On the Distributive Costs of Drug-Related Homicides

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Abstract

We exploit the manifold increase in homicides in 2008–11 in Mexico resulting from its war on organized drug traffickers to estimate the effect of drug-related homicides on housing prices. We use an unusually rich data set that provides national coverage of housing prices and homicides and exploits within-municipality variations. We find that the impact of violence on housing prices is borne entirely by the poor sectors of the population. An increase in homicides equivalent to 1 standard deviation leads to a 3 percent decrease in the price of low-income housing.

1. Introduction

Crime and violence are serious obstacles to human development, social inclusion, and economic growth (see, among others, Glaeser 1999). According to the World Health Organization (2002), high levels of crime and violence have dramatic consequences for social and human capital in that they reduce life expectancy and lead to the loss of years of healthy life. The associated cost is estimated to be 1.2 percent of the gross domestic product (GDP) annually in Latin America.

Drug production and trafficking are a major problem in many countries. These activities are often associated with violence, a lack of security, and corruption in the police force and legal system. In some countries, the large number of killings may have a negative impact on economic outcomes. In Mexico, there have been more than 50,000 drug-related homicides (DRHs) since 2006, when President Felipe Calderón took office and declared a war on drugs.[1] Compared with the deaths occurring in other recent conflicts, such as the campaigns waged by the Irish National Liberation Army (3,500) or the Euskadi Ta Askatasuna (1,000)

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[1] There were 8,901 homicide cases registered in 2000–2006 (Rios 2013).

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in Spain, the number of homicides in Mexico is more than an order of magnitude higher. As a result of this violence, five Mexican cities are among the 10 most violent in the world, and Mexican citizens consider drug-related violence to be their most important concern. Many analysts and prominent policy makers have estimated that this situation translates into a reduction in GDP of as much as 1–2 percentage points.[2] Nevertheless, these estimates are more in the nature of guesses rather than the result of a rigorous attempt to measure the economic causal effect of drug-related violence.

To our knowledge, this is the first paper that explores the effect of drug-trafficking-organization (DTO) violence. This is surprising, given that drug policy and its costs and benefits are an issue of concern to many countries and that DTOs contribute to more killings than many recent wars have. We estimate the causal effect of violence on housing prices by drawing on a unique data set compiled using information about all of the houses and apartments that were appraised in connection with applications for mortgages in Mexico between 2008 and 2011. Housing prices are not only important in and of themselves; they also reflect the (dis)amenities of living in given locations. Our data set contains more than 1.3 million appraisals distributed among more than a thousand of the country's municipalities (out of 2,445 municipalities) and take various dwelling characteristics into account. For statistics on homicides, we use a national data set of deaths (we focus on murders) collected by the Mexican Secretariat of Health. The sharp increase in DRHs allows us to identify the causal effects of interest. We contend that the nature of local DRHs is unrelated to local economic conditions, since DRHs are mainly associated with retaliation killings, battles among drug organizations, and clashes with the army.

Our findings indicate that increases in DRHs have a negative effect on housing prices, but only for low-quality housing. In other words, this negative impact on housing price is borne entirely by the poorer segments of the population. Using a hedonic price equation while conditioning on municipality and period fixed effects, secular trends by type of house, and state trends and controlling for a large set of dwelling characteristics, we estimate that an increase in homicides of 1 standard deviation lowers the price of poor-quality houses by more than 3 percent. In light of Rosen's (1974) hedonic price model, in which the price of a differentiated good can be described by a vector of characteristics, our parameters of interest could be interpreted as the average marginal willingness to pay (WTP) for security amenities. Given that many municipalities registered DRH increases of much more than 100 percent and that housing wealth is typically the largest source of wealth for Mexican families and especially for low-income households, the economic costs of this type of violence may be substantial. In spite of this large bur-

[2] The governor of the Bank of Mexico, Agustín Carstens, said that it is "the most important factor inhibiting growth and investment" (Vargas 2011). See also the bank BBVA's estimate issued in late 2010 (Jimenez 2010) and the statement made by the minister of the treasury, Ernesto Cordero, who estimated the reduction in gross domestic product (GDP) caused by the violence to be 1.2 percent (Mena 2010).

den on the poor, the level of WTP to reverse the increase in drug-related crime is not high in terms of the whole economy: we estimate it to be approximately .1 percent of Mexico's GDP. This is because the cost of the violence induced by drug trafficking is suffered mainly by poor households. Nevertheless, the cost is high relative to the social transfers made by the national government to the poor. We also find that when the increase in violence occurs over the long term, the estimated negative effects on housing prices for the poor are up to 36 percent larger. Our results are robust across different sources of data on homicides.

This paper is related to Linden and Rockoff (2008), Besley and Mueller (2012), and Di Tella, Galiani, and Schargrodsky (2010).[3] Exploiting panel data, Linden and Rockoff (2008) find that prices of homes near sex offenders decline considerably (approximately 4 percent on average) following an offender's arrival in the neighborhood. Besley and Mueller (2012) examine the effect of violence in Northern Ireland on housing prices. They exploit the spatial and temporal variation in violence and model the transition from violence to peace with a Markov switching model. They find that peace leads to an increase in housing prices of between 1.3 and 3.5 percent, with the effect being stronger in the regions where the violence was greatest.

The findings described in this paper are also in line with those of Di Tella, Galiani, and Schargrodsky (2010), who, while studying another environment and type of conflict, also find that violence places a heavy burden on the poor. These authors exploit the sharp increase in crime that took place during the second half of the 1990s and, in particular, during 2001 in Buenos Aires. Their main research question is whether the rich or the poor have been the main victims of the rise in crime. In the case of home robberies, they find that the poor have been the primary victims of increases but that the channel for this effect is the fact that the rich, unlike the poor, are able to protect their homes by hiring security services and/or installing security devices (see also Levitt 1999).

The remainder of this paper is structured as follows. Section 2 describes the political context in which Mexico has experienced this DRH increase. The data sets employed for crime and housing variables are presented in Section 3. Section 4 discusses the identification strategy used in the analysis and its results. Section 5 presents the main results of the study. Section 6 explores what happens when violence is persistent, and Section 7 concludes.

2. Recent Increases in Drug-Related Homicides in Mexico

The number of drug-related homicides in Mexico started to rise in 2006, and this increase began to grow steeper in 2008, with the cumulative total climbing to almost 50,000 cases by the end of 2011; in contrast, during the preceding presidential term (2000–2006), the number of DRHs was below 10,000 (Rios 2013). Some analysts believe that this sharp upswing is attributable to Calderón's frontal attack on DTOs, which he launched almost as soon as he took office in Decem-

[3] See Ajzenman, Galiani, and Seira (2014) for a more extensive review of the literature.

ber 2006. The hypothesis is that the killings and apprehension of DTO leaders fragmented those organizations, which split into many different units and began to fight each other to gain control of their areas of operation (see, among others, Rios 2013; Guerrero-Gutiérrez 2011). Other analysts claim that when the Institutional Revolutionary Party lost the presidency after holding sway for almost 70 years, there was no longer a single political power to keep the DTOs in check and to strike deals with them (Astoga and Shirk 2011; Bailey and Godson 2000; Snyder and Duran-Martinez 2009). In addition, some authors contend that the successful fight against drug organizations in Colombia displaced operations to Mexico and led to increasing violence there as DTOs strove to gain the upper hand in their new areas of operation (Castillo, Mejía, and Restrepo 2012).

These hypotheses are based on reasonable arguments, although it is difficult to disentangle their effects. In any case, it is well documented that the increase in violence coincided with the start of the army's operations throughout the country (Escalante 2011). Dell (2012), exploiting a regression discontinuity design applied to close elections, shows that municipalities in which the mayor belonged to the same party as the president witnessed more DRHs just after the crackdowns in Mexico began. Her empirical evidence suggests that the violence reflects rival traffickers' attempts to usurp territories after the crackdown weakened the position of the incumbent DTO.[4] Dell's (2012) results support qualitative and descriptive studies that advance the argument that the Mexican government's antidrug policies have been the primary cause of the sharp increase in violence seen in recent years.

Dell (2012) finds that the number of major DTOs increased from six in 2007 to 16 in 2011, with groups splitting into factions as a result of leadership disputes. The fragmentation of these organizations and the ensuing struggle for preeminence and territory are, according to this view, the most likely causes of the increase in violence. According to Molzahn, Ríos, and Shirk (2012), of the 50,000 DRHs in 2006–11, about 35,000 were due to conflicts among DTOs. Castillo, Mejía, and Restrepo (2012) draw attention to the fact that the violence has been concentrated in municipalities where two or more cartels operate, with the presence of each additional cartel increasing the homicide rate by about 100 percent.

A second probable exogenous shock to the crime rate is related to Colombia's crackdown on DTOs. Castillo, Mejía, and Restrepo (2012) exploit drug seizures in Colombia to account for the DRH rate in Mexico, arguing that these seizures could account for 17 percent of the increase in DRHs in Mexico. Regardless of whether the spike in DRHs is attributable to political factors or to the consequences of an exogenous shock to the crime rate generated by Colombia's successful war on drugs, it is unlikely that it was the result of changes on the demand

[4] According to Dell (2012, p. 5), "Over 85 percent of the drug violence consisted of people involved in the drug trade killing each other" as a way of either exacting revenge or expanding their territories. She also notes that the killings are especially frequent after one side is weakened by government intervention.

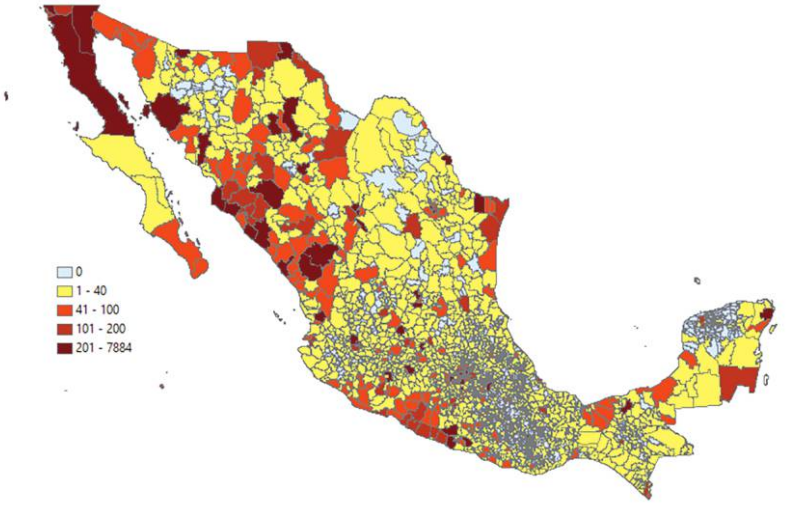

Figure 1. Total drug-related homicides by municipality, 2007–10

side of the drug market, since most demand for drugs is external,[5] Mexico is the main supplier of illicit drugs to the United States, and demand there did not undergo any major or sudden change during the period in question (United Nations Office on Drugs and Crime 2011).

One interesting aspect of the situation in Mexico is that the violence tends to be geographically concentrated (see Figure 1, which uses SINAIS data). This may have to do with the localized nature of drug production. Indeed, Dell (2012) reports that illicit drugs are cultivated in 14 percent of the country's municipalities. It may also have something to do with proximity to transportation routes to the US border and along the Pacific coast (Castillo, Mejía, and Restrepo 2012).

Nevertheless, at the municipality level, we find that the increase in violence was sudden and discontinuous and that it occurred in different municipalities at different times, independent of the economic or social characteristics of any particular municipality. To illustrate our argument, Figure 2 shows examples of the spikes seen in the number of DRHs in two of the most affected municipalities, but these patterns are present in dozens of others as well. The spikes in the crime rates in these examples occur at different moments of time (and space) and thus are plausibly unrelated to local economic trends.

Given that property crime has not been found to be strongly correlated with

[5] Whereas 14 percent of Americans used illicit drugs during 2007 (Substance Abuse and Mental Health Services Administration 2008), only 1.4 percent of Mexicans did (Instituto Nacional de Salud Pública 2008).

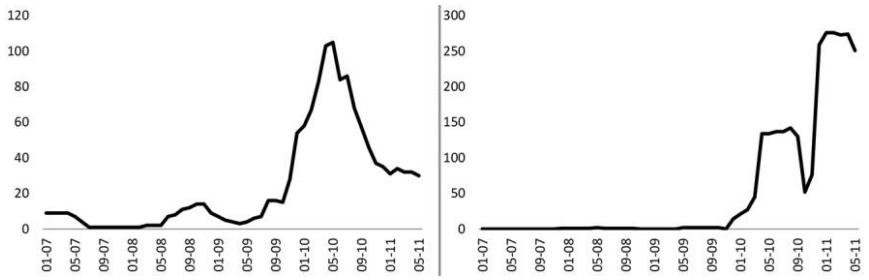

Figure 2. Monthly drug-related deaths: cumulative 6-month rates for Cuernavaca (*left*) and San Fernando Tamaulipas (*right*).

economic variables such as unemployment,[6] and in view of the patterns described above, it comes as no surprise that DRHs are not correlated with employment either. This finding is discussed in Section 4.

Finally, DRHs are generally more common in poor sectors of the population. In their study of a gang of drug dealers in the United States, Levitt and Venkatesh (2000) find that gangs hire low-income people, almost all of whom earn very low wages. In Mexico, too, drug dealers are recruited from low-income segments of the population. *Proceso,* a popular Mexican news magazine, calls the poor the "stockfeed of the illicit drug industry" (Olmos 2011). Criminal gangs have terrorized the poorest sectors of the population, who live in what have become lawless no-man's-lands.

3. Data and Descriptive Statistics

One of the strengths of this paper is the quality of the data on the main factors examined: homicides and housing prices. To measure homicides, we use two data sources. One is the data collected from hospitalization records, which register all deaths from homicides (whether or not related to DTOs). The other is the data on DRHs reported by the Office of the President, which are compiled from the registries of several government ministries in Mexico. For data on housing prices, we use a database that comprises 25 house characteristics and 1,370,676 valuations. The pricing data are available from January 2008 through December 2011, and our final data set therefore covers that period.

3.1. Data on Crime

Our main source of data on homicides is the death certificates prepared by civil servants and doctors, which identify the cause, date, and place of death. The information is centralized by the National Health Information System (Sistema Nacional de Información en Salud [SINAIS]). The SINAIS database contains a registry of deaths in Mexico but does not provide a clear indication of whether homicide deaths were related to drug dealing.

[6] A typical estimate is that a 1-percentage-point increase in the unemployment rate is associated with a 1 percent increase in property crime (Levitt 2004).

The other source of crime data in Mexico is the Office of the President. The data are collected mainly by the police and armed forces and specifically focus on drug-related crime. However, mostly because of the time span of data coverage, we prefer the SINAIS database to the Office of the President's database, since the latter data set covers a shorter period: from December 2006 to September 2011. As our estimations include data from January 2008 to December 2011,[7] we would lose the data for just 1 quarter (from September 2011 to December 2011). However, we use cumulative homicide rates (for the preceding 6-, 12-, and 24-month periods) as the causal variable of interest, and we cannot obtain the cumulative 24-month rate using the Office of the President's database for the entire period for which we have data on housing prices. Nevertheless, as can be seen in Figure 3, the correlation between the two sources is almost perfect. Thus, estimating the effect of total homicides or drug-related homicides can be expected to generate similar results. A comparison of the series of total homicides (SINAIS) and the series of drug-related homicides (Office of the President) reveals that the variability in the former is almost completely explained by the variability in the latter.[8]

3.2. Data on Housing Prices

By law (Ley de Transparencia y Fomento a la Competencia en el Crédito Garantizado, DO, February 7, 2005), an official appraisal must be made of property used as security for all collateral-backed mortgages granted by financial intermediaries, and those appraisals must be reported to the Federal Mortgage Society (Sociedad Hipotecaria Federal [SHF]), a government development bank. The appraisal has to be performed by an authorized appraiser (designated by the SHF) using a very specific, explicit, and detailed SHF procedure. According to the applicable rules, the appraisal must be based on sufficient information concerning at least six transactions involving similar houses on the local market. Violations of this rule can result in the revocation of the appraiser's license. Our data include all of the houses, apartments, and other real estate assets that were appraised in connection with a loan application.

Our data on housing-unit appraisals cover the 4 years between January 2008 and December 2011. In addition to the price variable—which is our main outcome—the data set includes a number of dwelling characteristics such as size of the plot, size of the built-up area, size of the accessory areas (without any construction), remaining life of the dwelling, year of construction, number of bedrooms, number of bathrooms, number of parking places, whether the dwelling is an apartment or a house, its proximity to the city center, a classification of services, and codes for the bank, appraiser, and municipality. In our main analysis, we retain only those observations that provided global positioning system (GPS) information at the locality level (that is, appraisals in localities identified by GPS

[7] The National Health Information System database covers the period from 2002 onward, but we are limited by the housing valuation database, whose coverage starts in 2008.

[8] See Ajzenman, Galiani, and Seira (2014, sec. 5.2) for evidence showing that the estimates and levels of statistical significance derived from the two databases are indeed very similar.

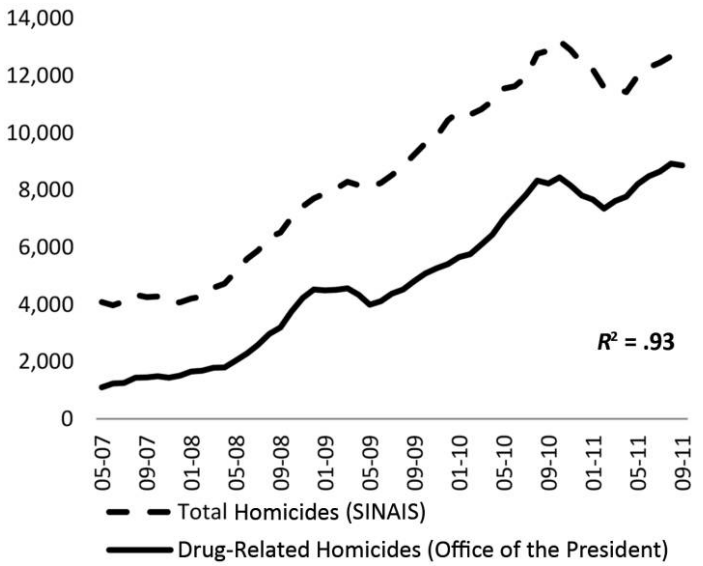

Figure 3. Monthly drug-related homicide rates and total homicide rates in Mexico

coordinates). The reason is that we need to control for the size of the locality, which is not possible to determine without knowing the exact location of the house.[9] Despite the loss of some observations, we have 1,370,676 observations of housing prices and 25 variables for each dwelling.

It is important to clarify that the housing prices in our data set are not final transaction prices but rather appraisals that are supposed to be based on going market prices in the relevant neighborhood. A skeptical reader could claim that the appraisal values might not be closely correlated with market prices, however, we have evidence that appraisal prices are in fact strongly correlated with market prices. Although we do not have data on market prices for multiple years, we do have data for 2006.[10] In Figure 4, we present the distribution of percentage differences between market and appraisal values (as a percentage of the market price) for 2006. The median difference is about 3.5 percent. We also find that, controlling for city fixed effects, the mean difference in appraisal and market prices is close to 0 and that the variability in actual prices explains about 93 percent of

[9] Although we lost a significant number of observations (about 40 percent) because of missing global positioning coordinates, we verified that the results obtained using the entire database and those obtained using the trimmed database are very similar (see Ajzenman, Galiani, and Seira 2014, sec. 6.2).

[10] Systematic data on appraisals are available from 2008 onward. However, for 2006, we obtained a data set with a sample of appraisals (and market prices) from one of the major mortgage lenders (Infonavit), which includes 50 municipalities (our data set includes more than 1,100 municipalities). The data set does not contain as many housing characteristics as our data set does, but the valuation methods are very similar.

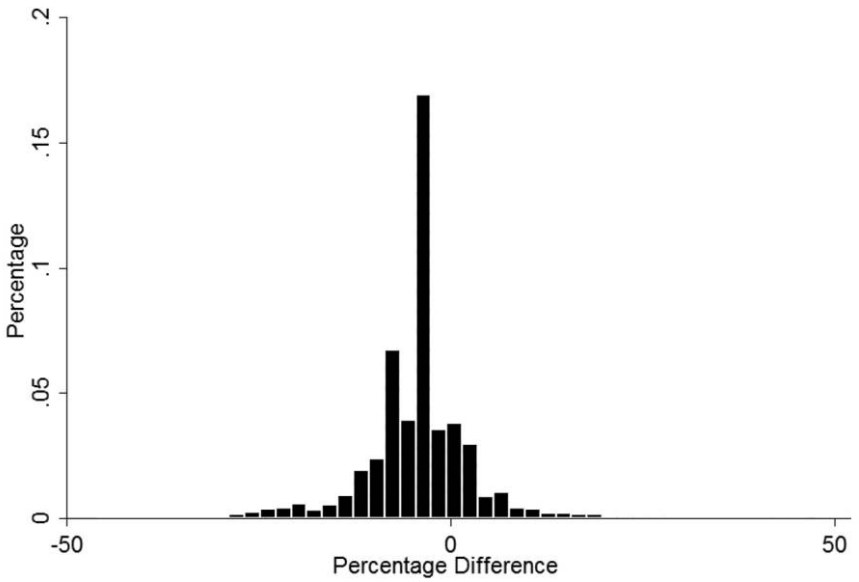

Figure 4. Differences between market and appraisal prices in Mexico: Federal Mortgage Society data for 2006.

the variability in appraisal prices. This indicates that the appraisal valuations are indeed very close to market prices.

3.3. Final Data Set

We merged the two data sets (homicides and appraisals) using municipality and year-month as the matching variables. The merged data set comprises 1,370,367 dwellings in 1,165 municipalities on a monthly basis from January 2008 to December 2011.

Mexico is politically divided into approximately 2,500 municipalities that vary substantially in size but are generally not very large in terms of population. The 25th, 50th, and 75th percentiles for population are 4,192, 12,963, and 34,696, respectively. In terms of number of houses, the respective percentiles are 1,408, 4,118, and 10,589. The sizes in square kilometers are 80, 226, and 655, respectively. In the 2010 census, about 10 percent of inhabited houses are rented. One rough indication of segregation is the share of the population older than 18 with more than a middle school education. There is a mix of inhabitants in municipalities along this measure: the 25th, 50th, and 75th percentiles have a 7 percent, 10 percent, and 16 percent share of the adult population with more than a middle school education, respectively. However, Figures 5 and 6 use data from the social deprivation index to clearly show that poverty appears to be geographically concentrated.

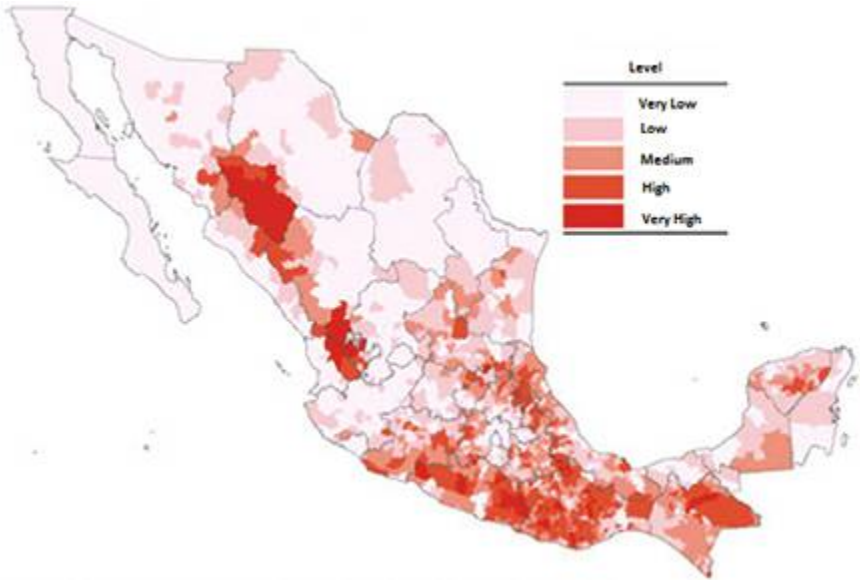

Figure 5. Social deprivation index: poverty by municipality, 2010 (CONEVAL 2011)

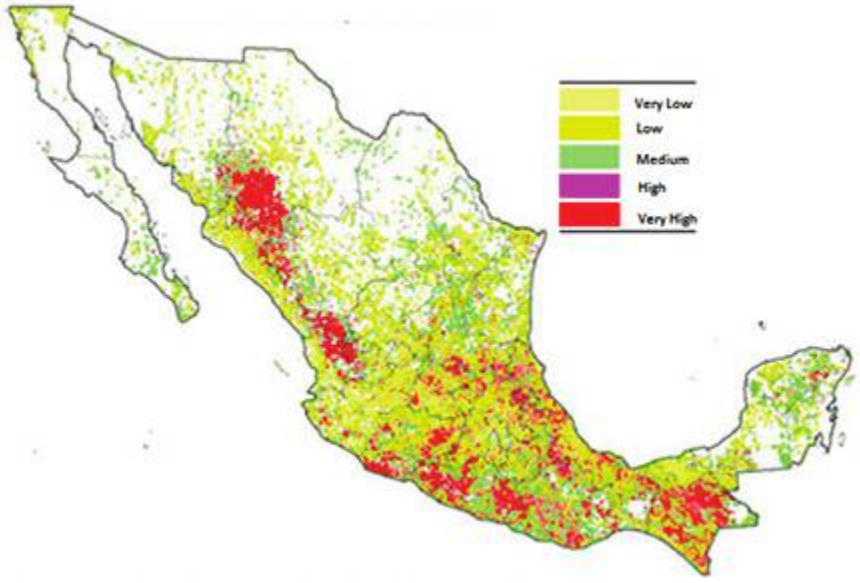

Figure 6. Social deprivation index: poverty by locality, 2010 (CONEVAL 2011)

Dwellings are the main unit of analysis, and we have 25 variables for each of them.[11] Each house can be associated with the cumulative homicide rate for the municipality in which it is located. On average, there are 1,176 appraisals per municipality (over the 4 years of the sample), 28,549 appraisals for each of the 48 months included in the period of analysis, and 24.5 appraisals for each municipality-month.[12] Table 1 provides definitions and descriptive statistics.

Figure 7 displays the categories of dwellings (low income, middle income, high income, and so forth) by the quality of their infrastructure. In our sample, 3 percent of the dwellings are classified as high income (semiresidential, residential, and residential plus), 22 percent as middle income (intermediate), 64 percent as low income (low income), and 10 percent as poor (minimum and economical).[13,14]

In our estimations, we define poor dwellings as those that fall into the appraisal categories "minimum" or "economical." Poor dwellings have substandard infrastructure and were not built to conform to required architectural plans (these dwellings are usually informal constructions). As shown in Table 2, poor dwellings have fewer bedrooms and bathrooms, are older and smaller, have less useful life remaining, afford access to fewer services, and have general infrastructure of a poorer quality.

4. Econometric Models and the Identification Strategy

Our goal is to measure the causal effect of the number of DRHs on housing prices. Simply regressing housing prices on the number of DRHs is likely to be problematic, since crime is likely to be endogenous. Our identification strategy exploits the panel structure of our data by conditioning on municipality and period fixed effects and municipality-specific linear time trends. Our basic empirical model is as follows:[15]

[11] Having a data set that includes a considerable number of dwelling characteristics enabled us not only to include a large number of relevant controls in our regression, but also to analyze the differential impacts on housing prices for poor and nonpoor segments of the population.

[12] The sample contains 1,165 municipalities. Thus, we have 55,920 municipality-months. Each municipality-month corresponds, on average, to 24.5 home appraisals (the unit of observation).

[13] This classification scheme is the one used by the Federal Mortgage Society (Sociedad Hipotecaria Federal [SHF]). The intermediate category, for instance, corresponds to housing that has rooms that are differentiated by use, such as living rooms, bedrooms, and kitchens. According to the SHF classification, low-income housing is built in groups, with identical housing based on a prototype, but has adequate infrastructure.

[14] There is no straightforward way to compare these housing characteristics to those used in the national census because the definition of poor housing that we use is based entirely on the SHF classification. However, it is possible to compare a few of the housing characteristics recorded in our database with the census averages. In our data, dwellings with telephones represent 53 percent of the total versus 43 percent in the census results. The distribution for the number of bedrooms follows (our data versus census data, respectively) one bedroom (20 percent versus 35 percent), two bedrooms (53 percent versus 40 percent), three bedrooms (23 percent versus 20 percent), four bedrooms (2 percent versus 4 percent), five bedrooms (.4 percent versus .8 percent), and six or more bedrooms (.2 percent versus .3 percent).

[15] If we were to use per capita homicides instead of total homicides, we would have to use a linear approximation of the population based on 2005 and 2010 census data (at the municipality level). This does not make any difference to our specification.

Table 1

Descriptive Statistics

Variable	Min	Max	Mean	SD	Description
Log Value	9.90	16.11	12.87	.62	Appraisal value of the house or apartment in pesos
Log Homicides, 6 months	0	7.74	2.87	1.5	Cumulative homicide rate for the preceding 6 months
Log Homicides, 12 months	0	8.23	3.45	1.53	Cumulative homicide rate for the preceding 12 months
Log Homicides, 24 months	0	8.78	4.02	1.55	Cumulative homicide rate for the preceding 24 months
Log Plot Size	2.94	8.00	4.65	.59	Size of the plot (square meters)
Log Built-up Area	3.43	7.94	4.16	.48	Area of the plot with a structure (square meters)
Log Accessory Area	0	7.82	.33	.92	Area of the plot without a structure (square meters)
Log Remaining Lifespan	.69	7.09	6.50	.24	Remaining months of the dwelling's useful life
Log Age	7.55	7.60	7.60	.01	Years since construction completed
Log Bedrooms	.00	2.39	1.10	.24	Number of bedrooms
Log Bathrooms	.00	2.39	.78	.20	Number of bathrooms
Log Parking Spaces	.00	3.43	.69	.24	Number of parking spaces
Small Locality	.00	1.00	.51	.50	Equals one if the locality has a population of less than 50,000
Log Poor Dwelling	.00	1.00	.11	.30	Equals one if the house or apartment is considered poor (10 percent of the sample is economical or minimum)
Telephone	.00	1.00	.53	.50	Equals one if the house or apartment has telephone
House with Condominium Ownership	.00	1.00	.26	.44	Equals one if the house's ownership is like that of a condominium
Apartment with Condominium Ownership	.00	1.00	.09	.29	Equals one if the apartment's ownership is like that of a condominium
Central	.00	1.00	.04	.20	Equals one if the house or apartment is in an urban area
Near	.00	1.00	.28	.45	Equals one if the house or apartment near an urban area
Peripheral	.00	1.00	.49	.50	Equals one if the house or apartment is on the periphery of an urban area
Outskirts	.00	1.00	.18	.38	Equals one if the house or apartment is near the outskirts of an urban area
Three Services	.00	1.00	.05	.21	Equals one if the house or apartment block has potable water, plumbing, and electricity
Five Services	.00	1.00	.78	.41	Equals one if the house or apartment block has potable water, plumbing, electricity, street lighting, and paved roads
Seven Services	.00	1.00	.16	.36	Equals one if the house or apartment block has potable water, plumbing, electricity, street lighting, paved roads, natural gas, and private security
Medium Comfort	.00	1.00	.22	.42	Equals one if the amenities and comfort level of the house or apartment are classified as intermediate
Semiresidential Comfort	.00	1.00	.02	.14	Equals one if the amenities and comfort level of the house or apartment are better than intermediate
Residential Comfort	.00	1.00	.01	.09	Equals one if the amenities and comfort level of the house or apartment are better than semiresidential

Note. $N = 1{,}370{,}767$.

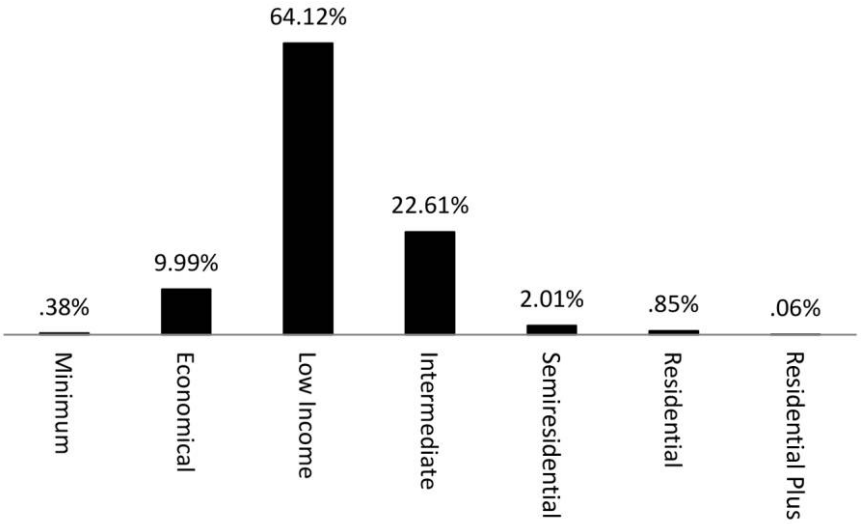

Figure 7. Distribution of Federal Mortgage Society housing categories in Mexico

$$\log(P_{ijt}) = \alpha_t + \partial_j + t\gamma_j + \delta \boldsymbol{X}_{ijt} + \beta \log(\text{CumHom}_{jt}) + \varepsilon_{ijt}, \quad (1)$$

where $\log(P_{ijt})$ is the logarithm of the price of dwelling i in municipality j in month t; α_t and ∂_j are fixed effects that control for time trends and differences across municipalities that are fixed over time, respectively. We include a set of 25 dwelling and locality characteristics ($\boldsymbol{X}_{ijt}$), including indicator variables for the appraiser and for the banks to which the loan application was submitted. The term $t\gamma_j$ controls for municipality-specific monthly linear time trends.

The causal variable is the cumulative number of homicides in municipality j at time t. The cumulative number of homicides is the sum of those incidents over the previous 6, 12, and 24 months; these figures provide a more stable measurement that can then be used to characterize dangerous places and to take into account potential lags in the effect of crime on housing prices. We do not expect a short-lived jump in crime (that is, an increase lasting for just 1 or 2 months), even if very large, to affect housing prices. Longer-lasting changes in housing amenities, on the other hand, are the kinds of factors that we would expect to be reflected in their prices. Standard errors are clustered at the level of the municipality.

Equation (1) is a partially identified hedonic price equation that conditions identification on municipality and period fixed effects and municipality trends. In light of Rosen's (1974) hedonic price model, in which the price of a differentiated good can be described by a vector of characteristics, our parameters of

Table 2
Characteristics of Poor and Nonpoor Dwellings

Variable	Nonpoor	Poor
Bedrooms	2.15	1.87
	(.76)	(.84)
Bathrooms	1.26	1.09
	(.6)	(.35)
Age	4.44	7.24
	(8.99)	(10.44)
Built-up Area	73.82	66.01
	(53.24)	(45.62)
Remaining Lifespan	688	624.88
	(117.01)	(119.7)
Telephone	.54	.44
	(.49)	(.50)
Poor infrastructure	.046	.17
	(.21)	(.37)
Acceptable infrastructure	.95	.82
	(.21)	(.37)

Note. Housing with no services and housing with only potable water, plumbing, and electricity are considered to have poor infrastructure. Housing with potable water, plumbing, electricity, street lighting, and paved roads and housing with natural gas and private security as well are considered to have acceptable infrastructure.

interest could also be interpreted as the average marginal WTP for security amenities.[16]

The causal effect of homicides on housing prices is derived from within-municipality variations in cumulative homicides and housing prices after controlling for a large number of housing characteristics and other determinants of appraisals. In other words, to identify the effect of interest to us here, we assume that changes in cumulative homicide rates are strictly exogenous in equation (1).

Equation (1) controls for municipality characteristics fixed over time. For example, local amenities (such as good schools) may influence housing prices and are captured by the municipality fixed effects. We use period fixed effects to control for secular trends in housing prices associated with changes in macroeconomic or seasonal conditions. We also include municipality linear trends in the model to take into account the presence of differential trends in prices across municipalities resulting from unobserved local time-varying effects. Finally, we also control for a large set of observable housing characteristics (and characteristics of the bank and the individual who appraises the house).

The validity of our identification strategy could be undermined if changes in homicide rates are also driven by economic factors that influence housing prices.

[16] However, see Ekeland, Heckman, and Nesheim (2004) for a very general examination of identification and estimation of hedonic price models.

This does not seem to be the case, however. There is evidence that DTOs operate at a regional level (their area of operations thus encompasses many different municipalities) and that their behavior is not driven by the economic situation of the municipality (Dell 2012), which reinforces our identification strategy.

To provide further evidence that the timing and intensity of violence do not seem to be driven by the economic situation in a municipality, we investigate the link between formal employment and homicides at the municipality level. We use a data set containing a municipality-month measure of all formal employment in Mexico prepared by the Mexican Social Security Institute (Instituto Mexicano del Seguro Social) and the SINAIS database on homicides.[17] Table 3 reports the estimates of the following equation for all municipalities for which we have homicide and employment data:

$$\log(\text{CumHom}_{jt}) = \alpha_t + \partial_j + \beta\text{Formal Employment}_{tj} + \varepsilon_{tj}. \quad (2)$$

The correlation between homicides and employment is not statistically different from 0, which is consistent with our identifying assumption that the type of crime being analyzed is not related to the labor market or, more broadly, to economic variables.

Another potential concern with regard to our identification strategy, which is common to all studies that use home sale prices, is that we are consider houses that have only been appraised for sale. If, for example, richer people who own better houses were to decide to sell their homes so that they could move away from a high-crime area, and the regression model does not control for that, we would underestimate the negative impact of violence on housing prices. To deal with this statistical nuisance, we control for an unusually large set of housing characteristics. These characteristics alone can account for up to 92 percent of the variation in prices (Table 4) when fixed effects for period, municipality, bank, and appraiser are included. This considerably mitigates concerns about selection bias being generated by the types of houses that enter the market in each municipality over time.

Moreover, our sample includes all appraisals—for low-income and high-income households—that were conducted as part of the home mortgage application process. In Mexico, even the poorer segments of the population apply for and obtain mortgage loans: about 65 percent of our sample comprises loans furnished by Infonavit, Fovisste, or Cofinavit, which are government institutions that subsidize loans for the poorer segments of the population.[18] This unique feature of our data set allows us to investigate the distributional effect of DRHs.

Finally, since we are interested in the differential impact that homicides may

[17] We would like to thank Judith Frias for providing the social security data, which are even more reliable than survey data because, since they come from a census of the formal employment sector, they are representative at the level of the municipality and have no measurement error associated with the definition of formal employment. Data were provided at the municipal level; no individual data were provided.

[18] Infonavit loans are designed for members of the population who earn less than MX$6,000 per month (less than US$500).

Table 3
Correlation between Employment and Homicides: Quarterly Averages

	Log Per Capita Homicides	Log Homicides	Log Homicides, 6 Months	Log Homicides, 12 Months	Log Homicides, 24 Months
2006–8 ($N = 39{,}888$):					
Log Employment Rate	.0015	.0027	.0029	−.002	.007
	(.003)	(.005)	(.008)	(.010)	(.012)
R^2	.98	.97	.97	.97	.97
2006–11 ($N = 127{,}734$):					
Log Employment Rate	.0019	−.005	.002	.007	.014
	(.002)	(.004)	(.006)	(.007)	(.009)
R^2	.94	.94	.94	.94	.94

Note. Standard errors, clustered at the municipality level, are in parentheses. All regressions include quarter and municipality fixed effects.

have on different socioeconomic groups, we also estimate an econometric specification that identifies the differential effect of homicides on low-quality housing. However, there may be factors other than a sudden increase in homicides that affect the poor by driving down low-quality housing values. Therefore, in order not to confuse this differential effect with a differential secular trend in the price of houses by socioeconomic status, we also include a differential secular trend for low-quality houses and estimate the following empirical model:

$$\begin{aligned}\log(P_{ijt}) = {} & \alpha_t + \partial_j + t\gamma_j + \phi \text{PoorDwelling}_{ijt} \\ & + \alpha_t \text{PoorDwelling}_{ijt} + \delta \boldsymbol{X}_{ijt} + \beta \log(\text{CumHom}\, s_{jt}) \\ & + \theta[\text{PoorDwelling}_{ijt} \log(\text{CumHom}_{jt})] + \varepsilon_{ijt}.\end{aligned} \tag{3}$$

5. Main Results

Our main results are based on the SINAIS data and the data from the Office of the President. We find an average effect of 0 on housing prices (Table 5). However, we do find a negative impact on the prices of low-quality housing. A 100 percent increase in homicides is associated with a decrease in housing prices of between −.9 and −1.2 percent, depending on the specification adopted. While Besley and Mueller (2012) find that a decrease of 1 standard deviation in homicides leads to an increase of between .8 and 1.4 percent in prices (when using an ordinary least squares benchmark with region and time fixed effects), we find a price reduction of between 3 and 4 percent as a result of DRHs in Mexico, but this applies only to poor-quality housing.

Our results indicate that violence, as reflected in the number of homicides, has a regressive distributive effect, since it affects poorer households more than richer ones. These results are consistent with a limited body of existing literature that contends that the effects of crime are different for the rich and poor and that wealthier people can either flee from violent places or invest in technologies to

Table 4
Variance in Appraisal Values Explained by Controls

	(1)	(2)	(3)
Bank fixed effects	No	Yes	Yes
Appraiser fixed effects	No	Yes	Yes
Property characteristics	No	No	Yes
R^2	.39	.62	.92

Note. All regressions include municipality and month fixed effects. $N = 1{,}370{,}767$.

reduce the chances of falling victim to crime (see Di Tella, Galiani, and Schargrodsky 2010; Levitt 1999).

The size of the effect that we find is quite large, considering that some municipalities experienced sharp increases in crime. According to official data (SINAIS), the increase in crime that occurred between 2006 and 2011 amounted to a rise of more than 200 percent nationally. Taken at face value and extrapolated to the national level, our results indicate that from 2006 to 2011 housing prices of poor households decreased by 2.5 percent, while municipalities such as Monterrey, where the number of DRHs soared, had a price decrease several orders of magnitude larger. Given that their houses are one of the most valuable assets that households possess, this decline represents a substantial loss of wealth, and it is a loss that is concentrated among the poorer segments of the population.

One important welfare calculation is the computation of the relevant households' WTP to eliminate the increase in DRHs during the period studied. Under certain assumptions, the gradient estimate of the hedonic price function provides the average marginal WTP (MWTP) for a change in the number of DRHs. A standard assumption that is widely used in the literature is that the MWTP function is constant.

The effect of the number of DRHs on the value of low-quality houses, using our main specification (6 months cumulative, Table 5), is −.0121 percent for each 1 percent increase in total homicides. According to our data, the average price of a poor-quality house in Mexico is approximately MX$320,000 (US$24,000), and homicides increased by about 83 percent between 2008 and 2011, so the monetary impact of homicides on an average low-quality house was MX$2,700 during the period under study. According to the last census (2010), Mexico has 28,607,568 houses (with 10 percent of them being poor-quality dwellings in our sample). This means that the total monetary effect of homicides, measured as its total impact on houses prices, is MX$7,600,000,000 (US$600,000,000) in 2008–11.

Thus, the cost of violence associated with drug trafficking and borne by the poor is large, for example, relative to what the Mexican government spends on social programs. Indeed, it represents about 11 percent of the annual cost of Oportunidades—the conditional cash transfer program that is a showpiece in Mexico and by far the most expensive single program of the national government. However, when compared with Mexico's GDP, it represents only .1 percent because the

Table 5
The Effect of Homicides on Housing Prices

	Regression (1)			Regression (3)		
	Log Homicides, 6 Months	Log Homicides, 12 Months	Log Homicides, 24 Months	Log Homicides, 6 Months	Log Homicides, 12 Months	Log Homicides, 24 Months
Log Cumulative Homicides	−.0008	.0030	.0013	.0002	.0042	.0025
	(.0019)	(.0025)	(.0040)	(.0020)	(.0026)	(.0041)
Log Cumulative Homicides × Poor Dwelling				−.0123**	−.0128**	−.0130**
				(.0033)	(.0032)	(.0030)
Poor Dwelling				−.0121**	−.0086*	−.0105*
Month × Poor Dwelling	No	No	No	Yes	Yes	Yes
N	1,370,767	1,370,768	1,370,769	1,370,770	1,370,771	1,370,772

Note. Standard errors, clustered at the municipality level, are in parentheses. All regressions include month, bank, appraiser, and municipality fixed effects, municipality trends, and controls for property and locality characteristics. $R^2 = .93$.

* $P < .05$.

** $P < .01$.

cost of this type of crime is borne only by the poor. The fact remains that the cost to those households is relatively large.

This having been said, according to the canonical Roback (1982) model, the full implicit price of an amenity is the sum of the land or real estate price differential plus the negative of the wage differential. Table 6 reports the results of fitting the following wage equation:

$$\log(W_{ijt}) = \alpha_t + \partial_j + t\vartheta_{jz} + \delta \boldsymbol{X}_{ij2000} + \phi \boldsymbol{X}_{ij2010} + \beta \log(\text{CumHom}_{j2010}) + \varepsilon_{ijt}, \tag{4}$$

where W_{ijt} is the monthly wage (or hourly wage, in Table 6) of person i in municipality j during period t, $\boldsymbol{X}_{ijt}$ includes controls at the individual level (years of education, age, age squared, gender, and a dummy for low skill levels), and CumHom_{j2010} represents the cumulative homicide rate in municipality j for 2008–10. We use the latest available data from the last two censuses (2000 and 2010).[19] The model includes year and municipality fixed effects and linear trends at the state level ($t\theta_z$). Table 6 presents the results of our estimations using total monthly wages and hourly wages. Models 1 and 2 differ in terms of how "low skilled" is defined: model 1 uses the sample of individuals who have not completed secondary school (attended by students ages 12–14), whereas model 2 uses the sample of individuals who have not completed high school (attended by students ages 15–17). None of the models show significant effects of homicides for the sample as a whole or specifically for low-skilled workers.[20] Consequently, the above welfare calculations are unchanged when we account for changes in wages.

6. The Effect of Persistent Violence

Besley and Mueller (2012) argue that violence affects housing prices and that homicides are an observable proxy for violence. The distinction turns out to be important: patterns of homicide that lead to more violence in the future affect housing prices more than short-lived increases in violence. We now test this prediction using a reduced-form model, taking advantage of the fact that the duration of the violence varied widely across municipalities.

We use four definitions of persistent violence that reflect the magnitude of the increase seen in 2008–11 and the changes in the level of violence witnessed in the interim years. To be considered persistent, the pattern of homicides must fulfill two conditions: the increase in crime must have been at least 150 percent (or 200 percent) from 2008 to 2011, and each year, the crime rate must have been higher than it was the previous year or there must have been an increase in homicides over the base year (2008). Depending on the definition, we identify about 270 municipalities as experiencing a persistent increase in violence.

We modify the specification for equation (3) to include interactions with a per-

[19] The results of the 2005 census are available but do not include wage data.

[20] Results are similar if cumulative homicides are not expressed in per capita terms.

Table 6
The Effect of Homicides on Wages

	Secondary Incomplete		High School Incomplete	
	(1)	(1)	(2)	(2)
Monthly wages:				
Log Cumulative Homicides (2008–10)	−.006	−.004	−.007	−.006
	(.004)	(.004)	(.005)	(.005)
Log Cumulative Homicides × Low Skilled		−.00001**		−.00001**
		(.000)		(.000)
Effect on Low Skilled		−.004		−.006
Hourly wages:				
Log Cumulative Homicides (2008–10)	−.006	−.005	−.005	−.004
	(.005)	(.005)	(.005)	(.005)
Log Cumulative Homicides × Low Skilled		−.00001**		−.00002**
		(.000)		(.000)
Effect on Low Skilled		−.005		−.005

Note. Standard errors, clustered at the municipality level, are in parentheses. All regressions include municipality fixed effects, linear trends at the state level, and controls for age, age squared, years of education, a literacy dummy, and gender (for 2000 and 2010). $N = 4{,}509{,}831$.
** $P < .01$.

sistent increase in the number of DRHs. Thus, we estimate the following empirical models:

$$\begin{aligned}\log(P_{ijt}) = {} & \alpha_t + \partial_j + t\gamma_j + \phi \text{PermanentIncrease}_{ijt} \\ & + \alpha_t \text{PermanentIncrease}_{ijt} + \delta \boldsymbol{X}_{ijt} + \beta \log(\text{CumHom}\, s_{jt}) \\ & + \theta \text{PermanentIncrease}_{ijt} \log(\text{CumHom}_{jt}) + \varepsilon_{ijt}\end{aligned} \tag{5}$$

and

$$\begin{aligned}\log(P_{ijt}) = {} & \alpha_t + \partial_j + t\gamma_j + \phi \text{LowQuality}_{ijt} + \alpha_t \text{LowQuality}_{ijt} + \delta \boldsymbol{X}_{ijt} \\ & + \beta \log(\text{CumHom}\, s_{jt}) + \theta \text{LowQuality}_{ijt} \log(\text{CumHom}_{jt}) \\ & + \tau \text{PermanentIncrease}_j \log(\text{CumHom}_{jt}) \\ & + \rho \text{PermanentIncrease}_j \text{LowQuality}_{ijt} \log(\text{CumHom}_{jt}) + \varepsilon_{ijt}.\end{aligned} \tag{6}$$

Table 7 shows the effect of persistent violence on housing prices.[21] Columns 1

[21] As in Section 5, to show that our results are not heavily dependent on excluding houses for which there is no geolocalization data in our original database, we performed the regression for equations (5) and (6) with the entire database (and thus without controlling for locality size). Table 7 shows the resulting effect of persistent violence on housing prices. Columns 1 and 3 indicate the presence of persistent violence if the homicide rate rose by at least 150 percent (200 percent for the other columns) between 2008 and 2011 and if the homicide count climbed every year or relative to its 2008 level. Our main results remain unchanged: there is no average effect of either short-lived or persistent increases in crime. These effects appear only for the dwellings of the poorer segments of the population. When using the full database, the effect of temporal crime has no effect on the home values of either lower-income or higher-income households. However, the impact of a long-term increase in homicides has no effect on the home values of higher-income households but a negative and highly significant effect on the home values of households with lower incomes. As conjectured, the negative effects on prices for homes of lower-income households are about 100–150 percent

and 3 indicate the presence of persistent violence if the homicide rate rose by at least 150 percent (200 percent for columns 2 and 4) between 2008 and 2011 and if the homicide count climbed every year or relative to its 2008 level. Our main results hold true: there is no average effect of either short-lived or persistent increases in violence, on average. These effects appear only for the dwellings of the poorer segments of the population. As conjectured, the estimated negative effects on prices for lower income housing are about 25–36 percent larger when the increase in the number of DRHs is persistent than when the increase is short lived.

7. Conclusion

Crime is a serious social phenomenon that affects welfare in many ways. Although crime is much prevalent in less-developed countries than in developed ones, the literature on this phenomenon in the former is woefully limited. In Mexico, crime rates have increased sharply in recent years. Since 2008, more than 50,000 Mexicans have been killed, which is a shockingly high number compared with the deaths occurring in other recent conflicts. Although the government and the private sector both claim that this violence hurts the Mexican economy, no rigorous study has been undertaken to support this claim.

We focus on the effect of crime on housing prices, which reflect people's willingness to live in a certain area, by computing the (negative) value of the disamenities of a location. Taking advantage of the unpredictable nature of DRHs in Mexico, we exploit within-municipality variation over time and an extensive database on housing prices and characteristics at the national level. We first show that crime has tended to appear as shocks (or deviations from trend) and, thus, has not been related to economic variables. Second, we show that homicides have triggered a substantial reduction in housing prices, but only in poor areas: 1 standard deviation in homicides corresponds to a change of about 3–4 percent in the price of poor people's houses but does not lead to any change in the prices of houses owned by people who are not poor. Given that houses are usually one of the most valuable assets that families have, especially in the case of the poor, a decline of this magnitude represents a substantial loss of wealth. Crime thus has a regressive redistributive effect. In spite of the heavy burden on the poor that this represents, the level of WTP to decrease the increase in drug-related crime rates is not high relative to the size of the whole economy. Nevertheless, it is large relative to the incomes of the poor, who suffer most of the consequences of the violence associated with drug trafficking. We estimate the WTP to be equivalent to approximately 3.2 percent of the annual household income of the poor (with

larger when the increase in drug-related homicides is persistent than when the increase is short lived. This again suggests that homicides significantly affect the home values of lower-income households when the increase is long-standing, whereas the home values of higher-income households do not seem to be affected by long- or short-lived increases in homicide rates. In models 1 and 3, persistent increases are defined as increases in homicides greater than 150 percent between 2011 and 2008 and a number of homicides in every year greater than or equal to the number of homicides in the previous year or a number of homicides greater than the number in 2008.

Table 7

The Effect of Homicides on Appraisal Values: Persistent versus Short-Lived Increases in Homicides

	Regression (5)		Regression (6)	
	(1)	(2)	(3)	(4)
Log Cumulative Homicides	−.0003	−.0013	.0010	.0000
	(.0026)	(.0026)	(.0028)	(.003)
Log Cumulative Homicides × Persistent Increases	−.0014	0.0010	−.0019	.0006
	(.0037)	(.0038)	(.0039)	(.0039)
Log Cumulative Homicides × Poor Dwelling			−.0120**	−.0120**
			(.0035)	(.0034)
Log Cumulative Homicides × Poor Dwelling × Persistent Increases			−.0029	−.0038
			(.0029)	(.0033)
Persistent Increases	−.0016	−.0003		
Short-Lived Increases: Poor Dwelling			−.0110**	−.0120**
Persistent Increases: Poor Dwelling			−.0150**	−.0150**
Short-Lived Increases: Nonpoor Dwelling			.0011	.0000
Persistent Increases: Nonpoor Dwelling			−.0008	.0006
Month × Poor Dwelling	No	No	Yes	Yes

Note. The dependent variable is Log Homicides, 6 Months. Standard errors, clustered at the municipality level, are in parentheses. All regressions include municipality trends, controls for property and locality characteristics, and month, bank, appraiser, and municipality fixed effects. $N = 1{,}370{,}767$. $R^2 = .03$.

** $P < .01$.

respect to the poverty line) and 11 percent of the annual cost of the most important Mexican social program (Oportunidades).

Finally, we also find that, where there has been a large, sustained increase in the number of homicides, the estimated negative effects on housing prices in poor areas are up to 36 percent larger than in areas experiencing short-lived spikes in DRHs. Our findings are in line with those of Di Tella, Galiani, and Schargrodsky (2010), who also find that violence places a heavy burden on the poor, and with those of Besley and Mueller (2012), who find that the advent of peace leads to a significant increase in housing prices and that this effect is stronger in the regions where the violence was greatest.

A plausible interpretation of our results is that DHRs negatively affect the housing amenities of poor segments of the population to a disproportionate extent in municipalities that are subject to violence-related shocks. In keeping with this conclusion, poor households tend to move more often than nonpoor households, and the prices of low-income houses tend to decrease in those municipalities as a function of the intensity of the crime-related shock. We present evidence that indicates that crime has a large differential effect on the poor in terms of their perception of security. We also show that although both poor and nonpoor households tend to move more in the municipalities where the increase in crime is the greatest, the effect is more than 50 percent greater for poor households (Ajzenman, Galiani, and Seira 2014). Taken together, the various pieces of empirical evidence are consistent with our interpretation.

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