Crime and violence effects on economic diversity:  
The case of Mexico’s drug war

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Abstract

This paper exploits a substantial increase in homicides created by a war between drug trafficking organizations in Mexico to estimate the causal effects of crime and violence in the diversity of local economies. Relying on a dataset of homicides caused by organized criminal rivalry, a text-analysis algorithm that allowed us to track activities of Mexico’s drug trafficking cartels, and an exceptionally detailed economic census, we developed a panel fixed-effect model, and a model that controls for the possible endogeneity using instrumental variables. Our identification shows that subnational economies afflicted with large increases in crime and violence experience reductions in the diversity of its production structure and increases their degree of production concentration. Specifically, an increase of 10% in homicides rates reduces the number of sectors that exists in an economy by 0.006 units. A similar increase in the number of criminal organizations has a reduction effect of 0.032 units. Our results are robust by several specifications and various controls to account for the potential endogeneity of violence.

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It has been proven that crime and violence negatively affect the economy (Blattman and Miguel, 2010; Detotto and Otranto, 2010). However, do crime and violence also affect the types of goods produced in an economy? In other words, are the diversity of production structure or the degree of production concentration affected by crime and violence? This paper develops a methodology to answering this question and by doing so, contributes to literature on economies affected by crime and violence by focusing on the causal impacts to economic sector diversity.

The topic of this paper is fundamental to understanding the long-term consequences on economic development. Since the 1950s, development has been defined as a process of creating a competitive and profitable productive structure, such as diversifying from agriculture and extractive industries to more sophisticated forms of services and manufacturing (Hirschman, 1958; Rosenstein-Rodan, 1943; Singer, 1950). Most recently, in a “revived interest in the macroeconomic role of structural transformations” (Hartmann et al., 2017), scholars have shown how a country’s productive structure is strongly predictive of future economic growth and development (Hidalgo and Hausmann, 2009). Finding a relationship between levels of crime and violence and the diversity of local economies opens an interesting debate as to how the lack of rule of law can affect economic development.

Mexico is an ideal case study to evaluate how the crime and violence impact production diversity due to the large increases in homicides attributed to DTOs (Guerrero-Gutiérrez, Guerrero-Gutiérrez, and Ríos, 2013). Mexico is home to seven DTOs that supply cocaine and other drugs to the United States. According to the DEA (2015), Mexican DTOs have the largest and most powerful cocaine supply infrastructure, selling drugs in almost every U.S. city, which provides them with yearly profits over three hundred billion dollars (Grillo, 2016). In 2007, the capture of several important drug lords unleashed an unexpected
wave of violence between potential drug lord successors battling for turf (Dell, 2015; Ríos, 2015; Robles et al., 2013). As a result, homicides from 2007 to 2011 doubled, causing at least 60 thousand casualties during this period (SNSP, 2011). Levels of violence varied in intensity and geographical location, providing an ideal range to capture the effect of violence on subnational economic activity (Molzahn et al., 2012; Osorio, 2015).

The existence of several exceptional data sets from Mexico contributed to this research study. First, we obtained official registries of homicides caused by organized criminal rivalry (SNSP, 2011). Mexican authorities keep record of whether a homicide was caused by organized criminal rivalry or not, giving us the unique ability to identify violence caused by the war between DTOs. Second, we used the results of a text-analysis algorithm that tracks recorded activities of Mexico’s drug trafficking cartels over at two-decade period (Coscia and Ríos, 2012). The use of this data technique has been successfully applied in many specialized academic papers on Mexico’s organized crime (Osorio, 2015; Castillo et al., 2014; Dube et al., 2016; Holland and Ríos, 2017). Finally, we linked the performance of subnational economies with the aforementioned datasets by merging them with Mexico’s national economic census (INEGI, 2014). This economic census is one of the most detailed censuses available in the developing world with firm-level panel measures of investments, added value and remunerations by economic sector. We were granted preferential access to the census at the firm-level due to a specific legal agreement signed by our universities and the Mexican Census Office.

To identify a possible causal relationship between crime, violence, and economic diversity, we used two different identifications. We developed a panel-fixed effect model that relies on the panel structure of our data by conditioning on municipality, period fixed effects and standard errors clustered at the level of the municipality. Crime and violence are
our main independent variables of interest. Alternatively, to further control for possible
endogeneity, we developed a second specification that uses a lagged violence measure and
lagged government deterrence measure as instrumental variables. This method has been
used in several previously published academic papers (Angrist and Kugler 2008; Camacho
and Rodriguez 2013). With this last methodology, we find that violence and crime create
a significant reduction in the number of sectors present in a local economy. Specifically,
an increase of 10% in homicides rates reduces the number of sectors in an economy by
.006 units and a similar increase in the number of criminal organizations reduce has a
reduction effect of 0.032 units.

This paper is divided in four sections. First, we discuss the known impact of violence in
economic performance and how this paper contributes to such literature. Then, we explain
the main argument behind the paper and the unique data that we used to reinforce the
argument, including the unusual challenges involved in gathering said data. The third
section presents the strategy of analysis, reports the analysis results and conducts several
robustness tests to debunk alternative hypotheses. Finally, we conclude by discussing the
relevance of the results, and exploring further avenues of research.

The impact of crime and violence in the economy

Crime and violence significantly impacts economic performance. It has been proven that
violence has the potential to reduce GDP per capita (Alesina and Perotti 1996; Abadie
and Gardeazabal 2008) and to negatively affect economic growth (Blattman and Miguel,
2010; Detotto and Otranto 2010; Bozzoli et al. 2012). It is also well known that the
effects of crime and violence are significant stronger in environments with already elevated
levels of macroeconomic uncertainty (Goulas and Zervoyianni, 2013) or those with highly
corrupt economic and government elites (Blackburn et al., 2017).

Several studies around the world have systematically linked crime and violence to signif-
icant economic consequences. Violence has reduced Italy’s gross domestic product and
GDP per capita (Pinotti, 2015; Carboni and Detotto, 2016), lowered the long-term potential
growth of Pakistan (Ahmad et al., 2014), diminished income and employment levels
of Sierra Leone (Collier and Duponchel, 2013), inhibited economic activity in Mexico (En-
amorado et al., 2014; Robles et al., 2013), and promoted a high firm exit rate in Colombia
(Camacho and Rodriguez, 2013). Indeed, the impacts of violence and crime on trade,
national income, and economic welfare are large, global and persistent (Glick and Taylor,
2010).

The mechanisms through which crime and violence affect economic performance are
mostly linked to changes in factor accumulation. Organized crime reduces incentives
to invest in human capital (Shemyakina, 2011; Leon, 2012; Rodriguez and Sanchez, 2012,
Brown et al., 2017), discourages domestic and foreign investments (Daniele and Marani,
2011; Pshisva and Suarez, 2010; Singh, 2013), and inhibits innovation and employment
generation (Bozzoli et al., 2013; Cook et al., 2014). Additionally, there is evidence
that crime and violence increase capital risks (Guidolin and La Ferrara, 2010), promote
inefficient human capital flows (Rios, 2014), and reduce the value of capital assets. Waves
of violence, for example, have limited the value of tangibles (such as housing) in Ireland
(Besley and Mueller, 2012) and real estate markets in Mexico (Ajzenman et al., 2015).
Finally, crime has been associated with a significantly lower probability of enterprise expansion and income growth (BenYishay and Pearlman, 2014), with diminished labor productivity (Cabral et al., 2016) and increases in income inequality (Enamorado et al., 2013).
Spillover effects have also been tested (Murdoch and Sandler 2004; Pan et al. 2012).

More recently, academic studies have investigated how crime and violence may create heterogeneous effects. By diverting resources that could have been used in more productive ways, crime and violence cultivates a market failure that affects investments allocated in the informal sector (Bozzoli et al. 2012), women employees (BenYishay and Pearlman 2013; Dell 2015), younger and smaller firms (Camacho and Rodriguez 2013), smaller urban areas (Enamorado et al. 2014), and firms whose inputs are predominantly imported (Amodio and Di Maio 2017).

This paper enriches our understanding of the economic impacts of crime and violence by analyzing a relationship that has been mostly neglected: how crime affects the diversity of local economies. Specifically, we study how crime and violence impact the number of economic sectors/industries in which labor, capital and technology are allocated.

Our paper builds upon previous studies that suggest some economic sectors tend to be more resilient to crime and violence than others. For example, investments in the oil industry tend to be less affected by organized crime in Latin America (Maher 2015; Ashby and Ramos 2013), and sectors, such as mining, manufacture & agriculture, are more likely to remain profitable regardless of violent circumstances (Driffield et al. 2013). Thus, when facing extended periods of violence and crime, some economic sectors may have a higher potential to disappear than others, leading to economies with less diverse production.

However, unlike previous literature that focuses on identifying how violence changes firm or sector-level investment strategies (Camacho and Rodriguez 2013; Ashby and Ramos 2013),
2013; Maher, 2015), our paper is the first to explicitly provide evidence of how crime and violence induce long-lasting changes in the production composition of subnational economies, leading to less diversified and more concentrated economic environments.

Studying the impacts of crime and violence in the diversity of subnational economies is critical. From pioneer studies (Hirschman 1958; Rosenstein-Rodan 1943; Singer 1950) to more recent empirical studies of economy composition (Felipe et al., 2012), there is plenty of evidence measuring economic diversity in correlation with economic performance (Hausmann et al., 2007; Boschma and Iammarino, 2009; Lee, 2011), productivity (Feenstra and Kee, 2008), future growth (Cristelli et al., 2015), and income inequality (Hartmann et al., 2017). It has been strongly established that countries tend to converge to a level of income dictated by the number and type of specialized sectors (Hidalgo and Hausmann, 2009). Furthermore, non-diverse economies are more susceptible to suffer economic and political failures (Engerman and Sokoloff, 1997), and tend to have limited knowledge and capabilities in the face of external shocks (Frenken et al., 2007).

Indeed, if crime and violence affect the productive structure of an economy, establishing rule of law is critical to creating an environment where sustained growth and democratic prosperity can thrive.

**Research question and data collection**

Our testable hypothesis is that violent crime and criminal presence reduces the diversity of local economies, limiting the types sectors that operate in an economy and favoring a concentrated economic environment.
We expect this result due to the distinct levels of sensitivity that different sectors demonstrate in relation to levels of violence. Previous literatures have identified that some economic sectors are more affected by violence than others (Ashby and Ramos, 2013; Driffield et al., 2013). Typically, sectors that are resource-bound tend to be particularly resilient to crime and violence. The high profits of resource-bound sectors allow these sectors to internalize violence as a cost to their production function (Oetzel et al., 2007). Multinational companies in old globalized and extractive industries have considerable experience operating in violent areas with criminal presence (IPA, 2001; Bennett, 2002; Ashby and Ramos, 2013). On the other hand, sectors lacking geographic-specific inputs are less resilient to violence, due to a higher probability of leaving a conflict area. The retail industry and tourism, for example, are more likely to be targets of criminal organizations, and are highly movable, which makes them less resilient to violence (Daniele and Marani, 2011). Criminal activity significantly impacts these industries because it can promote immigration (Ríos, 2013), reduce consumption (Castillo et al., 2014), and promoted relocations and closures (Greenbaum et al., 2007). Size can also matter. Multinational companies are more resilient to violence due to large high sunk costs, long investment horizons, and often a developed expertise in coping with difficult regions. However, industries with smaller firms tend to be less resilient to violence (Bennett, 2002; Oetzel et al., 2007; Ashby and Ramos, 2013). Consequently, if crime and violence do indeed affect certain sectors more significantly than others and ceteris paribus, we should expect to see more diverse economies in environments that have been peaceful for extended periods of time.

To test our hypothesis, we selected Mexico as our case study. Mexico is an ideal case to conduct our subnational analysis due to the significant increase in homicides. In recent years, Mexico faced a large, exogenous increase in homicides created by a competitive
war between DTOs (Guerrero-Gutiérrez; Ríos, 2013). The arrival of a new federal administration brought an increase of enforcement operations against drug-lords (Dell, 2015; Ríos, 2015; Robles et al., 2013). Through these operations, many traffickers were killed or captured, which caused the internal structure of DTOs to destabilize. The inherently complex process of replacing leadership within a trafficking organization prompts internal competition and violence within DTOs. From 2007 to 2012, DTOs caused an estimated 60,000 casualties, more than tripling Mexico’s homicide rate (Molzahn et al., 2012). During the peak of instability, bodies were found tortured and decapitated with direct messages to “all those in charge of applying the law” saying, “Do not take part in our affairs or you’ll die”, and warning society that “this war is between us, the traffickers” (Holland and Ríos, 2017). This case study was ideal to estimate the causal effects of crime and violence in the diversity of local economies due to the exogenous variance.

Given how suitable Mexico is for this type of study, it is not surprising that academia has already investigated the impacts of crime and violence in Mexico’s economy. However, all studies have concentrated on illustrating the cost of violence on economic factors, such as employment and capital investments. For example, (Dell, 2015) found that female labor participation decreases in municipalities where drug violence erupts after law enforcement crackdowns. It has also been shown that for every 10 drug-related homicides per a 100 thousand populace, unemployment increases by 0.5% (Arias and Esquivel, 2012). Ashby and Ramos (2013) identified that violence deters FDI in financial services, commerce and agriculture, and BenYishay and Pearlman (2013) illustrated that an increase in homicide rates (per 100 thousand) reduces the weekly hours worked by 0.3. Enamorado et al. (2014) also contributed by finding that a one standard deviation increase in the number of drug-
related homicides decreases income growth by 0.2 percentage points. Robles et al. (2013) found a negative effect of violence on labor participation. Most recently, Rozo (2014) estimated that consumption among white and blue-collar workers is reduced by 2.8% and 6.3% when homicide rates increase by 10%. Velásquez (2014) found that elevated violence leads self-employed women to leave the labor market. (Ajzenman et al., 2015) discovered that increases in homicides led to a 3% decrease in the price of low-income housing, and Yepes et al. (2015) found that crime shocks are responsible for 0.25% reductions in GDP per capita. This research study is unique as none of the aforementioned studies focused on the impacts of violence on factor allocation and economic diversity.

Shedding light on how local economic diversity is potentially affected by crime and violence is possible due to several, exceptional subnational panel data sets.

First, to measure violence at the local level, we accessed official registries of homicides caused by organized criminal rivalry, also known as “crime-rivalry homicide rate” (SNSP, 2011). Mexican authorities keep record of whether a homicide was caused by organized criminal rivalry or not, giving us the unique opportunity to identify violence caused by the war between DTOs in a panel dataset. Additionally, these records can be geographically identified. A homicide needs to meet six criteria to be categorized as a crime-rivalry homicide. These are (i) the use of high-caliber firearms, (ii) signs of torture or severe lesions in victims, (iii) bodies found at the crime scene or in a vehicle, (iv) victims taped, wrapped or gagged, (v) murders committed in a prison and involving criminal organizations, and (vi) if one of several “special circumstances” occurred. These “special circumstances” include: if the victim was ambushed, chased or abducted prior to assassination (levantón), if the victim was an alleged member of a criminal organization, and if a criminal organization publicly claimed responsibility for the murder (Molzahn et al., 2012). We were also able
to assess a sub-classification of crime-rivalry homicide rates, called “targeted execution rates”, meaning homicides perpetrated by organized criminal rivalry where the victim was visibly targeted (rather than assassinated as part of a shooting). This sub-classification encompasses about 80% of all crime-rivalry homicide and is considered the most accurate identification of the war between DTOs. Finally, we complemented these models with general homicides rates (INEGI, 2016).

Second, to measure criminal presence, we relied on a published big-data framework that uses a text-analysis algorithm to extract web content about recorded criminal activities by subnational economy (Coscia and Ríos, 2012). The algorithm “reads digitalized records”, news content, blogs and Google-News indexed content, searching for instances in which DTOs operations are mentioned. The Python crawler was created to extract JSON objects using unambiguous query terms to perform text analysis. The final data, cleaned by using an hyper-geometric cumulative distribution function, includes 2,449 sub-national economies, and 178 “actor terms” associated with traffickers and drug trafficking organizations. Each actor was classified according to 13 criminal organizations and a residual category. A more detailed description of the methodology followed can be found within the subsequently cited publication (Coscia and Ríos, 2012).

This framework enabled us to obtain information that would otherwise require large scale, expensive intelligence exercises. Most importantly, this procedure helped us to disentangle violence from crime. Many of the recorded DTO operations are non-violent, consistent with peacefully trading, transporting, producing or cultivating illegal drugs. The data set has been a source to study criminal activity in several published papers (Osorio, 2015; Castillo et al., 2014; Dube et al., 2016; Holland and Ríos, 2017).
Overall, by merging our dataset of criminal rivalry homicides and criminal operations, we obtained information of 13 DTOs operating in Mexico for 19 years (1991 - 2010). As figure 1 shows, the disaggregation by municipal level allows us to challenge the widespread assumption that drug traffickers control vast regions of Mexico’s territory and that criminal organizations operate in oligopolistic markets. In actuality, drug trafficking organizations only operate in 713 of 2,441 municipalities in Mexico. Large areas of Mexico completely lack the presence of a drug trafficking organizations. Furthermore, as of 2010, 444 (62 %) of all municipalities with trafficking operations had more than one criminal organization operating simultaneously.

Finally, in order to obtain information about the diversity of subnational economies, we used Mexico’s economic census. The census is a firm-level, multi-year panel classified as one of the most detailed economic censuses of the developing world. The census contains information about investments, added value, remunerations and yearly production, classified by economic sector according to the North American Industry Classification System (NAICS). The census has more than 15 years of panel data for 4,231 thousand firms among its territory [INEGI 2014]. The last iteration of the census was released during the fall of 2015 making it highly up to date and mostly unexplored. It is important to mention that due to confidentiality issues, accessing this data was quite difficult. We were granted preferential access only after signing specific legal agreements by our universities and the Mexican Census Office. The process itself took many months to be fully vetted.

Table 1 shows descriptive statistics for all the most relevant variables of our panel datasets. The natural log of homicide rates mean is 1.92, while the value for municipality with the highest homicide rate is 7.21. In addition, we can see that the average number of criminal organizations present in each municipality is 0.4. Moreover, the average crime-
rivalry homicide rate is higher than the average targeted execution rate. Considering our economic variables, we can see that each municipality has an average of 17.75 industries.

(Table 1 about here)

Empirical specification, results and robustness checks

Using the data described above, we now proceed to empirically estimate the effect of crime and violence on economic diversity. We rely on two different estimation techniques: a panel fixed effects model, and instrumental variable (IV) model. Both estimations are better than using a simple OLS because violence and crime are likely to be endogenous.

Both estimation models disaggregate the data by year and municipality. Municipalities are the unit of analysis, with a total of i=2,456 municipalities and data for t=[2003, 2008, 2013] years. It makes sense to use municipalities as the measure of analysis because according to Mexican legislation, municipalities determine many important legal frameworks and incentives used to attract domestic and foreign investment. Important development policies, such as the recently launched “Mexican Economic Zones” have been designed according to municipalities as the unit of analysis.

First, we present the results of a panel fixed effects model that is useful to control for constant unobservable factors potentially affecting the outcome of interest.

We took advantage of the panel structure of our data by conditioning on municipality and period fixed effects, and using standard errors clustered at the level of the municipality. In other words, our first specification controls for geographic characteristics, secular trends
in economic performance over time, and geographic linear trends to capture unobserved local time-varying effects.

Specifically, the panel fixed effects model is given by

$$D_{it} = \beta_0 + \beta_1 \ln(\nu_{it}) + \sum_{k=1}^{l} \beta_k C_{it} + \cdots + e_{it}$$ (1)

where $D_{it}$ measures the diversity of the local economy. Diversity represents the number of economic sectors that exists in the municipality $i$ in time $t$. Following literature of economic diversity [Hartmann et al., 2017; Hidalgo and Hausmann, 2009], an economic sector is one in which added value is above zero, and added value is defined as the difference between revenue and intermediate consumption. The economic census contains information of more than 5 million firms.

Our causal variable $\nu$ measures crime or violence with different specifications. When $\nu$ measures crime, it functions as the number of criminal organizations that operate in $i$ during $t$ [Coscia and Ríos, 2012]. When $\nu$ tries to measure violence, it functions as either homicide rates [INEGI, 2016], crime-rivalry homicide rates [SNSP, 2011], or targeted execution rates [SNSP, 2011]. All rates are calculated per 100,000 inhabitants and for the cumulative two years preceding $t$. Figures accumulating 24 months provide a more representative analysis of dangerous places and takes into consideration the potentially delayed effect of crime and violence on local economic diversity. Note that, because zeros are considered valuable information about criminal violence, homicide rates were logarithmically transformed according to [2].
\[
\ln(\nu_{it}) = \begin{cases} 
\ln(\nu_{it} + 1) & \text{if } \nu_{it} \geq 0 \\
-\ln |\nu_{it}| & \text{if } \nu_{it} < 0
\end{cases}
\] (2)

To obtain the causal effect of crime and violence on the diversity of the local economy, we need to capture within-municipality variations- after controlling for other determinants of economic diversity. Given that the diversity of the local economy will be determined by whether firms within a specific sector do or do not continue producing, we can assume that an economic sector will produce if at least one firm within the specified sector of local economy \(i\) finds that (Camacho and Rodriguez, 2013).

\[
VA_t - wL_t - rI_t > 0
\] (3)

where \(VA\) is added value, \(wL_t\) is the cost of payroll, and \(rI_t\) is return of investments in period \(t\). We know that \(VA\) is given by:

\[
VA_t = Y_t - C_t
\] (4)

where \(Y_t\) is total revenue, and \(C_t\) is intermediate consumption.

Thus, following this equation and to capture within-municipality variations, we controlled all the models for (a) added value, (b) remunerations (INEGI, 2014), and (c) investments (INEGI, 2014). All values have been logged and refer to period \(t\).

The results of the panel fixed-effects model, conditioning on municipality and period fixed effects and with standard errors clustered at the level of the municipality, are presented
In Table 2, columns (1) and (2) use homicide rates as the explanatory variable (INEGI, 2016), whereas columns (3) to (4) use the number of DTOs operating in the municipality. We used two different dependent variables to measure economic diversity. In columns (1) and (3), we use the number of economic sectors that have positive added value in a municipality (see eqsector). We call these DV “sectors”. In column (2) and (4), we use “diversity”, meaning the number of economic sectors that have positive added value in a municipality and in which the municipality has relative comparative advantage. To calculate Relative Comparative Advantage (RCA), we followed the definition of Hausmann et al. (2007). The value of both dependent variables is larger when the municipality is more diverse, i.e. has more sectors or more sectors with RCA.

The results are consistent with our expectations. We can see a strong and negative relationship between homicide rates and the number of sectors that exist in a municipality. As column (1) shows, a 10% increase in homicide rates is correlated with a 0.006 reduction in the number of industries that operate in a municipality. The result is also significant and negative for diversity measures. In column (2), a 10% increase in homicide rates is correlated with a 0.003 reduction in diversity. As we expected, eliminating a sector with RCA is harder than just eliminating any economic sector.

When we evaluate the impact of crime, the effects are larger. As column (3) shows, a 10% increase in the number of operational criminal organizations in a municipality is correlated with reductions of 0.031 in the number of operational industries within the
respective municipality. Finally, column (4) shows that an increase of 10% in the number of operational criminal organizations in a municipality is correlated with reductions of 0.009 in the number of economic sectors with relative comparative advantage within the respective municipality.

It is important to note that our controls are significant for added value and remunerations, but not for investment. In all models, value added is positive and significant and remunerations are negative and significant. This means that lower remunerations are correlated with less diversified economies, and high value-added economies tend to be more diverse.

In Table 3, we present some robustness checks. We decided to use these subsamples to discard the alternative hypothesis that (a) our hypothesis only applies to non-violent municipalities that suddenly turn violent, and (b) our hypothesis only apply to municipalities where drug traffickers DTOs operate (column 2 and 4). Specifically, we show the same models from the previous table but with two subsamples: (a) municipalities that have been consistently violent since the nineties (at least one homicide), and (b) municipalities with no existing evidence of drug markets (see Dube et al. (2016)). All models use the number of sectors as dependent variable. Yet, when the models were also run using diversity as main independent variable, the same results were attained. Columns (1) to (2) use homicide rates as the main explanatory variable, and columns (3) to (4) use the number of DTOs operating in the municipality. Columns (1) to (3) only present municipalities that have been consistently violent since the nineties, and columns (2) and (4) only show municipalities where there is no existing evidence of DTOs.

(Table 3 about here)
Again, the results are consistent with our expectation. For municipalities that have been consistently violent since the nineties (column 1 and 3), an increase of 10% in homicide rates and in the number of criminal organizations are respectively correlated with reductions of 0.007 and 0.035 in the number of industries in a municipality. For municipalities where DTOs do not operate (columns 2 and 4), an increase of 10% in homicide rates and in the number of criminal organizations are respectively correlated with reductions of 0.006 and 0.032 in the number of industries in a municipality. As in previous models, DTOs have larger effects than homicides. Moreover, as in the previous models, the impact of crime is larger than the impacts of violence. The controls are consistent with previously presented results. Added value and remunerations are significant, but not for investment. In all models, value added is positive and significant and remunerations are negative and significant. This means that lower remunerations are correlated with less diversified economies, and high value-added economies tend to be more diverse.

Overall, all the models with municipality and period fixed effects and standard errors clustered at the level of the municipality assume that changes in our causal variable are strictly exogenous. Thus, our identification strategy requires that homicide rates be not driven by economic factors that could also determine local economic diversity.

Focusing Mexico, there is convincing evidence that illustrates this to be the case. Dell (2015) proved that the behavior of DTOs is not driven by the economic situation of the municipality. Ajzenman et al. (2015) demonstrated that the timing and intensity of violence are not driven by the economic situation in a municipality. In particular, he developed an econometric specification that shows that, in the case of Mexico, employment levels are not statistically related to homicide rates. Ajzenman et al. (2015) publication has proven to be quite relevant given and empirically challenged the common fear that
economic activity could, for example, be correlated with fewer labor opportunities and consequently, more DTO activities.

Yet, to further prove that our results are solid, we decided to add a second specification to avoid reverse causality: an IV model. IV models address and reduce biases caused by either omitted variables or measurement error.

The IV model is specified in equations (5) and (6). Equation (6) is the first stage of a 2SLS model containing an instrument I.

\[
D_{ij} = \beta_0 + \beta_1 \ln(\nu_{ij}) + \sum_{k=1}^{l} \beta_k C_{ij} + \cdots + e_{ij} \tag{5}
\]

\[
\ln(\nu_{ij}) = \alpha_0 + \alpha_1 I_{ij} + \sum_{k=1}^{l} \alpha_l K_{ijl} + \cdots + u_{ij} \tag{6}
\]

We used two possible IV specifications, depending on the instrument we selected. Following published papers in the topic, we used two instruments: homicide rates during the early nineties [INEGI 2016], and a measure of lagged government deterrence.

There is plenty of evidence to justify the lagged values of independent variables as instruments. Using lagged values of an endogenous explanatory variable as an instrument leads to consistent estimates when (i) the lagged values are not part of the estimating equation, and (ii) when the lagged values are sufficiently correlated with the main independent variable Reed (2015). Both conditions apply to our data. Lags are less likely to be influenced by current shocks, and have been used many published research papers, such as Buch et al. (2014); Clemens et al. (2012); Stiebale (2011); Vergara (2010); Hayo et al. (2010).
There are at least 15 recently published papers in the International Studies Quarterly, 14 in the Comparative Political Studies, 10 in the American Journal of Political Science, and 10 more in the Journal of Politics that use lagged values as instruments. In our case, while it is plausible to assume that firms may take into account the last period’s violence when making production decisions or even entering into business, it is less likely to believe that production decisions of today are directly influenced by violence that happened more than two decades ago. It is particularly hard to believe if, in between, Mexico made a meaningful change in productive structure by signing NAFTA ([Esquivel and Rodríguez-López, 2003; Moreno-Brid et al., 2005; Chiquiar, 2008]). We believe it is safe to assume that any potential inertia in the violence measure on economic activity was eliminated by Mexico’s open market shock of 1994.

Evidence has also showed that lagged government deterrence is correlated with current crime and violence, but not with the number of current economic industries. Plenty of published research shows that government deterrence triggers violence waves in Mexico ([Dell, 2015; Ríos, 2015; Robles et al., 2013; Castillo et al., 2014]), and that this instrument is valid ([Angrist and Kugler, 2008; Camacho and Rodriguez, 2013]). It is also safe to assume that the commercial decisions of firms are not affected by central government deterrence decisions, which are normally conducted in secret or in environments not easily detected by citizens. Empirically, [Angrist and Kugler, 2008] found that when coca production expands, it tends to increase violence, but not change the economic activity of the producing regions. This finding is attributed to the fact that regional economies are not necessarily tied to the drug business, instead resources of illegal activity go directly into the hands of criminals to conduct other criminal activities ([Angrist and Kugler, 2008]).

Our IV specifications are presented in Table 4 and 5. Diagnostics for IV specifications
are shown in both tables.

Estimations with the instrument of lagged government deterrence are presented in Table 4. Columns (1) to (4) use various measures of violence and crime as the main explanatory variables. In column (1) we use homicide rates (INEGI, 2016), in (2) the number of operating DTOs (Coscia and Ríos, 2012), in (3) crime-rivalry homicide rates (SNSP, 2011), and in (4) targeted execution rates (SNSP, 2011). All models from (1) to (4) use the number of sectors in a municipality as the dependent variable.

(Table 4 about here)

The results are consistent with our expectations. They show a strong and negative relationship between all different homicide rates and the number fluctuation of industries that exist in a municipality. As column (1) shows, a 10% increase in homicide rates is correlated with a 0.215 reduction in the number of sectors in a municipality. For column (2), a 10% increase in the number of operational DTOs is correlated with a 1.08 reduction in the number of sectors in a municipality. For column (3) an increase of 10% in crime-rivalry homicide rates is correlated with a 0.186 reduction in the number of sectors in a municipality. For column (4) an increase of 10% in targeted execution rates is correlated with a 0.179 reduction in the number of sectors in a municipality. These results illustrate that an increase in the number of operating DTOs in a municipality has the largest effect over the number of sectors. Moreover, we can see how IV models show larger effects of violence and crime over the number of sectors in a municipality than panel fixed-effects models.

We tested all models with alternative and complex versions of the dependent variables. In this paper, we only present the results for diversity and economic concentration. This
last measure is particularly interesting because it allow us to identify whether the negative effects of crime and violence on the number of economic sectors, can also affect the concentration of economic production structures. To measure concentration, we use the Herfindhal-Hirschman index, a classic measure used in plenty of literature (Hirschman, 1958; Boschma and Iammarino, 2009; Frenken et al., 2007; Saviotti and Frenken, 2008; Cristelli et al., 2015; Hidalgo and Hausmann, 2009). The Herfindhal-Hirschmann index is the sum of squares, calculated by squaring the share of added value of each industry in a municipality and then, summing these squares (Frenken et al., 2007). Models with diversity and concentration as dependent variables were also tested for different specifications of homicides and cartels.

The results are consistent with our expectations. There are strong relationships between increases in homicide rates and decreases in diversity, as well as, increases in concentration. In column (5) an increase of 10% in homicide rates is correlated with reductions of 0.046 in diversity. Column (6) shows that an increase in homicide rates is correlated with increases in the Herfindhal-Hirschman index. Specifically, an increase of 10% in homicide rates is correlated with an increase of 78.55 in the H-H index. Note that, to control for unobserved time invariant, and state effects, all models use time and state and fixed effects.

Note that, all controls are significant and positive. When the dependent variable is the number of sectors in the municipality or diversity, high value added investment and remunerations are correlated with more sectors and diversity (columns 1-5). Only investment has a negative coefficient for diversity in column (5). For column (6), the relationship is negative due to the expected positive relationship between violence and concentration.

Table 5 illustrates the same IV specifications, but with our second instrument. The order
is the same as before. Columns (1) to (4) use various measures of violence and crime as the main explanatory variables. In column (1) we use homicide rates [INEGI 2016], in (2) the number of operational DTOs [Coscia and Ríos 2012], (3) crime-rivalry homicide rates [SNSP 2011], and in (4) targeted execution rates [SNSP 2011]. All models from (1) to (4) use the number of sectors in a municipality as dependent variable.

(Table 5 about here)

As expected, an increase in homicide rates (column 1) and in the number of criminal organizations (column 2) is correlated with reductions in the number of sectors in an economy. However, when we evaluate crime-rivalry homicide rates (column 3) and targeted execution rates (column 4), rather than homicide rates, the effects are smaller. As column (1) shows, a 10% increase in homicide rates is correlated with reductions of 0.24 in the number of sectors in a municipality. For column (2), a 10% increase in the number of operational DTOs is correlated with reductions of 0.070 in the number of sectors in a municipality. For column (3) an increase of 10% in crime-rivalry homicide rates is correlated with reductions of 0.186 in the number of sectors in a municipality. For column (4) an increase of 10% in targeted execution rates is correlated with reductions of 0.179 in the number of sectors in a municipality.

Moreover, results are solid in showing a strong and positive correlation between increases in homicide rates with economic concentration (column 4). Specifically, an increase of 10% in homicide rates is correlated with an increase of 52.75 in the H-H index. Finally, as expected, there is a negative and strong correlation between homicide rates and the number of economic sectors with relative comparative advantage. Specifically, an increase of 10% in homicide rates is correlated with reductions of 0.062 in the number of economic
sectors with relative comparative advantage.

The controls are positive and significant in most models. High value added economies tend to have more sectors, higher remunerations and investment are also correlated with having more sectors. For models 3-4, investment is not significant; for model 5, high value added is correlated with more concentrated economies, while high levels of investment and remunerations can be correlated to less concentrated economies; and for model 6, high value added economies can be related to economies with less relative comparative advantage, while high levels of investment and remunerations can be correlated to more diversified economies.

Conclusion

Previous literature has focused its attention on identifying how crime and violence impact economic factor accumulation, not on how crime and violence affect factor allocation, particularly the diversity of local economies. This paper attempts to address this gap in the literature. Using an IV specification to address problems of reverse causality and relying on a unique dataset created with a text-analysis algorithm of web content, this paper illustrates that increases in criminal presence and violent crime reduce economic diversification, increased industry concentration and diminished economic complexity.

The presented results are strong, consistent, significant, and hold over a variety of specifications and robustness tests.

Using a unique dataset representing the number of homicides attributed to drug cartel rivalry, along with a text-analysis algorithm that tracks Mexico's drug trafficking activi-
ties, this paper demonstrates that the areas most affected by the escalation of conflict between rival drug trafficking organizations experienced a change to its productive economic structure. Specifically, the number of economic sectors was reduced, limiting economic diversification and increasing market concentration.

Our more conservative specification, government deterrence, shows that increases of 10% increase in homicide rates is correlated with a 0.215 reduction in the number of sectors in a municipality. This is equivalent to say that a 46% increase in the rate of homicides reduces by one the number of sectors that operate in an area. The results show that increases in the number of operational criminal organizations in a municipality, crime-rivalry homicide rates and targeted execution rates also reduce the number of industries.

Our more innovative specification, which relies on a big data exercise of text analysis to identify where criminal organizations operate, shows that increases of 10% in criminal presence correlate to reductions of 0.32 in the number of industries in a municipality. Results show that increases in homicide rates are also correlated with reductions in the number of industries in a municipality. Finally, we show that, increases in homicide rates and in the number of criminal organizations are correlated with reductions in the economic diversity in a municipality.

By investigating the impact that crime has on the diversification of production factors, this paper takes current literature one step forward: It goes from exploring the effects of crime on the demand/supply of production factors, to analyzing its effects on economic composition. Furthermore, our results are valuable to scholars analyzing the effects of criminal violence on growth, and provide a strong foundation towards better understand why highly violent areas do not always exhibit diminished growth in the short term. If,
as argued, the negative effects of violence in economic growth are not only explained by reductions in investments, outflows of human capital, or increased production costs, but by changes in the productive composition of an area, it follows that, in the short time, violence may not necessarily reduce economic growth, but rather change the variety of economic sectors.

Further work is needed to address whether economic growth can continue in the short term, even with a less diverse economy. In other words, while violence will most likely reduce economic growth in the long term (via diversification reductions), violence may leave growth unaffected in the short term. The comparative differences of the long-term and short-effects of violence on economic growth is a promising agenda that begs to be explored.
### Tables

Table 1: Descriptive statistics

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<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
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<td>1.51</td>
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<td>7.21</td>
</tr>
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<td>Criminal organizations</td>
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<td>0.92</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Criminal-rivalry homicide rates (log)</td>
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<td>1.32</td>
<td>0</td>
<td>6.45</td>
</tr>
<tr>
<td>Targeted execution (log)</td>
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<td>6.44</td>
</tr>
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<th>(2) Sectors</th>
<th>Diversity</th>
<th>(3) Sectors</th>
<th>Diversity</th>
<th>(4) Sectors</th>
<th>Diversity</th>
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<td>(0.320)</td>
<td>(0.300)</td>
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<td>0.974</td>
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Note: * p < 0.1; ** p < 0.05; *** p < 0.01. All models use municipality and period fixed effects and standard errors clustered at the level municipal level.
Table 3: Panel Fixed-Effects, Robustness checks

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<th>(3) Sectors</th>
<th>(4) Sectors</th>
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<td>No DTOs</td>
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<td></td>
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</tr>
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<td>Remunerations</td>
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<td>0.213***</td>
<td>0.204***</td>
<td>0.203***</td>
</tr>
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<td>0.974</td>
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Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. All models use municipality and period fixed effects and standard errors clustered at the municipal level. Columns (1) and (3) include only municipalities with at least one homicide during the nineties. Columns (2) and (4) include only municipalities where drug is not produced.
<table>
<thead>
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<th>Variables</th>
<th>(1)</th>
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<th>(4)</th>
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<td>Sectors</td>
<td>Sectors</td>
<td>H-H index</td>
<td>Diversity</td>
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<td></td>
<td>(0.544)</td>
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<td></td>
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<td>(4.479)</td>
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<td>(0.836)</td>
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<td></td>
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<tr>
<td>Crime-rivalry homicide rates</td>
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<td>-0.141***</td>
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<td>(0.069)</td>
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<td>(0.103)</td>
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<td>3.377***</td>
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<td>(1.373)</td>
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<td>1.34e-05 ***</td>
<td>1.49e-09 ***</td>
<td>1.49e-09 ***</td>
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</table>

Note: * p < 0.1; ** p < 0.05; *** p < 0.01.
Table 5: Instrumental Variables, Homicide rates nineties

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<tr>
<th>Variables</th>
<th>(1)</th>
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<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
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</thead>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>(2.718)</td>
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</tr>
<tr>
<td>Targeted execution rates</td>
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</tr>
<tr>
<td>Diagnostic check (weak instrument)</td>
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</tr>
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Note: * p < 0.1; ** p < 0.05; *** p < 0.01.
References


Molzahn, C., V. Ríos, and D. A. Shirk (2012). Drug violence in Mexico. *San Diego, Trans-Border Institute, University of San Diego*.


Notes

1See also [Organski and Kugler 1977; Imai et al. 2000; Hoeffler and Reynal-Querol 2003; Busse and Hefeker 2007]