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There Will Be Blood: Crime Rates in Shale-Rich U.S. Counties

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Abstract

Over the past decade, the production of shale oil and gas significantly increased in the United States. This paper uniquely examines how this energy boom has affected regional crime rates throughout the United States. There is evidence that, as a result of the ongoing shale-energy boom, shale-rich counties experienced faster growth in rates of both property and violent crimes including rape, assault, murder, robbery, burglary, larceny and grand-theft auto. These results are particularly robust for rates of assault, and less so for other types of crimes. Examining the migratory behavior of convicted sex offenders indicates that boomtowns disproportionately attract convicted felons. Policy makers should anticipate these effects and invest in public infrastructure accordingly.

Keywords: Natural Resources; Hydraulic Fracturing; Crime; Resource Curse.

JEL Classification: Q3; R11; K42;

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1 Introduction

In the early 2000's, the exploration and production of oil and gas sharply increased in the United States. While some of the increased production was arguably due to high oil and gas prices, it is largely due to advancements in horizontal drilling and hydraulic fracturing technology that have made the extraction of shale gas and tight oil deposits economically feasible. From 2000 to 2011, U.S. tight oil production increased from 94 to 507 million barrels of oil, a 440% increase. Production of shale gas has followed a similar trend. From 2000 to 2011, production of shale gas increased from .30 to 7.94 trillion cubic feet, a 2,500% increase (U.S. Energy Information Administration).

The direct economic effects of resource booms and the shale boom in particular have been studied in the existing literature (see for example Black, McKinnish and Sanders, 2005; Weber, 2012; Alcott and Keniston, 2014). Generally, this literature finds that resource booms attract labor, decrease unemployment rates and inflate local wages. However, much less attention has been given to the economic and social externalities associated with resource booms. This paper considers one such externality: crime.

This is a timely question to consider as recent publications in popular media outlets have raised concerns that regional resource booms in places like North Dakota and Montana have fueled epidemics of crime. In a New York Times article titled "An Oil Town Where Men are Many and Women Are Hounded" John Eligon writes:

> *Jessica Brightbill, a single 24-year old who moved here [Williston, North Dakota] from Grand Rapids, Mich., a year and a half ago, said she was walking to work at 3:30 in the afternoon when a car with two men suddenly pulled up behind her. One hopped out and grabbed her by her arms and began dragging her. She let her body go limp so she would be harder to drag. Eventually, a man in a truck pulled up and began yelling at the men and she got away, she said. The episode left her rattled.*

Such news stories are not rare. Writing for CNN Money, Blake Ellis describes the apparent influx in criminal activity in Williston, North Dakota. He writes that "In a single month this summer [2011], the [police] department received 1,000 calls—compared to the 4,000 calls it received in the three-year period between 2007 and 2009." While the majority of such articles are written about the experience of North Dakota, similar articles have been written about current boom towns in, for example, Montana (Healy, 2013), Pennsylvania (Levy, 2014) and New Mexico (Clausing, 2014). There is a lack of consensus among policy makers though, that energy booms attract or produce criminal activity. Responding to such concerns, Brad Gill, the executive director of the Independent Oil and Gas Association of New York says "We've found that the anti-natural gas folks will say just about anything to further their cause." He goes on to say that "We think that local governments are well equipped to deal with the benefits and challenges that will arise out of increased natural gas development" (Engquist, 2013). Similarly, while the North Dakota State Attorney General, Wayne Stenehjem, acknowledges that crime has recently increased in North Dakota, he argues that there has been a proportional increase in population such that crime rates have not changed (Michale, 2011).

Comprehensive and systematic studies documenting the relationship between a booming resource sector and criminal activity are surprisingly scant. To the best of our knowledge, the existing relevant literature is limited to case studies or regional examinations. There is little unconditional evidence that resource booms led to higher rates of crime in North Dakota (Putz *et al.*, 2011)[1] and Louisiana (Luthra, 2006), though, some evidence that the recent gas boom has created crime in Sublette, Wyoming (Ecosystem Research Group, 2009). A report by the Pennsylvania State University Justice Center for Research finds no evidence that the recent increase in shale gas extraction in Pennsylvania has lead to increased crime rates. Though, the authors of this study note that "...it is difficult to detect strong trends within such a short time period [e.g., 2006-2010] and any observed changes may be due to

[1]The report by Putz *et al.* describes crime rates in so-called "oil" counties in North Dakota from 1980 to 2005. Though, as can be seen in Figure 3, the oil boom in the Bakken started post 2005.

natural variation" (Kowalski and Zajac, 2012). Earlier research examining the criminal impact of the oil price boom of the late 1970's offers a mixed bag of evidence as well. Brookshire and D'Arge (1980) examine how the booming resource industry in Rock Springs Wyoming in the early 1970's affected the quality of ecosystem services (hunting and related recreational activities) and the level of criminal activity. Constraining the control group of cities to minimize unobserved heterogeneity, they find little to no evidence that the resource boom elevated total crime rates in Rock Springs. Freudenburg and Jones (1991) offer a nice review of some of this earlier literature. They conclude that while existing case studies largely support the idea that population growth leads to a more than proportional increase in crime, county-level studies offer inconclusive evidence. Wilkinson *et al.* (1984), for example, found no significant effect of population growth on violent crime rates in 197 non-metropolitan counties in Arizona, Colorado, Utah, Wyoming, New Mexico and Montana. They did however find that energy development projects significantly affected violent crime rates. Freudenburg and Jones conclude by saying that "As is almost always the case, further research would be desirable, although the feasibility of some of the desired research may remain quite low until the next time a dramatic surge in commodity prices leads to the creation of new boomtowns."

Using data from all U.S. counties across 12 years (2000 to 2011) this paper uniquely examines how the recent shale-energy boom has affected regional crime rates. We find some evidence that shale-rich U.S. counties experienced more rapid growth in rates of forcible rape, aggravated assault, robbery, larceny and murder. With the exception of assault, these results are only moderately robust. For assaults, we find statistically and economically significant results across a variety of model specifications. Examining the migratory behavior of convicted sex offenders indicates that boomtowns heterogeneously attract labor of a criminal type. While shale-rich North Dakota counties have a large and disproportionate number of sex offenders living in them, the majority of these offenders were registered offenders prior to moving to North Dakota. This paper offers policy implications for optimal resource management in the

U.S. Local policy makers should anticipate a surge in crime, especially violent crime, at the beginning of a resource boom. To the extent that crime may be averted through adaptation and learning, such as locking ones doors and walking in pairs late at night, an information campaign warning the public of elevated levels of risk may be a fruitful crime-fighting strategy. One speculative interpretation of the results is that a resource boom—via induced criminal behavior and subsequent heterogeneous labor migration—may facilitate a drain of human and physical capital and could propagate a long-term resource curse.

2 Theoretical Motivation

There is of course a large economic and sociological literature that examines the causes of both violent and property crimes. The seminal work of Gary Becker (1968) treats criminals as rational economic agents that weigh the benefit of committing a crime against the expected cost—the product of the probability of being caught and the associated punishment. It follows that increasing the probability of being caught and increasing the resulting punishment may effectively reduce crime rates. The corresponding empirical literature largely supports this theory. For example, there is evidence that increasing the number of police officers per person decreases crime rates (Marvell and Moody, 1996; Levitt 2004; Di Tella and Schargrodsky, 2004). This provides a clue as to why boom towns may experience elevated levels of criminal activity. A booming resource sector inflates local wages and is likely to attract labor to both the resource and the non-traded (service) industries from other economies. In the absence of a proportional increase in police officers, this reduces the number of police per capita and thus increases the probably of getting away with a crime. According to this theory, there need not be anything peculiar or especially criminal about the migrants that move to a boom town, a sudden increase in population alone is enough to fuel illegal activity.

It is also possible that the types of people that are attracted to boom towns may be particularly prone to illegal behavior. Oil and gas drilling jobs are physically demanding and are especially attractive to young men. Indeed, while 20-29 year-olds accounted for 35% of the crimes in 2011, they represented only 14% of the U.S. population. Similarly, while roughly half of the population is female, males accounted for 74% of the crimes committed in the U.S. in 2011. Table 1 describes some of this data in more detail.[2] Males account for a large majority of all types of crimes with the exception of Larceny-theft, for which they have only a slight majority (56%). Note that for violent crimes including murder, forcible rape and robbery, males account for close to or above 90% of all crimes. While roughly equal proportions of the U.S. population was aged 20-29 and 50-59 in 2011, many more crimes were committed by the younger group. For example, while less than 6% of murders were committed by people aged 50-59, 43% of murders were committed by those aged 20-29. Similar relationships hold for other types of crime as well, including rape, assault, robbery, burglary and theft. Illegal activity that results from the demographic shift in boom towns may be aggravated by the sudden income gains associated with resource booms as young and single men suddenly have the financial means to use and abuse illicit substances and alcohol. Such concerns can be further compounded by the unusual work schedules that often exist in the energy industry, e.g., 14 days on and 7 long and boring days off (Carrington, Hogg and McIntosh, 2011).

Beyond criminal activity resulting directly from the demographic distribution of boom towns, labor shortages, high wages and low levels of unemployment may heterogeneously attract individuals that otherwise face barriers to enter into the labor market, e.g., those that are currently unemployed or underemployed and looking for work. Among a host of factors that determine labor market success rates, a history of drug use and a recorded criminal conviction significantly reduce an individual's ability to find employment. In a controlled field experiment, Pager (2003) finds that white convicted felons receive callbacks from a controlled

[2]Crime data was collected from the Federal Bureau of Investigations 2011 Uniform Crime Statistics and is available at www.fbi.gov/stats-services/crimestats. Population and demographic data were collected from the Census Bureau, Population Estimates and can be found at www.census.gov.

Table 1: Demographic Crime Rates in 2011

Crime	Total	% Male	%Age 20 - 29	%Age 50 - 59
Total	7,994,216	0.74	0.35	0.08
Murder	6,752	0.88	0.43	0.06
Forcible rape	12,069	0.99	0.32	0.07
Robbery	67,791	0.88	0.37	0.03
Aggravated assault	258,765	0.78	0.35	0.08
Burglary	193,993	0.84	0.34	0.04
Larceny-theft	840,187	0.56	0.31	0.06
Motor vehicle theft	40,876	0.82	0.33	0.03

Note. The population between the ages of 20 and 29 and between 50 and 59 both represent approximately 14% of the U.S. population.

first-round interview 17% of the time, compared to 34% for their white, un-convicted counterparts. This discrepancy according to conviction history is aggravated for minorities. While only 14% of un-convicted African Americans received callbacks, this number was a mere 5% for those that had a criminal record. There are currently around 12 million ex-felons in the U.S. today, accounting for 5.4% of the working age population and 9.2% of the working age male population (Uggen, Manza and Thompson, 2006). Difficulty in finding employment may be especially hard for people that have felony sexual offense records. Registered sexual offenders (RSO's) notoriously have difficulty finding employment (Tewsbury and Lees, 2006). Those that are employed often work low-wage, low skill types of jobs. For example, Tewsbury and Lees (2006) quote an RSO named Paul as saying "It's just tough. You're just about going to be stuck with McDonalds, bottom-of-the-ladder type of jobs. That's all you're going to get. I don't care what kind of education you have."

In our analysis of the migratory behavior of sex offenders, we find evidence in support of the idea that boomtowns disproportionately attract labor that is of a criminal type.[3]

[3] Berger and Beckmann (2009) similarly document more sexual offenders living in energy-rich counties in parts of Montana and Wyoming. We extend upon Berger and Beckmann (2009) by considering the prevalence of sex offenders living in all North Dakota counties (Berger and Beckmann use a panel of 9 counties, 3 of which are resource rich). Additionally, the nature of the data we use in our analysis allows us to distinguish between "domestic" and "migrant" sexual offenders.

Referencing again the seminal work of Gary Becker (1968) and Ehrlich (1973), unequal growth in income and wealth may increase the expected gains from participating in a property crime, at least for the so-called "have-nots". And crimes resulting from observed income inequality are not isolated to crimes against property either. According to strain theory, an individual may be more likely to commit a violent crime when they feel economically or socially alienated from a majority group (Merton, 1938). There is empirical evidence in favor of the idea that economic inequality generates violent criminal activity. For example, in a study of urban U.S. counties, Kelly (2000) finds that "for violent crime the impact of inequality is large, even after controlling for the effects of poverty, race, and family composition." The current U.S. shale boom has generated high wages for people working in a variety of industries. In North Dakota, for example, it is not uncommon for oil companies to pay workers $100,000 per year and truck drivers $80,000 per year. Fast-food restaurants there have experienced labor shortages, forcing them to raise wages up to $15.00 per hour (Ellis, 2011). [4] For some property owners though, oil and gas lease payments have played the most critical role in generating additional income. In a 2011 New York Times article titled "A Great Divide Over Oil Riches", A. G. Sulzberger writes that "No other county [than Mountrail] in the state [of North Dakota] has had a bigger jump in the number of households earning more than $100,000, which spiked to 21 percent from 6 percent during the last decade...But much like the crude below, the benefits have spread unevenly, often as a result of decisions made long ago...As with any major boom—from real estate to tech stocks to natural resources—the sudden split between the winners and the witnesses has been painful. But this is happening in a small town, where proximity and familiarity make a sudden reordering all the more difficult." He goes on to discusses the experience of Lenin Dibble, a retired farmer living in a mobile home that receives monthly royalty checks for as much as $80,000, per month. In describing the

[4] In other parts of the country, fast-food workers earn an average wage of $9.00 per hour (Greenhouse, 2013) and the average wage per job in the U.S. was just shy of $50,000 in 2012 (according to data collected from the Bureau of Economic Analysis).

experience of Mr. Dibble, Sulzberger writes "What he and the others in town notice more than the new-found money are the problems: locking the door to his house, taking the keys out of his car and seeing a quiet community where everyone knew everyone overrun by the bustle of strangers."

Finally, an established sociological literature has argued that so-called "social disorganization" contributes to regional crime trends. Unlike theories that concentrate on the types of people that commit crimes, this literature focuses on the types of places that attract, nurture or maintain criminal activity (Shaw and McKay, 1969; Sampson and Groves, 1989; Krubin and Weitzer, 2003). According to Krubin and Weitzer, "Social disorganization refers to the inability of a community to realize common goals and solve chronic problems. According to the theory, poverty, residential mobility, ethnic heterogeneity, and weak social networks decrease a neighborhood's capacity to control the behavior of the people in public, and hence increase the likelihood of crime." Residential mobility may play a key role in explaining criminal activity in boom towns as such events are typically characterized by a sudden inflow (and possibly an outflow) of migrants. A loss of social cohesion and control offers would-be criminals two advantages. First, it reduces the social cost of acting in socially undesirable ways and second, it reduces the risk of getting caught as people don't know each others' names and neighbors are less likely to keep a watchful eye on the neighborhood. As Freudenburg (1986) puts it "When more of the faces in town are strange...a lawbreaker probably will find it easier to escape detection and capture. He becomes a 'white male, about 5 feet, 10 inches tall, between the ages of 16 and 19,' instead of 'Ruth Johnson's nephew, Frank."'

3 Data

3.1 Crime Data

The Federal Bureau of Investigations (FBI) provides county-level crime statistics as part of the Uniform Crime Reporting (UCR) program.[5] The Unified Crime Reports collect information on reported crimes, not just those for which there was a conviction. The crimes considered in this paper are those that the FBI refers to as "Part 1" crimes. These crimes are listed below along with their definitions, taken directly from the 2009 FBI Uniform Crime Reporting Handbook.[6]

Criminal homicide—a.) Murder and non-negligent manslaughter: the willful (non-negligent) killing of one human being by another. Deaths caused by negligence, attempts to kill, assaults to kill, suicides, and accidental deaths are excluded. The program classifies justifiable homicides separately and limits the definition to: (1) the killing of a felon by a law enforcement officer in the line of duty; or (2) the killing of a felon, during the commission of a felony, by a private citizen. b.) Manslaughter by negligence: the killing of another person through gross negligence. Deaths of persons due to their own negligence, accidental deaths not resulting from gross negligence, and traffic fatalities are not included in the category Manslaughter by Negligence.

Forcible rape—The carnal knowledge of a female forcibly and against her will. Rapes by force and attempts or assaults to rape, regardless of the age of the victim, are included. Statutory offenses (no force used—victim under age of consent) are excluded.

Robbery—The taking or attempting to take anything of value from the care, custody, or control of a person or persons by force or threat of force or violence and/or by putting

[5]The Census Bureau provides this data for the years 2000 to 2008 and is available at: http://www.census.gov/support/USACdataDownloads.html. Crime data for the years 2009, 2010 and 2011 were collected from the National Archive of Criminal Justice Data and was matched to that earlier data collected from the Census Bureau.

[6]The FBI also considers Arson to be a part 1 offense, but this paper does not examine this component of crime due to lack of data.

the victim in fear.

Aggravated assault—An unlawful attack by one person upon another for the purpose of inflicting severe or aggravated bodily injury. This type of assault usually is accompanied by the use of a weapon or by means likely to produce death or great bodily harm. Simple assaults are excluded.

Burglary (breaking or entering)—The unlawful entry of a structure to commit a felony or a theft. Attempted forcible entry is included.

Larceny-theft (except motor vehicle theft)—The unlawful taking, carrying, leading, or riding away of property from the possession or constructive possession of another. Examples are thefts of bicycles, motor vehicle parts and accessories, shoplifting, pocket-picking, or the stealing of any property or article that is not taken by force and violence or by fraud. Attempted larcenies are included. Embezzlement, confidence games, forgery, check fraud, etc., are excluded.

Motor vehicle theft—The theft or attempted theft of a motor vehicle. A motor vehicle is self-propelled and runs on land surface and not on rails. Motorboats, construction equipment, airplanes, and farming equipment are specifically excluded from this category.

3.2 Resource Data

Shale gas and tight oil production began to grow rapidly starting around 2007. As can be seen in Figure 1, shale gas production increased from less than 1 trillion cubic feet in 2000 to around 8 trillion cubic feet by 2011. Similarly, production of tight oil increased from just over .2 million barrels per day to about 1.3 million barrels per day by 2011.[7] National levels of

[7]There is an important distinction that should be made between shale oil and tight oil. Shale oil is oil that can be produced from oil shale, though, given current mining technologies, this process is not economically feasible. The extraction of tight oil can be considered analogous to shale or tight gas, gas which is trapped within porous rock formations.

employment in the oil and gas industry reflect this surge in production. As shown in Figure 2, mining employment began to increase in 2005 and started increasing rapidly in 2008. This paper exploits this temporal variation in national mining activity along with the geographic variation in shale formations to identify the causal relationship between resource booms and criminal activity. Our baseline specification examines all U.S. counties and shale plays, though later we will restrict our control and treatment group to minimize unobserved heterogeneity.

A shale "play" is defined as "A set of known or postulated oil and gas accumulations sharing similar geologic, geographic and temporal properties such as source rock, migration pathway, timing, trapping mechanism, and hydrocarbon type" (EIA). Importantly, plays are not defined by the degree of energy exploration or production, but by the geological characteristics of the formation. This provides us with an exogenous source of variation that allows us to say something about the causal relationship between energy booms and criminal activity.

Shale plays, or formations, are scattered from California to West Virginia. Not all shale formations have similar geological features, making some more economically feasible to harvest than others. The Bakken formation that largely resides in North Dakota and the Eagle Ford formation in southern Texas account for the vast majority of tight oil production in the U.S. (85% in 2011). Conversely, the Marcellus formation in Pennsylvania and West Virginia, the Haynesville in Louisiana and Texas, the Fayetteville in Arkansas and the Eagle Ford, Woodford and the Barnett in Texas account for the large majority of shale gas production (96.25% in 2011) (EIA, 2014). Figure 2 is a map of 2011 U.S. shale plays (data for which was collected from the EIA).

3.3 Population Data

We use census population estimates throughout the paper, including in the construction of crime rates per 1000 people. One complicating factor for this paper is that the census does not count workers who are residents of other states in their population figures. As pointed out by

Table 2: 2011 Production of Tight Oil and Shale Gas by Major Play

Play	Location	Shale Gas (% of Total)	Tight Oil (% of Total)
Eagle Ford	TX	5	31
Bakken	ND, SD, MT	-	54
Barnett	TX	25	3.5
Marcellus	PA, WV, OH, NY	17.5	-
Niobrara	CO, KS, NE, WY	-	.88
Haynesville/Bossier	TX, LA	31	-
Woodford	TX, OK	6.25	-
Fayetteville	AR	11.25	-
Total		96	89

Data Source: EIA U.S. Crude Oil and Natural Gas Proved Reserves, 2014.

Hodur & Bangsund (2013), the petroleum boom in North Dakota has brought in many workers that live in other states or are temporary, and thus not counted by the census. The authors use two different models to estimate a “service population” that includes all workers. In the extreme case of the city of Williston, North Dakota, they estimate a 2012 service population of between 25,349 and 33,547, compared to a census estimate of 14,716. While as of this draft we do not have service population estimates for other counties, we create an alternative population estimate that reflects a worst-case scenario in which all mining employees are not counted by the census. Hence we simply add our estimates of mining employees to the census population estimates. Rerunning all regressions in this way has very little influence on the main results, so these results are not shown.

4 Empirical Strategy

We use a difference-in-difference identification strategy to examine the relationship between crime rates and resource booms. One seemingly straightforward identification strategy involves examining the conditional relationship between county-level mining employment and crime rates. This approach offers the advantage of great transparency, but raises concerns of endogeneity. While productive oil wells must be placed above oil deposits (which are exogenously determined), the exact location of oil and gas wells may be endogenous to economic factors such as property values, income and poverty levels, tax rates and environmental policies. To avoid such potentially confounding effects, the identification strategy employed in this paper exploits the geographic variation in oil and gas-rich shale formations as well as the national temporal variation in shale energy production. Specifically, we define our treatment group as the set of counties for which the geographic center lies above one of the major play formations listed in Table 2. We hereafter refer to this set of plays as "booming plays." All other US counties, subject to the restrictions described below, are controls.

We restrict our baseline sample of counties in three ways. First, if a county reports zero crimes of any kind in a year, we assume that no data was collected and drop the observation. Second, we drop Illinois, Kansas and Kentucky from all specifications, as these states demonstrate implausible patterns of year-to-year changes in crime reporting over the period studied. Lastly, since large, densely populated cities are presumably not affected by the shale boom (insofar as crime rates are concerned) and are not suitable as controls for shale boom-towns, we omit from all specifications counties that are coded as being a "Large-in a metro area with at least 1 million residents or more" by the Population Studies Center at the University of Michigan. These restrictions and the treatment definition leave us with 215 treated counties.

The effects of the shale boom over time are estimated with the following equation:

$$Y_{i,t} = \alpha + \beta(D_i \times Post_t) + Z_t + C_i + \epsilon_{i,t}, \tag{1}$$

where Y_{it} is the outcome of interest for county i in year t, D_i is an indicator variable equal to one if the center of county i lies above a booming play, Z_t are year fixed effects, C_i are county fixed effects, and $Post_t$ is equal to one for all years from 2005 onwards. As Fetzer (2013) notes, 2005 and onwards is a reasonable definition for the shale "boom" period in the United

States. The Energy Policy Act of 2005 controversially included an exemption for fluids used in the fracking process from restrictions under the Clean Air Act, Clean Water Act, and Safe Drinking Water Act, a provision that came to be known as the "Halliburton loophole". As can be seen in Figure 1, increases in shale and tight gas production are negligible over the first half of the decade and the sharpest increases in production are later in the decade. Figure 3 shows mining employment starts to increase indefinitely starting in 2005. β then measures the average difference in Y between treatment and control counties after the start of the boom, relative to the difference in the five years before the boom, conditional on county and year fixed effects.

While the specification of equation (1) is meant to provide a more powerful statistical test and single treatment effect estimate, we also estimate a more flexible specification that allows us to examine heterogeneous treatment effects over each individual year in the sample. This has the advantage of revealing any interesting patterns in effects that may exist, and also allows us to check for pre-existing trends in the outcomes that may confound the traditional specification of equation (1). We estimate the following equation:

$$Y_{i,t} = \alpha + \sum_{t=2001}^{2011} \beta_t (\mathrm{Z}_t \times D_i) + Z_t + C_i + \epsilon_{i,t}, \tag{2}$$

where D_i, Z_t, and C_i are as defined in equation (1). The average effect of lying over a booming play in year t, relative to the reference year 2000 is given by β_t. More precisely, β_t measures the average difference in Y between booming play counties and non-booming play counties in year t, compared to the relative difference in 2000. Since 2000 is before the start of the shale boom, this is essentially a difference-in-difference specification in which the treatment effect is allowed to vary over time.

In the following section we first present results for equations (1) and (2) for the Mountain West region only. This is essentially a de-facto North Dakota state case study as the majority of booming play counties in the region lie above the Bakken shale formation in North Dakota, which has by far experienced the largest increases in hydrocarbon production in the country, resulting in dramatic economic and sociological effects.We then run the same specifications including all counties and booming plays. Later, we will perform several robustness checks. We replace year fixed effects with state-by-year fixed effects, so that any state-specific shocks common to both booming and non-booming counties are controlled for. The drawback of including state-by-year fixed effects is that they soak up much of the variation in states dominated by booming play counties, particularly West Virginia (which is almost entirely covered by the Marcellus formation), and also effectively cut out many states that did not experience a boom from the treatment effect estimation.

We perform further robustness checks by limiting the sample of counties to test the generalizability of the main results. We limit the sample to non-urban and non-densely populated counties. To do this we first omit counties that are classified as being in a metropolitan or micropolitan area by the Population Studies Center. We then also omit counties with a population density of 100 people or more per square mile. While this specification cuts a significant number of counties from the sample, it indicates whether the shale boom differentially affects more rural, sparsely populated counties. We also run specifications (1) and (2) while omitting North Dakota. This robustness check addresses the concern that fracking-induced crime is strictly a North Dakota phenomenon.

Finally, we expand the definition of a treated county to include all counties in which the center lies over any play, not just booming plays. By this definition the baseline sample includes 378 treated counties, rather than 215 as with the booming play definition. This definition has the disadvantage that it includes a large number of counties that are in fact seeing little to no increase in shale production. However, it is more strongly exogenous since plays are strictly geographically determined. This method could arguably be described as an "intent to treat" approach, as not all counties in the treatment group are actually treated. We therefore should expect to find weaker but comparable effects to the baseline specifications.

5 Results

5.1 Mountain West

We begin by assessing the effect of the shale boom on crime in the Mountain West region, which we define as the states of Colorado, Wyoming, Montana, South Dakota and North Dakota. Within this region, 16 of the 20 counties lying over a booming play are above the Bakken shale play in North Dakota. Hence, these results document the effect of a tremendous energy boom in an isolated region and my not reflect national trends.

We first estimate equation (1) for several demographic and economic variables. We choose outcomes to establish that our treatment definition is indeed capturing counties experiencing a shale boom. Those outcomes are GDP per capita and population (both variables normalized using natural logs), the percent of the population that is young (between the ages of 20 and 39), male, and the percent of the population that is working in the mining industry. Industry employment data was collected from the Bureau of Labor Statistics, Quarterly Census of Employment and Wages database.

Table 3 gives the results of equation (1) for the Mountain West region. Column 1 shows a large and statistically significant increase in GDP per capita caused by the boom in treated counties. The coefficient implies an average income effect of approximately 10 percentage points during the boom period. That is to say, averaged from 2005-2011, incomes were 10% higher in treatment counties as a result of the shale boom. The percentage of the population employed in mining or mining support activities increased by 1.1 percentage points. While this result is statistically significant, it is surprisingly small in magnitude. However, the results for mining employment should be treated with caution as several shale-producing counties report zero mining employment where the data is in fact likely to be missing due to proprietorial issues. This problem is especially pronounced in North Dakota. These two results nonetheless suggest that our treatment group definition is indeed capturing counties experiencing rapid economic growth, and that the growth is at least partially associated with mining activity. Columns 3 and 4 indicate no significant effect on population or the male population percentage, although we will see in the non-parametric specification that population was trending downward before the boom. There was a significant increase in the percentage of the population aged between 20 and 39, which is the age group most likely to commit crimes.

Table 3: Economic & Demographic Effects, Mountain West Only

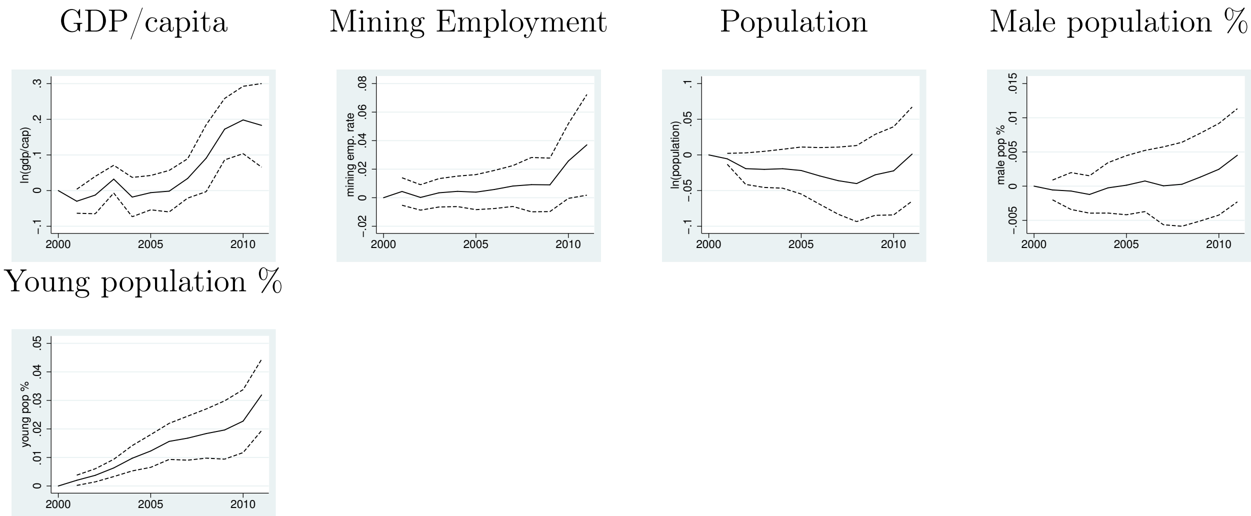
	(1) GDP	(2) Mining emp. %	(3) Population	(4) Male %	(5) Young %
Boom play*post-2005	0.102***	0.011+	-0.012	0.002	0.015***
	(0.029)	(0.007)	(0.018)	(0.002)	(0.004)
N	2645	2544	2645	2645	2645
r2	0.80	0.08	0.04	0.12	0.17

Notes: The dependent variables are shown in the column headers. All regressions include county and year fixed effects. +,*,**,*** represent significance at 10%, 5%, 1%, .1%, respectively.

Figure 5 presents the results of the non-parametric specification of equation (2) for demographic variables in the Mountain West. For GDP and mining employment, there is no effect prior to the boom, after which both increase significantly. The rise in mining employment lags behind the rise in GDP. Again however, the results for mining employment should be treated with caution.

The young population percentage was also trending upwards throughout the period, but sharply accelerates at the end of the period, likely reflecting the increase in young people working in the energy sector. A similar trend holds for the male population, though the effect is not statistically significant. Population in booming counties had been trending downward prior to the boom, but this trend reverses after 2005. These results collectively suggest that our treatment definition is effectively capturing counties experiencing a shale boom (even if not all treatment counties are in fact booming) and that this is bringing about some expected demographic changes.

Figure 5: Demographic Effects-Mountain West



Notes: Each graph displays the results of estimating equation (2) with the dependent variable given above the graph. Each point on the graph represents the treatment effect estimate for year t, relative to the reference year 2000. 95% confidence intervals with errors clustered at the county level are shown.

We next examine the effects of the boom on crime rates in the Mountain West. Table 4 shows the difference-in-difference results for all seven different crime categories. All dependent crime variables are expressed relative to population and have been normalized by taking natural logs. This has the added benefit of easing the econometric interpretation. The effect on assaults is extremely large, implying a near doubling of incidents due to the boom. As we will see, the effect on assaults is typically the largest and most robust crime outcome of the boom, both in the Mountain West and nationwide. The effects on rape and murder are not statistically significant, and there is actually a significant decrease in robberies. However, these results, particularly for robbery, must be viewed with caution as the sample sizes are severely curtailed by the large amount of observations with zero crimes of each respective crime recorded, which are dropped from the regression since we are taking logs. Finally, incidences of auto theft, burglary and larceny increased by around 30%. Taken together, the energy boom in North Dakota appears to have induced an increased in property crimes, but not violent crimes, with the clear exception of a significant increase in assaults.

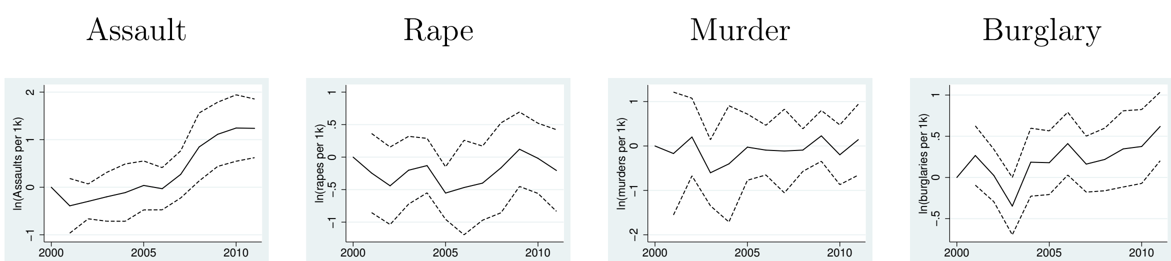
Table 4: Crime Effects, Mountain West Only

	(1) Assault	(2) Rape	(3) Murder	(4) Burglary	(5) Larceny	(6) Robbery	(7) Auto
Boom play*post-2005	0.867***	-0.002	0.232	0.299*	0.378*	-0.325*	0.285*
	(0.210)	(0.157)	(0.215)	(0.130)	(0.151)	(0.156)	(0.136)
N	2188	1515	571	2465	2554	995	2221
r2	0.11	0.02	0.03	0.02	0.05	0.02	0.03

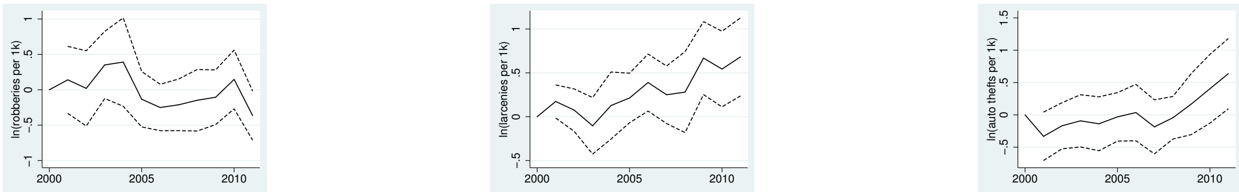
Notes: The dependent variables are shown in the column headers. All regressions include county and year fixed effects. Standard errors are clustered at the county level. +,*,**,*** represent significance at 10%, 5%, 1%, .1%, respectively.

Figure 6 shows the non-parametric crime results for the Mountain West. While some of the pre-boom outcomes are somewhat erratic, there are little to no pre-existing trends prior to the boom. For the crimes found to have a significant increase in Table 4, the increases generally occur after 2005. The results on assault are especially striking, as the increase is over 100 log percentage points by the end of the period. Although there is no particularly strong overall pattern for rape, it does begin to rise sharply after 2005, but then declines significantly in 2010 and 2011, which could reflect adaptation and learning on the part of would-be victims (e.g., locking doors, walking in pairs or taking self-defense classes (Havens, 2014)).

Figure 6: Crime Effects-Mountain West



Robbery Larceny Auto Theft



Notes: Each graph displays the results of estimating equation (2) with the dependent variable given above the graph. Each point on the graph represents the treatment effect estimate for year t, relative to the reference year 2000. 95% confidence intervals with errors clustered at the county level are shown.

5.2 Full National Sample

We now turn our attention to the full set of U.S. counties and booming plays to assess the degree to which the large effects seen in the Mountain West region (which, again, amounts to a de facto case study of the North Dakota boom) can be generalized to the nation as a whole. Table 5 reports the demographic effects of the boom for the full national sample. There are again positive and statistically significant effects for GDP and mining employment percentage, although the effects are not as economically large as for the Mountain West, as expected. Population decreases significantly, but this is again due to a negative pre-existing trend, as will be shown below. Male and young population percentages see statistically significant effects, but economically the effects are rather small.

Table 5: Demographic Effects, Full Sample

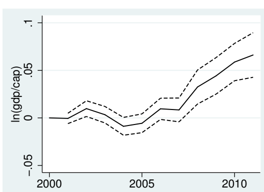
	(1) GDP	(2) Mining emp. %	(3) Population	(4) Male %	(5) Young %
Boom play*post-2005	0.030***	0.003**	-0.016***	0.002**	0.003**
	(0.006)	(0.001)	(0.004)	(0.001)	(0.001)
N	27607	27058	27607	27573	27573
r2	0.85	0.01	0.12	0.11	0.43

Notes: The dependent variables are shown in the column headers. All regressions include county and year fixed effects. Standard errors are clustered at the county level. +,*,**,*** represent significance at 10%, 5%, 1%, .1%, respectively.

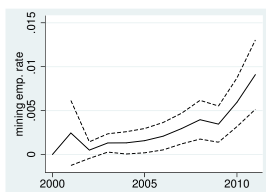
Figure 7 shows the non-parametric demographic results. GDP and mining employment experience gains that nearly all occur post 2005. Population experienced a strong downward trend that ceased in the last 3 years of the sample, likely due to the energy boom. Young and male percentages, and to a lesser extent mining employment, followed a steady upward trend throughout the period. One advantage of the previous mountain west specification is that treatment counties experienced the energy boom at the same time, i.e., the Bakken boomed at once. Relaxing the analysis to the full sample case adds more noise to the model as different plays were explored and developed at various times (the majority occurring post 2005). This may help explain some of the upward trends present in Figure 7.

Figure 7: Demographic Effects-Full Sample

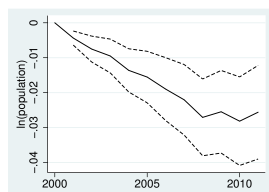
GDP/capita



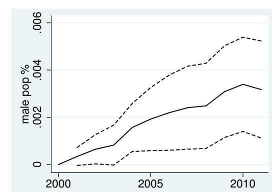
Mining Employment



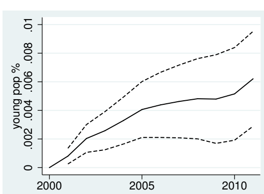
Population



Male population %



Young population %



Notes: Each graph displays the results of estimating equation (2) with the dependent variable given above the graph. Each point on the graph represents the treatment effect estimate for year t, relative to the reference year 2000. 95% confidence intervals with errors clustered at the county level are shown.

We next examine effects on crime for the full national sample, which is our main baseline set of results. Table 6 gives the results from the estimation of equation (1). Consistent with our expectations, the magnitudes are lower than for the Mountain West region. There are, however, positive and statistically significant effects for all seven crime categories, with effects ranging from 5.3-11.9 percentage points, and assault again experiencing the largest effects.

Figure 8 shows the non-parametric crime results for the national sample. In all cases average crime rates are clearly higher in the post-boom period, although for some crimes

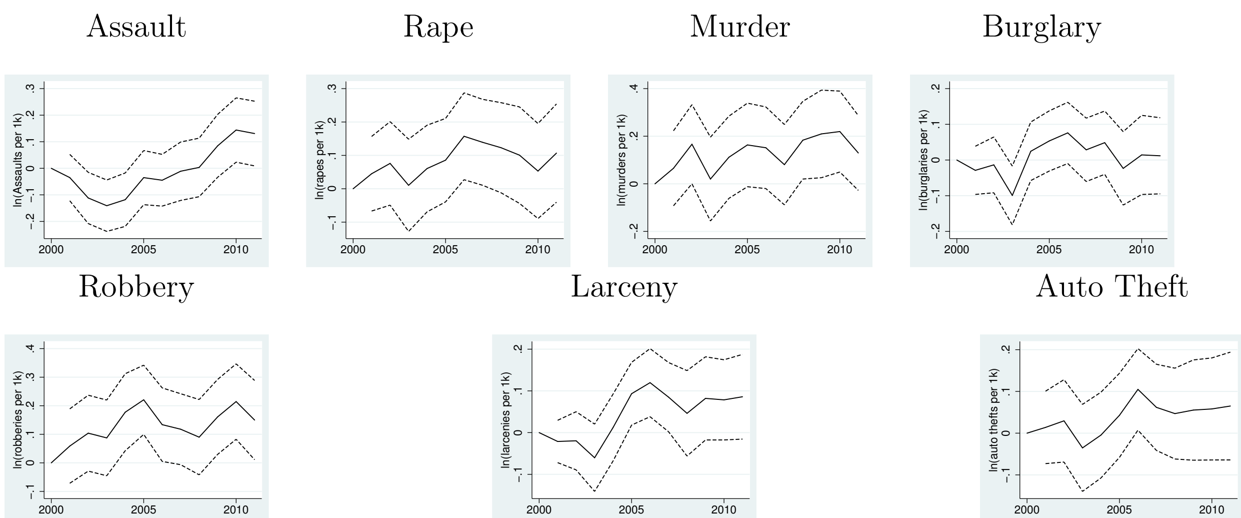
Table 6: Crime Effects, Full Sample

	(1) Assault	(2) Rape	(3) Murder	(4) Burglary	(5) Larceny	(6) Robbery	(7) Auto
Boom play*post-2005	0.119**	0.070+	0.089*	0.053+	0.102***	0.069*	0.061*
	(0.037)	(0.037)	(0.035)	(0.031)	(0.029)	(0.032)	(0.029)
N	26463	21968	13198	27245	27352	19967	26160
r2	0.09	0.01	0.00	0.00	0.01	0.01	0.06

Notes: The dependent variables are shown in the column headers. All regressions include county and year fixed effects. Standard errors are clustered at the county level. +,*,**,*** represent significance at 10%, 5%, 1%, .1%, respectively.

much of the increase comes before 2005. The main exception to this is assault, which has the largest effects and has nearly all of the increases occur in the post-boom period.

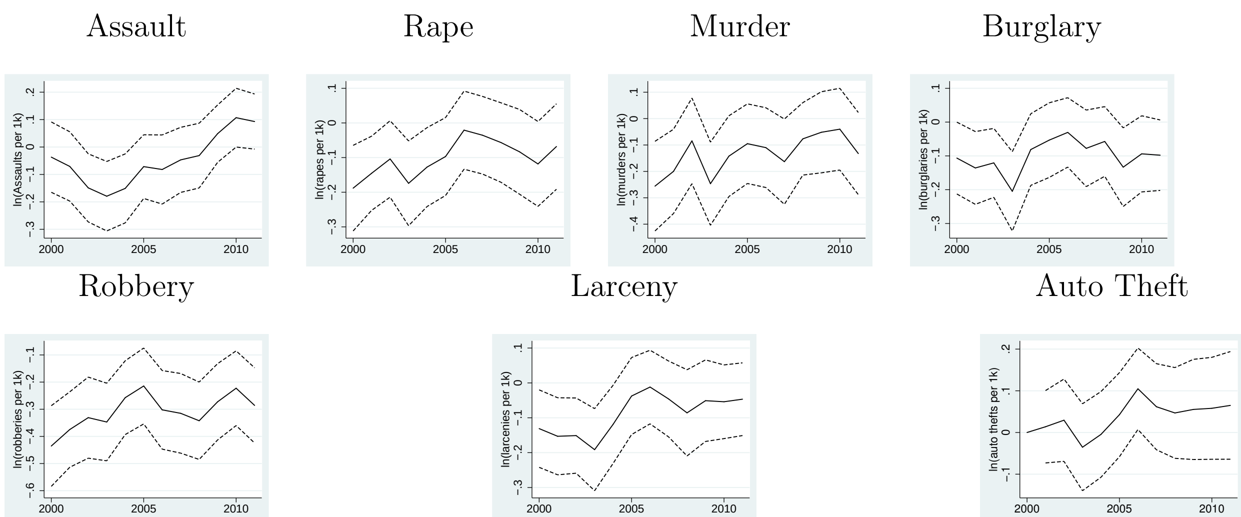
Figure 8: Crime Effects-Full Sample



Notes: Each graph displays the results of estimating equation (2) with the dependent variable given above the graph. Each point on the graph represents the treatment effect estimate for year t, relative to the reference year 2000. 95% confidence intervals with errors clustered at the county level are shown.

To provide additional context to the results, we run a specification very similar to equation (2), except with each booming play by year interaction term included, rather than excluding the year 2000. In this specification, each interaction term will show the absolute conditional difference in outcomes between treatments and controls, rather than the differences relative to the reference year 2000. Removing county fixed effects is also necessary to get absolute differences, so the regressions can be thought of as a cross-sectional regression performed for each year. The graphical results are shown in Figure 9 (Note that the shapes of the graphs are quite similar to those presented earlier despite the exclusion of county fixed effects). Assaults begin the period slightly lower in treated counties than non-treated, but are significantly higher by 2011. For other crimes, rates are generally lower in treated counties and remain lower in 2011, despite the relative rise during the period. This implies that while treatment counties generally experienced more rapid growth in criminal activity during the energy boom period, excluding assaults, crime rates remained lower in treatment counties relative to the controls (at least by 2011).

Figure 9: Crime Effects-Full Sample, Absolute Differences



Notes: Each graph displays the results of estimating equation (2) with the dependent variable given above the graph. Each point on the graph represents the treatment effect estimate for year t, relative to the reference year 2000. 95% confidence intervals with errors clustered at the county level are shown.

5.3 Robustness

We next run several robustness checks (fully described in the previous section) for the baseline results of Table 6. Table 7 reports the crime results when replacing the year fixed effects with state-by-year fixed effects, which controls for any year-level shocks common to all counties within a state. Table 8 shows results when limiting the sample to non-urban, sparsely populated counties. Table 9 presents results when omitting all North Dakota counties, thus eliminating the most extreme case of the shale boom and rise in crimes. Finally, Table 10 reports results when redefining treatment counties as any for which the center lies above a play, not just a booming play.

Controlling for state-year fixed effects causes the results for rape, murder and robbery to become insignificant, while the other four outcomes remain significant. For the non-urban, low density sample, the effect on assault increases substantially. For several other crimes, the point estimates are similar but slightly smaller, which causes them to lose significance when combined with the larger standard errors due to the smaller sample size. The effects when omitting North Dakota are generally slightly smaller but remain significant, demonstrating that the increase is not being driven solely by the extreme case of the Bakken play. Finally, using all plays rather than booming plays for the identification causes the effects to become smaller, as expected since this definition captures more non-booming counties, but the results largely remain significant, mitigating concerns about the endogeneity of the booming play treatment definition.

Overall, the positive effect on almost all types of crimes remain for all robustness checks, though some lose statistical significance. The most robust effect is that for assault, which remains large and significant in each specification. Since assaults are quite a serious crime (recall we are only considering aggravated assaults, which strictly include assaults with the intent to cause severe bodily injury, usually with use of a deadly weapon) occur much more frequently than the other violent crimes studied (murder, rape, robbery), this is a highly important result that local policy makers in current and prospective boom towns should consider.

5.4 Do Criminals Disproportionately Move to Boom Towns?

Why do shale-rich booming communities experience elevated levels of criminal activity? Do boom towns provide people with the opportunties and incentives to commit crimes, or do criminals simply move to boomtowns? Ideally, one could examine the migratory behavior of convicted fellons throughout the United States to test whether fellons move in disproportionate numbers to boom towns. Such a federal registry does not exist, or is at least not publically available. However, in 1996 the Sexual Offender Act was signed by President Bill Clinton. This law, commonly refered to as "Megan's Law" made public a registry of previously convicted sexual offenders. We make use of this data to examine i) whether shale-rich counties in North Dakota have a disproportionate number of sex offenders residing in them and ii) if sexual offenders have moved in disproportionate numbers to live in shale-rich counties.

Data on sexual offenders living in North Dakota is available at sexoffender.nd.gov. This data source details where each offender lives and the time and place of all previous offenses. We omitt those offenders that are currently incarcerated as such individuals are not a threat to society. A shortcoming of the analysis is that it is cross-sectional in nature, with a total of 53 data points (there are 53 counties in North Dakota), and registry data reflects up-to-date, 2014 records. While the results are quite striking, they should nonetheless be viewed with caution as bias created from unobserved heterogeneity is an obvious concern when working with cross-sectional data sets.

As a starting point, we individually regress the natural log of sex offenders per capita, aggregated at the county level, on a variety of indicator variables that describe whether a county is shale rich. We then restrict the data set by omitting those RSO's that committed the registering offense in another state. The implicit assumption being made is that offenders commit crimes where they live. For example, an RSO that committed the registering offense in New Hampshire in 1999, but currently lives in Williams, North Dakota, is assumed to have previously lived in New Hampshire, but moved to North Dakota sometime between 1999 and

2014.

We use three different treatment definitions. First, we apply the methodology previously employed in this paper, namely, we define a treatment county as one lying above the Bakken shale formation. As previously discussed, this approach provides us with exogenous variation in our treatment definition, but comes at the cost of added statistical noise. We therefore also define a treatment county as one that was producing any oil in 2011 (the last year for which we have county-level energy production data). Lastly, we define a county as being a "key" oil producing county if it was one of the top five oil producers in the state of North Dakota in 2011.

The reuslts are given in Table 7. There is evidence that shale-rich North Dakota counties have a disproportionately large number of registered sex offenders living in them. For all treatment definitions, the coefficient of interest is positive, albeit insignificant when treatment counties are defined as those lying above the Bakken shale play. The results are also economically significant. For example, the top five oil producing counties had nearly twice as many registered sex offenders living in them when compared to the control group of counties. However, after restricting the data to only include those RSO's that did not previously commit a crime in another state, the results are insignficant or actually negative. This suggests that perhaps the shale boom incentivised local and existing sex offenders to leave the boom town. We consider this evidence that local shale booms have heterogeneously attracted labor that may be more prone to have a criminal record. This of course is not to say that other mechanisms, e.g., social disorder or inadequate police protection, are not also contributing to the documented elevated levels of criminal activity.

Table 7: Registered Sex Offenders Per Capita

Dep. Variable	Bakken	Oil Producing	Key Producer
ln(RSO's/Pop)	.233	.323*	.90***
	(.182)	(.172)	(.185)
ln(Domestic RSO's/Pop)	-.333*	-.220	-.470**
	(.176)	(.180)	(.191)
N	53	53	53

Note: ln(RSO's/Pop) refers to the natural log of the number of registered sex offenders per person. ln(Domestic RSO's/Pop) refers to the natural log of the number of registered sex offenders, that committed the regiserting offense in North Dakota, per person. *Bakken* is an indicator variable for whether the center of the county lies above the Bakken shale play. *Oil Producing* is an indicator variable for whether the county produced any oil in 2011. *Key Producer* is an indicator variable for whether the county was one of the top five North Dakota producers in 2011.

6 Conclusion

The production of shale gas and tight oil increased tremendously in the United States from 2000 to 2011. While many of the direct economic impacts of this energy boom have been documented in the economics literature, significantly less attention has been given to the economic and social externalities associated with this surge in mining activity. This paper uniquely considers the effect that the shale energy boom has had on local crime rates.

Using a variety of model specifications, we document evidence that regional shale booms have elevated crime rates in communities across the United States. In a baseline specification, we document a statistically and economically significant increase in rates of all types of crimes including assault, rape, murder, larceny, robbery and auto theft. For a majority of crime categories, the results are moderately robust. Rates of assault clearly surge in response to the energy boom, a result robust to a variety of model specifications and constraints on the control group of counties designed to limit unobserved heterogeneity.

In documenting the relationship between the fracking boom and crime rates, this paper has raised a series of additional interesting and important questions. Perhaps the most begging concerns the mechanism that generates criminal activity in boom towns. Future research will explore potential mechanisms in more detail. Incorporating county-to-county migration data would allow us to measure the degree of social disorganization and mobility that may be plaguing boom towns. Incorporating this data into the paper may also allow us to distinguish between crime generation and crime redistribution, which is an important distinction from a general equilibrium perspective. Along this line of thought, considering drug and alcohol-related offenses would be an interesting extension to the current draft.

One speculative interpretation of these results is that a resource boom—via induced criminal behavior and subsequent heterogeneous labor migration—may facilitate a drain of human and physical capital and could propagate a long-term resource curse. Future research may consider the long-run impact of short-lived resource booms that results from crime-induced outward migration.

Table 8: Crime Effects with State-Year Fixed Effects

	(1) Assault	(2) Rape	(3) Murder	(4) Burglary	(5) Larceny	(6) Robbery	(7) Auto
Boom play*post-2005	0.121**	-0.017	0.061	0.070+	0.081*	0.005	0.094*
	(0.045)	(0.045)	(0.044)	(0.036)	(0.036)	(0.036)	(0.037)
N	26463	21968	13198	27245	27352	19967	26160
r2	0.16	0.06	0.05	0.08	0.08	0.05	0.12

Notes: The dependent variables are shown in the column headers. All regressions include county and year fixed effects. Standard errors are clustered at the county level. +,*,**,*** represent significance at 10%, 5%, 1%, .1%, respectively.

Table 9: Crime Effects, Low-Density Counties Only

	(1) Assault	(2) Rape	(3) Murder	(4) Burglary	(5) Larceny	(6) Robbery	(7) Auto
Boom play*post-2005	0.178**	0.040	-0.001	0.054	0.138**	-0.011	0.129**
	(0.061)	(0.062)	(0.065)	(0.052)	(0.050)	(0.051)	(0.045)
N	12675	9319	4241	13261	13370	7678	12472
r2	0.08	0.01	0.01	0.01	0.01	0.00	0.03

Notes: The dependent variables are shown in the column headers. All regressions include county and year fixed effects. Standard errors are clustered at the county level. +,*,**,*** represent significance at 10%, 5%, 1%, .1%, respectively.

Table 10: Crime Effects, North Dakota Omitted

	(1) Assault	(2) Rape	(3) Murder	(4) Burglary	(5) Larceny	(6) Robbery	(7) Auto
Boom play*post-2005	0.086*	0.070+	0.084*	0.044	0.095***	0.079*	0.048+
	(0.034)	(0.038)	(0.035)	(0.032)	(0.029)	(0.032)	(0.029)
N	26112	21733	13126	26750	26823	19832	25723
r2	0.09	0.01	0.00	0.00	0.01	0.01	0.06

Notes: The dependent variables are shown in the column headers. All regressions include county and year fixed effects. Standard errors are clustered at the county level. +,*,**,*** represent significance at 10%, 5%, 1%, .1%, respectively.

Table 11: Crime Effects, Alternative Treatment Definition

	(1) Assault	(2) Rape	(3) Murder	(4) Burglary	(5) Larceny	(6) Robbery	(7) Auto
Play*post-2005	0.070*	0.038	0.051+	0.053*	0.084***	0.055*	0.004
	(0.029)	(0.027)	(0.027)	(0.025)	(0.023)	(0.025)	(0.024)
N	26417	21956	13154	27199	27306	19921	26114
r2	0.09	0.01	0.00	0.00	0.01	0.01	0.06

Notes: The dependent variables are shown in the column headers. All regressions include county and year fixed effects. Standard errors are clustered at the county level. +,*,**,*** represent significance at 10%, 5%, 1%, .1%, respectively.

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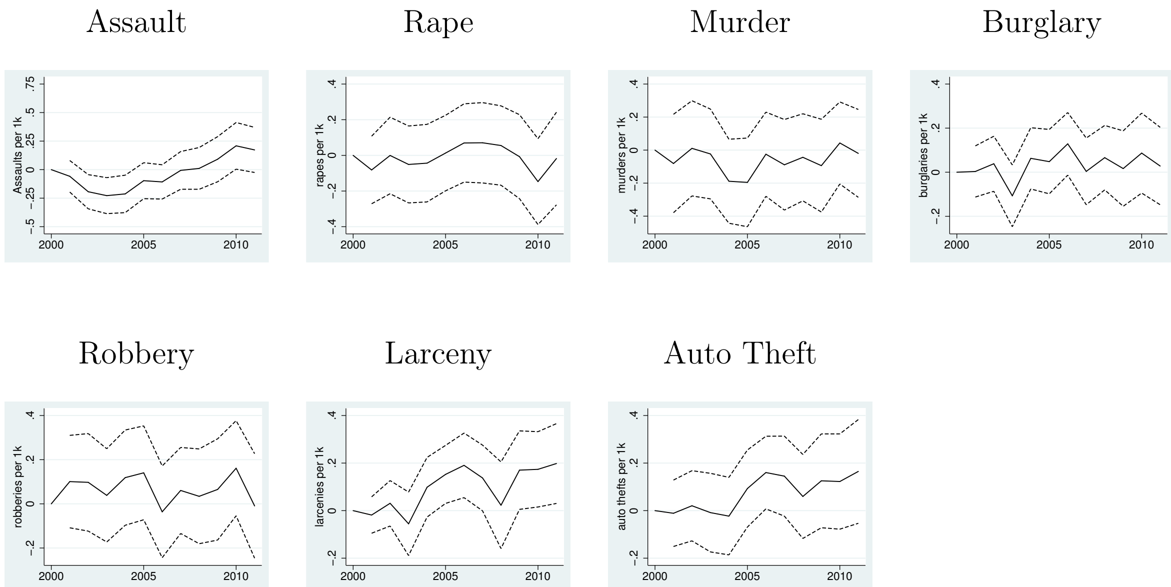
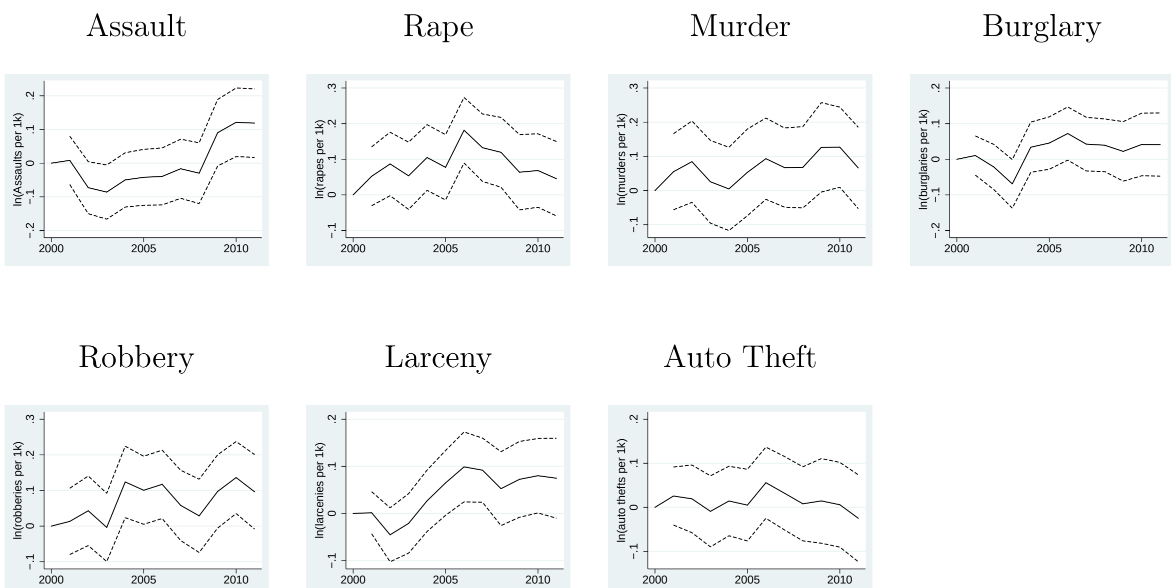
8 Appendix

Appendix Figure A1: Crime Effects-Low-Density Counties Only

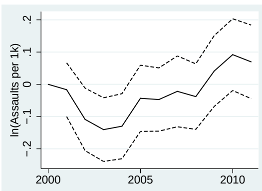


Appendix Figure A2: Crime Effects-Alternative Treatment Definition

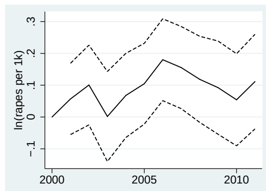


Appendix Figure A3: Crime Effects-North Dakota Omitted

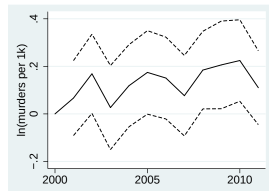
Assault



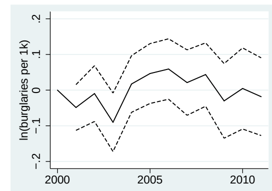
Rape



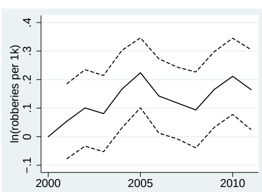
Murder



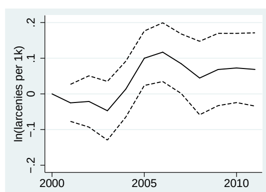
Burglary



Robbery



Larceny



Auto Theft

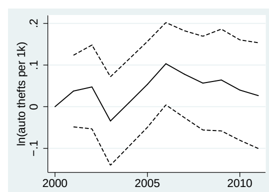
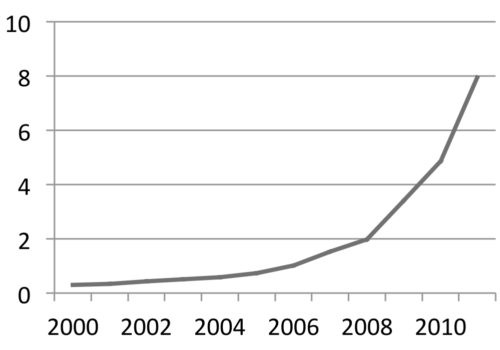


Figure 1: Shale Gas and Tight Oil Production, 2000 - 2011

Shale Gas (tcf)



Tight Oil (mmbbls)

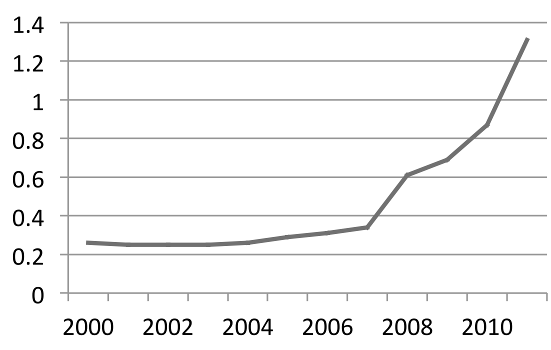


Figure 2: Oil and Gas Mining Employment, 2000 - 2011

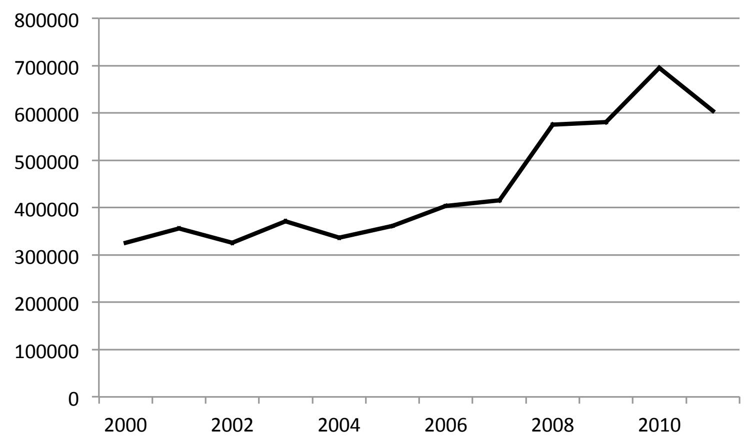
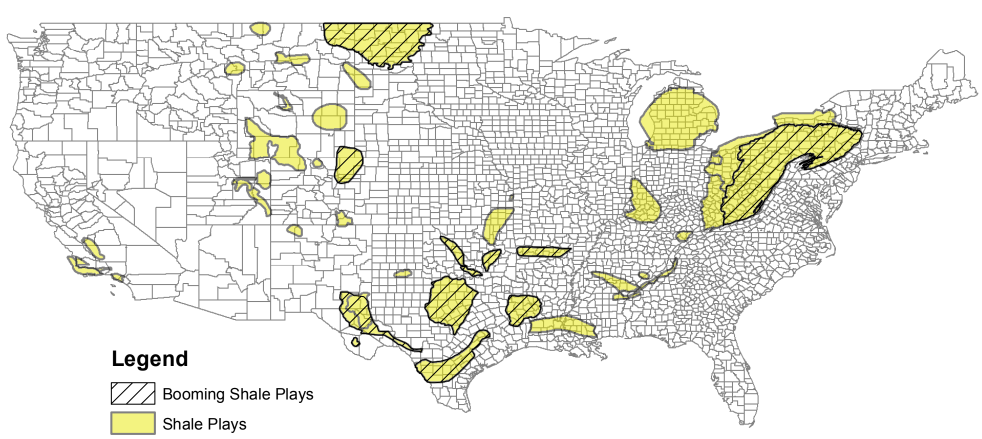


Figure 3: U.S. Shale Plays, 2011



Data Source: Energy Information Administration