Working Paper nº 01/2020

Oiling up the field. Forced internal displacement and the expansion of palm oil in Colombia

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WP-01/2020

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April 15, 2020

Abstract

The analysis of the relationship between natural resources and violent conflicts has shown how positive shocks in agricultural commodities are usually linked with reductions in violence (opportunity cost effect), while positive shocks to minerals or extractive commodities seem to increase conflict (rapacity effect). In this paper we examine the case of palm oil expansion in Colombia and find that our results differ from previous studies. We use changes in international prices of palm oil to show how positive income shocks increased forced displacement in palm producing municipalities.

We found that a 1% increase in the price of palm oil raises the forced internal displacement rate in palm municipalities by 0.42 standard deviations. We also show evidence that the negative effect of palm oil income shock was stronger in areas with paramilitary armies, weak contract institutions and better land distribution. In addition, increases in palm prices increase rural violence but not urban violence. Our results support the hypothesis that the violence linked with the palm expansion was the result of the search for new lands for palm trees in a framework of weak institutions. Therefore, one can argue that in the case of the palm expansion the rapacity effect over new lands was stronger than possible labor market effects.

Keywords: Income shocks, Conflict, Commodity prices, Natural resources, Forced displacement.

JEL: D74, F14, O13, O15, Q17

[*] Any errors are only the responsibility of the authors and do not represent the views of any public or private institution.

[†] This paper is based on and expands the author Sebastián Pulgarín MSc in Economics dissertation work at Universidad de los Andes - Colombia (Pulgarín-Castañeda, 2018).

Thus, the paramilitary expansion project was guided by a logic of land accumulation for projects such as the planting of palm oil, a sector on the rise due to the development policy promoted by the State that promoted biofuels as a strategy of competitive insertion in the world market for the national economy ...

(Centro Nacional de Memoria Histórica, 2015)

1 Introduction

The ambiguous relationship between natural resources and wealth has always been at the center of the economic discussion. What is known as the *"Resource Curse"* has captured the attention of many academics (see Van der Ploeg, 2011, for a comprehensive review). Lately, one area of the resource curse which called for more interest, is the analysis between natural resources, income shocks and civil conflict or violence. According to previous literature, there are two main ways in which income shocks linked with natural resources increase or decrease violent processes.

On the one hand, there is the *opportunity cost* effect. In this case, positive income shocks increase wages and improve labor market conditions. Following a simple model of crime (for example Becker, 1968), better labor markets imply a higher opportunity cost of committing crime and reduces the incentives to become involved in criminal activities (or getting involved in insurgency). Evidence of the *opportunity cost* effect is shown in Miguel et al. (2004), Dube and Vargas (2013), Hodler and Raschky (2014) and Harari and La Ferrara (2018). The common factor among these works is that the positive income shock is in agricultural products which are labor intensive. Also, Brückner and Ciccone (2010) shows similar results with a mix of agricultural and non-agricultural commodities in the case of Africa. Once again, the commodity price downturns increase civil conflict through worsening local economic conditions.

On the other hand, there is a *rapacity* effect. Positive income shocks increase the incentives to obtain benefits from a new income source, increasing the incentives to fight for control of the resources linked to the rise in income. In other words, the larger the prize, the greater the incentives to fight for. Evidence of this effect has been found in Collier and Hoeffler (2004), Fearon (2005), Humphreys (2005), Dube and Vargas (2013), Idrobo et al. (2014) and Lei and Michaels (2014). In general, these works analyze positive income shocks in natural mineral resources such as oil and gold, which are more capital than labor intensive.

This paper contributes to this literature. We study the relationship between the palm oil expansion in Colombia from 2002 and the violent conflict in the country. Specifically, we show that positive income shocks linked with the African Palm market and weak institutions are linked with the increase in *Forced Internal Displacement* (FID) rates in Colombia.

Multiple reports have shown anecdotal evidence of the relationship between palm and violence (for example Ballvé, 2009, Centro Nacional de Memoria Histórica, 2015). Furthermore, the link between the palm oil expansion and illegal groups has been documented by some authors (Goebertus, 2008, Grupo Semillas, 2010, Gómez et al., 2015). Additionally, Hurtado et al. (2017) and Maher (2015) describe some regional cases and estimate a positive relationship, possibly causal, between African Palm cultivation and FID. However, to our knowledge, there is no systematic evidence of the causal effect of better conditions in the palm market and the violent conflict in Colombia (or elsewhere).

Following previous literature, we use a *difference in difference* strategy to show that a positive expected income shock, from a rise in the international price of palm oil, increases FID rates in the municipalities where African Palm already existed before the expansion. What is more, we show that such an effect focuses on the period where the national government strongly supported palm producers in areas with a strong right-wing paramilitary presence and where land was better distributed. Our results suggest that the positive palm income shock only increased violence when legal institutions were replaced by illegal ones from the paramilitary armies. Also, we show that the effect is driven by the need for additional lands in order to be able to get the benefits of the new profits in the rising palm oil market.

In order to identify the causal effect of the palm income shock on FID rates we mixed strategies from previous works. First, we define municipalities that already had African palm before the expansion as treated municipalities .[1] Following the assumption used in previous literature, we assume that municipalities with palm crops before the expansion are more likely to be affected by a shock in the expected returns of palm than municipalities without palm crops before the shock. Therefore, an increase in the prices of palm oil should affect the local economies in palm producing municipalities more with respect to municipalities that did not have palm before 2002. We show evidence that palm expansion to new municipalities was limited. We also show that the effect of palm prices on FID rates in new palm producing municipalities was significantly smaller than the effect of palm prices on FID rates in original palm producing municipalities.

Second, to comply with the difference-in-difference's parallel trends assumption, we limit the control group to municipalities that have the natural characteristics to grow African palm and in the same regions where palm was already cultivated. Third, we use the price of palm in international markets as a source of income shock and showed evidence that Colombian producers do not affect international prices given their marginal participation in the international markets.

Our second contribution to the literature is about the causes and consequences of the Colombian armed conflict. There is extended literature analyzing the causes and consequences of the long-lasting violence, focusing on the violence linked with the cocaine market (for example Angrist and Kugler, 2008, Mejía and Restrepo, 2016, Millán-Quijano, 2020). Our study of palm oil joins the analyses of Dube and Vargas (2013) and Idrobo et al. (2014) who focused on understanding the effect of income shock in legal commodities, such as coffee, oil and gold, on different violence indicators.

We contribute as well to the study of factors that explained the Colombian FID. By 2018, the number of internally displaced individuals added up to more than 5.7 million individuals, the second largest worldwide, only after Syria with 6.3 million IDPs (Internal Displacement Monitoring Center, 2019). Analyzing the channels in which the palm expansion contributes to FID dynamics adds to other studies such as Ibáñez and Vélez (2008) and Ibáñez (2009).

[1] For example, Angrist and Kugler (2008) define coca cropping regions as regions with coca crops before the expansion in Colombian production in the 1990s. Miller and Urdinola (2010) use coffee intensity before different price shocks to estimate differential effects of changes in international coffee prices on infant mortality.

Our results are unique in the sense that they contradict previous evidence of positive income shocks in agriculture, reducing violence via the opportunity cost effect. We do not deny or doubt the positive effect of better palm oil prices on labor market conditions. However, we conclude that in this case we have a new type of *rapacity* effect. Given that the palm crop is capital (land) intensive and has increased returns to scale with respect to land, larger expected returns increase the incentives of palm owners to increase their crops. We argue that due to weak institutions and the availability of illegal armies, landowners preferred to use violence to reduce the price of new lands in their region instead of paying the market price. The *rapacity* effect on new lands supersedes the positive effect of better labor market conditions, increasing violence.

This paper has the following structure. Section 2 describes the palm oil market in Colombia and the possible negative effects of its expansion throughout the 2000's. Section 3 describes our strategy and section 4 describes the data we use. We show and discuss our results in section 5 and section 6 shows our conclusions.

2 Institutional context

2.1 African Palm, Palm Oil and its expansion in Colombia

African Palm grows under very specific conditions (Info Agro, 2018). First, it requires a median monthly temperature between 26°C and 28°C, with a minimum that does not go below 21°C. Second, annual precipitation must be between 1800 mm to 2300 mm. Third, the monthly average of relative humidity must be around 75%. Finally,African Palm only grows below 500 meters above sea level (masl). These features concentrate international palm oil production in a few tropical countries such as Indonesia, Malaysia and Thailand.[2]

Another feature of African Palm is the production cycle. From seedlings to production takes around 5 years, which implies that palm producers need large swathes of land in order to maintain regular, annual production (Info Agro, 2018). What is more, African Palm has the largest yield per hectare among natural oils, increasing the incentives to obtain extra lands when a positive income shock comes.[3]

From the early 2000s, international production rose rapidly due to strong changes in demand such as the worldwide increase in consumption of natural oils and fuels. For example, between 2000 and 2018, Indonesias production increased from 8,300 thousand metric tons (tmt) to 41,500 tmt and Malaysian production increased from 11,937 tmt to 20,800 tmt. In addition, domestic consumption in the US rose from 175 tmt to 1,501 tmt, while in China consumption rose from 2,028 tmt to 7,012 tmt over the same period.[4]

Colombia has also seen a large increase in production since 2000. The increase in production is concentrated in specific regions of the country which fulfill the characteristics described above. In addition to the increase in international demand, the Colombian government put a lot of effort into the expansion of this market. As part of a strategy to reduce coca cultivation, the government gave subsidies, fiscal benefits and reduced the cost of land access to palm producers, specifically in lands with coca cultivation (Grupo Semillas, 2010; Restrepo,

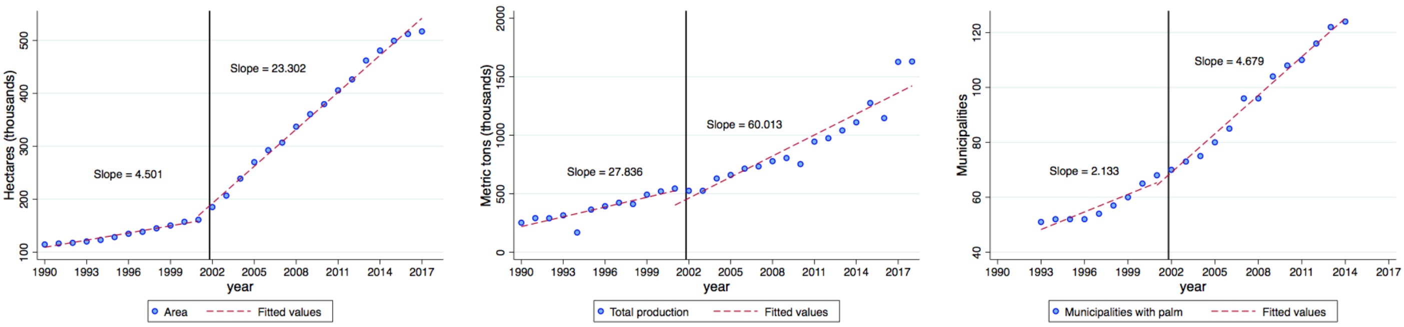
[2]By 2013 these three countries represented 88% of the total production (data from oil world June 2016 database)

[3]The average palm oil yield is 3.74 mt per hectare per year while the yields for rapeseed, sunflower and soybean are only 0.67, 0.48 and 0.38 mt per hectare per year respectively (information from Green Palm Oil)

[4]Information from www.indexmundi.com

2000). The rapid increase in cultivation and production from 2002 is what we call the Colombian palm oil expansion.

Figure 1: Total land area of palm trees, palm oil production and municipalities with palm - 1990 – 2017



(a) Area (b) Production (c) Municipalities with palm

Source: FEDEPALMA and www.indexmundi.com

Figure 1 clearly shows the size of the expansion. By 2001, the total area cultivated was 161,000 hectares, the total production was 544 tmt and only 68 municipalities were cultivating palm. By 2017, the total area cultivated covered 430,000 hectares, total production reached 1627 tmt, and 124 municipalities were involved in the market. In the figure above we can also see that 2002 broke the market trends. Cultivation prior had grown at a rate of 4 thousand hectares per year. From 2002, the annual increase rose to an average of 23 thousand hectares per year. This represents an average yearly increase of more than 500%. The annual rate of increase doubled for total production and the number of municipalities involved. It is important to note that these changes were unique for the palm market. The agricultural sector as a whole only grew 13.8% from 2002 to 2014 (Sociedad de Agricultores de Colombia, 2018).

2.2 Problems linked to palm oil

The palm oil industry produces large positive returns for farmers, producers and even has an impact at the national level. In 2016 for example, palm oil contributed USD 2.6 billion to the Colombian GDP (Federación Nacional de Cultivadores de Palma de Aceite, 2018). Palm oil also allows regional stability and helps ease the transition from conflict to peace. For example, in San Alberto, in northern Colombia, a palm oil company worked with poverty stricken cooperatives in order to compete in the oil market, allowing many families to overcome poverty and reducing the violence in the region (Ocampo, 2009). However, there are some social costs associated with this market that have called the attention of academics and policy makers. Previous studies described the link between the palm oil industry with environmental issues, labor conflicts and problems related to land property rights (Castiblanco et al., 2015).

First, the African palm expansion is strongly linked with deforestation. By 2013 nearly 4.1% of the crop expansion in Indonesia, Malaysia and Papua New Guinea replaced 32.4% of secondary forests (Gunarso et al., 2013). In Colombia, Fergusson et al. (2014) documented the role of palm oil in deforestation from 2002 to 2005.

Second, the cropping of palm oil has been linked with extremely poor labor market conditions. In Indonesia and Malaysia, problems related to forced and child labor are frequently featured in the media and reports from international agencies, e.g., Amnesty International (2016). Additionally, McCarthy (2010) described how contracts between farmers and firms in Indonesia expose poor farmers at a high rate due to price volatility. In Latin America, Verité (2013) described similar issues regarding contracts and labor market conditions, pointing to many poor labor conditions in Guatemala.

Finally, land expansion has been linked with issues regarding land property rights. A lack of legal regulations and weak rural institutions enable large producers to displace farmers who have little leverage on their small tracts (McCarthy, 2010, Castiblanco et al., 2015). For example, Castiblanco et al. (2015) documents 630 conflicts over land property rights between palm oil firms and local communities in Indonesia. These conflicts, in some cases, lead to the use of violence as a method to get new lands where weak institutions exist. This is not a unique characteristic of the Colombian market, as we demonstrate in this paper. Palacios (2012) reported the case of the Dayaks tribe in Malaysia and Indonesia, where a large part of their land was taken for palm production using violence.

The case of weak property rights has also been documented in this context. Grupo Semillas (2010) describes the use of contract violations used by firms to overcome the claims of forcefully displaced individuals when they return to their lands, e.g., tampered signatures or payments below the official appraised land value. Multiple studies also present evidence from multiple sources about the relationship between illegal violent groups (mainly paramilitary armies), violence against small farmers and the acquisition of lands by palm producers (Mingorance et al., 2004, Oslender, 2007, Goebertus, 2008, Rettberg et al., 2011, Gómez et al., 2015).

This relationship between weak institutions, violent groups and the acquisition of new lands for African Palm is the key hypothesis we aim to test in this work.

2.3 FID in Colombia.

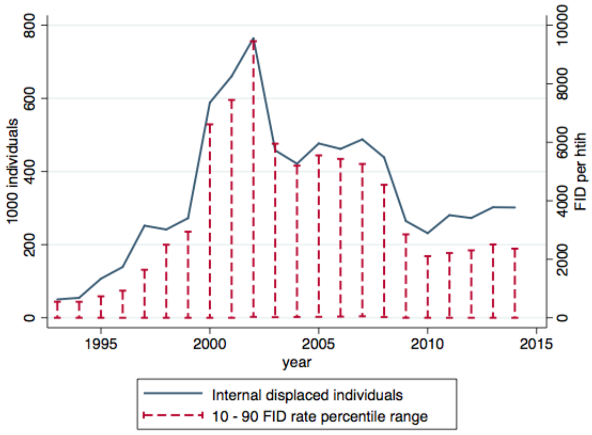
FID is one of the main characteristics of the continuing conflict in Colombia. Between different illegal organizations and the national government, more than 5 million individuals were displaced by the conflict, according to official statistics. By 2009, more than 90% of Colombian municipalities had been affected by displacement, either by the outflows or inflows of displaced individuals (Ibáñez, 2009).

Figure 2 shows the rate of expulsions by year over the period of our analysis. From 1993 to 2002, FID increased constantly until reaching a historic peak, close to 800,000 expulsions. The rate of expulsion was reduced over 2 years after 2002, and once again fell from 2007 to 2010, due specifically to the demobilization of paramilitary armies. The figure below also shows the large dispersion of FID rates, from 2000 to 2002. Some municipalities lost more than 5% of the population due to flow.

Previous literature studied the main causes of FID in Colombia (Ibáñez, 2008, for a review). In Colombia IAG tried to displaced individuals in order to: (1) obtain lands and territorial control, (2) gain control of crops and trafficking of illegal drugs and (3) to prevent civil resistance movements, weaken social networks and frighten the population, according to the literature.

The relationship between land conflicts and displacement goes further than the use of land for coca cultivation. Previous works have documented the alliance between IAG and big landowners in order to gain control

Figure 2: National FID by year. Total expulsion headcount and municipality FID rate dispersion (90 to 10 percentile range) 1993 - 2014.



Source: RUV-CEDE.

over new lands after violence reduced the price Ibáñez (2009).

In addition, Ibáñez and Vélez (2008) estimated the direct cost of displacement. According to their calculations, on average, a household which has been forcefully displaced suffers a 37% loss of their lifetime consumption. For the poorer households, this loss can be around 80%. These welfare losses are only part of the total loss, which includes the negative effects on local economies which have inflows and outflows of internally displaced persons (IDPs).

3 Estimation strategy

As explained above our main hypothesis states that under weak institutions the palm oil expansion driven by larger expected returns, used violence as a mechanism to obtain new lands. To test this hypothesis, following previous literature, we use changes in international prices of palm oil to assess the differential changes in FID rates between municipalities with and without African Palm crops, in a continuous difference-in-difference style.

FID_{it} is defined as the FID rate at municipality i and year t. Given that displacement in year t affects the total population in year $t+1$, we fixed the population in 2001, the year before the palm expansion began. Then, $FID_{it} = (\text{displaced individuals}_{it}/\text{total population}_{i2001}) \times 100,000$.[5] Therefore, our main specification is summarized in the following equation.

$$FID_{it} = \alpha_1 + \alpha_2 C_i \times Ln\left(P_{t-1}\right) + X_{it} + T_t + M_i + \eta_{it} \tag{1}$$

Where, $C_i = 1$ if municipality i has palm trees, P_{t-1} is the international price of palm oil in the year $t-1$, X_{it} are some time variant municipality characteristics that could affect the FID rate, T_t are year fixed effects and M_i are municipality fixed effects to control for some other unobserved factors that may be correlated to FID's behavior.

In addition, the decision of cropping palm is endogenous and may respond to some time variant variables

[5] FID rates are measured as displacements per hundred thousand inhabitants (dphtih)

that are not observable. Particularly, if a municipality decides to harvest palm to enter the market as a response to increasing prices, our estimates for α_2 would be upper biased.

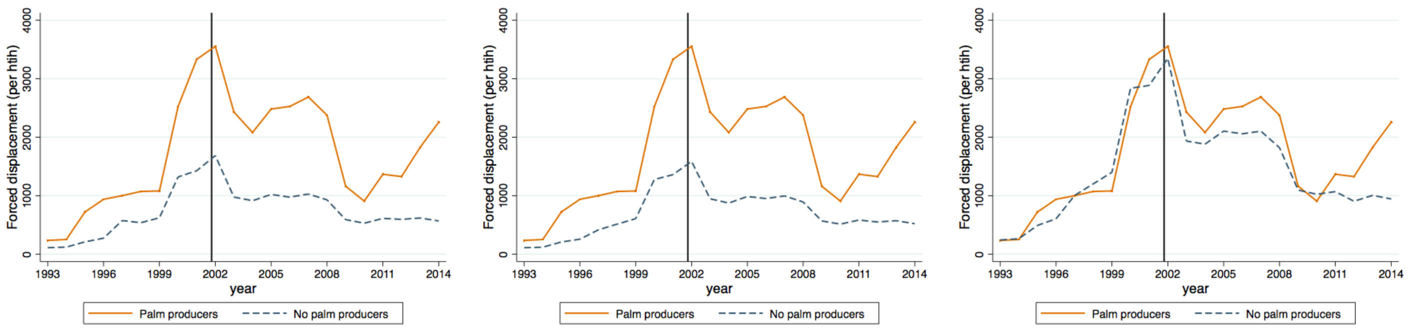
Thus, to categorize a palm producing municipality we follow Angrist and Kugler (2008). We define $C_i = 1$ if the municipality i has African palm trees before the palm expansion. As we showed in the previous section, the market dynamics radically change from 2002, it is expected that the decision of cropping earlier was not directly driven by the national and international changes in 2002. In addition, following Angrist and Kugler (2008) logic, those municipalities are the ones where with are a larger increase in palm cultivation as a response to the international and national shocks.

Equation 1 could represent a *difference-in-difference* estimation where changes in the international price of palm oil represent a continuous treatment. In order to be able to compare the effect of changes in prices between municipalities with and without palm, we need to look for control municipalities where the parallel trend assumption holds (Abadie, 2005).

Figure 3 compares the FID level for treated (with palm prior 2002) and non-treated (without palm prior 2002) municipalities. When we include all municipalities without palm as non-treated (panel A), the common trends assumption seems not to be credible. Comparability improves when we use only the municipalities that are part of Fedepalma's regions (panel B).[6] Fedepalma is the association that represents palm farmers in Colombia. Fedepalma divide palm producing municipalities in four regions – North, Central, Southwest and East – taking into account access to natural resources, land characteristics and palm oil distribution chains (Fedepalma, 2017, 2011).[7]

Finally, as explained before, palm only grows below 500 masl. Thus, we keep the control group as municipalities in Fedepalma's regions with lands below 500 masl. The control group includes municipalities that could crop palm before 2002 but did not. Figure 3.c shows FID trends for municipalities in the final treatment and control groups. In this case, the average FID rates before 2002 were very close between groups, but more importantly showed similar trends.

Figure 3: FID rate by producing and non-producing municipalities



(a) All

(b) Only Fedepalma's regions

(c) Only municipalities with land lower than 500 masl in Fedepalma's regions

Source: RUV-CEDE, Fedepalma and IGAC.

[6] Fedepalma stands for in Federación Nacional de Cultivadores de Palma de Aceite in spanish.

[7] They also exclude some regions which are natural parks, indigenous and African-descendant reservations, and the amazon and pacific jungles.

Therefore, if the parallel trends assumption holds, an estimation of α_2 will capture the difference in the average change of FID rates in original palm municipalities with respect to the average change of FID in municipalities with no palm before 2002, due to an increase in the price of palm oil the previous year. If α_2 is significantly larger than zero, one can say that palm municipalities suffer more FID than municipalities without palm due to an income shock from increases in the palm oil price.

An estimation of α_2 would be biased if Colombian palm producers could affect the international price of palm oil when their profits are affected by the internal conflict. Even though Colombia is among the top ten international palm oil producers, even after the rapid expansion by 2014 they only count for less than 4% of total production, showing small (or none) market power to affect prices.[8]

According to figure 1.c part of the palm expansion happened in municipalities that did not crop palm before 2002. The latter will undermine our analysis because α_2 will only capture the effect of changes in palm oil prices on FID when illegal armies aim to claim more land in municipalities where palm was already cropped. However, it will not capture the effect of searching for land in new municipalities. In other words, we are capturing the intensive margin of the expansion but not the extensive margin. Nevertheless, figure 11 in appendix A shows that the palm area in new palm producing areas is around a fourth of the palm area in palm producing areas before 2002. We will show strong evidence that the violent part of the palm expansion was driven by municipalities that had palm prior to the expansion instead of in the new palm producing municipalities.

Another important point for our analysis is the structural changes between 2007 and 2008. As we explained before, the main armed actor behind the relationship between the conflict and the palm expansion were the paramilitary armies. From 2002 the Colombian government opened peace talks with the Autodefensas Unidas de Colombia (AUC), the largest paramilitary organization. The talks ended with the demobilization of more than 30,000 paramilitary soldiers, changing the institutional framework in the areas where those armies were located.[9] Therefore, if the AUC was really the main armed actor behind the African palm expansion, the effect of palm prices over local economies should have changed once the AUC were removed.

In addition, the use of the oil production changed (see figure 4). Before 2007, the production was divided between internal consumption and oil exports. As expected, the rise in international demand inflated exports. However, from 2007, oil producers started the switch to biodiesel. The share of biodiesel continued increasing and by the end of the period was the top byproduct. Thus, one can expect that the income shock from oil prices weakened from 2007, weakening our estimations.

For the last two reasons, we divide all our estimations into two temporal groups, 2002 to 2007, and 2008 to 2014. We also test the influence of biodiesel prices.

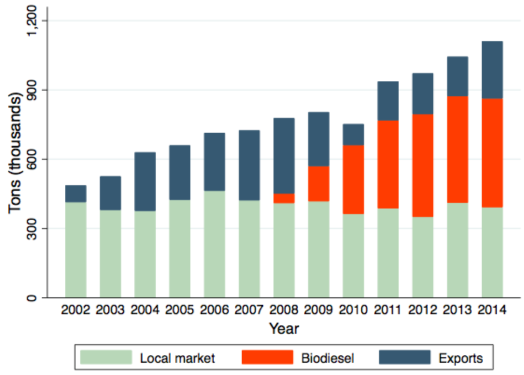
4 Data

This work uses data from different administrative sources. As previously described, FID rates are measured by the number of individuals expelled from the municipality they were living in over 2001s population. Displacement

[8]This differs from the cases of coffee and coca discussed in Dube and Vargas (2013) and Angrist and Kugler (2008), Millán-Quijano (2020) respectively.

[9]Data from the Human Rights Observatory - CEDE

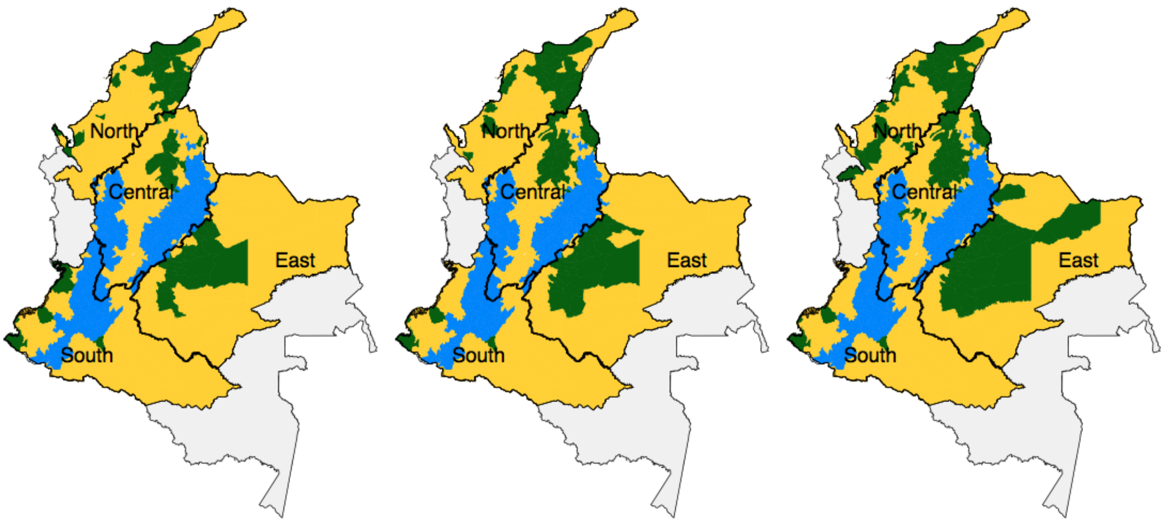
Figure 4: Oil palm production by destination



Source: Fedepalma.

data at the municipality level comes from *Registro Único de Víctimas (RUV)*.[10] This is a demand driven registration, counting individuals who registered as displaced at the local (or national) authorities. Government officials validate each case once a person is registered as displaced. Once a registration is accepted, the individual enters the system and can receive certain benefits. This may appear to incentivize individuals to register even if they were not forcefully displaced by the conflict. However, according to some estimates, about 30% of displaced individuals never registered due to the fear of being identified (Ibáñez et al., 2006). Therefore, FID rates may be deflated.

Figure 5: Geographical distribution of palm crops in Colombia.



(a) 1993-2001 (b) 2002-2007 (c) 2008-2014

Legend: With palm crop. Without palm crop but with lands below 500 mals. Without lands below 500 mals. Outside Fedepalma's regions.
Source: Fedepalma and IGAC.

Information about palm crops and production comes from Fedepalma's annual reports. We also use GIS information from the *Instituto Geográfico Agustín Codazzi (IGAC)*, which is the official office for geographical records in Colombia. We use altitude data to determine the minimum altitude at municipality level and identify municipalities with lands below 500 masl. Figure 5 shows the geographical distribution of municipalities with

[10]We use municipality panel data from *Centro de Estudios sobre Desarrollo Económico – CEDE* at Universidad de los Andes.

palm prior to the expansion, from 2002 to 2007 and from 2008 to 2014. One can see how the palm expansion to new municipalities in the Central region and East region happened in neighboring municipalities while in the North region, new municipalities created a new cluster in the southern part of the region.

Figure 6: Palm oil average yearly price

Notes:Palm oil (Malaysia), 5% bulk, c.i.f. N. W. Europe. Real prices in USD 2015 = 100.
Source: ISTA Mielke GmbH, Oil World; US Department of Agriculture; World Bank. (downloaded from www.indexmundi.com)

Finally, we use the palm oil price in Malaysia, which is the reference price in the international market. Our source is indexmundi.com, which uses information from different sources such as the US Department of Agriculture, the World Bank and Oil World. Figure 6 shows the evolution of the international price of palm oil. Using this figure, one can expect that FID increased more in palm oil producing municipalities from 2002 to 2008 due to a continuous increase in the price, while FID should have increased less in palm municipalities than in non-palm producing municipalities from 2010 due to the continuous fall in the international price.

Table 1 summarizes the main statistics for palm and non-palm municipalities for our period of analysis (2002 - 2014). Firstly, it is important to point out that our treatment only includes 75 of the 502 municipalities in the analysis. Additionally, only 7% among the non-palm producers at some point had palm crops, with an average area a third of the average area cultivated by original palm producers. We understand that our analysis cannot explain the extensive margin of the palm expansion, but the descriptive evidence shows that the intensive margin is more important than the extensive margin.

Regarding FID and other indicators of violence, on average there are no large differences between original palm producers and the non-producers. However, it is important to point out that the expulsion rates are above 2,000 cases per 100,000 inhabitants, meaning that on average, more than 2% of the individuals in a given municipality were displaced at some point. Additionally, the presence of paramilitary armies is larger in palm producing municipalities (52% against 29%). This difference supports the evidence of the involvement of this specific group in the violent process linked with the expansion of palm (Goebertus, 2008, Rettberg et al., 2011).

Table 1: Descriptive statistics for palm and no palm municipalities (2002 - 2014)

Variable	All		Palm municipalities		No palm municipalities	
	Mean	S.D	Mean	S.D.	Mean	S.D.
Observations	6526	.	975	.	5551	.
Municipalities	502	.	75	.	427	.
Palm indicators						
Palm oil crops	0.19	0.39	0.91	0.29	0.07	0.25
Palm area (hectares)	4091.07	6617.46	5614.26	7796.06	1749.78	2950.82
Palm area (% of total area)	0.04	0.07	0.06	0.08	0.02	0.03
Armed conflict indicators						
FID rate[1]	2571.62	4835.20	2596.46	4240.72	2567.21	4933.47
Homicide rate[1]	44.36	57.47	51.36	57.78	43.11	57.33
FARC presence	0.49	0.50	0.52	0.50	0.48	0.50
ELN presence	0.23	0.42	0.32	0.47	0.22	0.41
AUC presence	0.32	0.47	0.52	0.50	0.29	0.45
Coca crop presence	0.31	0.46	0.25	0.43	0.32	0.47
Demobilization rate[1]	6.13	31.30	6.87	48.72	6	27.09
Other variables						
Population	37848.48	92605.93	61949.02	104932.68	33615.37	89610.88
Rurality index	0.53	0.24	0.41	0.22	0.55	0.24
Municipality income per capita	0.68	0.72	0.92	1.36	0.64	0.52
Municipality tax income per capita	0.02	0.08	0.06	0.18	0.02	0.04
Coffee intensity	26.13	88.37	29.09	114.22	25.61	83.01
Oil intensity	0.22	3.43	0.31	1.53	0.20	3.66

Notes: Sources describe in table 14 in appendix A

[1] in events per hundred thousand inhabitants (htih).

5 Results

Before showing our main results we present some initial evidence using the characteristics of African palm crops. As explained in section 2 African palm only grows in specific conditions. Thus, one can expect that those features create discontinuity in the probability of having palm trees. Figure 14 in appendix A shows a discontinuity in the probability of having palm plantations with respect to altitude at 300 masl, and temperatures of 26°C.[11] Even though this discontinuity is important, it is not sharp and there still some municipalities with palm above 300 masl and with maximum temperatures below 26°C.

Figure 15 in the appendix also shows a small discontinuity in FID rates just before 300 masl. Graphically, we do not observe any jump in FID rates with respect to the discontinuity in temperature. Table 2 shows the differences in palm cultivation and FID rates around the altitude and temperature cutoffs more formally, Calonico et al. (2014) regression discontinuity estimates.[12]

The evidence is not very strong. For the estimations using altitude as running variables we found a significant positive change in the probability of having palm trees; however, we only found a negative significant effect to FID rates from 2008 to 2014. We do not have information about labor markets. However, this effect can be related to better wages or more jobs after the rapid expansion from 2002 to 2007. In the case of temperature, we found no significant differences in any variable around the cutoff. The results in figure 15 and table 2 may be disappointing. Yet, a RDD does not directly test our idea of palm producers reaction to income shocks. For that reason, we believe that our difference-in-difference strategy better represents the hypothesis we want to

[11] Figure 12 in appendix A shows that with respect to altitude and temperature the average yield in a municipality does have a clear discontinuity. However the discontinuities do not perfectly match with the expected values – 500 masl and 26°C, but we do find discontinuities in 300 masl and 24°C. This difference comes from the strong correlation between temperature and altitude – figure 13 appendix A

[12] It is important to point out that in our case a *fuzzy regression discontinuity design (FRDD)* does not apply. Using FRDD we would be instrumenting palm crops with the discontinuity around the cutoffs, in order to estimate the effect of palm on FID. Nevertheless, we want to test the opposite mechanism in which violence was used to displace individuals in order to get new lands for palm.

Table 2: The effect of discontinuities in altitude and temperature requirements to crop African palm on the probability of having African palm plantations and FID rates.

	Altitude ≤ 300		Temperature ≥ 26	
	African Palm	FID	African Palm	FID
Panel A: 2002 - 2007				
RD estimate	0.096^{**}	-0.201	0.379^{**}	-0.110
	(0.010)	(0.136)	(0.059)	(0.235)
Bandwidth	0.12	0.14	0.14	0.19
N	1188	1218	1134	1338
Panel B: 2008 - 2014				
RD estimate	0.054^{**}	-0.384^{**}	0.053	0.063
	(0.013)	(0.084)	(0.076)	(0.162)
Bandwidth	0.07	0.17	0.14	0.20
N	623	1440	1160	1529

Notes:
Standard errors in parentheses. $^{+}$ $p < .1$,* $p < 0.05$,** $p < 0.01$. RD estimates and bandwidths as Calonico et al. (2014). All the estimations include year and region fixed effects. Municipality level controls include one lag of logarithm of population, rurality index, the municipality income and tax income per capita, presence of each IAG (FARC, ELN and AUC), presence of coca crops, IAG demobilization rates and oil and coffee intensity from Dube and Vargas (2013). Altitude estimations control for max temperature and temperature estimations control for minimum altitude.

test.

Table 3: Effects of changes in palm oil prices on FID rates over palm producing municipalities.

	2002 - 2007				2008 - 2014			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Palm producer	-4.197^{**}				0.326			
	(1.416)				(1.103)			
$Ln(P_{t-1})$	-0.943^{**}				-0.263^{**}			
	(0.149)				(0.067)			
$Ln(P_{t-1}) \times$ Palm producer	0.681^{**}	0.429^{*}	0.236	0.401^{+}	-0.059	-0.063	-0.268	-0.068
	(0.225)	(0.203)	(0.224)	(0.238)	(0.160)	(0.160)	(0.180)	(0.180)
Mun. level controls		Y	Y	Y		Y	Y	Y
Year F.E.		Y	Y	Y		Y	Y	Y
Municipality F.E.		Y	Y	Y		Y	Y	Y
Control group mean	3710.20		2179.20	3148.96	1587.51		976.29	1332.86
S.D.	6350.11		5158.28	5742.42	2574.51		2071.03	2422.67
R^2	0.017	0.084	0.041	0.083	0.002	0.096	0.072	0.085
N	2988	2988	6366	2346	3486	3475	7414	2727

Notes: Standard errors clustered at municipality level in parentheses. $^{+}$ $p < .1$,* $p < 0.05$,** $p < 0.01$. Municipality level controls include one lag of logarithm of population, rurality index, the municipality income and tax income per capita, presence of each IAG (FARC, ELN and AUC), presence of coca crops, IAG demobilization rates and oil and coffee intensity from Dube and Vargas (2013).

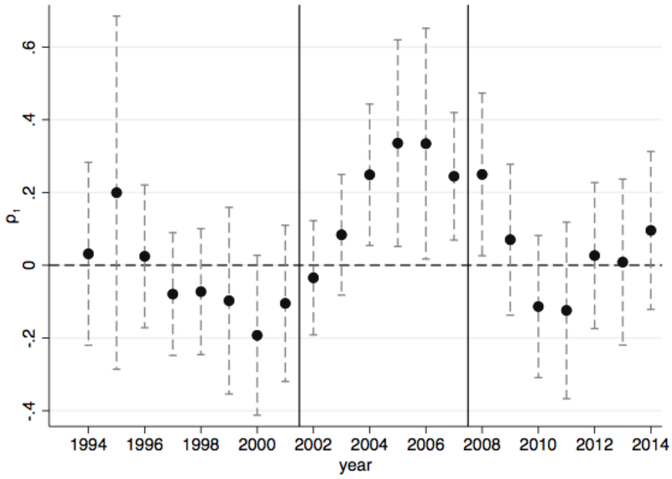
Table 3 shows the resulting estimates of equation 1. Columns 1 through 4 show the results for the period of 2002 – 2007, and columns 5 to 8 show the results for the period of 2008 to 2014, to take into account the 2007's structural changes explained before. For columns 1 and 5 we exclude all the control variables and fixed effects to see some initial effects.[13] We can already see a positive and significant effect of palm prices from 2002 to 2007, and a negative but not-significant effect from 2008 to 2014.

Our favorite estimation is in Column 2. According to our results, a 1% increase in the international price

[13] For columns 1 and 5 we also include a dummy for palm producers and the prices of palm independently to keep the difference-in-difference structure.

of palm oil increases the FID rate on palm producing municipalities with respect to the non-palm producers by 0.429 standard deviations. This effect disappeared for the period 2008 to 2014 (see column 6). In column 3 (and 7) we expand our control group to all municipalities in Fedepalma's regions. In this case our estimates diminished and are no longer significant. Finally, column 4 (and 8) use a temperature above 26°C to determine availability of land for palm.[14] The estimated coefficient in column 4 is marginally smaller than the one in column 2. Both column 2 and 4 show that, as we expected, a positive income shock in the palm market increased FID in those municipalities with respect to the FID rates in similar municipalities but that did not have palm before the expansion.

Figure 7: Estimated FID difference between palm producers and non-producers by year (1994 - 2014)



Notes: We estimate $FID_i = \rho_0 + \rho_1 C_i + X_i + \mu_i$ yearly. Confidence interval at 95% in dashed lines. All estimations include the same municipality level control variables as table 3.

Additionally, in figure 7 we show the estimated difference between producers and non-producers, annually. We can see that this difference is only significantly positive from 2004 to 2008, which aligns with the positive increase in the price from 2001 to 2008. As explained before, 2008 fixed a structural change with respect to the market for different factors. The figure then shows that after 2008, despite the sharp decrease in the price, FID rates have not been smaller in palm municipalities with respect to non-palm municipalities. Additionally, the fact that we do not find statistically significant differences before 2002 counts as supporting evidence of the parallel trend assumption, essential for our estimations.

When we divided the sample by palm region, we found that increases in oil prices only significantly increase FID rates of palm municipalities in the Central region and East region.[15] In the South region and the North region, the effect is weaker and not significant. Finally, we did not find significant effects in any region from 2008 to 2014.

In order to understand these regional differences we investigate the way in which the expansion happened in each region. Figure 8 shows how the palm area and the municipalities with crops increased over the expansion period. From panel A, we can observe that the South region grew parallel to other regions until 2006 where the area dropped radically over next three years due to a rot disease epidemic (Martínez et al., 2008). This could

[14] Hence, the control group includes municipalities with temperatures above 26°C in Fedepalma's regions without palm before 2002

[15] Our results in the East region corroborate the findings by Maher (2015)

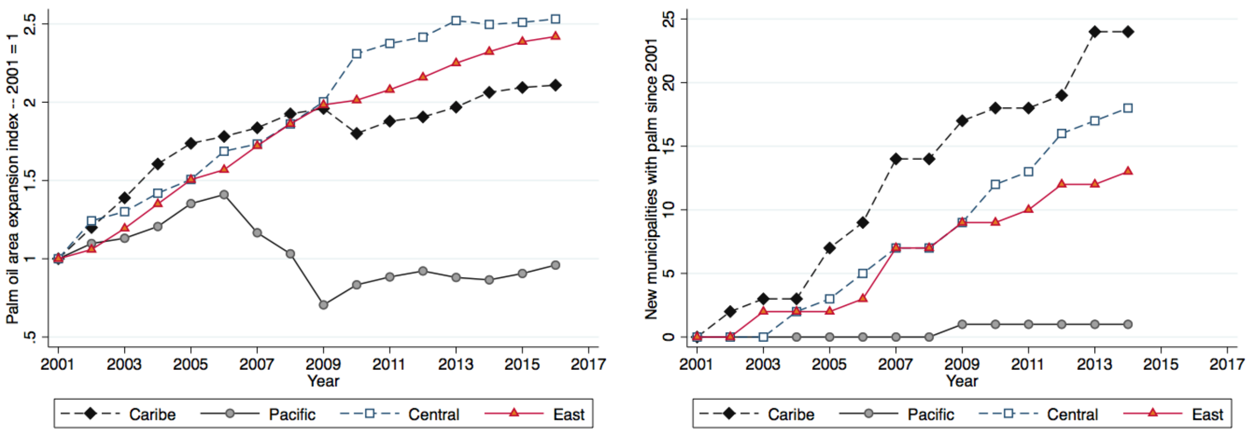
Table 4: Effects changes in palm oil prices on FID by palm region and period

	North	South	Central	East
Panel A: 2002 - 2007				
$Ln(P_{t-1}) \times$ Palm producer	0.107	0.082	1.113**	1.259**
	(0.360)	(0.436)	(0.352)	(0.407)
Control group mean	2956.14	5100.01	3560.81	4628.65
S.D.	4992.66	9757.22	7421.44	5412.51
R^2	0.169	0.167	0.122	0.080
N	1140	210	912	726
Panel B: 2008 - 2014				
$Ln(P_{t-1}) \times$ Palm producer	-0.274	0.736	-0.004	0.119
	(0.242)	(0.770)	(0.217)	(0.260)
Control group mean	814.81	4590.56	1309.37	2215.52
S.D.	1720.04	4329.07	2421.53	2386.09
R^2	0.177	0.167	0.044	0.316
N	1322	245	1064	844

Notes: As per table 3 column 2.

explain why we do not find significant results for the South.

Figure 8: Palm oil expansion since 2001 by region. Additional area and new municipalities



(a) Area expansion (b) New municipalities

Source: Fedepalma

Regarding the Palm expansion in the North, we expect that the effects were similar to those in the Central region and East region, because they closely follow a trend of increased cultivated area (panel A). However, the expansion in the North was driven by the access to lands in new municipalities instead of expanding on the original municipalities (panel B). By 2007, the 14 new municipalities in the North had palm crops, while only 7 new municipalities in the Central and East regions had palm. We do not claim that violence did not play a part in the expansion in the North; however, our estimations capture the intensive margin (new lands in the same municipality) instead of the extensive margin (new lands in new municipalities).

For this reason, in table 5, we try to separate the effect of the palm expansion on FID rates in the intensive (expansion of palm in municipalities already with palm) and extensive margin (the expansion of palm into new municipalities). Column 1 is exactly as table 3 column 2. In column 2, we change the definition of treatment with a dummy that takes the value of 1 if the municipality has palm crops in a given year. In this case, even when using municipality fixed effects, one can expect that the decision of having or not palm trees in a given

Table 5: Effects changes in palm oil prices on FID rates – Intensive vs Extensive margin (2002 – 2007).

	All			By region			
	(1)	(2)	(3)	North	South	Central	East
Palm producer (θ_1)		-2.342$^+$	1.172	1.351	0.000	-2.063	15.249
		(1.314)	(1.310)	(2.439)	(.)	(2.576)	(9.888)
$Ln(P_{t-1}) \times$ Palm producer$_{2002}$ (θ_2)	0.429*		0.594**	0.288	0.425	0.849*	3.664*
	(0.203)		(0.202)	(0.363)	(0.434)	(0.371)	(1.575)
$Ln(P_{t-1}) \times$ Palm producer (θ_3)		0.375$^+$	-0.182	-0.183	-0.653$^+$	0.316	-2.410
		(0.208)	(0.206)	(0.388)	(0.378)	(0.395)	(1.575)
$\theta2 + \theta3 = 0$ (p. value)			0.055	0.781	0.610	0.003	0.003
R^2	0.08	0.08	0.08	0.17	0.17	0.12	0.08
N	2988	2988	2988	1140	210	912	726

Notes: As per table 3 column 2.

year is endogenous and depends on unobservable time variant characteristics that could be correlated with the costs and returns of using displacement as a strategy to begin palm productions. The estimated coefficient is smaller than the one in Column 1 which tells us that FID may not have been part of the strategy in this new municipality, and maybe improvements in labor market conditions could have reduced FID with respect to those municipalities that did not crop African palm. From Column 3 onwards, we estimate the following equation:

$$FID_{it} = \theta_1 C_{it} + \theta_2 C_{i\ 2002} \times Ln\left(P_{t-1}\right) + \theta_3 C_{it} \times Ln\left(P_{t-1}\right) + X_{it} + T_t + M_i + \eta_{it} \tag{2}$$

C_{it} takes the value of 1 if the municipality i has palm crops in year t and $C_{i\ 2002}$ equals to 1 if the municipality i had palm crops before 2002. In this case, θ_3 represents the effect of palm prices on FID rates of municipalities where palm crops started after 2002, and as response of the better market conditions. The effect of palm prices over original palm producers, if they continue producing, is now the sum $\theta_2 + \theta_3$. For this reason we also report the p-value of such sum to be able to see if the effect is statistically significant.

All the results aligned with the idea that the effect of international palm oil prices focus on the municipalities with palm before 2002 (intensive margin) but not in the new municipalities with palm crops (extensive margin). As described before, the estimated coefficient in Column 2 is smaller than the one in Column 1, showing that increases in palm prices may have reduced FID in new palm municipalities. Despite not being statistically significant, the estimation of θ_3 is negative for all estimations except for the Central region. The effect of prices on original producers remains positive and significant for all regions (Column 3) and for the Central region and East region as well (as shown in table 4).

These results give us information about the production function of palm producers. Taking into account that palm is intensive in lands, the cost-benefit of using displacement as a strategy to increase benefits after the income shock may depend on the initial capacities (initial land).

5.1 Possible channels

As we explained before, there are some features that set the ground for a relationship between FID and the palm oil expansion. First, using the assumption that palm oil is intensive in capital (land) and with increasing returns to scale, the positive income shock should have given incentives to palm producers to look for new lands in order to increase production. Hence, one can expect that the violent mechanism was more prevalent in areas where land was owned by many small producers because it would be easier to bargain with landowners who won small swathes instead of landowners who own large swathes.

We estimate our main model (as table 3 column 2) over different levels of land concentration. We divide the sample by quartiles of the estimated Gini coefficient at the municipality level using the land distribution in 2000. Table 6 panel A shows the resulting estimates by quartile. We can see that our estimate is larger for the first quartile (better land distribution), than in the last 2 quartiles (more land concentration). What is more, the effect is only statistically significant in the first quartile.

Table 6: Effects changes in palm oil prices on FID rates by land concentration and informality quartiles (2002 – 2007).

	Quartile			
	1	2	3	4
Panel A: By land concentration (Gini) quartile				
$Ln(P_{t-1}) \times$ Palm producer	0.935*	0.351	-0.057	0.147
	(0.463)	(0.368)	(0.660)	(0.346)
Gini quartile	0.60	0.68	0.73	0.98
Control group mean	5114.01	3736.00	2560.25	2014.20
S.D.	7253.78	6195.51	4698.81	3145.73
R^2	0.103	0.109	0.127	0.089
N	630	636	636	636
Panel B: By land formality quartile				
$Ln(P_{t-1}) \times$ Palm producer	-0.317	1.120**	0.137	0.613
	(0.414)	(0.307)	(0.456)	(0.428)
Informality quartile	0.07	0.16	0.34	1.00
Control group mean	1989.01	2919.79	3967.50	4437.87
S.D.	3910.20	4905.22	6643.87	6204.72
R^2	0.104	0.116	0.163	0.070
N	546	630	630	624

Notes: As per table 3 column 2.

Second, we also argue that weak institutions, specifically in the context of land ownership, facilitated the alliance between palm owners and violent organizations. Table 6 panel B shows the estimated results by land formality quartiles (measured by the proportion of lands with official registry). The results aligned with the ones in panel A. Palm oil prices only have a significant effect over palm producing municipalities where institutions are weak and not a lot of land was registered.

Third, the relationship between palm expansion and violence is strongly connected with the presence of paramilitary armies. Thus, we split the analysis by the presence or lack thereof of the main illegal armed groups before the expansion. Table 7 shows the results by illegal armed group.

When we divide the sample with respect to the presence of AUC (paramilitary), the results are only significant for municipalities with AUC. When we compare regions with and without guerrilla groups (FARC and ELN), the results are stronger for areas without FARC. With respect to ELN, the estimates are statistically significant in both cases. These results support previous evidence about the link between paramilitary armies and the effect relationship between the palm expansion and the violent conflict (for example Goebertus, 2008). In addition, the fact that the positive effect disappear after the AUC's demobilization corroborates the hypothesis.

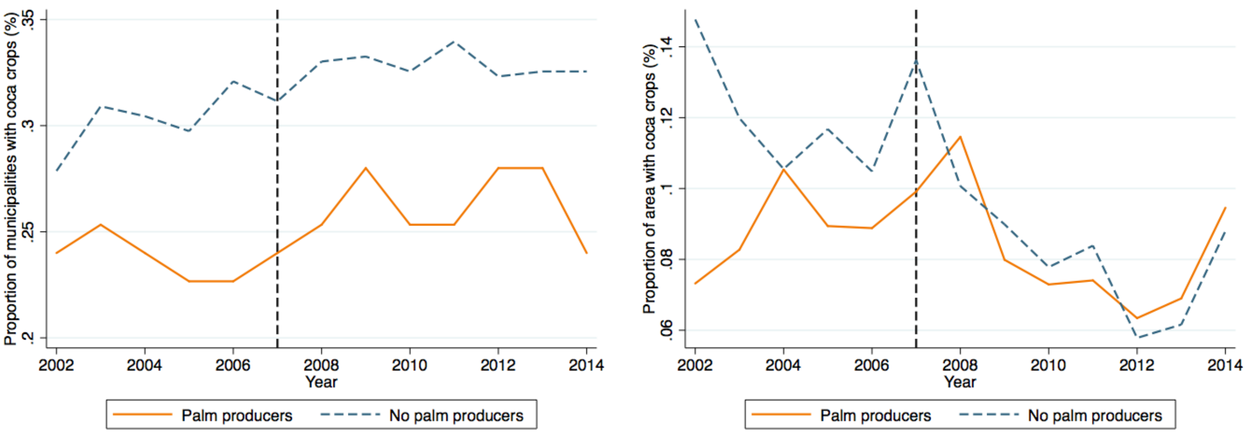
Table 7: Effects changes in palm oil prices on FID rates by presence of illegal armies before the palm expansion (2002 – 2007).

	AUC		FARC		ELN	
	YES	NO	YES	NO	YES	NO
$Ln(P_{t-1}) \times$ Palm producer	0.649^{*}	0.336	0.328	0.706^{*}	0.547^{+}	0.620^{**}
	(0.276)	(0.345)	(0.276)	(0.296)	(0.317)	(0.217)
R^2	0.146	0.045	0.116	0.053	0.132	0.063
N	1392	1596	1716	1272	1278	1710

Notes: As per table 3 column 2, excluding presence of IAG. Presence of IAG before the expansion is defined as having a given IAG in the year 2000.

Finally, we explore the relationship between coca cultivation and palm oil expansion. As explained before, the national government focused its efforts on promoting palm as a way to substitute illegal coca crops (Grupo Semillas, 2010). Thus, one could expect that if the government strategy was successful, the rise in palm production would be correlated with a decrease in coca cultivation. First, figure 9 shows the evolution of coca crops with palm and without palm. Panel A shows that among the municipalities without palm before the expansion, the proportion of municipalities with coca crops slowly increased from 2002 to 2014. Meanwhile, among palm producers, the proportion of municipalities with coca barely decreased until 2006 but increased consistently until 2009. Panel B shows the evolution of the area cultivated with coca. Among municipalities without palm before 2002, there was a sharp decrease in the area with coca crops until 2012 (from 14% to less than 6% between 2002 and 2012). In palm municipalities from 2002 to 2008 the area with coca crops increased from about 8% to 11%. Afterwards, the area of coca crops also decreased in the palm producing municipalities until 2012 reaching a proportion of close to 6%. Coca crop areas increased in both areas from 2012 to 2014. These trends show that the governments aim of replacing coca for palm may have had a limited effect.

Figure 9: Coca cultivation in palm producers and no palm producers (2002 – 2014).



(a) Municipalities with coca (b) Area with coca

Notes: Authors' calculations using Fedepalma and Human Rights Observatory (CEDE) data.

We also check if the effect of prices on FID defers from the regions where there were coca crops before the expansion (table 8). Our estimations in Panel A show that from 2002 to 2007 the effect of prices focused on the regions where coca crops were present before the palm expansion, even if the presence of IAG is controlled for. Also, in Column 6, we included the presence of coca crops with one year lag as a control variable and the resulting coefficient only reduces marginally. This result suggests little interaction between the decisions of cropping palm and coca.

Table 8: Effects changes in palm oil prices on FID rates by presence of coca crops before the expansion.

	Without coca crops			With coca crops		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: 2002 – 2007						
$Ln(P_{t-1})$ × Palm producer	0.228	0.228	0.234	0.860*	0.852*	0.822*
	(0.257)	(0.257)	(0.258)	(0.357)	(0.362)	(0.363)
IAG presence (1 lag)		Y	Y		Y	Y
Coca crops (1 lag)			Y			Y
R^2	0.084	0.085	0.087	0.110	0.111	0.112
N	1962	1962	1962	1026	1026	1026
Panel B: 2008 – 2014						
$Ln(P_{t-1})$ × Palm producer	-0.199	-0.214	-0.219	-0.011	-0.013	-0.007
	(0.244)	(0.246)	(0.248)	(0.295)	(0.298)	(0.299)
IAG presence (1 lag)		Y	Y		Y	Y
Coca crops (1 lag)			Y			Y
R^2	0.126	0.135	0.136	0.126	0.127	0.127
N	2281	2281	2281	1194	1194	1194

Notes: As per table 3 column 2. Only marked columns include the presence of IAG group and coca crops with one year lag as control variables. Presence of coca crops before the expansion is defined as having coca in the year 2000.

We add as well estimations from 2008 to 2014 (panel B), because a reduction in palm cultivation until 2012 was observed. However, we do not find any statistically significant effect of palm prices on FID rates, neither in regions with or without coca before the expansion. Once again, as previously shown in tables 3 and 4, and figure 7, income shocks in palm prices seem not to have any effect on FID rates after 2008.

The results in table 8 panel A show that the negative effect of palm prices focused on coca regions but we actually do not see a reduction in palm cultivation (figure 9). These results align with the hypothesis of weak institutions in coca cropping regions as a key factor to understand the increase in FID as a result of a positive income shock in the palm market.

5.2 Palm, violence and displacement

Thus far, we have shown how the income effect raised FID rates in palm municipalities with respect to the FID rates in municipalities without production. We also showed evidence that supports the idea that the shock in expected income due to an increase in the price of palm oil, increased FID in regions with weak institutions and larger land availability. However, there is still an unanswered question. Why did people leave their towns? According to Ibáñez and Vélez (2008), some violent events are highly correlated with a households decisions to migrate. The most important indicators among these are receiving threats, suffering indirect violence and the presence of paramilitary and/or guerrilla armies. Ibáñez and Vélez (2008) also shows that individuals who used to own land were more likely to be violently displaced. Also, many individuals reported losing their lands after leaving their hometowns.

We have already shown evidence of the importance of the AUC. In this section we want to explore which type of violence could have been used by IAG (and the possible alliance with landlords) to displaced households

Table 9: Violence indicators on FID rates in regions with African Palm and lands below 500 masl (2002 – 2007).

Violence	All municipalities (1)	Central & East (2)	With AUC in 2000 (3)
Threats (rate)	0.312**	0.341**	0.279*
	(0.081) [2408]	(0.123) [1323]	(0.121) [1279]
Homicides (rate)	0.288**	0.310**	0.315**
	(0.055) [2490]	(0.073) [1365]	(0.073) [1160]
Targeted homicides (rate)	0.388**	0.468**	0.440**
	(0.050) [2988]	(0.071) [1638]	(0.074) [1392]
Collective homicides (at least 1)	0.174*	0.131	0.168
	(0.088) [2490]	(0.113) [1365]	(0.110) [1160]
Landmines accidents (rate)	0.147**	0.142**	0.114+
	(0.040) [2988]	(0.053) [1638]	(0.058) [1392]
Landmines accidents (at least 1)	0.218**	0.117*	0.144*
	(0.060) [2988]	(0.049) [1638]	(0.068) [1392]
Kidnapping (rate)	0.029*	0.024	0.028
	(0.013) [2490]	(0.020) [1365]	(0.022) [1160]
Kidnapping (at least 1)	0.021	0.007	0.018
	(0.040) [2490]	(0.048) [1365]	(0.063) [1160]
Attacks to town (rate)	-0.009	0.002	-0.025+
	(0.011) [2490]	(0.002) [1365]	(0.014) [1160]
Terrorist attacks (rate)	0.098*	0.123*	0.141**
	(0.041) [2490]	(0.053) [1365]	(0.052) [1160]
Terrorist attacks (at least 1)	0.059	0.068	0.003
	(0.053) [2490]	(0.047) [1365]	(0.078) [1160]
Illegal roadblock/checks (at least 1)	0.124*	0.105	0.132+
	(0.058) [2490]	(0.067) [1365]	(0.074) [1160]
Ambush (at least 1)	0.127	0.115	0.122
	(0.102) [2490]	(0.133) [1365]	(0.125) [1160]
IAG clashes with public forces (rate)	0.148**	0.163**	0.147**
	(0.040) [2988]	(0.053) [1638]	(0.053) [1392]

Notes: As per table 3 column 2 except for column 3 where we exclude the presence of AUC. Observations in squared brackets [ ]. Rates in events per htih and standardized to mean 0 and standard deviation 1. The dependent variable in all estimations is the standardized FID rate.

and get new lands. In our first exercise, we explore which violent events are more correlated with FID rates in our region of analysis. Therefore, for the municipalities in Fedepalma's regions and lands below 500 masl, we estimate a series of linear estimations where the outcome variable is FID_{it} and our variables of interest are different violence estimators, VIO_{it}.[16] We estimate the relationship between FID and each violence indicator independently, acknowledging that violent events may be strongly correlated within each municipality. We also made estimations limiting the sample to only the Central region and East region, and to the municipalities with a previous AUC presence.

Similar to findings in previous literature, our results show that direct attacks to populations are positively correlated with FID rates (see table 9 column 1). First, we identify a positive correlation between FID rates and threats, homicides, targeted homicides, accidents with landmines and illegal roadblocks or checks. These results remain significant when we only restrict the sample to the Central region and East region (column 2) and regions with AUC (column 3).[17] Second, terrorist attacks and IAG clashes against public forces are also

[16] We also control for all the variables and fixed effects as table 3 column 2.

[17] The effects of collective homicides and kidnapping are only significant for the entire sample of our analysis.

Table 10: Palm prices on violence indicators in regions with African Palm and lands below 500 masl (2002 - 2007).

Violence outcome variable (VIO_{it})	All municipalities (1)	Central & East (2)	With AUC in 2000 (3)
Threats (rate)	0.196	0.052	0.384
	(0.310) [2408]	(0.597) [1323]	(0.391) [1279]
Homicides (rate)	0.206	0.541	-0.016
	(0.433) [2490]	(0.687) [1365]	(0.499) [1160]
Targeted homicides (rate)	-0.205	0.355	0.069
	(0.265) [2988]	(0.361) [1638]	(0.279) [1392]
Landmines accidents (at least 1)	-0.181	-0.100	-0.301^{+}
	(0.122) [2993]	(0.194) [1638]	(0.172) [1392]
Terrorist attacks (rate)	0.695^{+}	0.864	0.395
	(0.402) [2490]	(0.585) [1365]	(0.588) [1160]
Illegal roadblock/checks (at least 1)	-0.355	0.189	-0.051
	(0.281) [2495]	(0.489) [1365]	(0.364) [1160]
IAG clashes with public forces (rate)	0.824*	1.227**	1.412**
	(0.336) [2988]	(0.470) [1638]	(0.471) [1392]

Notes: As per table 3 column 2 except for column 3 where we exclude the presence of AUC. Observations in squared brackets [ ]. Rates in events per 100 thousand inhabitants and standardized to mean 0 and standard deviation 1. We report the estimated coefficient λ_2 from estimations of the equation $VIO_{it} = \lambda_1 + \lambda_2 C_i \times Ln\,(P_{t-1}) + X_{it} + T_t + M_i + \upsilon_{it}$, by different VIO_{it} outcomes.

positively correlated with FID rates. Confrontations between IAG and public forces do not directly involve households (especially urban households), but do create fear in rural households which are closer to combat areas.

After identifying which violent events are more closely related with FID in our analysis, we examine if they change in palm municipalities as a result of changes in the international price of palm oil. For that reason, we estimate the equation 1 but using the violence indicators with positive correlation with FID rates instead of FID rates as outcome variables. Table 10 shows the resulting estimates for the impact of the price of palm oil on each violence indicator. Our estimates show that terrorist attacks and specifically IAG clashes with public forces increases in palm producing municipalities when the price of palm oil increased the year before. According to Ibáñez (2008) terrorist attacks and conflict affect more rural than urban population increasing rural displacement. Therefore, one can expect that the violence linked with the palm expansion is more rural as our results suggest.

In addition, and following our results from the previous section, we further investigated the behavior of AUC. We replicated the estimates in tables 9 and 10 but only for violent actions from AUC and in regions with previous AUC presence. Table 11 Column 1 shows the resulting estimates of the correlations of AUC actions on FID rates, while Column 2 shows the estimates of the effect of international palm prices on AUC action in palm producing municipalities. Combining the results from both columns, one can argue that the resulting income shock from changes in the prices of palm oil increased AUC offensive actions and confrontations against public forces in palm producing municipalities, increasing FID rates there. Once again, prices seem to affect rural AUC violence which could be behind the increase in rural FID rates.

Finally, one can expect that illegal armies do not use a unique specific action but a strategy combining

Table 11: AUC violence indicators on FID and Palm prices on AUC violence indicators in regions with African Palm, lands below 500 masl and AUC's presence in 2000.

Violence outcome variable	Violence on FID (1)	Palm prices on violence (2)
Homicides (rate)	0.043	-1.286^{+}
	(0.033) [1160]	(0.747) [1160]
Targeted homicides (at least 1)	0.123	0.026
	(0.086) [1392]	(0.150) [1392]
Kidnapping (at least 1)	0.129^{+}	-0.257
	(0.068) [1160]	(0.433) [1160]
Attacks against civil Population (rate)	0.067*	-0.104
	(0.029) [1392]	(0.355) [1392]
Terrorist attacks (at least 1)	0.331*	0.080
	(0.167) [1160]	(0.156) [1160]
Attacks to town (at least 1)	0.096	0.083^{+}
	(0.072) [1392]	(0.047) [1392]
Offensive acts against public forces (rate)	0.125**	0.776*
	(0.045) [1392]	(0.325) [1392]
Clashes with public forces (rate)	0.152**	1.257**
	(0.050) [1392]	(0.446) [1392]

Notes: As per table 3 column 2 except for column 3 where we exclude the presence of AUC. Observations in squared brackets [ ]. Rates in events per 100 thousand inhabitants and standardized to mean 0 and standard deviation 1.

different violent actions. In order to capture this possible combination of strategies, we compute a violence index using a Principal Components Analysis (PCA) as introduced by Anderson (1963). Table 12 summarizes the results. For the violence index in Columns 1 to 3, we extract the first component of the PCA using all the continuous variables that have a significant correlations with FID rates (as shown in table 9). Meanwhile, for column 4 we use the continuous variables of AUC actions that have a significant correlation with FID rates (as table 11 column 1).[18]

The results are stronger than in our previous analyses. Panel A shows the correlation between different violence indexes and FID rates. For all cases, the violence index is strongly positively correlated with FID rates. Afterwards, Panel B estimate the effect of palm prices on the violence index over palm producing municipalities. In this case, palm prices show a positive significant effect on the violence index. According to these results, an increase in the international price on palm oil increased the violence on those municipalities with palm with respect to the municipalities without palm. Combining this result with the results in table 3 column 2, we show that violence increased when palm prices increased, this violence increased FID rates in palm producing municipalities, allowing palm owners to access more land and get benefits from the palm expansion.

5.3 Other possible uses of African palm

In this section we analyze the effect of other related prices on the relationship between palm expansion and the displacement process in Colombia. First, figure 10 shows the evolution of palm oil prices again together with the price of biodiesel (B20 and B90). The figure shows that despite some common trends, there are important

[18] PCA coefficients are in table 15 appendix A.

Table 12: Violence index on FID rates and palm prices on violence index, in regions with African Palm and lands below 500 masl (2002 - 2007).

	Violence from all violent actors			AUC violence
	All municipalities	Central & East	With AUC in 2000	With AUC in 2000
	(1)	(2)	(3)	(4)
Panel A. Violence index on FID rates				
Violence index (pca)	0.274**	0.318**	0.272**	0.120**
	(0.044)	(0.060)	(0.053)	(0.035)
R^2	0.21	0.33	0.27	0.18
Panel B. Palm prices on violence index				
$Ln(Pt-1)$ × Palm producer	1.423*	1.840+	0.834	1.201**
	(0.685)	(1.025)	(0.890)	(0.430)
R^2	0.18	0.23	0.22	0.10
Eigenvalue	2.33	2.40	2.40	1.87
N	1989	1093	1062	1392

Notes: Standard errors clustered at municipality level in parentheses. $^+ p < .1, ^* p < 0.05, ^{**} p < 0.01$.
All estimations control for department fixed effects, log of population, urban area proportion, we also include the presence of illegal armies (FARC, ELN and AUC), the municipality income and tax income per capita with one year lag. Columns 3 and 4 do not control for the presence of AUC. The violence index for columns 1 to 3 uses threats, homicides, targeted homicides, terrorist attacks and combats with public forces as inputs. For column 4 the violence index uses attacks against the population, offensive acts against public forces and combats with public forces by AUC as inputs.

differences among them.

It is important to remember that one of the reasons we divide the analysis in two periods is the change in the use of African palm from palm oil consumption to biodiesel from 2008 onwards. Thus, if the price of palm oil represents the income shock from 2002 to 2007, biodiesel prices should represent the income shock from 2008 to 2014. We have already shown that FID rates only reacted to changes in the price of palm oil from 2002 to 2007.

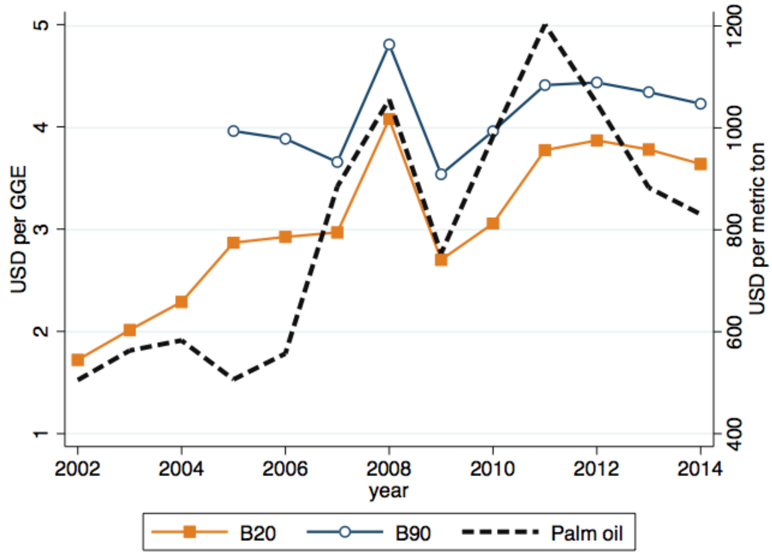
Table 13: FID rates on international prices of palm oil and alternative palm oil based fuels.

	Palm oil	Biodiesel (B20)	Biodiesel (B90)
Panel A. 2002 - 2007.			
$Ln(P_{t-1})$ × Palm producer	0.429*	0.068	
	(0.203)	(0.202)	
R^2	0.084	0.083	0.083
N	2988	2988	2988
Panel B. 2008 - 2014.			
$Ln(P_{t-1})$ × Palm producer	-0.063	0.114	0.028
	(0.160)	(0.187)	(0.273)
R^2	0.096	0.096	0.096
N	3475	3475	3475

Notes: As per table 3 column 2.

Table 13 shows the estimates of equation 1 using different prices. Once again, we divide the analysis into two periods (2002 to 2007 and 2008 to 204). Column 1 shows the results using again the price of palm oil as reference point (as table 3 columns 2 and 5). Columns 2 and 3 show the resulting estimates of different alternative fuels. We do not find any statistically significant effects. Therefore, one can conclude that an income shock alone does not create a negative externality without the institutional weakness associated with the presence of AUC

Figure 10: Palm oil and alternative fuels prices - 2002 - 2014



Notes: Ethanol and Biodiesel prices in USD per Gasoline-Gallon Equivalents (GGE) – left axis. Palm oil price in USD per metric tons – right axis. All prices in constant USD, 2015 = 100.
Source: US Department of Energy (2020) and ISTA Mielke GmbH, Oil World; US Department of Agriculture; World Bank. (downloaded from www.indexmundi.com).

in these regions.

5.4 Magnitude of the results

First, it is important to point out that on average, FID rates decreased from 2002 to 2007 (see figure 3 panel c). However, FID rates fell more in the non-palm producing municipalities than in palm producing municipalities. Second, our favorite specification is the one in table 3 Column 2, where a 1% yearly increase in the price of palm implies an increase in FID rates by 0.429 standard deviations in palm producing municipalities.

We computed the average FID rate in palm and non-palm producing municipalities in 2002 and 2007. For non-palm municipalities the rate dropped from 5,805.6 to 647.5 dphtih. In palm producing municipalities the average FID rate fell from 4,780.9 to 3,697.5 dphtih. Therefore, the FID fell by 1,141.9 dphtih more in non-palm producing municipalities than in palm producing municipalities.

In addition, the increase in the price of palm oil from 2001 to 2006 was 0.39 log points. Taking into account our estimated coefficient and the FID standard deviation, the increase in price over five years represented an increase in the FID rate by 1,073.6 dphtih. Therefore, one can argue that the rise in palm oil prices accounted for 74.4% of the difference in the FID rates between palm and non-palm producers. Taking into account the average municipality population (55,501 inhabitants), the shock represents about 596 displaced individuals in a given municipality over 6 years. On average, 1,457 people were displace per municipality per year from 2002 to 2007 among palm producing municipalities. Therefore, the price increase could account for 7% of the total displacement in these municipalities.

Even though these exercises are not taking into account the effects heterogeneity, one can conclude that palm expansion was very important, especially in helping understand the differences in FID trends between non-palm and palm producing municipalities. We do acknowledge that the expansion did imply significant gains for the economy at the local and national levels. However, due to the great cost of displacement on displaced households and on the local economies in origin and receiving municipalities, the negative externality is not negligible.

Furthermore, we observe a rapid increase in FID rates in palm producing municipalities from 2010 to 2014 (figure 3 panel c). Additionally, we also observe an increase in the price of biodiesel during the same period (figure 10). However, we do not find any significant effect from this price increase to FID (table 13 panel B). Hence, our results suggest that the positive economic shock which led to the palm expansion in Colombia only resulted in more displaced individuals due to weak institutions in certain palm producing regions.

6 Conclusions

In order to add more about commodity income shocks and armed violence to the literature, the goal of this article was to provide quantitative evidence about the relationship between the palm oil expansion and the violent conflict in Colombia. Even though the palm oil market seemed like a great opportunity for rural development in the middle of the conflict, weak institutions drove a positive income shock into an increase of violence.

Our estimates showed that the increase of palm oil prices increase FID rates in palm producing municipalities, particularly in regions with paramilitary armies, low land registration, and better land distribution. We also show evidence of how a combination of armed action, especially by AUC, increased when the price of palm increased and that this increase may have induced households to leave their hometowns. These results align with the idea of palm producers using violence in order to gain cheap access to new lands.

Palm differs from other agricultural commodities like coffee. In this case, the positive effects of the price increase on rural labor markets was canceled out by the rapacity effect for the need of new land. This effect only applied when institutional framework was poor.

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A Supplementary tables and figures

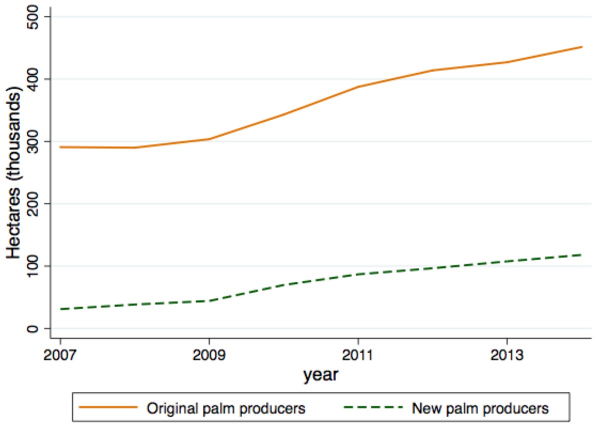
Table 14: Data sources

Variable	Period	Source
Forced internal displacement	1993 - 2014	RUV-CEDE
Palm oil international price	1990 - 2014	ISTA Mielke GmbH, Oil World; US Department of Agriculture; World Bank.
Palm oil presence and area by municipality	1992 - 2014	Fedepalma
Violence indicators		
Homicide rate	1993 - 2014	Human Rights Observatory – CEDE
Presence of IAG	1993 - 2014	Human Rights Observatory – CEDE
Municipalities with coca trees	1993 - 2014	Human Rights Observatory – CEDE
Demobilizations	1993 - 2014	Human Rights Observatory – CEDE
Threats	1993 - 2014	RUV – CEDE
Homicides	2003 - 2014	Ministry of Defense – CEDE
Targeted homicides	1993 - 2014	CNMH
Collective homicides	2003 - 2014	Ministry of Defense – CEDE
Mines accidents	1993 - 2014	DAIMA – CEDE
Kidnapping	2003 - 2014	Ministry of Defense – CEDE
Attacks to town	2003 - 2014	Ministry of Defense – CEDE
Terrorist attacks	2003 - 2014	Ministry of Defense – CEDE
Illegal roadblock/checks	2003 - 2014	Ministry of Defense – CEDE
Ambush	2003 - 2014	Ministry of Defense – CEDE
Combats with public forces	1993 - 2010	National police/DAS – CEDE
Other indicators		
Population	1993 - 2014	DANE
Municipality income per capita	1993 - 2014	DNP-CEDE
Municipality tax income per capita	1993 - 2014	DNP-CEDE
Coffee & Oil intensity	1993 - 2014	Dube and Vargas (2013)
Land concentration Gini index	2000 - 2012	IGAC
Land informality index	2000 - 2012	IGAC & CEDE
Alternative fuels prices	2002 - 2014	US Department of Energy (2020)

Table 15: PCA's first component coefficients using violence indicators in regions with African Palm and lands below 500 masl (2002 - 2007)

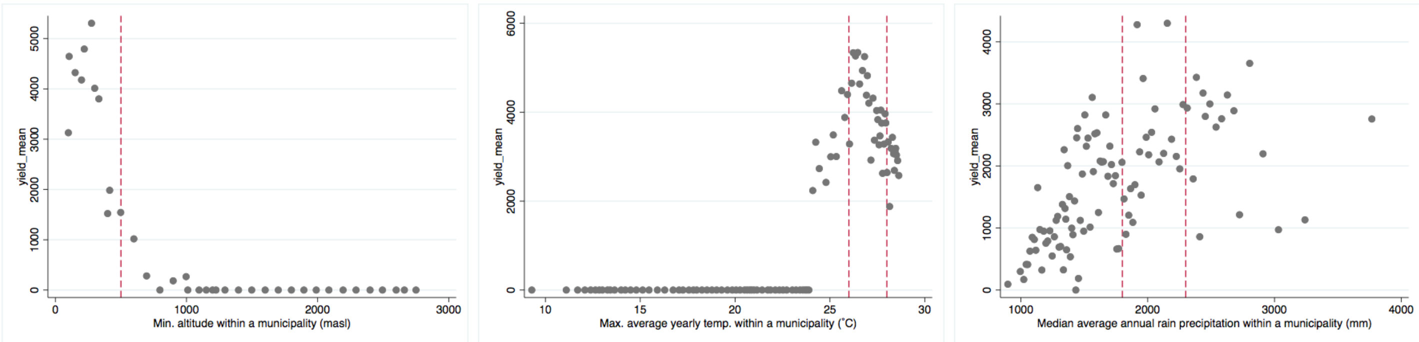
Violence indicator	All municipalities (1)	Central & East (2)	With AUC in 2000 (3)
Panel A. Violence from all violent actors			
Threats	0.243	0.276	0.246
Homicides	0.568	0.565	0.566
Targeted homicides	0.547	0.543	0.553
Terrorist attacks	0.470	0.469	0.475
Clashes with public forces	0.313	0.300	0.297
Panel B. AUC violence			
Attacks against the population	.	.	0.475
Offensive acts against public forces	.	.	0.651
Clashes public forces	.	.	0.593

Figure 11: Area of palm by original producing municipalities and new palm producing municipalities (2007 - 2014)



Source: FEDEPALMA

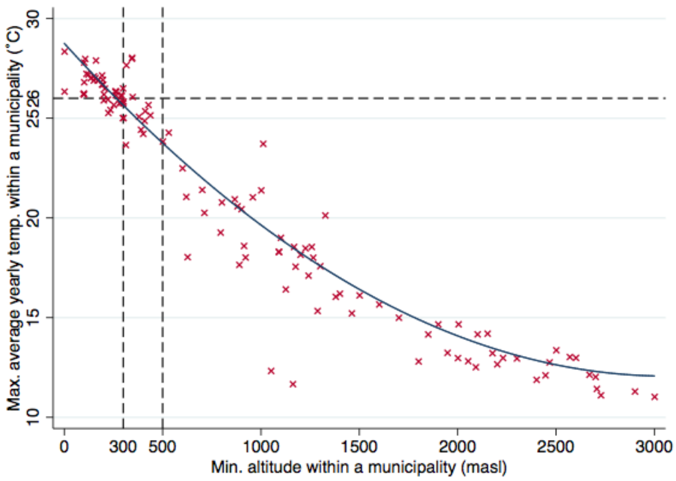
Figure 12: Minimum potential palm oil yield within a municipality with respect to environmental characteristics



(a) Altitude (b) Temperature (c) Rain

Notes: Authors' calculations using data from GAEZ-FAO. All the indicators refer to the period 1961-1990. a) Dotted line at 500 masl. b) Dotted lines at 26°C and 28°C. c) Dotted lines at 1800 and 2300 mm.

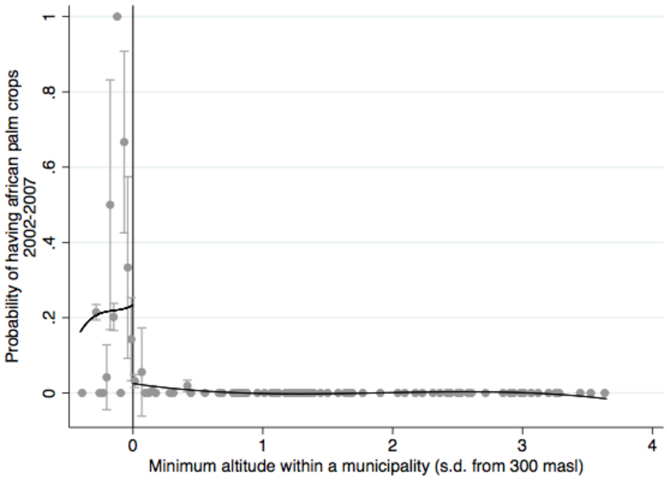
Figure 13: Minimum altitude and maximum average yearly temperature at municipality level



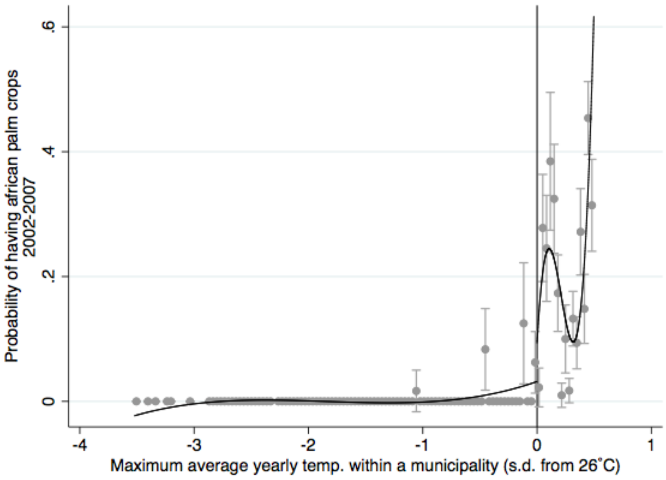
Notes: Authors' calculations using data from GAEZ-FAO. All the indicators refer to the period 1961-1990. Dotted lines at 300 and 500 masl, and at 26°C.

Figure 14: Probability of having African palm by maximum temperature and minimum altitude within a municipality.

2002-2007

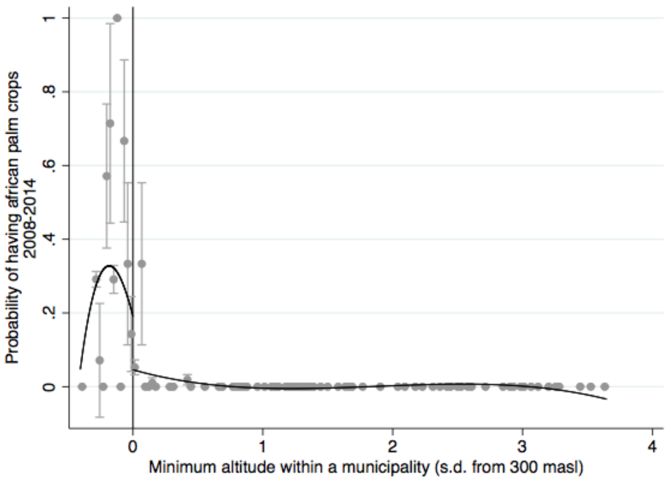


(a) Altitude

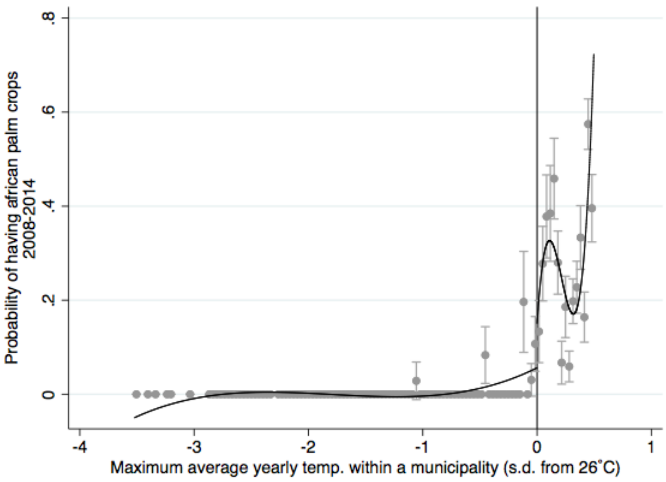


(b) Temperature

2008-2014



(c) Altitude

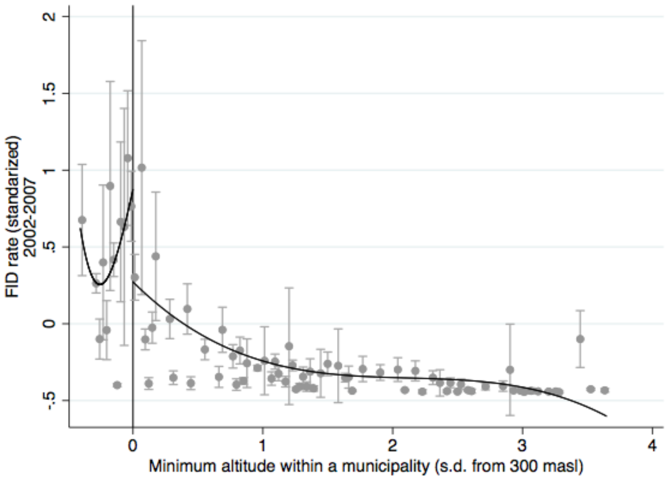


(d) Temperature

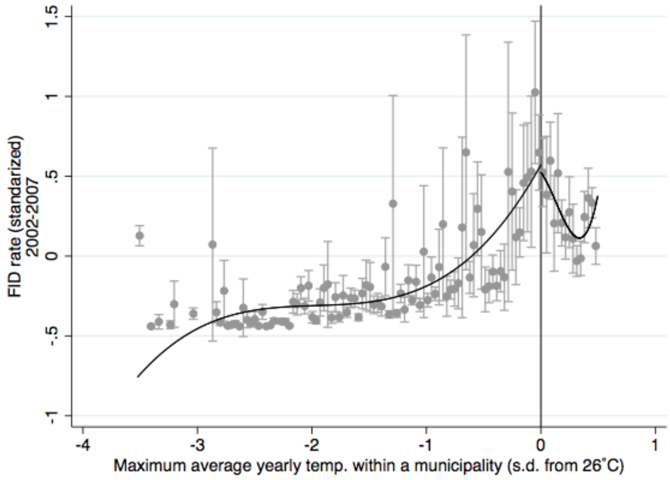
Notes:
Authors' calculations using data from GAEZ-FAO. All the indicators refer to the period 1961-1990.

Figure 15: FID rates from 2002 to 2007 and 2008 to 2014, by minimum altitude and maximum temperature within a municipality.

2002-2007

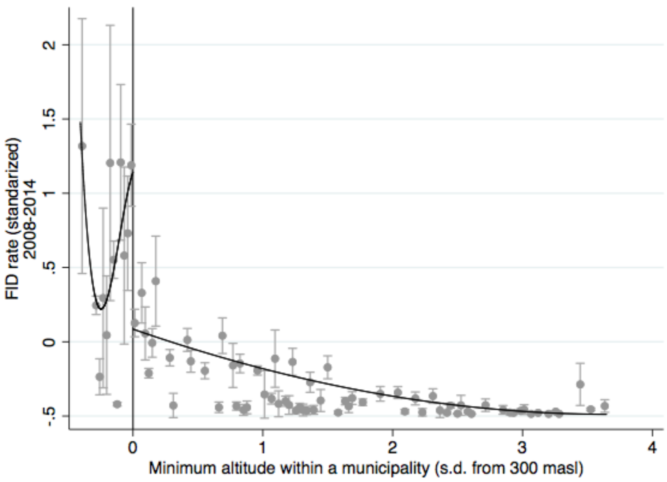


(a) Altitude

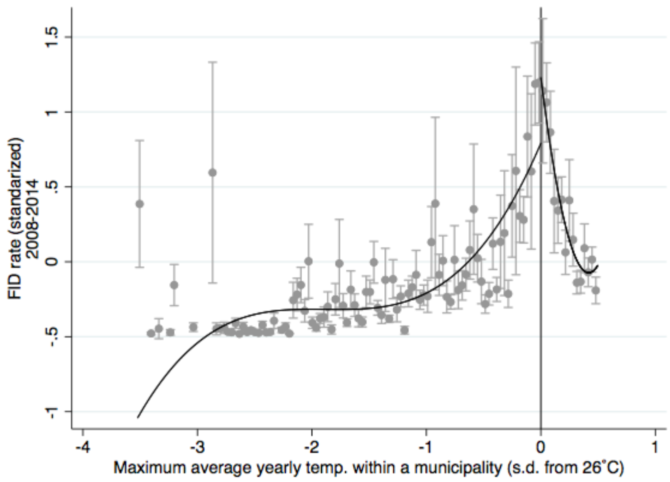


(b) Temperature

2008-2014



(c) Altitude



(d) Temperature

Notes: Authors' calculations using data from GAEZ-FAO. All the indicators refer to the period 1961-1990.