# Insurgency and Long-Run Development: Lessons from the Mexican Revolution*

Melissa Dell

April, 2012

**Abstract:** This study exploits within-state variation in drought severity to identify how insurgency during the Mexican Revolution, a major early 20th century armed conflict, impacted subsequent government policies and long-run economic development. Using a novel municipal-level dataset on revolutionary insurgency, the study documents that municipalities experiencing severe drought just prior to the Revolution were substantially more likely to have insurgent activity than municipalities where drought was less severe. Many insurgents demanded land reform, and following the Revolution, Mexico redistributed over half of its surface area in the form of *ejidos*: farms comprised of individual and communal plots that were granted to a group of petitioners. Rights to *ejido* plots were non-transferable, renting plots was prohibited, and many decisions about the use of *ejido* lands had to be countersigned by politicians. Instrumental variables estimates show that municipalities with revolutionary insurgency had 22 percentage points more of their surface area redistributed as *ejidos*. Today, insurgent municipalities are 20 percentage points more agricultural and 6 percentage points less industrial. Incomes in insurgent municipalities are lower and alternations between political parties for the mayorship have been substantially less common. Overall, the results support the hypothesis that land reform, while successful at placating insurgent regions, stymied long-run economic development.

*Keywords*: insurgency, agrarian reform, long-run development.

*I am grateful to Daron Acemoglu, Ben Olken, Abhijit Banerjee, Esther Duflo, Chappell Lawson, and seminar participants at Harvard and MIT for helpful comments and suggestions. Contact email: mdell@mit.edu.

# 1 Introduction

Bringing conflicted regions under the control of the central state has been a paramount motivation of state policy in the modern world. The extension of the state's authority often involves fundamental economic and political changes designed to weaken local elites and resolve longstanding disputes. While these reforms plausibly exert large persistent economic effects, few attempts have been made to quantify the long-run impacts of specific policies. This study examines how the central state brought conflicted regions in Mexico under control historically and relates this to long-run economic outcomes.

Specifically, I examine the Mexican Revolution, a multi-sided civil war that began in 1910 with the overthrow of long-time autocrat Porfirio Díaz. "Land and liberty" served as the battle cry of the Revolution, and at its heart were disputes about land distribution and the degree to which political power should be centralized. When fighting abated in 1918, rampant conflicts over land remained unresolved and the central state had limited authority outside the national capital. In the decades following the Revolution, major state priorities included a massive expansion of the federal bureaucracy and large scale agrarian reform. Mexico redistributed over half of its surface area in the form of *ejidos*: farms comprised of individual and communal plots that were granted to a group of petitioners. While individuals had inalienable usage rights to *ejido* plots as long as they remained in the community, *ejidal* land could not be sold, rented, or legally converted to non-agricultural use. In the decades following the Revolution, Mexico's single party bureaucracy controlled access to credit for essential inputs, as *ejidal* farmers could not use their land as collateral to access private credit markets, and state credit served patronage purposes (Deininger and Bresciani, 2001; Benjamin, 1989; de Janvry et. al, 1997; Ronfeldt, 1973). *Ejidos* still account for 54% of Mexico's land area and about half of its rural population today.

This study identifies how insurgency affected subsequent policies and economic development by using drought severity to instrument for insurgent activity, conditional on state fixed effects.[1] Miguel used There is a strong correlation between drought severity and insurgency, which is defined as the sustained use of violent force by local residents to subvert representatives of the government. Moving from half of long-run average precipitation - a severe drought - to average precipitation decreased the probability of insurgent activity by around 38 percentage points, and the first stage F-statistic on this relationship is equal to 19. In contrast, drought severity is uncorrelated with a host of characteristics measured in 1900.

[1]Ted Miguel, Satyanath Shanker, and Ernest Sergenti (2004) pioneered the use of rainfall shocks to empirically examine conflict. They utilize rainfall as an instrument for growth in order to identify the causal effect of growth on conflict in Africa.

Instrumental variables estimates document that municipalities with sustained revolutionary insurgency had substantially more land reform in the years following the Revolution and are today poorer and more agricultural. Around 22 percentage points more of municipal surface area was redistributed through land reform in municipalities that experienced historical insurgency. Today incomes in municipalities with insurgency historically are around 30 percent lower, the fraction of the municipal labor force working in agricultural is 20 percentage points higher, and the fraction of the labor force working in industry is six percentage points lower. Moreover, alternations between political parties for the mayorship have been 33 percentage points less common over the past forty years. In contrast, I find little evidence for a persistent impact of insurgency on violence or public goods provision, which is largely determined at the state level.

There are many potential mechanisms through which insurgency could impact long-run development. This study focuses on agrarian structure, which historical and quantitative evidence emphasize as a particularly plausible mechanism. I hypothesize that the Mexican state promoted stability in insurgent regions by implementing large-scale agrarian reform, and this in turn lowered industrialization, income, and political competition in the long run.

Empirically identifying how Mexican land reform has affected long-run development requires alternative samples and identification approaches, and hence space constraints require that this question be examined in separate work. Here, I discuss existing empirical and historical evidence supporting the plausibility of agrarian reform as a central channel through which the effects of historical insurgency persist. Most closely related to this paper is work by Beatriz Magaloni, Barry Weingast, and Alberto Diaz-Cayeros (2008) that uses a standard growth regression framework applied to Mexico's 31 states between 1950 and 1995 to measure the economic impact of land reform. They estimate that Mexican GDP per capita would have been 124 percent higher in 1995 had there been no land reform in Mexico. They also provide evidence that the distribution of *ejidal* lands was a key patronage instrument for generating support for the PRI (Institutionalized Revolutionary Party), which dominated Mexican politics from the 1920s through the end of the 20th century. Additionally, in ongoing work I examine the empirical relationship between agrarian structure and industrial development. I show that while high-productivity, irrigated agricultural areas tended to industrialize, this effect has been muted in regions with a high concentration of *ejidal* lands. Agribusinesses have preferred to locate in areas where they could vertically integrate by purchasing farms, which has not been possible in *ejidal* areas due to the prohibitions on land market transactions (Johnston et al., 1987). Moreover, the federal government, which for much of the 20th century controlled nearly a quarter of the Mexican food processing industry, tended to purchase food and locate state-owned processing industries near well-connected private farmers (Ochoa, 2000). Descriptive and historical evidence discussed later in this paper also points to large inefficiencies in the *ejidal* sector (see Deininger and Bresciani, 2001 for a review).

This study contributes to a growing literature on the economic effects of conflict (see Blattman and Miguel, 2010 for a review). The literature focuses primarily on the impacts of conflict on the labor, capital, and human capital stocks, whereas empirical work on the institutional effects of conflict is limited.[2] Studies have found rapid recovery of population following bombings (Davis and Weinstein, 2002; Brakman, Garretsen, and Schramm, 2004; Miguel and Roland, 2011). Miguel and Roland (2011) also find that in Vietnam local living standards and human capital levels converged rapidly across regions after the war, leaving few visible economic legacies of bombings twenty-five years later.[3] In the specific context of the Mexican Revolution, Stephen Haber, Armando Razo, and Noel Maurer (2003) document that while the latter years of the revolution were disruptive of commerce, for the most part they did not result in the destruction of assets, as insurgents had strong incentives to use productive assets to finance their activities. Manufacturing and mining recovered rapidly once the railroads resumed operations, and export agriculture boomed during the 1920s. These findings, combined with the large literature on the persistent impacts of institutions (see Nunn, 2009 for a review), suggest that persistent effects of insurgency are likely to work at least in part through institutional channels. This study shows that the Mexican Revolution exerted major long-run effects on property rights institutions, which are in turn likely to have had persistent economic consequences.

The Mexican government's use of agrarian reform to promote stability and extend its control over the agricultural sector is by no means unique. For example, parallels exist between the Mexican case and the Iraqi land reforms of the 1950s and early 1960s, in which the state did not fully distribute confiscated lands to private holders but rather became "a very large absentee landowner" (Warriner, 1969, p. 92). "Those who were responsible for carrying out the [land reform] law did not believe in the principle of small ownership; they aimed at keeping the peasants in the hire of the government to use for narrow party gains" (Warriner, 1969, p. 99). Communist bloc countries such as China, Cuba, and Vietnam went even further, with revolutionary regimes collectivizing farming (King, 1977). In contexts ranging from 6th century BCE Greece to Bolivia and Egypt in the 1950s, revolutionary regimes have used agrarian reform to quell unrest and bring peasant support to their coalitions (Tuma, 1965; Warriner, 1969, p. 242; King, 1977, p. 377). While many land reforms have extended

[2]For example, Blattman and Miguel (2010) argue: "The social and institutional legacies of conflict are arguably the most important but least understood of all war impacts."

[3]In contrast, other researchers have found impacts of conflict on children's height and school attendance (Alderman, Hoddinott, and Kinsey, 2006; Bundervoet, Verwimp, and Akresh, 2009; Shemyakina, 2006).

state control over the agrarian sector, others have emphasized the transfer of land to private smallholders. For example, during the occupation of Japan the Allied Forces administered large-scale agrarian reforms that aimed to reduce peasant unrest by transferring land to individual, private producers (King, 1977, p. 192). In South Korea, which implemented a large scale agrarian reform in the 1950s, many landowners transacted with peasants in private land markets under the threat of confiscation if the maximum farm size threshold was exceeded (Putzel, 2000).[4] Land distribution remains central in many conflicts today, including those in Afghanistan, Iraq, Uganda, Guatemala, Indonesia, Cambodia, and elsewhere. This paper's empirical results highlight the potential for persistent economic inefficiencies to arise when reforms to resolve land disputes extend the state's power by replacing market interactions with political patronage.

In the next section, I provide historical background on the Mexican Revolution, and Section 3 examines the relationship between drought and revolutionary insurgency. Section 4 tests whether insurgency impacted agrarian reform and long-run economic development by using drought as an instrument for insurgency. Section 5 discusses the mechanisms relating historical insurgency, land reform, and long-run development. Finally, Section 6 offers concluding remarks.

# 2 Historical Background

## 2.1 The Mexican Revolution

The Mexican Revolution began in 1910 with the overthrow of autocrat Porfirio Díaz, who first ascended to the presidency of Mexico in 1876. While Mexico's constitution stipulated a democratic government with no re-election of the president, Díaz repeatedly claimed that Mexico was not yet ready for democracy and remained in power through rigged elections. His 35 year tenure was marked by industrialization, a dramatic increase in land concentration, and the centralization of political power.

In a 1908 interview with the U.S. journalist James Creelman, Díaz - then approaching eighty - stated that he would retire and allow other candidates to compete for the presidency. However, Díaz ultimately changed his mind and ran again for re-election in 1910, allowing northern opposition politician Francisco Madero to run against him. Despite widespread popular support for Madero, Díaz claimed to have been re-elected almost unanimously and

[4]Because the state offered minimal compensation for the confiscation of lands from Korean landowners who violated the maximum farm size threshold and required peasants to pay a relatively high price to purchase confiscated lands, large landowners and landless farmers had strong incentives to engage in market transactions.

had Madero jailed. Madero subsequently issued a letter from jail calling for popular revolt, and his vague promises of agrarian reform attracted peasants throughout Mexico, leading to numerous rebellions. The time was particularly ripe for successful rebellion, given the advanced age of Díaz and many of his military allies, and Díaz and the federal army were defeated in May of 1911.

Madero was elected to the presidency, but proved an unpopular leader. He angered the peasant revolutionaries who had brought him to power by failing to implement agrarian reform and by increasingly allying with members of the Porfirian elite to quell unrest amongst those demanding radical change (Knight, 1986). While he faced armed opposition from the left, Madero was ultimately overthrown in a 1913 coup by counter-revolutionary General Victoriano Huerta. Numerous revolutionary movements against Huerta's military government arose in 1913, occurring largely in the same places that had witnessed revolutionary activity in 1910-1911. These disparate movements were able to unite in their opposition to Huerta and overthrow his regime in July of 1914. However, their differences proved irreconcilable and soon after Huerta's defeat the conflict deteriorated into a multi-sided civil war.

The ultimately victorious faction, referred to as Constitutionalism, emphasized economic modernization and state centralization under a political class that was different and somewhat broader than the Porfirian elite. Constitutionalism was centralized under a single military and political command and unambiguously sought national power. The movement's backbone was in the northern Mexican states of Sonora and Coahuila, which were relatively prosperous. It garnered its primary support from middle class, urban, and industrial interests and also gained the official recognition of the U.S. government. The victorious Constitutionalists ultimately formed the Institutionalized Revolutionary Party (PRI), which dominated Mexico as a single party political system for most of the twentieth century.

In contrast, the most widespread type of revolutionary movement sought to defend local political structures against incursions by the central government. Many of these movements called for agrarian reform to return lands confiscated by large estates during the Díaz regime to the peasants who had previously held them, and they were typically local in their demands, scope, and political aspirations.[5] The rebellions led by Pancho Villa in northern Mexico and Emiliano Zapata in central Mexico are the largest and most well-known of these movements.

The Revolution witnessed some traditional pitched battles, fought primarily between the Constitutionalists and Pancho Villa in northern and north-central Mexico, but much of the

[5]Prominent examples of movements calling for radical agrarian reform include the Zapatistas operating in Morelos as well as parts of Puebla, Mexico state, and some other regions; the Cedillo brothers in San Luis Potosi; and Calixto Contreras in Durango. Examples of movements that did not pursue agrarian goals including rebellions in the Misantla and Huatusco-Córdoba regions of Veracruz led by large landowners, the Manuel Peláez rebellion in the Huasteca, and the Natividad brothers in Tepic (Knight, 1986).

fighting consisted of guerrilla warfare. By the end of 1915, Villa had been reduced to guerrilla tactics in his home base of Chihuahua, and it took the Constitutionalist army several more years of fighting to defeat him and the large number of other local guerrilla movements, one of the most tenacious of which was the Zapatistas in Morelos. Purges of local rebel leaders continued throughout the 1920s and in some cases into the 1930s.

## 2.2 Bringing insurgent regions under the control of the state

The rallying battle cry of the Revolution was "land and liberty" (*tierra y libertad*), and while not all insurgent groups were fighting for land redistribution, this was a central demand of many insurgent movements (Knight, 1986). Towards the close of the Revolution, Mexico ratified a new constitution that stated that centers of population that lacked access to adequate land would be granted land in sufficient quantities for their inhabitants' needs. According to Article 27, estates whose size exceeded a maximum limit could be expropriated; and religious institutions could not hold, administer, or acquire land. All properties belonging to the Catholic Church, which held extensive property, reverted to the state.

In the decades following the Revolution, the government operationalized Article 27 through the creation of state-owned properties called *ejidos*. *Ejidos* consisted of communal and individual plots that were granted by presidential decree to a group of petitioners. Communal plots were devoted to purposes such as grazing and firewood, whereas crops were typically cultivated on individual *ejidal* plots. *Ejido* members received usufruct rights to their plots, but ownership rights were held by the community and ultimately controlled by the central state. While the rights to the produce from one's plot were inalienable as long as one remained on the land, they could not be transferred, and the rental of *ejidal* land and hiring of labor to work *ejidal* plots were also prohibited.

*Ejidos* were central to Mexican agriculture, as nearly half of Mexico's surface area entered the *ejidal* sector during the 1920s and 1930s. The state obtained the land for the *ejdial* sector from estates that had been confiscated from the pre-revolutionary elite during the Revolution, from the extensive holdings confiscated from the Church, and from the purchase of lands from large landowners whose estates exceeded the legal maximum size.

*Ejidos* met the demands of Mexico's peasant revolutionaries for access to land, and simultaneously served as a central vehicle for the state to extend its control into the countryside. The central state controlled access to essential inputs, such as water resources (including wells on *ejidal* properties) and credit. *Ejido* producers could not use their land as collateral to access private credit markets since the state owned the land, and thus were reliant on the state for the credit necessary to buy seeds, fertilizer, and other inputs. Pervasive corruption in the state bank serving the *ejidal* sector has been well-documented (DeWalt, 1979; Wilkie, 1971). *Ejidal* elites exerted disproportionate influence over decisions about the reallocation of vacated *ejidal* lands, with plots became concentrated in the hands of individuals who held political positions in the *ejidos* (DeWalt, 1979; Wilkie, 1971). Many decisions about land allocation and credit had to be countersigned by state politicians from Mexico's single party bureaucracy (Deininger and Bresciani, 2001; Benjamin, 1989; de Janvry et. al, 1997; Ronfeldt, 1973).

*Ejidos* today account for 54% of Mexico's land area, and about half of its rural population. In 1992, Mexico reformed Article 27 of the constitution so that the state no longer has an obligation to provide *ejidos*. The state began an *ejido* titling program called PROCEDE in the same year, seeking to resolve conflicts over plot boundaries within and between *ejidos* and to facilitate investment and markets. Through PROCEDE, an *ejido* assembly selects which parts of the *ejido* will be designated for common use and which parts will be designated for private plots. Boundaries are delineated and rental of the plots designated for private use is permitted. Once the individual plots have been delineated, producers have the option of registering their plot in the private domain - allowing it to be bought and sold in land markets - if a super-majority of the *ejido* members agree. To date, approximately 90% of *ejidos* have had their internal and external boundaries delineated through PROCEDE, and around 2.5% of the surface area in the *ejidal* sector has entered the private domain.

There are various mechanisms through which agrarian organization could affect long-run development. These will be discussed in more detail in Section 5, after the relationships between insurgency and land reform and between insurgency and long-run economic outcomes have been examined.

# 3 Drought and Insurgency

In order to examine the impact of insurgency on subsequent state policies and long-run economic development, I use drought severity to instrument for insurgent activity. Scholars have argued that a major drought occurring between 1907 and 1910 was central in spurring revolutionary activity (see Tutino, 1981; LaFrance, 1990), but this hypothesis has not been tested empirically. In this section, I explore the first stage relationship between drought severity and insurgency, conditional on state fixed effects. I also test whether drought is correlated with a number of important pre-characteristics and examine whether the size of the first stage relationship differs across various sub-groups.

## 3.1 Identification Strategy

I test whether drought severity in the years leading up to the Revolution affected insurgency by running the following regression:

$$insurgency_{ms} = \gamma_0 + \gamma_1 drought_{ms} + X'_{ms}\beta + \alpha_s + \epsilon_{ms} \quad (1)$$

where $insurgency_{ms}$ is a dummy variable equal to 1 if the citizens of municipality $m$ - during the period between 1910 and 1918 - used violent force in a sustained attempt to subvert representatives of the Mexican government (i.e. local authorities and the military) or to confiscate others' property. $drought_{ms}$ measures the severity of drought during the 1906-1910 period, $X_{ms}$ contains a vector of time invariant geographic characteristics, and $\alpha_s$ is a state fixed effect. All variables are described in more detail in the following section.

I then use drought severity as an instrument for insurgency in the following regression:

$$y_{ms} = \delta_0 + \delta_1 insurgency_{ms} + X_{ms}\beta + \alpha_s + \mu_{ms} \quad (2)$$

where $y_{ms}$ is the outcome of interest.

This instrumental variables approach requires the two following assumptions (Angrist, 2009). First, drought must be correlated with insurgency. If this correlation is only marginally different from zero, the resulting instrumental variables estimates are unlikely to be informative. Second, drought must be uncorrelated with any other determinants of the outcomes of interest: in other words, $\text{corr}(drought_{ms}, \mu_{ms}) = 0$. This condition is referred to as the exclusion restriction. It will obtain if drought is as good as randomly assigned, conditional on state fixed effects, and if drought has no effect on long-run economic and political outcomes other than through the insurgency channel.

While the exclusion restriction relies on the instrument being uncorrelated with unobserved determinants of the outcomes and hence is untestable, I shed light on its plausibility by running two sets of placebo checks. First, I test whether drought is uncorrelated with a number of important observable characteristics measured in 1900. Second, I examine whether drought in other five year periods exerts persistent effects on long-run development. To the extent that similar droughts in other periods do not have persistent effects, this would increase our confidence that any long-run effects of the 1906-1910 drought are acting primarily through its impacts on insurgency.

## 3.2 Data

Monthly five year averages of precipitation during 1906-1910 are available for 217 municipalities, located in district seats throughout Mexico.[6] These data are preserved in a government publication *Atlas termopluviometrica* that was sent to the World's Fair and is now held by Tulane University. I measure drought severity as the ratio of average monthly precipitation in 1906-1910 to long-run average monthly precipitation, which it taken from World Clim 4's monthly long-run average precipitation rasters. Motivated by the historical and agronomic literature (i.e. Hollinger and Changnon, 1993), I censor the measure at one[7] I focus on rainfall during non-harvest months for corn - Mexico's main staple crop in 1910. While drought is harmful during most of the year - lowering soil moisture content and reducing plant growth - it is beneficial during the harvest season. Results are generally robust to using drought severity over the year as a whole, but the first stage is weaker. Drought severity is plotted in Figure 1.

I have also examined robustness to using the standardized precipitation index to measure drought severity. The standardized precipitation index is calculated as (1906-1910 mean precipitation - long run mean precipitation)/(long run standard deviation of precipitation). The long-run standard deviation is calculated from the Mexican government's precipitation records, maintained in the government's climate database ERIC 3. The long-run precipitation record is highly incomplete, with weather stations shifting locations over time, and it takes more data to estimate a long-run standard deviation than it does to estimate long-run mean.[8] The sample for which there is enough information to calculate the long-run standard deviation is smaller than the sample for which information on 1906-1910 precipitation is available, and hence my main focus is on the larger sample for which the percent normal measure is available.

Data on insurgency were compiled from multiple regional histories and from detailed municipal timelines available in the *Encyclopedia of Mexican Municipalities*. These sources are listed in the appendix. A municipality is classified as having insurgent activity if - during the period between 1910 and 1918 - its citizens used violent force in a sustained attempt to subvert representatives of the Mexican government (i.e. local authorities and the military) or to confiscate others' property. Because the literature on the Revolution is enormous, with

[6]Districts are a political unit larger than municipalities but smaller than states that were abolished in 1916.

[7]In field experiments, agronomists have found only marginal benefits to corn yields from augmenting precipitation above long-run average levels. On the other hand, additional precipitation is beneficial in dry years (see for example Holliinger and Changnon, 1993).

[8]While climate models can be effective in predicting long-run average precipitation with relatively limited data, models have not been extensively developed to predict the long-run standard deviation.

multiple regional histories existing for each state as well as detailed municipal histories, I am able to explicitly document the absence of revolutionary activity. In the appendix, I create a timeline for each municipality in the sample, documenting what occurred during the revolutionary period and whether this included insurgent activity. Insurgency is plotted in Figure 2.

For example, for the town of Torreon (Coahuila), I document revolutionary activity beginning in 1911 with the overthrow of the federal military garrison and widespread popular attacks on large property holders. I document that revolutionary activity persisted into 1914, when Torreon fell to Pancho Villa's forces, and so forth. In contrast, I document that the town of Coatepec (Mexico state), did not witness insurgent activity. In listing notable events in the town's history, the Encyclopedia of Mexican Municipalities focuses for the revolutionary period on the construction of a three room schoolhouse in 1915. It explicitly states "In Coatepec Harinas, the revolutionary era did not cause the disruptions that other areas suffered." Moreover, maps in *Revolucion en el estado de Mexico* (Palafox, 1988) show that this municipality is not near the areas of the state that experienced rebel activity or widespread banditry. While the binary insurgency measure is a considerable simplification of a complex event, more detailed measures would be difficult to construct in a systematic way. Summary statistics for the drought and insurgency variables are presented in Table 1.

## 3.3 Results

Table 2 documents the first stage relationship between 1906-1910 drought severity and insurgency during the Mexican Revolution and examines whether this relationship is robust to different measurements of drought severity. Robust standard errors are in parentheses and Conley standard errors that correct for spatial correlation are in brackets. All columns include controls for time-invariant municipal geographic characteristics: long-run average precipitation (1950-2000), long run average minimum and maximum temperature (1950-2000), elevation, and slope, as well as state fixed effects.[9]

Column 1 uses the percent normal measure of drought severity in non-harvest months, the measure that concurs most closely with the biology of plant growth. This measure divides precipitation in 1906-1910 by long-run average precipitation and is available for the full sample of municipalities for which we have data on 1906-1910 precipitation. Column 2 examines the percent normal measure calculated over the entire year. In both cases, the correlation between drought severity and revolution is statistically significant at the one percent level, with a somewhat stronger relationship when the non-harvest drought measure

[9]Results (not shown) are similar when the geographic controls are excluded or when municipal-level characteristics measured in 1900 are included.

is used (first stage F-statistic of 19.1) than when the full year drought measure is used (first stage F-statistic of 9.9). Moving from half of long-run average precipitation - a severe drought - to average precipitation decreases the probability of insurgent activity by around 38 percentage points. In the sample as a whole, the probability of insurgency is 59%.

Columns 3 through 6 examine the relationship between standardized precipitation indices and insurgency. Recall that the standardized precipitation index subtracts the long-run monthly mean from the 1906-1910 monthly mean and the divides by the long-run standardized deviation, averaging these standardized monthly deviations across the year. Columns 3 and 4 construct the standardized precipitation index by using weather stations within 25 km of a 1906-1910 weather station to calculate the long-run standard deviation of precipitation. Columns 5 and 6 use data from weather stations within 10 km of a 1906-1910 weather station to calculate the long-run standard deviation. In 182 municipalities, a weather station appearing for at least 25 years in the weather record is located within 25 kilometers of the 1906-1910 weather station, and 120 municipalities have one of these stations within 10 kilometers of their 1906-1910 weather station. These samples compare to the full sample of 210 municipalities for which 1906-1910 precipitation data are available. Columns 3 and 5 calculate the standardized precipitation index averaged over non-harvest months, and columns 4 and 6 average the monthly standardized precipitation index over all months in the year.

There is typically a first stage relationship between the drought measure and insurgency, but the first stage F-statistics are smaller than they are in columns 1 and 2. Moving from one standard deviation below normal precipitation to normal precipitation decreases the probability of insurgency by around 17 percentage points. Because the first stage is not as strong for the standardized indices and the sample size is smaller, I use the percent normal drought measure for the remainder of the analysis. Results using the standardized precipitation index as an instrument for insurgency can be found in the appendix.

The instrumental variables approach will estimate the impact of insurgency on various outcomes for those municipalities that were induced by drought to participate in insurgent activity. While we cannot observe whether citizens in a given municipality took up arms in response to drought, Table 3 sheds light on which sorts of municipalities were influenced by the drought by examining the size of the first stage for different sub-populations.

Column 1 reports the baseline first stage relationship from the full sample, reproducing column 1 of Table 2 for comparison purposes. Column 2 limits the sample to municipalities in states that are closer than the median distance to the U.S., and column 3 limits the sample to municipalities in states that are farther than the median distance from the U.S. The coefficient on drought severity in the full sample is $-0.770$ (s.e.$= 0.254$). This coefficient is $-0.650$ for places nearer the U.S. and $-0.917$ (s.e.$= 0.224$) for places further from the U.S.

Both are statistically different from zero, and they are not statistically distinguishable from each other.

Columns 4 and 5 divide the sample by whether the municipality had a higher percentage of its male population working in agricultural in 1900 than the median municipality. The correlation between drought severity and insurgency is statistically significant in both samples but is substantially larger in the more agricultural sample, at -1.288, than in the less agricultural sample. In the more agricultural sample, moving from half of long-run average rainfall in 1906-1910 (a severe drought) to long-run average rainfall decreases the probability of insurgency by around 64 percentage points. Next, columns 6 and 7 divide the sample by whether the municipality had more or less of its population living in an *hacienda* in 1900 relative to the median municipality. The relationship between drought severity and insurgency is large and highly statistically significant for both samples. Finally, columns 8 and 9 divide the sample by whether a higher or lower percentage of the municipality's population spoke an indigenous language in 1900 than in the median municipality. The relationship between drought and insurgency is large and statistically significant in both sub-samples. Overall, these results document that drought led to insurgency in municipalities with a wide variety of initial characteristics, and this relationship was particularly pronounced in more agricultural municipalities.

Identification requires drought severity between 1906 and 1910 to be as if randomly assigned. In other words, in the absence of differences in rainfall during these years, municipalities that suffered drought would not have been different on average from municipalities that received above average rainfall. To shed light on the plausibility of this assumption, Table 4 regresses a variety of outcomes from the 1900 Mexican Population Census on drought severity, measured as the percent of normal precipitation in non-harvest months. The sample sizes are slightly different across outcomes, as portions of the 1900 census volumes have not been preserved for the state of Oaxaca.

For comparison purposes, column 1 reports the first stage relationship between drought severity and insurgency from Table 2. The dependent variable in column 2 is the percentage of the municipal male population that worked in agricultural in 1900.[10] The dependent variable in column 3 is the percentage of the population living in *haciendas*, landed estates with an attached labor force. The dependent variable in column 4 is the percentage of the population that primarily spoke an indigenous language, in column 5 it is the percentage that was literate, in column 6 it is the number of public employees per 1,000 inhabitants, and in column 7 it is the number of police per 1,000 inhabitants.

[10]Nearly all women are counted in the 1900 census as having a domestic occupation, and hence are excluded from this measure.

The correlations between these outcomes and drought severity are all statistically insignificant. The magnitudes of these relationship also tend to be smaller, relative to the sample mean, than the magnitude of the relationship between drought and insurgency. The next section will document that some of these outcomes diverge in municipalities with insurgent activity as compared to municipalities that did not experience insurgent activity, in the years following the Revolution.

# 4 Insurgency's impacts on policy and development

This section uses an instrumental variables approach to test whether insurgency affected two of the most central Mexican federal government policies in the years following the Revolution: agrarian reform and the expansion of the federal bureaucracy. During the 1920s and 1930s, the federal government redistributed almost half of Mexico's surface area through a major agrarian reform program, and the size of the federal bureaucracy increased more than fivefold. I find that agrarian reform was concentrated in insurgent municipalities, whereas there is little relationship between insurgency and the expansion of the federal bureaucracy. After examining insurgency's impacts on these major policies, I test whether it has exerted persistent effects on economic outcomes. Instrumental variables estimates document that insurgency has lowered income and industrialization and increased the percentage of the labor force in agriculture in the long-run. In the next section, I provide evidence that agrarian reform is a plausible central mechanism explaining insurgency's persistent economic impacts.

## 4.1 Data

I obtained data on agrarian reform from Mexico's online *Sistema de Información del Padrón e historial de núcleos agrarios*, which compiles information on all government actions related to agrarian reform and titling, at the level of the *ejido*, from 1916 until the present. Data on over 31,000 ejidos were used to calculate information on municipal-level agrarian reform, titling, and entry of ejidal plots into the private domain.

Data on income, the labor force, public employees, and education are taken from Mexican census data for the years 1900, 1910, 1930, 1940, 1960, 2000, and 2010. Data on household access to water are from CONAPO (National Population Council) (2005). Electoral data are from *Electoral -Banamex* and electoral results published by the Electoral Tribunals in each of Mexico's 31 states. The geographic characteristics are from Acemoglu and Dell (2010). Data on homicides (1990-2006) are from INEGI and data on drug trade-related violence and subversion are from confidential government sources. Data on municipal tax collection are from *Sistema de Cuentas Municipales, INEGI.*

## 4.2 Insurgency and government policies

Table 5 tests whether insurgency influenced the targeting of agrarian reform, using the percentage of a municipality's surface area redistributed by agrarian reform as the dependent variable. Panel A reports the IV estimates, and for comparison purposes Panel B reports the OLS estimates. The percent normal drought measure is used as the instrument. Robustness to alternative measures of drought and to the inclusion of additional controls is documented in the appendix.

Overall, Table 5 provides strong evidence that insurgency led to increased land reform. The IV estimates in column 1 document that in the sample as a whole, insurgency increased the percentage of municipal surface area redistributed as *ejidos* by 21.8 percentage points (s.e.= 0.111), relative to the sample mean of 48.9 percent. When we focus attention on municipalities where participation in agricultural was above the sample median in 1900, the estimated effect is 31 percentage points, and this effect is statistically significant at the one percent level. In contrast, the impact of insurgency is smaller and not statistically different from zero in the sample with below median participation in agricultural in 1900. This pattern is what we would expect, given that the demand for agrarian reform is likely to be higher in areas where a greater percentage of the population is employed in agriculture. While producers now have the option of registering *ejidal* lands in the private domain, only 2.5% of *ejidal* lands have been registered thus far, so agrarian reform numbers are largely reflective of how much land remains in the *ejidal* sector today.

In columns 1 and 2, the IV estimates are somewhat larger than the OLS estimates. There are a number of reasons why this could occur: because of measurement error in the insurgency variable, because of omitted variables bias in the OLS specification, because the IV measures a local average treatment effect on municipalities induced to take up arms by drought severity (whereas the OLS measures the correlation across the full sample), or because drought severity violates the IV exclusion restriction. It is not possible to fully disentangle or explicitly test these possibilities since they depend on characteristics the researcher does not observe. However, it is unlikely that a violation of the exclusion restriction is the primary reason why the IV estimates are larger than the OLS estimates, since the instrument is uncorrelated with a host of pre-characteristics (Table 4). Moreover, when I examine the estimates across the different sub-samples in Table 4, the insurgency coefficient is not substantially different in the sub-samples with larger first stages. Thus, it appears unlikely that the IV estimates reflect a local average treatment effect that only applies to a small sub-population. In contrast, both omitted variables bias and measurement error appear plausible, given the inherent difficulties in quantifying insurgent activities and the many factors that could influence the decision to take up arms. For example, while there are some well-known examples of indigenous revolutionary leaders, on average municipalities with revolutionary activity were substantially less indigenous in 1900. In turn, it is likely that more indigenous places received more land reform, since their land was more likely to be taken in the first place, and this would lead to a downward bias in OLS coefficient on revolution.

A major expansion of the federal bureaucracy also occurred in the decades following the Revolution. In 1900, there were 3.2 government employees per 1,000 municipal residents in the sample examined in this paper. By 1940, this number had risen to 20. On average, 16 of these were federal government employees. Table 6 explores whether insurgency differentially affected the number of public employees present in a municipality in 1940. Given the greater amount of agrarian reform, we might expect that the number of government employees would be higher in municipalities that had experienced insurgent activity. On the other hand, since a major demand of many insurgents was greater autonomy from the central government, to the extent that these demands were met we would expect lower federal bureaucracy presence. We see from Table 5 that the IV does not estimate statistically significant differences between municipalities that experienced insurgent activity and those that did not. If anything the number of federal and state employees was lower in municipalities that experienced insurgency. Moreover, important measures of government bureaucracy today do not differ. Column (5) documents that in 2005 the number of school teachers per 1000 school aged children was statistically identical in municipalities with historical insurgency and in those without historical insurgency. Column (6) documents that local tax receipts per dollar of municipal income in 2005 also did not differ.

## 4.3 Insurgency and long-run development

The previous section documented a large impact of insurgency on subsequent agrarian reform. This section examines whether insurgency has exerted long-run impacts on economic prosperity.

First, Table 7 tests whether insurgency impacts economic prosperity today. Columns 1 through 4 examine income, using microdata from the 2000 Mexican Population Census. The IV coefficient reported in column 1 estimates that historical insurgency has lowered income by around 33%. Columns (2) through (4) divide the sample into individuals working in agriculture, in industry, and in services. Care should be taken in interpreting the results given that insurgency may also influence selection into economic sectors, but the exercise is nevertheless informative about where the income effects are concentrated. The IV coefficient is large and negative in all three sectors, though it is not statistically significant for agriculture. This is not surprising given that income tends to be poorly measured for household agricultural producers. As in Table 6, the IV coefficients are larger than the OLS coefficients, likely for the same reasons that were discussed in the previous section.

Next, columns 5 and 6 examine the percentage of households in a municipality that lack access to running water and to electricity. Households in municipalities with insurgent activity historically are 14 percentage points more likely to lack access to running water and around three percentage points more likely to lack access to electricity. These effects are large, given that in the sample as a whole around 11 percent of households lack access to water and three percent lack access to electricity.

Next, Table 8 tests whether insurgency has influenced the sectoral allocation of the labor force. Columns 1 and 2 examine the percentage of the municipal labor force working in agriculture and industry in 2010, columns 3 and 4 do the same for 1960, and columns 5 and 6 examine the percentage of the male population working in agriculture and industry in 1940. The instrumental variables estimates document that today, the percentage of the labor force working in agricultural is around 20 percentage points higher in municipalities that experienced insurgent activity historically, and the percentage of the population working in industry is around six percentage points lower. The insurgency coefficient in the agricultural labor force regression is significant at the 5% level and the estimated impact on industry is marginally significant. The point estimates are of similar magnitude in both 1960 and 1940, though they are very noisily estimated for 1960.

While there are many channels through which historical insurgency could impact income, Tables 4 through 7 - combined with the qualitative literature - provide strong suggestive evidence that the restrictions imposed by agrarian reform in Mexico have discouraged people from leaving agriculture and reduced industrial development, lowering income in the long-run. Lower agricultural productivity in municipalities with more land reform could also help explain the persistent impacts of historical insurgency on income. Section 5 provides a detailed historical and empirical examination of the relationship between land reform and current economic outcomes.

It is also well-documented that agrarian reform created and sustained a political patronage system linking *ejidal* elites to government officials at the municipal and state levels (Varley, 1989; DeWalt, 1979; Wilkie, 1971). This patronage system may plausibly have stifled political competition in the long-run. The evidence in Table 9 supports this hypothesis, documenting that alternations between political parties for the mayorship have been substantially less common in municipalities with insurgent activity historically. The IV coefficient is large and highly significant, estimating that insurgency has lowered alternations between parties holding the mayorship by 32.7 percentage points between 1974 and 2009, relative to a sample mean of 24.4 percent. The effect is present both before 1994, when Mexico was less politically competitive, and after 1994, when it became more democratic. It is particularly pronounced for the post-1994 period. However, differences in local political competition do not appear to have lowered the provision of important public goods, which are provided by the state and national governments. Results, available upon request, fail to find a large or statistically significant relationship between historical insurgency and the public provision of education, health care, or road infrastructure in recent years.

# 5 Mechanisms

There are many potential mechanisms through which insurgency could exert persistent economic effects. While it is infeasible to examine all possible channels of persistence, the existing literature provides considerable guidance on mechanisms that are especially likely to be important. In particular, there is a large literature emphasizing the economic effects of Mexico's agrarian organization. I first discuss the relationship between land reform and economic outcomes and then present empirical evidence on potential alternative mechanisms relating insurgency to long-run economic development.

## 5.1 Land reform

Empirically identifying how Mexican land reform has affected long-run development requires alternative samples and identification approaches, and hence space constraints require that this question be examined in separate work. Here, I discuss existing empirical and historical evidence supporting the plausibility of agrarian reform as a central channel through which the effects of historical insurgency persist.

Most closely related to this paper is work by Beatriz Magaloni, Barry Weingast, and Alberto Diaz-Cayeros (2008) that empirically examines the impact of land reform on economic growth and politics. Magaloni et al. use a standard growth regression framework applied to Mexico's 31 states between 1950 and 1995 to measure the economic impact of land reform. They estimate that Mexican GDP per capita would have been 124 percent higher in 1995 had there been no land reform in Mexico. They also provide evidence that the distribution of *ejidal* lands was a key instrument for generating political support for the PRI - Mexico's historically dominant party - and show that land was distributed as a function of the presidential election cycle and social unrest. These results are consistent with large and highly significant municipal-level correlations between land reform and contemporary economic and political outcomes. They are also consistent with the hypothesis that insurgency affects current economic and political outcomes at least in part through land reform. Overall, this evidence suggests that while Mexico's policy of creating *ejidos* was highly inefficient, the government pursued it because it furthered the PRI's goals of reducing instability and maintaining political control.

Additionally, in ongoing work I examine the empirical relationship between agrarian structure and industrial development. I show that while high-productivity, irrigated agricultural areas tended to industrialize, this effect has been muted in regions with a high concentration of *ejidal* lands. Agribusinesses have preferred to locate in areas where they could vertically integrate by purchasing farms, which has not been possible in *ejidal* areas due to the prohibitions on land market transactions (Johnston et al., 1987). Moreover, the federal government, which for much of the 20th century controlled nearly a quarter of the Mexican food processing industry, tended to purchase food and locate state-owned processing industries near well-connected private farmers (Ochoa, 2000). Given that industry is a relatively high-paying sector, differences in industry are likely to translate into disparities in income.

Historical and descriptive evidence also point to large inefficiencies in the *ejidal* sector. Evidence reviewed in Deininger and Bresciani (2001) suggests that land reform reduced long-run agricultural productivity and opened up various possibilities for political manipulation in the distribution of land and credit (see also Varley, 1989; DeWalt, 1979; Wilkie, 1971). By the 1990s, 53% of *ejido* households, as compared to 26% of the total population, earned less than the minimum wage. The land-labor ratio in the private sector was more than double that in the *ejidal* sector, and the median private farm size was more than twice as high as the median farm size in the *ejidal* sector. Private farmers had larger herds, owned more machinery, and were more likely to use improved seeds. As discussed in Deininger and Bresciani, similar results hold even when only nearby municipalities are compared. While measuring agricultural productivity for the sample in this paper is not feasible due to data limitations, this evidence suggests that insurgency may have significantly lowered long-run agricultural productivity. Overall, this study's empirical results highlight the potential for persistent economic inefficiencies to arise when reforms to resolve land disputes extend the state's power by replacing market interactions with political patronage.

## 5.2 Other mechanisms

While I have argued that agrarian reform is an important mechanism linking historical insurgency to modern economic and political outcomes, an alternative hypothesis is that insurgency permanently increases the level of violence and conflict in a community, making it more difficult for the state to monopolize violence in the future. For example, Besley and Reynal-Querol (2012) find that places in Africa that experienced more conflicts during the pre-colonial period have had more civil wars recently. To the extent that violence and instability lower productivity, such forces could reduce economic prosperity in the long-run.

This hypothesis is explored in Table 10. Column 1 examines the municipal homicide rate between 1992 and 2008, Column 2 the number of police deaths caused by confrontations with drug traffickers since late 2006, Column 3 drug trade related homicides since late 2006, and Column 4 the presence of guerrilla insurgents in 2008. None of the IV or OLS coefficients are statistically significant, and the coefficients in columns 1 through 3 are relatively small in magnitude. The coefficient on insurgency in the guerrilla activity regression, equal to 0.13 (s.e.= 0.16), is large but very noisily estimated. Based on these results, it appears unlikely that the impacts of revolutionary insurgency persist primarily through the state's long-run capacity to monopolize violence. As discussed above, I also do not find a large or statistically significant relationship between historical insurgency and the public provision of education, health care, or road infrastructure in recent years.

Another alternative interpretation of the results is that historical drought severity could exert direct impacts on modern outcomes, violating the IV exclusion restriction. To examine this possibility, Table 11 regresses the study's main outcome variables on separate measures of drought severity in 1906-1910 and in all five year periods between 1960 and 1995. The dependent variable in column 1 is the historical insurgency indicator. The dependent variable in column 2 is the percentage of municipal surface area in the *ejidal* sector, the dependent variable in column 3 is the percentage of the municipal labor force working in industry in 2010, the dependent variable in column 4 is log income in 2000, and the dependent variable in column 5 is the percentage of elections held between 1974 and 2009 in which the party controlling the mayorship changed. The coefficient on 1906-1910 drought severity is large and statistically significant in all columns. In contrast, of the 35 drought variables from other periods (7 of which enter each regression), only one is marginally significant. This supports the study's assumption that 1906-1910 drought interacted with specific historical circumstances to produce long-lasting effects through insurgency.

I have also explored droughts occurring between 1925 and 1960. Because weather data for this period is quite limited, it would reduce the sample size substantially to include these drought measures in the regression analysis reported in Table 11. However, I have looked at these periods separately and do not find evidence of a relationship between drought and current outcomes, either for the sub-sample of municipalities that also have weather data for 1905-1910 or for Mexico as a whole (results available upon request).

# 6 Concluding Remarks

This study identifies how insurgency during the Mexican Revolution affected subsequent policies and economic development by using drought severity to instrument for revolutionary activity, conditional on state fixed effects. Instrumental variables estimates document that insurgent municipalities received substantially more land reform in the years following the Revolution and are today poorer, more agricultural, less industrial, and less politically competitive.

Based on the quantitative and historical evidence, I hypothesize that the Mexican state gained a monopoly on violence in rebellious regions through implementing large-scale agrarian reform in the years following the Revolution. Agrarian reform imposed considerable restrictions on redistributed lands and fostered a clientalistic political system dominated by a single party bureaucracy. This study discusses evidence that agrarian reform stifled industrialization and economic growth in places that received more land reform relative to places that received less.

While agrarian reform may be important for promoting stability and reducing inequality in conflicted regions, this study highlights the potential costs when agrarian reform places major restrictions on markets and fosters clientalistic politics. How agrarian disputes can be most effectively resolved remains an important question for future research.

# References


Alderman, H., J. Hoddinott, and B. Kinsey (2006): "Long term consequences of early childhood malnutrition," *Oxford Economic Papers*, 58, 450–474.

Austin, J. and G. Esteva (1987): *Food Policy in Mexico: the search for self-sufficiency*, Cornell University Press.

Ávila Palafox, R. (1986): "Revolución en el Estado de México," *La Revolución en las regiones. Memorias, II, Guadalajara, Instituto de Estudios Sociales de la Universidad de Guadalajara*, 337–372.

Benjamin, T. (1989): *A rich land, a poor people*, University of New Mexico Press.

Besley, T. and M. Reynal-Querol (2012): "The Legacy of Historical Conflict: Evidence from Africa," *Manuscript: London School of Economics.*

Blattman, C. and E. Miguel (2010): "Civil War," *Journal of Economic Literature*, 48, 3–57.

Brakman, S., H. Garretsen, and M. Schramm (2004): "The strategic bombing of German cities during World War II and its impact on city growth," *Journal of Economic Geography*, 4, 201–218.

Bundervoet, T., P. Verwimp, and R. Akresh (2009): "Health and civil war in rural Burundi," *Journal of Human Resources*, 44, 536–563.

Carey, J. (1984): *The Mexican Revolution in Yucatán, 1915-1924*, Westview Press.

Davis, D. and D. Weinstein (2002): "Bones, Bombs, and Break Points: The Geography of Economic Activity," *American Economic Review*, 92, 1269–1289.

Deininger, K. and F. Bresciani (2001): "Mexico's Ejido Reforms: their impacts on factor market participation and land access," *Unpublished Report, The World Bank: Washington, DC.*

DeWalt, B. (1979): "Alternative adaptive strategies in a Mexican ejido: A new perspective on modernization and development," *Human Organization*, 38, 134–143.

Haber, S., N. Maurer, and A. Razo (2003): *The politics of property rights: political instability, credible commitments, and economic growth in Mexico, 1876-1929*, Cambridge University Press.

Hollinger, S. and S. Changnon (1993): "Response of Corn and Soybean Yields to Precipitation Augmentation and Implications for Weather Modification in Illinois," *Bulletin*, 73.

Jacobs, I. (1982): *Ranchero Revolt: The Mexican Revolution in Guerrero*, University of Texas Press.

Janvry, A., G. Gordillo, and E. Sadoulet (1997): *Mexico's second agrarian reform: household and community responses, 1990-1994*.

Johnston, B. (1987): *US-Mexico Relations: agriculture and rural development*, Stanford University Press.

King, R. (1977): *Land reform: a world survey*, Westview Press Boulder.

Knight, A. (1986a): *The Mexican revolution: Counter revolution and reconstruction*, Cambridge University Press.

——— (1986b): *The Mexican Revolution: Porfirians, Liberals, and Peasants*, Cambridge University Press.

LaFrance, D. (2003): *Revolution in Mexico's heartland: politics, war, and state building in Puebla, 1913-1920*, Sr Books.

LaFrance, D. and F. Madero (1989): *The Mexican Revolution in Puebla, 1908-1913: the Maderista movement and the failure of liberal reform*, SR books.

Martínez Vásquez, V. and F. Chassen de López (1985): "La revolución en Oaxaca 1900-1930," *Mexico, Instituto de Administración Pública de Oaxaca.*

Miguel, E. and G. Roland (2011): "The long-run impact of bombing Vietnam," *Journal of Development Economics*, 96, 1–15.

Miguel, E., S. Satyanath, and E. Sergenti (2004): "Economic shocks and civil conflict: An instrumental variables approach," *Journal of Political Economy*, 112, 725–753.

Nunn, N. (2009): "The Importance of History for Economic Development," *Annual Review of Economics*, 1, 65–92.

Ochoa, E. (2000): *Feeding Mexico: The political uses of food since 1910*, Scholarly Resources Inc.

Olea, H. (1964): *Breve historia de la Revolución en Sinaloa (1910-1917)*, Patronato del Instituto Nacional de Estudios Históricos de la Revolución Mexicana.

Pasztor, S. (2002): *The Spirit of Hidalgo: The Mexican Revolution in Coahuila*, 2, University of Calgary Press & Michigan State University Press.

Pazuengo, M. (1988): "La Revolución en Durango," Comisión Editorial del Congreso del Estado.

Putzel, J. (2000): "Land Reforms in Asia: Lessons from the past for the 21st century," *LSE Development Studies Institute Working Paper Series*, 00-04.

Ronfeldt, D. (1973): *Atencingo: The politics of agrarian struggle in a Mexican ejido*, Stanford University Press.

Sanderson, S. (1986): *The transformation of Mexican agriculture: International structure and the politics of rural change*, Princeton University Press.

Shemyakina, O. (2006): "The Effect of Armed Conflict on Accumulation of Education: Results from Tajikistan," *Journal of Development Economics*.

Tuma, E. (1965): *Twenty-six Centuries of Agrarian Reform: A comparative analysis*, University of California Press.

Velez, F. (1995): "Los desafíos que enfrenta el campo en México," *L. Rubio and A. Fernández (eds.), México a la hora del cambio, Cal y Arena, México*, 135–159.

Warriner, D. (1969): *Land reform in principle and practice*, Clarendon Press.

Yates, P. (1981): *Mexico's agricultural dilemma*, University of Arizona Press.

## Table 1: Summary Statistics

| | Mean | S.D. | p10 | p90 |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Rainfall | 0.78 | 0.21 | 0.49 | 1.00 |
| Insurgency | 0.59 | 0.49 | 0.0 | 1.0 |
| Agrarian reform | 0.49 | 0.26 | 0.13 | 0.82 |
| Public employees/1,000 inhab. (1940) | 20.03 | 9.5 | 2.0 | 25.4 |
| Log income (2000) | 7.7 | 0.9 | 6.8 | 8.8 |
| Percent agricultural (2010) | 0.07 | 0.10 | 0.02 | 0.45 |
| Percent industrial (2010) | 0.25 | 0.08 | 0.14 | 0.37 |
| Percent agricultural (1960) | 0.26 | 0.28 | 0.16 | 1.00 |
| Percent industrial (1960) | 0.21 | 0.12 | 0.01 | 0.23 |
| Percent agricultural (1940) | 0.24 | 0.19 | 0.19 | 0.53 |
| Percent industrial (1940) | 0.12 | 0.09 | 0.01 | 0.14 |
| Percent party alternations (1974-2009) | 0.24 | 0.19 | 0.00 | 0.50 |
| Percent party alternations (1974-1993) | 0.08 | 0.19 | 0.00 | 0.40 |
| Percent party alternations (1994-2009) | 0.37 | 0.27 | 0.00 | 0.80 |

**Notes:** This table provides the mean, standard deviation, 10th percentile, and 90th percentile for rainfall and for the paper's main outcome variables. *Rainfall* is 1906-1910 precipitation during non-harvest months as a percentage of long-run average precipitation, censored above at one. *Insurgency* is a dummy equal to one if the municipality experienced insurgent activity during 1910-1918 and equal to zero otherwise. *Agrarian reform* is the percentage of a municipality's surface area redistributed through agrarian reform. *Log income* is the log of mean municipal income in 2000. *Percent agricultural (2010)* and *Percent agricultural (1960)* are the percentage of the municipal labor force working in agriculture in the years 2010 and 1960, respectively. *Percent industrial (2010)* and *Percent industrial (1960)* are the percentage of the municipal labor force working in industry in the years 2010 and 1960, respectively. *Percent Agricultural (1940)* is the percentage of municipal male population working in agriculture in 1940, and *Percent Industrial (1940)* is the percentage of municipal male population working in industry in 1940. *Percent party alternations* gives the percentage of elections in which the party controlling the mayorship changed, during the time period listed in parentheses. Sources for all variables are provided in the text.

## Table 2: First Stage

| | Dependent variable is insurgency<br>Drought measured by: | | | | | |
|---|---|---|---|---|---|---|
| | Percent normal | | Standardized Deviation | | | |
| | Across months | | Station within 25km | | Station within 10km | |
| | Non-harvest | All mos. | Non-harvest | All mos. | Non-harvest | All mos. |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Rainfall | -0.770*** | -0.586*** | -0.165** | -0.139** | -0.176** | -0.134 |
| | (0.176) | (0.186) | (0.068) | (0.065) | (0.081) | (0.082) |
| | [0.183] | [0.183] | [0.066] | [0.063] | [0.081] | [0.083] |
| F-statistic on drought variables | 19.1 | 9.9 | 6.0 | 4.6 | 4.7 | 2.7 |
| R-squared | 0.449 | 0.422 | 0.406 | 0.398 | 0.467 | 0.453 |
| Observations | 210 | 210 | 182 | 182 | 120 | 120 |

**Notes:** Rainfall is a drought severity measure, as described in the column headings, with lower values indicating more severe drought. The dependent variable is insurgency, a dummy equal to one if the municipality experienced insurgent activity during 1910-1918 and equal to zero otherwise. All columns include controls for long-run average precipitation, long-run average minimum and maximum temperature, slope, and elevation, as well as state fixed effects. Robust standard errors are in parentheses. Conley standard errors corrected for spatial correlation are in brackets.

## Table 3: Compliers

| | Dependent variable is insurgency. Sample is: | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Baseline | Close U.S. | Far U.S. | More agricultural | Less agricultural | More *haciendas* | Less *haciendas* | More indigenous | Less indigenous |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Rainfall | -0.770*** | -0.650** | -0.917*** | -1.288*** | -0.498* | -0.646*** | -0.935*** | -0.649* | -0.671*** |
| | (0.176) | (0.254) | (0.224) | (0.293) | (0.265) | (0.243) | (0.268) | (0.334) | (0.242) |
| R-squared | 0.449 | 0.371 | 0.502 | 0.534 | 0.499 | 0.522 | 0.475 | 0.530 | 0.434 |
| Observations | 210 | 97 | 113 | 104 | 103 | 106 | 103 | 100 | 105 |
| Mean Dep. Var. | 0.59 | 0.68 | 0.51 | 0.58 | 0.62 | 0.57 | 0.62 | 0.51 | 0.67 |

**Notes:** Rainfall measures 1906-1910 precipitation during non-harvest months as a percentage of long-run average precipitation. The dependent variable is insurgency, a dummy equal to one if the municipality experienced insurgent activity during 1910-1918 and equal to zero otherwise. All columns include controls for long-run average precipitation, long-run average minimum and maximum temperature, slope, and elevation, as well as state fixed effects. The samples are defined in the column headings. Column 1 examines the full sample. Municipalities in states that are closer than the median distance to the U.S. are examined in column 2, whereas municipalities in states farther than the median distance from the U.S. are examined in column 3. Municipalities that had a higher percentage of their male population working in agriculture in 1900 than the median municipality are examined in column 4, whereas municipalities that had a lower percentage of their population working in agriculture as compared to the median municipality are examined in column 5. Municipalities that had a higher percentage of their population living in an *hacienda* in 1900 than the median municipality are examined in column 6, whereas municipalities that had a lower percentage of their population living in an *hacienda* as compared to the median municipality are examined in column 7. Municipalities in which a higher percentage of the population spoke an indigenous language in 1900 than in the median municipality are examined in column 8, whereas municipalities in which a lower than average percentage of the population spoke an indigenous language are examined in column 9. Robust standard errors are in parentheses.

# Table 4: Placebo Checks

| | Insurgent activity | Percent 1900 population agricultural | Percent 1900 population in *haciendas* | Percent 1900 population indigenous | Percent 1900 population literate | Pub. employ. per 1,000 inhab. | Police per 1,000 inhab. |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Rainfall | -0.770*** | 0.089 | -0.057 | -0.044 | 0.057 | -0.711 | -0.260 |
| | (0.176) | (0.122) | (0.052) | (0.063) | (0.047) | (1.108) | (0.603) |
| F-statistic | 19.1 | | | | | | |
| R-squared | 0.449 | 0.497 | 0.421 | 0.573 | 0.634 | 0.585 | 0.362 |
| Observations | 210 | 207 | 209 | 205 | 204 | 205 | 205 |
| Mean Dep. Var. | 0.58 | 0.50 | 0.10 | 0.06 | 0.23 | 3.22 | 0.98 |

**Notes:** Rainfall measures 1906-1910 precipitation during non-harvest months as a percentage of long-run average precipitation. All columns include controls for long-run average precipitation, long-run average minimum and maximum temperature, slope, and elevation, as well as state fixed effects. The dependent variable in column 1 is insurgency, a dummy equal to one if the municipality experienced insurgent activity during 1910-1918 and equal to zero otherwise. The dependent variable in column 2 is the percentage of male municipal population working in agriculture in 1900, in column 3 it is the percentage of municipal population living in *haciendas* in 1900, and in column 4 it is the percentage of municipal population that was literate in 1900. The dependent variable in column 5 is public employees per 1,000 municipal inhabitants in 1900, and in column 6 it is the number of police per 1,000 municipal inhabitants in 1900. Robust standard errors are in parentheses.

## Table 5: Agrarian Reform

| | Full sample | More agricultural | Less in 1900 |
|---|---|---|---|
| | (1) | (2) | (3) |
| *Panel A: IV* | | | |
| Insurgency | 0.218* | 0.311*** | 0.052 |
| | (0.111) | (0.110) | (0.234) |
| *Panel B: OLS* | | | |
| Insurgency | 0.100*** | 0.146*** | 0.087 |
| | (0.037) | (0.054) | (0.060) |
| Observations | 210 | 104 | 103 |
| Mean Dep. Var. | 0.49 | 0.52 | 0.45 |

**Notes:** Insurgency is a dummy equal to one if the municipality experienced insurgent activity during 1910-1918 and equal to zero otherwise. The dependent variable is the percentage of municipal surface area redistributed by agrarian reform. Panel A reports instrumental variables estimates, with insurgency instrumented by 1906-1910 precipitation during non-harvest months as a percentage of long-run average precipitation. Panel B reports ordinary least squares estimates. All columns include controls for long-run average precipitation, long-run average minimum and maximum temperature, slope, and elevation, as well as state fixed effects. The samples are defined in the column headings. Column 1 examines the full sample. Municipalities that had a higher percentage of their male population working in agriculture in 1900 than the median municipality are examined in column 2, whereas municipalities that had a lower percentage of their population working in agriculture as compared to the median municipality are examined in column 3. Robust standard errors are in parentheses.

## Table 6: Public Employees

| | All | Federal | State | Local | Teachers per 1000 students | Local taxes per income |
|---|---|---|---|---|---|---|
| | authorities/1000 inhabitants in 1940 | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Panel A: IV* | | | | | | |
| Insurgency | -5.648 | -3.769 | -0.811 | 0.298 | -3.694 | -0.001 |
| | (4.564) | (3.276) | (1.848) | (0.750) | (4.746) | (0.001) |
| *Panel B: OLS* | | | | | | |
| Insurgency | -4.134*** | -2.880** | -0.748 | -0.827*** | -0.400 | -0.001 |
| | (1.571) | (1.129) | (0.638) | (0.242) | (1.325) | (0.001) |
| Observations | 205 | 205 | 205 | 205 | 205 | 205 |
| Mean Dep. Var. | 20.03 | 16.27 | 2.436 | 1.104 | 53.89 | 0.002 |

**Notes:** Insurgency is a dummy equal to one if the municipality experienced insurgent activity during 1910-1918 and equal to zero otherwise. Panel A reports instrumental variables estimates, with insurgency instrumented by 1906-1910 precipitation during non-harvest months as a percentage of long-run average precipitation. Panel B reports ordinary least squares estimates. All columns include controls for long-run average precipitation, long-run average minimum and maximum temperature, slope, and elevation, as well as state fixed effects. The dependent variable in column 1 is total public employees per 1,000 municipal inhabitants in 1940, in column 2 it is federal employees per 1,000 inhabitants in 1940, in column 3 it is state employees per 1,000 inhabitants in 1940, and in column 4 it is local employees per 1,000 inhabitants in 1940. The dependent variable in column 5 is school teachers per 1,000 school-age children in 2005, and in column 6 it is municipal tax receipts per dollar of municipal income in 2005. Robust standard errors are in parentheses.

## Table 7: Economic outcomes today

| | Overall | Agricultural | Industrial | Services | Percent | |
|---|---|---|---|---|---|---|
| | log wage | | | | no water | no electricity |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Panel A: IV* | | | | | | |
| Insurgency | -0.292** | -0.322 | -0.289* | -0.218** | 14.095** | 2.922* |
| | (0.141) | (0.274) | (0.169) | (0.109) | (6.255) | (1.657) |
| *Panel B: OLS* | | | | | | |
| Insurgency | -0.109*** | -0.082* | -0.122*** | -0.086*** | 0.715 | 0.404 |
| | (0.021) | (0.044) | (0.021) | (0.019) | (1.603) | (0.465) |
| Observations | 734,127 | 53,363 | 222,267 | 458,497 | 210 | 210 |
| Clusters | 210 | 210 | 210 | 210 | 210 | 210 |
| Mean Dep. Var. | 7.72 | 7.13 | 7.73 | 7.78 | 11.12 | 3.32 |

**Notes:** Insurgency is a dummy equal to one if the municipality experienced insurgent activity during 1910-1918 and equal to zero otherwise. Panel A reports instrumental variables estimates, with insurgency instrumented by 1906-1910 precipitation during non-harvest months as a percentage of long-run average precipitation. Panel B reports ordinary least squares estimates. All columns include controls for long-run average precipitation, long-run average minimum and maximum temperature, slope, and elevation, as well as state fixed effects. The dependent variable in columns 1 through 4 is log income in 2000. The sample in column 1 includes all individuals earning positive income, in column 2 it includes individuals working in agriculture, in column 3 it includes individuals working in industry, and in column 4 it includes individuals working in services. In column 5 the dependent variable is the percentage of households in a municipality who lack access to running water, and in column 6 it is the percentage of households who lack access to electricity. Robust standard errors, clustered by municipality, are in parentheses.

## Table 8: Economic organization

| | Percent labor force in | | | | Percent male pop. in | |
|---|---|---|---|---|---|---|
| | Ag | Industry | Ag | Industry | Ag | Industry |
| | 2010 | | 1960 | | 1940 | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *Panel A: IV* | | | | | | |
| Insurgency | 0.206*** | -0.060* | 0.171 | -0.077 | 0.164* | -0.094** |
| | (0.077) | (0.037) | (0.117) | (0.050) | (0.086) | (0.040) |
| *Panel B: OLS* | | | | | | |
| Insurgency | 0.059*** | -0.020* | 0.086** | -0.078*** | 0.069** | -0.036*** |
| | (0.020) | (0.011) | (0.043) | (0.018) | (0.380) | (0.170) |
| Observations | 210 | 210 | 190 | 190 | 188 | 188 |
| Mean Dep. Var. | 0.07 | 0.25 | 0.26 | 0.21 | 0.243 | 0.127 |

**Notes:** Insurgency is a dummy equal to one if the municipality experienced insurgent activity during 1910-1918 and equal to zero otherwise. Panel A reports instrumental variables estimates, with insurgency instrumented by 1906-1910 precipitation during non-harvest months as a percentage of long-run average precipitation. Panel B reports ordinary least squares estimates. All columns include controls for long-run average precipitation, long-run average minimum and maximum temperature, slope, and elevation, as well as state fixed effects. The dependent variables in columns 1 and 3 are the percentage of the municipal labor force working in agriculture in the years 2010 and 1960, respectively. The dependent variables in columns 2 and 4 are the percentage of the municipal labor force working in industry in the years 2010 and 1960, respectively. The dependent variable in column 5 is the percentage of municipal male population working in agriculture in 1940, and the dependent variable in column 6 is the percentage of municipal male population working in industry in 1940. Robust standard errors are in parentheses.

## Table 9: Political competition

| | Percent alternations | | |
|---|---|---|---|
| | 74-09 | 94-09 | 74-93 |
| | (1) | (2) | (3) |
| *Panel A: IV* | | | |
| Insurgency | -0.327*** | -0.382*** | -0.210* |
| | (0.101) | (0.143) | (0.111) |
| *Panel B: OLS* | | | |
| Insurgency | -0.028 | -0.050 | 0.006 |
| | (0.031) | (0.048) | (0.037) |
| Observations | 205 | 205 | 203 |
| Mean dep. var | 0.244 | 0.369 | 0.088 |

**Notes:** Insurgency is a dummy equal to one if the municipality experienced insurgent activity during 1910-1918 and equal to zero otherwise. Panel A reports instrumental variables estimates, with insurgency instrumented by 1906-1910 precipitation during non-harvest months as a percentage of long-run average precipitation. Panel B reports ordinary least squares estimates. All columns include controls for long-run average precipitation, long-run average minimum and maximum temperature, slope, and elevation, as well as state fixed effects. The dependent variable is the percentage of elections in which the party controlling the mayorship changed, during the time period listed in parentheses in the column headings. Robust standard errors are in parentheses.

## Table 10: Violence today

| | Homicides 92-08 | Police deaths | Drug trade homicides | Guerrillas 2008 |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *Panel A: IV* | | | | |
| Insurgency | 0.441 | -0.578 | -0.008 | 0.130 |
| | (0.564) | (0.745) | (0.042) | (0.158) |
| *Panel B: OLS* | | | | |
| Insurgency | -0.080 | -0.194 | -0.014 | 0.032 |
| | (0.168) | (0.382) | (0.015) | (0.056) |
| Observations | 210 | 210 | 210 | 210 |
| Mean dep. var | 1.544 | 0.750 | 0.058 | 0.118 |

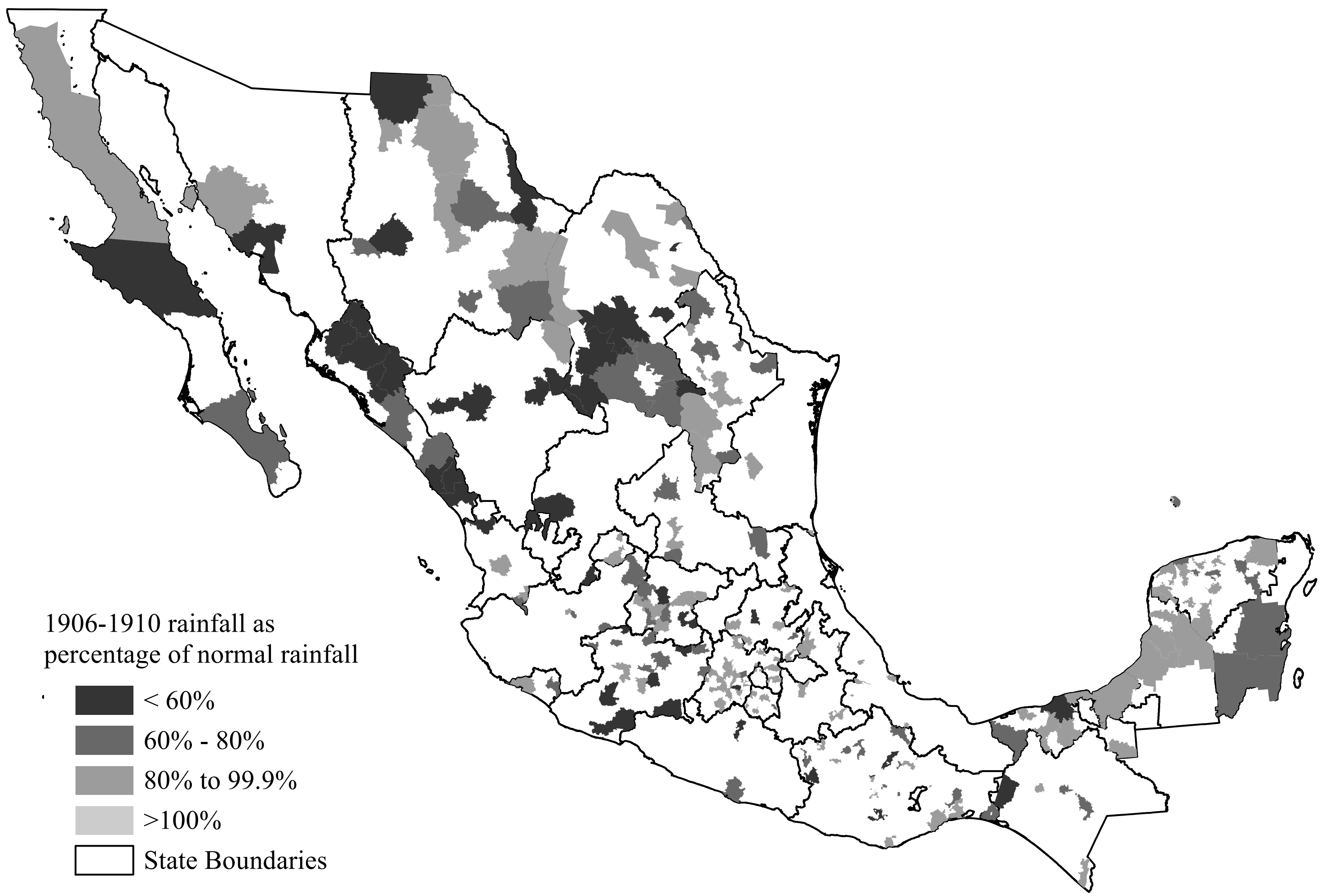
**Notes:** Insurgency is a dummy equal to one if the municipality experienced insurgent activity during 1910-1918 and equal to zero otherwise. Panel A reports instrumental variables estimates, with insurgency instrumented by 1906-1910 precipitation during non-harvest months as a percentage of long-run average precipitation. Panel B reports ordinary least squares estimates. All columns include controls for long-run average precipitation, long-run average minimum and maximum temperature, slope, and elevation, as well as state fixed effects. The dependent variable in column 1 is the average municipal homicide rate between 1992 and 2008, in column 2 it is the number of police deaths caused by confrontations with drug traffickers since late 2006, in column 3 it is the average rate of drug trade related homicides since late 2006, and in column 4 it is a dummy equal to 1 if guerrilla insurgents were present in the municipality in 2008 and equal to zero otherwise. Robust standard errors are in parentheses.

## Table 11: Droughts in other periods

| | Insurgency | % ejido | % agricultural | log income | % alternations |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Rainfall 1906 | -0.793*** | -0.182* | -17.490** | 0.153** | 0.240*** |
| | (0.230) | (0.089) | (8.382) | (0.072) | (0.072) |
| Rainfall 1960 | 0.425 | 0.161 | 12.114 | -0.038 | -0.082 |
| | (0.289) | (0.186) | (12.781) | (0.141) | (0.148) |
| Rainfall 1965 | -0.014 | 0.134 | 47.100 | 0.075 | -0.332 |
| | (0.456) | (0.406) | (33.486) | (0.261) | (0.307) |
| Rainfall 1970 | 0.247 | 0.245 | -21.345 | -0.112 | 0.135 |
| | (0.715) | (0.280) | (19.224) | (0.150) | (0.234) |
| Rainfall 1975 | 0.072 | 0.251 | -26.571 | 0.412 | -0.244 |
| | (0.527) | (0.513) | (32.687) | (0.257) | (0.146) |
| Rainfall 1980 | 0.586 | 0.077 | 3.426 | -0.411* | 0.155 |
| | (1.002) | (0.368) | (16.466) | (0.205) | (0.289) |
| Rainfall 1985 | 0.245 | -0.299 | -20.326 | 0.064 | 0.219 |
| | (0.424) | (0.368) | (30.188) | (0.180) | (0.247) |
| Rainfall 1990 | 0.116 | 0.112 | 29.701 | -0.079 | -0.336 |
| | (0.547) | (0.308) | (19.970) | (0.173) | (0.267) |
| Observations | 210 | 210 | 210 | 733,153 | 205 |
| R-squared | 0.467 | 0.460 | 0.340 | 0.357 | 0.358 |

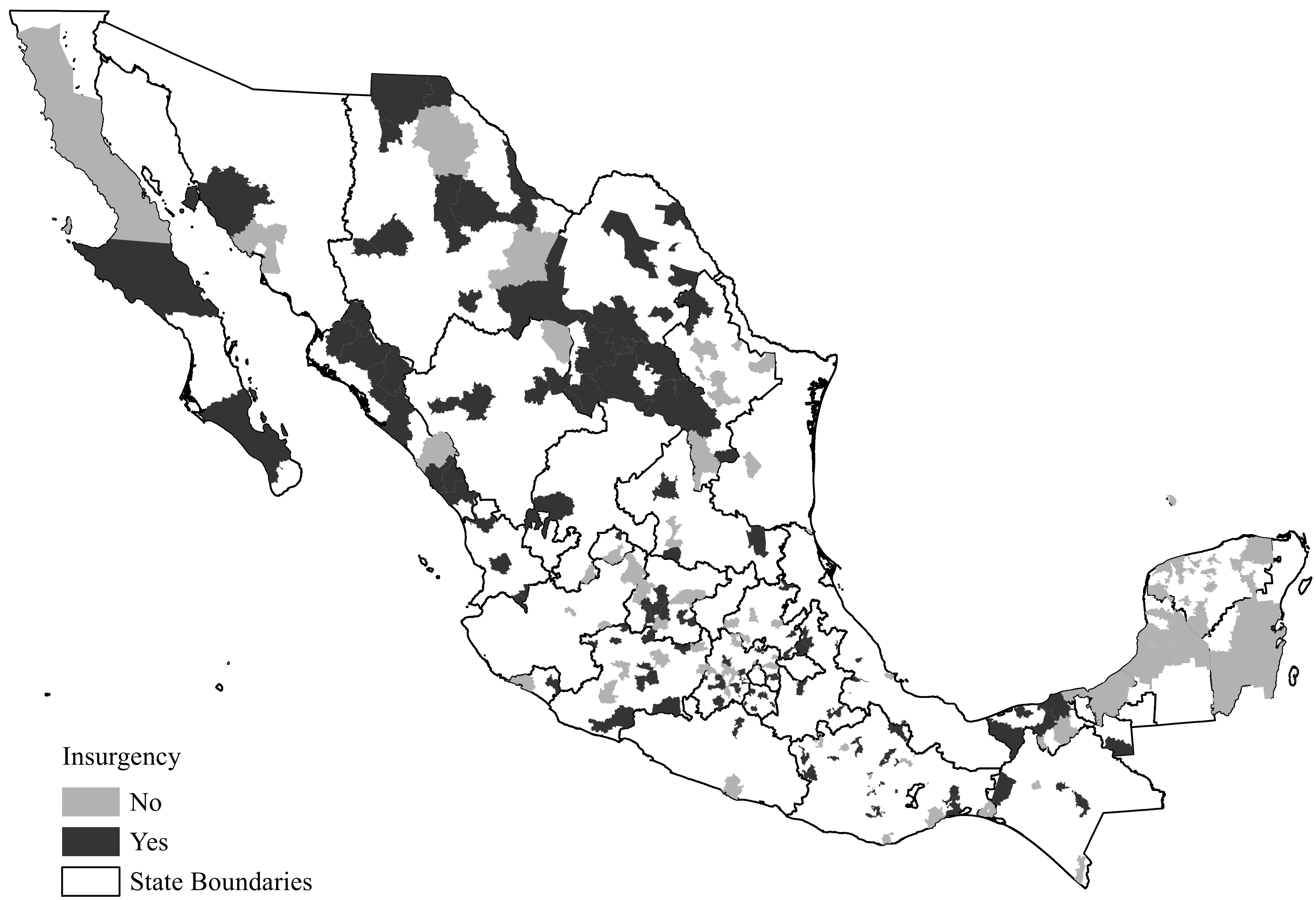
**Notes:** Rainfall measures precipitation during non-harvest months as a percentage of long-run average precipitation for the respective period. All columns include controls for long-run average precipitation, long-run average minimum and maximum temperature, slope, and elevation, as well as state fixed effects. The dependent variable in column 1 is insurgency, a dummy equal to one if the municipality experienced insurgent activity during 1910-1918 and equal to zero otherwise. The dependent variable in column 2 is the percentage of municipal surface area in the *ejidal* sector, the dependent variable in column 3 is the percentage of the municipal labor force working in agriculture in 2010, the dependent variable in column 4 is log income in 2000, and the dependent variable in column 5 is the percentage of elections held between 1974 and 2009 in which the party controlling the mayorship changed. Robust standard errors are in parentheses.

## Figure 1: Drought Severity




**Notes:** 1906-1910 precipitation as a percentage of long-run average precipitation is plotted, following the scheme given in the legend. State boundaries are in black.

**Figure 2: Insurgency**




**Notes:** Insurgency during 1910-1918 is plotted, following the scheme given in the legend. State boundaries are in black.