base on the data from the welfare programme Juntos in 2011. The sample includes 77 municipalities.
Standard errors clustered by municipality in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Thus, the joint effect of violence on the turning offer would be:

$$\frac{\partial \tilde{x}}{\partial Vio} = \frac{\beta}{b} \left[\overset{-}{\frac{\partial \Lambda_{\underline{x}}}{\partial Vio}} \overset{+/-}{\left(v\left(\hat{x}\right) + \Psi_{\hat{x}} - \kappa\right)} + \overset{-}{\frac{\partial \hat{x}}{\partial Vio}} \overset{+}{\Lambda_{\underline{x}}} + \overset{-}{\frac{\partial \Delta q \Delta c}{\partial Vio}} \right] < 0 \tag{3.6}$$

Consequently, $\frac{\partial h}{\partial Vio} > 0$.

Increased violence raises the incentives to anticipate pregnancy. However, there

[7] More information about the programme is available in http://web.presidencia.gov.co/especial/juntos/index.html

may be ways is such violence decreases the teenage pregnancy rate. Following Shemyakina (2009), when the shock on male deaths is substantial, women may postpone marriage and motherhood due to the decreased availability of men in the area. Consequently, the final effect can be ambiguous. Less women may get offers at $t = 0$, which means that the pregnancy rate falls. Yet, the women who do get a signal are more likely to become pregnant, which means that the pregnancy rate increases.

Following Acemoglu et al. (2004) male deaths could have a positive effect on the female labor market, thereby increasing the premium of postponing motherhood. Their analysis is based on the situation of a massive confrontation such as the World Word II. However, Singh and Shemyakina (2013) have shown the opposite effect during the Punjab insurgency.

A further consideration is that women perceive the shock of violence to be temporary. The difference $(\Lambda_{\underline{x}}\Psi_{\hat{x}} - \Psi_{\tilde{x}})$ may increase so $\frac{\partial\left(\Lambda_{\underline{x}}\Psi_{\hat{x}} - \Psi_{\tilde{x}}\right)}{\partial Vio} > 0$ because a future with no violence will allow even better conditions for infants. I cannot rule out these last two options which imply a reduction in the probability of being a young mother by an increase in the level of violence. However, I argue that the effects on the marriage and labor market overcome the effect on $(\Lambda_{\underline{x}}\Psi_{\hat{x}} - \Psi_{\tilde{x}})$.

Unfortunately, the data available for this chapter does not allow me to disentangle each channel. I do not have individual information about women's expectations in the labour and marriage markets. Nevertheless, my results support the notion that the negative effects on the labor and marriage market overcome the opposite effects. In summary, an increase in violence reduces the expected revenues of young women in the labor and marriage market. Teenage pregnancy therefore works as insurance when a loss in future utility is foreseen by young women.

3.3 Estimation strategy

Equation 3.5 shows how the probability of being a young mother depends on the turning offer $\tilde{x}_i$. What is more, the last part of section 3.2 discusses how the level of exposure to armed violence affects the turning offer and the pregnancy decision. Hence, equation 3.5 is written as the probability of being a young mother as a function of the violence she is expose to: $P_{imt}\left(young\,mother\right) = f\left(Vio_{mt},\, X_i\right)$, where Vio_{mt} is the violence at municipality m at period t.

In order to accurately estimate the probability of early motherhood, this chapter proposes to follow a survival analysis where the variable of interest will be the hazard function $h_{ij} = P(T_i = j \mid T_i \geq j)$ - which represents the probability of a woman i become pregnant at period $T_i = j$ given that she has not been pregnant in any period before j. For this estimation I follow the strategy of discrete duration estimations of Lancaster (1979) and Jenkins (2005)[8]. Therefore, in discrete time $hij = P\left(j-1 < T \leq j \mid T > j-1\right)$. Then, the hazard function can be written as $h_{ij} = h\left(j,\, X_i,\, Vio_{ij}\right)$ where X_i are the individual variables that affect the pregnancy hazard and Vio_{ij} is the level of violence an individual i suffered at age j.

The first model to estimate would be a discrete time proportional hazard model - PH - where h_{ijmt} represents the probability that woman i will become pregnant at age j, given she was not pregnant before age j, and that she is living in municipality m at period t. Once again, following Jenkins (2005), h_{ijmt} can be written as a function of the unconditional hazard rate $h_0\left(j\right)$ and a linear index on X_i, Vio_{mt} and ε_{ijmt}.

$$h_{ijmt} = h_0\left(j\right) g\left(\beta X_i + \gamma Vio_{mt} + \varepsilon_{ijmt}\right) \tag{3.7}$$

From the latest equation according to the model developed in section 3.2, I expect that $\frac{\partial h}{\partial Vio} = h_0\left(j\right)\gamma g' > 0$. With this model, and assuming that violence shocks are predictable[9], and Vio_t and $g\left(Vio_{mt}\right)$ are bounded, it is possible to identify $\hat{\gamma}$ and the underline hazard function $h_0\left(j\right)$ using standard regression methods(Van den Berg (2001)). Accordingly, figure 3.6 (in section 3.5), will suffice to show that conflict, measure by homicide intensity[10], has a direct impact on the probability of becoming a mother when young. Figure 3.6 shows how the probability of becoming pregnant at age j is always greater for women who live in violent towns.

However, the orthogonality condition may not be credible when the variable of analysis is the violence that a household is expose to at certain period of time. In the sense of duration models the endogeneity refers to unobservable variables that affect the level of exposure to armed violence, and the underlying hazard function of first pregnancy (Bijwaard (2008)). In other words, there is an unobservable

[8]Given that the dependent variable will group all the observations in a yearly interval I use a discrete duration model for my estimations. See further discussions in Jenkins (2005) chapter 3.

[9]Predictability is associated with weak exogeneity in time series models.

[10]Homicide intensity divide the municipality by a dummy such that $homDm100 = 1\left[homicide\,rate \geq 100\right]$.

force that may make some women more likely to be affected by the local violence of conflict and, at the same time, this affects the probability that the woman becomes pregnant at a certain age. Then, if $Vio_{mt} \not\perp \varepsilon_{ijmt}$ we could expect that $Vio_{mt} \not\perp h_0(j)$, thus we cannot identify γ using a PH model.

As I explained in the introduction to this chapter, the violent process in Colombia does not have the characteristics of the strong exogenous shock found by previous authors when they analysed the link between conflict, marriage and motherhood. In Colombia, the differential effect of the long lasting violent process could be correlated with different institutions, the low presence of the state and risk aversion profiles of the community. The latest list of variables can explain the differences in the fertility profiles as well.

For this reason, this work proposes an instrumental variable strategy using the variation in international cocaine prices and its interaction with the network of roads that is used to trafficking cocaine from the cultivation regions to the international borders. Identification relies on the following statement: Drug dealers react to changes in the relative profits that they could gain from different international markets. In my case, I only use the markets of Europe and United States. What is more, I assume that the violence is the main force use by traffickers in order to control the network. The usage of a fixed network varies in time as a response of the relative profitability. Furthermore, the latest reaction implies different violent forces over certain regions at different times.

The details of this strategy were described in section 2.3 of chapter 2. I define DD_{mt} to be the influence of the potential drug trafficking over municipality m at year t. Moreover, I assume that $DD_{mt} \perp \varepsilon_{ijmt}$ therefore $DD_{mt} \perp h_0(j)$. In order to estimate γ, I write the proportional hazard model of equation 3.7 as a linear indicator function[11]:

$$preg_{ijmt} = 1\left[h_0(j) + \gamma Vio_{ijmt} + X_i + T + M + \varepsilon_{ijmt} > 0\right] \tag{3.8}$$

Thus, if F is the $C.D.F$ of the error term $-\varepsilon_{ijmt}$ I rewrite the latest equation as $preg_{ijmt} = F(h_0(j) + \gamma Vio_{ijmt} + X_i + T + M)$. Moreover, as I discussed previously $Vio_{mt} \not\perp \varepsilon_{ijmt}$ and $Vio_{mt} \not\perp h_0(j)$. I therefore define Vio_{ijmt} as:

$$Vio_{ijmt} = \delta DD_{jt} + h_0(j) + X_i + T + M + \mu_{ijmt} \tag{3.9}$$

[11] T and M represent the year fixed effects and municipality fixed effects

Endogeneity comes from the fact that $(\varepsilon, \mu) \sim \Pi$ such that $\varepsilon_{ijmt} = \pi(\mu_{ijmt}) + \omega_{ijmt}$ where ω has a *C.D.F.* defined by the function Λ. Then, if I replace ε in equation 3.8 and I use the *C.D.F* Λ. I rewrite the equation of first pregnancy as:

$$preg_{ijmt} = \Lambda\left(h_0(j) + \gamma Vio_{ijmt} + \pi(\mu_{ijmt}) + X_i + t + m\right) \tag{3.10}$$

Identifications relies on the distributional assumption on Π which will determine the distribution of ω. Then, if I assume joint normality I can rewrite ε as a linear function of μ and Λ would be a normal function. Following I estimate a probit over *preg* (like Blundell and Powell (2004)). Moreover, Lillard (1993) assumes joint normality between the probability of dissolve marriage and pregnancy inside marriage. This allows him to estimate the parameters of the function Π. For this reason, I estimate my duration model using different functional forms for $\pi(\mu)$ and ω.

Now that I defined my estimation strategy, the next section will describe the data before showing the results of my model for the Colombian case.

3.4 Data

In order to estimate the model described in section 3.3, which uses as an instrument the internal cocaine trafficking, following the model of chapter 2, I need three different data sets. Firstly, I use data about women pregnancy and sexual behaviour. Secondly I need information of violence at municipality level. Finally, I need information about the international prices of cocaine, coca fields and roads to create the instrument.

In this chapter, I analyse the effect of the homicides at municipality level over the age of first pregnancy. Precisely, I use the homicide rate define as the number of homicides per 100000 habitants[12]. The instrument *DD* follows the strategy I developed in chapter 2 over a sample of municipalities that I specify later in this section. Table 3.13 in the appendix of this chapter lists the different data sources.

The individual data about women comes from the Colombian Demographic and Health Survey *(DHS)* from 2000 to 2010[13]. The data includes three cross sec-

[12] $Vio_{mt} = hr_{mt} = 100000 \frac{homicides_{mt}}{population_{mt}}$

[13] Despite of I have data from the cohorts of 1986, 1990 and 1995, the survey has changed over the years which allow

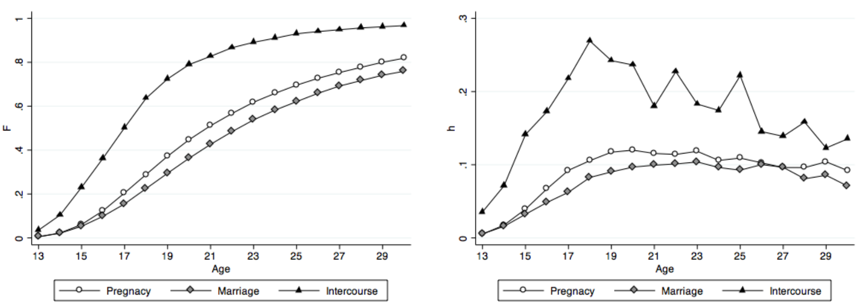
tion cohorts (2000, 2005 and 2010) of women from 13 to 49 years old from 358 municipalities in Colombia. Table 3.3 summarises the main characteristics of the sample of analysis. My sample adds up to 106405 women from 13 to 49 years old in 361 municipalities. 23% of my sample are adolescents (from 13 to 19 years old).

The first part of table 3.3 describes the main outcome variables in my analysis. The average age of first intercourse, subject to having had intercourse, is 18 years old. First pregnancy was around 19 years old, and first marriage around 20. Even though these statistics are important for my analysis, a better approach to my variables of interest appears in figure 3.4. Panel a shows the failure function while panel b shows the hazard function of first intercourse, pregnancy and marriage following Jenkins (2005). As we can see from panel a, at the age of 19 almost 80% of my sample have already had their first intercourse. While 40% and 35% have been already pregnant or married for the first time. From panel b we can see that the peak for the hazard of first intercourse is 18 years old. However, the hazard for first pregnancy and marriage do not vary significantly from the age of 19 .

Figure 3.4: Discrete Failure and Hazard Functions for the age of first intercourse, first pregnancy and first marriage

(a) Cumulative probability of failure - $F(j)$

(b) Unconditional hazard rate - $h(j)$



The survival is related with the event of being pregnant for the first time.

Cumulative probability of failure $F(j) = 1 - P(T > j)$

Unconditional hazard rate $h(j) = P(j - 1 < T \leq j \mid T > j - 1)$

The estimation does not include individuals who migrate town at some point after turning 13 years old.

Furthermore, 78% of the households are in urban areas and on average each household has 5.02 members. However, only 7% of the sample belong to indigenous or black-Colombian communities. Around 70% of my sample was born before 1985. In addition, I use in my estimations a quartile classification of households according to the a wealth index measure by the survey (see Rustein and Kierstern (2004)). It is important to point out that characteristics such as ethnicity, wealth

Table 3.3: Individual data descriptive statistics (DHS Sample)

	Full sample				Adolescent (13 to 19 y.o.)			
Variable	**mean**	**sd**	**min**	**max**	**mean**	**sd**	**min**	**max**
Age	29.45	10.65	13	49	16.03	1.97	13	19
% 13 to 19	0.23	0.42	0	1				
% 20 to 24	0.15	0.36	0	1				
% 25 to 29	0.14	0.35	0	1				
% 30 to 49	0.48	0.50	0	1				
Sexual activity and marriage								
Age at first intercourse	17.81	3.59	8	45	15.22	1.58	8	19
Age at first pregnancy*	19.95	4.46	13	45	15.76	1.49	13	19
Age at first birth	20.75	4.50	13	46	16.30	1.43	13	19
Age at first marriage	20.37	4.88	13	47	15.75	1.60	13	19
Migration (%)								
Ever migrate	0.47	0.50	0	1	0.33	0.47	0	1
migrate after 13 y.o.	0.36	0.48	0	1	0.13	0.34	0	1
migrate after 15 y.o.	0.33	0.47	0	1	0.09	0.28	0	1
migrate after 20 y.o.	0.22	0.42	0	1				
migrate after 25 y.o.	0.14	0.34	0	1				
Birth cohort								
before 1985	0.70	0.46	0	1	0.09	0.28	0	1
1985 to 1989	0.14	0.34	0	1	0.27	0.44	0	1
1990 to 1994	0.12	0.32	0	1	0.46	0.50	0	1
after 1994	0.04	0.20	0	1	0.19	0.39	0	1
Household								
% in urban areas	0.78	0.41	0	1	0.75	0.43	0	1
# of household members	5.02	2.26	1	21	5.47	2.34	1	21
Ethnicity								
white	0.50	0.50	0	1	0.49	0.50	0	1
indigenous	0.02	0.14	0	1	0.02	0.14	0	1
afro-colombian	0.05	0.22	0	1	0.06	0.23	0	1
other minority	0.43	0.50	0	1	0.43	0.50	0	1
Household wealth index (%)								
poorest	0.16	0.37	0	1	0.20	0.40	0	1
poor	0.19	0.40	0	1	0.20	0.40	0	1
middle	0.21	0.41	0	1	0.21	0.40	0	1
rich	0.22	0.41	0	1	0.21	0.40	0	1
richest	0.21	0.41	0	1	0.19	0.39	0	1
Parents mortality (%)								
mother is dead	0.14	0.34	0	1	0.02	0.16	0	1
father is dead	0.27	0.45	0	1	0.09	0.28	0	1
both parents are dead	0.07	0.26	0	1	0.01	0.07	0	1

DHS Sample	**2000**	**2005**	**2010**	**overall**
Individuals†	11585	41244	53521	106405
	(70)	(231)	(258)	(361)

Source: DHS - Colombia 2000 to 2010. Author calculations. Mean and standard deviations estimations using probability weights.

† Municipalities in each sample in parentheses

* Includes women whose first pregnancy ended up with a miscarriage

and household composition do not show significant differences between the full sample and the sample of adolescents. Moreover, only 10% of my sample of adolescents were born before 1985, which reduces the probability of left censoring. Finally, for 9% of the teenagers in my sample, their father was deceased, while only 2% have lost her mother.

Migration plays an important role in my analysis, and simultaneously represents a major weakness of my analysis. I am unable to use observations from individuals who migrate after the minimum age of analysis. If the women migrate after 13 years old, perhaps fleeting conflict, I cannot link her household with the violence she was suffering at each age. Consequently, when analysing the pregnancy from 13 to 19, I lose 13% of my observations. I understand the bias this represent and I take this into account while discussing my results.

Having described my outcome variables and the main characteristics of the individuals of my analysis, I now outline the main features of the municipality homicide rate for the sample of 343 municipalities of the DHS sample. The main statistics are shown on table 3.4. The average rate is 54.8 with a standard deviation of 58.1. The rates vary with age and gender: While the average male homicide rate is about 100 homicides per 100000 habitants the female rate is no larger than 10. Likewise, on average 92% of the casualties in a municipality were men. The rate increases in age from a rate of smaller than 3 for younger than 14 and a rate of 96 for people from 14 to 44. After 44 years old the rate declines. .

The features I described in table 3.4 do not differ from the ones I showed for all the municipalities in chapter 2. This is important for my analysis, even though I have already shown that municipalities get exogenous homicides shocks in response to international prices of cocaine. I expect to get similar results using only the sample of 341 municipalities on the DHS survey. What is more, figure 3.5 show the evolution of the total homicide rate for the entire country and the municipalities in the DHS sample. Both series only show minimal differences until 1997, apart form that, the peak of violence is in 1992 with a decreasing tendency until 1997. Then the violence increases again until 2002 when it radically drops until 2008.

Finally, table 3.14 (appendix 3.A), summarise the main statistics of the set of variables at municipality level that I use as controls in my estimation. I compare the municipalities in the DHS sample with all the municipalities in Colombia to show that the sample does not represent only a subset of the national level.

As I have mentioned, the construction of my instrumental variable uses the information of international wholesale prices from UNODC and the network of

Table 3.4: Municipality data descriptive statistics - homicide rates and municipality control variables

	mean	sd	min	max
Total homicide rate	54.83	58.13	0	561
4 y.o. or less	2.02	10.85	0	407
5 to 14 y.o.	3.00	10.09	0	362
15 to 44 y.o.	96.13	107.04	0	1076
45 to 64 y.o.	59.13	78.99	0	1145
65 y.o. or older	26.41	59.27	0	1015
within municipality s.d. (Total)	31.79	26.61	0	157
Male homicide rate	99.94	106.11	0	957
4 y.o. or less	2.04	13.25	0	352
5 to 14 y.o.	4.05	16.72	0	685
15 to 44 y.o.	177.33	197.70	0	2022
45 to 64 y.o.	107.07	141.11	0	1471
65 y.o. or older	47.14	109.48	0	1887
within municipality s.d. (Total)	58.49	48.13	0	281
Female homicide rate	8.95	14.09	0	218
4 y.o. or less	1.99	16.60	0	820
5 to 14 y.o.	1.91	9.68	0	249
15 to 44 y.o.	14.24	25.34	0	353
45 to 64 y.o.	9.72	32.99	0	758
65 y.o. or older	5.82	33.37	0	712
within municipality s.d. (Total)	9.54	8.01	0	64
Male homicide proportion - $\frac{male\,homicides}{total\,homicides}$				
Total	0.92	0.13	0	1
4 y.o. or less	0.56	0.46	0	1
5 to 14 y.o.	0.68	0.41	0	1
15 to 44 y.o.	0.92	0.13	0	1
45 to 64 y.o.	0.92	0.18	0	1
65 y.o. or older	0.87	0.28	0	1

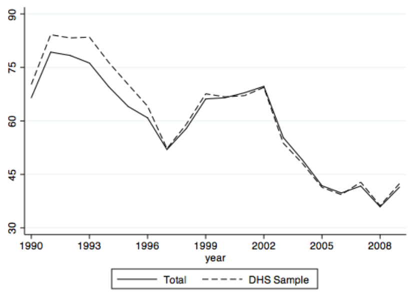
Notes: Author calculations, statistics over 343 municipalities in the DHS sample.
†Homicide data source: Vital statistics - DANE. Homicide rate is measure as homicides per 100000 habitants.

potential internal cocaine trafficking. These were developed in chapter 2.

3.5 Results

In this section I show and discuss the results of my estimations. I initially show the effect of homicides on the hazard of first pregnancy without using my instrumental variable. Afterwards, I show the results from the first stage, which are not exactly the same I found in the previous chapter due to sample structure. Following this, I show the estimations of my hazard function using the control function

Figure 3.5: Annual Homicide Rate from 1990 to 2009



Source: DANE - Vital Statistics (Deaths report). Homicide rate = homicides per 100000 habitants.

resulting from the first stage. I complete my analysis estimating the hazard function for first marriage, first intercourse and second pregnancies. This supports my my discussion of the mechanisms in which homicides affect the first pregnancy decision.

Before starting my estimations I need to transform my data to the shape of a survival panel like Jenkins (2005). Therefore, I use the information of age, municipality of residence and age at first pregnancy in the following way. The first step is to determine using the year of birth, when each individual had her 13th birthday. At this age women become at risk of becoming pregnant. Once I have the year when each individual is 13 years old, I create a dummy variable which is equal to zero if that year she has not been pregnant. That dummy turns to one at the age she reported to have become pregnant for the first time. Subsequently, I leave her out of the sample for the following years. This dummy is my variable $preg_{ijmt}$ from equation 3.7 which will be 0 if women i that lives in municipality m at year t has not be pregnant at age j. It is important to point out that an individual is right censored if she has not been pregnant at the time of the interview. In addition, left censoring occurs when a woman turned 13 before 1990 and was not pregnant the first year I observe her. I control for both censoring cases in my estimations.

Once I have the panel on age, year and pregnancy, I create a key using the municipality of residence and year to merge the data at municipality level. Especially the information of homicides Vio_{mt}. Now is important to return to the problem I face with migration. If a woman has changed municipality of residence at some point over the period of my analysis, I am not able to link the data of violence she was facing in the origin municipality. For that reason, if we are analysing pregnancy between age $\underline{j}$ and $\bar{j}$ and she has migrated at some point between these to points, she must be remove from my sample.

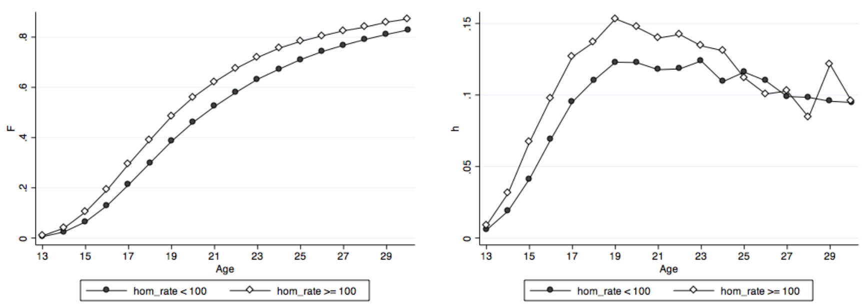
Migration implies different sources of bias that I am unable to control for. On the one hand, migration is a strategy used by households to escape from violent conflict. Thus, women who do not migrate may have different preferences for motherhood given that moving or starting a family may be two substitute strategies against conflict. In this case, my estimates will be upper bias. On the other hand, pregnancy may have been the reason that they migrate. If so, my estimate will be lower bias. This is without doubt a very interesting and challenging problem for future research.

Another constraint I face with my panel is that for each individual I only have information at one period in time. Therefore, I cannot control for changes in some variables that may affect the pregnancy decision. For that reason, in my individual controls I only use variables that do not change in time and leave the variables that vary in time in the error term. What is important for identification is that those variables will no be correlated with my instrument.

My initial approach will be a proportional odds hazard model, following Jenkins (2005). Additionally I will use a logarithm function for the underline hazard function[14]. Without correcting for endogeneity, figure 3.6 shows that for any age $j < 25$ the unconditional hazard of pregnancy is larger if a woman lives in a municipality where the homicide rate is larger than 100. Furthermore, table 3.5 shows a significant and positive correlation between the homicide rate and the hazard of becoming pregnant at a given age. The effect seems to be significant from 15 to 19 years old. There is no impact on older women (25 to 29 years old).

Figure 3.6: Discrete Survival Functions by Homicide Rate Category

(a) Probability of Failure - $F(j)$ (b) Age hazard rate - $h(j)$



The survival is related with the event of being pregnant for the first time. $F(j) = 1 - P(T > j)$ and $h(j) = P(j-1 < T \leq j \mid T > j-1)$. The estimation does not include individuals who migrate town at some point after turning 13 years old.

[14]I estimate the model as well using polynomial and non parametric forms for $h_0(j)$ and the results did not change significantly. I decided to use the logarithmic form to simplify the analysis and future calculations.

Table 3.5: Discrete Logistic Duration Model: Age of first pregnancy on Homicides per 100000 hb

	Age Range			
	13-19	13-17	15-19	25-29
$Zhom.rate$	0.042**	0.040	0.048***	-0.003
	(0.016)	(0.028)	(0.016)	(0.068)
$ln\,(age)$	1.802***	2.008***	0.845***	-0.054**
	(0.034)	(0.060)	(0.024)	(0.023)
Constant	-7.389***	-10.233***	-4.285***	-0.972
	(1.220)	(1.642)	(1.241)	(3.333)
R^2	0.13	0.13	0.07	0.03
Ind.	46865	44890	42792	11309
Mpios	355	346	355	317
N	187569	149866	126337	31229

Standard errors in parentheses clustered by municipalities. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All regression control for ethnicity, household income, living in urban areas birth cohort, municipalities with coca fields, a dummy if the parents are dead, Log of total population, department level GDP per capita and a dummy if the municipality was part of the CCT programme "Familias en Acción". Finally I include year and municipality fixed effects.

However, I still cannot claim that this is a causal effect because the orthogonality condition - $Vio_{ijmt} \perp \varepsilon_{ijmt} \mid j$ and $h\,(j) \perp \varepsilon_{ijmt}$ may not hold for the reasons I already discuss in section 3.3. Thus, I follow a two stage estimation as I described in in equations 3.9 and 3.10.

Recalling my results from the previous chapter, I set the maximum length of the traffic routes to 1000km. What is more, I use the extended model specification without constraining when using the interactions between international prices and the length function by cluster. Accordingly, table 3.6 shows the results for the estimation of equation 3.9 over the sample of DHS municipalities and individuals of different age groups. We must remember that, as result of the sample composition, some results differ marginally from the previous chapter when the estimation included all Colombian municipalities - (see table 2.6). However, the main relationships hold. What is more, the results are homogenous among age groups.

Table 3.7 shows the second stage results over different age groups. Initially I assume that the relationship between the errors is linear. From my analysis, I argue that an increase in the homicide rate (one standard deviation increase), caused by changes in the international prices of cocaine, increases the probability that an adolescent (13 to 19 years old), will become pregnant at a certain age given that she was not pregnant before. Furthermore, the effect is stronger in girls between ages 15 to 19 than the effect from 13 to 17. The latest result suggests that homicides do not affect very young teenagers, but teens who may be finishing

Table 3.6: First Stage: Discrete Logistic Duration Model of Age of first pregnancy on Homicides Rate instrumented using cocaine trafficking

	P_ι	D_f	Age Range			
			13-19	13-17	15-19	25-29
$P_\iota D_f$	US	Pacific	0.589***	0.587***	0.595***	0.509**
			(0.222)	(0.222)	(0.226)	(0.218)
		Atlantic	0.560**	0.583**	0.570**	0.414*
			(0.235)	(0.239)	(0.242)	(0.221)
		Ven. South	-0.282	-0.248	-0.327	-0.248
			(0.357)	(0.352)	(0.361)	(0.290)
		Ven. North	0.305	0.256	0.302	0.590
			(0.518)	(0.496)	(0.543)	(0.470)
	EU	Pacific	-0.615**	-0.594**	-0.636**	-0.670***
			(0.264)	(0.269)	(0.257)	(0.221)
		Atlantic	-0.080	-0.060	-0.085	-0.117
			(0.281)	(0.286)	(0.275)	(0.266)
		Ven. South	0.856*	0.873*	0.871*	0.572
			(0.496)	(0.511)	(0.491)	(0.405)
		Ven. North	-1.694***	-1.751***	-1.669***	-1.257***
			(0.598)	(0.604)	(0.602)	(0.463)
$P_\iota D_f \pi_f$	US	Pacific	4.903***	4.755***	4.982***	5.207***
			(1.586)	(1.561)	(1.583)	(1.271)
		Atlantic	0.121	0.038	0.089	-0.080
			(1.012)	(0.976)	(1.004)	(0.750)
		Ven. South	0.802	0.844	0.843	0.402
			(0.803)	(0.785)	(0.800)	(0.808)
		Ven. North	-0.383	-0.391	-0.237	-0.235
			(1.027)	(0.994)	(1.050)	(1.073)
	EU	Pacific	6.915***	6.748***	7.017***	6.349***
			(1.143)	(1.172)	(1.118)	(1.284)
		Atlantic	-0.617	-0.628	-0.600	0.099
			(1.154)	(1.149)	(1.162)	(0.506)
		Ven. South	0.206	0.223	0.166	-0.097
			(1.156)	(1.147)	(1.160)	(0.975)
		Ven. North	2.114	2.362*	2.094	0.126
			(1.445)	(1.426)	(1.490)	(1.484)
F_{Test}			7.97	6.76	10.29	6.55
R^2			0.72	0.71	0.72	0.78

Standard errors in parentheses clustered by municipalities. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All regression control for ethnicity, household income, living in urban areas birth cohort, municipalities with coca fields, a dummy if the parents are dead, Log of total population, department level GDP per capita and a dummy if the municipality was part of the CCT programme "Familias en Acción". Finally I include year and municipality fixed effects.

high school and may be thinking about whether to continue education or begin work. In contrast to the adolescents experience, the effect of violence over the hazard of first pregnancy disappears for older women (25 to 29 years old).

Table 3.7: Second Stage: Discrete Logistic Duration Model of Age of first pregnancy on Homicides Rate instrumented using cocaine trafficking

	Age Range			
	13-19	13-17	15-19	25-29
Zhom.rate	0.088***	0.016	0.104***	-0.003
	(0.032)	(0.046)	(0.025)	(0.083)
Control Function	-0.061	0.032	-0.075**	-0.003
	(0.043)	(0.058)	(0.037)	(0.103)
ln (*age*)	1.801***	2.006***	0.845***	-0.054**
	(0.034)	(0.060)	(0.024)	(0.023)
Constant	-8.079***	-11.967***	-4.992***	-5.594
	(1.648)	(2.270)	(1.716)	(3.952)
1 s.d. on H (*age Range*) (p.p)†	2.65**	0.36	2.58*	-0.01
	[1.32]	[1.37]	[1.40]	[0.79]
Zscore stats				
mean	56.35	56.41	56.36	58.25
s.d.	53.69	53.88	53.27	55.89
Fist Stage Fitness				
F_{TEST}	7.97	6.76	10.29	6.55
First Stage R^2	0.13	0.13	0.07	0.03
R^2	0.13	0.13	0.07	0.03
Ind.	40766	39102	36756	9790
Mpios	357	357	357	351
N	187569	149866	126337	31229

Standard errors in parentheses clustered by municipalities. * $p < 0.1$, **$p < 0.05$, ***$p < 0.01$. All regression control for ethnicity, household income, living in urban areas birth cohort, municipalities with coca fields, a dummy if the parents are dead, Log of total population, department level GDP per capita and a dummy if the municipality was part of the CCT programme "Familias en Acción". Finally I include year and municipality fixed effects.
†Bootstrap standard errors clustered by individuals over 1000 repetitions.

Finally, it is important to mention that the linear control function is only negative and significant for the 15 to 19 age group. This suggests that the endogeneity of violent crime and women decisions may not be strong for younger adolescents, however, it is important for older teenagers.

It is important to recall that my logistic functional form in a discrete duration model identifies the proportional odd ratio. For a given age j and a vector of observables X, I can define the odds as function of violence as $\rho\,(Vio|\,j,\,X) = \frac{h(j,Vio,X)}{1-h(j,Vio,X)}$. Then, for two values of violence $(v_1,\,v_2)$ the odd ratio if h is a logistic function would be $\frac{\rho(v_1|\,j,X)}{\rho(v_2|\,j,X)} = e^{\gamma(v_1-v_2)}$. Given that I standardised the homicide rate in my analysis, for the age range from 15 to 19 years old, one standard deviation increases the log of the odd ratio by 0.104.

So far, the interpretation of my coefficients is not very clear. For this reason, I use the coefficients from the upper panel of table 3.7 to construct the hazard function $h\left(j,\, Vio\right)$ from the logit form. Once I know the shape of $h\left(j,\, Vio\right)$ I use Jenkins (2005) to construct the cumulative probability of becoming pregnant in the age range of analysis. The cumulative failure function is $F\left(\underline{j},\, \bar{j},\, Vio\right) = 1 - \prod_{x=\underline{j}}^{\bar{j}} h\left(x,\, Vio\right)$. Using the latest function I can analyse the impact of one standard deviation on the probability of early motherhood. Then, following this calculations I suggest that a woman living in a town where the homicide rate is one standard deviation higher than the mean, increase her probability of becoming a mother from 15 to 19 years old by 2.56 percentage points.

I continue my analysis by examining whether female and male homicide rates have different effects on pregnancy, as I argue in section 3.2. Table 3.8[15] shows the results of the duration model for individuals between 15 to 19 years old but using the homicide rate by gender. As we can see, in both cases results are positive and significant. However, the coefficients for female homicides seem marginally larger than the ones for male homicides. Despite the difference in the coefficients is not statistically significant, the different impact of female and male homicides comes from the difference in the standard deviation of each rate. While in male homicides one standard deviation comes from 104 homicides per 100000 males, in females the same standard deviation comes from only 9 homicides.

Therefore, one can argue that the impact of one female homicide is larger than a male homicide. This could suggest that women are more sensitive to their own mortality than to changes in the couple market via changes in sex ratios. Nevertheless, my results are not very conclusive because my instrumental approach seems not to explain the behaviour of female homicides. The F test over the excluded variables is only 4.9, therefore, the estimator may still be bias.

Finally, I analyse the relationship between first pregnancy, first intercourse, first marriage and second pregnancy. I study if such pregnancy profiles are the result of an out of the wedlock motherhood strategy or, conversely if pregnancy is part of an strategy of creating family and getting household support. The results in table 3.9 suggest the latest hypothesis. Homicides have a positive and significant impact on marriage but negative impact on the initiation of sexual life. Nevertheless, the impact in percentage points over the cumulative probability function is larger in the case of first pregnancy. This seems puzzling. However, one can argue that

[15]The results of the first stage regression are shown in table 3.15 at appendix 3.A

Table 3.8: Duration Model on First pregnancy from 15 to 19 on Homicide Rate by Gender of Deaths (1990 - 2009)

	Gender of the homicides	
	Male	Female
zHom	0.103***	0.146***
	(0.025)	(0.037)
ControlF	-0.075**	-0.136***
	(0.036)	(0.045)
lnj	0.845***	0.845***
	(0.024)	(0.024)
_cons	-4.974***	-4.946***
	(1.715)	(1.262)
1 s.d. on $H\,(15-19)$ (p.p)	2.56	3.74
	[1.38]	[2.02]
Zhom Stats		
Mean	104.96	8.88
S.D.	98.53	10.97
Fist Stage Fitness		
F_{TEST}	12.06	4.98
$First\,Stage\,R^2$	0.73	0.48
R^2	0.07	0.07
Ind.	36756	36756
Mpios	357	357
N	126337	126337

Standard errors in parentheses clustered by municipalities. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All regression control for ethnicity, household income, living in urban areas birth cohort, municipalities with coca fields, a dummy if the parents are dead, Log of total population, department level GDP per capita and a dummy if the municipality was part of the CCT programme "Familias en Acción". Finally I include year and municipality fixed effects.

sexual life may be starting later given a shortage of men as result of killings and recruitment. Once a woman finds a suitable man, the violent context increases her incentive to create a family via marriage and motherhood.

What is more, figure 3.7 shows that the probability of being a mother but not being married, is never greater than 9% for women younger than 19. The probability of being married but not having a baby shows also a similar pattern. The probability of being married but not a mother before 19 is always lower than 9%.

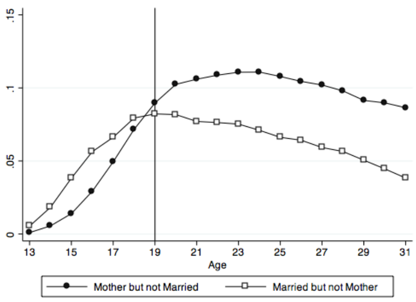
Finally, homicides have an negative impact on the hazard of having a second pregnancy, conditional on already being a mother. This result reinforces the hypothesis that early pregnancy and marriage strategy is an insurance strategy. Once a teenage woman has already secured her lifetime consumption in the marriage market (she already has a baby and a couple), the cost of having a second baby is higher than the expected benefits. Thus, when violence increases, condi-

Table 3.9: Discrete Logistic Duration Model of Age of first pregnancy, marriage, intercourse and second pregnancy from 15 - 19 y.o. on homicide rate.

	First Pregnancy	First Marriage	First Intercourse	Second Pregnancy
Zhom.rate	0.104***	0.085***	-0.073***	-0.104***
	(0.025)	(0.022)	(0.020)	(0.025)
1 s.d. on	2.58*	1.15	-2.31**	-4.67*
$H\,(15-19)$ (p.p)†	[1.40]	[1.12]	[1.06]	[2.57]
First Stage F	10.29	9.46	7.15	9.42
Ind	36726	36838	31865	10238

Standard errors in parentheses clustered by municipalities. * $p < 0.1$, **$p < 0.05$, ***$p < 0.01$. All regression control for ethnicity, household income, living in urban areas birth cohort, municipalities with coca fields, a dummy if the parents are dead, Log of total population, department level GDP per capita and a dummy if the municipality was part of the CCT programme "Familias en Acción". Finally I include year and municipality fixed effects.

Figure 3.7: Estimated probability of being a mother without being married or being married without having children by age



The estimation does not include individuals who migrate town at some point after turning 13 years old.

tional on already having a family, the woman has less incentive to have a larger family.

3.5.1 Robustness checks

3.5.1.1 The control function

The main concerns of my identification strategy come from the functional form of my probability function h and the control function π. For this reason, I give more freedom to the later functions in order to show that my functional assumptions do not constrain my results.

First, recalling from section 3.3, the control function approach comes from the joint distributional assumptions of the error terms (ε, μ). Hence, my estimations so far assume that the joint distribution is such that $\mu = \alpha\varepsilon + \omega$ where ω has a logistic form. This functional assumption is very strong. For this reason I allow $\pi(\varepsilon)$ to have a polynomial form in order to approach any nonlinear shape. Therefore, I assume $\mu = \pi(\varepsilon) + \omega$ for different shapes of π but keep the logistic distribution of ω.

Table 3.10 shows coefficients of main interest and the join significance test for the control function polynomial. As we can see, the results F test increase to 10 when I use a polynomial of degree 4 and 5 showing that the shape of π may not be linear. Nevertheless, the coefficients on the homicide rate do not vary with the polynomial form. This allows me to claim that the result using the linear approach are strong even when I am do not pick up the appropriate shape of the control function.

Table 3.10: Discrete Logistic Duration Model of Age of first pregnancy from 15 - 19 y.o. on Homicides Rate instrumented using cocaine trafficking
Using different polynomial for the control function $\pi(\mu)$

	Control Function polynomial				
	1	2	3	4	5
$Zhom.rate$	0.104***	0.103***	0.102***	0.101***	0.101***
	(0.025)	(0.026)	(0.026)	(0.026)	(0.026)
$ln\,(age)$	0.845***	0.845***	0.845***	0.845***	0.845***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Constant	-4.992***	-4.992***	-4.970***	-4.937***	-4.936***
	(1.716)	(1.716)	(1.705)	(1.704)	(1.705)
1 s.d. on $H\,(15-19)$ (p.p)	2.58	2.56	2.50	2.48	2.48
	[1.40]	[1.41]	[1.40]	[1.41]	[1.41]
Control Function F_{Test}	4.11	4.69	4.97	9.97	10.29
R^2	0.07	0.07	0.07	0.07	0.07

Standard errors in parentheses clustered by municipalities. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All regression control for ethnicity, household income, living in urban areas birth cohort, municipalities with coca fields, a dummy if the parents are dead, Log of total population, department level GDP per capita and a dummy if the municipality was part of the CCT programme "Familias en Acción". Finally I include year and municipality fixed effects.

Second, I keep the shape of π to the linear and change the assumptions on ω. This allows me to use different functional forms that are better known in the control function approach. For example, if I assume that (ε, μ) have a join normal distribution and $\sigma_\mu = 1$, then $\mu = \rho\varepsilon + \omega$ where $\omega \sim N(0, 1)$ - (Blundell and Powell (2004); Heckman (1978, 1979)). Therefore, the later will identify γ using a linear probability model or a probit model to estimate h. As we can see in table 3.11, specially the probit model seems very close to the results I found in my logistic model. Indeed, the main features of my initial estimations remain when I use the probit model.

Table 3.11: Second Stage: Discrete Duration of Age of first pregnancy on Homicides Rate instrumented using cocaine trafficking
Using different functional forms for $h\,(j,\,X,\,Vio)$

	Functional form			
	Logit	linear♣	Probit	Clog-log
$Zhom.rate$	0.104***	0.007***	0.054***	0.095***
	(0.025)	(0.002)	(0.013)	(0.024)
$Control\,Function$	-0.075**		-0.039**	-0.069**
	(0.037)		(0.019)	(0.035)
$ln\,(age)$	0.845***	0.057***	0.426***	0.796***
	(0.024)	(0.002)	(0.012)	(0.023)
Constant	-4.992***	-0.129	-2.600***	-4.368***
	(1.716)	(0.124)	(0.624)	(1.188)
R^2	0.07	0.04	0.07	0.03

Standard errors in parentheses clustered by municipalities. * $p < 0.1$, **$p < 0.05$, ***$p < 0.01$. All regression control for ethnicity, household income, living in urban areas birth cohort, municipalities with coca fields, a dummy if the parents are dead, Log of total population, department level GDP per capita and a dummy if the municipality was part of the CCT programme "Familias en Acción". Finally I include year and municipality fixed effects. The number ob observations, municipalities and the statistics from the first stage are the same for all functional forms. the information is in table 3.7 in the column from 15-19.
♣This are the results of a standard linear IV model.

The problem of using the probit and linear specification is that I do not have anymore properties of the proportional hazard model. Consequently, I use a clog-log regression which maintains the proportional hazard qualities but implies that ω has an extreme value distribution function. Once again the main features of my model remain.

3.5.1.2 Potential drug trafficking and local income effects

I want to find out if the drug trafficking is creating local income effects. Evidence of traffickers are increasing the income at municipality level would allow me to argue that my estimators may be bias because the exclusion restriction will not be valid anymore.

For this reason, I estimate the first stage of my analysis using municipality tax revenues per capita as outcome variable. I aim to prove that changes in the international prices of cocaine do not create changes in the legal municipality income, which will be evident in higher taxes revenue. Table 3.12 shows that when I run a regression at municipality level the F test of joint significance is only 2.58[16]. What is more, when I run the regression using the sample of individuals the F test is not larger than 5.

[16]The resulting coefficients could be seen in table 3.17 in the appendix.

Table 3.12: Internal cocaine trafficking on municipality taxes per capita (2000 - 2009) - Joint significance F test and R^2

	All taxes	Taxes without land value tax	Taxes to fuel
F_{TEST}	2.96	1.87	1.24
R^2	0.81	0.78	0.95
mpts	1101	1101	1101
N	10902	10902	10538

The joint significance test F is on $\sum_{\iota} \sum_{f} \{\beta_{\iota f} P_{\iota t} D_{mf} + \delta_{\iota f} P_{\iota t} \pi_{mf}\}$ as defined in section 2.3 of chapter 2. The cocaine traffic include only routes shorter than 1000km. All regression municipalities with a dummy per traffic cluster, a dummy for coca fields, log of total population, department level GDP per capita and a dummy if the municipality was part of the CCT programme "Familias en Acción". Finally I include year and municipality fixed effects. The individual level regression control as well for Log of the age, if the observation is left censored, ethnicity, household income, living in urban areas birth cohort, a dummy if the parents are dead

My last specification has two problems. Firstly, the information available comes only from 2000 leaving the 1990's out of the analysis. Secondly, taxes only represent changes in the legal economy. Thus, my analysis cannot distinguish if drug traffic has an income effect on the households. Nevertheless, taxes represent increases in consumption, thus, if the illegal income was changing the household consumption my analysis would have behave differently.

3.6 Conclusions and policy implications

Does armed violence affect the incentives of young women regarding the timing of first pregnancy? This work aimed to understand the behavioural rationale underlying differential teen pregnancy profiles in conflict areas. An analysis of the Colombian case implies several challenges for researchers trying to find out causal effects. In such a way, I take advantage of my findings in chapter 2, which give us a source of exogenous variation in violence to identify the effect of changes in the homicide rate on the pregnancy decision of teenagers.

Thus, first of all, I set up a theoretical framework following closely Kearney and Levine (2011). This is in order to describe the possible channels in which violence could affect the cost-benefit relation of postponing motherhood. I claimed that increases in homicide rates change the marriage market composition and reduce the expected value of a future partner. Furthermore, I claim that armed violence reduces the subjective probability of achieving economic and personal success in the future. This increases the incentives to invest in motherhood rather than education when young.

Following my theoretical model, I propose a 2 stage duration model in order to estimate the effect of increases in the homicide rate on the hazard of becoming pregnant before 19 years old. In order to correct for endogeneity in my non-linear model, I use a control function approach using different assumption on the joint distribution of the error terms of my structural equations. To estimate my model I use data on women sexual behaviour from the DHS, the reports of homicides at municipality level and the cocaine traffic model, which I explained in the previous chapter.

Accordingly, for my sample I estimated the effect of drug trafficking on the municipality homicide rate. My results were very close to the the results in chapter 2 when I estimated the same model over all municipalities in Colombia. Afterwards, using a linear control function, I estimated a discrete logistics duration model on the age of first pregnancy. I went one step further than the usual duration literature and rebuilt the cumulative probability of pregnancy from the hazard function I estimated.

I found that for the women between the ages of 15 to 19 the probability of becoming pregnant increases by 2.58 percentage points when the homicide rate increases in one standard deviation. Opposite to the later result, the effect is negative and not significant for women between the ages of 25 to 29. The probability of having the first marriage between 15 to19 increases by 1.15 percentage points in contexts of more homicides, while the probability of early first intercourse decreases. I argue that women choose to invest in a family, which could be a source of stability and protection when the environment is violent and volatile. The reduction in the probability of the first sexual event may be answering a shortage of suitable male. When women secure the consumption in the marriage market, becoming pregnant a second time when young is more costly than beneficial when the homicide rate increases. My results proved this last fact.

Afterwards, I use a set of different functional form for either the probability function and the control function in order to investigate if my results were caused by strong identification assumptions. My main results remain. What is more, I found some evidence of non linearity in my control function.

This chapter used a new source of exogenous variation and found strong evidence of indirect cost to household welfare due to the violent conflict in Colombia. As a result, I have an open window to analyse more possible consequences of violence in Colombia and other countries with similar violent scenarios.

Appendix 3.A Tables

Table 3.13: Main Data Sources

Group	Data description	Period	Source
Women Fertility	Demographic and Health Survey (DHS)	1986 - 2010	Demographic and Health Surveys - Profamilia
Violence	Homicides at municipality level	1990 - 2009	CEDE- Human Rights Observatory - Vice-presidency of Colombia
		1990 - 2009	DANE - Vital statistics - Deaths Reports
Cocaine traffic	Colombian Road Network	2005	IGAC - SIG-OT
	Wholesale cocaine price - Europe and United States	1990 - 2010	UNODC - World Market Reports
	Coca crops in Colombia	2001 - 2010	UNODC- SIMCI
Support data	Population	1990 - 2009	DANE: Population estimates
	DGP per capita (By department)	1990 - 2009	DANE
	Municipality tax revenues	2000 - 2009	DANE - DNP
	Municipalities in Familias en Acción	2002 - 2009	Acción Social - Econometría S.A.

Table 3.14: Municipality data descriptive statistics - homicide rates and municipality control variables

	Full Sample (1014 municipalities)				DHS Sample (343 municipalities)			
	mean	sd	min	max	mean	sd	min	max
Population - Logarithm	9.54	1.06	5	16	10.30	1.16	8	16
GDP per capita*	4633.19	3812.02	311	28966	4467.53	3594.17	311	28966
With Coca fields (%)‡	0.25	0.43	0	1	0.28	0.45	0	1
Familias en Acción (%)$^{\circ}$	0.19	0.39	0	1	0.20	0.40	0	1

Notes: Author calculations

*GDP in thousands of pesos (COP) per year.

‡% of municipalities who have coca fields at some point from 2001 to 2009

$^{\circ}$% of municipalities with the CCT programme Familias en Accíon. The programme star in 2002 and increase its presence until 2007.

Table 3.15: First Stage: Discrete Logistic Duration Model of Age of first pregnancy on Homicides Rate by Gender instrumented using cocaine trafficking

	P_ι	D_f	Gender of the homicides Male	Female
$P_\iota D_f$	US	Pacific	0.619***	0.250
			(0.227)	(0.182)
		Atlantic	0.583**	0.343
			(0.247)	(0.219)
		Ven. South	-0.342	-0.225
			(0.374)	(0.298)
		Ven. North	0.264	0.616
			(0.561)	(0.388)
	EU	Pacific	-0.690***	-0.133
			(0.264)	(0.184)
		Atlantic	-0.090	-0.084
			(0.284)	(0.201)
		Ven. South	0.876*	0.606
			(0.494)	(0.375)
		Ven. North	-1.599***	-1.609***
			(0.588)	(0.440)
$P_\iota D_f \pi_f$	US	Pacific	5.213***	3.113***
			(1.635)	(1.150)
		Atlantic	0.019	0.100
			(1.016)	(0.631)
		Ven. South	0.909	0.009
			(0.829)	(0.555)
		Ven. North	-0.137	-1.175
			(1.086)	(0.942)
	EU	Pacific	7.021***	4.843***
			(1.055)	(0.855)
		Atlantic	-0.598	-0.120
			(1.139)	(0.722)
		Ven. South	0.031	0.728
			(1.161)	(0.922)
		Ven. North	1.949	2.267
			(1.434)	(1.415)
F_{Test}			12.06	4.98
R^2			0.73	0.48

Standard errors in parentheses clustered by municipalities. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All regression control for ethnicity, household income, living in urban areas birth cohort, municipalities with coca fields, a dummy if the parents are dead, Log of total population, department level GDP per capita and a dummy if the municipality was part of the CCT programme "Familias en Acción". Finally I include year and municipality fixed effects.

Table 3.16: First Stage: Discrete Logistic Duration Model of Age of first pregnancy on Homicides Rate by Gender instrumented using cocaine trafficking

	P_ι	D_f	First Pregnancy	First Marriage	First Intercourse	Second pregnancy
$P_\iota D_f$	US	Pacific	0.595***	0.608***	0.562**	0.538**
			(0.226)	(0.221)	(0.223)	(0.215)
		Atlantic	0.570**	0.616**	0.497**	0.749***
			(0.242)	(0.247)	(0.231)	(0.261)
		Ven. South	-0.327	-0.274	-0.279	-0.252
			(0.361)	(0.347)	(0.351)	(0.459)
		Ven. North	0.302	0.278	0.364	-0.031
			(0.543)	(0.523)	(0.513)	(0.727)
	EU	Pacific	-0.636**	-0.648**	-0.603**	-0.623**
			(0.257)	(0.254)	(0.256)	(0.257)
		Atlantic	-0.085	-0.069	-0.116	0.146
			(0.275)	(0.278)	(0.268)	(0.286)
		Ven. South	0.871*	0.829*	0.850*	0.785
			(0.491)	(0.485)	(0.499)	(0.535)
		Ven. North	-1.669***	-1.635***	-1.630***	-1.800***
			(0.602)	(0.580)	(0.620)	(0.669)
$P_\iota D_f \pi_f$	US	Pacific	4.982***	5.058***	5.504***	4.963***
			(1.583)	(1.583)	(1.553)	(1.508)
		Atlantic	0.089	-0.033	0.441	0.082
			(1.004)	(0.957)	(1.043)	(1.159)
		Ven. South	0.843	0.813	0.712	1.145
			(0.800)	(0.801)	(0.832)	(0.836)
		Ven. North	-0.237	-0.241	-0.302	0.055
			(1.050)	(1.025)	(1.014)	(1.407)
	EU	Pacific	7.017***	7.000***	6.977***	6.353***
			(1.118)	(1.148)	(1.128)	(0.929)
		Atlantic	-0.600	-0.553	-0.815	-0.960
			(1.162)	(1.066)	(1.276)	(1.087)
		Ven. South	0.166	0.173	0.126	0.523
			(1.160)	(1.165)	(1.180)	(1.087)
		Ven. North	2.094	1.736	2.091	1.962
			(1.490)	(1.536)	(1.537)	(1.494)
F_{Test}			10.29	9.46	7.15	9.42
R^2			0.72	0.72	0.73	0.73

Standard errors in parentheses clustered by municipalities. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All regression control for ethnicity, household income, living in urban areas birth cohort, municipalities with coca fields, a dummy if the parents are dead, Log of total population, department level GDP per capita and a dummy if the municipality was part of the CCT programme “Familias en Acción”. Finally I include year and municipality fixed effects.

Table 3.17: Internal cocaine drug traffic on municipality taxes per capita (2000 - 2009)

			Tax type		
	P_ι	D_f	All taxes	Taxes without land value tax	Taxes to fuel
$P_\iota D_f$	US	Pacific	-0.035	-0.115**	0.005
			(0.062)	(0.057)	(0.024)
		Atlantic	0.071	0.017	0.029
			(0.074)	(0.070)	(0.029)
		Ven. South	-0.209*	-0.226	0.009
			(0.114)	(0.139)	(0.011)
		Ven. North	0.079	0.131	-0.014
			(0.101)	(0.124)	(0.016)
	EU	Pacific	0.513	0.363	0.220
			(0.341)	(0.319)	(0.193)
		Atlantic	-0.465	-0.433	0.091
			(0.311)	(0.304)	(0.164)
		Ven. South	-0.624	-0.697	-0.167
			(0.448)	(0.523)	(0.191)
		Ven. North	-0.372	0.136	-0.174
			(0.425)	(0.514)	(0.140)
$P_\iota D_f \pi_f$	US	Pacific	0.014	0.071	-0.152
			(0.130)	(0.131)	(0.195)
		Atlantic	-0.130	-0.054	-0.097
			(0.186)	(0.223)	(0.119)
		Ven. North	0.299	-0.407	0.369
			(0.950)	(1.171)	(0.226)
	EU	Ven. South	-0.135	-0.062	0.015
			(0.257)	(0.319)	(0.048)
F_{TEST}			2.96	1.87	1.24
R^2			0.81	0.78	0.95
Mpios			1101	1101	1101
N			10902	10902	10538

The join significance test F is on $\sum_\iota \sum_f \{\beta_{\iota f} P_{\iota t} D_{mf} + \delta_{\iota f} P_{\iota t} \pi_{mf}\}$ as defined in section 2.3 of chapter 2. The cocaine traffic include only routes shorter than 1000km. All regression municipalities with a dummy per traffic cluster, a dummy for coca fields, log of total population, department level GDP per capita and a dummy if the municipality was part of the CCT programme "Familias en Acción". Finally I include year and municipality fixed effects. The individual level regression control as well for Log of the age, if the observation is left censored, ethnicity, household income, living in urban areas birth cohort, a dummy if the parents are dead

Chapter 4

Designing Optimal Reintegration Contracts

4.1 Introduction

> "In the civil conflicts of the post-cold-war era, a process of disarmament, demobilisation and reintegration has repeatedly proved to be vital to stabilising a post-conflict situation; to reducing the likelihood of renewed violence, either because of relapse into war or outbreaks of banditry; and to facilitating a society's transition from conflict to normalcy and development." Annan (2000)

This quote, from the United Nations Security Council Report in 2000, summarises the importance of Disarmament, Demobilisation and Reintegration programmes (*DDR*[1]), in the international political affaires. In countries with active armed conflict and post-conflict environments where these types of programmes dominate policy agendas. DDR programmes have been running over the last 20 years in more than 20 countries in Africa, Asia, East Europe and Latin America. However, given the heterogeneity and individual dynamics of conflict, there is no clear rule or fixed guidelines as to how these programmes should be design and implemented[2].

[1] See the UN definitions from Annan (2000)

[2] These are some countries with DDR in the world. Africa: Angola, Burundi, Central African Republic, Republic of Congo, Democratic Republic of Congo, Côte d'Ivory, Eritrea, Guinea Bissau, Liberia, Mozambique, Namibia, Rwanda, Sierra Leone, Somalia, South Africa, Sudan, Uganda, and Zimbabwe. Asia: Afghanistan, Cambodia, Philippines, Indonesia. Europe: Latvia, Hungary, Poland. Serbia. Latin America: Colombia, Honduras, Haiti, Honduras and Nicaragua.

The *DDR* programmes can be an outcome of peace negotiation, or in some other countries the programmes begin while the conflict is still active. In some cases, the *DDR* is imposed by the victors as a concession to the defeated parties as part of bargaining in post-conflict negotiations. According to OSAA and DRC (2007), in Africa the DDR programmes have developed a a consequence of varied negotiation processes. In Zimbabwe, Namibia and South Africa, the DDR was the results of a negotiated peace following external pressure. In Angola, Rwanda, Uganda and Ethiopia, the DDR programmes were established by the winning party over the defeated one. In Mozambique, Angola, Sierra Leone, Liberia and Côte d'Ivore, the DDR programme resulted from a peace agreement, due to external intervention in a mutually destructive stalemate.

It is important to point out that the literature about DDR is rich and strongly developed in political sciences and sociology. Unfortunately, there is a lack of economic analysis. In political science Clark (1995) describes the main challenges and issues that the UN faces when setting up and running DDR interventions. Some of the issues for DDR pointed out by Clark were the legal constraints of bringing back soldiers that had been the perpetrators of violence in some communities. Moreover, DDR implementation could face disruptions as well due to the political fragility during and after confrontations, the uneven negotiations for differences in the bargaining power of the parts, the reactions of external agents and operational issues. Clark's main concerns have been affirmed in other cases as well (see Caramés et al. (2007); Annan (2000, 2006)).

Additionally, there is an international movement to create guidelines, common strategies and monitoring systems to improve the implementation of the DDR programmes. In 2002, the Multi-Country Demobilisation and Reintegration Programme (MDRP), was launched to combine efforts on the reintegration of more than 400 thousand combatants from the conflicts in the Great Lakes region in Africa. Further, in 2006 the UN published the Integrated DDR Standards (IDDRS), where the UN compiled and standardised guidelines towards a common approach to this kind of programmes - see UN (2006).

Despite of the policy and social implications of DDR processes, the economics literature concerning this topic are extremely poor. However, to begin my analysis of DDR programmes I review the literature of job search and crime. I use the papers of Burnett et al. (2004) and Engelhardt et al. (2008) as an starting point for my study. These papers propose a model where crime is a parallel opportunity for agents who are competing in the job market. Thus, the probability distribution of the job searching and crime success and the different payments for each action will shape the optimal choice of job searching and crime.

This work does not analyse the political implications of DDR and focuses in the economic features of the reintegration process, particularly, I set up a model to describe the characteristics of an optimal reintegration contract. This work aims to answer the following questions: What is the shape and duration of the optimal benefits? What is the optimal trade-off between security and benefits? What is the role of households and firms when designing the contract?

This chapter places the analysis of reintegration in Colombia, where the armed conflict has been on going for over than 50 years. External to international debates about DDR, different type of post-conflict processes and approaches to the DDR have been implemented in Colombia. The latest DDR experience in Colombia began with the peace negotiations with the Paramilitary Armies in 2002 and the final agreement in 2006. Since 2006, Colombian's DDR programme has received more than 55000 excombatants and has invested around USD 35 million.

The programme includes the opportunity for any combatant to join individually, without being part of peace negotiations with the government. This feature is one of the keys of the model I develop in my theoretical framework. The characteristics of the target individuals make DDR programmes very challenging to carry out. According to official reports around 65% of the excombatants have only primary school education or less, opposite to 7 years of war experience (see DNP (2008); Arjona and Kalyvas (2011)).

Thus, this chapter proposes a theoretical framework in order to describe the main features of what an optimal reintegration contract should be. The model focuses on the interaction between an individual combatant and a government that wants to bring this individual back into society. This part of the model emphasises the importance of the trade off between treats and benefits and the influence of informational rents over the shape of the optimal menu of benefits. Following this, I introduce heterogeneity and include a tax payer in order to solve the selection problem. In simple terms, the tax payer would decide the Principal's budget constraint in order to reduce the impact of conflict.

As I said before, my models are very close to the literature of job searching and crime. However, the main differences to the existing literature are the following. Firstly, the active role of a Principal who is designing the contract. Secondly, the importance of the selection process and the social cost of the outsiders.

Therefore, I build from the fact that DDR programmes are usually managed by a central government and make my models close to the literature of optimal welfare programmes. Accordingly, I use a similar structure to the social welfare models of Shavell and Weiss (1979) and others.

This chapter has the following order. After this introduction section 4.2 describes the history and main features of the DDR programme in Colombia. I also describe the main characteristics of the participants in the programme. Thereafter, section 4.3 introduces my first model and analyses the moral hazard problem that arises when a Principal needs to offer a benefit menu to a excombatant. Afterwards, I introduce heterogeneity in the combatants and the role of the tax payer to find out which is the shape of the optimal selection of individuals to be treated in a DDR programme. Each of the last two chapters shows some calculations to understand the role of different parameters on the optimal shape of the contracts. Finally, section 4.5 concludes[3].

4.2 DDR in Colombia

The current DDR programme in Colombia - from now on Colombian Reintegration Programme - CRP, has been running since 2006. However, this is not the only DDR experience in the country. Since the creation of the first guerrilla movement in 1964[4] the armed conflict in the country has had different stages that have included different groups involve and several peace negotiations.

The first peace talks between guerrillas and the central government were in the Belisario Betancourt[5] period in 1983 - see Turriago-Piñeros and Bustamante-Mora (2003). The first agreement with the FARC guerrillas include the law 35 of 1982, which set the guidelines for amnesty and the reintegration of combatants to society. Unfortunately, after years of negotiation the violent reaction of right-wing paramilitary armies did not allow the parties to reach a successful peace agreement.

However, some other guerrilla groups such as the M-19, EPL, ADO and some small fronts of ELN signed peace agreements with the government from 1985 to 1990. They were the first participants in a reintegration process in Colombia.

[3]This draft includes the section 1 and the introduction of section 2. I am now working in the data analysis.

[4]Despite there were some guerrilla actions from 1958 the origin of FARC comes for the creation of the South Guerrilla Block in 1964 - see Offstein (2003).

[5]Belisario Betancourt was the president of Colombia from 1982 to 1986.

Since those initial agreements, the reintegration programmes included a scheme of economic benefits in order to guarantee the return of the former combatants to the legal life.

It is important to point out that since the initial programme in the 1990's the government has allowed the mechanism to be used on an individual basis. In spite of the proposal to have an open reintegration programme future negotiations, with no formal peace talks the the reintegration programme swapped its role. Therefore, the programme involve individual combatant who surrendered and left their armies without peace talks or local negotiations.

According to Pinto et al. (2002) by 2001, 4715 excombatants were part of the RP in Colombia. The majority of these individuals came into the programme individually without a peace process. This initial group of participants showed characteristics common to future individuals in the programme. According to the authors, 82% of these excombatants entered into the illegal armed groups (IAG), when they were 17 years old or younger; 84% have incomplete primary school. As I said before, these features impose great challenges for a welfare system.

The core of this chapter aims to analyse the DDR programme running in Colombia since 2003 in the government of Alvaro Uribe[6]. The programme is part of the set of reforms that followed the peace process between the government and the paramilitary armies - AUC. There is strong debate around the political implications of the transitional justice regimes and the agreements made with the AUC. Even though this is not part of my analysis, it is important to point out the significant political and institutional cost implied in a process of this kind. Some authors like Betancourt and Theidon (2006) and Cardenas-Sarria (2005) analyse the main components of the institutional debate that followed the peace agreement.

One of the main outcomes of this process was National Policy for the Social and Economics Reintegration of Illegal Armed Groups (PRSE). As part of the PRSE, the government created the Office of the High Commissioner of Peace, from now on ACR. ACR is the government office who manage the reintegration policies. The process to enter into reintegration is the following. Firstly, after disarmament each excombatant has to get a certification of demobilisation. This certification indicates that he/she need to fulfil requirements to prove that he/she was indeed part of an IAG and that he/she has no direct responsibility in crimes against

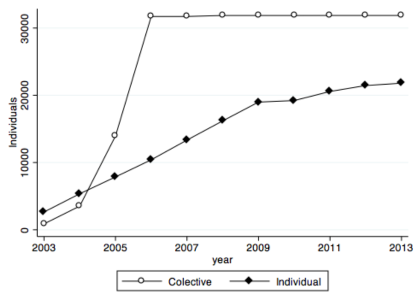
[6] Alvaro Uribe was the president of Colombia over 2 consecutive periods, 2002 to 2006 and 2006 to 2010.

humanity[7].Afterwards, ACR specially provides psychological support, education and work training, financial and entrepreneurship advice or provide help for the individuals to find a job. What is more, after the demobilisation the ACR gives around USD 200 monthly[8] to each excombatants.

The CRP was the result of the peace talks with the AUC. Therefore, the programme started with the participants of the collective demobilisation process of the paramilitary armies that began on November 2004 and went until December 2006. On this period 31671 soldiers demobilised from the IAG.

Since 2006, the government, once again, left the window open for any soldier of an IAG to enter into the programme. This was in order to offer incentives to combatants to demobilise and leave war without further peace negotiations. As we can see in figure 4.1, collective demobilisations of the AUC were carried out from 2004 to 2006. The individual demobilisation, participants of guerrilla groups, shows a stable trend increasing year by year until 2009. Around 2700 individuals were demobilised each year. By 2013, 53600 individuals have left their armies, 22 thousand chose to demobilise individually. According to administrative data from ACR, 57.8% of the demobilised individuals (31168 excombatants) have been part of the DDR programme.

Figure 4.1: Aggregate demobilised combatants by type of demobilisation (2003 - 2009)



Source: ACR

Table 4.1 describes the participants in the DDR programme in Colombia since 2002. As we can see, 88% of the population are male, mainly from 26 to 50 years old. By 2008, almost 70% came from the paramilitary armies of AUC. That proportion reduces from 2008 to 2013 given the increase in the individual demobilisation, described above. Moreover, by 2013 almost all the participants in

[7]The crimes against humanity are defined by Rome Statute of the International Court.

[8]According to ACR the payment comes from COP 160000 to COP 480000 monthly subject to participation in the ACR activities. Between 2008 to 2009 the ACR payed about USD 147. millions between 28932 individuals. (Source ACR (2010))

the programme received psychological support while about 10 thousand receive some education, and less that 4 thousand some work training. However, by 2008, more than 1600 participants were killed either by the governmental forces or other illegal groups. More than 1700 were recaptured by the police forces due to having returned to illegal activities.

Table 4.1: Main characteristics of the participants in the DDR programme in Colombia

% of male		88.2
Age (% by age group)	8 to 25	8.9
	26 to 50	82.4
	Older than 50	4
Group of Origin* (%)	FARC	24.1
	ELN	5.1
	AUC	69.9
	Other	1
Death or recapture*	Death	1676
	Recapture	1726
ACR Services†	Total	32128
	Psychological support	32123
	Education	10260
	Work training	3715

Source: ACR - Several reports and DNP (2008)
* Only include individuals from August 2002 to April 2008
† Only include the period from june 2012 to may 2013

Table 4.2 gives a more detailed view of the demobilised group from a sample of 1458 individuals[9]. In that group, the average age is 29 years, although, on average individuals enter into the IAG at the age of 21 and had been part of the IAG for 6 years. What is more, these individuals have their first experience with a gun when they were only 17 years old, and exited the education system at the age of 13. The later shows the spacial combination of very low skills to work in the legal labour market as opposed to extensive training in illegal work. Despite the kind of human capital and the 'bad' skills they have for employment, more than 80% have worked after they demobilise. Nevertheless, only 53% were working at the time of the interview.

The aim of the following section is to define a reintegration contract that takes into account the social cost of conflict and the human capital characteristics of the individuals who will be participating in the DDR programme.

[9]The information was collected by Fundación Ideas para la Paz (FIP).

Table 4.2: Descriptive Statistics by type of demobilisation

	Type of Demobilisation		Total
	Individual	Collective	
Sample proportion	0.508	0.492	1
FARC - %	61.3	2.06	32.9
ELN - %	15.0	0.8	8
AUC - %	19.4	96.4	56.8
Male proportion	0.779	0.908	0.842
	(0.415)	(0.289)	(0.364)
Age	28.46	31.42	29.91
	(8.136)	(7.504)	(7.968)
Age at IAG entrance	18.60	23.84	21.17
	(6.815)	(7.255)	(7.504)
Time in the IAG	6.628	4.862	5.752
	(5.564)	(4.484)	(5.132)
Age of first gun use	15.76	19.20	17.43
	(5.248)	(5.485)	(5.631)
Age when left school	12.22	14.08	13.14
	(4.879)	(4.721)	(4.889)
Previous disarmament effort	0.609	0.527	0.569
	(0.488)	(0.500)	(0.495)
Disagree with Demobilisation	.	0.111	0.111
	(.)	(0.314)	(0.314)
Has worked since demobilised	0.822	0.886	0.853
	(0.383)	(0.318)	(0.354)
Currently employed	0.494	0.578	0.535
	(0.500)	(0.494)	(0.499)
Observations	754	731	1485

Source: Fundación Ideas para la Paz (FIP) - Author estimations. standard deviations in parentheses.

4.3 A DDR contract with moral hazard

The initial approach to the optimal reintegration contract follows the main idea of unemployment insurance literature. This model follows the structure of Shavell and Weiss (1979), Hopenhayn and Nicolini (1997) and Pavoni and Violante (2007). This literature sets a framework where a Principal (Government), offers a set of benefits to an Agent (unemployed individual) who has to exert some effort in order to get a job. In this case, the Principal will offer a contract to an specific kind of Agent, who is a combatant part of an IAG in order to support him abandoning war, to being looking for a legal job. My model fits with the environment of individual demobilisation and not collective demobilisation where IAG set the reintegration condition when the negotiate with the governments.

This section initially deals with homogeneous agents. The next section introduces heterogeneity in the preferences for crime and human capital, which will be the link between the moral hazard and the selection problem. The initial results differ from the known literature of UI because there is an open window to an increasing benefits scheme in order to avoid the return to crime. What is more, the model shows the optimal trade off between benefits and punishments.

4.3.1 Initial set up - Timing, Players and Strategies

Assume a two periods game $t = \{0, 1\}$ with a discount rate β. At $t = 0$ both Principal and Agent choose actions and at $t = 1$, nature plays and final outcomes are realised[10]. The first player is the Principal. He is a risk neutral government with a set of policy variables $\Gamma = \{b_0, b_1, s, \underline{c}\}$, where b_t is the benefit offered to the Agent at period t. On the other hand, s is the expenditure in security per Agent[11] and $\underline{c}$ is the level of consumption offered at prison.

The Agent is a soldier member of an *IA*G. He gets utility from consumption and has a cost from the actions that he chooses. His utility function any stage is increasing and concave in consumption and separable in consumption and cost of effort. The utility function is $U(x, a)$, where x is his consumption at stage t.

The set of actions of each agent is $A = \{out, in - search, in - no\, search, in - crime\}$. Initially he decides if he goes in or stays out the Reintegration Programme (RP). If he stays out he will get his outside option which is his live time utility as an Illegal Soldier (IS). I denote this as $J(s, \underline{c})$ with $\frac{\partial J(\cdot)}{\partial s} < 0$, $\frac{\partial J(\cdot)}{\partial \underline{c}} > 0$ and $\frac{\partial^2 J(\cdot)}{\partial s^2} < 0$, $\frac{\partial^2 J(\cdot)}{\partial \underline{c}^2} < 0$. If he chooses to go into the RP he will choose between three different actions; he can search for a job, no search for a job or commit crime. To simplify, the agent inside the programme will choose an action $a \in A_{RP} \subset A$ where $A_{RP} = \{search, no\, search, crime\}$. Furthermore, the cost function for this actions is $v(a \in A_{RP}) = \{\alpha, 0, \theta\}$. Assumption 1 summarises the main characteristics of the agents' utility function in the programme and assumption 2 the characteristics of his utility outside the programme.

Assumption 1. *The utility function of the Agent is separable in consumption and cost of actions. Moreover, the Agent is risk averse* $U(x, a) = u(x) - v(a)$ *where* $u'(x) > 0$, $u''(x) < 0$ *and cost function* $v(a) = \{\alpha, 0, \theta\}$ *for* $a = \{search, no\, search, crime\}$ *with* $\alpha, \theta > 0$.

[10]Another view can be an static game when players play at the beginning of the period and nature plays at the end.

[11]Like investment in more police or military technology.

Assumption 2. *The life time utility of the agent outside the programme is a decreasing and weakly convex function on security and increasing and weakly concave function in consumption in jail. Then,* $J(s,\, \underline{c})$ *with* $\frac{\partial J(\cdot)}{\partial s} < 0$, $\frac{\partial J(\cdot)}{\partial \underline{c}} > 0$ *and* $\frac{\partial^2 J(\cdot)}{\partial s^2} \leq 0$, $\frac{\partial^2 J(\cdot)}{\partial \underline{c}^2} \leq 0$.

4.3.2 Crime Market

The crime market follows the basic idea of Becker (1968) and many others. The Agent who commits a crime has two possible outcomes, with probability $p(s,\, a)$ he fails and goes to jail where he gets consumption $\underline{c}$. On the other hand, with probability $(1 - p(s,\, a))$ the Agent succeeds in the crime and gets a prize Z. Assumption 3 summarises the main characteristics of the probability of failure in criminal activities.

Assumption 3. *The probability of failure in criminal activities does not exist if the action chosen by the Agent is different to* $a = crime$. *Then,*$\forall s \rightarrow p(s,\, a = crime) \in (0,\, 1)$ *and* $p(s,\, a \neq crime) \notin \mathbb{R}$.

Furthermore, $p(s,\, a = crime)$ *is an non-decreasing weakly concave function in security expenditure:* $\frac{\partial p(s,a)}{\partial s} \geq 0$, $\frac{\partial^2 p(s,a)}{\partial s^2} \leq 0$.

4.3.3 Labour Market

The initial set up summarise a simple search environment when for a given action - a - and a level of legal human capital – h, the Agent finds a job with probability π^a and gets a wage W

Assumption 4. *The probability of finding a legal job is increasing in effort and is equal to zero if the Agent chooses action crime. Then:* $0 = \pi^{crime} < \pi^{no\, search} < \pi^{search} < 1$.

4.3.4 The Optimisation Problem - Finding the Optimal Benefit Scheme

To simplify the problem lets assume no budget constraints, no informational asymmetries, homogeneous agents and fixed security expenditure and consumption in jail. Now, given assumptions 1 to 4, the Principal wants the Agent to choose the action $a = search$. Then, the Principal minimises the benefits expenditure for any $\{s,\, \underline{c}\}$ solving the following problem[12]:

$$\begin{aligned}
&\min_{\{b_0,\, b_1\}} b_0 + \beta\left(1 - \pi^{search}\right) b_1 \\
s.t.& \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad (4.1)\\
&u\left(b_0\right) - \alpha + \beta\left[\pi^{search} u\left(W\right) + \left(1 - \pi^{search}\right) u\left(b_1\right)\right] \geq J \quad \{IR1,\, \lambda\}
\end{aligned}$$

Constraint IR1 (associated with Lagrange multiplier λ), is the individual rationality constraint and ensures that agents prefer go into the RP over staying outside in illegality. No different from previous results in literature, with no information asymmetries $\frac{1}{u'(b_0)} = \frac{1}{u'(b_1)} = \lambda$, therefore $\lambda > 0$ and $b_0 = b_1 = b^*$, then the individual rationality constraint bind with equality and the principal offers constant benefits to the agent.

Before extending the analysis and introduce asymmetries in information it is important to remark some features of this simplified model. Firstly, the lack of budget constraints and homogeneity reduce the Principal problem to a standard framework of one principal and one agent. This can be driven by an ability of the Principal to observe any source of heterogeneity and the ability of offering a different contract to each agent. Secondly, fixing security expenditure and jail consumption can represent independence between the RP and the National Security budget.

To introduce the information problem, lets assume the following: The principal can observe Agent's first level actions but not second level actions. This means that the Principal observes if the Agent stays out or comes into the RP. However, once the Agent is inside the programme the Principal is unable to observe the Agent's actions. Although, the Principal still observes final outcomes (*employed*, *unemployed*, *in jail*). Then, to the problem described in equation 4.1 I add up the following constraints.[13]:

---

[12] Notation note: for any constrained optimisation problem I use the following notation

$$\begin{aligned}
&\underset{x_i}{max/min} \quad \text{Objective function} \\
&s.t. \\
&\qquad\qquad \text{constraint} \qquad \{\text{Constraint Name, Lagrange Multiplier}\}
\end{aligned}$$

[13] $p = p\left(s,\, a = crime\right) \forall s$

$$\beta\left(\pi^{search} - \pi^{no\,search}\right)\left(u\left(W\right) - u\left(b_1\right)\right) \geq \alpha \qquad \{IC1,\, \phi_1\}$$

$$\beta\left[\begin{array}{c}\left(\pi^{search}u\left(W\right) + \left(1 - \pi^{search}\right)u\left(b_1\right)\right)\\ \\ -\left(pu\left(\underline{c}\right) + \left(1-p\right)u\left(Z + b_1\right)\right)\end{array}\right] \geq \left(\alpha - \theta\right) \quad \{IC2,\, \phi_2\} \tag{4.2}$$

Equation 4.2 describes the incentive compatibility constraints, *IC1* and *IC2*. The new constraints assure that the Agent will optimally choose action *search* over actions *no search* and *crime*. In *IC1* the expected difference between the payoffs of get a job or not must be larger than cost of searching. Conversely, in *IC2* the difference in the expected benefits of looking for a job and committing a crime have to be larger or equal to the difference in the cost of actions search and crime.

Is important to remark on the role of b_1 in *IC1* and *IC2*. In *IC1* b_1 needs to be as small as possible in order to give incentives to search for jobs penalising the action *no search*. On the other hand, in *IC2* the effect of b_1 is ambiguous because an increase on b_1 increases the expected utility in both scenarios, legal and illegal markets. Then, if the probability of failing in legal markets is larger than the probability of succeeding in crime[14] the Principal might want to increase b_1 in order to encourage legal markets over illegal markets. The latest would be clearer after solving the first order conditions (FOC) of this problem.

$$u'\left(b_0\right) = \frac{1}{\lambda} \tag{4.3}$$

$$\begin{aligned} 1 = \quad & \left[\lambda - \frac{\phi_1\left(\pi^{search} - \pi^{no\,search}\right)}{1-\pi^{search}}\right]u'\left(b_1\right) \\ & +\phi_2\left[u'\left(b_1\right) - \frac{1-p}{1-\pi^{search}}u'\left(Z + b_1\right)\right] \end{aligned} \tag{4.4}$$

From equation 4.3, the FOC on b_0, we can see that $\lambda > 0$ then the IR1 binds. The latest result means that for the government it is optimal to offer the minimum benefit such that the agent will leave the IAG. Moreover, equation 4.4 rules the behaviour of b_1. The first part of the equation is the standard UI result in the literature, then if $\phi_2 = 0$ then $u'\left(b_0\right) < u'\left(b_1\right)$ and the benefits are decreasing in time in order to incentivise job searching, same result of Shavell and Weiss

[14] $\left(1 - \pi^{search}\right) > \left(1 - p\right)$

(1979).

However, if $\phi_2 > 0$ the benefits can be increasing, constant or decreasing over time depending on the relative advantages that the principal finds in the legal or illegal markets. It may not be clear in the equation 4.4 but the intuition behind is really straight forward. When the labour market prizes the effort of looking for a job and there is a large difference $\left(\pi^{search} - \pi^{no\,search}\right)$ there is no need for the Principal to punish the action *no search.* In this case the Principal has a window to offer an increasing benefit scheme in order to prevent future crime. Yet, if the labour market conditions do not help and the difference $\left(\pi^{search} - \pi^{no\,search}\right)$ is very small, the Principal might need to use a decreasing benefits scheme.

Figure 4.2 is a simple example when is easier to understand how the benefit scheme could vary depending on the different market conditions. Firstly, the graphs show the expected utility of a representative Agent *(ceteris paribus)*, as a function of b_1 fixing $b_0 = 4$ (vertical line) under 3 different labour market conditions. The dotted line represents the utility if the Agent searches for a job, the dashed line is the utility if the Agent does not search and the filled line represents the utility when the action crime is chosen[15]. An incentive compatible contract is such that the utility of search is larger than the utility of choice any of the other 2 actions. In this framework, a contract will be incentive compatible if, for a given b_1, the dotted line is above the dashed and the filled lines. This is represented by the shadowed area over the horizontal axes[16]. Finally define $\triangle\pi = \left(\pi^{search} - \pi^{no\,search}\right)$.

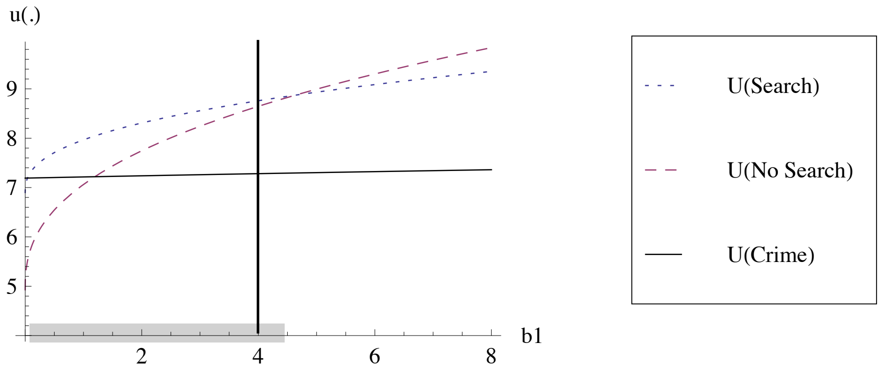
Under good labour market conditions (Figure 4.2a), the range of IC contracts is very large and leaves space for having $b_1 > b_0$. In this case, the Principal might choose increasing benefits because the labour market is giving natural incentives for searching and he can reduce crime with larger benefits. On the other hand, with poor labour market condition (figure 4.2b), the government needs to punish the *no effort* action, and constrained to use decreasing payments, the shadow area is always below $b_1 = 4$. What is more dangerous for the principal is the scenario with very poor labour market conditions (Figure 4.2c). Under this conditions there is no *IC* contract, the labour market is poor and the crime market offers always a better option. With this last environment the Principal would need to choose a no *IC* option when he would need to choose if he prefers the agents not looking for jobs or the agents coming back to crime.

[15]The line is almost horizontal because I assume a large prize on crime, then $\frac{\partial U(Z+b_1)}{\partial b_1} \approx 0$

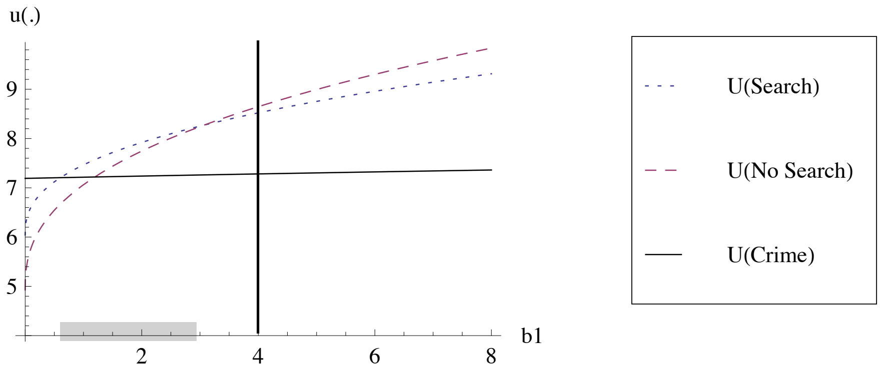
[16]I am assuming that the IR holds.

Figure 4.2: The Role of b_1 under different labour market conditions

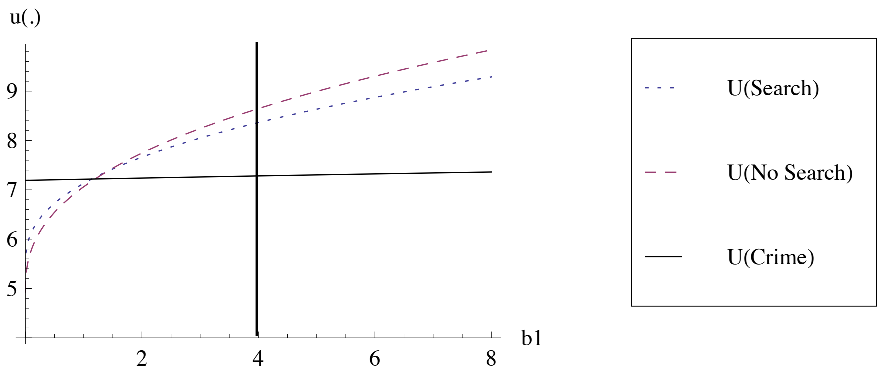
(a) Good Labour Market Conditions - $\triangle\pi = 0.55$



(b) Poor Labour Market Conditions - $\triangle\pi = 0.3$



(c) Very Poor Labour Market Conditions - $\triangle\pi = 0.2$



Assume $u(x) = \frac{x^{1-\sigma}}{1-\sigma}$. The parameters for this calculations: $w = 9$, $p = 87\%$, $\underline{c} = 2$, $z = 15$, $\beta = 95\%$, $\sigma = 0.6$, $\alpha = 0.6$, $\theta = 0.8$

This last fact encourage the first extension of the basic model. I introduce a new control variable, now the Principal will be able to affect directly the criminal market in order to guaranty *IC* contracts. The first variable to be introduced in the model is the expenditure in security.

4.3.5 The role of security expenditure

Figure 4.2c showed that the assumptions and instruments in the model are not enough for the existence of equilibrium. If the criminal activities give the Agent a high utility, the benefits scheme will not be *IC,* and possibly will not be *IR* either. To solve this problem, I introduce a new control variable: The Principal will be able to choose s, which is the expenditure in security per Agent. As I said before the security expenditure increases the probability of catching a criminal and reduce the expected utility for any criminal activity (either war or committing crime in the *RP*). Now, the Principal's problem is:

$$\min_{b_0, b_1, s} \; b_0 + s + \beta\left(1 - \pi^{search}\right) b_1$$

$$s.t.$$

$$u(b_0) - \alpha + \beta\left[\pi^{search} u(W) + \left(1 - \pi^{search}\right) u(b_1)\right] \geq J(s) \quad \{IR1,\, \lambda\} \tag{4.5}$$

$$\beta\left(\pi^{search} - \pi^{no\, search}\right)\left(u(W) - u(b_1)\right) \geq \alpha \qquad \{IC1,\, \phi_1\}$$

$$\beta \begin{bmatrix} \left(\pi^{search} u(W) + \left(1 - \pi^{search}\right) u(b_1)\right) \\ \\ -\left(p(s)\, u(\underline{c}) + (1 - p(s))\, u(Z + b_1)\right) \end{bmatrix} \geq (\alpha - \theta) \qquad \{IC2,\, \phi_2\}$$

Taking FOC on s and combining it with the FOC in b_0 I can find the following expression[17]:

[17]With symmetric information $b_0 = b_1 = b^*$ and $\lambda > 0$. Given that IR1 binds the solution of the problem is the vector a vector $[b^*,\, s^*]$ which solves the following system:

$$\begin{bmatrix} u(b^*) - \alpha + \beta\left[\pi^{search}(h)\, u(W) + \left(1 - \pi^{search}(h)\right) u(b^*)\right] - J(s) & = 0 \\ u'(b^*) + \frac{\partial J(s)}{\partial s} & = 0 \end{bmatrix}$$

$$u'(b_0) = -\left(J'(s) + \frac{\phi_2}{\lambda}p'(s)\left(u(\underline{c}) - u(Z + b_1)\right)\right) \tag{4.6}$$

The last equation summarises the Principal's optimal choice of security expenditure. In the left hand side I have the marginal utility of b_0 and in the right hand side I have the weighted marginal disutility to the Agent by an increase of security expenditure. Then, the optimal choice of benefits and punishments will make the Agent indifferent between receiving an extra unit of benefit or suffering and extra unit of security. The solution of this problem should be a vector $[b_0^*, b_1^*, s^*, \phi_1, \phi_2]$ which solves the system of equations 4.3, 4.4, 4.6 and the Kuhn Tucker conditions $\{\phi_1 IC1 = 0, \phi_2 IC2 = 0\}$.

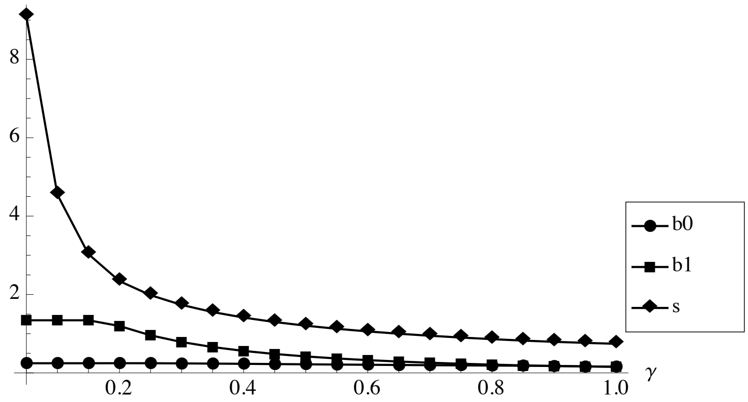
In order to gain a better understanding of the solution of the maximisation problem I simplify the system. I assume Z is a very large number, then by concavity of $u(x)$ when $Z \to \infty$ then $u'(Z + b_1) \to 0$. Equation 4.4 would look like $u'(b_0) = \left(\lambda + \phi_2 - \phi_1\left(\frac{\pi^{search} - \pi^{no\, search}}{1 - \pi^{search}}\right)\right)$. As shown before, the relation between s and b_0 are linked by the IR constraint and the optimality condition described by equation 4.6. In other words, you look for the minimum expenditure possible but keeping the agent indifferent between the principal tools. Therefore, the FOC on b_1 will look as Shavell and Weiss (1979), and the role of benefits is to incentivise searching over no search. Meanwhile, security should reduce the left hand side and equalise the equation 4.6 which guarantees searching over staying in the illegal group and returning to criminal activities.

Nevertheless, the main forces once again are the capability of absorbing of the labour markets and the capability of deterrence of security investment. Therefore, I illustrate how different values of the security technology and the search premium $\triangle\pi = \left(\pi^{search} - \pi^{no\, search}\right)$. In my calculations, I assume that the agents utility functions has CARA form like $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$, the probability of being caught in crime has an exponential form like $p(s) = 1 - exp(-\gamma s)$; and the outside utility for the agent will be $J(s) = \gamma_1 exp(-\gamma s)$. In this set up, γ will capture changes in the security technology.

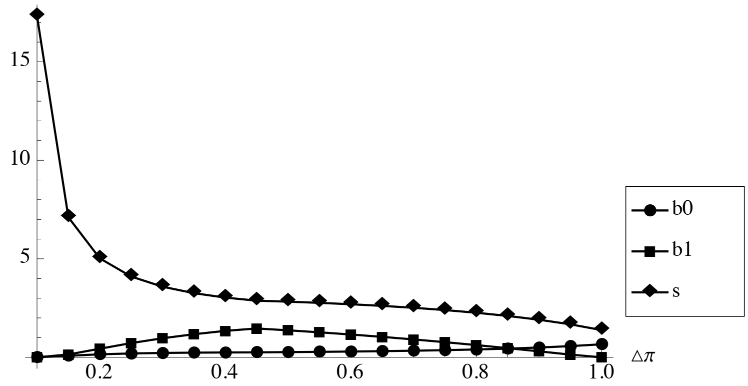
The first analysis on figure 4.3a shows the effect of security technology. When γ is very small and the security technology is not efficient, the principal needs to increase the benefits over the time in order to disincentives the agent to come back to criminal activities. Once the technology improves there are two effects: Firstly, the Principal need less expenditure to reduce the criminal utilities of the Agent. Secondly, the efficiency of the threat gives to the Principal the opportunity to use the benefits in order to incentives search over no search. Therefore, for large

Figure 4.3: Simulating the optimal solutions for s, b_0, b_1

(a) Changes in Security Technology parameter - γ



(b) Changes in the search premium - $\Delta\pi^{\dagger}$



Assume $u(x) = \frac{x^{1-\sigma}}{1-\sigma}$, $p(s) = 1 - exp(-\gamma s)$ and $J(s) = \gamma_1 exp(-\gamma s)$.
The base line set of parameters is: $w = 3$, $\underline{c} = 0$, $Z = 5$, $\beta = 85\%$, $\sigma = 0.65$, $\alpha = 0.35$, $\theta = 0.25$, $\pi(a = search) = 40\%$, $\pi(a = no\,search) = 0\%$ $\gamma = 0.15$, $\gamma_1 = 7$
† Change π^{search} keeping $\pi^{no\,search} = 0$

values of γ the Principal finds optimal having $b_1 \geq b_0$.

The second exercise on figure 4.3b fixes the probability of finding a job if *a=no search* and describes the equilibrium over different levels of π^{search}. It means that the premium of search $\Delta\pi = \left(\pi^{search} - \pi^{no\,search}\right)$ varies between the different scenarios. Initially, when the labour market does not reward the search effort, the Principal uses security investment as the main instrument to keep the constraints. Thereafter, while $\Delta\pi$, increases the pressure on security expenditure falls and the principal uses increasing benefits to maintain the Agent outside crime. Once the labour market conditions and the expenditure can be low enough to keep the Agent out of crime, the Principal now can come back to the decreasing benefit scheme to incentives job searching.

The latest result support the importance of ACR in Colombia and many other

DDR programmes all around the world for education and job training. As soon as the excombatant leaves war his human capital composition is such that the search premium is close to zero. This means that, security and deterrence are the key tool for keeping the Agent out of crime. When the former IS improves his skills for the legal labour market the benefit structure plays an important role.

Up to this point, my simple principal-agent framework shows some very important features of what an optimal reintegration contract should be. However, there are two assumptions that narrow my analysis in terms of public policy. Firstly, this is 1 to 1 game between one principal and one agent. So next section will firstly introduce heterogeneity in the agents and will set up the selection problem for the Principal. The second assumption is the lack of budget constraints. I will add up a tax payer into my model to set up an endogenous budget constraint to the problem.

4.4 The selection problem for a DDR programme

The model in the previous section is equivalent to a game between one Principal and one Agent. This kind of relationship was the result of some of the model assumptions. With no budget constraint and the ability of the Principal of observe and design a contract for any kind of agent the latest model suggests a benefit and threats scheme depending on the market parameters as I showed before. But, what would happen if the Principal cannot observe every single Agent characteristic? What would happen if the Principal has a budget constraint? Who should the Principal target to come into the RP?

To answer these questions, in this section I propose a selection model. Initially, introducing unobservable heterogeneity in agents outside utility the Principal will not be able to design individual contracts. However, I fixed the Principal's budget constraint and solve the problem under symmetric and asymmetric information. I propose an endogenous budget constraint where the community decides how much to spend in order to reduce the effect of war.

4.4.1 Unobserved Heterogeneity with Exogenous Budget Constraint

Assume that each *IS* is different from others by an unobservable preference for war. I denote the individual preference for war with the Greek letter iota where $\iota \in \mathbb{R}$. I define $F(\iota)$ to be the cumulative probability distribution function of ι. Assumption 5 describes the shape $F(\iota)$. Furthermore, each IS gets utility from the damage he/she produces. I define $z(\iota)$ to be the damage that each IS produces for a given. What is more, each *IS* produces a damage $z(\iota)$ and assumption 6 complements assumption 2 and summarises the new characteristics of $J(s, \iota)$.

Assumption 5. *The preferences for war ι have a cumulative probability function $F(\iota)$ and a density probability functionf (ι). $F(\iota)$ continuous and twice differentiable on $\iota \in \mathbb{R}$.*

Assumption 6. ***(Complementing assumption 2)**. The IS lifetime utility in war is a monotone non-decreasing and concave function on war preferences - ι - for all s. Then, $\frac{\partial J(s,\iota)}{\partial \iota}>0$, $\frac{\partial^2 J(s,\iota)}{\partial \iota^2}<0$ and $\frac{\partial J(s_i,\iota)}{\partial \iota} = \frac{\partial J(s_j,\iota)}{\partial \iota}$ for all s_i, $s_j \in \mathbb{R}^+$*

Finally, the Principal has a fixed budget to the programme denote by $\Omega > 0$. This initial set up has the following implications: firstly, the Principal cannot differentiate between two agents, and thus cannot adjust the contract to every single agent. Given the monotonicity of u and J, the principal would optimally offer an unique contract $\chi(\hat{\iota})$. Secondly, assuming that the expenditure in security is not per agent but affects any agent in the same way. S represents the total security expenditure. Thus, the budget constraint obliges the Principal to select the number of agents to be included in the programme and under what conditions.

Given that $J(s, \iota)$ is monotone and non-decreasing in ι, any contract $\chi(\hat{\iota})$ which is individual rational for the agent $\hat{\iota}$ would be individual rational for any $\iota \leq \hat{\iota}$. Therefore, with symmetric information in actions the Principal will choose $\chi(\hat{\iota}) = [b^*, S^*, \hat{\iota}^*]$ such that:

$$\begin{array}{lr} S^* + b^* F\left(\hat{\iota}^*\right) = \Omega & \{BC\} \\ \begin{bmatrix} u\left(b^*\right) - \alpha + \\ \\ \beta\left[\pi^{search} u\left(W\right) + \left(1 - \pi^{search}\right) u\left(b^*\right)\right] \end{bmatrix} = J\left(S^*, \, \hat{\iota}^*\right) & \{IR\left(\iota^*\right)\} \\ \frac{\partial u(b^*)}{\partial b^*} = -\frac{\partial J(S^*, \hat{\iota}^*)}{\partial S^*} & \{OC\left(\iota^*\right)\} \end{array} \tag{4.7}$$

The system of optimal conditions is simple. Given that the Principal does not gain any utility from saving and there is no credit market, the budget constraint binds. Thus, the Principal will look for the agent $\hat{\iota}^*$ such that he will expend all his budget to take the agent $\hat{\iota}^*$ and all the other combatants below this agent into the RP. All these agents choose optimally to leave the IAG. The last two equations of the system described in 4.7 define the shape of the optimal contract $\hat{\iota}^*$ when the actions are observable. It is important to note that the monotonicity of $J\left(S, \, \iota\right)$ assures that what is optimal for $\hat{\iota}^*$ will be accepted by anyone below $\hat{\iota}^*$.

Moreover, in the previous section I showed that with unobservable actions in the RP the optimal shape of the benefits, depend on the security technology and the search premium. Therefore, by assumption 6 and given that $\triangle\pi$ is not a function of ι, the latest result also applies in this case. Thus, if $\chi\left(\hat{\iota}^*\right)$ is the optimal contract for agent $\hat{\iota}^*$, then, IR, IC1 and IC2 will hold for all the agents who will enter into the programme.

The main features of my last result depend on the size of the budget - Ω. For this reason, in the next section I allow tax payers to decide the budget dedicated to reducing the cost of conflict.

4.4.2 Endogenous Budget Constraint

This far, the Principal aims to minimise the number of illegal soldiers in war assuming implicitly that utility is gained from this behaviour. Simply, the result of the conflict is a transmission of utility from the law-abiding community to the IAG. The Principal acts as a Social Planner who maximise the welfare of the entire community (legal and illegal). In order to achieve the goal the Principal allocates illegal soldiers in or out the programme. The Principal, moreover, collects taxes from law-abiding community to fund the security policy.

Initially I split the total population between *Civil Community* – CC – and the Illegal Armed Group – *IA*G. Where Λ represents the proportion of CC and $(1-\Lambda)$ the proportion of the population who are part of an IAG[18]. The CC produces Y and gets utility from final consumption. Declare $V(x)$ a increasing and concave aggregate utility function of CC[19]. The output of conflict is a loss in consumption for CC and the size of the loss depends on the size of the illegal army. I call $Z(x)$ the consumption loss produced by an IAG of size x.

What is more, each *IS* gains utility from consumption, as I defined previously the *IS* utility function is $U(x)$. Inside a *RP* each *IS* consumes benefits b and outside the programme consumes the value of the damage made - $z(i)$.

The Principal now wants to maximise the utility of the entire community (*CC* and *IA*G) allocating *IS* in and out the *RP*. This initial approach fixes the expenditure in security and assumes no informational asymmetries and no credit markets. The Principal collects taxes from *CC* in order to fund his policy. Thus, assumption 7 defines *CC's* utility function and assumption 8, the damage function. Thereafter, I define the Principal's problems.

Assumption 7. *The utility function of the Civil Community* $V(x)$ *is increasing and weakly concave in consumption* x. *Then,* $V'(x) > 0$, $V''(x) \leq 0$.

Assumption 8. *The individual damage function* $z(\iota)$ *is monotone, increasing and weakly convex in* ι. $z'(\iota) > 0$, $z''(\iota) \geq 0$.

Thus, the Principal now solves:

[18]This model does not try to explain the initial decision of entrance in an IAG so the proportion Λ is predetermine.

[19]This work differentiate between the utility function of civilians and illegal soldiers. The main hypothesis is differences in risk aversion levels..

$$\max_{b,\tau,\hat{\iota}} \left\{ \begin{array}{c} \Lambda V\left(Y-\tau-Z\left(1-F\left(\hat{\iota}\right)\right)\right) \\ \\ +\left(1-\Lambda\right)\left\{U\left(b\right)F\left(\hat{\iota}\right)+\int_{\hat{\iota}}^{\infty}U\left(z\left(\iota\right)\right)f\left(\iota\right)d\iota\right\} \end{array} \right\}$$

$$\begin{aligned} & s.t. \\ & Z\left(1-F\left(\hat{\iota}\right)\right)=\int_{\hat{\iota}}^{\infty}z\left(\iota\right)f\left(\iota\right)d\iota \rightarrow \text{Transmission Rule} \\ & U\left(b\right)=U\left(z\left(\hat{\iota}\right)\right) \rightarrow \text{Decision rule} \\ & b\left(1-\Lambda\right)F\left(\hat{\iota}\right)\leq\Lambda\tau \rightarrow \text{Budget constraint} \end{aligned} \tag{4.8}$$

Before explaining the problem's equations, it is useful to make a some notes about my model. Firstly, it is important to clarify the role of $\hat{\iota}$. $\hat{\iota}$ defines the proportion of the IAG who enter in the RP and have left war. Given assumptions 1, 5 and 8 any IS such that $\iota \leq \hat{\iota}$ would optimally choose to leave war and get the benefits of the RP. However, any $\iota > \iota^{*}$ remains outside the programme and gains utility from armed conflict $U\left(z\left(\iota\right)\right)$. The utility functions $\{V, U\}$ look like static utility functions but they can be understood as life time utilities for different agents in different states[20].

I can describe each equation in order to understand better the maximisation problem. The objective function is the weighted sum of the utilities of CC and IAG. The final consumption of civilians is $\left[Y-\tau-Z\left(1-F\left(\hat{\iota}\right)\right)\right]$ when $Z\left(1-F\left(\hat{\iota}\right)\right)$ is the loss generated by an IAG of final size $1-F\left(\hat{\iota}\right)$, because the proportion $F\left(\hat{\iota}\right)$ is in the RP and will not produce any further damage anymore. Additionally, the IAG utility has 2 components: the proportion $F\left(\hat{\iota}\right)$ enter in the RP and each one gets utility $U\left(b\right)$. Each IS that stays in war produces a damage $z\left(\iota\right)$ and gains utility from this. Thus, the aggregated utility of those who stay at war is $\int_{\hat{\iota}}^{\infty}U\left(z\left(\iota\right)\right)f\left(\iota\right)d\iota$.

The Principal in this case faces three constraints. The first is the Transmission Rule. As I explain above each IS produces a damage $z\left(\iota\right)$. If all the ISs whose $\iota > \hat{\iota}$ stay at war, the aggregated loss would be $\int_{\hat{\iota}}^{\infty}z\left(\iota\right)f\left(\iota\right)d\iota$. Therefore, this damage is equal to the total loss in utility for the CC. The second constraint is the Principal's decision rule. Using the monotonicity of $U\left(x\right)$ and $z\left(\iota\right)$, the Principal chooses an agent $\hat{\iota}$ such that he is indifferent between being in or out

[20] For example $U\left(b\right)$ in the same framework of the moral hazard model can be written as $U\left(b\right)=u\left(b\right)-v\left(a\right)+\beta\left[\pi^{a}u\left(W\right)+\left(1-\pi^{a}\right)u\left(b\right)\right]$

the *RP*, once again, any agent with $\iota \leq \hat{\iota}$ will come to the programme and all the agents with $\iota > \hat{\iota}$ would stay at war. The last constraint is a standard budget constraint without credit markets. In order to simplify my problem I plugged the Transmission Rule into the objective function and solve for b in the Decision Rule, thus, I can rewrite the problem in equation 4.8 as:

$$\underset{\tau,\hat{\iota}}{max} \left\{ \begin{array}{c} \Lambda V\left(Y-\tau-\int_{\hat{\iota}}^{\infty} z\left(\iota\right) f\left(\iota\right) d\iota\right) \\ \\ +\left(1-\Lambda\right)\left\{U\left(z\left(\hat{\iota}\right)\right) F\left(\hat{\iota}\right)+\int_{\hat{\iota}}^{\infty} U\left(z\left(\iota\right)\right) f\left(\iota\right) d\iota\right\} \end{array} \right\} \tag{4.9}$$

$s.t.$

$$z\left(\hat{\iota}\right)\left(1-\Lambda\right) F\left(\hat{\iota}\right) \leq \Lambda\tau \quad \{BC,\, \mu\}$$

Taking FOC with respect to $\hat{\iota}$ and τ and simplifying:

$$V'_{\hat{\iota}^*,\tau^*} = \mu \tag{4.10}$$

$$\left(\frac{2\Lambda-1}{1-\Lambda}\right)\frac{z\left(\hat{\iota}^*\right)}{z'\left(\hat{\iota}^*\right)}\lambda\left(\hat{\iota}^*\right) = 1-\frac{U'_{\hat{\iota}^*}}{V'_{\hat{\iota}^*,\tau^*}} \tag{4.11}$$

Where $V'_{\hat{\iota}^*,\tau^*}$ is the marginal utility of consumption[21] at the optimal $\{\hat{\iota}^*,\, \tau^*\}$ and $\lambda\left(\hat{\iota}^*\right) = \frac{f\left(\hat{\iota}^*\right)}{F\left(\hat{\iota}^*\right)}$ is the Inverse Mills Ratio at $\hat{\iota}^*$. Therefore, from the FOC I take the following conclusions. First, using assumption 7 in equation 4.10 I can show that $\mu > 0$ and the budget constraint binds. Therefore, the optimal level of taxation is represents only a consumption transfer from the CC to the ISs in the RP.

What is more, given assumptions 5 and 8, for any $\Lambda > \frac{1}{2}$ the marginal utility of the *ISs* inside the programme is lower than the marginal utility of the *CC*[22]. If the *CC* and the *IS* have the same level of risk aversion, giving that both functions are concave equation 4.11 implies that the consumption for an *IS* is larger that the consumption of *CC*. Thus, $b^* = z\left(\hat{\iota}^*\right) > W_{\hat{\iota}^*,\tau^*}$. In order to reduce the externality that the *IAG* creates the *CC* will pay a premium. This implies a larger consumption level for the *IS* who decides to leave the war. Furthermore, it is pretty likely that someone who is involved in a risky activity like war can have

[21] *CC* consumption is $W_{\hat{\iota},\tau} = Y-\tau-\int_{\hat{\iota}}^{\infty} z\left(\iota\right) f\left(\iota\right) d\iota$

[22] In Colombia the largest guerrilla FARC will no represent more than 0.1% of the total population.

a lower level of risk aversion than someone who has never been in war. Thus, V is more concave than U, and my last result becomes stronger.

According to the size of the IAG $(1-\Lambda)$, their capacity to induce damage $\frac{z}{z'}$ and the skill distribution characteristics $\lambda(\iota)$, the CC will pay a premium to achieve higher utility reducing the level of conflict.

Following the framework I use in the last part of section 4.3, I introduce security investment into my analysis. In order to do so, I redefine the damage function z as $z(\iota, S)$ where $z_S(\iota, S) < 0$. The latter means that security reduces the damage made by each IS. What is more, the price of S will be q_s. Then, assumption 9 complements assumption 8.

Assumption 9. ***(Complementing assumption** 8).* The damage function is now a strictly decreasing function on the total security expenditure. $z(\iota, S)$ *where* $z_S(\iota, S) < 0$.

Furthermore, the new budget constraint will be $q_s S + z(\hat{\iota}, S)(1-\Lambda)F(\hat{\iota}) = \Lambda\tau$. Therefore, if I plugged the budget constraint into the objective function, the new Principal's problem will be:

$$\underset{\hat{\iota}, S}{max} \left\{ \begin{array}{c} \Lambda V\left(Y - \frac{q_s S + z(\hat{\iota}, S)(1-\Lambda)F(\hat{\iota})}{\Lambda} - \int_{\hat{\iota}}^{\infty} z(\iota, S) f(\iota)\, d\iota\right) \\ \\ +(1-\Lambda)\left\{U(z(\hat{\iota}, S))F(\hat{\iota}) + \int_{\hat{\iota}}^{\infty} U(z(\iota, S)) f(\iota)\, d\iota\right\} \end{array} \right\} \tag{4.12}$$

Then, in the FOC with respect to $\hat{\iota}$ I find the same expression as 4.11. Moreover, the FOC with respect to S will be:

$$\frac{(1-\Lambda)\nabla_S U}{V'_{\hat{\iota}^*, S^*}} - \Lambda\nabla_S z + (1-2\Lambda)\, z(\hat{\iota}^*, S^*) f(\hat{\iota}^*) \frac{\partial\hat{\iota}}{\partial S} = q_s \tag{4.13}$$

$\nabla_S U = \int_{\hat{\iota}^*}^{\infty} U'(z(\iota, S^*))\, z_S(\iota, S^*) f(\iota)\, d\iota$ is the cumulative disutility of the IAG when the principal increases security. Furthermore, $\nabla_S z = \int_{\hat{\iota}^*}^{\infty} z_S(\iota, S^*) f(\iota)\, d\iota$ is the reduction in damage to the CC for an increase in security. Then, the choice of security expenditure equals the price of the investment with its marginal benefit. The marginal benefit of security is described in the left hand side of equation 4.13. The first part $\frac{(1-\Lambda)\nabla_S U}{V'_{\hat{\iota}^*, S^*}}$ weighs the disutility of the IAG with the increase in consumption by the CC. What is more, by assumption 9, $-\Lambda\nabla_S z$ is the marginal benefit for damage reduction. The last part of the left hand side of equation 4.13

includes the trade-off between benefits and security that I have developed in this chapter. This measures the efficiency of security as a tool to incentivise more IS to join the RP at the level of benefits that the IS who join the RP will obtain. It is important to remember that each IS in RP will receive the same the benefits of the optimal pivotal agent - $z(\hat{\iota}^*, S^*)$.

To conclude this section, the Principal will use the available tools, benefits and security depending on the price of the latest and the relative efficiency in order to get IS out of war. What is more, the CC it self will pay the taxes τ that reduce optimally the damage they are suffering for war.

4.5 Conclusions and policy implications

The analysis of the social and political issues that governments, international agencies and communities face are well analysed in the political and sociological studies. However, there is no economical and technical analysis of these type of programmes. This chapter aims to contribute to this gap in existing literature.

Specifically this chapter models two informational issues: (1) The moral hazard driven by the hidden action of participants in these type of programmes, especially, the incentives that some *IS*s have to commit crimes while receiving some benefits from a *RP.* (2) The selection problem that governments could face given the limited resources available and the informational asymmetries.

To explain the implications of hidden actions I proposed a simple static moral hazard problem with one Principal (government) and one Agent (*IS*). In this model the Principal uses benefits and security expenditure to bring the *IS* to a *RP* and make the Agent optimally search for a job over no search, or commit crime. In the model the search premium $\left(\pi^{search} - \pi^{no\,search}\right)$ and the technology in security define the trade off between benefits and punishments. When the security technology is good, the principal can set decreasing benefits to provide incentives for the job search. However, if the labour market prizes the search and the security in technology returns turn to zero the Principal could use a scheme of increasing benefits to make the Agent choose searching for a job over returning to criminal activities.

Afterwards, I introduce unobserved heterogeneity in the agent's preferences for war to analyse the selection issues. Initially with exogenous budget constraint the Principal offers an unique contract that is individually rational and incentive compatible for a pivotal Agent with $\hat{\iota}^*$ preference for war. Given the monotonicity assumption, this contract will bring any agent with $\iota \leq \hat{\iota}$ inside the RP and leave all the others active in war.

Finally, I model the role of the tax payer or CC who is the one to decide how much to pay in order to reduce the effect of conflict. In this case the Principal collects taxes from CC and chooses a pivotal agent $\hat{\iota}$ such that this agent is indifferent between war and RP. The benefit of bringing this agent back to legality (given the reduction in damage) is equal to the cost that the CC will have to pay to make his contract individually rational. What is more, once again, the relative productivity of benefits and security over the pivotal agent will define the shape of the optimal contract.

This chapter aimed to provide simple policy guidelines for running and carrying out or forthcoming DDR programmes. I intend to explain the main implications of the informational problems that a policy maker may find while implementing a reintegration contract. What is more, this chapter opens a window for further research. Using administrative or survey data about individuals in the RPs, would be possible to estimate, for instance, the trade-off between security and labour market benefits, or the evolution of an individual in the RP as a function of his levels of human capital.

Chapter 5

Conclusions

Colombia is world famous for the production of coffee, Gabriel Garcia Márquez (Literature Nobel Prize in 1982), and more recently, the pop singer Shakira. However, sadly the country is also famous for the production of cocaine and the violent armed conflict that has lasted over 50 years. This thesis uses microeconometric methods to analyse the economic implications of the Colombian armed conflict.

Chapter 2 develops a strategy to deal with the endogeneity problem that arises when researches want to estimate the impact of violence on households in the environment of a long-lasting conflict. I use the geographical comparative advantage that some regions have in cocaine trafficking, through access to certain international markets in order to estimate exogenous violent variations when the price of cocaine international markets increases. I constructed a network that links the coca cropping municipalities with Colombian's frontiers using the system of primary and secondary roads. The network represents the set of possible trafficking choices available to drug dealers aiming to sell cocaine to international traffickers at the Colombian border.

After finding more than eleven thousand trafficking routes I restricted my analysis to the routes of less than a 1000 km. I divided the network further according to the border where each route finishes. I claimed that the routes that finish on the Pacific coast serve traffic to the US while the ones ending on the southern border with Venezuela supply to EU market. As follows, my reduced form estimation shows that when the cocaine price in the Unites States increases, the homicide rates increase in the municipalities that are part of the traffic that finish on the Pacific, Atlantic and the northern border with Venezuela. On the other hand, homicides rise in the municipalities involved in trafficking through the southern

Venezuelan border when the price of cocaine increases in Europe. The latest conclusions hold when I weighted each municipality according to the average length of the traffic routes.

I extended my analysis to the behaviour of illegal armies. According to my estimations the ELN follows closely the rents of cocaine. The probability of its presence increases in the Pacific, Atlantic and Venezuela North traffic clusters when the cocaine price in US increase. Moreover, ELN presence increases in the Venezuela South cluster when the returns in the European market rises. FARC guerrillas, however, follow the rents on the cluster of the southern border with Venezuela, while not getting directly involved in the traffic of the Pacific to the US.

Chapter 3 uses the exogenous variation on homicides found in the previous chapter to study if armed violence affects the incentives of young women regarding the timing of first pregnancy. The chapter presents a theoretical framework following closely Kearney and Levine (2011) to describe the possible channels that such violence could affect the cost-benefit relation of postponing motherhood. I claim that increases in homicide rates change the marriage market composition and reduce the expected value of a future partner. Furthermore, I claim that violence reduce as well the subjective probability of achieving economic and personal success in the future. This increases the incentives of investing in motherhood when young.

Afterwards, I propose a two-stage discrete duration model in order to estimate the effect of increases in the homicide rates on the hazard of becoming pregnant before 19 years old. I found that women from 15 to 19 years of age, increase their probability of becoming pregnant by 2.58 percentage points when the homicide rate increases in one standard deviation. Conversely, the effect is negative and not significant for women from 25 to 29 years old. Besides, the probability of having the first marriage between 15 and 19 years of age, increases by 1.15 percentage points. However, the probability of earlier first intercourse or second pregnancies when teen decrease. My results suggest that when violence increases women invest in family, which could be a source of stability and protection.

Finally, my last chapter focuses in the DDR programmes. I developed a Principal-Agent model to describe the features of an optimal reintegration contract. I pay particular attention to the cost of informational asymmetries.

In the model the Principal uses optimal benefits and security expenditure depending on the labour market and security capabilities. When the security technology is very good, the Principal can set decreasing benefits in order to give incentives to job searching. Moreover, if the labour market prizes the job search and the security in technology is poor the Principal can use a scheme of increasing benefits to make the Agent to choose the job search over returning to criminal activities.

I conclude chapter 4 by introducing unobserved heterogeneity in the agent's preferences for war and a tax payer, or *CC,* who decides how much to pay to reduce the effect of conflict. In this case the Principal collects taxes from the *CC* and chooses a pivotal agent $\hat{\imath}$ such that the this agent is indifferent between war and *RP.* Moreover, the benefit of bringing this agent back to legality (given the reduction in damage) is equal to the cost that the *CC* will have to pay to make his contract individually rational. Once again the relative productivity of benefits and security over the pivotal agent define the shape of the optimal contract.

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