ONLINE APPENDIX

Non-Economic Factors in Violence: Evidence from Organized Crime, Suicides and Climate in Mexico*

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A Literature Review

A.1 Consequences of violence

There is a large literature in economics and political science documenting the negative effects of crime, conflict, and war (from now on "conflict") on different outcomes. For example, in relatively new papers researchers have documented the effect conflict has on health outcomes (Bundervoet et al. 2009, Baez 2011, Akresh 2012, Akbulut-Yuksel 2014b), human capital formation (Blattman and Annan 2010, Shemyakina 2011, Chamarbagwala and Moran 2011, León 2012, Verwimp and Van Bavel 2014, Akbulut-Yuksel 2014a), labor outcomes (Kondylis 2010, Fernandez et al. 2011, Bozzoli et al. 2012), consumption (Serneels and Verpoorten 2013, Velasquez 2019), agricultural investment (Singh, 2012), firm exit (Camacho and Rodriguez, 2012), family formation (Akbulut-Yuksel et al., 2013), wages and prices (Rozo, 2019), and the development of institutions (Voors, 2014). Reviewing this large literature is beyond the scope of this paper, but it is clear that conflict has increasingly negative and pervasive effects in societies.[1]

Researchers have also started to document the consequences of the dramatic increase in violence after 2007 in Mexico. For example, Rios (2014) shows that cities on the U.S.–Mexico border have received relatively more Mexican immigrants in recent years, despite the fact that Mexican immigration to the U.S. reached its lowest point since 2000 across the country as a whole (Cave 2011, The Economist 2012). Other researchers have estimated the impact on labor markets. Robles et al. (2014) use an instrumental variables approach and finds that violence has had negative effects on labor participation and unemployment, and caused a decrease in local economic activity.[2] In the same line of research, Velasquez (2019) uses a differences-in-differences approach at the individual level and finds that increased violence (i) decreases labor market participation and the number of hours worked by self-employed women, (ii) decreases hourly and total earnings of self-employed males, and (iii) decreases per capita expenditure. In addition, Brown (2018) findings suggest that the escalation of violence decreased average birth weight by 70 grams (~ 40 percent), and by ~ 120 for mothers with low socioeconomic status.[3] In a related study, Leiner et al. (2012) results suggest that exposure to violence causes mental health problems (e.g. depression, anxiety, attention, aggressive behavior).

A.2 Seasonality in suicides

For empirical studies analyzing the relationship between temperature and suicides see Rohden (1933), Mills (1934), Pokorny et al. (1963), Grove and Lynge (1979), Dixon and Shulman (1983), Chiu (1988), Marion et al. (1990), Souetre et al. (1990), Linkowski et al. (1992), Barker et al. (1994), Salib and Gray (1997), Jessen et al. (1998), Preti and Miotto (1998), Yan (2000), Leung et al. (2002), Deisenhammer et al. (2003), Lee et al. (2006), Ajdacic-Gross et al. (2007), Preti et al. (2007), Hajat et al. (2007), Qi et al. (2009), Toro et al. (2009), Ruuhela et al. (2009), Tsai (2010), Likhvar and Honda (2011), Kim et al. (2011), Yang et al. (2011), Inoue et al. (2012),Helama et al. (2013), Holopainen et al. (2013). See Ajdacic-Gross et al. (2010)

[1] See Blattman and Miguel (2010) for a review of the literature before 2010, and Miguel and Roland (2011) for long-run consequences of violent events.

[2] The same authors also find evidence of spillovers from homicides to other criminal activities such as extortions, kidnappings, and car thefts, something also noted by Guerrero (2010) and Brown (2018).

[3] For comparison, this effect is larger than estimates of the positive impact on birth weight of federal nutrition programs such as the Supplemental Nutrition Program for Women, Infants, and Children, and the Food Stamp Program in the United States.

and Christodoulou et al. (2012) for a review of the literature on the seasonality of suicides, Deisenhammer (2003) for a review of the literature on weather and suicides until 2003. See Burke et al. (2018) for a summary of the more recent studies.

B Additional Data

In this section we describe our additional data sources and the construction of variables associated with it. We proceed describing variables in the same order that they appear on the main text.

B.1 Drug Trafficking Organizations

We use a number of variables related to the presence of a drug trafficking organization (DTO) in a state. In particular, we use two sets of variables: (1) the number of DTOs operating in a state s in year t, and (2) the shares of the state where the DTOs "Sinaloa" and "Zetas" operate. We define a share of some DTO as the total number of municipalities where that DTO operates over total number of municipalities in that state. We chose these two DTOs because anecdotal evidence (and some quantitative evidence we show later on) shows that the Zetas have been trying to take control over the territory controlled by Sinaloa, and hence many DTO killings seem to be associated with this rivalry.

The data we use to construct these variables comes from Coscia and Rios (2012). These authors use newspapers and blogs, aggregated through Google News, as sources of information to estimate where DTOs operate. In particular, they generate a panel dataset of all municipalities in Mexico, observed *yearly* between 1990 and 2010, with ten indicator variables (one for each DTO). These indicator variables take the value of one if the corresponding DTO is operating in that municipality.

There are two main differences between this DTO dataset and ours. First, we work with states in our analysis, while DTO operations are recorded at the municipality level. Second, our time interval is a month, while DTO operations are recorded on a yearly basis. To facilitate exposition, let $k = 1, \ldots, 10$ represent a certain DTO. To merge DTO operations with our dataset we collapse the yearly data at the state level and create (i) a series of indicator variables DTO_{kst} that take the value of one if a DTO k is operating in state s and year t, and (ii) the corresponding state shares previously described. When doing this we assign yearly information to all months in that year.

Then, we construct our three main variables in the following way. The variable *DTOs* is simply the sum of DTOs operating in state s and year t, i.e. $DTO_{st} = \sum_{k=1}^{10} D_{kst}$. The shares are defined as previously mentioned. In order to show some evidence for the rivalry between Sinaloa and the Zetas, we collapsed our dataset at the state-year level and ran the following regression:

$$y_{st} = \alpha + \lambda_t + \zeta_s + \sum_{k=1}^{10} \beta_k DTO_{kst} + \varepsilon_{st}$$

where y_{st} is DTO killings for each 100,000 inhabitants, α is a constant term, λ_t is a year fixed effect, ζ_s is a state fixed effect, DTO_{kst} are ten indicator variables, and ε_{st} is an error term clustered at the state level. Then, a DTO k is classified as violent if $\beta_k > 0$ and is statistically significant. Figure A.3 presents estimates of this regression equation. Note that the Zetas are operating in every state-month in our sample, so these regression estimates effectively show how DTO killings respond to the presence of DTO pairs of Zetas and another organization. We can see from this figure that the only DTO pair that is statistically associated with DTO killings is the one Zetas-Sinaloa. Sinaloa operates in 46 percent of state-years in our sample period. Descriptive statistics for all these variables are presented in Table A.2.

B.2 Criminal activities

In Table 6 we use a different data source to measure (1) homicides, and we add three variables measuring criminal activities that have a clear economic objective: (2) kidnappings, (3) extortions, and (4) car thefts. This data was collected by the *Secretariado Ejecutivo del Sistema Nacional de Seguridad Pública* (SESNSP) at the Mexican Secretariat of the Interior (*Secretaría de Gobernación*).

To incorporate this information into our dataset we downloaded it from the website of the Mexican Secretariat of the Interior. The raw data is transformed into rates per 100,000 inhabitants in the state using population census data. The only exception is car thefts. When using this variable we add up the raw variables *robo de vehículo con violencia* (violent car theft), and *robo de vehículo sin violencia* (non-violent car theft) to create a variable we call "car thefts". There are, on average, 39 homicides, 2.4 kidnappings, 13 extortions, and 515 car thefts in a state-month in the period between January of 2007 and December of 2010. Table A.2 presents descriptive statistics for these variables in rates, showing the overall standard deviation, and the deviation after removing state, year, and month fixed effects.

Although these variables are available at the state-month level for the period 1997–2014, we only use them for the period 2007–2010 to be consistent with our empirical analysis. Finally, we refer the reader to Merino (2011) for a comparison between this alternative homicide variable and the two variables we use in our main empirical analysis (i.e. DTO killings and homicides from Mexico's Bureau of Statistics).

B.3 Economic variables

In Table 4 we use a series of economic variables. *Log GDP per capita* is measured in 1999 at 1993 prices and the source is Mexico's Bureau of Statistics (INEGI). *Houses with air-Conditioning* is the saturation of residential air-conditioning, from the National Household Income and Expenditure Survey of 2010 (*Encuesta Nacional de Ingresos y Gastos de los Hogares*), officially managed by the Mexico's National Bureau of Statistics since 1984. This is a nationally representative survey of rural and urban areas. This measure is based on an indicator variable for whether a household has an air-conditioning unit, which falls under the category of durable goods. This measure was then aggregated to the state level using ENIGH sampling weights. *Gini* is an income inequality index constructed by Jensen and Rosas (2007) using the 1990 and 2000 Mexican national census. The authors calculate the Gini indices using methods proposed by Abounoori and McCloughan (2003) and Milanovic (1994). Finally, *Unemployment* is monthly unemployment data for each state from the National Survey of Employment and Occupation, and is available since March of 2005 until the end of our period of study.

B.4 Progresa transfers

In Table 3 we use variation in income generated by the program OPORTUNIDADES in Mexico. This social program started in 1997 with the name of PROGRESA (*Programa de Educación y Salud*, Education and

Health Program), and it consisted of conditional cash transfers that targeted poor families in marginal rural areas between 1997 and 2002. A main feature of this program is that it included an evaluation component from its inception. From 2002 the program changed its name and scope and began to incorporate urban areas as well. The budget for this program was approximately 133 million USD in 1997 ($\sim 0.03\%$ of GDP), and it has expanded to almost 5 billion USD in 2010 ($\sim 0.5\%$ of GDP).

We downloaded bimonthly monetary transfers to each state from the program's official website. This information is available for the OPORTUNIDADES program, i.e. from 2002 onwards. In our empirical analysis we use the logarithm of one plus the total amount of bimonthly transfer to a state. Less than 2% of observations correspond to no monetary transfers (i.e. transfer equals zero) in the period we analyze. We take a bimonthly transfer, e.g. 100 USD in January-February, and we split it equally between both months, i.e. 50 USD in January and 50 USD in February. Descriptive statistics for this variable are presented in Table A.2.

B.5 Wage and unemployment

In Panels A and B of Figure A.6 we plot the average bimonthly income and unemployment of agricultural and non-agricultural workers in Mexico. To construct this data we use the National Household Survey of Income and Expenditure (*Encuesta Nacional de Ingresos y Gastos de los Hogares*), officially managed by the Mexico's National Bureau of Statistics since 1984. This is a nationally representative survey of rural and urban areas, and is done every two years since 1992. For these calculations we use the years 1989, 1992, 1994, 1996, 1998, 2000, 2002, and 2004.

The interviews for this survey are done between the months of July and October. One part of this questionnaire constructs, retrospectively, workers' income in the past 6 months. In addition, the occupation of the individual is always part of this questionnaire. Exploiting variation in the distribution of interviews, and classifying individuals in the agricultural and non-agricultural sectors, we were able to construct (i) average monthly income, and (ii) percentage of individuals without income, both from February to October. Finally, we construct two months bins from these numbers to estimate seasonality in income and unemployment for both sectors.

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Table A.1: Operation of Mexican drug cartels

Cartel	Municipalities in 2010	Start Year	Entry	Exit	Years Operated
Sinaloa	176	1993	25.6	17.0	2.8
Golfo	244	1994	35.6	23.5	3.0
Juárez	74	1997	13.9	10.2	2.8
Tijuana	39	1997	10.1	8.2	2.7
Zetas	405	2003	42.2	22.0	2.8
Beltrán-Leyva	157	2004	18.7	10.8	2.1
Fam	227	2005	18.8	7.4	2.1
Barbie	66	2006	5.8	2.5	1.6
Mana	32	2006	3.8	2.2	2.2
Sinaloa*	53	2008	5.2	2.5	2.0
Beltrán-Leyva*	57	2008	5.0	2.2	1.8
Other	24	2008	2.2	1.0	1.4

Source: Table 1 in Coscia and Rios (2012). Entry is the average number of municipalities cartel k enters in a year. Exit is the average number of municipalities cartel k exits in a year. Years operated is the average number of years cartel k operates in a municipality. *Factionalized cartel.

Table A.2: Descriptive statistics for additional variables

	Mean	*St. Dev.*	*St. Dev within*	*Min*	*Max*
Criminal activities					
Homicides	1.22	1.54	0.83	0	11.92
Kidnappings	0.07	0.11	0.09	0	0.90
Extortions	0.41	0.57	0.36	0	5.91
Car thefts	13.41	16.56	5.60	0	112.00
Drug trafficking organizations					
DTOs	6.30	2.47	0.92	1	10
Sinaloa	0.03	0.05	0.03	0	0.27
Zetas	0.21	0.21	0.08	0	0.94
Other					
Log Progresa transfers	17.24	3.75	2.88	0	20.16

Notes: Descriptive statistics for all 32 Mexican states at the month level during the period between January of 2007 and December of 2010.

Table A.3: Differential effect of temperature shocks by type of violence

	Homicide rate		*Standardized homicide rate*	
	(1)	(2)	(3)	(4)
Temperature	0.064*	0.073*	0.013*	0.018*
	(0.034)	(0.039)	(0.007)	(0.010)
$\times$ **DTO killing**	0.003	-0.015	-0.002	-0.010
	(0.010)	(0.020)	(0.003)	(0.007)
Municipality (n), year (y) & month (m) F.E.	Yes	No	Yes	No
F.E. n, y, m by type of violence	No	Yes	No	Yes
Observations	234,916	234,916	234,916	234,912

Notes: Each observation corresponds to a municipality-type-month, where type is the homicide rate or the DTO killing rate. Data for all municipalities in Mexico in the 2007-2010 period . Standard errors clustered at the state level in parenthesis. The standardization in columns 3 and 4 takes the dependent variable and subtracts the type-specific mean and divides by the type-specific standard deviation . All regressions are weighted by population. Levels of significance are reported as ***p$<$0.01, **p$<$0.05, *p$<$0.1.

Table A.4: Including temperature in the previous month

	DTO killings		*Homicides*		*Suicides*	
	(1)	(2)	(3)	(4)	(5)	(6)
Temperature$_t$ (α)	0.035**	0.063	0.019***	0.013***	0.011***	0.007***
	(0.016)	(0.046)	(0.003)	(0.004)	(0.002)	(0.002)
Temperature$_{t-1}$ (β)	0.020		-0.007		-0.006***	
	(0.036)		(0.004)		(0.001)	
Temperature$_{t+1}$ (β)		-0.017		0.003		0.000
		(0.032)		(0.004)		(0.002)
$\alpha + \beta$	0.055*	0.046**	0.012***	0.015***	0.006***	0.007***
	(0.032)	(0.019)	(0.004)	(0.003)	(0.002)	(0.001)
State, year & month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,536	1,504	6,496	6,528	6,496	6,528
R^2	0.649	0.644	0.697	0.697	0.472	0.470

Notes: Estimates for all 32 states in Mexico. All regressions include state, year, and month fixed effects, and precipitation as control variable. Standard errors clustered at the state level in parenthesis. Levels of significance are reported as ***p<0.01, **p<0.05, *p<0.1.

Table A.5: Drug trafficking organizations

	Dependent variable is DTO killings				
	(1)	(2)	(3)	(4)	(5)
Temperature	0.050**	0.049**	0.048**	0.049*	0.046*
	(0.024)	(0.024)	(0.024)	(0.025)	(0.025)
× **DTOs**		0.005			
		(0.004)			
× **Sinaloa**			0.279		0.242
			(0.317)		(0.306)
× **Zetas**				0.109	0.116
				(0.086)	(0.090)
× **Sinaloa** × **Zetas**					1.371
					(2.682)
DTOs		0.071			
		(0.082)			
Sinaloa			6.627**		6.909**
			(2.890)		(2.794)
Zetas				-0.021	0.203
				(0.983)	(1.011)
Sinaloa × **Zetas**					-21.777
					(27.452)
Mean of dep. variable	0.737				
(Within st. dev.)	(0.962)				
State, year & month F.E.	Yes	Yes	Yes	Yes	Yes
R^2	0.649	0.651	0.665	0.649	0.666

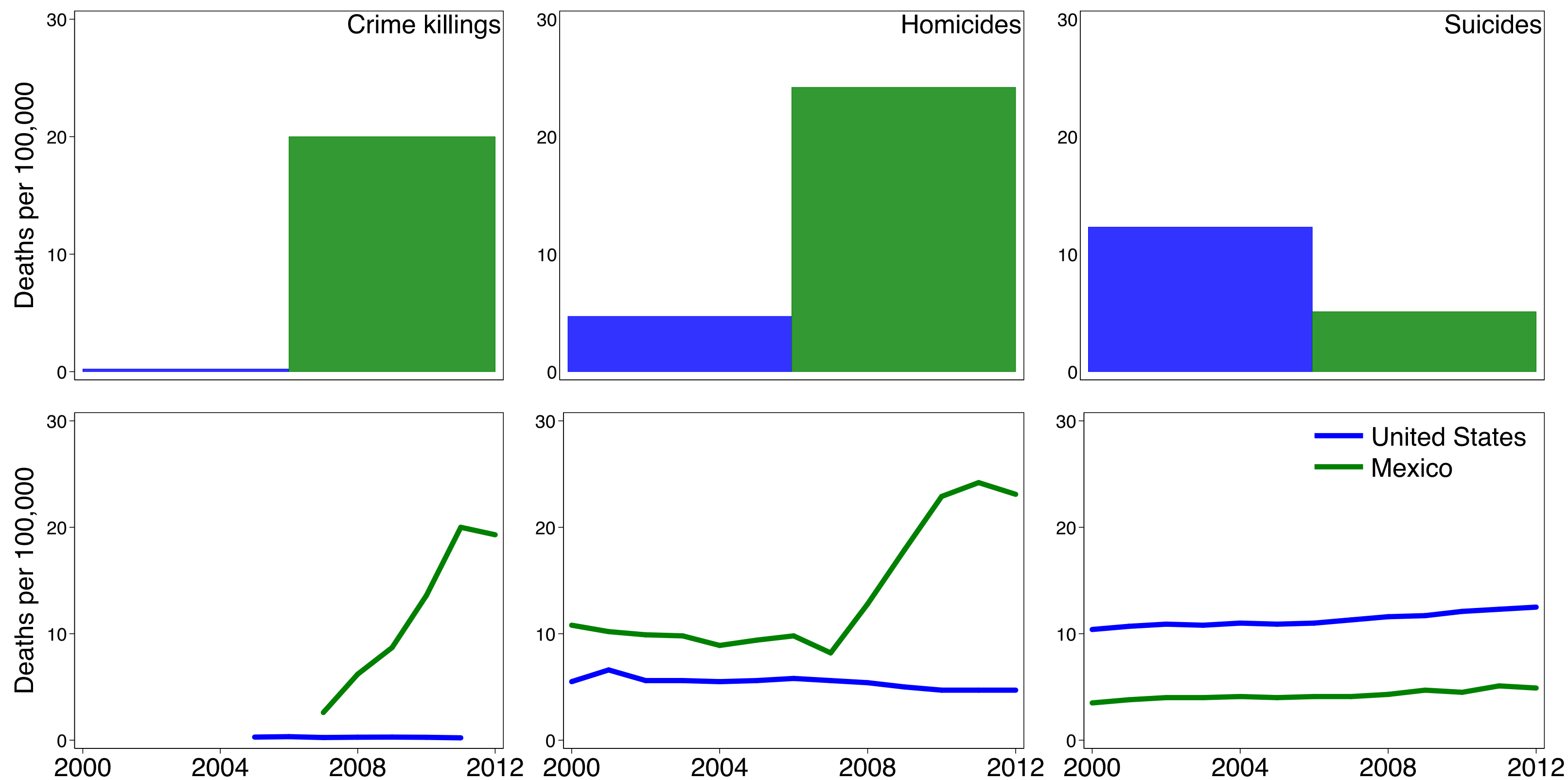
Notes. See Appendix for data on drug-trafficking organizations. **DTOs** is the number of cartels that are operating in State s and year t. **Sinaloa** and **Zetas** are the *shares* of the state in which these DTOs operate. *Share* is defined as total number of municipalities where they operate over total number of municipalities in that state. All regressions control for precipitation. Standard errors clustered at the state level in parenthesis. Levels of significance are reported as ***p<0.01, **p<0.05, *p<0.1, $^{+}$p< 0.11.

Table A.6: Temperature and suicides in Mexico

Dependent variable:	*Suicides*		
	(1)	(2)	(3)
Temperature	0.007***	0.007***	0.009**
	(0.001)	(0.001)	(0.003)
	[7.4]	[7.2]	[8.7]
Precipitation	-0.053	-0.034	-0.040
	(0.039)	(0.038)	(0.047)
	[-1.3]	[-0.8]	[-1.0]
Mean of dep. variable	0.321		
(Within st. dev.)	(0.167)		
State F.E.	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes
Month F.E.	No	Yes	No
Month–state F.E.	No	No	Yes
State trends	No	Yes	No
Observations	6,528	6,528	6,528
R^2	0.470	0.490	0.499

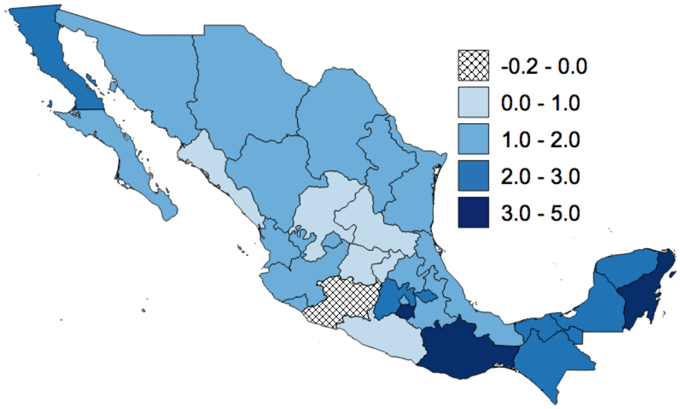
Notes. Estimates for all 32 states in Mexico in period 1990–2006. **State trends** is a complete set of linear trends interacted with state indicators. Standard errors clustered at the state level in parenthesis. Standardized effects in brackets. Levels of significance are reported as ***p<0.01, **p<0.05, *p<0.1.

Figure A.1: Comparison between Mexico and the U.S.

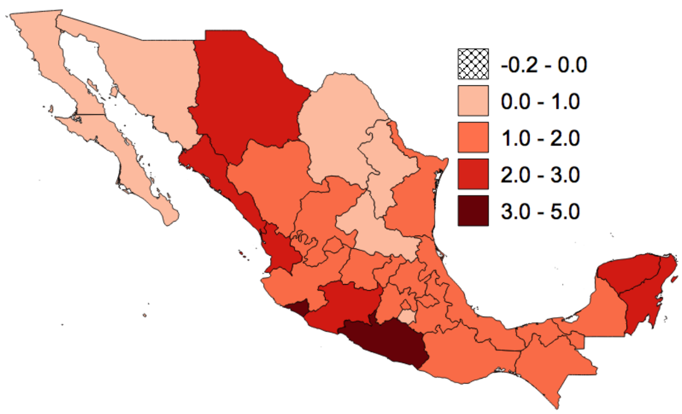


Notes: These figures show comparison between death rates per 100,000 inhabitants between Mexico and the United States. In particular, the upper panels show the country comparison in 2011, and the lower panels show the time series variation. Data for the U.S. comes from the United Nations Office on Drugs and Crime (UNODC) and the American Foundation for Suicide Prevention. Data for Mexico comes from INEGI.

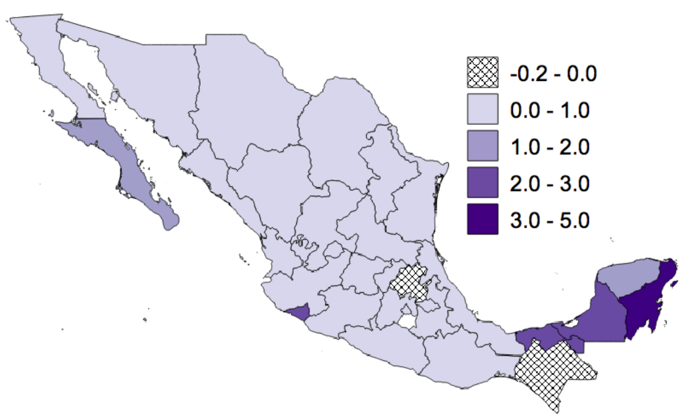
Figure A.2: Geographic distribution of estimates



(a) DTO killings



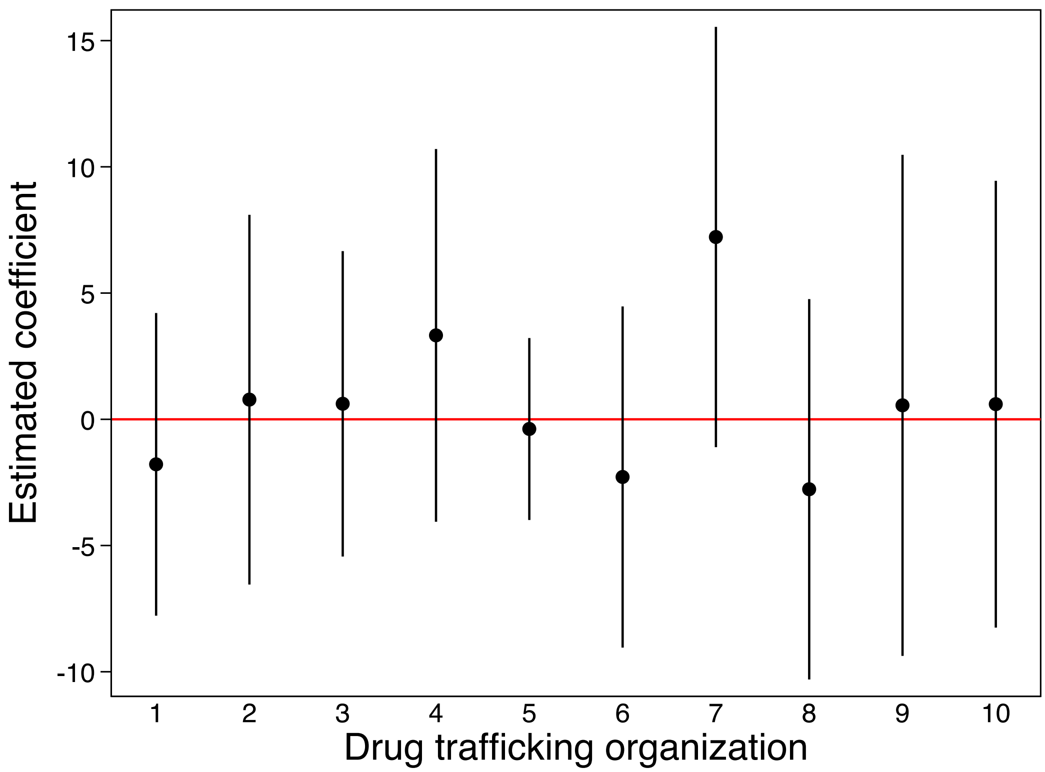
(b) Homicides



(c) Suicides

Notes: Estimated effect of temperature on the outcome of interest for each state in Mexico. Coefficients are expressed as percentage of the average coefficient for comparison across maps. Categories in these maps correspond to intervals of the same size. Darker colors for larger coefficients. States colored in gray indicate a negative estimated coefficient.

Figure A.3: Classification of violent DTO

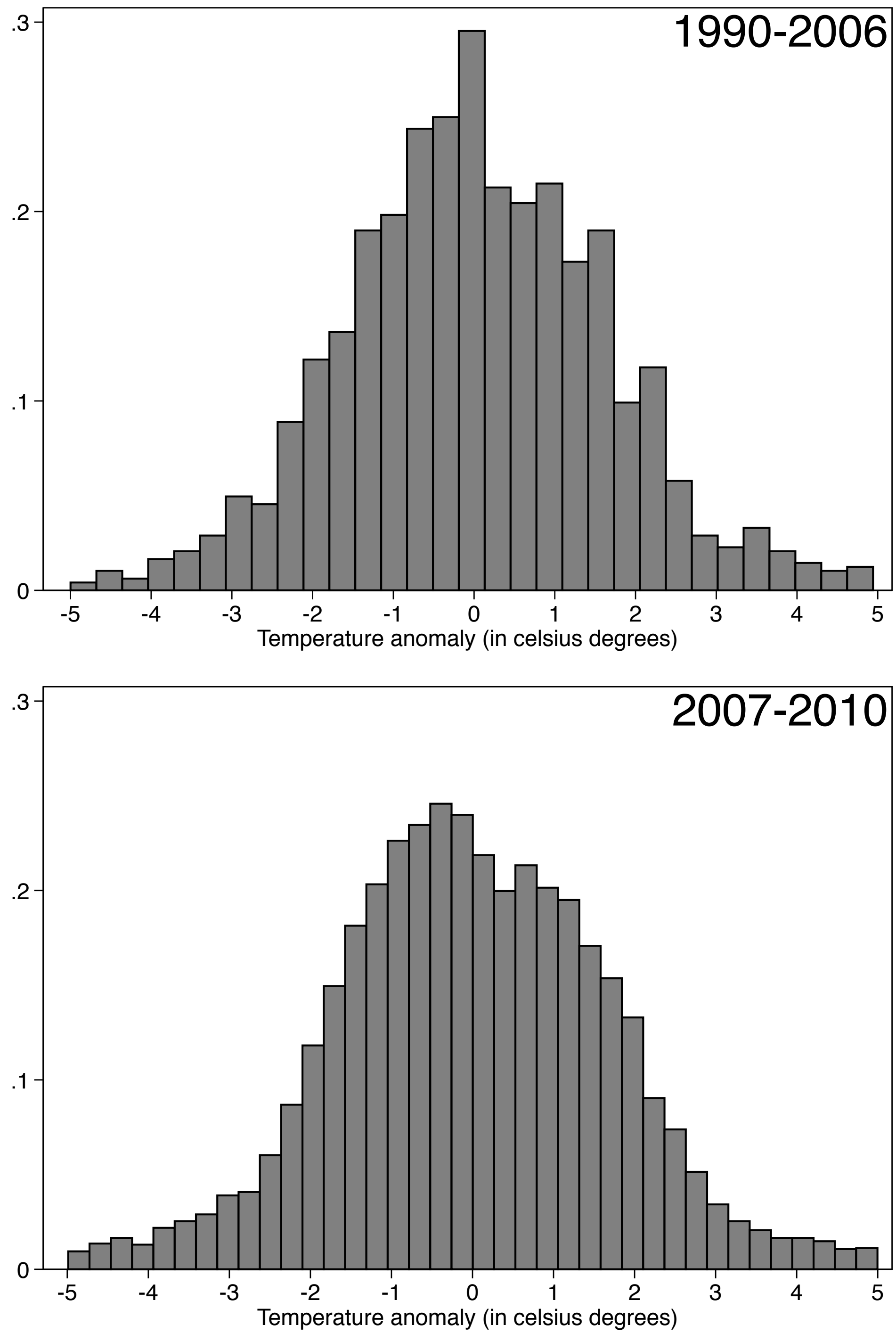


Notes: This figure presents estimates β_k of the following equation:

$$\text{y}_{st} = \alpha + \lambda_t + \zeta_s + \sum_{k=1}^{10} \beta_k DTO_{kst} + \varepsilon_{st}$$

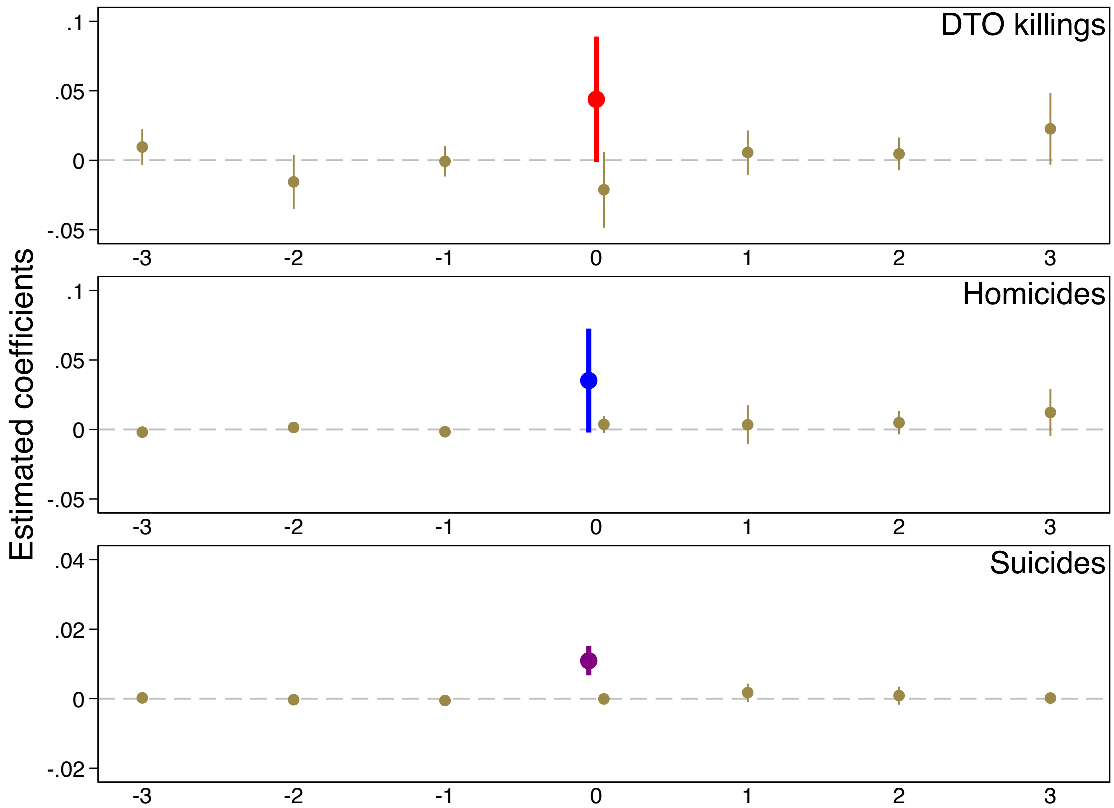
Where y_{st} is DTO killings for each 100,000 inhabitants, α is a constant term, λ_t is a year fixed effect, ζ_s is a state fixed effect, DTO_{kst} are ten indicator variables, and ε_{st} is an error term clustered at the state level. According to our definition, DTO number 7 is then classified as violent.

Figure A.4: Distribution of temperature



Notes: This figure presents the distribution of temperature — net of state, year, and month fixed effects— for (A) the period from January of 1990 to December of 2006, and (B) the period from January of 2007 to December of 2010.

Figure A.5: Effects of leads and lags of PROGRESA transfers

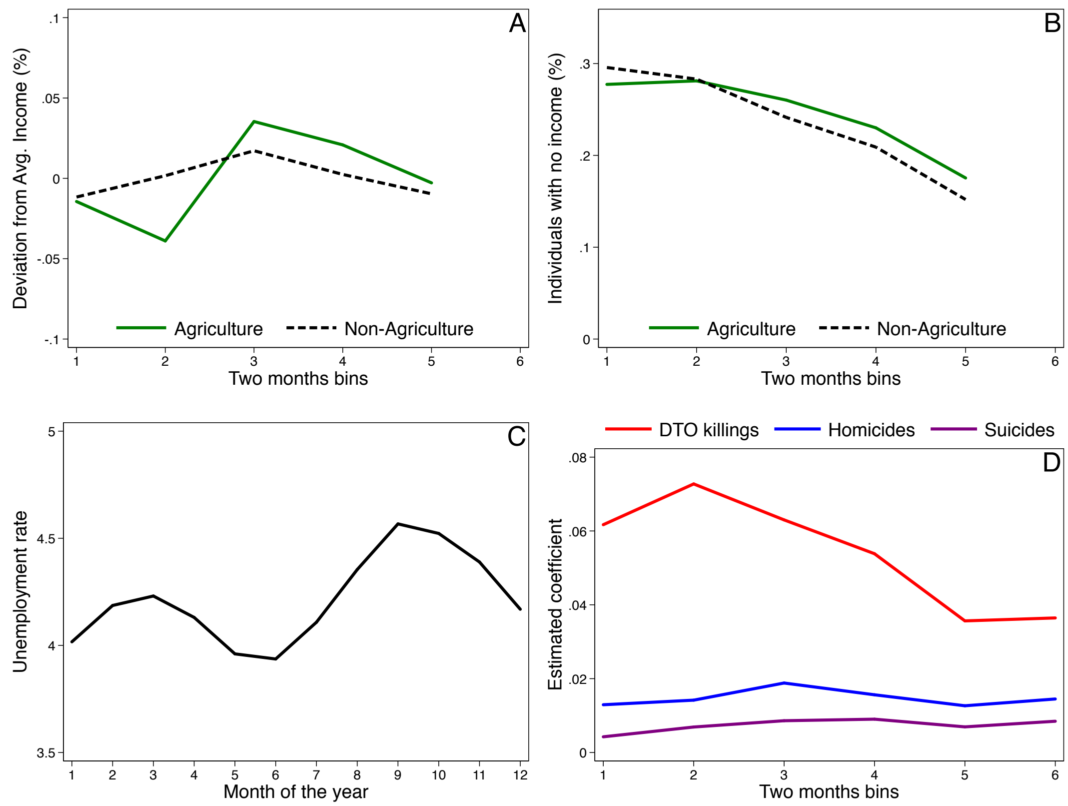


Notes: This figure presents estimates of the following regression:

$$\begin{aligned} y_{smt} &= \alpha + \beta \text{Temp}_{smt} + \delta \text{Precip}_{smt} \\ &+ \sum_{k=-3}^{3} \left[\gamma_k (\text{Progresa}_{s(m+k)t} \times \text{Temp}_{smt}) + \phi_k \text{Progresa}_{s(m+k)t} \right] \\ &+ \lambda_t + \xi_m + \zeta_s + \varepsilon_{smt} \end{aligned}$$

where everything is defined as in the main text, and $\text{Progresa}_{s(m+k)t}$ is the logarithm of Progresa transfers in state s, month $m + k$, and year t. The main effect of temperature on DTO killings, homicides, and suicides (i.e. β) is plotted with the corresponding color we use in the paper. In addition, this figure presents the effects of progresa transfers three months before and after, interacted with temperature, i.e. $(\gamma_{-3}, \gamma_{-2}, \gamma_{-1}, \gamma_0, \gamma_1, \gamma_2, \gamma_3)$.

Figure A.6: Economic variables and estimated effects by month



A Deviation (in %) from average wage for agricultural and non-agricultural workers for two months bins (e.g. bin 1 is January and February). Data for November and December is missing. **B** Percentage of individuals with wage equal to zero in agricultural and non-agricultural sectors. **C** National unemployment rate by month using data from the National survey of occupation (*Encuesta Nacional de Ocupación y Empleo), available monthly since 2005.* **D** *Estimated effect of temperature in a particular month on the outcome on interest.*