Cultivation and competition in Colombia: disentangling the effects of coca price changes on violence

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Abstract

Though evidence indicates the presence of coca increases violence, changes to the price of coca products can have both negative and positive effects on conflict. This study addresses this matter. Using novel data on local prices of coca products, production and supply chains, this study disentangles the returns to employment in the agricultural sector (cultivators) and employment in the criminal sector (guerillas and paramilitaries). I identify each agents' respective exposure to price changes, and estimate the effect of such changes on violence. The results show the presence of the opportunity cost effect: an increase in income from coca results in a reduction in violence. This reduction comes with an increase in school attendance for rural households. An increase in the objective prize (OP) leads to more violence. Moreover, guerillas flock to the area that witnesses such an increase, resulting in higher levels of competition which coincides with the timing of the increase in violence. Additionally, increasing expected returns to joining an armed group can lead to higher school dropout rates among children.

Keywords: conflict, income, objective prize, coca, competition

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1 Introduction

As coca cultivation in Colombia tripled between 2013 and 2017, there are signs of escalating violence (International Crisis Group, 2021). Though there is evidence that the presence of coca increases violence (Angrist & Kugler, 2008), changes to the value (price) of coca products can have negative and positive effects on conflict: increasing wages for farmers draw labor out of the criminal sector into the agricultural sector, thus reducing violence. However, violence can also increase as higher prices make coca a more valuable good, increasing competition. This paper disentangles these contradicting forces. It develops separate measures for the returns to being active in the agricultural sector and criminal sector, and estimates the effect of changes to these returns on violence.
This is done by focusing on the 2007 – 2018 time period, which witnessed fundamental changes in the Colombian coca sector. The breakdown of the large cartels and the demobilization of the United Self-Defence forces of Colombia (*Autodefensas Unidas de Colombia*, or AUC). The resulting power vacuum changed the market drastically. The presence of fewer oligopolies in the market caused the bargaining power of international buyers to increase, while Colombian agents saw their position weaken (UNODC & Europol, 2021). Simultaneously, the government eradicated record amounts of hectares of coca, dismantled coca laboratories, and the demand for cocaine in the United States and Europe grew (Mejía & Restrepo, 2016; UNODC, 2007; UNODC & Europol, 2021). The changes affected the ability of armed groups to finance themselves through coca and increased competition for control over the market. Moreover, the effects of the effects trickle down, affecting the livelihood, safety and security of those cultivating coca. The new dynamics call for re-examining the relationship between coca, violence, and the roles played by various actors.

This study relies on a conceptual frameworks of Arjona et al. (2015), Becker (1968), Grossman (1999), Hirshleifer (1989), and Olson (1993) to adequately address the intrinsicalities of the conflict. Agents are considered to choose between employment in the agricultural and criminal sector. For those employed in the agricultural sector (farmers, cultivators and agricultural households) coca presents an important source of income. A relative increase in income from coca would draw labor out from the criminal sector, reducing violence: the opportunity cost effect (Angrist & Kugler, 2008; Collier & Hoeffler, 2005; Dube & Vargas, 2013). Agents active in the criminal sector (armed groups) finance themselves through coca (O'Connor, 2009). The larger the share of the coca market that is under control of an armed group, the larger their source of income. For these agents coca forms an objective prize (OP). A positive shock to the expected returns to the criminal sector entices those active in the agricultural sector to join an armed group, and forms a strong incentive for existing groups to expand their territory in order to gain access to the resource (as 'roving bandits' (Olson, 1993)) leading to an increase in violence: the rapacity effect (Collier & Hoeffler, 2005; Dal Bó & Dal Bó, 2011; Hirshleifer, 1989). Moreover, the increase in value encourages rebels to strengthen

their hold over the areas they have under control (Arjona et al., 2015; Estancona, 2021; Olson, 1993). The latter allows armed groups to engage in rebel governance and create mutually beneficial partnerships with local agents, which are affected by the economic needs of the rebels (Arjona et al., 2015). Applying the framework to the Colombian conflict, I consider the effect of an increase in the income from coca (for farmers) and in the OP (for guerillas and paramilitaries) on the intensity of violence in Colombian municipalities.[1]

The econometric analysis relies on rich and detailed data on the local prices of specific coca products (coca base, paste, leaf and hydrochloride (HCI)), coca production and supply chain differences, agricultural wages, coca cultivation, eradication efforts and the dismantling of laboratories, and measures of violence. The first step of the analysis consists of creating proxies for returns from the agricultural sector (income from coca) and returns from the criminal sector (OP). Second, the effect of a one percent increase in farmers' income from coca and of the OP for armed groups on local violent intensity is estimated. Violent intensity is measured as the total number of violent events, fatalities, guerilla and paramilitary attacks per 100,000 inhabitants. The results are explained through two channels: the opportunity cost and rapacity effect.
I examine the presence of the two effects further. Since coca is frequently cited as the reason that parents can afford to send their children to school or university (International Crisis Group, 2021; Sanín, 2019), I consider the impact of an increase in income on educational outcomes. Moreover, an increase to the returns to employment in the agricultural sector can lead to higher levels of income, self-employment, or hours worked. Evidence of increasing labor market and/or educational outcomes would support the assumption that the opportunity cost effect drives the decrease in violence. Moreover, the data used in this study allows me to examine the impact of changes to the OP on local competition amongst armed groups. Doing so provides further insight into the role of competition as a determinant of violence.
Concerns with respect to endogeneity are mitigated in various ways. First, the coca prices (originally observed on municipality-month level) used to construct the proxies are averaged to region-year level. As regions contain between twenty and a couple of hundred municipalities, local dynamics affecting these average prices is unlikely. Second, only lagged values of the proxies are used in the analysis. Furthermore, the proxies are constructed in a similar fashion to a Bartik instrument, fixed effects are included, and the control variables are carefully selected to capture other determinants of violence, prices, supply and demand. I conduct extensive robustness tests to verify the results.

The results show a clear presence of the opportunity cost effect: an increase in income of coca products for farmers (an increase in the returns to employment in the agricultural sector

[1] Administratively, Colombia is made up of 31 departments and one capital district. Each departments consist of various municipalities: there are 1,122 municipalities in total. The UNODC (2017) distinguishes seven different regions in the coca-cultivation surveys. These are not official administrative units, but are 'natural' or geographical regions. These are Amazonía, Central, Meta-Guaviare, Orinoquía, Pacifico, Putumayo-Caquetá and Sierra Nevada.

relative to the returns from employment in the criminal sector) is associated with a reduction in the intensity of violence on municipality level. The results indicate that for the average coca-producing municipality, the total increase in income from coca between 2007 – 2018 resulted in 16.9% fewer total violent events, 16% less fatalities, and 11.6% fewer guerilla attacks per 100,000 inhabitants. Moreover, this higher income is associated with higher school attendance rates and less competition among armed groups. Similarly, higher relative returns to employment in the criminal sector can lead to an intensification of violence: the total increase in the OP for the time period considered is associated with 25.6% more violent events, 23.18% more fatalities and 27.8% more guerilla attacks. Further analysis of these effects indicates that armed groups, especially guerillas, flocked to areas that witnessed an increase in the value the OP and competition among armed groups increases with approximately 10%. The timing of this increase in competition coincides with the rising intensity of violence in the municipality. Additionally, there is evidence that suggests that the higher relative returns to joining an armed group might lead to lower levels of school attendance.

This paper is structured as follows. Section 2 discusses the coca sector in Colombia and recent changes that affected the market. A conceptual framework is presented in section 3, followed by a discussion of the data in section 4. The methodology and empirical strategy is laid out in section 5. Section 6 presents the results, interpreting these as elasticities and net effects. The section also includes robustness tests, and relates the findings of this study to the literature. Section 7 concludes.

Literature

This paper contributes to the extensive literature on the coca sector in Colombia. However, whereas most research on this topic studies the link between the presence of coca and conflict, I focus on the economic incentives for agents involved in the coca sector and on how these affect local intensity of violence. I consider the relationship between coca prices and violence, focusing on a time period marked by significant changes with respect to agents' bargaining power, control over the supply chain, and competition. This time period has – to my knowledge – not been examined. By identifying the economic incentives and disentangling the separate effects, the results of this study present a more detailed and nuanced picture than is common in the literature, which frequently does not take regional differences in coca production technologies and prices into account or (solely) relies on the presence or intensity of coca cultivation.[2] In doing so, this study specifically extends

[2]Though the latter has been shown to have an effect on violence by Angrist and Kugler (2008) the presence of coca is not necessarily a good indication of the local value of coca. As noted by the UNODC (2010), coca prices do not follow the 'regular' rules of supply and demand as they are affected by many other factors. Moreover, there is a considerable amount of variety in the extent to which farmers process the coca leaves they harvest, and thereby the value of the product and their income. Finally, it is common that farmers suffer a drop in income due to government interference (Thoumi, 2002), or are pressured by local militias to sell their products for a lower value (UNODC, 2018)

the work of Angrist and Kugler (2008) who exploit an upsurge in coca cultivation and prices, and show this led to small but positive economic gains for self-employed people living in rural areas as well as to higher levels of violence. The data used in this paper allows for studying these dynamics in much more detail. In addition to labor market outcomes, I consider educational effects of changes to income from coca. Moreover, by distinguishing income from coca cultivation and the OP, I am able to show the strength and opposing signs of the effects.

I show that increase in the OP leads to heightened competition and that especially guerilla groups are likely to attempt to gain control over territory. These results illustrate the working of the rapacity channel and the extent to which competition contributes to violence, as well as the behavior of different armed groups in the Colombian conflict (Estancona, 2021). Moreover, by estimating such effects, this paper is related to the crime-rebellion nexus narrative (Cornell, 2007), rebel governance (Arjona et al., 2015) and work of Anderson and Worsnop (2019) showing that the potential financial reward of engaging in drug production and trafficking can form an incentive to use violence to maintain control over cultivation and (production) processes.

Importantly, this study contributes to the literature on the more general effects of coca as a source of income for agricultural families. The positive effect of coca on educational outcomes (Sanín, 2019) as well as its negative impact (Bjørkhaug, 2010; Sviatschi, 2018) have been documented. This study disentangles the effects of a change in income and the OP, providing evidence of the simultaneous presence the positive and negative impact of coca on education.

This study builds on work that focuses natural resources and conflict (Collier & Hoeffler, 2005; Ross, 2003) and drug-fueled conflict (Cornell, 2005, 2007). The relationship between changes in the prices of agricultural goods and violence in Colombia has been documented by Dube and Vargas (2013) who consider the effects of changes in the coffee and oil price, and Rettberg (2010) who studied the breakdown of the International Coffee Agreement and the violence in Colombian coffee regions that followed. Though coca is an agricultural good as studied in those papers, it is an illicit good which' cultivation presents a different dynamic and challenge, and comes with severe risks for cultivators (UNODC, 2017). As this study is closely related to the mentioned works, the results of this study are compared to those of Dube and Vargas (2013) in section 6.

Finally, by using new data and focusing on a different time period, I contribute to and build upon the large literature on the coca-fueled conflict in Colombia. Other work in this field focuses on violence and the armed groups involved in coca trafficking, such as on coca eradication efforts (Fisher & Meitus, 2017; Moreno-Sanchez et al., 2003), modelling the war on drugs as a resource problem (Grossman & Mejía, 2008; Mejía & Restrepo, 2016), explaining different levels and types of violence (Holmes et al., 2006), armed groups involved in the coca sector (Bottía Noguera et al., 2003; Estancona, 2021; O'Connor, 2009; Suárez, 2000; Thoumi, 2002), and expansion of coca cultivation (Mejia & Restrepo, 2013).

while the price of coca chlorhydate (HCI) - armed groups' OP - remains constant.

2 Institutional background

To understand the coca market in Colombia, it is important to understand the basic steps in the production process of cocaine.[3] The part of process that takes place in Colombia can be roughly divided into four stages (UNODC, 2010). In the initial three stages coca leaf is cultivated, processed into coca base, and eventually turned into coca paste. These stages are carried out by agricultural households, farmers or cultivators. In the fourth stage coca paste is processed into coca HCI. This stage is carried out by armed groups that possess the capital to obtain the scarce ingredients (such as acid and acetone) and have the technical expertise required for production (O'Connor, 2009; UNODC, 2018, 2021). Coca HCI is the product that is trafficked to its final destination by international wholesale buyers, where it is eventually processed into cocaine.

2.1 Armed groups and cultivators

This study focuses on the dynamics within the Colombian coca market, and considers cultivators and armed groups as agents in this market. There are various armed groups involved in the Colombian coca sector, but these are generally divided into two categories: left-wing guerillas and right-wing paramilitary groups (Estancona, 2021; Sanín, 2008). The groups have different origins and objectives, and differ with respect to their involvement in the coca sector, relationships with cultivators, responses to changes to the value of coca, and use of violence.

The largest guerilla group active in Colombia to date was the FARC (*Fuerzas Armadas Revolucionarias de Colombia*).[4] FARC funded itself through kidnapping, extortion, illegal mining practices, and involvement in the coca sector, with the majority of its drug-related income coming from a 'protection tax' (Bruce-Jones & Smith, 2021).[5] The group took on the role of regulators of the coca paste market, arranging and controlling transactions between cultivators and cartels (Vargas, 2011). During the peace talks between the Colombian government and FARC that started in 2012, many dissident factions were formed (Flores & Vargas, 2018). These factions, together with other guerilla groups – such as the ELN and EPL – are the left-wing organizations currently active in Colombia.

[3] For an excellent in-depth discussion on the history, violence related to, and production of coca in Colombia, see Díaz and Sánchez (2004).

[4] Other groups are the Ejército de Liberación Nacional (ELN), Ejército Popular de Liberación (EPL), and M-19.

[5] Coca has been an important source of funding for decades. According to Vargas (1999), almost half of the income of guerilla groups in the period 1991-1996 came from drug trafficking. About one-fourth came from extortion and robbery, and one-fifth from kidnapping, and a small fraction originated from municipal funds. However, illicit alluvial gold mining has also proved to be a source of financing for these groups since 2007 (Rettberg & Ortiz-Riomalo, 2016) and is linked to coca production (UNODC, 2013). When the international gold price collapsed in 2015, more groups were pushed into the cocaine market to make up for lost profits, exacerbating the conflict further (International Crisis Group, 2021).

The Colombian government opposed guerilla groups through military means, but also encouraged the formation and involvement of paramilitaries (Estancona, 2021; Sanín, 2008). The paramilitaries were formed by landowners to protect their property from appropriation by guerillas, and worked with cartels to protect coca trafficking routes and thereby prohibit left-wing groups from acquiring additional income (Estancona, 2021). AUC emerged as one of the largest paramilitary organizations in Colombia and relied on coca as a way of financing itself.[6]

AUC disbanded in 2006, after which former members and other paramilitaries formed new, smaller organizations. These groups are often referred to as *Bandas Criminales Emergentes*, or BACRIM. The BACRIM are generally considered to be continuations of paramilitary groups (Maher & Thomson, 2018; Saab & Taylor, 2009).

The main difference between guerillas and paramilitary organizations is that guerillas are an oppositional group, whereas paramilitaries are pro-governmental organizations with connections to the state (Sanín, 2008).[7] This structural difference has a significant impact on each groups' use of violence and the relationship it has with those who cultivate coca. One of the paramilitaries' main objectives is to protect cartels' interests and prevent cultivators from producing coca for left-wing organizations (Estancona, 2021). This is reflected in their use of violence: paramilitaries employ selective violence aimed at controlling civilians and discouraging them from selling coca to guerillas. On the other hand, guerilla groups are often engaged in battles with the government and have significantly higher levels of violence. Guerillas are known to target civilians to intimidate and influence the population in order to maintain access to the coca grown in areas (Estancona, 2021; Sanín, 2008).

This emphasizes the risk and uncertainty associated with cultivating coca: municipalities where coca is grown experience significantly more violence (Angrist & Kugler, 2008), cultivating coca brings farmers in direct contact with violent armed groups that often force cultivators to grow coca instead of other crops (Estancona, 2021; UNODC, 2021) and governments' eradication efforts can result in instant loss of the entire harvest.[8] However, coca forms a reliable and highly profitable source of income. It is an easy, and often the most lucrative crop to grow since the market for coca products is almost guaranteed (Ibáñez, 2010; Mansfield, 1999; Thoumi, 2002).[9] As a consequence, about 125.000 to 170.000 households are involved in the production of coca leaves, base and paste (UNODC, 2019).

[6] AUC obtained about 70% of its funding from drug activities, and 30% from voluntary contributions from landowners (Saab & Taylor, 2009).

[7] Even though the BACRIM receive significantly less support than the AUC, there is evidence that there is some cooperation between local political, judicial and military institutions (Hristov, 2009).

[8] The chemicals used for eradication can affect coca as well as other crops and render land unusable for years. Additionally, the chemicals used present significant health risks (Veilette & Arvelo-Velez, 2003).

[9] According to Ibáñez (2010) coca crops are three to five times more lucrative than other licit crops. Moreover, Ibáñez (2010) presents evidence that coca is often cultivated due to not being able to make a living from legal crops.

2.2 The changing coca market

The coca market in Colombia has changed significantly over the past years. Two main trends can be distinguished. First, the large cartels and armed groups are being replaced by smaller organizations (the aforementioned BACRIM) vying for control over the coca market (UNODC & Europol, 2021). The second trend is that the main destination markets for Colombian cocaine - the United States and Europe - are growing, increasing the potential profits to be made from producing, trafficking and selling coca for some of the agents involved (UNODC & Europol, 2021). These two shifts have significantly affected both armed groups and cultivators.

The first change was set on by the gradual breakdown of the large cartels, after which the paramilitaries and guerillas took over drug trafficking (Flores & Vargas, 2018).[10] This was followed by the disbandment of the AUC in 2006, and the peace negotiations and eventual demobilization of FARC in 2017. Especially the disbandment of AUC had a large impact on the Colombian coca market. Prior to its disbandment, AUC was involved in every part of the production process within Colombia, and trafficked cocaine to international markets. According to some estimates, the AUC controlled about 40% of the cocaine exports from Colombia (Saab & Taylor, 2009).

Along with the gradual disappearance of the cartels and the AUC in Colombia, the monopoly positions of these international trafficking organizations (such as the Italian *'Ndrangheta*) in their respective markets deteriorated (UNODC & Europol, 2021). This made it possible for other (new) international organizations to enter the market. Brokers in Latin America started playing an increasingly important role in supplying these international traffickers with bulk quantities of HCI, which they obtained from Colombian groups. The increasingly fragmented market and presence of brokers caused the bargaining power of guerillas and paramilitaries involved in the coca sector to deteriorate, turning the latter into price takers (Millán-Quijano, 2020; UNODC & Europol, 2021). Especially the BACRIM faced a competitive environment in which they had less bargaining power: in many areas where the AUC was initially present "two or more emerging criminal bands with no obvious relationship and often exhibiting an environment of mutual tensions and retaliations would occupy the vacated space" (Saab & Taylor, 2009, p. 463). On average, guerilla groups were less involved in all the aspects of coca production. Their focus was primarily on the taxation of coca products and regulation of the sale of coca products to cartels and criminal organizations in their territory (Vargas, 2011), and therefore already had a working relationship with various criminal organizations and brokers. This implies that guerilla groups and their activities were somewhat less affected by the changing landscape then the paramilitaries.

The loss of bargaining power lowered profits for these groups, causing them to compete over areas where coca is produced to secure access to the resource. Aside from access to coca, territorial

[10] Such as the Medellin and Cali cartel in the '90s, and eventually the Norte del Valle cartel around 2008.

control is of fundamental importance as it also guarantees trafficking routes, a social base – in terms of a local labor force and farmers to buy products from – and income from taxation (Díaz & Sánchez, 2004).

The recent changes in the coca market exacerbated the uncertainty faced by those cultivating coca. One of the ways the recent trends have affected cultivators is through the prices they receive for their coca products. Coca prices are affected by other factors than (the usual) supply and demand dynamics, and are often set by buyers in an area (International Crisis Group, 2021; UNODC, 2017).[11] As the weaker party, cultivators have little to no bargaining power and have to accept a price offer – trying to sell coca products to another group is dangerous and can lead to retribution. As armed groups find it increasingly difficult to finance themselves through coca due to the loss of bargaining power, they raise taxes or extract more resources from farmers and cultivators, for example by decreasing the prices paid for products. Additionally, groups might use violent means to pressure farmers to increase coca production or prohibit them from cultivating other crops (Estancona, 2021; International Crisis Group, 2021; UNODC, 2018).
Moreover, the larger number of armed groups vying for territorial control exposes cultivators to changing buyers and different prices for coca products, causing uncertainty with respect to the income from coca for cultivators. The uncertainty and risk is illustrated by a situation recorded by the UNODC (2017): a drop in market activity due to a sudden absence of buyers in a local market lead to an oversupply of leaf, base and paste and a negative income shock for cultivators. The markets started working again only when new buyers appeared.

3 Conceptual framework

Common frameworks in the conflict literature consider price shifts to affect violence through the opportunity cost and rapacity channel. This is based on the notion of civilians joining the rebels when the opportunity arises and rebels as 'roving bandits'. On the other hand, rebels can act as long-term, stationary agents (or 'stationary bandits') who make choices to maintain access to resources present in the territory under their control in order to survive as a group (Estancona, 2021; Olson, 1993; Sánchez De La Sierra, 2020). Combining the above, this section describes a conceptual framework that addresses the intrinsicalities of the coca market, economic incentives of agents, and the connection to violence.

[11] For example, FARC was known to set a fixed price for coca products that was guaranteed to cover the basic costs incurred for farmers (Cook, 2011). Paramilitaries, however, maximize profits, and wages in areas where paramilitaries are in control are lower than in areas controlled by guerillas (Felbab-Brown, 2005).

3.1 Roving and stationary rebels, guerillas and paramilitaries: the opportunity cost and rapacity effect

Following the work of Becker (1968) as described in Dube and Vargas (2013) and Wright (2016), agents are considered to choose employment in the agricultural or criminal sector, depending on where the expected returns are the highest. Employment in the agricultural sector focuses on the production of a good or resource, and the criminal sector on extracting value through (illegal) taxation, appropriation, rent-seeking and theft (Grossman, 1999). In this setting, goods and resources can lead to violence and conflict through two channels: the opportunity cost or rapacity channel. First, a relative increase in expected returns to employment in the agricultural sector would draw labor from the criminal sector into the agricultural sector, reducing violence. This is the opportunity cost effect (Angrist & Kugler, 2008; Collier & Hoeffler, 2005; Dube & Vargas, 2013). Vice versa, a positive shock to the expected returns to the criminal sector would draw labor from the agricultural sector into the criminal sector, leading to an increase in violence. This is the rapacity effect (Collier & Hoeffler, 2005; Hirshleifer, 1989).

This framework is applied to the coca market in Colombia, as to understand the relationship between returns to cultivating coca and producing leaves, base and paste (the agricultural sector), the returns to being a member of a guerilla or paramilitary group that finances itself through trafficking and producing coca HCI (the criminal sector), and violence.[12] The expected returns to being employed in the agricultural sector are presented by the income from cultivating coca and selling coca products (leaf, base and paste). An increase in the expected returns to cultivating coca has the potential to draw labor out of the criminal sector, i.e., members of armed groups might forego criminal activities to work in the agricultural sector, reducing violence.

The presence of this opportunity cost effect will be estimated empirically by using a proxy for returns to being active in the agricultural sector. Moreover, as there is evidence that positive income shocks can affect the number of hours worked and employment rates (Angrist & Kugler, 2008), or educational outcomes such as education level and school attendance (International Crisis Group, 2021; Sanín, 2019; Sviatschi, 2018), the relationship between shifts in coca income and these outcomes will be investigated.

The returns to employment in the criminal sector are captured by the value that can be obtained through appropriation and rent-seeking, and will be referred to as the OP. An increase in the relative value of the OP with respect to the income from coca cultivation can cause the rapacity effect. One way in which this can occur is through a negative income shock for those employed in the agricultural sector. Facing such a shock, these agents can choose to increase coca production,

[12] Cultivating coca is illegal and can be considered 'criminal' activity. However, for simplicity and in line with the literature, this study refers to engagement in the cultivation of coca as being employed in the agricultural sector, and involvement with guerillas or paramilitaries as being involved in the criminal sector.

cultivate other crops, or – especially day-laborers, being more flexible and not tied down by farm-ownership – potentially find employment in the criminal sector.[13,14,15] The flow of labor from the agricultural sector into the criminal sector could lead to an increase in violence. Additionally, an increase in the OP can also motivate those already employed in the criminal sector to act as roving bandits (Olson, 1993). These rebels may attempt to expand their territory in order to gain access to the OP. Heightened competition might increase violence: violence is linked to armed groups vying for territory and access to resources (UNODC & Europol, 2021) as well as instilling fear in the local population after having taken over control (Díaz & Sánchez, 2004; International Crisis Group, 2021).

Stationary rebels secure long-term access to coca by establishing a permanent presence in areas and creating partnerships with local coca cultivators (Estancona, 2021). They engage in rebel governance (Arjona et al., 2015; Kalyvas, 2006; Mampilly, 2012), providing security and stability to cultivators, who supply the rebels with coca in return. As stationary rebels, guerillas and paramilitaries are concerned with maintaining access to the resources under their control in order to extract rents, and aim to prevent the opposing group from obtaining access to that resource. When the value of coca decreases, a group might no longer be able to pay pre-determined prices to the cultivators in its area, forcing them to resort to violence: "rebels may employ selective violence —lethal or nonlethal— against suppliers during temporal windows in which more costly tactics to prompt continued cooperation become too expensive" (Estancona, 2021, p. 1113).[16] An increase in the OP – aside from making it more attractive to act as a roving bandit – can cause groups to use violence to discourage cultivators from selling coca to a competing group that might promise higher prices. According to Estancona (2021), guerilla groups are most likely to use violence to ensure continued production of the resource in response to a price decrease; paramilitaries use violence to discourage cultivators from selling coca to guerillas, when the latter try to encroach on an area under paramilitary control in response to a price increase.[17]

[13]Employment in either sector is not mutually exclusive - it is possible that cultivators divide their efforts between the agricultural and criminal sector.

[14]The link between coca production and gold mining is discussed in Rettberg and Ortiz-Riomalo (2016) As it is a feasible option in regions where gold is present, the empirical analysis will account for this: see section 5.

[15]Militias are known to pay wages to their members (Angrist & Kugler, 2008). This has also recently been reported by the International Crisis Group (2021). However, whereas there is very little to no opportunity for personal enrichment in the guerillas and the groups require life-long commitments from its members, the paramilitaries rely on contracts – and members can technically resign, though reality seems to be more complicated – and pay wages and allow for personal enrichment. This implies that both offer very different prospects for potential recruits (Sanín, 2008).

[16]FARC, the largest guerilla group, was known to pay fixed prices for coca products such as leaf, base and paste in the areas it controlled.

[17]It is worth noting that the type of violence a group engages in can be affected by their capacity (income). Moreover, guerillas and paramilitaries are known to traditionally engage in different types of violence due to systemic differences between the two groups as noted earlier. This is also discussed in Estancona (2021) and Wright (2016), among others. Though not at the core of this study, part of the empirical strategy will examine the type of violence groups engage in, in response to increase in the OP.

Empirically, the rapacity effect will be examined by estimating the effect of a change in a proxy that captures the OP on various measures of violence. Due to the differences between guerillas and paramilitaries, the measures include the attacks carried out by either group separately. Moreover, the presence of paramilitaries or guerillas will be accounted for in the analysis as it can affect the use of violence by either group. Finally, aside from examining competition as the number of different groups active in an area, I will consider the likelihood of a guerilla or paramilitary group entering an area due to an increase in the OP.

4 Data and sample

Data on coca cultivation and eradication is obtained from the United Nations Office on Drugs and Crime (UNODC) and SIMCI.[18] Data on coca derivative prices and production processes comes from the productivity studies from the UNODC. These productivity studies focus on three general areas: coca cultivation and general productivity trends, socio-economic characteristics of agents active in coca cultivation, and the persistence of coca cultivation. The data is collected through interviews conducted with cultivators, and harvest trials are carried out to estimate the potential coca yield. The studies provide the UNODC with insight into local price fluctuations, long-term trends of production processes, and technological developments in the coca sector.

There are a few important things to note with respect to the prices of coca products. First, production studies and reports that focus on the prices of coca products in Colombia, such as the UNODC (2013), mention that these prices "retain no logical relation to variations in supply and demand" and that "buyers can pressure the production exchange, presenting a controlled price scenario [...]. This situation forces producers to adopt the enforced condition" (p. 56). These observations support the fact that cultivators are price takers with limited to no bargaining power. Second, prices of the coca products considered in this study vary across municipalities. They depend on the ease of reaching markets, presence of buyers and the rules set by them, quality of the product, and municipal or village-level supply and demand for coca products (UNODC, 2013). The UNODC collects municipality-month level price data and reports the average monthly prices for each region. Every region contains a varying number of municipalities. In the final sample, the smallest region contains 23 and the largest region a few hundred municipalities (the average number of municipalities per region is 159). This study uses annual averages of the regional prices. The risk of prices being endogenous to municipality-level dynamics is thereby mitigated (this is discussed further in section 5.2). All prices are adjusted for inflation. Figure 1 shows the annual changes in the prices for the four different coca products considered in this study for the various

[18] This data is also commonly used in other studies focusing on coca production in Colombia, and is the source of much of the coca-related data from the Centro de Estudios sobre el Desarrollo Económico (CEDE).

Colombian regions.

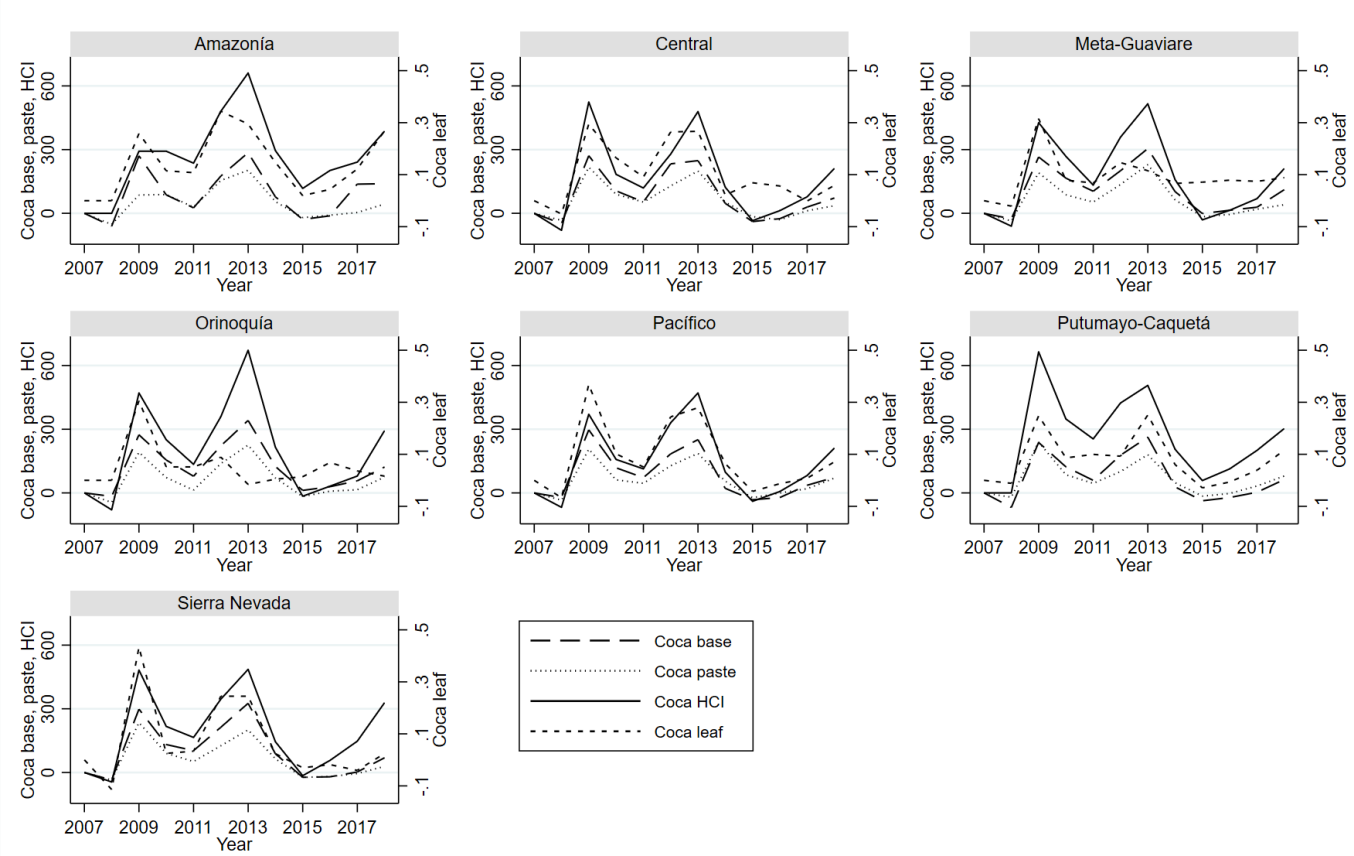

Figure 1: Prices of coca products by region and year. *Note:* Annual levels of the inflation-corrected prices of coca base, paste and HCI (left y-axis) and leaf (right y-axis) in thousands of Colombian pesos by region (as defined by the UNODC) and year. To illustrate fluctuations in the prices over time and ensure comparability across products, 2007 is taken as the base year for the price of each product.

Data on violence comes from the Global Terrorism Database (GTD) and the Centro Nacional de Memoria Histórica (CNMH). Both the GTD and CNMH are event-based data sets. The GTD (LaFree & Dugan, 2007) spans the temporal range of this study, which is not the case for all the variables included in the CNMH. Both data sets include the location, perpetrator(s), target, number of fatalities, and the type of attack. The GTD only contains acts of terrorism, and any 'regular' crime or homicide is excluded. The CNMH does include data on (mass) homicides conducted by armed groups, and this section of the data will be used to supplement the GTD data set.

The measures of violence used in this study are the number of violent events, fatalities, guerilla and paramilitary attacks.[19,20] All variables capturing violent events are measured as the number of

[19]In the time period considered there was a low frequency of paramilitary attacks, but it is considered due to its importance given the relationship between violence and coca in Colombia.

[20]Results focusing on the type of attacks (bombings, assassinations, kidnappings, attacks on infrastructure, etc.) are included in the appendix.

occurrences per 100,000 inhabitants of the municipality. This is done to account for more attacks taking place in more densely populated municipalities.
Cross-sectional data on monthly income for agricultural labor comes from the rural component of the Great Integrated Household Survey (GEIH) (DANE, 2011). The sample is restricted to include respondents that indicate that they are self-employed or work in agriculture and is averaged to municipality-year level. As not every municipality is sampled monthly, some observations are missing and the sample does not include all Colombian municipalities. This sub-sample is therefore not nationally representative and these restrictions affect the external validity of the results. However, the data is solely used to examine a potential relationship between coca production, income and education in coca-producing municipalities.
Additional data on municipality characteristics, as well as on the presence of guerillas or paramilitaries in a municipality comes from CEDE. Data on international crop prices comes from the Federal Reserve Economic Database (FRED). This data is adjusted for inflation and converted from US dollars to Colombian pesos using the annual exchange rates, in order to ensure comparability to the prices of coca products. Rainfall and temperature data is from Murray et al. (2020).

All data is combined to create a panel data set on municipality-year level spanning 2007-2018. The data set has 13,435 observations across 1119 municipalities, in 32 departments within seven regions.[21] Of these municipalities, 195 were coca-producers in 2007. These municipalities were spread across 23 departments within all regions included in the sample. An overview of the variables and their descriptive statistics can be found in table A.3.

4.1 Relationship between coca (prices) and violence

The conceptual framework suggests that a relative increase (decrease) in the returns to employment in the criminal sector can lead to an inflow (outflow) of labor into the criminal sector. An inflow of labor would increase competition, rent-seeking and appropriation in coca producing municipalities, leading to an increase in violence. Figure 2 presents a simple, straightforward visualization to examine the potential relationship between the OP and violence using the data described above. The figure shows the average value of coca HCI, an indicator of the OP value, and average number of violent events, fatalities, guerilla and paramilitary attacks per 100,000 inhabitants for coca and non-coca producing municipalities for the 2007 – 2018 time period. It is clear that those that produce coca have considerably higher levels of violent intensity than non-producers. Moreover, the spike in violent intensity for coca-producing municipalities around 2014 seems to be preceded by an increase in coca HCI. At least when considering the second part of the time period (as we do

[21] The UNODC distinguishes seven regions: Amazonia, Central-Sur de Bolivar-Catatumb, Meta-Guaviare, Orinoquia, Pacifico, Putumayo-Caqueta and Sierra Nevada.

not see such effects for the increase in HCI around 2009), it appears that the relationship between the value of the OP and violence might be present.[22] Furthermore, the decrease of the value of coca HCI – which could cause an outflow of labor from the criminal sector into the agricultural sector – seems to lead to a decrease in violence between 2014 – 2016.

This study emphasizes the importance of distinguishing the economic incentives that coca forms for different agents, and examines how these incentives affect violence in the light of the changing dynamics in the coca market. An underlying assumption of this research is that shifts in the value of coca precede changes in violence. The trends shown in figure 2 address any concerns regarding potential reverse causality, i.e., shifts in violence leading to changes in prices instead of the other way around. However, it becomes clear that paramilitary attacks are rare and seem to follow a different pattern than guerilla attacks, which make up the majority of all violent events in the time period considered. Paramilitary attacks coincide, more so than follow, the increases in the value of coca HCI. Moreover, it seems that attacks are more common in non-coca producing municipalities than coca producing municipalities: this might be related to the link between paramilitary's use of violence aimed at preventing guerillas gaining ground and coercing farmers to cultivate coca as discussed earlier.

For completion, figure 3 visually depicts the often discussed link between coca production and violence. It seems that the increase in violence (especially the large spike that started around 2011 and ended in 2014) precedes the increase in coca production rather than follows it. This is contrary to previous findings of, for example, Angrist and Kugler (2008), who, studying the upsurge in coca production in 90s', found that "areas that saw accelerated coca production subsequently became considerably more violent" (p. 191). The fact that this relationship might not be present in the period considered in this study emphasizes the need to re-examine the link between coca and violence in Colombia.

5 Empirical approach

One of the contributions of this paper is the disentanglement of the effects of a change to the returns to the agricultural and criminal sector in the coca market in Colombia, i.e., the income generated from coca for farmers and the OP for armed groups, on violence. Rich data on local prices of coca products and production processes is used to, first, create proxies for farmers' income from coca and armed groups' OP. Second, the effect of a one percent increase of farmers' income from coca and the OP of armed groups on local violent intensity is estimated, while accounting for

[22] There is evidence that the decreasing gold prices around 2015 pushed armed groups into the coca market (International Crisis Group, 2021). First, this does not seem to drive the levels of violence presented in the graph as these levels, across the board, are decreasing around 2015. However, to allow for the possibility that some violence is explained by this, the presence of gold in the municipality will be accounted for in the analysis.

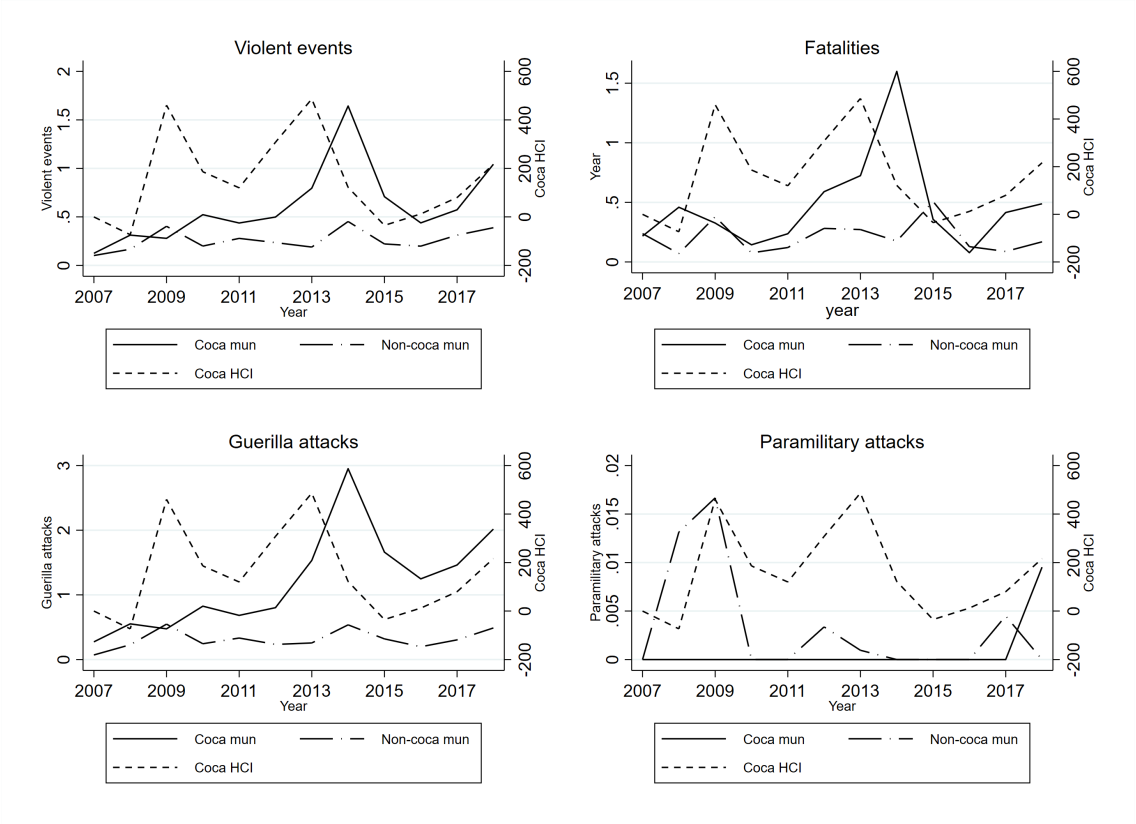

Figure 2: Violence and the price of coca HCI. *Note:* The panels show the average annual levels of violent intensity in terms of number of events, fatalities, guerilla and paramilitary attacks per 100,000 persons (left y-axis) for coca and non-coca producing municipalities. The inflation-corrected prices of coca HCI (right y-axis) in thousands of Colombian pesos with 2007 as base year as before.

the presence of guerilla and paramilitary groups. These effects are investigated further, considering the relationship between income and labor market and educational outcomes, as well as the link between the OP and local competition.

5.1 Income and objective prize

For those who cultivate coca, the price of their final product (leaves, base or paste) largely determines their income. A proxy for the income from coca is created using data on the prices of coca leaf, base and paste, weighted by the fraction of farmers that indicate that they produce each of these products.[23] Similar to Dube and Vargas (2013), this price is weighted by the relative coca production in the municipality at $t = 1$ (similar to a Bartik instrument). Doing so prevents poten-

[23]In UNODC production surveys farmers are asked whether they only produce and sell leaf, or process leaf to base or paste. The extent to which farmers process leaf varies greatly within regions. For this reason the prices are weighted by this 'prevalence of production' rate, to create a proxy for the average price that farmers receive for their products.

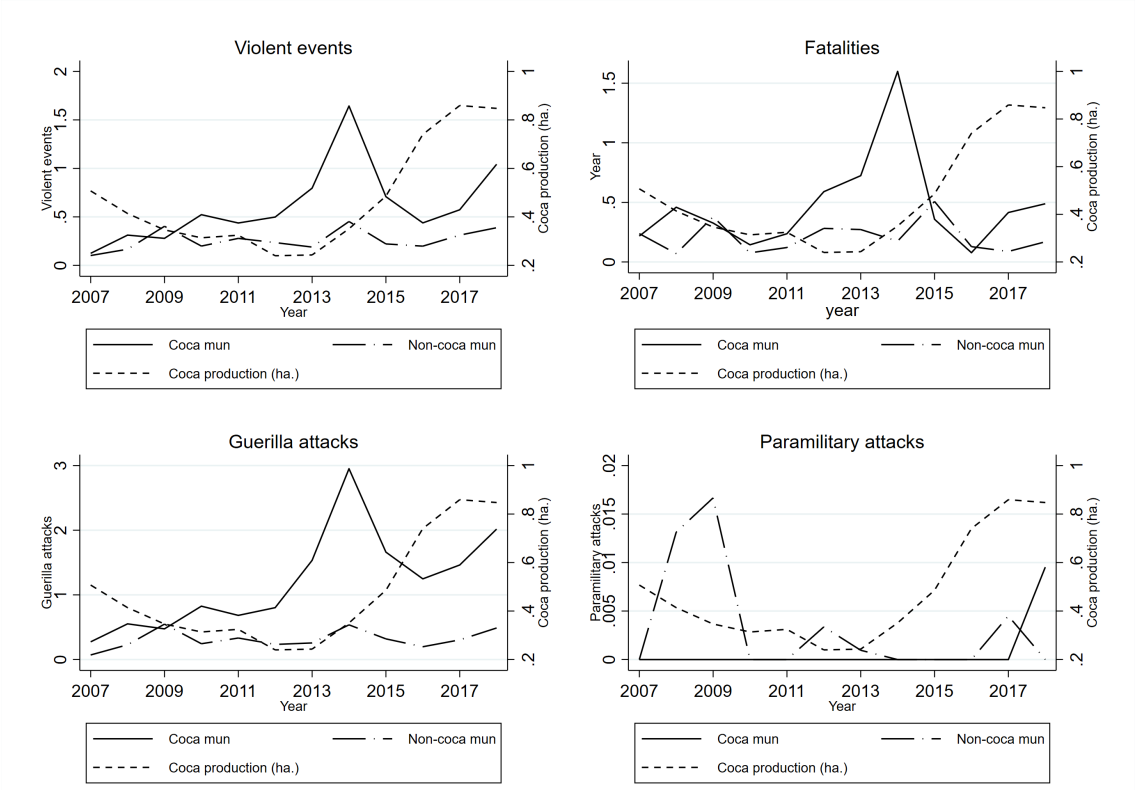

Figure 3: Violence and coca production. *Note:* The panels show the average annual levels of violent intensity in terms of number of events, fatalities, guerilla and paramilitary attacks per 100,000 persons (left y-axis) for coca and non-coca producing municipalities and the average coca production (measured in hundreds of hectares dedicated to coca cultivation) in coca producing municipalities (right y-axis).

tial adjustments of the production level in response to external factors from biasing the results. For example, there is evidence that coca production can be scaled up or down based on the needs of armed groups (Díaz & Sánchez, 2004), as well as that cultivators adjust production to coca prices – though it is noted that the price elasticity of coca cultivation is relatively small (Moreno-Sanchez et al., 2003). Possible adjustments of coca production are controlled for by using the level of coca production in 2007 (the first time period of this study, i.e., $t = 1$) in the construction of the proxy. Moreover, by weighting prices by the prevalence of coca production the relative exposure to coca, or coca intensity, on municipal level taken into account. The proxy is constructed as follows:

$$Income_{i,d,t} = coca_{i,d,t=1} * ln(\sum_{x=l,b,p} (F_{x,r,t} * P_{x,r,t})) \tag{1}$$

Where *coca* is the number of hectares, in thousands, dedicated to coca cultivation in municipality i in department d and year t. $F_{x,r,t}$ is the fraction of farmers dedicated to cultivating and producing x in region r, and $P_{x,r,t}$ is the price of x per kilo in ten thousands of COP, where x is either leaf (l),

paste (p) or base (b). In order to verify whether the proxy is significantly correlated to agricultural wages, the following equation is estimated:

$$wage_{i,d,t} = \pi_t + \rho_i + \beta Income_{i,d,t} + \theta X_{i,d,t} + \epsilon_{i,d,t} \tag{2}$$

Where $wage_{i,d,t}$ are monthly wages, averaged to municipal-year level (as described in section 4) for those living in rural areas and who indicate that they, or their household, work(s) in agriculture as a day laborer or is/are self-employed. The proxy for farmers' income from coca is captured by $Income_{i,d,t}$. $X_{i,d,t}$ includes control variables on municipal and departmental level, among which the logs of international prices of common other (agricultural) goods such as bananas, cocoa, coffee, sugar, palm kernel and gold.[24] These prices are interacted with the relative production intensity on municipal level (measured in thousands of hectares dedicated to the cultivation of the good) of each good. This is done to control for shifts in prices of other goods aside from coca, as coca is often grown by households who also cultivate other crops (Mansfield, 1999). Additional controls included are rain, temperature, and the average age, highest education completed, and the fraction of people that are employed per municipality. π_t and ρ_i capture year and municipality fixed effects, respectively. $\epsilon_{i,d,t}$ is the error term. Finally, it is likely that there are spatial spill-overs, as well as serial-correlation over time and across municipalities within a department. In order to address this all standard errors are clustered on departmental level in every analysis moving forward.
The results for the estimation of equation 2 are shown in table A.4 for the sample of coca-producing municipalities for which the GEIH data was available. Interpreting the coefficient as a deviation at the mean, a one percent increase in the proxy from coca is associated with an approximate 0.9% increase in monthly income. This supports the assumption that the proxy captures farmers' income from coca.[25]

Guerillas and paramilitary groups produce (or control the production of) coca HCI and sell this to international traffickers and resellers. For these groups, the value of coca HCI forms an OP.[26] Similar to the proxy for income from coca, the OP is measured as:

$$OP_{i,d,t} = coca_{i,d,t=1} * ln(P_{HCI,r,t}) \tag{3}$$

Where $OP_{i,d,t}$ captures the OP in municipality i, in department d, in year t. $P_{HCI,r,t}$ is the value of coca HCI in region r in year t. $coca_{i,d,t=1}$ is, as before, the production of coca in municipality i at $t = 1$ to account for the local presence and size of the coca sector.

[24] Illicit alluvial gold mining (Rettberg & Ortiz-Riomalo, 2016) is linked to coca production (UNODC, 2013) and can be a feasible alternative source of income for cultivators in certain areas.

[25] As there are only 16 clusters in the sub-sample, the robustness of the results is tested by using the wild bootstrap method proposed by Cameron et al. (2008). The results presented are robust to this specification.

[26] The value of HCI is also used by the UNODC (2018) as a variable that captures the value of coca for producers.

The average fluctuations of the income from coca and the OP for coca producing municipalities, together with the four measures of violence for the average coca and non-coca producing municipalities, are illustrated in figure 4. Though the figure shows relatively similar trends for income and OP there are various shocks or determinants that affect one proxy but not the other, and vice versa.[27] *For example, the value of the product being sold by cultivators is susceptible to a large variety of shocks, many of which are related to the production process. The type of leaf harvested, shifts in the price of gasoline and other ingredients required to process coca leafs into base or paste affect the production costs incurred by cultivators. Rainfall affects accessibility of markets and whether buyers can reach the farm (UNODC, 2011). Moreover, government interference – such as the eradication of coca fields – can destroy the harvest and lead to farmers suffering a significant drop in income (Thoumi, 2002). Finally, armed groups have the option to suppress wages in order to increase revenue in response to, or independently of, shifts in the OP.*[28] *For example, as noted in section 2, guerillas can pay higher wages to cultivators when the OP increases in value but also in situations where competing groups encroach on their territory. This emphasizes the importance of accounting for the correlation between the two proxies when estimating the effect of each on violence. This is discussed in section 5.2 below.*[29]

These sources of variance in both proxies cause the average annual changes and the largest in- and decreases in both proxies to differ considerably. For the average coca producing municipality, with 396 hectares dedicated to coca cultivation, the income from coca that cultivators received increased with 2.4% and the OP with 3.81%. Across the entire time period (2007 - 2018), taking all fluctuations into account, the proxies increased with 8.9% and 12.2%, respectively. I will return to this in order to interpret the results.

5.2 Baseline model

Having established proxies for the income from coca and the OP, we can estimate the effect of both measures on the intensity of violence in a municipality.

$$violence_{i,d,t} = \lambda_t + \phi_i + \delta Income_{i,d,t-1} + \psi OP_{i,d,t-1} + \theta Z_{i,d,t} + \epsilon_{i,d,t} \tag{4}$$

[27] Note that the similarity of the trends in the figure is also largely due to averaging of the proxies across all municipalities.

[28] Farmers can be pressured by local groups to sell their products for a lower value while the price of coca chlorhydate (HCI) - armed groups' OP - remains constant (UNODC, 2018)

[29] The fact that income can change but the OP can stay constant can also partially be explained by the fact that bargaining power shifted to international resellers. Additionally, shocks that affect the OP but not necessarily the income for cultivators stem from activities of other guerilla or paramilitary groups - that for example expand their territory in order to achieve a stronger bargaining position - or changes in demand for cocaine in foreign markets.

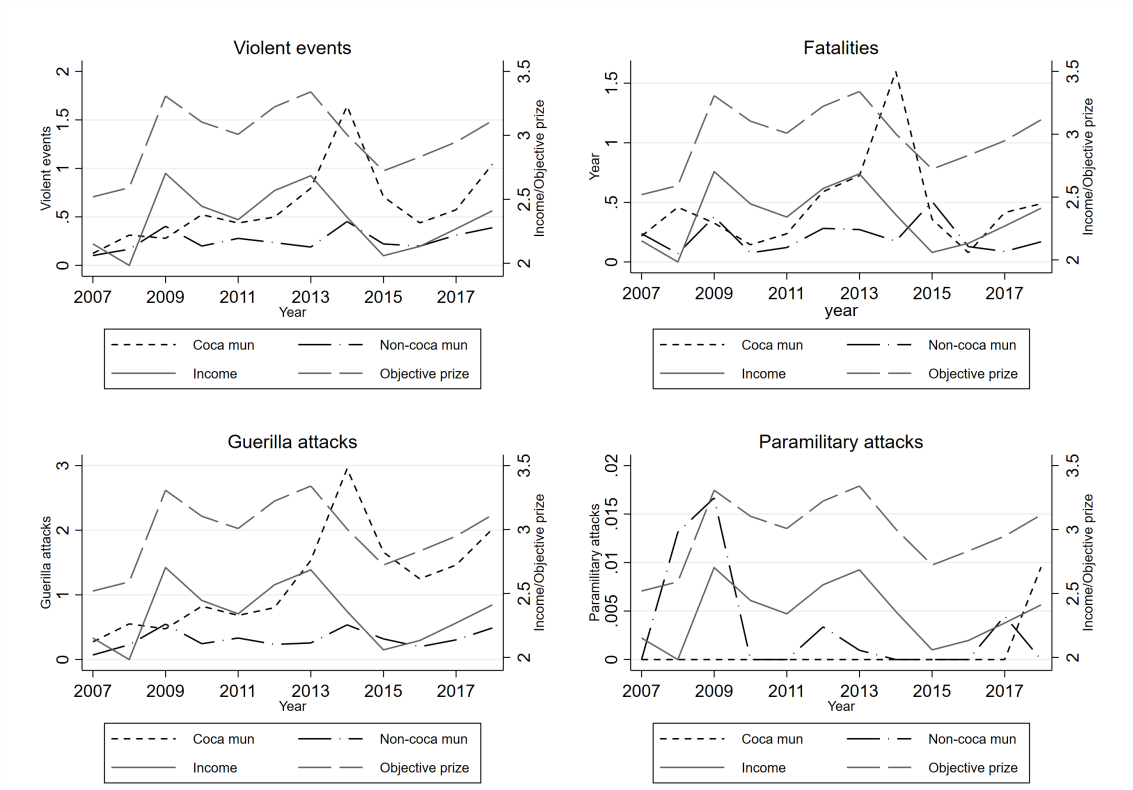

Figure 4: Income, OP and violence. *Note:* The panels show the average annual levels of violent intensity in terms of number of events, fatalities, guerilla and paramilitary attacks per 100,000 persons (left y-axis) for both coca and non-coca producing municipalities, as well as the average annual income and OP proxies (right y-axis).

Where $violence_{i,d,t}$ captures the number of fatalities, violent events, guerilla or paramilitary attacks per 100,000 inhabitants of municipality i in department d and year t.[30,31]

The potential presence of endogeneity in this model is addressed in various ways. First, lagged values of both proxies are used as controls: $Income_{i,d,t-1}$ is the lagged value of the proxy for income from coca for cultivators, and $OP_{i,d,t-1}$ the lagged value of the OP for armed groups. Second, the original municipality-month level data on coca product prices and production technology underlying the proxies has been averaged to region-year level as discussed in section 4. By using these averaged prices, it is unlikely that the local municipal circumstances affect prices or technology the data on the level used in this study.[32] *Third, the correlation between the two proxies is accounted for in the analysis by treating both proxies as independent variables and simultaneously estimating their effects on violence. This allows for estimating the effect of one proxy on violence while controlling*

[30]The results are robust for specification of violence in levels: see table A.13.

[31]The analysis focusing on alternative measures of violence capturing the type of attack – assassinations, assaults, mass homicides, kidnappings, bombings, attacks on infrastructure – can be found in table A.12.

[32]In a way this is similar to Dube and Vargas (2013), who use international prices for coffee and oil while ensuring that Colombia's internal price does not affect these international prices.

for the effect that the variance of the other proxy has on the outcome variable: i.e. examining the effect of shifts in income for cultivators on violence given the effects of shifts in the OP on violence (and vice versa). This addresses, for example, scenarios in which lower values of the OP would lead to armed groups suppressing wages for cultivators. Combined, these measures – as well as additional measures discussed below – ensure that endogeneity concerns are mitigated.

Many drivers of coca-related violence are also determinants of prices of coca products. $Z_{i,d,t}$ captures control variables on municipal and departmental level that are measures of these drivers. First, local government intervention in the coca sector, affecting both prices and violence, is addressed by including time-varying, municipality level controls for the number of hectares (in thousands) of coca fields that are eradicated (both manually and through aerial eradication), the number of coca processing laboratories that were dismantled or destroyed, as well as growth rates capturing changes in the levels of the kilos (in thousands) of coca leaf, base, paste and HCI that have been confiscated. Controlling for such types of government interference in the coca sector also captures whether government forces are active in a municipality, and potential violence or conflict stemming from this presence. Moreover, though the analysis will focus on the first lag of each proxy, additional lags of the proxies are included as controls. The final number of lags (four in total) included in the model is chosen based on the Bayesian Information Criterion (BIC), in order to select the model that presented the best fit. The leading principle was to include sufficient lags to address endogeneity and autocorrelation concerns while ensuring to not over-fit the model. In addition, changes to the presence of guerilla or paramilitary groups – especially when a guerilla group enters paramilitary territory or vice versa, as discussed in section 3 – can lead to heightened levels of violence, lower prices for farmers' products, or an increase in coca production through competition. Following Estancona (2021), this is controlled for by including time-varying variables that capture the presence of paramilitary or guerilla groups in the municipality at $t-1$, when examining the effect of changes in income or the OP on paramilitary or guerilla attacks.[33]

Furthermore, $Z_{i,d,t}$ includes linear time trends for municipalities that produce coca, gold and coffee. The latter two are included to account for outside options of coca cultivators to change to another sector, as well as potential alternative sources of financing for armed groups (both coffee production and (illicit alluvial) gold mining are associated with conflict (Dube & Vargas, 2013; International Crisis Group, 2021). Finally, rain and temperature are included as important measures of potential production levels as well as determinants of conflict. Year (λ_t) and municipality (ϕ_i) fixed effects are included to capture any additional (un)-observed time-invariant variables. $\epsilon_{i,d,t}$ is the error term. The coefficients of interest are δ and ψ. δ captures the differential effect of the income from coca for farmers, cultivators and agricultural households on violence in municipalities that

[33]Following Estancona (2021), the presence of a guerilla group is controlled for when considering paramilitary activity and vice versa.

cultivate relatively more coca. Similarly, ψ captures the differential effect of the OP for guerillas and paramilitaries violence in municipalities that cultivate relatively more coca.

By specifying the baseline model as above, I allow for continuous variation in both independent variables of interest ($Income_{i,d,t-1}$ and $OP_{i,d,t-1}$). Hence the identification strategy relies on variation between the coca-producing municipalities stemming from the proxies. The inclusion of non-coca producing municipalities in the sample contributes to the estimation of the year fixed-effects and the control variables, capturing non-coca related factors that potentially affect violence. However, the estimation can be conducted without the inclusion of these non-coca producing municipalities. To address concerns that the inclusion of the non-coca producing municipalities drives the results, these municipalities are excluded from the sample in a robustness analysis – see section 6.3. Additional tests are carried out to verify the results. First, the lagged value of each dependent variable (violent events, fatalities, paramilitary or guerilla attacks) is added as a control, following an Arellano and Bond (1991) framework. Secondly, department-level linear trends, to capture potential time-varying social or political trends, are included. The latter two are also combined in one analysis. The results are robust to these specifications.

5.3 Opportunity cost and rapacity channel

If the results show that an increase in income from coca leads to lower levels of violence, the conceptual framework posits that this might be due to the opportunity cost effect. The opportunity cost effect suggest that an increase in potential returns to cultivating coca leads to an increase in employment in the agricultural sector. This can imply, first, an increase in the number of hours worked by those active in the sector in order to reap the higher returns (Angrist & Kugler, 2008). I examine this by regressing the income proxy on the number of hours worked per week.
Second, the income from coca cultivation is frequently cited as the reason that parents can afford to send their children to school (International Crisis Group, 2021), with one national survey finding that more than half of the families involved in coca cultivation invested their profits mainly in education (Sanín, 2019). However, Sviatschi (2018) shows that an increase in coca prices leads to higher levels of child labor in areas suitable for coca cultivation, as well as children (especially of secondary school age) dropping out of school to help their family. This implies that the effect of increased income from coca cultivation on education can go both ways. Moreover, there is anecdotal evidence that an increase in the potential returns to joining an armed group have been associated with children dropping out of school (Bjørkhaug, 2010).[34] This suggests that an increase in the OP does potentially not only draw labor out of the agricultural sector, but can also entice children to

[34]In the same vein, Vargas and Restrepo-Jaramillo (2016) show that lack of access to education contributes to child recruitment.

drop out of school. These potential effects are examined by regressing the income and OP proxies on school attendance rates and average educational attainment. Importantly, since the feasibility of joining a paramilitary and guerilla group differs starkly as discussed earlier, the analysis includes controls capturing the presence of either or both groups.
Third, one of the main predictions of the conceptual framework is that an increase in the OP causes an increase in violence through higher levels of competition among armed groups. The baseline analysis accounts for the presence of guerilla or paramilitary group in the municipality as this by itself can strongly affect the levels of violence. However, additionally, the extent to which a shift in the OP affects changes in the number of individual groups active in the area is examined.[35] This measure is referred to as competition, and differs from the measure for the presence of a guerilla and/or paramilitary group in the municipality that is included as a control in $Z_{i,d,t,}$.

I examine these outcomes and present a more detailed picture of the effects that changes in income and the OP have, and through what channels the opportunity cost and rapacity effect work.

$$Y_{i,d,t} = \lambda_t + \phi_i + \beta Income_{i,d,t-1} + \psi OP_{i,d,t-1} + \theta Z_{i,d,t} + \epsilon_{i,d,t} \tag{5}$$

Where $Y_{i,d,t}$ is either the municipal average of the number of hours worked per week, school attendance rates, or the highest education achieved for those living in rural areas and that indicate that they, or their household, work(s) in agriculture as a day laborer or is/are self-employed. When considering the rapacity channel, $Y_{i,d,t}$ captures the level of competition in the municipality, and the presence (entry) of a paramilitary or guerilla group. All other variables are as before. However, in the case that labor market or educational outcomes are considered, gender and age are included as additional controls.

6 Results

6.1 Baseline model

Table 1 shows the results of the baseline model 4. The coefficients capture the effect on violence in response to a one percentage point increase in income and OP for the average coca producing municipality with 396 hectares of coca. The results show a negative, significant differential effect from an increase in the coca income for cultivators on violent intensity. This suggests the presence of the opportunity cost effect. Additionally, there is a positive, significant differential effect from an increase in the OP on violent intensity, which suggests that the rapacity effect is present.
Interpreting the results as elasticities and the coefficients as deviations from the mean, the results

[35] Measured as the number of different perpetrators responsible for at least one violent event per year in a municipality.

imply that a one percent increase in income from cultivating coca results in 1.9% fewer total violent events, 1.8% fewer fatalities and 1.3% fewer guerilla attacks per 100,000 inhabitants for the average coca-producing municipality. Similarly, a one percent increase in the OP leads to 2.1% more events, 1.9% more fatalities and 1.2% more guerilla attacks.

Across the time period considered, the average coca producing municipality witnessed an annual increase in the proxy for coca income of 2.4% and an average annual increase in the OP of 3.81%. This implies that the average increase in income from coca for cultivators – or returns to employment in the agricultural sector – is associated with 4.6% fewer violent events, 4.3% fewer fatalities and 3.1% fewer guerilla attacks. Similarly, the average annual OP increase is associated with 7.6% more violent events, 7.2% more fatalities and 4.6% more guerilla attacks.[36]

Table 1: Income, OP and violence

	Total events	**Fatalities**	**Guerilla attacks**	**Paramilitary attacks**
Income_{t-1}	-1.303***	-0.869**	-1.722**	-0.029
	(0.368)	(0.405)	(0.681)	(0.023)
OP_{t-1}	1.345***	0.915**	1.518**	0.023
	(0.416)	(0.356)	(0.594)	(0.022)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
N	8857	8857	8857	8857
Cluster	32	32	32	32

Note: The table shows the results for estimation 4. Dependent variables capture violent intensity on municipal level, measured as number of events, fatalities, guerilla or paramilitary attacks per 100,000 inhabitants. The full results, including controls, are shown in table A.6. The results for the dependent variables measured in levels are presented in table A.13. Standard errors, clustered by department, in parentheses. *p<0.1; **p<0.05; ***p<0.01.

The results for the different types of attacks are shown in table A.12. Interestingly, an increase in the income from coca seems to lead to an increase in the number of assassinations, while an increase in the OP is associated with a decrease in assassinations. Paramilitaries are known to carry out more assasinations than guerillas: this result might be related to the argument of Estancona (2021), who notes that increases in farmers' coca prices can result in paramilitaries using coercive (violent) means to prevent cultivators from growing coca for guerillas. The number of bombings per 100,000 inhabitants is positively affected by an increase in the OP, and negatively by the increase in income.

[36]The average coca producing municipality witnessed, across the entire time period studied (2007 - 2018) witnessed, an increase of 8.9% in the income from cultivating coca and an increase of 12.2% of the OP. This increase in income is associated with 16.9% fewer violent events, 16.02% fewer fatalities and 11.57% less guerilla attacks. Similarly, the increase in the OP is associated with 25.62% more events, 23.18% more fatalities, and 27.82% more guerilla attacks. The average increases in income and the OP across the entire time period, broken down by region, are shown in table A.11.

6.2 Opportunity cost and rapacity channel

Having found evidence that supports the presence of the opportunity cost and rapacity effect, the effects of changes in income and the OP on additional outcomes are considered. Labor market and educational outcomes, as well as competition among armed groups on a local level are examined following equation 5. The results are presented in table 2. Column one, two and three show the results for labor market and educational outcomes.
First, considering the effect of an increase in income from cultivating coca, there do not seem to be (significant) effects on either the number of hours worked or level of education achieved. However, an increase in income from coca cultivation does seem to be associated with higher municipal school attendance rates. Considering that the average coca producing municipality witnessed an annual increase in the proxy for coca income of 2.4%, this corresponds to a 3.1% increase in school attendance the year following the increase. In response to an increase in the OP, school attendance decreases: the average annual 3.81% increase in the returns to the criminal sector leads to a 5.3% decrease in municipal school attendance the following year. These findings are in line with literature that cites that income from coca in rural areas is frequently invested in education of children. However, the results also support the evidence presented by Bjørkhaug (2010): when the potential returns to joining a militia are relatively high, it can be attractive - especially for young males - to drop out of school and join an armed group. By having separated the effects from an increase in income and an increase in the OP, the results present the magnitudes of each effect individually and confirm both the positive and negative impact of coca on education.

The conceptual model explained the relationship between competition and violence through the rapacity channel. Agents, active in the criminal sector, compete for control over the market as 'roving bandits' (Olson, 1993). The role of competition with respect to a change in income or OP is examined by estimating equation 5, and the result is presented in column four of table 2.
The level of competition in a municipality seems to decrease in response to an increase in the returns from employment in the agricultural sector: controlling for the presence of guerilla and paramilitary groups, a coca producing municipality witnesses a decrease in the number of armed groups active in an area. However, this effect is quite small when considered as a deviation from the mean – the 2.4% average annual increase in income is associated with a 1.8% decrease in local competition. The average OP increase of 3.81% is associated with an increase in local competition of approximately 3.3%. However, there is evidence that an increase in the OP leads to guerilla groups expanding their territory – most likely driving the increase in competition. Interestingly, the coefficient for an increase in the income of coca for cultivators is negative. This can be due to reverse causality, with guerillas being less likely to enter or be present in an area where income from cultivation is higher on average. These higher prices might make it less feasible for guerillas

to finance themselves through coca.

Table 2: Opportunity cost and rapacity effect

	Hours worked	**Highest level of education**	**Attending school**	**Local competition**	**Guerilla presence**	**Paramilitary presence**
Income_{t-1}	-2.200	-0.126	0.013*	-0.160**	-0.159***	-0.014
	(2.944)	(0.185)	(0.006)	(0.073)	(0.050)	(0.012)
OP_{t-1}	0.463	0.107	-0.014*	0.183**	0.185***	0.011
	(2.835)	(0.196)	(0.007)	(0.068)	(0.040)	(0.011)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes
N	3437	3437	3437	8857	8857	8857
Clusters	24	24	24	32	32	32

Note: The table contains the results for estimation of equation 5. The full results, including controls, are shown in table A.14. Standard errors, clustered by department, in parentheses. *p<0.1; **p<0.05; ***p<0.01.

6.3 Robustness and comparison of magnitudes

The results are tested for robustness. First, all non-coca producing municipalities are excluded from the sample. The results of this estimation are shown in table A.7. The results are very comparable to those of the baseline estimation. Second, values of each dependent variable are included, as an additional measure for addressing endogeneity in dynamic panel data (Arellano & Bond, 1991). The results, shown in table A.8, are robust to this specification. Third, though the baseline analysis includes time-variant linear trends for coca producing municipalities, a time-variant department level linear trend is included to control for potential departmental level trends (see table A.9). Finally, both the lagged values and department-level trends are included simultaneously (table A.10).

I compare the results from this study to similar estimates and results in the literature. Most importantly, Dube and Vargas (2013) report similar effects on violence when considering a change in prices of a labor-intensive agricultural good (coffee) in Colombia. The sizes of the estimates of the two studies are similar. For example, Dube and Vargas (2013) find that a one percent increase in coffee price – for the average coffee producing municipality – results in 0.611 fewer guerilla attacks, while I find that a one percent increase in income from cultivating coca results in 0.77 fewer attacks.[37]

[37]Interestingly, the authors find an effect of the coffee price shock on paramilitary attacks whereas this study does not. Importantly, the time period considered by Dube and Vargas (2013) is 1988 - 2004. This time period was significantly more violent, and differs fundamentally from the period considered in this study (with one of the main differences with respect to paramilitary activity is that AUC was not disbanded in the time frame studied by Dube and Vargas (2013)). Finally, the fact that violence seems higher in this study, focusing on coca, versus the work of Dube and Vargas (2013) is most likely due to the fact that coca has a more violent history than coffee. Moreover, the scenario with respect to the prices is quite different: whereas Dube and Vargas (2013) study one extremely large, sudden drop in prices, this paper focuses on a time period that is not characterized by such large and unexpected price shifts.

Moreover, the evidence shown in this study supports various findings with respect to the activity and behavior of guerilla groups. For example, this study supports the results of Estancona (2021), who presents evidence of an increase in the number of guerilla attacks in response to a positive price shock of coca. Similarly, the results suggest that guerilla presence has a positive effect on violent events (shown in column one and three to six of table A.12), which is in line with earlier findings of Angrist and Kugler (2008). However, whereas Estancona (2021) uses a variable capturing shocks in the street price of cocaine in the United States, and Angrist and Kugler (2008) rely on the size of the municipality-level coca production, the measures used in this study are more fine-grained. I use local-level proxies that incorporate the local intensity of coca production to account for the prevalence of the crop, technology, and – most importantly – distinguish between the prices that cultivators and armed groups are exposed to, thereby providing more nuanced results. Using these measures, I explicitly estimate the impact of an increase in the OP on the likelihood of the presence of a guerilla group. By doing so I support the assumption of Estancona (2021) that guerilla groups expand their territory in response to a positive price shock. Finally, Angrist and Kugler (2008) note that an increase in the coca price can lead to increases in (agricultural) wages. This study presents quantitative evidence to support the link between the price of coca and agricultural wages using the novel price data which was not available for the time period studied by Angrist and Kugler (2008).

7 Concluding remarks

Coca cultivation in Colombia tripled between 2013 and 2017, reaching an all-time high, and violence escalated (International Crisis Group, 2021). It is a difficult matter: on the one hand, coca is a very lucrative crop and stable source of income in a country with a large rural agricultural sector, where approximately 36% of people live in poverty (Worldbank, 2018). Simultaneously, coca is an important source of financing and a good worth competing for among armed groups, who are involved in a conflict considered responsible for at least 260,000 deaths (Reuters, 2020). The complexity emphasizes the need for a deep understanding of the economic incentives for agents involved in the sector, and how these incentives affect their choices and behavior. This is illustrated by the extent to which many policies aimed at decreasing cultivators' reliance on coca are based on economic incentives, such as subsidy or crop substitution programs. This study contributes to the understanding of the conflict by identifying incentives, disentangling the separate effects, examining the impact on labor market and educational outcomes, and (violent) competition among and behavior of the various armed groups involved in the conflict.

This paper focuses on 2007 – 2018, a time period during which the Colombian coca sector changed fundamentally. First, the large cartels were replaced by an increasing number of smaller

criminal groups vying for control over the coca market. The second trend is that the main destination markets for Colombian cocaine - the United States and Europe - are growing, increasing the potential profits to be made from producing, trafficking and selling coca for some of the agents involved (UNODC & Europol, 2021). These two trends have significantly affected armed groups and cultivators. The first are confronted with less bargaining power and higher levels of competition; for the latter these changes have significantly impacted their livelihood, safety and security. The changing market structure and shifting roles of agents in the Colombian coca market emphasize the need for understanding agents' behavior and how they respond to (economic) incentives.

This study aims to shed light on how these recent changes have impacted the link between coca and violence. It examines the effect of changes in the returns to being active in the agricultural sector and in the criminal sector on violent intensity in Colombian municipalities. This is done by developing a proxy for the income from coca for those employed in the agricultural sector and a proxy for the OP, presenting the returns to being employed in the criminal sector. By constructing separate measures, the paper identifies and disentangles the (contradicting) effects of changes to the value of coca on violent intensity.

The results indicate that, with respect to cultivators and farmers active in the agricultural sector, increases in the income from coca result in lower levels of violence (the opportunity cost effect). Moreover, there is evidence that increasing income can lead to higher school attendance rates, supporting previous findings that a share of the proceeds of coca is invested in education. There is suggestive evidence that a relatively higher – compared to the OP – income from cultivation might entice members of armed groups to seek employment in the agricultural sector, as well as reduce the pressure on groups to compete for territory and financial gain. Furthermore, the results indicate the presence of the rapacity effect: an increase in the OP is associated with an increase in the intensity of violence. This increase in the potential return from joining an armed group might entice children or young adults to drop out of school, lowering school attendance rates. Finally, armed groups – especially guerillas – tend to gravitate towards areas where the expected returns are higher: the increasing value of the OP leads to higher levels of local competition.

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A Appendix

Table A.3: Descriptive statistics

Variable	Level	Mean	SD	Min.	Max.	Source
Total events	Municipality	0.324	2.450	0	75.429	GTD
Fatalities	Municipality	0.254	3.765	0	279.005	GTD
Guerilla attacks	Municipality	0.469	2.793	0	75.429	GTD
Paramilitary attacks	Municipality	0.003	0.146	0	14.618	GTD
Assassinations	Municipality	0.017	0.550	0	48.567	GTD
Bombings	Municipality	0.234	1.792	0	56.572	GTD
Kidnappings	Municipality	0.044	0.837	0	48.567	GTD
Assaults	Municipality	0.061	0.841	0	41.425	GTD
Infrastructure attacks	Municipality	0.035	0.795	0	39.659	GTD
Mass homicides	Municipality	0.061	0.671	0	22.561	CNMH
Paramilitary presence	Municipality	0.004	0.062	0	1	CEDE
Guerilla presence	Municipality	0.079	0.270	0	1	CEDE
Dismanteled laboratories	Municipality	0.216	1.307	0	46	UNODC
Eradication coca fields	Municipality	0.122	1.085	0	31.357	UNODC
Manual eradication coca fields	Municipality	0.038	0.385	0	15.678	UNODC
Confiscation coca HCI	Municipality	0.038	0.346	0	10.347	UNODC
Confiscation coca base & paste	Municipality	0.008	0.039	0	0.818	UNODC
Confiscation coca leaf	Municipality	0.078	0.535	0	13.086	UNODC
Competition	Municipality	0.111	0.783	0	52	GTD
Banana prod.	Municipality	0.081	0.322	0	3.04	Agronet
Cacao prod.	Municipality	0.339	1.633	0	19.986	Agronet
Coca prod.	Municipality	0.083	0.412	0	5.642	Agronet
Coffee prod.	Municipality	1.931	5.949	0	63.56	Agronet
Palm prod.	Municipality	0.738	3.907	0	37.632	Agronet
Sugar prod.	Municipality	0.489	2.680	0	33.9	Agronet
Tabacco prod.	Municipality	0.021	0.164	0	2.14	Agronet
Gold prod.	Municipality	14.022	146.58	0	3361.54	Agronet
Hourly wage, x1000 COP	Municipality	2.299	1.023	0	21.429	DANE
Monthly income, x1000 COP	Municipality	413.660	190.246	0	4800	DANE
Age	Municipality	42.890	4.687	24	74	DANE
Highest education	Municipality	3.182	0.410	1	6	DANE
Population (in 100,000)	Municipality	0.783	1.824	0.022	25.334	DANE
Rainfall, mm.	Department	124.928	64.251	1.926	424.884	Murray et al. (2020)
Temperature, Celsius	Department	21.914	3.403	16.181	28.953	Murray et al. (2020)
Coca leaf price	Region	0.248	0.0714	0.075	0.415	UNODC
Coca base price	Region	254.174	20.688	196.41	307.07	UNODC
Coca paste price	Region	188.679	20.859	145.63	222.55	UNODC
Coca HCI price	Region	457.775	34.315	310	583.54	UNODC
Farmers growing leaf (%)	Region	57.973	25.224	14	92	UNODC
Farmers growing leaf, producing paste (%)	Region	31.748	29.926	1	87	UNODC
Farmers growing leaf, producing base (%)	Region	10.246	14.702	0	66	UNODC
Banana price	International	192.34	81.67	68.55	338.31	FRED
Cacao price	International	0.510	0.192	0.179	0.899	FRED
Coca price	International	0.083	0.412	0	5.642	FRED
Coffee price	International	0.333	0.127	0.112	0.484	FRED
Palm price	International	148.394	55.185	70.136	233.465	FRED
Sugar price	International	0.035	0.016	0.010	0.062	FRED
Tabacco price	International	22.267	8.760	8.616	37.293	FRED
Gold price	International	252.088	111.725	70.834	431.208	FRED
N	13,428					

Note: Descriptive statistics of all variables used in the analysis. Violent incidents are per 100,000 inhabitants of the municipality; prices of coca products are in thousands of COP; growing variables indicate the percentage of farmers that grow leaf (only), and/or process it into paste/base; eradication is total number of hectares (in thousands) eradicated; confiscation variables are expressed in thousands of kilos; municipal production is measured in thousands of hectares in 2007; hourly and monthly wage/income is in thousands of COP; population is in 100,000; competition is measured as the number of active (carrying out violent attacks) armed groups in a municipality; rainfall in millimeters, temperature in degrees Celsius, both annual averages.

Table A.4: Proxy for income

	Monthly agricultural income
Coca	3.448**
	(1.353)
Banana	-16.473
	(12.746)
Tobacco	-1228.348*
	(598.641)
Palm kernel	0.596*
	(0.284)
Coffee	0.525
	(0.754)
Sugar	-6.735
	(6.757)
Cacao	-0.169
	(0.483)
Gold	0.011**
	(0.005)
Controls	Yes
Year FE	Yes
Municipality FE	Yes
N	616
Clusters	16

Note: The table shows the results of the estimation of equation 1, and indicates whether average monthly income, in thousands of COP, of agricultural workers is significantly correlated to the proxy of farmers' income from coca in coca-producing municipalities. Other variables are the production size (in thousands of hectares) in 2007 multiplied by the international price (expressed in thousands of COP, inflation-adjusted) for coffee, bananas, tobacco, palm kernel, sugar cane, cacao and gold to capture other sources of income. Additional controls, not shown, are average age, education level, and gender of the respondents on municipal level, as well as whether they were employed, and rain and temperature. These are included in table A.5. Standard errors, clustered by department, in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table A.5: Proxy for income – full results

	Monthly agricultural income
Coca	3.448**
	(1.353)
Banana	-16.473
	(12.746)
Tobacco	-1228.348*
	(598.641)
Palm kernel	0.596*
	(0.284)
Coffee	0.525
	(0.754)
Sugar	-6.735
	(6.757)
Cacao	-0.169
	(0.483)
Gold	0.011**
	(0.005)
Gender	-13.214
	(7.845)
Age	0.039
	(0.311)
Highest education	2.298
	(4.244)
Employment	-0.326
	(1.350)
Rain	0.030
	(0.025)
Temperature	9.824
	(6.634)
Controls	Yes
Year FE	Yes
Municipality FE	Yes
N	616
Clusters	16

Note: The table shows the results of the estimation of equation 1, and indicates whether average monthly income, in thousands of COP, of agricultural workers is significantly correlated to the proxy of farmers' income from coca in coca-producing municipalities. Other variables are the production size (in thousands of hectares) in 2007 multiplied by the international price (expressed in thousands of COP, inflation-adjusted) for coffee, bananas, tobacco, palm kernel, sugar cane, cacao and gold to capture other sources of income. Standard errors, clustered by department, in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table A.6: Income, OP and violence – full results

	Total events	**Fatalities**	**Guerilla attacks**	**Paramilitary attacks**
Income_{t-1}	-1.303***	-0.869**	-1.722**	-0.029
	(0.368)	(0.405)	(0.681)	(0.023)
OP_{t-1}	1.345***	0.915**	1.518**	0.023
	(0.416)	(0.356)	(0.594)	(0.022)
Competition, % growth	2.119***	2.112***	3.022***	0.016*
	(0.355)	(0.377)	(0.281)	(0.009)
Laboratories	-0.063***	-0.046*	-0.094**	-0.001
	(0.017)	(0.027)	(0.043)	(0.001)
Gold producer	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Coffee producer	-0.006	0.036	-0.008	-0.000
	(0.026)	(0.026)	(0.036)	(0.000)
Coca producer	-0.000	-0.000	-0.000	-0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
Man. eradication	-0.034	-0.118	-0.098	-0.002
	(0.088)	(0.233)	(0.176)	(0.002)
Eradication	0.013	-0.042	-0.011	-0.003
	(0.050)	(0.360)	(0.128)	(0.003)
Confisc. leaf	-0.000***	-0.000***	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Confisc. base/paste	-0.000	-0.000***	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Confisc. HCI	-0.000***	-0.000*	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Rain	-0.001	0.000	-0.001	-0.000
	(0.001)	(0.002)	(0.001)	(0.000)
Temperature	0.083	-0.131	0.073	-0.000
	(0.165)	(0.244)	(0.322)	(0.001)
Income_{t-2}	-1.875***	-1.101	-2.689*	-0.059
	(0.531)	(1.371)	(1.382)	(0.055)
Income_{t-3}	0.091	0.509	0.712	-0.016
	(0.699)	(0.741)	(1.022)	(0.016)
Income_{t-4}	-0.453	-0.642	-0.018	-0.019
	(0.434)	(0.718)	(0.449)	(0.024)
OP_{t-2}	2.251***	0.788	3.030*	0.055
	(0.746)	(1.513)	(1.741)	(0.048)
OP_{t-3}	-0.139	-0.460	-0.737	0.010
	(0.728)	(0.925)	(1.055)	(0.011)
OP_{t-4}	0.501	0.437	0.510	0.010
	(0.452)	(0.753)	(0.444)	(0.017)
$\text{Presence paramilitary}_{t-1}$			6.595**	
			(3.196)	
$\text{Presence guerilla}_{t-1}$				0.008
				(0.007)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
N	8857	8857	8857	8857
Cluster	32	32	32	32

Note: The table shows the results for estimation 4. Dependent variables capture violent intensity on municipal level, measured as number of events, fatalities, guerilla and paramilitary attacks per 100,000 inhabitants. Standard errors, clustered by department, in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table A.7: Robustness 1: Excluding non-coca producing municipalities

	Total events	**Fatalities**	**Guerilla attacks**	**Paramilitary attacks**
Income_{t-1}	-1.224***	-1.044*	-1.776**	-0.026
	(0.252)	(0.508)	(0.640)	(0.025)
OP_{t-1}	1.147***	0.659*	1.297**	0.024
	(0.323)	(0.380)	(0.521)	(0.024)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
N	1517	1517	1517	1517
Cluster	23	23	23	23

Note: The table shows the results for estimation 4, for a sample that excludes all municipalities that have no hectares dedicated to coca in 2007 ($t = 1$). Dependent variables capture violent intensity on municipal level, measured as number of events, fatalities, guerilla and paramilitary attacks per 100,000 inhabitants. Standard errors, clustered by department, in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table A.8: Robustness 2: Including lagged value of dependent variable

	Total events	**Fatalities**	**Guerilla attacks**	**Paramilitary attacks**
Income_{t-1}	-1.308***	-0.986**	-1.568**	-0.030
	(0.362)	(0.449)	(0.605)	(0.024)
OP_{t-1}	1.340***	1.060**	1.382**	0.023
	(0.405)	(0.395)	(0.574)	(0.022)
Guerilla presence_{t-1}				0.009
				(0.006)
Paramilitary presence_{t-1}			6.773**	
			(3.054)	
Total events_{t-1}	0.037			
	(0.031)			
Fatalities_{t-1}		-0.095***		
		(0.029)		
Guerilla attacks_{t-1}			0.145***	
			(0.033)	
Paramilitary attacks_{t-1}				-0.130***
				(0.015)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
N	8857	8857	8857	8857
Cluster	32	32	32	32

Note: The table shows the results for estimation 4, including the first lag of each dependent variable. Dependent variables capture violent intensity on municipal level, measured as number of events, fatalities, guerilla and paramilitary attacksper 100,000 inhabitants. Standard errors, clustered by department, in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table A.9: Robustness 3: Including department-level trend

	Total events	**Fatalities**	**Guerilla attacks**	**Paramilitary attacks**
Income_{t-1}	-1.315***	-0.851**	-1.767**	-0.029
	(0.370)	(0.403)	(0.687)	(0.023)
OP_{t-1}	1.364***	0.883**	1.596**	0.023
	(0.421)	(0.340)	(0.611)	(0.022)
Dept. trend	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
N	8857	8857	8857	8857
Cluster	32	32	32	32

Note: The table shows the results for estimation 4, including a time-varying linear trend for each department. Dependent variables capture violent intensity on municipal level, measured as number of events, fatalities, guerilla and paramilitary attacks per 100,000 inhabitants. Standard errors, clustered by department, in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table A.10: Robustness 4: Including lagged value of dependent variable and department-level trend

	Total events	**Fatalities**	**Guerilla attacks**	**Paramilitary attacks**
Income_{t-1}	-1.318***	-0.965**	-1.606**	-0.029
	(0.363)	(0.446)	(0.611)	(0.024)
OP_{t-1}	1.358***	1.025**	1.447**	0.023
	(0.409)	(0.375)	(0.587)	(0.022)
$\text{Total events}_{t-1}$	0.036			
	(0.031)			
Fatalities_{t-1}		-0.095***		
		(0.029)		
$\text{Guerilla attacks}_{t-1}$			0.144***	
			(0.033)	
$\text{Paramilitary attacks}_{t-1}$				-0.130***
				(0.015)
$\text{Paramilitary presence}_{t-1}$			6.822**	
			(3.059)	
$\text{Guerilla presence}_{t-1}$				0.009
				(0.006)
Dept. trend	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
N	8857	8857	8857	8857
Cluster	32	32	32	32

Note: The table shows the results for estimation 4, including a time-varying linear trend for each department and the first lag of the dependent variable. Dependent variables capture violent intensity on municipal level, measured as number of events, fatalities, guerilla and paramilitary attacks per 100,000 inhabitants. Standard errors, clustered by department, in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table A.11: Average percentage point change in proxies

Region	Income	OP
Amazonía	9.230	29.44
Central-Sur de Bolívar-Catatumb	6.825	9.058
Meta-Guaviare	8.112	7.834
Orinoquía	11.54	9.040
Pacífico	11.65	9.484
Putumayo-Caquetá	14.00	25.01
Sierra Nevada	-0.136	8.304

Note: The table shows the average (across 2007 - 2018) percentage point change in the proxies for income from farming and the OP, per region as defined by the UNODC.

Table A.12: Type of attack

	Assassinations	Mass homicides	Bombings	Kidnappings	Assaults	Infrastructure
Income_{t-1}	0.096***	0.121	-0.743*	0.043	-0.124	-0.137
	(0.030)	(0.333)	(0.397)	(0.099)	(0.121)	(0.153)
OP_{t-1}	-0.083***	-0.135	0.664**	-0.007	0.105	0.241
	(0.024)	(0.307)	(0.295)	(0.088)	(0.080)	(0.173)
$\text{Paramilitary presence}_{t-1}$	0.026	-0.172	4.373**	1.027*	1.485**	0.898**
	(0.092)	(0.157)	(1.671)	(0.560)	(0.683)	(0.354)
$\text{Guerilla presence}_{t-1}$	0.158***	-0.023	2.722***	0.564***	0.693***	0.439**
	(0.055)	(0.034)	(0.347)	(0.115)	(0.190)	(0.186)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes
N	8857	8857	8857	8857	8857	8857
Cluster	32	32	32	32	32	32

Note: The table shows the results for estimation 4, for different types of attacks. Dependent variables capture the type of violent event on municipal level, measured as number of events per 100,000 inhabitants. Standard errors, clustered by department, in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table A.13: Income, OP and violence – levels

	Total events	**Fatalities**	**Guerilla attacks**	**Paramilitary attacks**
Income_{t-1}	-0.548***	-0.383***	-0.772***	-0.015
	(0.190)	(0.126)	(0.201)	(0.012)
OP_{t-1}	0.798***	0.674***	0.972***	0.012
	(0.249)	(0.206)	(0.207)	(0.012)
Competition, % growth	0.338***	0.370***	0.485***	0.009**
	(0.044)	(0.053)	(0.020)	(0.004)
Laboratories	-0.018***	-0.011	-0.022*	-0.000
	(0.005)	(0.010)	(0.012)	(0.000)
Gold producer	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Coffee producer	-0.005	0.004	-0.008	0.000
	(0.004)	(0.004)	(0.007)	(0.000)
Coca producer	-0.000	0.000	-0.000	-0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
Man. eradication	-0.084***	-0.166**	-0.195***	-0.001
	(0.023)	(0.068)	(0.053)	(0.001)
Eradication	0.078***	0.075	0.062*	-0.002
	(0.026)	(0.102)	(0.035)	(0.002)
Confisc. leaf	-0.000***	-0.000***	0.000***	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Confisc. base/paste	-0.000	-0.000*	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Confisc. HCI	-0.000***	-0.000***	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Rain	0.000	-0.000	0.000	-0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
Temperature	0.008	0.017	0.011	-0.003
	(0.026)	(0.037)	(0.054)	(0.002)
Income_{t-2}	-1.188***	-0.924*	-1.542***	-0.031
	(0.415)	(0.512)	(0.298)	(0.028)
Income_{t-3}	0.060	0.262	0.156	-0.010
	(0.269)	(0.450)	(0.292)	(0.009)
Income_{t-4}	-0.075	-0.635	-0.065	-0.012
	(0.220)	(0.542)	(0.222)	(0.013)
OP_{t-2}	1.189***	0.488	1.571***	0.028
	(0.387)	(0.346)	(0.313)	(0.025)
OP_{t-3}	-0.045	-0.015	-0.138	0.007
	(0.264)	(0.470)	(0.290)	(0.006)
OP_{t-4}	0.127	0.312	0.167	0.006
	(0.213)	(0.415)	(0.218)	(0.009)
$\text{Paramilitary presence}_{t-1}$			1.832	
			(1.186)	
$\text{Guerilla presence}_{t-1}$				0.009
				(0.006)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
N	8857	8857	8857	8857
Cluster	32	32	32	32

Note: The table shows the results for estimation 4. Dependent variables capture the level of violence on municipal level, measured as number of events, fatalities, guerilla and paramilitary attacks. Standard errors, clustered by department, in parentheses. *p<0.1; **p<0.05; ***p<0.01. ***p<0.01.

Table A.14: Opportunity cost and rapacity effect

	Hours worked	**Highest level of education**	**Attending school**	**Local Competition**	**Guerilla presence**	**Paramilitary presence**
Income_{t-1}	-2.200	-0.126	0.013*	-0.160**	-0.159***	-0.014
	(2.944)	(0.185)	(0.006)	(0.073)	(0.050)	(0.012)
OP_{t-1}	0.463	0.107	-0.014*	0.183**	0.185***	0.011
	(2.835)	(0.196)	(0.007)	(0.068)	(0.040)	(0.011)
Age	-0.112***	-0.025***	0.002***			
	(0.028)	(0.003)	(0.000)			
Gender	-14.041***	0.513***	-0.024***			
	(2.771)	(0.070)	(0.007)			
Competition, % growth	0.326	0.000	0.002	0.820***	0.545***	0.009**
	(0.205)	(0.010)	(0.002)	(0.023)	(0.051)	(0.004)
Gold producer	0.000	-0.000	-0.000	-0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Coffee producer	0.138	0.002	-0.001*	0.000	-0.000	0.000
	(0.120)	(0.006)	(0.001)	(0.001)	(0.001)	(0.000)
Coca producer	0.000	0.000	-0.000	0.000	-0.000	-0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Man. eradication	-0.944**	-0.045**	0.002*	0.007	-0.021	-0.001
	(0.340)	(0.021)	(0.001)	(0.011)	(0.019)	(0.001)
Eradication	0.784**	0.029*	-0.001	0.010*	0.011	-0.002
	(0.295)	(0.014)	(0.001)	(0.005)	(0.007)	(0.002)
Rain	-0.012*	-0.000	0.000	0.000	0.000	-0.000*
	(0.006)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Temperature	-0.435	0.012	-0.001	0.018	-0.002	-0.003
	(0.883)	(0.032)	(0.003)	(0.018)	(0.012)	(0.002)
Confisc. leaf	-0.000	-0.000	0.000*	-0.000***	0.000***	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Confisc. base/paste	-0.000	-0.000	-0.000	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Confisc HCI	-0.000	0.000	0.000	0.000	-0.000***	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Income_{t-2}	-3.181	0.105	-0.013	-0.227***	-0.425***	-0.030
	(2.153)	(0.119)	(0.016)	(0.073)	(0.095)	(0.028)
Income_{t-3}	-3.204	0.067	-0.004	0.041	0.104	-0.010
	(3.305)	(0.185)	(0.022)	(0.061)	(0.062)	(0.009)
Income_{t-4}	3.071	0.140**	0.006	-0.066***	-0.065***	-0.011
	(2.993)	(0.056)	(0.012)	(0.021)	(0.019)	(0.013)
OP_{t-2}	4.199*	-0.081	0.013	0.218**	0.463***	0.028
	(2.353)	(0.136)	(0.017)	(0.087)	(0.128)	(0.025)
OP_{t-3}	2.556	-0.088	0.005	-0.046	-0.085	0.007
	(3.467)	(0.225)	(0.022)	(0.065)	(0.062)	(0.007)
OP_{t-4}	-3.186	-0.130*	-0.007	0.061**	0.089***	0.006
	(2.772)	(0.065)	(0.011)	(0.025)	(0.026)	(0.009)
$\text{Paramilitary presence}_{t-1}$	-3.908***	0.028	-0.032	0.869***	0.381***	-0.136***
	(1.016)	(0.044)	(0.036)	(0.069)	(0.068)	(0.005)
$\text{Guerilla presence}_{t-1}$	0.469	0.023	0.002	0.839***	0.563***	0.009
	(0.446)	(0.020)	(0.003)	(0.031)	(0.047)	(0.005)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes
N	3437	3437	3437	8857	8857	8857
Clusters	24	24	24	32	32	32

Note: results for estimation of equation 5. Competition growth is the annual relative change in the number of different groups active in a municipality, the control variable included in each analysis. Standard errors, clustered by department, in parentheses. *p<0.1; **p<0.05; ***p<0.01.