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Crime and the Economy in Mexican States: Heterogeneous Panel Estimates (1993-2012)

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Crime and the Economy in Mexican States: Heterogeneous Panel Estimates (1993-2012)[1]

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Abstract

This paper studies the transmission of crime shocks to the economy in a sample of 32 Mexican states over the period from 1993 to 2012. The paper uses a panel structural VAR approach which accounts for the heterogeneity of the dynamic state level responses in GDP, FDI and international migration flows, and measures the transmission via the impulse response of homicide rates. The approach also allows the study of the pattern of economic responses among states. In particular, the percentage of GDP devoted to new construction and the perception of public security are characteristics that are shown to be associated with the sign and magnitude of the responses of economic variables to crime shocks.

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EXECUTIVE SUMMARY

This paper investigates the effect of crime on the overall economic activity over the period 1993–2012 and attempts to (i) uncover underlying causal relationships; (ii) account for the dynamic nature of any such relationships; and (iii) explain the heterogeneous nature of such relationships among different Mexican states.

Due to limitations of both data and methodology, much of the literature to date has taken a fairly simplified approach to the topic, in effect highlighting a negative association between rates of crime and overall economic activity. However, mere associations do not disentangle the effect of crime on overall economic activity from the reverse causal effect of overall economic activity on crime. For example, a negative association may arise because increased crime reduces economic activity, or because reduced economic activity increases crime. The policy implications can be quite different, depending on the extent to which either of these two causal mechanisms between crime and the economy may be present and on the channels through which they operate.

The paper attempts to uncover the causal relationships between crime rates and overall economic activity upon which policy could be developed. Toward this end, it seeks to isolate the causal elements, or "shocks" which are responsible for driving both crime and overall economic activity. The paper recognizes that the responses of crime and overall economic activity need not occur at the same time as the shocks, but may occur gradually over time. To ignore this feature risks miscalculating the full magnitude and importance of the shocks. Similarly, it is important to recognize that relationships at the aggregate level often mask large and important but sometimes opposing effects that occur at a dis-aggregated level. For Mexico, the fact that different states experience potentially different responses to local, national, or international shocks can lead to the false impression that the consequences of the shocks are relatively minor if one does not take this feature into account. There are substantial differences in the economic activities of the states of Mexico, reflecting for example the varying importance of manufacturing, resource extraction, agriculture and tourism, and it is natural to expect that the response to internal and external shocks, whether from crime or economic activity in general, will differ among the states.

To address these points, the paper takes a more nuanced approach than is typical in the existing literature. It does so based on newly published econometric techniques that are being used in numerous fields of economics and have been employed successfully in other published IMF research. The approach uses a blend of economic concepts and econometric methods to identify causal effects. For example, the approach disentangles the source of causal shocks as originating on the supply side or the demand side of the economy based on whether the estimated effect of the shocks moves per capita output in the long run, regardless of what the shorter term dynamic consequences might be for crime. Similarly, shocks originating from crime independently of the economy are disentangled from supply and demand shocks on the basis of whether they have short term immediate effects on the crime variable. In this regard, it is important to note that, in its primary analysis, this paper does not study a particular category of crime shocks, but rather studies the response of both homicide data and economic data in response to general crime shocks. The longer term dynamic consequences for crime or overall economic activity are then examined. In this regard, the approach builds on other structural econometric methods, and further expands on the set of key features that can be addressed by doing so in the context of data sets that take the form of panel data, namely data that is observed both over time and over geographic space. In the case

of the paper this constitutes the 32 states of Mexico, with data on homicides, state gross domestic product, state foreign direct investment and state population migrations, observed annually for each state from 1993 to 2012. The approach taken in the paper is limited in several regards. For example, the approach is limited due to the measurement error inherent in the data. Most importantly, interpretations are dependent upon the particular econometric identification scheme, which employs homicide data in part to capture the response of crime shocks, and is subject to assumptions that must be made on whether the class of relevant shocks has been captured by the set of econometric restrictions that are imposed on the data. In this regard, the research aims to contribute to the analysis of the relationships, but is not intended to be conclusive in its findings.

Based on this approach, the paper finds the following results. The first set of results pertains to the evidence that crime has been intertwined with overall economic activity in the states of Mexico, including international factor flows in the form of foreign direct investment and migrations during the sample period. In this context, the paper isolates the relative magnitude and importance of various shocks. For example the study finds that crime shocks which originate at the national or international level are responsible for a quarter of a percent impact on national per capita GDP over time. But more importantly, the state level analysis is able to reveal the considerable range of responses among the various states. In particular, the responses are mixed, and vary both in sign and magnitude. Since individual state estimates are not sufficiently accurate as to be reliable with such short spans of data, the paper instead reports the estimated sample distribution of state responses in terms of quartiles. For example, state-specific crime shocks that are associated with on average an initial one fifth percent increase in homicides for the states, induce on average a one-half percent temporary decrease in per capita GDP, which persists for up to two years after the shock before eventually dissipating after the third year. However, for the quarter of the sample of states that experience the biggest effect, the impact is more extreme and persistent, leading to roughly a one-half percent decrease in per capita GDP that does not dissipate, but rather remains permanently reduced. The primary finding in this regard is that the response of among states is complex, nuanced and varied by state.

The second set of results pertains to the state-specific characteristics that are associated with larger or smaller economic responses to crime shocks. The paper finds state-specific factors that are associated with mitigating the decrease in GDP per capita that follows a crime shock. For example, one such state-specific characteristic is a measure of the importance of the construction industry as a share of the state economy. Those states with a bigger proportion of their economic activity devoted to construction appear to experience smaller magnitude impacts of crime shocks on per capita GDP. Another such state-specific characteristic relates to the size of the economic response, and particularly the foreign direct investment response to a crime shock, and is the overall sense of security on the part of public as reflected in household survey responses. Systematically, when the perception of a sense of security is higher, an equal sized crime shock appears to have a smaller consequence for the economy as a whole. This points to the potential importance of the perception and public confidence in the quality of institutions which provide for public security.

The paper presents an econometric research study on the effect of crime on overall economic activity in Mexico at the state level, and does not advocate any specific policy responses. The sample period does not cover the analysis of developments in the recent period since 2012. However, more recently, Mexico is reported to be engaged in making efforts toward a further strengthening of its AML/CFT regime. Also, the recent data by INEGI have recorded a decrease in the total number of homicides in the recent period

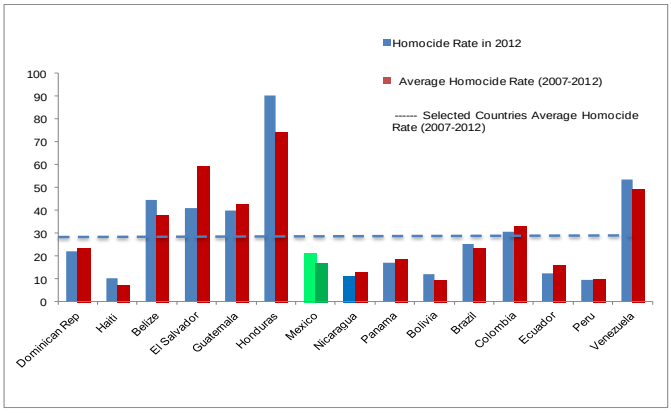
since 2012. In addition, Mexico has put forward a judicial reform agenda, which is expected to be in place in all states by 2016. While these efforts and reforms should contribute to mitigating the impact of crime on overall economic activity at the state level, they remain components of a broader strategy, the effects of which are yet to be assessed.

I. INTRODUCTION

Recently, the problem of crime has been a source of concern for international organizations, policy makers, and the populations in Mexico. Mexico has recently put forward an ambitious structural reform agenda, including initiatives that aim at improving the rule of law. In light of this, understanding the relationships between crime and overall economic activity is as important as ever.

Despite the increase in Mexico's crime rates over the sample period of this study (from 1993 to 2012), over similar periods crime has been much higher elsewhere in the Americas, as measured by homicide rates—one of the most commonly used indicators for comparing levels of crime (see UNODC 2014).[2] As illustrated in Figure 1, Honduras has a homicide rate nearly four times that of Mexico, El Salvador's rate is three times as high, and Venezuela's is more than twice as high. Even Colombia has a homicide rate that is nearly 50 percent greater than Mexico's.

Figure 1. Selected Countries: Intentional Homocide Rates (per 100,000 inhabitants)



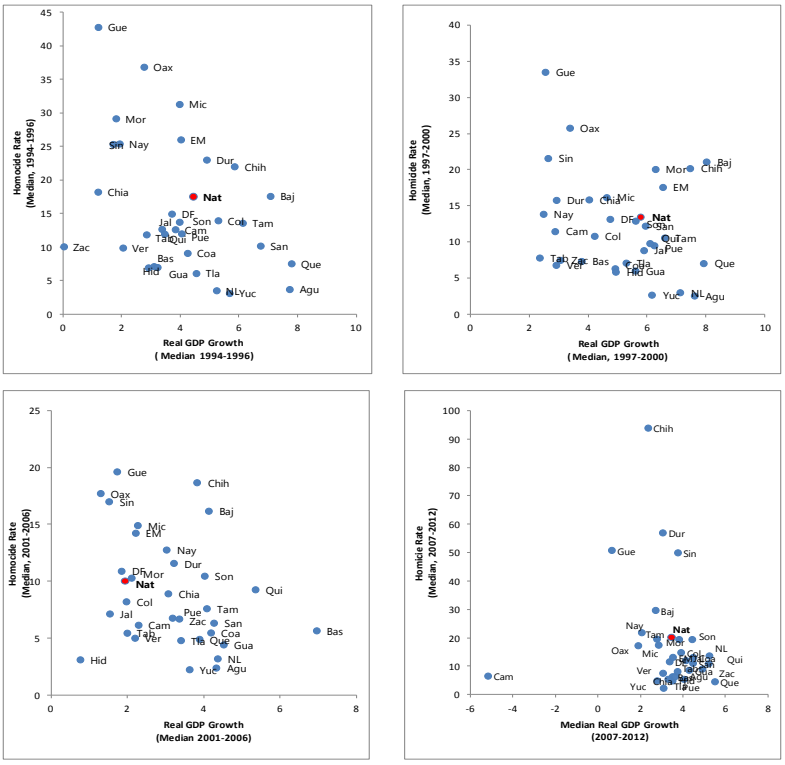
Source: UNODC Global Study on Homicide (2014), Heinle et al.(2014) and authors' calculations

The incidence of crime varies widely across Mexican states. According to the Mexican National Institute of Statistics (INEGI), during most of the last decade, from 1997 to 2007, Mexico's homicide rate plunged from 14 homicides per 100,000 to a much lower level of 8 per 100,000 in 2007. However, over the next few years, Mexico's relatively successful story in decreasing homicides reversed itself with more than 21.5 per 100,000 recorded in 2012. As discussed in numerous studies (see for example Robles et al., 2013, Mejia et al., 2012b; Guerrero, 2011a; Dell, 2012; Calderon et al., 2013), this remarkable surge in homicide rates is considered to be a direct result of the dramatic increase in violence associated with drug trafficking organizations and other organized crime groups. To a large extent, the growth of the drug trafficking organizations was likely in response to shocks taking place not only internally, but also in other latitudes: the drug demand from the U.S. market; the success of other governments, such as Colombia's in regaining control of the country from crime; and the closing of the drug-trafficking routes in the Caribbean achieved by the U.S.

[2] See *United Nations Office on Drugs and Crime (2014), Global Study on Homicide on 2013*, page 9. According to this source, "Moreover, as the most readily measurable, clearly defined and most comparable indicator for measuring violent deaths around the world, homicide is, in certain circumstances, both a reasonable proxy for violent crime as well as a robust indicator of levels of security within States."

It has long been recognized that crime has effects on the economy (for references see the literature review in section II below). In the short run, crime has the potential to inhibit the accumulation of part of the physical and human capital stock, the allocation of which may be further distorted by the infiltration of criminal organizations into the formal economic system. From a dynamic perspective, crime potentially increases the risk and uncertainty of the business environment, which in turn may hinder the accumulation process and lower the long-run growth rate of the economy.[3] For example, according to Hallward-Driemeier and Stewart (2004) and Daniele and Marani (2011), the primary effect of organized crime is to increase the costs of doing business. Other adverse effects of crime include extortion (Brock, 1998 and Daniele and Marani, 2011), kidnapping of workers (Clegg and Gray, 2002), and disruptions in supply chains (Barnes and Oloruntoba, 2005; Czinkota, 2005; Globerman and Storer, 2009; and Branzei and Abdelnour, 2010). Local demand may decline due to emigration, business relocation, and firm closures (Greenbaum et al., 2007). Also, Ashby and Ramos (2013) find a negative effect of organized crime on foreign investment in Mexico.

Figure 2. Mexico: Real GDP Growth vs. Homicide Rates [1/]



Source: INEGI, CONAPO, and authors' estimates
1/ For the methodology used to estimate the Real GDP, see the technical Appendix A.

Figure 2 reflects the evolution of real GDP (RGDP) growth and homicides rates for different periods between 1993–2012. In particular, the last period (2007–2012) illustrates an important increase in the median homicide rate at the national level. It also shows that a number of states have homicide rates well above the national median. It is interesting to observe, however, that for some states with increases in homicide rates the economic growth rates are above the national median, while others fall below the median RGDP growth rate for the period.

Against this backdrop, the objective of this paper is to investigate the relationship between crime and other economic activities in Mexico at the state level from 1993–2012, with an eye toward the broader potential role of crime for domestic stability as a whole.[4] For example, does crime lower overall economic

[3] See Pinotti (2011).

[4] For IMF discussions on the effect of predicate crimes on stability, please refer to the following documents: AML/CFT—Report on the Review of the Effectiveness of the Program, see http://www.imf.org/external/np/pp/eng/2011/051111.pdf, May 11, 2011, and Acting Chair's Summing Up, (continued…)

activity in Mexico in the long run, at both the individual state and aggregate levels, and if so, by what mechanisms? How important are shocks at the state level versus the national and international level for the relationship between crime and overall economic activity? What role, if any, do international factor flows in the form of foreign direct investment (FDI) and international migration play in the channel by which crime impacts overall economic activity at both the state and national levels? How do the dynamic relationships between crime, FDI, and overall economic activity differ across the states of Mexico and what socio-economic factors if any may account for these differences? In this regard, it is important to note that, in its primary analysis, this paper does not study a particular category of crime shocks, but rather studies the response of both homicide data and economic data in response to general crime shocks.

In addressing these questions, we recognize that the relationships are potentially complex in terms of the dynamic interdependency between crime and economic activity, and that these dynamic interdependencies may differ substantially among different states. In light of this, as described in section III of our paper, we employ the panel SVAR methodology of Pedroni (2013), which is designed to accommodate these issues for panels comprised of relatively short and possibly noisy data. Furthermore, by using a structurally identified VAR approach, subject to our econometric identification scheme, we are able to study the role of shocks to crime in general, rather than on the basis of more narrowly defined proxies. Thus, while we use recorded homicide data as one of our endogenous variables, in the VAR analysis the crime shocks are defined as any crime which induces a movement in the homicide rate subject to the econometric identifying restrictions that we place on the other economic variables in the system, as we discuss in further detail in section III of the paper.

On the basis of such an approach, we find that crime has played an important role in driving the variation in several key economic variables at the state level. For example, we find that on average state-specific and common national and international crime shocks together are responsible for up to 5.5 percent of the variation state-level GDP in the years following the shocks. We also find considerable heterogeneity among the states, with up to one-fourth of all states experiencing as much as 11 percent of the variation in their GDP to crime shocks. Furthermore, we show that the specific impulse responses are heterogeneous, but with up to a quarter of all states seeing on average a 1.6 percent per annum decrease in GDP for the first five years following a crime shock. We also find that crime shocks have a considerable, but also very heterogeneous relationship to FDI flows at the state level. When we study the pattern among states of the magnitude of the responses of GDP and FDI to crime shocks, two important characteristics stand out, namely the relative importance of the construction sector as a percentage of the state economy and the degree of a perception of public security as reflected in survey responses. On average, the prevalence of construction is associated with a diminished negative impact of crime on overall economic activity, while a sense of insecurity, as reflected in public survey data, is on average associated with an increased negative impact of crime on economic activity and FDI in particular. These findings are potentially

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AML/CFT—Report on the Review of the Effectiveness of the Program, https://www.imf.org/external/pubs/ft/sd/index.asp?decision=EBM/11/55, June 6, 2011. See also AML/CFT—Inclusion in Surveillance and Financial Stability Assessments—Guidance Note, http://www.imf.org/external/np/pp/eng/2012/121412a.pdf, December 17, 2012. See also a discussion of the IMF Member's Commitments on stability issues in the IMF Review of the 1977 Decision on Surveillance over Exchange Rate Policies, Further Considerations, and Summing Up of the Board Meeting, chart 1, page 3.

important for the ongoing process of judicial reform in Mexico as well as for the continuing efforts toward a further strengthening of the Anti-Money Laundering/Countering the Financing of Terrorism (AML/CFT) regime in Mexico. We should note of course that our study is focused on the period from 1993 to 2012 and therefore does not account for the reforms that have taken place in Mexico since 2012.

The remainder of the paper is organized as follows. In the next section, we present the empirical framework for examining the effect of crime on the economy. In section III, we describe our empirical methodology and strategy for identifying crime shocks, other key structural shocks in a panel VAR context, and limitations of the analysis. Section IV describes the data. The paper's empirical results are presented and discussed in section V, while section VI summarizes and concludes. A technical appendix includes a brief description of the methodology used for constructing a sufficiently long series for real GDP using a single base year, which we also consider to be an important contribution in support of the primary objective of the paper.

II. Related Literature on the Relationship Between Crime and Other Economic Activity

The importance of crime in determining a country's economic progress has long been recognized both in the academic literature and in policy-making circles. Some contributions have tried to establish a relationship theoretically between crime, growth, and development (e.g., Bourguignon, 2001; Fajnzylber et al., 2002; Mauro and Carmeci, 2007) and some studies quantify economic and social cost of organized crime for different countries (Fajnzylber et al., 2002c; Buvinic and Morrison, 1999; Glaeser, 1999; and International Centre for the Preventing of Crime, 1998; Londono and Guerrero, 2000; and Rios, 2011). Other scholars, such as Prasad (2012), try to examine the link between economic controls and black markets, by exploring the effects of India's liberalization experiment on its murder rate. A number of studies have analyzed the transmission channels through which crime, either directly or indirectly, impacts economic growth (see e.g., Goulas and Zervoyianni, 2013; Detotto and Otranto, 2010; Detotto and Vannini, 2009; Czabanski, 2008; Brand and Price, 2000; and Anderson, 1999).

Nevertheless, despite the growing literature, empirical studies have not yet produced a definitive conclusion regarding the impact of crime on economic growth. A way to measure the crowding-out effect of crime is to estimate its impact on the economic performance of a country, a region, or a municipality. We can distinguish two approaches. The first approach is to compare the overall macroeconomic performance of countries or regions with high levels of crime to that of countries with low levels of crime, controlling for other explanatory variables (this approach comes from Barro, 1996). For example, Peri (2004), using a large data set (from 1951 to 1991), shows that the annual per capita income growth is negatively affected by murders after controlling for other explanatory variables. Gaibulloev and Sandler (2008) measure the impact of domestic and transactional terrorism on income per capita growth for 1971–2004 in a panel of 18 Western Europe countries.

The second approach consists of univariate and multivariate time series methodologies. Recently, there have been many contributions to this approach, wherein crime is considered along with various macro variables. For example, Detrotto and Otranto (2010) show that crime negatively impacts economic performance in Italy. The findings suggest that the economic costs of crime include a significant fixed component, and that the dynamics of the economic cost is time-varying, but always significant. Chen (2009) implements a VAR model to examine the long-run and causal relationships among unemployment,

income, and crime in Taiwan. Narayan and Smyth (2004) implement a Granger causality tests to examine the relationship among seven different crime typologies, unemployment, and real wage in Australia within an AutoRegressive Distributed Lag (ARDL) model. Kumar (2013) empirically examines the causality between crime rates and economic growth using a reduced form equation and an instrumental variable based on state level data in India. Pinotti (2011) examines post-war economic growth of two regions in southern Italy which were exposed to the presence of mafia organizations after the 1970s, and applies synthetic control methods to estimate the counterfactual growth performances in the absence of organize crime.

Other studies have quantified different economic effects of organized crime. For example, Hallward-Driemeier and Stewart (2004) and Daniele and Marani (2011) show that the primary effect of organized crime is to increase the costs of doing business. The potential adverse effects are through assessment of regional security risks (Kotabe, 2005), security budgets (Spich and Grosse, 2005 and Czinkota et al., 2010), extortion (Brock, 1998 and Daniele and Marani, 2011), kidnapping of workers (Clegg and Gray, 2002), disruptions in supply chains (Barnes and Oloruntoba, 2005; Czinkota, 2005; Globerman and Storer, 2009; and Branzei and Abdelnour, 2010), and decreases in local demand (Greenbaum et al., 2007). Local demand may decline due to emigration, business relocation, and firm closures (Greenbaum et al., 2007). Brock (1998) finds relatively higher FDI in regions of Russia where the level of crime is lower. Madrazo Rojas (2009) finds empirical evidence of a negative association between violent organized crime and foreign direct investment (FDI) in Mexican states. Daniele and Marani (2011) find support for a negative relationship between total regional crime and FDI in Italy. Many of these scholars, including Fajnzylber et al. (2000), Detotto and Otranto (2011); Forni and Paba (2000), Cardenas (2007), Ashby and Ramos (2013), and Robles et al. (2013), use the number of recorded intentional homicides as a crime indicator.

Finally, for Mexico, Dell (2012) examines the direct and spillover effects of Mexican policy towards the drug trade, and finds that crime creates a contagion effect between those municipalities closer to drug trafficking routes. Ashby and Ramos (2013) find that organized crime deters foreign investment in the financial services, commerce, and agricultural sectors, but not the oil and mining sector, for which they find increased crime associated with increased investment. Robles et al. (2013) find that there is a threshold for crime, below which individuals and companies internalize the cost of security and protection in accordance with their economic capacity. Once the threshold is surpassed, companies and individuals will modify their investment decisions, production, labor participation, and employment, all of which have a negative impact on economic activity.

In our paper, we use a relatively novel approach to investigate the effect of crime on economic performance in Mexican states in a manner that more systematically accounts for dynamic endogeneity. We seek to do so subject to the double challenge of employing credible identifying restrictions while deriving results for a large group of possibly quite heterogeneous states. Conventional dynamic panel methods are not appropriate in light of the fact that they require the dynamics of individual state responses to be identical among all the states. Instead, we employ a panel methodology that allows individual states' responses to structural shocks to be heterogeneous. In particular, to address these issues in the context of structural identification, we use the panel SVAR methodology developed in Pedroni (2013). Recent examples of the use of this methodology in policy relevant empirical applications include among others, Pedroni and Verdugo (2011), which analyzes the effect of drug production on the formal

economy in Peru, and Mishra et al. (2014), which analyzes the effectiveness of monetary policy in low income countries.

III. Estimation and Identification Strategy

A. Overview of the Methodology

As noted, the relationship between crime and economic activity is quite complex. The two can be deeply intertwined, such that crime has an impact on economic activity at the same time that economic activity has an impact on crime. Furthermore, the nature of this endogeneity is likely also to be dynamic, in the sense that the feedback between crime and economic activity occurs gradually over time, and with different intensities over different time horizons.

Adding to this complexity, when we study the relationship between crime and economic activities at the aggregate state level in a country such as Mexico, we need to recognize that the nature of these dynamic relationships need not be the same in different states and may differ substantially among states. The differences may arise for a number of reasons. For example, the structure of the economies differs at the state level. Factors affecting crime differ geographically at the state level. The nature and the intensity of both crime and economic activity can differ across states. Finally, the mechanisms by which crime and economic activity interact with one another over time can differ regionally among states.

Another dimension to this complexity arises from the fact that both crime and economic activity may respond differently to unobserved innovations in various types of economic activity and crime depending on whether the innovations originate locally or somewhere else. For example, changes in economic activity nationally or internationally, as well as changes in other factors that drive crime nationally or internationally can be expected to impact criminal and economic activity at the state level. This creates a potential further complexity in the form of a cross sectional, or spatial dependence of crime and economic activity among the states of Mexico.

For these reasons, our empirical approach is one that accommodates potentially complex dynamic endogeneities that differ among states, and which are responding to potentially unobserved shocks that occur either at the local state level or at the national and international level. A standard econometric tool that accounts for dynamic endogeneities in general is the structural VAR approach. The structural VAR approach begins by estimating the dynamic relationship among the variables by use of a system of equations that represent a sufficient number of lags of each of the variables in each of the equations, so that what remain as residuals in the equations are disturbances that are uncorrelated over time. Next, in order to relate these disturbances to structural shocks that have economic meaning, one exploits economic identifying restrictions. However, the approach requires time series data of substantial length, beyond what is available for the current analysis. A natural solution is a panel approach, which treats each state as a member of the panel, and compensates for the lack of a substantial time series dimension by exploiting the fact that the dynamic relationships are observed repeatedly among members of the panel.

However, in taking a panel approach, we must take care in how we treat the individual members of the panel. Most fundamentally, we must account for the fact that the states of Mexico differ from one another as reflected in potentially heterogeneous dynamic relationships between crime and other economic activity. Failing to account for heterogeneity in the estimation of dynamic relationships results in a well

known econometric problem that can lead to inconsistent estimation and inference of the relationships.[5] Consequently, we do not want to simply pool the Mexican state-level data as one would for conventional dynamic panel methods, which rely on the assumption of homogeneous dynamics among the members of the panel. Instead, the methodology we use must account for this heterogeneity directly.

Rather than considering the heterogeneity as an obstacle, the method we use exploits this heterogeneity as an asset that can help us to uncover some of the differing mechanisms by which crime and economic activity interact in the states of Mexico from 1993–2012. In particular, the methodology that we use is based on the panel structural VAR approach developed in Pedroni (2013). Specifically, the approach models heterogeneous state-specific dynamic responses to unobserved shocks that occur either at the state level or at the national and international level. In this manner, the technique accommodates both the heterogeneity and the cross sectional dependence that arises from the responses to shocks that are common across states.[6] The shocks are treated as structural and unobserved. They are identified and estimated via a method of structural identification analogous to the conventional structural VAR approach. The panel methodology then exploits the statistical relationship of the structural shocks to decompose them efficiently into shocks that are common to the members of the panel versus shocks that are idiosyncratic to individual members of the panel. The relative importance of the idiosyncratic versus common shocks is permitted to differ for each member of the panel, and each member is permitted to respond in a heterogeneous member specific manner to both the common and idiosyncratic shocks.

As is typical in structural VAR approaches, the responses to the structural shocks are represented as impulse responses, and the importance of the shocks are represented as dynamic variance decompositions. In the context of our panel approach, our identification provides us with sample estimates of a set of state-specific responses and variance decompositions to both the idiosyncratic and common structural shocks for each of the 32 states of Mexico. This sample distribution of state-specific responses allows us to study the economic conditions and characteristics of the states that are associated with particular patterns among the responses. For example, using the distribution of individual state responses we can investigate which state characteristics are associated with larger or smaller responses of economic activity to unexpected changes in crime. Of course, in doing so, we must take into account the fact that the responses and decompositions are estimated and are subject to uncertainty from the sampling variation associated with the estimation. Accordingly, we use a bootstrap estimator which produces confidence bands not only for the distribution of impulse responses and variance decompositions, but also for the subsequent analysis of the state characteristics associated with patterns in these distributions. For a more detailed discussion of the methodology, we refer readers to the discussions in Pedroni (2013) as well as the empirical application of the technique in Mishra et al. (2014).

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[5] See for example Pesaran and Smith (1995), for a discussion of this point.

[6] The methodology decomposes the structural shocks into two categories which for convenience are referred to as "common" and "idiosyncratic." More broadly, any shock which predominantly impacts only a single state, regardless of whether the geographic origin is specifically within the state or outside the state is picked up as an idiosyncratic shock. Similarly, a shock which predominantly impacts multiple states, regardless of the specific geographic origin, is picked up as a common shock. In this manner, interdependencies among states are in practice permitted to be more general and complex than the terms idiosyncratic and common might otherwise connote.

B. Overview of the Identification Strategy

Next, we discuss the identification strategy associated with our panel methodology. While we employ the identification scheme and corresponding methodology to the case of the states of Mexico, in principle, the same can be applied to any of a number of countries facing crime. In this regard, as a structural VAR-based method, a key feature involves the identification of the unobserved structural shocks to which the observed state level data is responding. Proper identification ensures that the impulse responses and variance decompositions can be given economic causal interpretations that account for the interdependent endogenous dynamics. It is also an essential element of our panel methodology in that with relatively short lengths of data it will allow us to efficiently decompose the structural shocks into identified common and idiosyncratic components.

A key strategy for successful identification is to consider the variables of interest in relationship to the shocks that drive them. In our case, we are primarily interested in the responses of crime and overall economic activity, as represented by GDP. However, we are also interested in studying the role that key international factor movements, such as capital flows in the form of FDI and labor flows in the form of migration, play in the relationship between crime and economic activity. For each of these variables, we will investigate the responses to the key structural shocks that potentially impact the economy. Among these, we have classified shocks into four broad categories. The first two we view as shocks to economic activity. In the regional and macroeconomic literatures, these are often loosely referred to as aggregate supply (AS) and aggregate demand shocks (AD). They are distinguished from one another on the basis of whether they correspond to shocks that permanently increase or decrease total economic activity (AS) versus shocks that have only a transitory effect on total economic activity (AD).

The next two shocks we view as perturbations in crime and migration that originate independently of other economic activity. The crime shocks can be thought of as shocks to either the supply or demand for criminal activity for a given level of economic activity,[7] and similarly the migration shocks can be conceptualized as shocks to either the supply or demand for net migration for a given level of economic activity. As we discuss in the next section on data sources, our GDP variable is measured as log per capita state GDP, our FDI variable is measured as log per capita cumulative FDI state inflows, our crime variable is measured as log per capita state homicides and our migration variable is measured as log per capita international net migration into the state. Each of the four categories of shocks is permitted to affect

[7] Changes in the demand for crime can be anything that creates a demand for the services that are provided by criminal activity, such as changes in the demand for illicit drugs, whether locally or nationally and internationally, for a given level of economic activity. One such simple example could be when U.S. households change their demand for illicit drugs and hence for the services provided by criminal activity. Changes in the supply of crime can be viewed as anything that induces individuals to become more or less willing to engage in criminal activity, whether locally, nationally or internationally for a given level of economic activity. One such simple example could be a change in legislation or the degree of enforcement related to crimes. However, since we capture both concepts in our crime shock, the distinction between supply and demand is not essential for our empirical analysis. In effect, our crime shock is a shock to equilibrium levels of crime, regardless of whether the equilibrium has moved in response to a change in the supply or a change in the demand for crime. In this regard, it should be noted that crime shocks are not synonymous with homicide shocks, but rather encompass all forms of crime that have the potential to move the homicide rate, including, but not limited to violent crime, organized crime, crimes to health, and so forth, which are discussed in section IV.

each of the four variables over time. Thus, in our setup, GDP responds to crime and migration shocks as well as economic activity shocks, and homicides respond to crime and migration shocks as well as economic activity shocks, and so forth.

However, the shocks are neither directly observed nor proxied. Rather, as in the structural VAR literature in general, we infer the shocks based on the pattern of responses among the observed variables. Doing so requires us to place a few minimal restrictions on the timing of the permissible responses of the variables to the shocks. These are known in the structural VAR literature as the identifying restrictions. The most commonly used identifying restrictions come in the form of exclusion restrictions on either the immediate impact effect of some of the shocks on some of the variables, or on the very long-run steady-state effect of some of the shocks on some of the variables. The former are loosely referred to as "short-run" restrictions while the latter are loosely referred to as "long-run" restrictions. As best as possible, these restrictions should be motivated on the basis of sound *a priori* economic reasoning. All of the transition dynamics between the initial impact and the eventual long-run steady state time horizon are then typically left completely unrestricted, and are permitted to be fully endogenous in terms of the feedback among the variables.

For the purpose of this paper, we use a mix of both short-run and long-run identifying restrictions and build on some of the typical restrictions that have been used periodically in the structural VAR literature. For example, to distinguish between AS shocks and AD shocks, we use the restriction that AD shocks do not cause permanent movements in GDP, while AS shocks do. This is in keeping with the literature and is consistent with their conceptual definitions. Similarly, to distinguish these two economic activity shocks from the crime shocks, we employ a restriction that reflects the idea that while both the crime and economic activity shocks can have an immediate impact effect on economic activity, only the crime shocks have an immediate impact on homicides. This is consistent with the idea that crime shocks potentially can induce rapid changes to the economy while homicides respond more slowly to changes in economic conditions with a lag, following the initial period of the shock. In similar spirit, we distinguish migration shocks via a similar short-run restriction, namely that migration can respond quickly to crime shocks, while homicides change more slowly in response to migration shocks. Notice that in this manner, the response of the economy in the form of GDP, net migration, and FDI responses to crime shocks, is left unrestricted.

It is also worth noting that, as with any structural VAR identification scheme, short-run and long-run exclusion restrictions as we have described only identify the shocks up to a sign, meaning that our restrictions are sufficient to distinguish the four shocks from one another, but are not sufficient to determine whether the particular shocks were positive or negative shocks, for which we need additional restrictions. Consequently, we identify the signs of the shock as follows. A crime shock is identified as a positive shock if it increases homicides in the impact period, and a migration shock is identified as a positive shock if it increases net international in-migration in the impact period. Similarly an aggregate supply shock is identified as a positive shock if it permanently increases GDP in the long-run steady state time horizon. Finally, an aggregate demand shock is identified as a positive shock if it increases GDP in the short-run impact period. Each of these identifies the sign in a manner that is consistent with the economic conceptualization of the shock.

As with all structural VAR analysis, since the shocks are conceptual and are not directly observed, they are unit free shocks. To associate economic units with the shocks, one must therefore look to the response

variables. Furthermore, one can use any of the response variables for this purpose. Thus, for example, one can study the effect on GDP of a crime shock that leads to an "x" percent increase in homicides. Or alternatively, one can study the effect on GDP of a crime shock that has a "y" percent increase in migration rates, and so forth. As is conventional in structural VAR analysis, we report impulse responses to the structural shocks symmetrically without associating units and allow the reader to choose any of the response variables as a means for scaling the shocks to an economic unit.

Since each of the variables is related to each of the four shocks, identification schemes are often depicted in matrix form. Thus, schematically, our set-up can be characterized as follows: where we have used a 0 to denote a zero restriction for the particular entry, we have used a + to indicate a sign restriction, such that while the value of the response is unrestricted, the sign of the response is dictated by our definitions of what constitute positive versus negative shocks. Finally, a * is used to denote a completely unrestricted value for the particular entry. (See Figure 3)

Figure 3. SVAR Identification Scheme

$$\begin{bmatrix} \text{hom} \\ \text{intmig} \\ \text{gdp} \\ \text{fdi} \end{bmatrix}^{\substack{\text{short-run} \\ \text{impact} \\ \text{response}}} = \begin{bmatrix} + & 0 & 0 & 0 \\ \bullet & + & 0 & 0 \\ \bullet & \bullet & \bullet & + \\ \bullet & \bullet & \bullet & \bullet \end{bmatrix} \begin{bmatrix} \varepsilon^{\text{crime}} \\ \varepsilon^{\text{mig}} \\ \varepsilon^{\text{AS}} \\ \varepsilon^{\text{AD}} \end{bmatrix}$$

$$\begin{bmatrix} \text{hom} \\ \text{intmig} \\ \text{gdp} \\ \text{fdi} \end{bmatrix}^{\substack{\text{dynamic} \\ \text{transition} \\ \text{response}}} = \begin{bmatrix} \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet \end{bmatrix} \begin{bmatrix} \varepsilon^{\text{crime}} \\ \varepsilon^{\text{mig}} \\ \varepsilon^{\text{AS}} \\ \varepsilon^{\text{AD}} \end{bmatrix}$$

$$\begin{bmatrix} \text{hom} \\ \text{intmig} \\ \text{gdp} \\ \text{fdi} \end{bmatrix}^{\substack{\text{long-run} \\ \text{steady-state} \\ \text{response}}} = \begin{bmatrix} \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & \bullet & \bullet \\ \bullet & \bullet & + & 0 \\ \bullet & \bullet & \bullet & \bullet \end{bmatrix} \begin{bmatrix} \varepsilon^{\text{crime}} \\ \varepsilon^{\text{mig}} \\ \varepsilon^{\text{AS}} \\ \varepsilon^{\text{AD}} \end{bmatrix}$$

Key: hom: log per capita homicides
gdp: log per capita real GDP
fdi: log per capita cumulative fdi inflow
intmig: log per capita international net in migration

0: zero restriction
+: sign definition restriction
•: completely unrestricted

Thus, as we see from the schematic representation, our VAR system includes a total of six exclusion restrictions on either the short-run impact or long-run steady state responses, and a total of four sign restrictions. Along with the standard assumption that the structural shocks are orthogonal, this is sufficient to exactly identify the VAR system of shocks and impulse responses, with all of the dynamic transition responses completely unrestricted. For the panel framework, we allow a similar set of restrictions to apply to both the response of the variables to the idiosyncratic state-specific shocks as well as the common national or international shocks, so that for each structural shock we have both a common and idiosyncratic component for a total of eight structural shocks. For each structural shock, we then obtain impulse responses for each of the four variables for a total of 32 impulse responses for each of the 32 states of Mexico. As discussed in the previous subsection, once we have the collection of impulse responses for each state, in the next stage we use a bootstrapped estimator to investigate state-specific characteristics associated with the heterogeneous patterns of responses.

In the conventional structural VAR literature, it is well known that results can be sensitive to the choice of identifying restrictions, and it is no different for panels. Accordingly, in our analysis, we confirm that our key findings are robust to viable variations in the identification scheme. In this regard, an additional attractive feature of this identification scheme is that various blocks of the system can be also investigated separately to confirm robustness of some of the key underlying results. For example, if we are only interested in the relationship between per capita crimes and economic activity in general, we can examine a bivariate structural VAR which includes only log per capita homicides and log per capita GDP with similar identifying restrictions to confirm that the key patterns hold in the subsystem. We elaborate on this further in the results section of our paper.

Finally, it is worth noting a few important limitations. For example, the approach is naturally limited due to the measurement error inherent in the data, which we further discuss in the next section. Furthermore, as with any structural VAR analysis, interpretations are dependent upon the particular econometric identification scheme, which employs homicide data in part to capture the response of crime shocks, and is subject to assumptions that must be made on whether the class of relevant shocks has been captured by the set of econometric restrictions that are imposed on the data. In this regard, the research aims to contribute to the analysis of the relationships, but is not intended to be conclusive in its findings.

Before proceeding to our results, next we discuss the details of the various data sources for Mexico.

IV. DATA SOURCES

A. Real GDP for the Period During 1993 to 2012

A key challenge in implementing our panel VAR is to estimate a sufficiently long series of RGDP for each of the Mexican states. INEGI has only recently published the RGDP aggregated data for 2003–2012 using base year 2008, but to date has not yet released the GDP aggregated data from 1993 to 2003 using the base year 2008.

There are a number of approaches to obtain real GDP values for multiple base years, among them, the annual chain-linked approaches.[8] In this paper, we present two different approaches. In the first approach (RGDP-1), we link two aggregated RGDP series for each state: (i) the first series contains aggregated RGDP data from 1993 to 2003 with base year 1993, and (ii) the second series contains aggregated RGDP data from 2003 to 2012 with base year 2008. For year 2003, for each state, we simply compute the ratio between the aggregate RGDP with base 2008 and the aggregate RGDP with base 1993, and then multiply the aggregated RGDP series with base 1993 by this ratio to obtain RGDP series for 1993–2002 with base 2008. However, this method does not account for the heterogeneous ratios among all RGDP sectors. In order to fix this, in

[8] For the purpose of this paper, we have followed recommendations provided Mc Lennan (1998), Introduction of Chain Volume Measures in the Australian National Accounts. Australian Bureau of Statistics. See also, Correa et al.(2002), and United Nations Statistics Division, *Review of Country Practices on Rebasing and Linking National Accounts Series.*

the second approach (RGDP-2), we apply the above method to calculate the ratio for each GDP sector to estimate the sector values with base 2008 for years 1993–2002. Then we sum up these sector values to obtain the aggregated RGDP estimates with base 2008 for years 1993–2002.

The methodological description of these two different approaches is included in the Technical Appendix 1. We also discuss each of the various robustness checks undertaken. In Figure 9, we compare each of the Mexican RGDP estimates using different approaches. For cases in which we use sectoral GDP estimates for the purposes of our second stage analysis (see section V), we restrict our attention to 2003–2012.

B. Measures of Crime

Intentional Homicides

The second important task in implementing our panel VAR is the choice of a crime variable which is measured relatively well and which is likely to move in response to general crime shocks as we define them in our econometric identification scheme described in section II. Toward this end, and also following numerous other scholars (Fajnzylber et al., 2000; Detotto and Otranto, 2011; Forni and Paba, 2000; Cardenas, 2007; and Robles et al., 2003), the number of recorded intentional homicides are used here as the crime variable. The homicide rates are chosen for their highest reliability among all crime variables.[9] Homicide data are of special interest because these crimes are usually thought to be the least affected by the problems of under-reporting and under-recording that afflict official crime statistics (Fajnzylber, 2000). Even for the United States, experts have frequently focused on homicides as a proxy for crime, not only because "it is a fairly reliable barometer of all violent crime ," but also because "at a national level, no other crime is measured as accurately and precisely." (Fajnzylber, 2000; and Fox and Zawitz, 2000). However, as Heinle et al. (2014) point out, what is of particular concern regarding Mexico's sudden increases in homicides in recent years (2007–2012) is that much or most of this could be attributable to organized crime groups. Although drug-related homicides are widely used to describe Mexico's security challenges from 2007 to 2012, there is no formal definition of this concept in Mexican criminal law. [10] Finally, it is important to note that it is not possible to distinguish between the homicides that are a result of criminal activity, much less any particular category of criminal activity such as organized crime, and those deaths that are the product of social conflict, demographic phenomena and so forth.

Official data on homicides in Mexico are available from two sources. Also, a number of non-governmental sources have collected estimates of the number of homicides that are specifically related to the drug trafficking in Mexico. On the official side, public health records filed by coroner's offices can be used to

[9] There are caveats to the homicides data that are worth considering, since this could reduce the reliability of the results. In Mexico, the phenomenon of intentional homicide presents features regarding its recording, since occurrences that are initially considered intentional homicides, are later determined to be of a different nature: suicide, accident due to fall, suspicious death, natural death, etc. This is a source of measurement error which could have implications for the results.

[10] As noted by one of our commentors, another variable that could closely track the reality of crime rates affecting the perception of public security could be vehicle theft.

identify cases where the cause of death was unnatural, such as cases of gunshots wounds, stabbings, etc. While all the datasets have limitations, the most consistent, complete, and reliable source of information in Mexico is the autonomous government statistics agency, INEGI, which provides data on death by homicide (Heinle et al., 2014). We compile a data set of these INEGI data for 32 Mexican states during the period 1993 through 2012.

A second source of data on homicide comes from criminal investigations by law enforcement to establish a formal determination of criminal wrongdoing, and the subsequent conviction and sentencing of suspect charged with these crimes. The Executive Secretary of the National System for Public Security (SESNSP) compiles and reports data on cases involving homicide that are identified by law enforcement. In recent years, SESNSP has its homicide data on a monthly basis.[11]

As we can observe in Figure 4,[12] there is a noticeable difference between public health and law enforcement homicide statistics, which appears to be attributable to the different timing and methodologies by which cases are classified. Still, data from the two sources (INEGI and SESNSP) are closely correlated and offer fairly consistent measures of the trends in overall homicide. Neither of the two official sources on homicide statistics identifies whether there is a connection to organized crime in a particular case. However, both government and independent sources have attempted to do so by examining other variables associated with a given crime.[13]

Some statistics on organized crime related homicides are available from SESNSP for a few years from 2006–2013. These are only comparable to some nonofficial organizations estimates from Mexico's National Human Rights Commission (CNDH) for 2000–2008.[14]

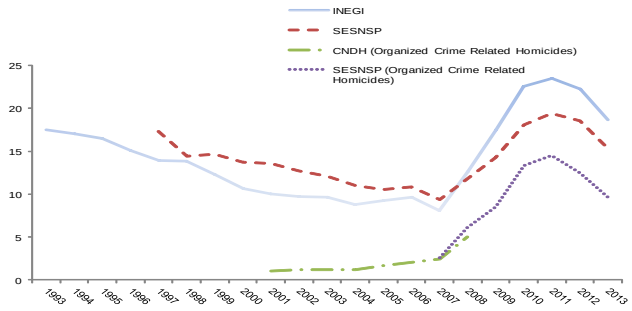
[11] For a discussion on data and analysis of drug violence in Mexico, see Heinle, Ferreira and Shirk (2014).

[12] In the figures, the homicide rate $(\mathrm{HOM})_{s,t}$ is computed as the reported number of intentional homicides (INEGI) by state and year and divided by population $(\mathrm{pop})_{s,t}$ and multiplied by 100,000. Population refers to each state population at a half of every year. $(\mathrm{HOM})_{s,t} = \frac{(\mathrm{Homicides})_{s,t}}{(\mathrm{pop})_{s,t}} 100{,}000$ (1)

[13] The statistics on homicides generated by INEGI and the databases by SESNSP report two completely different measures. INEGI compiles its statistics through the counting of death certificates, while SESNSP does the compilation based on complaints or reports of probable crimes of homicides done at *las procuradurías o fiscalías estatales*.

[14] For analytical and methodological concerns about this data, see Heinle et al. (2014).

Figure 4. Mexico: Comparative Homicide Rates from Different Sources



Source: INEGI, SESNSP, CNDH, CONAPO, Heinle et al. (2014), and authors' calculations.

Other Measures

As discussed in the previous section, once we have the collection of impulse responses for each state, in the next stage we use a bootstrapped estimator to investigate state-specific characteristics associated with the heterogeneous patterns of responses. Among those state-specific characteristics, we are particularly interested in exploiting all the incidence of crime data from the SESNSP database, in particular, the incidence of crime related to crimes against health and the federal law against organized crime (LFCDO), kidnapping, extortion, aggravated assault, and robbery.[15] In Mexico, one of the possible classifications of crimes corresponds to their jurisdictional nature. Following this logic, crimes can be catalogued as local crimes (*fuero comun*) or federal crimes (*fuero federal*).[16] This classification will indicate the authority responsible for their investigation and prosecution. *Fuero comun* crimes are those affecting individuals directly. Examples of such crimes are assault, robbery, threats, sexual crimes, frauds, homicides, extortion, kidnapping, among others.[17] On the contrary, *fuero federal* crimes are characterized as the ones affecting health, the economy and the national security or interests of the federation. These include drug trafficking, organized crime, environmental crimes, firearm crimes, crimes committed by public servants, money laundering, people and child smuggling, and electoral crimes, among others.[18] [19] The SESNSP reports crime

[15] According to Robles et al. 2013, the drug war lead to a general increase of extortion, kidnapping, and other common criminality.

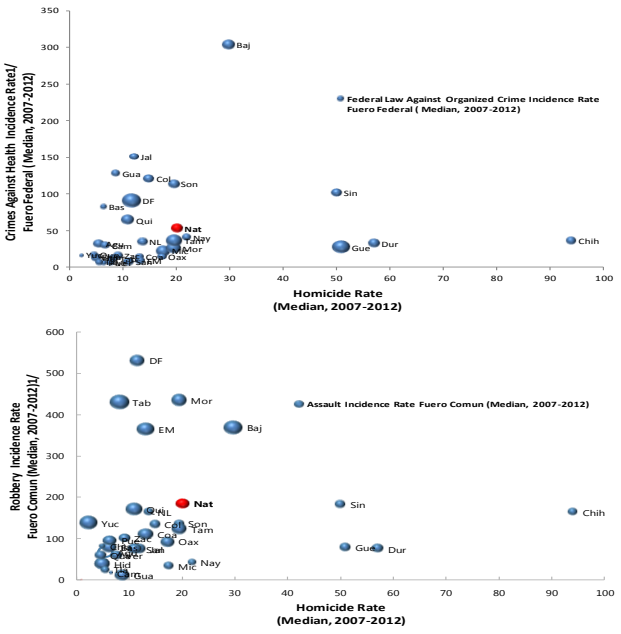
[16] For a detailed explanation of the official classification of federal and local crimes, please see http://www.pgr.gob.mx/Combate%20a%20la%20Delincuencia/Ministerio_Publico.asp.

[17] These crimes are investigated by the State's Prosecutors (*Ministerio Publico del Fuero Comun*) and prosecuted by the judicial branches of each state of the Mexican Republic.

[18] Additionally, federal crimes will also include those stipulated in Article 50 of the Organic Law of the Federal Judicial Branch and Articles 2–5 of the Federal Criminal Code. The former provisions qualify crimes as of federal jurisdiction when they, among other circumstances, are typified in federal special laws; are perpetrated abroad by diplomatic personnel; are committed in embassies or against federal public servants. Federal crimes are investigated and prosecuted by federal authorities: Mexican Attorney General (*Procuraduría General de la República*, *PGR*), Federal Prosecutor (*Ministerio Público Federal*, *MPF*), and the Federal Judicial Branch.

incidence information from initiated investigations by authorities, using data from the Institutional System of Statistical Information (*Sistema Institucional de Información Estadística*, *SIIE*). Since the crime incidence data refers to crimes of the federal and local jurisdiction, the information allows drawing conclusions on the macro and micro criminal situation in each state of the Mexico and at the national level. The conducts contemplated in the analysis by SESNSP refer to federal jurisdiction crimes which are typified in the Federal Criminal Code and Federal Special Laws. It has been mentioned that the reported data apparently refer to initiated investigations by MPF. Therefore, this likely would not give an accurate picture of the criminal scenario in Mexico, since data relating to the result of subsequent first and second judicial instances, and *amparo* procedures, are not reported.[20]

Figure 5. Mexico: Homicide Rates vs. Incidence of Crime



Source: INEGI, SESNSP, CONAPO, and authors' calculations

With regard to *fuero federal*, of particular interest is the incidence of crime related to crimes against health (i.e., drugs) and organized crime due to the economic activity associated with these types of crime. The top part of the Figure 5 shows the scatter plot of annual totals intentional homicides and incidence of federal crimes related to drug-related issues (production, traffic, etc) and organized crime from 2007 through 2012. However, there are some states in which the homicide rate is increasing, but the incidence of crime is decreasing. The latter could be related to two types of underreporting: (i) crimes are unobserved by the victim or authorities, (ii) crimes are known, but not reported. (See Shirk and Rios Cazares, 2007).

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[19] PGR is a Mexican institution of the Executive Branch. Among other functions, PGR is in charge of the investigation of federal crimes and of assigning jurisdictional criminal procedures among the federal criminal tribunals. The Attorney General presides over the PGR, the Federal Prosecutor, and its auxiliary organs, such as the investigative police and the experts. The MPF is society's representative and has the exclusive monopoly of criminal action, in the name of the Mexican State. MPF is the specific organ in charge of the investigation (*averiguación previa*) of federal crimes and may or may not charge individuals (*ejercer acción penal*) at criminal tribunals, depending on the outcomes of the preliminary investigation. MPF can only initiate a crime investigation if it gets notice of such investigations via complaint (*denuncia*), grievance (*querella*), or accusation (*acusación*).

[20] Another aspect that complicates the analysis is the broadness of two of the most relevant categories in the criminal incidence data referred as "other crimes" and crimes contemplated "under other special laws." Omission by PGR to specify and individually address the typified conducts does not permit identification of the weight of crimes such as concealment and operations involving resources from illicit operations (money laundering), terrorism, pornography, sexual tourism, kidnapping, human trafficking, among others, which seem to be covered under these broad categories.

From the *fuero comun* perspective, we are interested in two crimes that generate violence: robbery and assault.[21] The bottom part of the Figure 5 shows the scatter plot of annual totals intentional homicides vs. incidence of local fora crimes related to assault and robbery.[22]

C. Migration

We are also interested in the role that migration plays in the relationship between crime and economic activity. The *Consejo Nacional de Poblacion* (CONAPO) releases the demographic data at the state level from 1990 to 2010. It also forecasts the demographic data for 2011–2030. These data include the population, immigration, and emigration between Mexican states; immigration from and emigration to foreign countries; natural and social birth and death rates; life expectation; etc.

D. Foreign Direct Investment

As discussed in Section III, we are factoring in the role that FDI plays in the relationship with crime and economic activity. Mexico's Secretary of Economy releases nominal FDI at the state level by sectors, origins, and investment types. The currency is in U.S. dollars. There are three investment types: new investments, reinvestment of profits, and intercompany accounts. Over 140 countries and economies are listed as the FDI origins. The U.S. consumer price index is used to deflate the nominal FDI to generate the real FDI.

E. State-Specific Characteristics

For the analysis of the stated characteristics associated with patterns in the distributions of crime, GDP, FDI, and migration, we use the following list of variables:

Average schooling years: A large body of evidence suggests that education and labor market opportunities influence criminal activity. Someone with a poor education and bleak labor market opportunities is more likely to commit a crime. According to Lochner and Moretti (2004), schooling significantly reduces criminal activity. In order to understand whether average schooling years matters for the Mexican states' GDP, FDI, and migration responses to crime, we use the INEGI's *Statistical Yearbook By State*, which compiles average schooling for adults from 2003-2012.

Unemployment rates: Although time series have failed to uncover a robust, positive, and significant relation between unemployment and crime (Fleisher, 1966; and Erlich, 1973), most studies based on cross-sectional and individual data point in that direction (Freeman, 1986). In order to understand whether the unemployment explains the Mexican states' responses of GDP, FDI, and migration to crime, we use unemployment rates data compiled by INEGI based on the National Survey on occupation and employment (ENOE) from 2003 to 2012.

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[21] Violent crime consists of aggravated assault, rape and robbery, but excludes homicides. See Mexico Peace Index Methodology.

[22] Federal and local fora incidence of crime rates are calculated as $(\mathrm{IC})_{s,t} = \frac{(\mathrm{IC})_{s,t}}{(\mathrm{pop})_{s,t}} 100{,}000$

Bank Deposits: As discussed in International Monetary Fund (2001), criminal organizations and individuals sometimes rely on the legitimate banking system to hide illegally obtained assets. Financial institutions can be used as an instrumentality to keep or transfer the proceeds of a crime (IMF 2001). Although the circumstances vary from state to state in Mexico, sometimes where the criminal profits are laundered may be a different location from where the predicate crime was committed. To understand whether the size of banking assets explain the Mexican states' GDP response to crime, we use the deposit data from the National Banking and Securities Commission of Mexico (CNBS) during 2000 through 2010. The data include the amount of deposits for immediate repayment purpose or investment purpose.

Marginalization indices: There is strong evidence that social exclusion renders individuals vulnerable to criminal behavior (Hale, 2005). We use CONAPO data on marginalization indices for each five-year period since 1990. The indices are based on: (i) literacy rates; (ii) percentage in dwellings without drainage or toilet; (iii) percentage of households without power or without piped water or some level of overcrowding in houses; and (iv) percentage of population with income up to two minimum wages.

Perception of Lack of Public Security:[23] Periodic victimization surveys are the best tool that policy makers have for both detecting early trends and identifying the groups that are most at risk (Fajnzylber et al., 2000). INEGI published the household survey data on the perception of the lack of public security in ENSI (2005 and 2009), and *Encuesta Nacional de Victimización y Percepción sobre Seguridad Pública* (ENVIPE) (2010, 2011, and 2012). One common question in these surveys is "Do you think that living in your state is secure, insecure, or no response?" We use the percentage of the "secure" responses to measure the perception of public security in the state.

Government spending on security: Conventional wisdom focuses on the direct effect of greater policing in reducing the probability of a successful crime. Becker (1968) assumes that private and public preventive measures are substitutes and that if the state spends substantially on crime prevention, individuals need to spend less to achieve a given rate of arrest. For example, Lin (2009) suggests that a police force reduces crime. We take this into consideration and employ a measure of the government sending on security in the analysis of characteristics associated with patterns in the distribution of our main variables. Mora (2009) lists the public spending on security at the state level for years 2007, 2008, and 2009. The expenditure includes situational prevention, law enforcement, social reintegration, judiciary, ombudsman, and contributions to the Fund for Public Safety (FASP).

Informality: Yishay and Pearlman (2011) find a potential ambiguous response of formalization to robbery risks in Mexico, based on the dual potential effects of formality on raising the targeting of firms by criminals and improving protection by and recourse to official authorities. Despite this, we consider a

[23] However, we note that "perception of insecurity" could have a tendency to be overreported (Levit 1998). In addition, regarding the perception of public security, the document takes the ENVIPE data, which was first launched in 2010 and has been modified. For this reason one must use caution when using the data retroactively.

measure of informality in the analysis of characteristics associated with patterns in the distributions of crime, GDP, FDI, and migration. The informality is reported by the ENOE.[24]

Disaggregated GDP: the disaggregated GDP includes the following sectors: agriculture, livestock and forestry fishing and hunting; electricity, gas and water supply for final consumer products; construction; manufacturing industries; commerce, transport, postal and storage; mass media information; financial services and insurance; real estate services; professional services, scientific and technical; corporate management companies; support services business and waste management and remediation services; education services; health and welfare services; leisure services, cultural and sports, and other recreational; temporary housing services and preparation of good and beverages, other services; and government activities and international organizations. For a detailed description of disaggregated GDP sector see Table 2 in the appendix and INEGI (2013a).

The disaggregated FDI:[25] the disaggregated GDP includes the following sectors; agriculture, livestock and forestry fishing and hunting; electricity, gas and water supply for final consumer products; construction; manufacturing industries; wholesale; retail trade; transport, postal and storage; mass media information; financial services and insurance; real estate services; professional services, scientific and technical; corporate management companies; support services business and waste management and remediation services; education services; health and welfare services; leisure services, cultural and sports, and other recreational; temporary housing services and preparation of good and beverages, other government activities. For a detailed description of disaggregated FDI sectors see the reference *Secretaría de Economía* (2014)

In Table 3 of the appendix, we summarize the list of variables used in this paper as well as the data sources.

V. RESULTS OF THE EMPIRICAL ANALYSIS

In this section, we summarize some of the key findings of the empirical analysis. Since we are interested in both the short-run and long-run dynamic responses of our variables and use a combination of short-run and long-run identifying restrictions, one of the first empirical features of the data that we examine is the stationary properties. If variables are stationary, it implies that in response to any shock, over time they will revert back to their mean values. Consequently, for a variable that is stationary, no shock can cause a

[24] Informality is measured as an occupation rate in the informal sector.

[25] It is important to note that FDI statistics are recorded in the home of the company's headquarters, which may differ from the state in which the investment was actually made. To the extent that the company's headquarters are not in the same state in which the change in FDI actually occurred, it implies that these FDI movements are somewhat more likely to be registered by our econometric method as having been caused not by state specific shocks, but by common shocks, external to the state in which the shock occurred. This may cause some of the magnitudes of the responses to common shocks to be upwardly biased at the expense of some of the state specific shocks. Futhermore, the state-specific pattern of FDI responses must be interpreted with some caution in light of this. For example, the magnitude of the FDI responses to crime shocks, whether positive or negative, may be upwardly biased for states where companies tend to be headquartered.

permanent change. Only transitory changes are possible. By contrast, for variables that are nonstationary due to the presence of a unit root, at least some shock must be present that can cause a long-run permanent change in the variable. This carries important practical implications for our analysis. Firstly, there can be no lasting long-run change in a stationary variable; and secondly, a stationary variable does not contain information about shocks that may be responsible for causing a lasting long-run change in a nonstationary variable that follows a unit root process. Consequently, for the first stage of our analysis, we investigate the stationary properties of the data.

In particular, we use standard panel unit root tests such as the one developed by Im, Pesaran, and Shin (2003) to test our data.[26] Not surprisingly, we are unable to reject the null hypothesis that log per capita GDP follows a unit root for each of the states of Mexico, and that this holds regardless of which method we use to link the two GDP periods before and after 2003. Given that the tests have high power, this implies that GDP likely follows a unit root process at the state level, and therefore it is possible for some shocks in our VAR analysis to permanently lower or raise state level GDP.

By contrast, for the crime data, only per capita homicides, as measured by INEGI were similarly found to follow a unit root process at the state level. By contrast, other crime measures, such as the SESNSP data on homicides, violent crimes, organized crime, or crimes against health appear to be stationary in the sense that the null hypothesis of a unit root in all states is rejected in favor of stationarity. This implies that these other series revert to their respective means in response to any changes, and therefore any shocks in a VAR system can have only transitory effects on these. Similarly, shocks that drive these data cannot have long - term effects on variables that follow unit root process, such as GDP. If there are long-term causal effects present between crime and economic activity measured by GDP, they are likely to be reflected in the INEGI homicide data, and not these other measures. For these reasons, as well as the reasons discussed in the previous section, we use the INEGI homicide data as our primary crime measure in our identified structural VAR estimation. However, this is not to say that the information contained in these other measures might not interact to play a role in influencing the nature of the dynamic responses of GDP and INEGI recorded homicides at the state level, and therefore we employ these other variables in our second stage analysis to investigate the pattern of heterogeneous responses among the states.

Next, for our migration data, we find that most of the measures for internal migration are stationary. By contrast, per capita international net in-migration appears to follow a unit root at the state level, so that it is possible that it contains information regarding shocks that can cause permanent changes in the INEGI homicides data. Since our other variables are measured in logs, we similarly convert our migration data to log form. To address the fact that our migration data is net in-migration, and therefore can take on positive or negative values, we use a fairly standard approach to convert such series to logs. Specifically, we take the largest negative value and this value plus 1.0 to all values of per capita net in-migration, so that upon taking natural logs all values are positive. Adding a constant to the series in this fashion affects the value of the fixed effect intercepts in a VAR estimation, but does not affect the dynamic impulse response or variance decomposition estimates, which are the objects of interest. Similar to the crime data, we use some of the

[26] We tested both the raw data as well as the transformed data from which common time effects were extracted as used in the panel VAR estimation. Tables for test results are available upon request.

other stationary migration data for our second stage analysis to investigate whether they contain information which helps to explain the pattern of heterogeneous responses among states.

As the fourth variable in our VAR system, FDI is relatively unrestricted econometrically. Since we find that the flow variable for FDI is stationary, and we are interested in the relationship to the stock, we use accumulated net FDI for the purposes of our analysis. Since this variable is also measured as a net inflow, we use a similar method as we did for international per capita net in-migration to compute the log of per capita accumulated FDI.

Consequently, as alluded to in section III, the four state-level variables that we use in our most general VAR specification are log per capita INEGI recorded homicides, log per capita international net in-migration, log per capita GDP, and log per capita accumulated net FDI. The four categories of structural shocks are crime shocks, migration shocks, AS shocks, and AD shocks. For a more detailed motivation for these shocks and for a discussion of the structural identifying restrictions used to distinguish these shocks, please see section III.

One of the first things that we consider is the relative importance of the various shocks in driving the variations in the observed variables. This is reflected in the variance decompositions, which are depicted in Figure 11. Not surprisingly, the primary shock driving variations in homicides are the crime shocks, and the primary shocks driving variations in GDP are economic AS shocks. For example, the median percentage of GDP variation explained by state level aggregate supply shocks is roughly 70 percent. What is of note is that the median percentage of variation in state GDP driven by state-specific crime shocks is roughly five percent with another half a percent driven by common national or international crime shocks. If we consider the seventy-fifth percentile, this rises to as much as 10 percent due to state-specific crime shocks and another one percent due to national or international crime shocks. In other words, this tells us that for at least a quarter of the Mexican states, crime shocks are responsible for driving up to 11 percent of the variation in state GDP. To put this in perspective, according to Figure 11 these values are roughly comparable to the percentage variation in state GDP that is attributable to economic aggregate demand shocks, which would include private sector changes in demand for resources, as well as changes in government spending that stimulate the economy. Similarly, we see that crime shocks play a substantial role in driving the variation in both migration and FDI. In the case of migration, for at least a fourth of states, state-specific crime shocks initially account for 10 percent of the variation in the initial period of the shock, rising to close to 20 percent five years after the shock. For FDI, the median state variation explained by crime shocks is not much, at roughly one percent. However, for the states most affected, which lie in the top quartile, up to eight percent of the variation is driven by crime shocks in the initial period of the shock, rising to as much as 15 percent by five years after the shock.

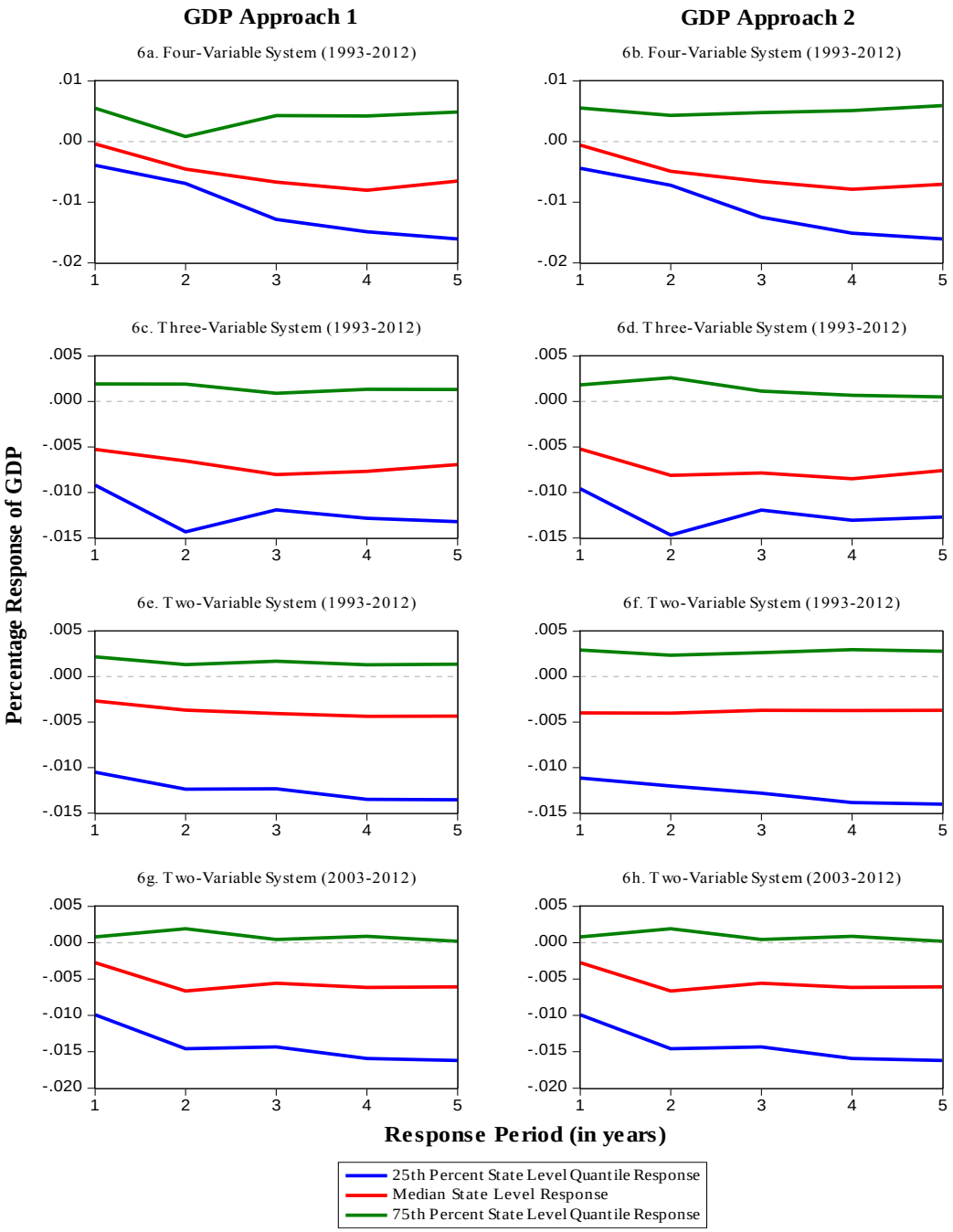
Similarly, one can examine which shocks beyond the crime shocks are most important for driving homicide rates. Here again, we see a large spread among the states. Whereas the variation in crime in some state, in other words those in the lowest quantile, attributable to other shocks is relatively low, in a few states, the contribution of is substantial. For example, in the top quartile states, over 10 percent in the variation in crime can be attributed to state-specific migration shocks, with a little over three percent each to state-specific AS shocks and AD shocks at the longer time horizons following the shocks.

Of course, while these variance decompositions point to the relative importance of the various shocks in explaining variations in the observed variables, they tell us nothing about the signs, magnitudes, or duration of the responses to these shocks. For this, we turn to the impulse response analysis. The quantile impulse response estimates for our general four variable VAR are reported in Figure10 for both the idiosyncratic and common shocks. However, before exploring these, it is worth delving a bit deeper into some basic robustness checks to confirm that our results are not specialized to some of the choices that we have made regarding the variables and the identification scheme. Toward this end, we investigated multiple variations in the identification and multiple variations in the data choices to confirm that results were similar. For example, as discussed in the previous section, we examined five different methods for chaining together the state-level GDP estimates into a single base year from 1993 to 2012. We explored our panel VAR estimation for all of these different methods and found that the key results were qualitatively invariant to the choice of method for chaining the GDP segments. As described in section III, a nice feature of our identification scheme is that it also permits us to examine subsystems of the general VAR, based on two and three variable blocks, to confirm that our primary results also hold for these specifications.

To see an example of this analysis, in Figure 6, we report one of the key sets of impulse responses, namely the quantile responses of log per capita GDP to crime shocks. Since the variance decompositions point to a more prominent role for the idiosyncratic state-specific crime shocks, we focus here on the responses to these idiosyncratic crime shocks. Thus, for example, Figures 6a and 6b show the quantile responses of state GDP to state-specific crime shocks based on two different methods for chaining together the GDP segments. While there are small quantitative differences, the shape of the response, and even the overall magnitudes are remarkably similar. For example, we see that the point estimate for the median response among states is initially slightly negative and eventually moves to approximately -0.005. The twenty-fifth percent quantile starts out at -0.004 and continues to drop to around -0.16 by five years after the shock. To translate this into economic terms, this implies that for at least a quarter of the Mexican states, a *ceteris paribus* shock to crime reduces real per capita GDP by 1.6 percent per year after a period of five years following the shock.

As discussed in section III B, to understand the magnitude of the shocks themselves, one can scale them by the units associated with any of the response variables, as depicted in the appendix figure 10. Thus for example, since the median state homicide rate increases by 0.2 percent in the initial period in response to the crime shock, one can say that a crime shock that induces an initial 0.2 percent increase in homicides causes a 0.5 percent decrease in GDP for the median state. Notice that this does not imply that a change in homicides causes GDP to move by this amount. Indeed, if the cause of the movement in homicides is due to one of our other shocks, such as an aggregate supply shock or an aggregate demand shock, then the multiplier between homicides and GDP will be very different. Finally, notice that one need not scale the crime shock by homicides. For example, since the median state accumulated FDI decreases by 0.1 percent by the fifth year following the crime shock, one could just as well describe these results by saying that a crime shock which decreases accumulated FDI by 0.1 percent over a five-year period for the median state causes a 0.5 percent decrease in GDP for the median state. It should be clear from this discussion that crime shocks are not being measured nor proxied by homicide rates. Rather, homicide rates, in conjunction with the other variables, assist in identifying crime shocks based on the structural VAR identification scheme. We elaborate more on the interpretation of these results later, as well as the confidence bands associated with these estimates.

Figure 6. State Level Response of GDP to Idiosyncratic Crime Shocks



First, we continue to examine the qualitative robustness of the results. For example, in Figures 6c and 6d, we see a similar comparison of results for the two GDP methods when we use a three variable specification for the VAR that excludes log per capita international net in-migration. Since we use similar identifying restrictions for the remaining variables, the interpretation of the shocks may be slightly altered for these relative to the four variable specification. In particular, some migration shocks are now potentially lumped into what we call the crime shock, while only AS and AD shocks are controlled for in the other shocks. Accordingly, the impulse responses change quantitatively somewhat relative to the four variable

specification. However, they are still remarkably similar in pattern to the four variable specification, and the results for the two GDP measures are again remarkably similar. Similarly, we also examined a streamlined two variable system, with just log per capita homicides and log per capita GDP. Under this specification, we no longer control for AS and AD shocks separately, but rather control for a single economic activity shock that encompasses both AS and AD. Again, there are small quantitative differences, but the basic pattern remains with a clearly heterogeneous response of GDP to the crime shocks, with again remarkable similarity among the two GDP measures.

The two variable system also affords us another useful opportunity relative to the three and four variable systems. Specifically, since the number of degrees of freedom required to estimate the lag structure for a two variable VAR system is considerably less than for a three or four variable VAR system, for the two variable system we are able to examine shorter spans of time. Thus, we take the opportunity to examine the impulse responses when we restrict the sample to 2003 to 2012. We choose this period for three reasons, namely (i) since the break in the base period for the original data occurs in 2003, it allows us a robustness check to confirm that chaining the GDP measures together across the two different periods does not alter our results; (ii) using 2003 as the sample break splits our sample into exactly two equal segments of 10 years; and (iii) we are particularly interested in the later period and take the opportunity to confirm that our general results are likely representative not only of the entire period, 1993–2012, but also of the more recent period, 2003-2012. Finally, to check our chaining methods, we also ran each of the full sample VAR specifications with a dummy break for the pre- and post-2003 segments and confirmed that the results are not affected by the use of a dummy for the two periods.[27]

Next, we examine in greater detail the various impulse responses that are of primary interest, for which we use the more general four variable VAR specification with our RGDP-2 data. Specifically, in Figure 7, we look in greater detail at the impulse responses of each of the variables to the state-specific crime shocks, as well as the response of crime to each of our other three shocks. In each case, we also report the bootstrapped 90 percent confidence bands based on 5,000 bootstrap draws to confirm that the heterogeneous spread in the individual state responses is statistically significant. Thus, for example in Figure 7b, we see the responses of state-level log per capita GDP to state-specific crime shocks. This time, however, we have also included the 90 percent confidence bands around both the upper and lower quantile responses. As we can see, these are both significantly different than zero. Thus, we can say with 90 percent confidence, equivalent to statistical significance at the 10 percent level or better that for at least a quarter of the states log per capita GDP decreases in response to crime shocks, while for at least a quarter of the states log per capita GDP increases. Furthermore, for the 25 percent or more states where log per capita GDP falls in response to a crime shock, we can say with 90 percent confidence that annual GDP falls by at least half a percentage point, and that this decrease appears to be permanent. On the other hand, for at least 25 percent of the states, we can say with 90 percent confidence that GDP actually rises by a small amount, though we cannot say that it is necessarily

[27] Additionally, we also performed a robustness check by including time dummies for the financial crisis. Specifically, we included dummies for the years 2008 and 2009. We found that the result for one of the impulse responses was affected qualitatively. Specifically, the response of homicides to migration shocks became more mixed. However, for all of the other impulse responses, including the ones that we report and focus on in the paper, the inclusion of the dummies for the financial crisis had only a relatively minor numerical effect on the results.

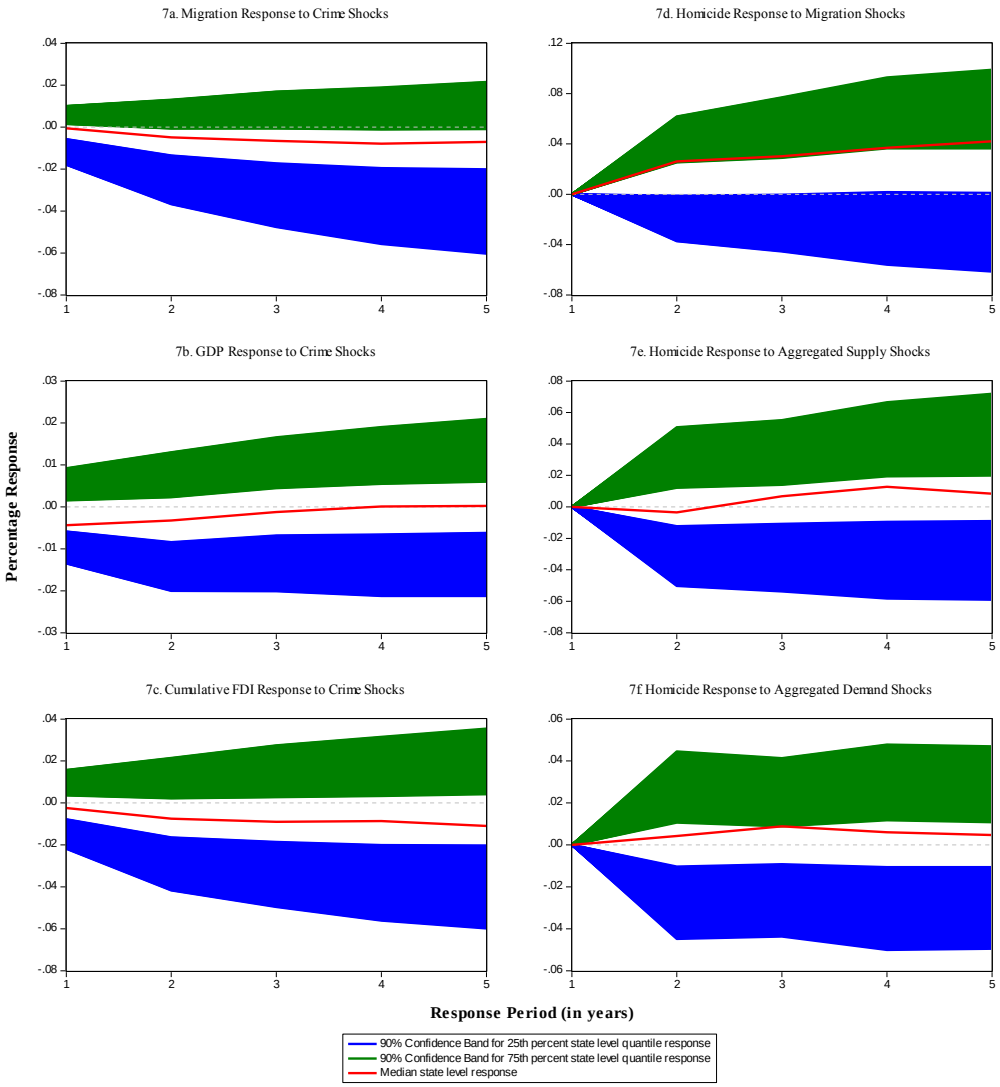
greater than around a fifth of a percent of GDP.[28] Our subsequent second stage analysis investigates for which types of states we can expect the response to be positive versus negative.

First, we discuss the other key impulse responses. For example it is interesting to see that there are other statistically significant spreads in the individual state responses to the various shocks. For example, when we look at Figure 7c, we see that the point estimates for the state median of the cumulative response of FDI to crime shocks is slightly negative as indicated by the red line. The blue band illustrates that there is a 90 percent confidence band that is significantly below zero for at least 25 percent of the states. For these states, by the time of the fifth year following the shock, cumulative FDI has decrease by somewhere between one percent and six percent. At the same time, the green band indicates that for at least 25 percent of the states' FDI actually increases following a crime shock. In the second stage analysis, we investigate which state characteristics are associated with this pattern of responses of FDI to crime shocks.

The prevailing pattern in all of the impulse responses depicted in Figure 7 is that regardless of whether the state median is above or below zero, there is in each case a group of states whose responses are either positive or negative with statistical significance at the 10 percent level or better (i.e., the 90 percent confidence band is entirely above or below the zero line). This is true for the response of migration to crime shocks as well as the response of homicides to each of the structural shocks. This is an important feature of the complexity of the relationship between crime and economic activity in Mexico. The relationship is by no means uniform, and there are differences in the patterns of responses that are statistically significant with a relatively high level of confidence.

[28] By contrast, the median state level responses to typical common shocks originating at the national and international level during the sample period appear to be smaller in magnitude with the most negatively affected quantile of states experiencing around a one-third percent decrease in its per capita GDPs, and the median state experiencing around a one-quarter percent decrease in its per capita GDP. In addition to computing the median state response, we also computed the implied aggregate national GDP response to a similar shock, which comes to roughly one-quarter percent of national GDP for a period of up to two years, decreasing in the third year, and eventually dissipating by the fourth year. It is also useful to bear in mind that the magnitude of the shocks can vary over the sample so that depending on the particular shock realization, the responses will be accordingly scaled up or down. In short, while national and international shocks impact both the state and national economy, it is the aggregation of the state-level responses to state-level crime shocks that has the bigger overall effect on the national economy.

Figure 7. State Level Quantiles Responses to Idiosyncratic Shocks



Next we discuss the second stage analysis in which we look for characteristics of the state that are associated with the heterogeneous responses among the different states. For example, what characteristics of the state are associated with a positive or negative response of log per capita GDP to a crime shock? Similarly, what characteristics of the state are associated with larger or smaller changes in log per capita accumulated FDI in response to a similar crime shock? To investigate this, one might consider computing correlations, or even simple linear regressions between the response estimates for each of the 32 states and measured characteristics of each of the states. However, the problem with this approach is that it treats the impulse responses as raw data and does not adequately account for the uncertainty associated with the fact that state-level impulse responses are themselves estimated. To address this, we instead use a bootstrapped estimator for the regression correlation between the state-specific responses and the measured state characteristics. Specifically, the bootstrapped estimator uses the same bootstrapped sampling distribution that was used to compute the confidence bands for the impulse responses and uses this to resample the regression correlation. Thus, for each of the 5,000 bootstrap draws, we compute 5,000 impulse responses, which we regress 5,000

times on the state characteristic measures. The 5,000 slope estimates give us a sample distribution for the bootstrapped regression correlation estimator. The tails of this distribution give us the 90 percent confidence bands for the regression correlation estimator and allow us to test the significance of the relationship in a way that accounts for the underlying uncertainty associated with the estimated impulse responses.

The state-specific characteristics that we consider are described in section IV and include average schooling years, unemployment rates, bank deposits, marginalization indices, perceptions of public security, government spending on security, and a measure of the importance of economic informality. In addition to these, we also investigate state characteristics associated with the concentration of different economic sectors as a percentage of state GDP, the concentration of the sectors to which FDI flows, as well as the various other crime measurements and migration measurements previously discussed. Whenever we have multiple observations over time for any of these variables for a given state, we use the sample average for that state. Whenever the measures are economic quantities, we use them in log per capita form.

A number of different characteristics appear to be statistically significant under certain scenarios. However, with so many characteristics and so many different impulse response configurations, we must take care not to inadvertently data mine the results. For example, at a five percent significance level, with so many characteristics and responses, we expect some significant responses to appear randomly and spuriously for certain specifications. Instead, we focus here only on the results that appear consistently significant for all of the various specifications. Among these, two stand out as particularly robust. The first is the relationship between the response of GDP to crime shocks and the percentage of GDP devoted to construction.[29] Figure 8a shows a scatterplot for this relationship. Specifically, the vertical axis depicts the percentage of state GDP devoted to construction. On the horizontal axis, we represent the response of log per capita GDP in the second year following the crime shock. Since the crime shock can have differing effects on homicides in different states as evidenced by the impulse responses in Figure 10, we also scaled this response by the magnitude of the first period homicide response to the crime shock. Thus, the horizontal axis can be interpreted as the percentage change in per capita GDP in the second year following a crime shock scaled by the percentage change in homicides caused by the same crime shock in the period in which the shock occurred. The positive association in the scatterplot implies that for states in which construction is more prominent, a crime shock is more likely to have a positive (or less negative) effect on overall state-level GDP.[30][31]

[29] For a detailed description of what economic activities are included in the construction GDP, please see *Sistema de Cuentas Nacionales de Mexico, Cuentas de Corto Plazo y Regionales: Fuentes y Metodologias* (2013a), page 219. Construction GDP includes classifications from number 2361 to number 2389.

[30] Various reports produced by the FATF and GAFISUD have made references to the possibility that the real estate sector may be one of the many vehicles used by criminal organizations to launder money. Emerging markets seem to be more vulnerable to misuse of the real estate sector. The worldwide market growth of real estate-backed securities and the development of property investment funds have meant that the range of options for real estate investments has also grown. Emerging markets in particular can offer attractive returns at low prices with considerable room for growth. See FATF (2007) and GAFISUD (2010, 2012), FATF-GAFI (2008, 2014) and Unger (2006). As described in FATF-GAFI (2008, p. 316-318), "No AML/CFT regulations and supervisory framework exist for any category of Designated Non-Financial Business Professions (DNFBPs)except trust services which are designated financial institutions." In Mexico, applicable DNFBPs include real estate agents, dealers in precious metals and stones, lawyers, (continued…)

The bootstrap estimator for this relationship indicates that the bootstrapped median estimator for the slope is 1.091 for the GDP-1 based VAR and 0.924 for the GDP-2 based VAR. The bootstrapped ninety-fifth percentile value for the GDP-1 based VAR is 2.065, and the fifth percentile value for the same is 0.112. Thus, very conservatively, taking into account all of the uncertainty associated with first stage VAR analysis, we can say that we have greater than 90 percent confidence that the relationship is positive and statistically significant. The values for the GDP-2 based VAR are similar, though with not quite as tight a confidence band, with the ninety-fifth percentile value at 1.944 and only the tenth percentile value in the positive range, also at 0.112.

The other state characteristic that stands out as robustly significant in many different scenarios is the sense of public security measure, and in particular in regard to the responsiveness of FDI to crime shocks. Accordingly, in Figure 8b, we present a scatterplot of the relationship between the second period response of FDI to a crime shock, again scaled by the effect that the crime shock has on homicides, and the corresponding measure of the sense of public security in the state. Here the positive association implies that the greater the sense of security, the more likely the per capita accumulated FDI response is to be less negative to a crime shock. Conversely, the higher the sense of insecurity, the more likely it is that a crime shock will induce a larger cumulative decrease in FDI.

The bootstrapped median estimator for the slope is 0.006 for the GDP-1 based VAR and 0.005 for the GDP-2 based VAR. The bootstrapped ninety-fifth percentile values for the two are both 0.01, and the fifth bootstrapped fifth percentile values are 0.002 and 0.001 respectively. Thus, in both cases we can say conservatively that, after taking into account all of the uncertainty associated with first stage VAR analysis, we are 90 percent confident in both cases that the relationship is statistically significant and positive.

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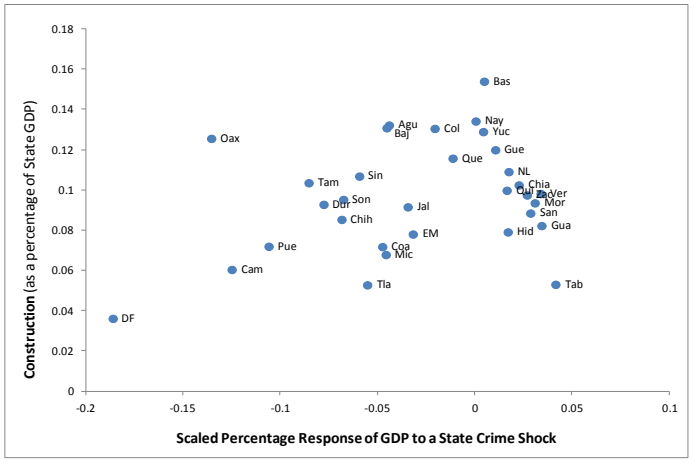
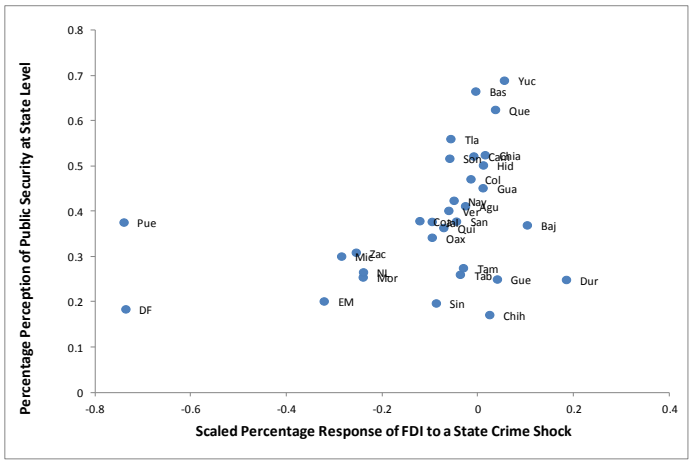
notaries, and other independent legal professionals and accountants, and company services providers. FATF-GAFI (2008, footnote p.9). In this context, at the end of 2012, on the basis of the Bill for a Federal Law for the Prevention and Identification of Transactions with Criminal Proceeds, Mexico forbade cash payments of more than a half million pesos ($38,750) for real estate transactions.

[31] As a robustness check, we examined whether the inclusion of dummies for the states with major international seaports or with borders to the U.S. made a difference for our second stage analysis associated with Figure 8. For the relationship between the GDP response to crime shocks and the prevalence of construction, the relationship became slightly more significant with the inclusion of the dummies (the raw unbootrstapped t-statistic went from 1.837 to 1.891). For the relationship between the FDI response to crime shocks and the sense of public security, the relationship was virtually unchanged (the raw unbootstrapped t-statistic went from 2.096 to 2.094).

Figure 8. Mexico: Response Patterns





Source: INEGI, Mexico's Secretary of Economy, ENSI, ENVIPE, and authors' calculations

VI. SUMMARY AND CONCLUSIONS

In this paper we have used a panel structural VAR approach to study the dynamic relationship between crime and economic activity, including FDI flows and international migration flows at the state level in Mexico from 1993–2012. We find that these relationships are both highly inter-related and also potentially very diverse among the different states of Mexico. On the whole, crime is shown to be a relevant factor of the economies of many of the states and to have an impact on the overall economic activity at the state level. However, we find that the relationships between crime and economic activity at the state level are not as simple as one might have thought, and are instead fairly nuanced.

In general, the overall picture that emerges from our analysis is that crime has been intertwined with other forms of economic activity in the states of Mexico from 1993-2012, including international factor flows. However, the relationships are complex and by no means uniform across the country. As with any important feature of an economy, a better understanding of the relationships at the aggregate economic level would be useful for the purposes of strengthening the policy response to crime and increasing potential economic growth.

In particular, the economic responses to crime are quite different among the states, as is the relative importance of crime for the economies of the various states of Mexico, with different quantiles of states experiencing different variations in GDP, FDI, and migration flows in response to crime shocks. To reiterate some of our quantitative results, we find that for the median state, a typical state-specific crime shock induces a roughly one-half percent temporary decrease in per capita GDP which persists up to two years after the shock before gradually dissipating after the third year. However, the median state responses obscure the fact that for some states the magnitude of the response is much greater. For example, for the most negatively affected quantile of states, we can say with 90 percent confidence that a typical crime shock induces at least one-half percent decrease in GDP that is permanent and does not dissipate. Furthermore, we find that the factor flow dynamics associated with these crime shocks, for both international migration and FDI, are by no means uniform across states, with a substantial number of states experiences factor flows in opposing directions.

Consistent with other findings in the literature, our study also shows that the percentage of GDP devoted to construction in a particular state is associated with the size and magnitude of the economic response to crime, as is also the overall sense of public security at the state level as measured by survey data. Finally, it is worth noting that our sample covers the period from 1993 through 2012, and therein does not account for the reforms that have occurred in the period since then. Furthermore, our analysis is primarily intended to focus on the state level.

A few of the policy relevant implications of our analysis are fairly straightforward. For example, one of the more robust findings in our second stage analysis of the patterns of responses among the states to crime shocks is that the overall sense of security on the part of the public as reflected in survey responses appears to be important. Systematically, when the sense of security is higher, the impact of an equal-sized crime shock has a less negative impact on overall economic activity at the state level and in particular on FDI flows. This points to the potential importance of the perception and public confidence in the quality of institutions which provide for public security. Mexico has already put forward an ambitious structural reform agenda, including initiatives improving the rule of law. Judicial reform at the federal level in Mexico was approved by Congress in 2008, and it is expected that this reform will be in place in all states by 2016. It will be interesting to see whether these judicial reforms contribute to an improvement in the sense of overall security and therein help to mitigate the impact of crime on overall economic activity at the state level.

Finally, in light of the economic aspect of crime and the degree to which we have shown how crime and economic activities have been interwined at the state level, both in response to local idiosyncratic as well as national and international common shocks, it will be interesting to see the extent to which current efforts toward a further strengthening of the AML/CFT regime, particularly in areas of high ML/TF related risks, might also help to further improve future potential economic growth prospects for Mexico.

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VIII. TECHNICAL APPENDIX FOR THE CHAIN LINKING OF TWO REAL GDP SERIES IN DIFFERENT BASE YEARS

Mexico has rebased the real GDP at the national and state levels in 1993, 2003, and 2008. In addition, Mexico has implemented new national accounts methodology in 2008. To compare the real GDPs with different bases and different accounting systems, we first need to chain link them.[32] Mexico has real and nominal data, implicit prices and volumes for GDP sectors, and totals for years 1993–2006 using the 1993 base year and 1993 accounting system [33] for all the Mexican states. It also has the same data for years 2003–2012 using the 2008 base year and the 2008 accounting system for all the states. Although the 2008 accounting system contains more subsectors than the 1993 accounting system, both accounting systems have three sectors in common: primarias (Sector 1), secundarias (Sector 2), and terciarias (Sector 3). Note that 2003-2006 are the overlapping years for both base years and both accounting systems.

Real GDP Estimate by Estimating Sectors[34]

For t=1993,...,2006, let $Q_{93}^{i}(t)$ be the real value of sector *i* at year *t for each Mexican State*, using the 1993 accounting system and the base year 1993. Also let $P_{93}^{i}(t)$ be the implicit price of sector *i* at year *t*, using base year 1993 and the 1993 accounting system. Note that $P_{93}^{i}(1993) = 100$ for all sectors *i* since the base year is 1993.

Note that $Q_{93}^{i}(t)$ is the *i*-th sector component of the real GDP:

$$\text{RGDP}_{93}^{(1993)}(t) = \sum_{i=1}^{3} Q_{93}^{i}(t), \quad t=1993,...,2006,$$

where the superscript denotes the 1993 accounting system and the subscript denotes the base year. No sectorial price appears in the above formula.

Now the nominal GDP using the 1993 accounting system and base year 1993 is

$$\text{NGDP}_{93}^{(1993)}(t) = \frac{1}{100} \sum_{i=1}^{3} Q_{93}^{i}(t) P_{93}^{i}(t), \quad t=1993,...,2006.$$

[32] Actually, there are three base years for Mexican national accounts, 1993, 2003, and 2008. However, base year 2003 and 2008 are comparable according to the authorities.

[33] (S INEGI BIB(2014)) SNM(2006, 2000))

[34] See approach followed by McLennan (1998) for chaining GDP series.

In this expression, $Q_{93}^{i}(t)P_{93}^{i}(t)/100$ is the *i*-th sector component in the NGDP and $P_{93}^{i}(t)/100$ is the *i*-th sector's relative price at year *t* with respect to that in year 1993. In a sense, the above equation relates sectoral RGDP to the aggregated NGDP: $Q_{93}^{i}(t)$ acts as quantity in calculating the aggregated volume NGDP and the relative price $P_{93}^{i}(t)/100$ as the corresponding price (ABS(1998, page 7)).

Let us re-base the 1993-base NGDP to the 2003-base NGDP, using the same accounting system. We will use similar notations. As usual, $P_{03}^{i}(2003)=100$. Thus $P_{03}^{i}(t)=\dfrac{100P_{93}^{i}(t)}{P_{93}^{i}(2003)}$ for *t=1993,1994 ,..., 2006*. Applying the Laspeyres method (ABS(1998, page 8)), the 2003-based NGDP for years 1993–2006 in the 1993 accounting system are

(1) $$\text{NGDP}_{03}^{(1993)}(t)=\frac{1}{100}\sum_{i=1}^{3}Q_{93}^{i}(t)P_{03}^{i}(t)=\sum_{i=1}^{3}Q_{93}^{i}(t)\frac{P_{93}^{i}(t)}{P_{93}^{i}(2003)},\quad t=1993,...,2006.$$

The change in the rebasing is: replacing the relative price at year *t* over 1993 with the relative price at year *t* over 2003. The quantities remain the same when rebasing NGDP under the same accounting system.

Again, let us re-base the 2008-based NGDP to the 2003-based NGDP for each state, using the same 2008 accounting system. The formula is

(2) $$\text{NGDP}_{03}^{(2008)}(t)=\frac{1}{100}\sum_{i=1}^{3}Q_{08}^{i}(t)P_{03}^{i}(t)=\sum_{i=1}^{3}Q_{08}^{i}(t)\frac{P_{08}^{i}(t)}{P_{08}^{i}(2003)},\quad t=2003,\ldots,2012$$

We want to extend $\text{NGDP}_{03}^{(2008)}(t)$ to the years *t=2002,2001,...,1993*. At this moment, we only use the data in the single common year 2003 to bridge the two accounting systems.

Let *t=2003* in both (1) and (2):

$$\text{NGDP}_{03}^{(1993)}(2003)=\sum_{i=1}^{3}Q_{93}^{i}(2003)$$

$$\text{NGDP}_{03}^{(2008)}(2003)=\sum_{i=1}^{3}Q_{08}^{i}(2003)=\sum_{i=1}^{3}\frac{Q_{08}^{i}(2003)}{Q_{93}^{i}(2003)}*Q_{93}^{i}(2003)$$

Define $R_i=\dfrac{Q_{08}^{i}(2003)}{Q_{93}^{i}(2003)}$. From the above comparison, a natural extension of $\text{NGDP}_{03}^{(2008)}(t)$ to the years 1993–2002 is

$$\text{NGDP}_{03}^{(2008)}(t)=\frac{1}{100}\sum_{i=1}^{3}R_iQ_{93}^{i}(t)P_{03}^{i}(t),\quad t=1993,\ldots,2002$$

Similarly to that in deriving (1), after re-basing from base year 2003 to base year 2008 under the same 2008 accounting system, we have the NGDP using the 2008 base year and the 2008 account system,

$$\mathrm{NGDP}_{08}^{(2008)}(t)=\frac{1}{100}\sum_{i=1}^{3}R_iQ_{93}^{i}(t)P_{08}^{i}(t),\quad t=1993,\ldots,2002$$

and finally the real GDP with the 2008 base year and the 2008 accounting system is

$$\mathrm{RGDP}_{08}^{(2008,1)}(t)=\sum_{i=1}^{3}R_iQ_{93}^{i}(t),\quad t=1993,\ldots,2003. \tag{3}$$

As we have four common years 2003–2006 in the two accounting systems, we can average the ratios of real sectorial values and define

$$\overline{R}_i=\frac{1}{4}\left(\frac{Q_{08}^{i}(2003)}{Q_{93}^{i}(2003)}+\frac{Q_{08}^{i}(2004)}{Q_{93}^{i}(2004)}+\frac{Q_{08}^{i}(2005)}{Q_{93}^{i}(2005)}+\frac{Q_{08}^{i}(2006)}{Q_{93}^{i}(2006)}\right) \tag{4}$$

Using the average ratios, the real GDP with 2008 base and 2008 accounting system is

$$RGDP_{08}^{(2008,2)}(t)=\sum_{i=1}^{3}\overline{R}_iQ_{93}^{i}(t),\quad \mathrm{t}=1993,\ldots,2002. \tag{5}$$

Thus, we have all RGDP data in the same 2008 base year and same 2008 accounting system.

Real GDP Estimates by Scaling of Aggregated Volumes

Without knowing the sectorial data, one may mimic the derivation of (3) using the aggregated RGDP. In this simplified version, we let $R^{(03)} = \dfrac{RGDP_{08}^{(2008)}(2003)}{RGDP_{93}^{(1993)}(2003)}$. Then (3) becomes

$$RGDP_{08}^{(2008,3)}(t) = R^{(03)} * RGDP_{93}^{(1993)}(t), \qquad t = 1993,\ldots,2002. \tag{6}$$

Again, to mimic (4), we define

$$\overline{R}^{(03-06)} = \frac{1}{4}\left(\frac{RGDP_{08}^{(2008)}(2003)}{RGDP_{93}^{(1993)}(2003)} + \frac{RGDP_{08}^{(2008)}(2004)}{RGDP_{93}^{(1993)}(2004)} + \frac{RGDP_{08}^{(2008)}(2005)}{RGDP_{93}^{(1993)}(2005)} + \frac{RGDP_{08}^{(2008)}(2006)}{RGDP_{93}^{(1993)}(2006)} \right)$$

And the corresponding of RGDP estimate is

$$RGDP_{08}^{(2008,4)}(t) = \overline{R}^{(03-06)} * RGDP_{93}^{(1993)}(t), \qquad t = 1993,...,2002. \tag{7}$$

Real GDP Estimates by Gradually Adjusted Ratios

Essentially, in the above scenarios (3),(5),(6), and (7), the scaling ratios are constant over time either in sectors in (3) and (5) or constant in the aggregated values in (6) and (7). This can mitigate (Correa et al (2002)).

Ignoring the accounting system changes, let us consider the ratio of RGDP of 2003 in two base years $D_{03} = \dfrac{RGDP_{08}(2003)}{RGDP_{93}(2003)}$ and assume that the ratio was the result of a geometric developed process over 10 years from 1993 to 2003. Then each year's rebasing ratio is $D^{1/10}$ and thus for years t=1993,1994,…,2002, the 2008-based RGDP has the estimation

$$RGDP_{08}^{(2008,5)}(t) = D_{03}^{(t-1993)/10} * RGDP_{93}^{(1993)}(t), \qquad t = 1993,...,2002. \tag{8}$$

If we capitalize on all four common years, (8) becomes

$$RGDP_{08}^{(2008,6)}(t) = \frac{D_{03}^{(t-1993)/10} + D_{04}^{(t-1993)/11} + D_{05}^{(t-1993)/12} + D_{06}^{(t-1993)/13}}{4} * RGDP_{93}^{(1993)}(t) \tag{9}$$

where $D_{04} = \dfrac{RGDP_{08}(2004)}{RGDP_{93}(2004)}, D_{05} = \dfrac{RGDP_{08}(2005)}{RGDP_{93}(2005)},$ and $D_{06} = \dfrac{RGDP_{08}(2006)}{RGDP_{93}(2006)}.$

To account for the GDP accounting changes, we use a log linear function to fit the ratios D_t as $\log D_t = c + \delta t + \varepsilon_t$ in which the constant *c* cares for the accounting change effects. We can use the ratios D_t at t=2003, 2004, 2005, and 2006 to estimate the coefficients $\hat{c}$ and $\hat{\delta}$. Then let $\hat{D}_t$ such that $\log \hat{D}_t = \hat{c} + \hat{\delta} t$ for t=1993,…, 2002. Finally, the formula which combines the accounting change and the geometrically rebasing is

$$RGDP_{08}^{(2008\$)}(t) = \hat{D}_t * RGDP_{93}^{(1993\$)}(t), \quad t = 1993,...,2002. \tag{10}$$

Robustness checks

In generating the reported empirical results, we have used two sets of linked real GDP series. The so-called GDP Approach 1 is linked by the formula (6) and the GDP Approach 2 series is linked by the formula (5). However, our experiment with other scenarios shows that our results are quite robust, regardless of the choice of approach to link the GDP series.

To test the robustness of our findings, we have also used all the above real aggregated GDP approaches for each Mexican state in (3), (5)–(9) Our results are very similar under these different scenarios. Please see plots of different approaches for linking two real GDP series for Mexican states in Figure 9.

Figure 9. Approaches for Linking Real GDP Series for Mexican States

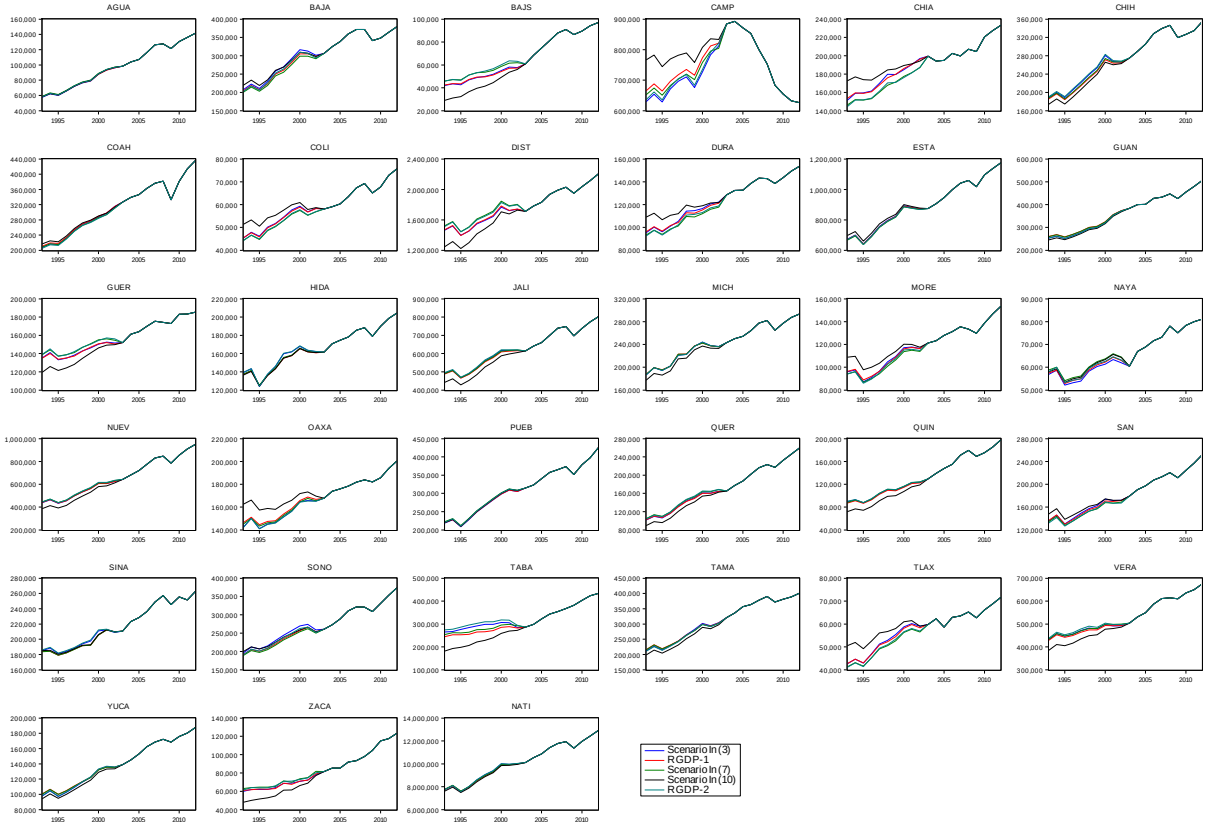

Table 1. GDP Sectors for years 1993 and 2008

Sectors in the 1993 Accounting System	Sectors in the 2008 Accounting System
Actividades Primarias	**Actividades Primarias**
GRAN DIVISIÓN 1: AGROPECUARIA, SILVICULTURA Y PESCA	11 Agricultura, ganadería, aprovechamiento forestal, pesca y caza
Actividades Secundarias	**Actividades Secundarias**
GRAN DIVISIÓN 2: MINERÍA	21 Minería
GRAN DIVISIÓN 5: ELECTRICIDAD, GAS Y AGUA	22 Electricidad, agua y suministro de gas por ductos al consumidor final
GRAN DIVISIÓN 4: CONSTRUCCIÓN	23 Construcción
GRAN DIVISIÓN 3: INDUSTRIA MANUFACTURERA	31-33 Industrias manufactureras
DIVISIÓN INDUSTRIAL I: PRODUCTOS ALIMENTICIOS, BEBIDAS Y TABACO	311 Industria alimentaria
DIVISIÓN INDUSTRIAL II: TEXTILES, PRENDAS DE VESTIR E INDUSTRIA DEL CUERO	312 Industria de las bebidas y del tabaco
DIVISIÓN INDUSTRIAL III: INDUSTRIA DE LA MADERA Y PRODUCTOS DE MADERA	313 Fabricación de insumos textiles
DIVISIÓN INDUSTRIAL IV: PAPEL, PRODUCTOS DE PAPEL, IMPRENTAS Y EDITORIALES	314 Confección de productos textiles, excepto prendas de vestir
DIVISIÓN INDUSTRIAL V: SUSTANCIAS QUÍMICAS, DERIVADOS DEL PETRÓLEO, PRODUCTOS DE CAUCHO Y PLÁSTICO	315 Fabricación de prendas de vestir
DIVISIÓN INDUSTRIAL VI: PRODUCTOS DE MINERALES NO METÁLICOS, EXCEPTUANDO DERIVADOS DEL PETRÓLEO Y CARB	316 Fabricación de productos de cuero, piel y materiales sucedáneos, excepto prendas de vestir
DIVISIÓN INDUSTRIAL VII: INDUSTRIAS METÁLICAS BÁSICAS	321 Industria de la madera
DIVISIÓN INDUSTRIAL VIII: PRODUCTOS METÁLICOS, MAQUINARIA Y EQUIPO	322 Industria del papel
DIVISIÓN INDUSTRIAL IX: OTRAS INDUSTRIAS MANUFACTURERAS	323 Impresión e industrias conexas
	324 Fabricación de productos derivados del petróleo y del carbón
	325 Industria química
	326 Industria del plástico y del hule
	327 Fabricación de productos a base de minerales no metálicos
	331 Industrias metálicas básicas
	332 Fabricación de productos metálicos
	333 Fabricación de maquinaria y equipo
	334 Fabricación de equipo de computación, comunicación, medición y de otros equipos, componentes y accesorios electrónicos
	335 Fabricación de equipo de generación eléctrica y aparatos y accesorios eléctricos
	336 Fabricación de equipo de transporte
	337 Fabricación de muebles y productos relacionados
	339 Otras industrias manufactureras
Actividades Terciarias	**Actividades Terciarias**
GRAN DIVISIÓN 6: COMERCIO, RESTAURANTES Y HOTELES	43-46 Comercio
GRAN DIVISIÓN 7: TRANSPORTE, ALMACENAJE Y COMUNICACIONES	48-49 Transportes, correos y almacenamiento
GRAN DIVISIÓN 8: SERVICIOS FINANCIEROS, SEGUROS, ACTIVIDADES INMOBILIARIAS Y DE ALQUILER	51 Información en medios masivos
GRAN DIVISIÓN 9: SERVICIOS COMUNALES, SOCIALES Y PERSONALES	52 Servicios financieros y de seguros
SERVICIOS BANCARIOS IMPUTADOS	53 Servicios inmobiliarios y de alquiler de bienes muebles eintangibles
	54 Servicios profesionales, científicos y técnicos
	55 Dirección de corporativos y empresas
	56 Servicios de apoyo a los negocios y manejo de desechos yservicios de remediación
	61 Servicios educativos
	62 Servicios de salud y de asistencia social
	71 Servicios de esparcimiento culturales y deportivos, yotros servicios recreativos
	72 Servicios de alojamiento temporal y de preparación de alimentos y bebidas
	81 Otros servicios excepto actividades del Gobierno
	93 Actividades del Gobierno y de organismos internacionales yextraterritoriales

Source: INEGI 2013b and 2013c

Figure 10. State Level Quantiles for Impulse Responses to Idiosyncratic and Common Shocks (Four variable system, 1993-2012, GDP approach 2)

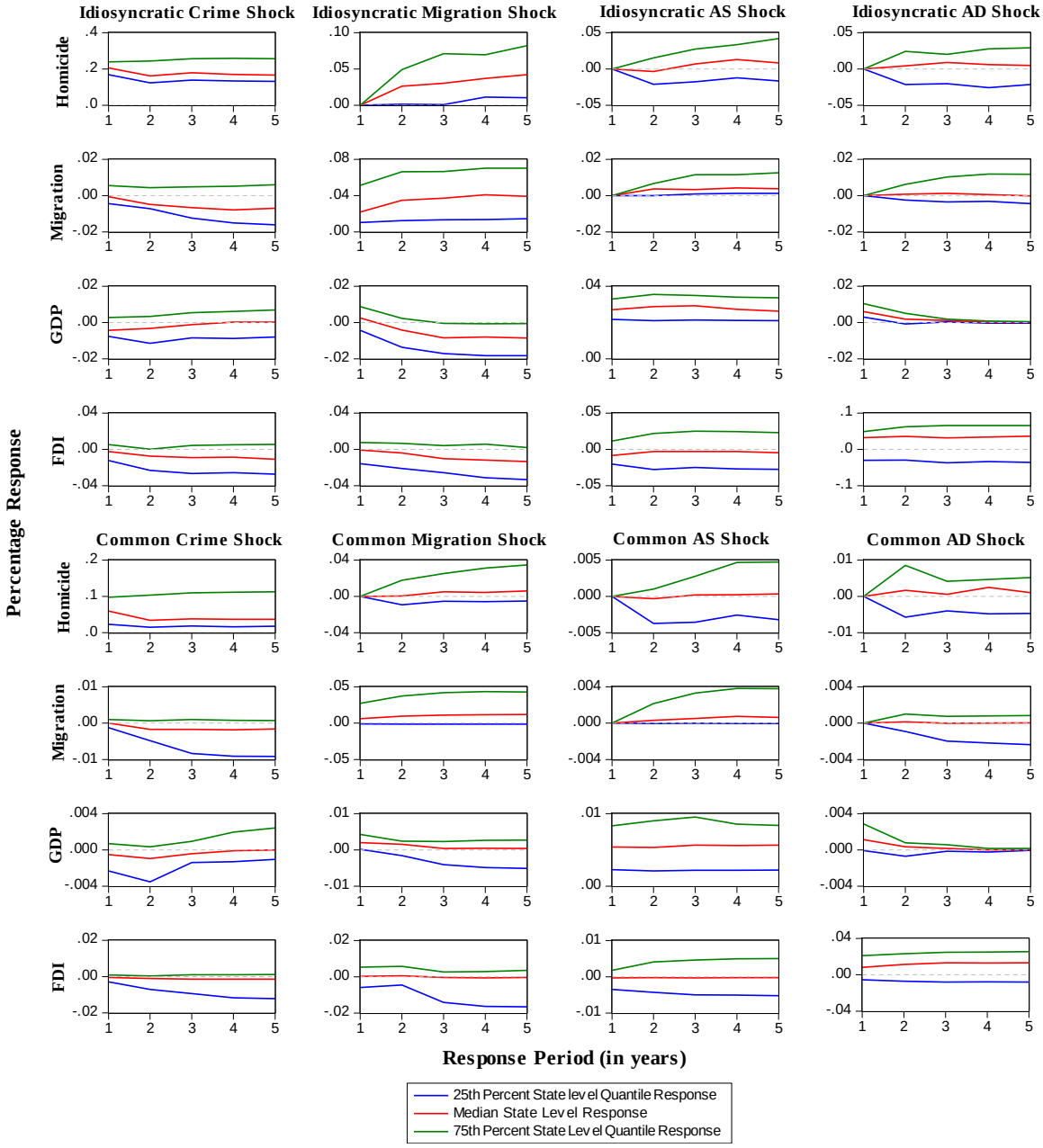

Figure 11. State Level Quantiles for Variance Decompositions for Idiosyncratic and Common Shocks (Four variable system, 1993-2012, GDP approach 2)

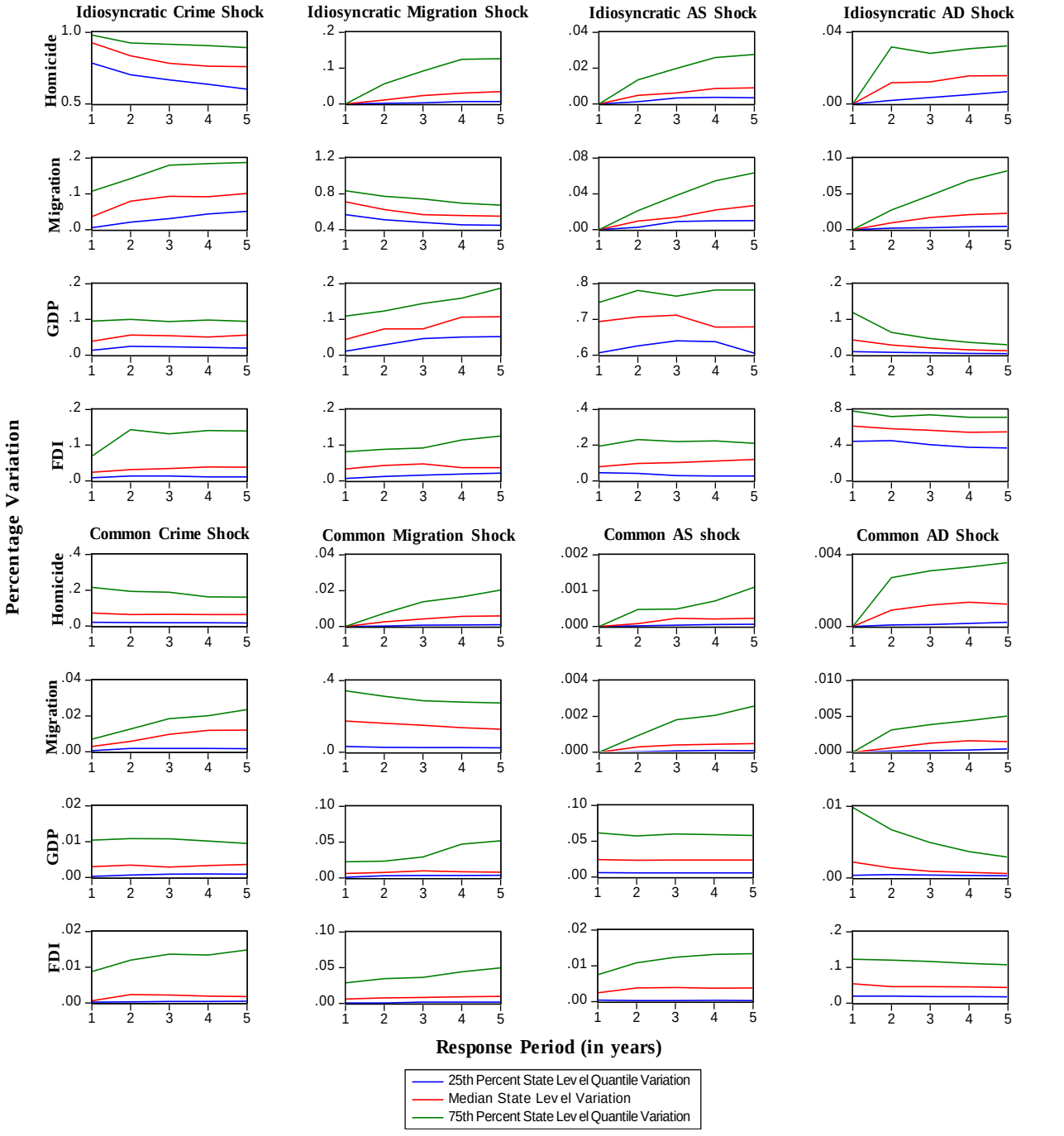

Table 2. Names of Mexican States

State Name	Abbreviation
Aguascalientes	Agu
Baja California	Baj
Baja California Sur	Bas
Campeche	Cam
Chiapas	Chia
Chihuahua	Chih
Coahuila	Coa
Colima	Col
Distrito Federal	DF
Durango	Dur
Estado de México	EM
Guanajuato	Gua
Guerrero	Gue
Hidalgo	Hid
Jalisco	Jal
Michoacán	Mic
Morelos	Mor
Nayarit	Nay
Nuevo León	NL
Oaxaca	Oax
Puebla	Pue
Querétaro	Que
Quintana Roo	Qui
San Luis Potosí	San
Sinaloa	Sin
Sonora	Son
Tabasco	Tab
Tamaulipas	Tam
Tlaxcala	Tla
Veracruz	Ver
Yucatán	Yuc
Zacatecas	Zac
National	Nat

Table 3. Data Sources

Variables	Range	Source
Aggregated Real GDP		
Base year=1993	1993-2006	INEGI
Base year=2008	2003-2012	INEGI
Rebasing to base=2008	1993-2012	See Appendix
Homicide Rate		
Intentional homicide incidences by death	1993-2012	INEGI
homicide statistics by law enforcement	1997-2012	SESNSP
Foreign Direct Investment (FDI)		
Aggregated nominal FDI (in US$)	1999-2012	Secretaria de Economia (2014)
US CPI	1993-2012	FRED database
Population and Migration		
Population observation and estimation	1990-2010	CONAPO
Population forecast	2011-2030	CONAPO
International Net In-migration	2003-2012	CONAPO

Schooling	1990, 1995, 2000, 2005, 2006, 2008-2011	INEGI
Unemployment	2003-2012	INEGI
Marginalization	1990, 1995, 2000, 2005, 2010	CONAPO
Government spending	Mora (2009)	
Bank Deposits	2000-2010	National Banking and Securities Commission of Mexico
Informality	2005,2007,2009-2011	INEGI and Ministry of Labour and Social Welfare
Perception of public security	2005, 2009, 2010, 2011, 2012	ENSI and ENVIPE
Disaggregated Real FDI by Sectors	1999-2012	Secretaria de Economia (2014)
Disaggegatd Real GDP by Sectors	2003-2012	INEGI (2014)
SESNSP		
Crimes against Health		SESNSP/CONAPO
Federal Law against Organized Crime		SESNSP/CONAPO
Agravated Assault (Violent Crime)		SESNSP/CONAPO
Robbery (Violent Crime)		SESNSP/CONAPO
Extorsion		SESNSP/CONAPO
Kidnapping		SESNSP/CONAPO

Notes: Most data is used in log per capita form. For the first stage VAR estimation, Homicides, GDP and Net In-migration were used in log per capita growth rates, and the subsequent impulse responses were accumulated. These transformations are discussed in the text of the paper.