The Impact of Economic Opportunity on Criminal Behavior: Evidence from the Fracking Boom

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Abstract

Economic theory suggests crime should decrease as economic opportunities increase the returns to legal employment. However, there are well-documented cases where crime increases in response to areas becoming more prosperous. This paper addresses this puzzle by examining the effects on crime only for residents already living in the area prior to the economic boom. This approach isolates the effect of local economic opportunity from the effect of changing composition due to in-migration during these periods. To identify effects, I exploit within- and across-county variation in exposure to hydraulic fracturing activities in North Dakota using administrative individual-level data on residents, mineral lease records, and criminal charges. Results indicate that the start of economic expansion – as signaled by the signing of leases – leads to a 22 percent reduction in criminal cases filed. Effects are smaller once the fracking boom escalates during the more labor-intensive period. This is consistent with improved economic opportunity reducing crime.

Keywords: Crime, Economic Opportunity, Fracking

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1 Introduction

Since Becker (1968), crime has been viewed as the outcome of rational individuals weighing costs and benefits of legal and illegal forms of employment. Thus, if individuals face improved labor markets, the returns to legal activity increase and individuals should substitute away from illegal activities. Yet, local economic booms are often associated with increases in crime (Grinols and Mustard, 2006; Freedman and Owens, 2016; James and Smith, 2017). Several theories can rationalize this phenomenon including increases in criminal opportunities, access to disposable income for activities that complement crime, and population changes. However, the extent to which each of these theories explains this puzzle is unclear, especially since changes in crime are typically observed at an aggregate level.

The purpose of this paper is to address this puzzle by estimating the effect of local economic opportunity on the criminal behavior of residents who already lived in the area prior to the economic boom. By focusing on the criminal behavior of existing residents, I distinguish the effect of economic opportunity from the effect of the compositional changes in the population caused by in-migration during the boom. This is important, as people tend to leave as labor market conditions worsen and migrate to areas during economic expansions. I do so by using the recent boom in hydraulic fracturing in North Dakota as a large, exogenous shock to an individual's relative returns to legal versus illegal behavior. This approach, combined with the focus on the behavior of residents already living there prior to the start of hydraulic fracturing, enables me to identify the effect of economic opportunity on individual criminal behavior.

I identify effects using a difference-in-differences framework comparing counties located in the shale play, to counties not located in the shale play over time. Importantly, I measure the impact on residents, separating out migration effects, using information on local residents prior to the economic shock. The sharp increase in hydraulic fracturing activity in the United States is an ideal economic shock for several reasons. First, areas were affected based on the formation of the shale play beneath the Earth's surface. Second, the shock was largely unforeseen, as fracking suddenly became a viable method due to a combination of technological innovations (Wang and Krupnick, 2013; Crooks, 2015). Together, these support the assumption that fracking affected local labor markets for reasons unrelated to prior local conditions and household behaviors, overcoming common critiques of the difference-in-differences design.[1] Third,

[1] For example, see Besley and Case (2000) for discussion about policy endogeneity in difference-in-differences frameworks.

hydraulic fracturing was large enough to affect the entire local economy in many areas. Finally, the shock affected predominately low-skill jobs, a population of policy interest.

Studying the effect at the individual level requires detailed data on hydraulic fracturing activities, criminal behavior, and local residents in North Dakota.[2] I identify residents in each county from printed directories in the early 2000s before the in-migration associated with production activities. As an important measure of criminal behavior, I obtained detailed administrative data on the universe of criminal cases filed in the state from 2000 to 2017. I also observe which residents signed a lease and received royalty payments during this period. This enables me to not only identify the effect of improved labor market opportunities, but also isolate differential effects of those receiving large, non-labor income shocks and those that do not. Matching these datasets makes it possible to study the effect of local economic shocks on the criminal behavior of local residents. This is an important advantage given the large migration effects that have been documented in response to economic conditions in general, and to fracking in particular (Wilson, 2017).

Results indicate that the start of the economic expansion — defined as the period when companies began leasing mineral rights and investing in the area — led to a statistically significant 0.44 percentage point (22 percent) reduction in criminal behavior by local residents. Effects are largest for drug-related crimes, though I also see some less precisely estimated declines in other crimes. The effect is smaller once production began, with a 0.27 percentage point decrease in the likelihood of committing a crime and not consistently statistically significant. This suggests that changes during the production period, such as increased income or changes in peer composition, offset some of the effect of improved job opportunities.

In addition, I exploit variation in mineral rights ownership and royalty income to assess the extent to which effects are driven by labor market opportunities versus non-labor income shocks. Results indicate that the reduction in crime seems to be driven by non-leaseholders. This is consistent with those not receiving income through alternative means being more responsive to increased job opportunities. However, I note that the effect sizes are not statistically distinguishable.

To my knowledge, this is the first paper to identify effects of economic shocks on individuals' criminal behavior separate from the effect of migration. In doing so, it contributes to two bodies of literature.

[2]North Dakota is well suited for this analysis as it was the third-slowest-growing state in 2000, and increased its real gross domestic product 115% by the end of the fracking boom in 2016 (U.S. Bureau of Economic Analysis, 2018). Also, it is the second largest crude oil producing state in the United States.

First, it contributes to the literature showing how aggregate crime changes in response to plausibly exogenous shocks to economic conditions (e.g., Dix-Carneiro, Soares and Ulyssea, Forthcoming; Axbard, 2016; Grinols and Mustard, 2006; Gould, Weinberg and Mustard, 2002; Raphael and Winter-Ebmer, 2001; Evans and Topoleski, 2002; Montolio, 2018; Grieco, 2017). These studies generally show aggregate crime is inversely related with economic conditions, with some exceptions.

In particular, this paper complements a subset of this literature that has documented the role of criminal opportunity and income inequality in explaining the observed increases in aggregate crime that arise during economic expansions (e.g., Mejia and Restrepo, 2016; Cook, 1986). For example, Freedman and Owens (2016) study the effect of BRAC funding in San Antonio on crime using individual-level data. They find an increase in property-related crime in neighborhoods with a high composition of construction workers, those most likely to benefit from the economic shock, and that crime is more likely to be committed by individuals with a prior criminal record, and thus unable to be employed by the project. In a similar way, this paper documents that once one accounts for population changes that accompany economic expansions, one observes the expected relationship between improved job opportunity and individual crime. Together, the findings of those papers and this paper suggest that both criminal opportunity as well as shifts in population can explain the puzzling finding that aggregate crime shifts during economic expansions.

Second, this study contributes to the growing literature on the effects of fracking, which has transformed many regions in the United States. Specifically, crime has generally been shown to increase in areas with fracking activities (Alexander and Smith, 2017; Andrews and Deza, 2018; Komarek, 2017; Bartik, Currie, Greenstone and Knittel, 2016).[3] However, the increase could be driven by changes in the population of workers moving to the area or an individual's response to the changing economic conditions. I measure a similar increase in aggregate cases filed in fracking counties, but find that local residents in the county are actually less likely to commit crime when exposed to relatively stronger labor market conditions. This is consistent with predictions of the economic theory of crime when the returns to legal employment increase, and indicates that fracking has reduced individuals' propensity to commit crime.[4]

[3] Alternatively, Feyrer, Mansur and Sacerdote (2017) do not find statistically significant evidence of an increase in crime across all counties with fracking.

[4] This is also consistent with empirical evidence documenting a similar inverse relationship between recidivism and

Finally, while the primary purpose of this study is to examine the role of economic expansions on the criminal behavior of local residents, this study's findings on aggregate crime also speak to the literature on (im)migration and crime. Immigration to the United States and Western Europe typically increases in response to improved relative economic opportunity in those countries. Many worry that the immigration to high-income countries could increase crime rates, though some recent empirical evidence suggests this fear may be misplaced (Bell, Fasani and Machin, 2013; Chalfin, 2015; Spenkuch, 2013; Miles and Cox, 2014; Butcher and Piehl, 2007).[5] Results on aggregate crime presented here indicate that the migration of mostly young, American men does lead to increased crime overall. Thus, changing the composition of a local population can be an important driver of criminal activity, although the effects may depend heavily on who the migrants are. Since young men are a particularly crime-prone population, economic booms that attract this group may be more likely to lead to higher crime rates.

2 Background

Advances in hydraulic fracturing contributed greatly to the recent oil boom in the United States. From 2000 to 2015, oil produced from fractured wells increased from 2% to over 50% of domestic production, increasing total oil production faster than at any other point in time (EIA 2018a). It suddenly became more profitable due to a breakthrough in directional drilling, hydraulic fracturing technologies, and seismic imaging (Wang and Krupnick, 2013; Crooks, 2015). Hydraulic fracturing involves injecting fluids at a high pressure into a shale play in order to crack the rock formation and extract tight oil and shale gas.[6] This process allowed mineral resources to be extracted from shale plays that were previously not economically viable.

Notably, the Bakken formation in North Dakota, smaller only than the Permian and Eagle Ford

economic conditions (e.g., Agan and Makowsky, 2018; Yang, 2017; Galbiati, Ouss and Philippe, 2018; Schnepel, 2017), as well as increased lifetime criminal behavior for cohorts graduating high school in harsher economic conditions (Bell, Bindler and Machin, Forthcoming)

[5]While the overall evidence on this question is mixed, Bell, Fasani and Machin (2013) finds no effect on violent crime and mixed effects on property crime, Chalfin (2015) shows an increase in aggravated assaults, but decreases in other crimes, and Spenkuch (2013) reports small increases in crime, particularly financial crime. Relatedly, Miles and Cox (2014) finds no effect of a deportation policy on local crime. Moreover, Butcher and Piehl (2007) shows that immigrants typically have lower crime rates than do native-born residents potentially due to a combination of heavy screening of would-be migrants, and self-selection of those migrants.

[6]The Energy Information Administration defines a shale play as a "fine-grained sedimentary rock that forms when silt and clay-size mineral particles are compacted, and it is easily broken into thin, parallel layers. Black shale contains organic material that can generate oil and natural gas, which is trapped within the rock's pores" (2018). I focus on oil production as North Dakota's production is typically only 10-20% gas, with the rest being oil.

formation in Texas in crude oil production, is one such formation. Figure 1 shows the 17 counties that produce oil and gas in North Dakota, classified by production levels as either a core (major) or balance (minor) county. Four counties make up the major fracking counties producing 80% of North Dakota's oil from 2000-2017, with the remaining 13 producing 20%.

Companies leased the mineral rights required for production from individuals or agencies in exchange for a portion of total revenue. Figure 2a plots the number of leases signed by households in North Dakota each year from 2000 to 2017. It is clear that lease signing spiked in 2004 signaling when companies first began investing in hydraulic fracturing in North Dakota. Similarly, Figure 2b graphs total oil production in North Dakota showing that production lagged leasing by a few years, starting to increase in 2008. From 2008 to 2017, North Dakota produced oil valued at an estimated $2,904,191 million dollars.[7]

Perhaps unsurprisingly, the presence of hydraulic fracturing activities has had a substantial impact on local labor markets. Feyrer, Mansur and Sacerdote (2017) estimate that every one million dollars of new production generates 0.78 jobs and $66,000 in wages in counties with a shale play across the United States.[8] Similarly, in response to the stronger labor markets, Wilson (2017) estimates that the in-migration of workers increased the baseline population in fracking counties by 12% on average in North Dakota. Additionally, individuals who also owned mineral rights received 10-20% percent of production revenues through royalty payments. As I show in the next section, I estimate that the average leaseholder earned a royalty of $36,000 per month, which is a substantial non-labor income shock.

Figure 3 shows that prior to the fracking boom, counties in North Dakota are relatively similar in terms of per capita income, total jobs, population, and total officers. The leasing period, when residents first knew of the fracking boom, was characterized by slight increases in per capita income, total jobs, and population (2004 to 2008). Oil production began ramping up in 2008 and is the more labor-intensive period. This is when companies began offering high paying jobs and moving in a large number of workers, often into camps due to housing shortages. It is also the period when the majority of households that had signed a lease received royalty payments and increases in overall crime were reported. This is reflected in the data, as Figure 3 shows fracking counties experienced large increases in income, jobs, population,

[7] This estimate is calculated based on total monthly oil production in North Dakota and the monthly North Dakota oil first purchase price.

[8] Other papers estimating increases in wages and employment from fracking activities include Bartik, Currie, Greenstone and Knittel (2016); Allcott and Keniston (2017); Fetzer (2014); Maniloff, Mastromonaco et al. (2014); Weber (2014) and Gittings and Roach (2018) to name a few.

and police officers during the post-2008 production period. While the economic opportunities continued through this period, counties changed in several other ways as well. As a result, in my analysis I will estimate the effect of expected economic opportunity that occurs after signing but before drilling, as well as the effect of drilling. I expect the former will pick up the effect of job opportunities both expected and realized, while the latter will measure the effect of job opportunities along with large population and income changes.

Economic theory predicts that the labor market changes from fracking activities may affect crime in several ways. First, the additional jobs and higher wages should induce individuals to substitute away from illegal activities now that the returns to legal activities are higher. Alternatively, the large cash transfers—via royalty payments—to some households may lead to more crime through increased income inequality and opportunity of crime. Additionally, the increased income through either royalties or higher wages could affect crime by easing financial constraints or providing more disposable income to consume goods that may complement crime (e.g. alcohol). Finally, the large migration effects observed in the production period are likely to affect crime both through population increases and compositional changes.

There are three main advantages of studying the effect of positive economic shocks on crime in this context. First, the sudden increase in hydraulic fracturing activities creates plausibly exogenous variation in exposure to improved labor market conditions. Second, I am able to distinguish the effect on crime by the existing population from aggregate effects which include individual changes in behavior as well as compositional changes. Specifically, I am able to focus my analysis on households already living in the area using directory files in each county to identify residents. Finally, I can study how these residents respond to changes in economic opportunity as well as the economic opportunity plus the subsequent influx of people and income by examining both the earlier leasing period and the more labor-intensive production period.

3 Data

For this analysis, it is necessary to identify residents in years prior to the fracking boom to account for migration. To do this, I collect a list of all rural residents for each county in North Dakota prior to

2008 from the Great Plains Directory Service.[9] Households listed in these directories represent roughly 20% of all households in North Dakota during this time. The directory information includes the name, address, and city of all rural residents.[10] In total, there are 31,169 households defined by resident last name, street number, city, and zip code. I consider this to be the universe of households for which I match to lease and crime data using a Levenshtein index.[11]

One potential concern with identifying residents is that some people may have moved into fracking counties prior to the large in-migration associated with the production period. For example, strategic households may move in advance to have first access to housing or jobs. However, to be recorded in the resident directories, any movers would have to move into the rural areas. If this were the case, we would expect to see an increase in property sales prior to the production period. I show in Figure A.1 that property sales in fracking counties remain similar to sales in non-fracking counties throughout the leasing period. Thus, the residents in directory files are likely all long-time residents of the county.

All leases spanning from 2000 to 2017 in North Dakota are collected from Drilling Info, a private company designed to aid companies participating in all steps of mineral production. Data include name and address of the grantor, company listed as grantee, number of acres leased, royalty rate, and date of record. Production data at the county- and well-level are collected from the North Dakota Department of Mineral Resources. I use these datasets to approximate the amount of monthly oil production from a given well that is attributed to an individual leaseholder. This amount is dollarized using the North Dakota Crude Oil First Purchase Price to estimate the amount leaseholders receive in the form of royalty payments.[12]

The State of North Dakota Judicial Branch provided restricted administrative data on all criminal cases filed in North Dakota from 2000 to 2017. Importantly, data include identifying information includ-

[9] All counties are included except Cass, Grand Forks, Pembina, and Traill, which are not covered by the Great Plains Directory Service during this time.

[10] Notably, residents living within city limits are not included in the directories and thus are not considered in this analysis.

[11] I allow matches with a string distance of 2 or less. In practice, this means two strings are matched across datasets if there are only two changes that need to be made to the concatenated string of last name, street number,city, and zip code in order for them to be exact matches. In Table A.1, I show that main results are robust to this index.

[12] Each well in North Dakota is assigned a spacing unit which defines the area of land surrounding the well with rights to production. These boundaries are determined in court hearings at the request of the proposed well operator and based on recommendation of geologists. By matching leaseholders to spacing units, I define the proportional interest in monthly production for each leaseholder based on acres leased. The dollar value is calculated using the monthly North Dakota Crude Oil First Purchase Price which I subtract $10/barrel to account for post production costs, namely transportation. I deduct 10% for severance tax, as North Dakota collects 5% for gross production in lieu of property tax on mineral rights and 5% for oil extraction. Leaseholders then get a fraction of depending on their negotiated royalty rate, typically 12-18%.

ing the name, date of birth, and address of individuals charged with a crime. This allows me to link to residential files and identify crime committed by local residents. I also observe the file date, specific charges filed, disposition of each charge, sentence received, and county of filing for every case.

There are two main advantages to using cases filed as a measure of criminal behavior. First, it is considerably more serious than 911 calls or arrests, as an individual has officially been charged with a crime. This is reflected by the fact that only 61% of all arrest charges in North Dakota were filed by the prosecutor's office over the last five years (North Dakota Attorney General Office 2018). As a result, charges filed are arguably a less noisy measure of criminality than the other possible alternatives. Additionally, the State of North Dakota specifically advises employers not to ask about prior arrests as "an arrest does not mean that someone actually committed a crime" (North Dakota Department of Labor and Human Rights 2018). Second, since cases filed are recorded in an administrative database, they do not suffer from voluntary reporting practices or a lack of coverage, particularly in areas that are sparsely populated. Additionally, these data report information on all charges, including offenses which are often not tracked in other commonly used datasets such as drug charges or driving while under the influence.

Summary statistics are shown in Table 1. Close to 20% of households are ever charged with a crime from 2000 to 2017 (Table 1, Panel A). The types of charges filed for this population, namely rural residents, are summarized in Panel C. The majority of crimes are misdemeanors (∼90%), with driving-, drug-, and property-related charges making up roughly 38%, 17%, and 14.5% of all charges, respectively. Smaller crime categories representing less than 10% of all charges, such as assault (4%), are grouped together in other charges. Of these households, roughly 20% sign a lease and may receive royalty payments during this period (Table 1). Close to 40% of leaseholders in my sample actually received payments during this period, with the average leaseholder receiving $36,000 per month. These royalty payments can be thought of as an additional treatment over the local economic shock, as some residents in fracking counties receive large, additional lump sums of money while others do not.

4 Methodology

4.1 Main analysis

The unexpected rise in fracturing activities coupled with spatial variation in the shale play provide a plausibly exogenous shock to local economic conditions. Using a generalized difference in differences framework, I compare the criminal behavior of residents in counties within the shale play to residents in counties outside the shale play before and after the fracking boom.[13] Given the timing of fracking activities and subsequent changes in affected counties, I consider the effects separately in each period: leasing (2004 to 2008) and production (2008 to 2017). Formally, I estimate the effects of local economic shocks on criminal behavior with the following linear probability model:

$$\begin{aligned} CriminalBehavior_{ht} &= \alpha_h + \gamma_t \\ &+ \theta_1 FrackingCountyXPostLease + \theta_2 FrackingCountyXPostProduction_{ht} + \epsilon_{ht} \end{aligned} \tag{1}$$

where criminal behavior is a binary indicator for whether a case was filed for household h in year t.[14] Criminal behavior is also separated into the four largest crime categories: property, driving, drug and other. Household fixed effects, α_h, account for any static differences in the propensity to commit crime across households. Year fixed effects, λ_t, control for factors that affect criminal behavior for all households in a given year, such as the Great Recession. $FrackingCountyXPostLease_{ht}$ and $FrackingCountyXPostProduction_{ht}$ are indicator variables equal to 1 for households in fracking counties during the leasing period and during the production period, respectively. Here, θ_1 and θ_2 are the coefficients of interest measuring the difference in criminal behavior of residents in fracking counties relative to residents in non-fracking counties in each of the treatment periods.

The assumption behind this approach is that residents' criminal behavior in fracking counties would have changed similarly over time with residents' criminal behavior in non-fracking counties, absent hydraulic fracturing activities. I check this assumption in several ways. First, I provide visual evidence that treated and control counties are tracking prior to any treatment. Relatedly, I formally test for

[13] I also report aggregate county-level estimates of equation 1 in appendix Figure A.3 for comparison.

[14] Since the dependent variable is binary, I additionally show results using a logistic regression in Table A.2. I also show results for the intensive margin using both the number of individual cases filed and the total number of charges in a given year using the Inverse Hyperbolic Sine (IHS) transformation and Poisson models.

pre-divergence using the above regression model with an indicator for the treated group one year before treatment. Additionally, I allow counties to trend differently over time by including county-specific linear time trends. I also include interactions between pre-treatment controls and year effects. In doing this, I allow for counties with different levels of observable characteristics, such as per capita income, to respond differentially to year-to-year shocks.

In all models, robust standard errors are clustered at the county level, allowing errors to be correlated within a county over time. I also report permutation-based inference for the primary specification when considering all crime, similar in spirit to Abadie, Diamond and Hainmueller (2010) for inference when using the synthetic control method. For this, I randomly assign treatment to 17 counties and compare the estimated coefficient to 1000 placebo estimates to compute p-values. In addition, I report False Discovery Rate (FDR) Adjusted Q-values when estimating effects separately by crime type (property, driving, drug, and other) following Anderson (2008). FDR Adjusted Q-values correct for the increased likelihood of rejecting the null hypothesis when making multiple comparisons, and are interpreted similar to p-values.

Given that some counties have larger shocks than others, detected effects could be driven solely by counties with more extreme local shocks. However, it is beneficial to know if smaller economic shocks also affect criminal behavior. Therefore, I also consider heterogeneous effects by the amount of fracking activity experienced by a county. Specifically, I estimate the treatment effect for the four major oil and gas producing counties as defined by the Labor Market Information Center, namely Dunn, McKenzie, Mountrail, and Williams, separate from the effect in the thirteen minor fracking counties.

4.2 Effects by leaseholder status

Finally, I examine the potentially differential effects of fracking on leaseholders and non-leaseholders. As previously discussed, some households receive large sums of money in the form of royalty payments while others do not. This creates the potential for increased crime due to changes in both income inequality and criminal opportunities. I consider leaseholders and non-leaseholders within fracking counties as separate treated groups, comparing each of them to residents in non-fracking counties. To the extent that signing or not signing a lease and receiving royalty payments is also a form of treatment, this strategy separates

the effect on the two groups living in fracking areas. Formally, I estimate the following regression model:

$$\begin{aligned} CriminalBehavior_{ht} &= \alpha_h + \lambda_t \\ &+ \beta_1 LeaseHolderXPostLease_{ht} + \beta_2 LeaseHolderXPostProduction_{ht} \\ &+ \phi_1 NonLeaseholderXPostLease_{ht} + \phi_2 NonLeaseholderXPostProduction_{ht} + \epsilon_{ht} \end{aligned} \tag{2}$$

where variables are defined as in equation 1. Now, β_1 and β_2 measure the change in criminal activity by leaseholders in fracking counties compared to residents in non-fracking counties during fracking activities. They capture both the effect of job opportunities and the additional income received by leaseholders in the form of royalty payments. Similarly, ϕ_1 and ϕ_2 measure changes in criminal activity by non-leaseholders in fracking counties to residents in non-fracking counties. Alternatively, they capture the effect of higher wages and job opportunities, along with any potential effect of not receiving royalty payments for non-leaseholders. As in the previous models, equation 2 is estimated using two periods: leasing starting in 2004 and production beginning in 2008. Notably, leaseholders receive a small signing bonus upfront with royalty payments closely following production, as leaseholders receive a percentage of production revenues.

5 Results

5.1 Main Results

I begin by estimating the overall effect of local economic shocks on crimes committed by residents. As noted above, I consider only the population of residents prior to the fracking boom in North Dakota. In doing so, I am able to exclude all crimes committed in the county by new workers who migrated to the relatively stronger labor markets. In this way, I can distinguish the effect of the economic shock from the impact of the changing demographics on overall crime rates.

First, I graph the estimated divergence over time in crimes committed by residents in fracking and non-fracking counties, relative to the difference between the two sets of counties in 2000 and 2001. Figure 4 plots the dynamic difference-in-differences estimates for all crimes, controlling for household and year fixed effects. Importantly, there is no evidence of divergence prior to the start of the fracking boom in 2004. This supports the identifying assumption that absent hydraulic fracturing activities,

residents in fracking counties would have experienced similar changes in criminal behavior as residents not in fracking counties. Additionally, the figure indicates that the probability of being charged with a crime falls in fracking counties when leasing starts, then rises some during the production process. This suggests economic opportunity is reducing crime, but the effect seems to be offset at least somewhat by the indirect effects that accompany oil production. For example, the production period also includes interactions with new workers and increases in disposable income from royalty payments or high-paying drilling jobs. I report the average treatment effects for each period in Table 2.

Starting with the leasing period, Column 1 indicates an initial drop of 0.44 percentage points in overall crime by residents in fracking counties relative to residents in non-fracking counties. This translates to a 22% drop in cases filed and is statistically significant at the 1% level. Moreover, the permutation-based p-value is less that 1% with 1 out of 1000 placebo estimates less than -0.0044, shown graphically in Figure A.4. In Column 2, I formally test for pre-divergence and find no evidence of it, with the coefficient on the lead indicator being close to zero, -0.0009, and statistically insignificant. In column 3, I allow for county-specific linear trends. This allows for both observable and unobservable county characteristics to change linearly over time. If results are driven by fracking counties being on a different path than non-fracking areas, then adding a county-specific linear trend should absorb the treatment effect. However, results indicate the coefficient increases slightly to -0.50 percentage points. Finally, counties with different baseline populations, total jobs, officers, per capita income, and production may respond differentially to year-to-year shocks. For example, if fracking counties also tend to be smaller in population then detected effects could be a result of small counties differentially responding to yearly shocks. In Column 4, I allow these observable characteristics in 2000 to differentially affect criminal behavior each year. The magnitude remains stable at -0.50 percentage points. Notably, all coefficients are statistically significant at the 1% level, and the estimated effect is robust to the inclusion of various controls and a lead term.

Overall, estimates in Table 2 are consistent with Figure 4 in showing that while there is a significant drop in criminality initially, the drop is somewhat diminished in the production period. Column 1 indicates a 0.27 percentage point reduction in cases filed for residents in fracking counties compared to residents in non-fracking counties, although not statistically significant at conventional levels. The permutation-based p-value is marginally significant at 8.8%, with 88 of the 1000 placebo estimates less

than or equal to the estimated coefficient. Moving across columns 2 through 4, coefficients remain negative ranging from -0.18 to -0.43 percentage points, and only two of which are significant at the 10 percent level. It appears as though the reduction in criminal behavior from the boost in economic activity may be at least somewhat offset by additional effects on criminal behavior during the production period. This could be due to the effects of in-migration such as peer effects and increased social interaction (Glaeser, Sacerdote and Scheinkman, 1996; Ludwig and Kling, 2007; Bernasco, de Graaff, Rouwendal and Steenbeek, 2017), or to an increase in the number of bars and illegal markets.[15]

To better understand the type of crime affected by local economic shocks, I present treatment effects separately for financial-related crimes (e.g. theft, criminal mischief, fraudulent checks), driving-related crimes (e.g. DUIs, reckless driving), drug-related crimes (e.g. possession), and other crimes (e.g. assault, resisting arrest, criminal conspiracy). The dynamic difference-in-differences estimates, controlling for household and year fixed effects, are plotted for each crime type in Figure 5. Notably, the figures show that residents in fracking and non-fracking counties do not diverge prior to the fracking boom in these types of crime. However, residents exposed to fracking activities change their criminal behavior relative to residents in non-fracking counties in response to the economic shock. Results show relatively large reductions in driving, drug, and other offenses after the leasing period. However, this reduction is diminished once production starts.

I follow the same format as Table 2 reporting average treatment effects for each period in Table 3, with panels for each crime type and reported FDR Q-values for statistical inference. Panel A indicates a -0.06 to -0.16 percentage point decrease in property cases filed during the leasing period, and a -0.11 to -0.20 percentage point decrease during the production period. Similarly, estimates are negative for driving-related cases during the leasing (-0.21 to -0.22 percentage points) and production period (-0.02 to -0.09 percentage points). Panel C shows a decrease in drug cases filed of -0.20 to -0.28 percentage points during the leasing period, and a reduction of 0.04 to -0.15 percentage points during the production period. Finally, all other crimes have a similar negative effect during the leasing period ranging from -0.15 to -0.25, with a smaller effect once production began ranging from -0.04 to -0.22 percentage points. All coefficients are fairly robust to the inclusion of controls and a lead term.

[15] This is graphically depicted in Figure A.2 with a large increase in the average total number of liqour licenses per county in counties with major fracking activity.

Because I consider four types of crime, I also report statistical significance of these estimates using the Adjusted False Discovery Rate Q-values proposed in Anderson (2008). These values correct for the increased chance of rejecting the null hypothesis when making multiple comparisons for two treatments across four groups (eight categories). The negative effects on driving and property cases are generally not statistically significant once corrected for multiple comparisons. However, the effect on drug cases filed during the leasing period is sufficiently large across all specifications in Column 1 through 4 as to not have occurred by chance with Q-values of 0.076, 0.049, 0.062, and 0.052, respectively, and no statistical effect during the production period. The effect on all other cases is less robust with two of the four FDR Q-values less than 0.10 during the leasing period, again with no estimated effect once production began.

For comparison, I also report the effect of hydraulic fracturing activities on aggregate changes in cases filed per 1000 persons. Appendix Figure A.3 plots the dynamic coefficients from the county level model of equation 1, with county and year fixed effects, for all cases and by case type. Again, counties do not diverge prior to fracking activities. However, estimates indicate increases in total cases filed, as well as drug, driving, assault, and all other cases during the fracking periods, specifically during production, which is consistent with prior literature.

Additionally, I test whether the migrants entering the fracking counties were committing crimes at higher rates than the native population. This enables me to speak directly to a question of interest in the immigration literature of whether those moving into an area are more criminogenic in general. I measure the propensity to commit crime for a subset of those moving into the county. Specifically, I calculate the crime rate using the number of cases filed with an out-of-state address over the number of migrant tax exemptions filed in the county. Similarly, I do the same for all crime committed by those with an address in North Dakota and the number of non-migrant tax exemptions in the county, fixing the total as of 2000. I find that the crime rate from 2004-2015 is higher for those moving into the county at 17%, as measured by crime committed by out-of-state individuals, compared to a rate of 7% for in-state individuals.[16]

[16]Notably, this can be thought of as a conservative estimate. First, the crime rate for people moving into the county only considers crime from out-of-state individuals even though there is some in-migration to fracking counties from other areas in North Dakota. This also means that any additional crimes committed by those that move into the county from within the state are being considered as crimes committed by non-migrants for this exercise. Second, migrant and non-migrant tax exemptions are based on whether there is a change in filing county and state. The denominator for out of state is the total of all inflows from 2000 through 2015 to be conservative. Similarly, I fix the total number of non-migrants in each county at the total in 2000 for each year as migrants that move into the area will be counted as non-migrants in their second year residing in the county.

Taken together, findings provide strong evidence of a reduction in residents' criminal behavior during the leasing period; these effects seem to be partially reduced by other effects during the production period. While all crime types are negative, results are primarily driven by drug-related crimes. This contrasts the county-level results, suggesting that compositional changes play an important role in the criminal response to economic conditions. Put differently, this suggests that the aggregate increases seen are due largely to additional crimes committed by those who move into the area. In contrast, the effect of the economic opportunity itself seems to have a negative effect on overall crime.

5.2 Results by intensity

Results thus far have treated all counties on the shale play as receiving the same economic shock. However, some counties experience much larger economic shocks than others, particularly the four major oil and gas producing counties. Specifically, the oil production in each of these four counties was greater than the amount produced in the other 13 counties combined over this time period. To estimate the differential effect by treatment intensity, I report estimates from equation 1 separately for major and minor fracking counties in Table 4. Following the same format as Table 2, I first discuss estimates for minor and major fracking counties during the leasing period, 2004 to 2008. Estimates in Column 1 indicate a 0.39 percentage point decrease in cases filed by residents in counties with minor fracking activity and a 0.55 percentage point decrease in the major fracking counties, significant at the 5% and 10% level respectively. This represents a 19.5% reduction in cases filed in counties with minor fracking activity and a 27.5% reduction in the major fracking counties. The estimated effect is stable to the inclusion of a lead indicator, county specific trends, and allowing for time-shocks that vary with levels of pre-period observables. Estimates in Columns 2 to 4 range from a 0.39 to 0.44 percentage point decline in minor fracking counties and 0.60 to 0.75 in major fracking counties. All estimates are significant at conventional levels.

During the production period, estimates for minor fracking counties are similar in magnitude ranging from a 0.19 to 0.40 percentage point reduction in cases filed, although marginally significant. Estimates for major fracking counties are smaller in magnitude during the production period relative to the leasing period (-0.07 to -0.62 percentage points), and not consistently significant at conventional levels.

As expected, the effect is larger in magnitude for the major fracking counties than in minor fracking

counties initially, although coefficients are not statistically different. Importantly, this demonstrates that the effect is not driven solely by the four large fracking counties, as counties experiencing more modest economic shocks also see a significant reduction in crime. Additionally, the effect seems to fade more dramatically in the major fracking counties which also experience larger population and income changes during the production period. This is consistent with the interpretation that it is the other consequences of the in-migration, such as peer effects, and income that lead to a diminished reduction in crime for residents.

5.3 Results by lease-holder status

In addition to the local economic shock, some residents in fracking counties also receive a large positive income shock in the form of oil royalties during the production period. Recall that the average household that signs a lease receives over $30,000 dollars per month from royalty payments. These payments may affect the decision to commit crime both for the leaseholder and the non-leaseholder as payments increase disposable income for illegal activities by leaseholders while increasing the income inequality and criminal opportunities for non-leaseholders. In Table 5, I estimate the extent to which the fracking activities may differentially affect residents using equation 2.

Estimates for lease-holders are all negative during leasing (-0.21 to -0.28 percentage points) and production (-0.08 to -0.27 percentage points), although none are significant at conventional levels. Estimates for non-lease-holders range from -0.66 to -0.70 percentage points during the leasing period and are all significant at the 1% level. During the production period, estimates range from -0.34 to -0.59 for non-lease holders, with three of the four estimates significant at the 5% level. While these estimates are not statistically different from each other, it is clear that the overall reductions in crime shown in Table 5 are primarily driven by reductions in crime by those who do not receive royalty payments. This suggests that it is the increase in job opportunities that reduces crime, rather than income per se. Moreover, the effect of job opportunities seems to be stronger than the effect of increased criminal opportunities.

6 Discussion

In summary, I find that crime decreases during the leasing period in response to improved job opportunities, and that the effect is partially reduced once drilling activities escalate throughout the production

period. Importantly, the effect is not driven by the four largest oil producing counties, and the fact that the effect shrinks more in these counties suggest that other factors related to production contribute to offsetting the effect of improved labor market conditions. Additionally, I find that effects are strongest for non-leaseholders and persist into the production period. This is consistent with those not receiving alternative income streams being most sensitive to the job opportunities.

One concern in interpreting the results described above is that the differences over time may be due to changes in the number of police. Becker (1968) and others highlight that the probability of detection factors into an individual's decision to commit crime, which is also echoed in the lab (Harbaugh, Mocan and Visser, 2013). Moreover, empirical evidence has shown that crime decreases in response to increased police presence (di Tella, 2004; Machin and Marie, 2011). To test for changes in the police force, I estimate the main model at the county level with total police officers as the outcome of interest. Figure 6a, indicates that change in the amount of police officers was negligible during the leasing period. As a result, changes in police are unlikely to be driving the significant reduction in crime observed during the leasing period. However, changes in police are potentially part of the treatment during the production period, although this is difficult to disentangle from other factors that changed during that period. Similarly, reductions in police resources from population increases may lead to fewer reported cases filed (Vollaard and Hamed, 2012). Figure 6b shows little evidence of changes in the population from 2004 to 2008, with large increases during the more labor-intensive production period. Again, population changes are less of a concern during the leasing period, but are likely to be a part of the treatment effects after 2008 as previously discussed.

Relatedly, a concern may be that people identified as residents may have moved out of the county or, more importantly, the State of North Dakota during the fracking periods. This could be an issue if changes in crime are simply from not observing the criminal behavior of an individual that moved out of the state. Anecdotally, it seems improbable that residents would disproportionately move out of fracking counties as economic conditions improved. I empirically check for evidence of out-migration using the number of tax exemptions that move out of a county each year. I find no evidence of differential out-migration during the initial leasing period and only signs of out-migration toward the end of the production period when those that had moved into the county begin leaving as shown in Figure 7

While I am not able to directly test for the mechanism underlying the decrease in crime from improved

economic opportunities, I suggest two potential pathways. First, it is possible that decreases in crime are the result of an incapacitation effect, as individuals become occupied with legal work and thus have less time for criminal activities. This is similar to school having an incapacitation effect on juvenile crime (Jacob and Lefgren, 2003). A second explanation is that residents may no longer feel the need to engage in activities related to crime, such as drug use, given their improved economic outlook. This is consistent with work by Case and Deaton (2015; 2017) and Autor, Dorn and Gordon (forthcoming), who document an increasing number of deaths from drugs, alcohol and suicide associated with deteriorating economic conditions. This is also consistent with Becker (1968) which predicts individuals are less likely to engage in criminal activity if they have more to lose if apprehended. As a result, a more positive outlook on economic conditions, whether expected or realized, may also lower crime.

7 Conclusion

This paper studies the effect of local economic shocks on individuals' decisions to commit crime. Specifically, I exploit the recent boom in hydraulic fracturing activities as a plausibly exogenous shock to local economic conditions. Using detailed administrative data on all criminal cases filed in North Dakota from 2000 to 2017, I estimate the effect of increased job opportunities on criminal behavior. An important strength of this study is that by focusing the analysis on all rural residents already living in the area prior to fracking, I can distinguish the effect of improved economic opportunity from the effect of population inflows on aggregate crime.

Results indicate that, consistent with the existing literature, aggregate crime increased in fracking counties relative to non-fracking counties. This was particularly true during the more labor-intensive fracking activities. However, local residents engage in less criminal activity at the start of the boom with a smaller effect in later years. Effects are largest and most robust for drug offenses, and are shown across all counties with fracking activity. Additionally, I show that effects are most pronounced for residents that do not also receive royalty payments. Taken together, results suggest that residents reduce their criminal activity in response to improved job opportunities, but that other changes from local economic shocks, such as peer composition, seems to reduce this effect. This is consistent with economic opportunities reducing crime and highlights the role of compositional changes on the aggregate effects on crime.

References

Abadie, Alberto, Alexis Diamond, and Jens Hainmueller, "Synthetic control methods for comparative case studies: Estimating the effect of California's tobacco control program," *Journal of the American statistical Association*, 2010, *105* (490), 493–505.

Agan, Amanda and Michael Makowsky, "The Minimum Wage, EITC, and Criminal Recidivism," 2018.

Alexander, James and Brock Smith, "There will be blood: Crime rates in shale-rich U.S. counties," *Journal of Environmental Economics and Management*, 2017, *84*, 125–152.

Allcott, Hunt and Daniel Keniston, "Dutch disease or agglomeration? The local economic effects of natural resource booms in modern America," *The Review of Economic Studies*, 2017, *85* (2), 695–731.

Anderson, Michael L, "Multiple inference and gender differences in the effects of early intervention: A reevaluation of the Abecedarian, Perry Preschool, and Early Training Projects," *Journal of the American statistical Association*, 2008, *103* (484), 1481–1495.

Andrews, Rodney J and Monica Deza, "Local natural resources and crime: Evidence from oil price fluctuations in Texas," *Journal of Economic Behavior & Organization*, 2018, *151*, 123–142.

Autor, David, David Dorn, and Hanson Gordon, "When Work Disappers: Manufacturing Decline and the Falling Marriage Market Value of Young Men," *American Economic Review: Insights*, forthcoming.

Axbard, Sebastion, "Income Opportunities and Sea Piracy in Indonesia: Evidence from Satellite Date," *American Economic Journal: Applied Economics*, 2016, *8* (2), 154–194.

Bartik, Alexander, Janet Currie, Michael Greenstone, and Christopher Knittel, "The local economic and welfare consequences of hydraulic fracturing," 2016.

Becker, Gary S, "Crime and punishment: An economic approach," *Journal of Political Economy*, 1968, pp. 169–217.

Bell, Brian, Anna Bindler, and Stephen Machin, "Crime Scars: Recessions and the Making of Career Criminals," *Review of Economics and Statistics*, Forthcoming.

Bell, Brian, Francesco Fasani, and Stephen Machin, "Crime and immigration: Evidence from large immigrant waves," *Review of Economics and statistics*, 2013, *21* (3), 1278–1290.

Bernasco, Wim, Thomas de Graaff, Jan Rouwendal, and Wouter Steenbeek, "Social interactions and crime revisited: An investigation using individual offender data in Dutch neighborhoods," *Review of Economics and Statistics*, 2017, *99* (4), 622–636.

Besley, Timothy and Anne Case, "Unnatural experiments? Estimating the incidence of endogenous policies," *The Economic Journal*, 2000, *110* (467), 672–694.

Butcher, Kristin F and Anne Morrison Piehl, "Why are immigrants' incarceration rates so low? Evidence on selective immigration, deterrence, and deportation," 2007. NBER Working Paper 13229.

Card, David and Laura Giulliano, "Peer Effects and Multiple Equilibria in the Risky Behavior of Friends," *Review of Economics and Statistics*, 2013, *95* (4), 1130–1149.

Case, Ann and Angus Deaton, "Rising morbidity and mortality in midlife among white non-Hispanic Americans in the 21st century," *PNAS*, 2015, *112* (49), 15078–15083.

Case, Ann and Angus Deaton, "Mortality and morbidity in the 21st century," *Brookings Pap Econ Act*, 2017, pp. 397–476.

Chalfin, Aaron, "The Long-Run Effect of Mexican Immigration on Crime in US Cities: Evidence from Variation in Mexican Fertility Rates," *American Economic Review Papers & Proceedings*, 2015, *105* (5), 220–25.

Cook, Philip, *The Supply and Demand of Criminal Opportunities*, Vol. 7 1986.

Crooks, Eds, "The US Shale Revolution," 2015. Financial Times Accessed 1-August-2018 https://www.ft.com/content/2ded7416-e930-11e4-a71a-00144feab7de.

di Tella, Rafael, "Do Police Reduce Crime? Estimates Using the Allocation of Police Forces After a Terrorist Attack," *American Economic Review*, 2004, *39* (1), 65–73.

Dix-Carneiro, Rafeal, Rodrigo Soares, and Gabriel Ulyssea, "Economic Shocks and Crime: Evidence from the Brazilian Trade Liberalization," *American Economic Journal: Applied Economics*, Forthcoming.

Evans, William N and Julie H Topoleski, "The social and economic impact of Native American casinos," 2002. National Bureau of Economic Research Working Paper.

Fetzer, Thiemo, "Fracking growth," 2014.

Feyrer, James, Erin Mansur, and Bruce Sacerdote, "Geographic dispersion of economic shocks: Evidence from the fracking revolution," *American Economic Review*, 2017, *107* (4), 1313–34.

Freedman, Matthew and Emily Owens, "Your Friends and Neighbors: Localized Economics Development and Criminal Activity," *Review of Economics and Statistics*, 2016, *98* (2), 233–253.

Galbiati, Roberto, Aurelie Ouss, and Arnaud Philippe, "Jobs, News and Re-offending after Incarceration," 2018.

Gittings, R. Kaj and Travis Roach, "Who really benefits from a resource boom? Evidence from the Marcellus and Utica Shale Plays," 2018. Working Paper.

Glaeser, Edward, Bruce Sacerdote, and Jose Scheinkman, "Crime and Social Interactions," *Quarterly Journal of Economics*, 1996, *11* (2), 507–548.

Gould, Eric, Bruce Weinberg, and David Mustard, "Crime rates and local labor market opportunities in the United States: 1979–1997," *Review of Economics and statistics*, 2002, *84* (1), 45–61.

Grieco, Justin, "BRAC and crime: examining the effects of an installation's closure on local crime," 2017. Working Paper.

Grinols, Earl and David Mustard, "Casinos, Crime, and Community Costs," *Review of Economics and Statistics*, 2006, *88* (1), 28–45.

Harbaugh, William T, Naci Mocan, and Michael S Visser, "Theft and deterrence," *Journal of Labor Research*, 2013, *34* (4), 389–407.

Jacob, Brian and Lars Lefgren, "Are idle hands the devil's workshop? Incapacitation, concentration, and juvenile crime," *American Economic Review*, 2003, *93* (5), 1560–1577.

James, Alexander and Brock Smith, "There will be blood: Crime rates in shale-rich US counties," *Journal of Environmental Economics and Management*, 2017, *84*, 125–152.

Komarek, Timothy, "Crime and Natural Resource Booms: Evidence from Unconventional Natural Gas Production," 2017. Working Paper.

Ludwig, Jens and Jeffrey Kling, "Is Crime Contagious?," *Journal of Law and Economics*, 2007, *50* (3).

Machin, Stephin and Oliver Marie, "Crime and Police Resources: the Street Crime Initiative," *Journal of the European Economic Association*, 2011, *9* (4), 678–701.

Maniloff, Peter, Ralph Mastromonaco et al., "The local economic impacts of hydraulic fracturing and determinants of Dutch disease," *Colorado School of Mines, Division of Economics and Business Working Paper*, 2014, *8*.

Mejia, Daniel and Pascual Restrepo, "Crime and Conspicuous Consumption," *Journal of Public Economics*, 2016, *135*, 1–14.

Miles, Thomas J and Adam B Cox, "Does immigration enforcement reduce crime? evidence from secure communities," *The Journal of Law and Economics*, 2014, *57* (4), 937–973.

Montolio, Daniel, "The Unintended Consequences on Crime of 'Pennies from Heaven'," 2018. IDB Working Paper No. IDB-WP-666.

Raphael, Steven and Rudolf Winter-Ebmer, "Identifying the effect of unemployment on crime," *The Journal of Law and Economics*, 2001, *44* (1), 259–283.

Schnepel, Kevin T, "Good jobs and recidivism," *The Economic Journal*, 2017, *128* (608), 447–469.

Spenkuch, Jörg L, "Understanding the impact of immigration on crime," *American law and economics review*, 2013, *16* (1), 177–219.

U.S. Bureau of Economic Analysis, "Real Total Gross Domestic Product for North Dakota," 2018. Accessed 18-September-2018 `https://fred.stlouisfed.org/series/NDRGSP`.

U.S. Bureau of the Census, "Median Household Income in North Dakota," 2018. Financial Times Accessed 18-September-2018 `https://fred.stlouisfed.org/series/MEHOINUSNDA646N`.

Vollaard, Ben and Joseph Hamed, "Why the Police have and Effect on Violent Crime After All: Evidence from the British Crime Survey," *Journal of Law and Economics*, 2012, *55* (4).

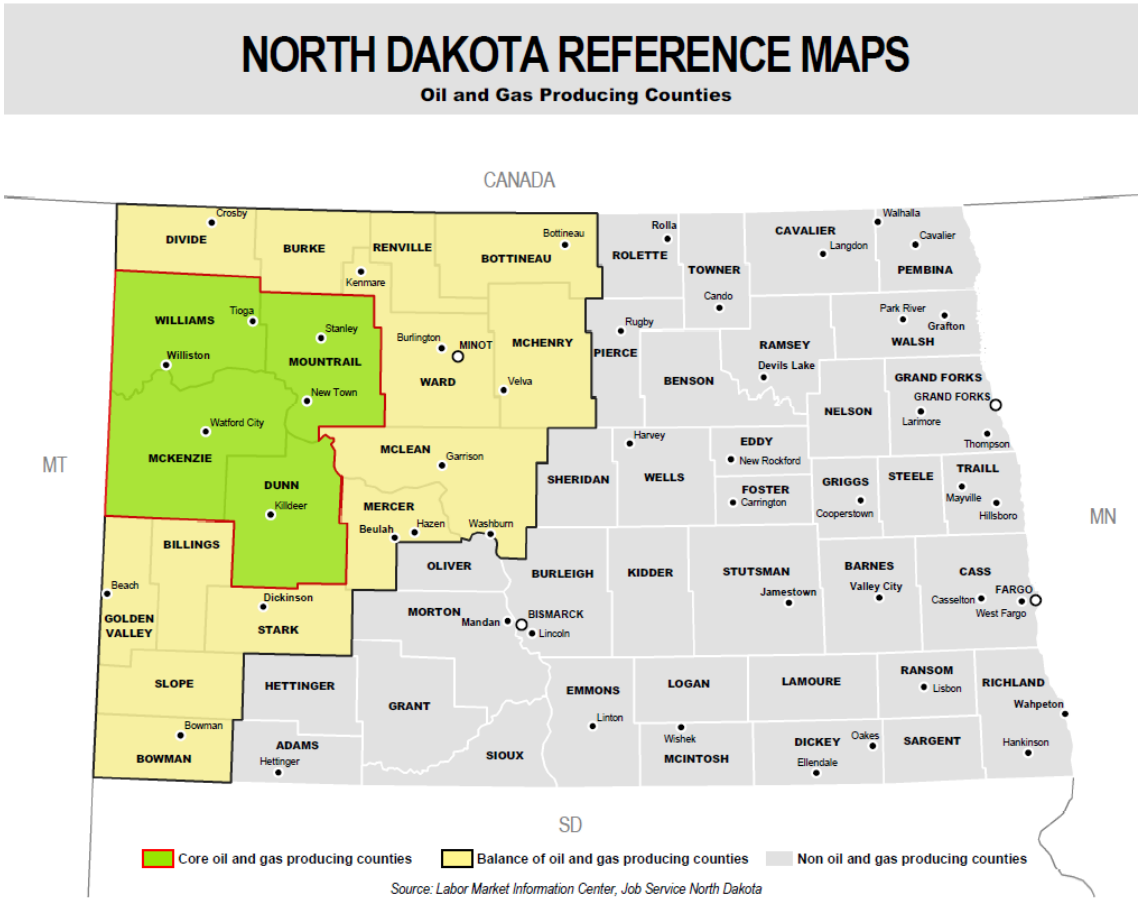
Wang, Zhongmin and Alan Krupnick, "A retrospective review of shale gas development in the United States: What led to the boom?," 2013.

Weber, Jeremy G, "A decade of natural gas development: The makings of a resource curse?," *Resource and Energy Economics*, 2014, *37*, 168–183.

Wilson, Riley, "Moving to Economic Opportunity: The Migration Response to the Fracking Boom," 2017. Working Paper.

Yang, Crystal, "Local labor markets and criminal recidivism," *Journal of Public Economics*, 2017, *147*, 16–29.

Figure 1: Fracking counties in North Dakota



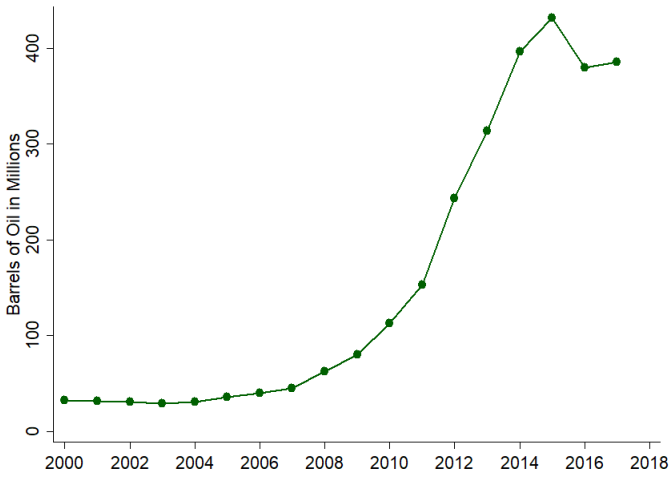
Source: Labor Market Information Center, Job Service North Dakota

8 Figures

Figure 2: Leasing and production

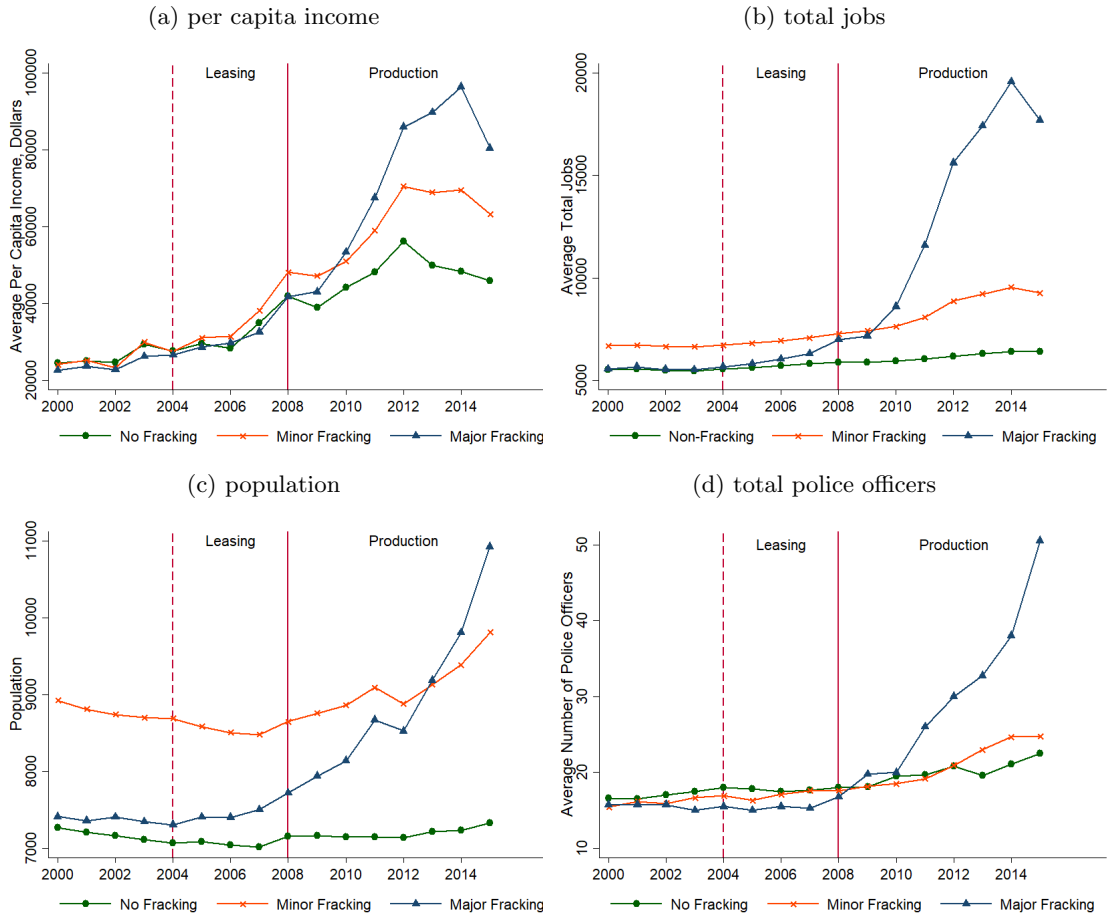
(a) leases

(b) production



Notes: All leases in North Dakota are collected from Drilling Info for 2000-2017. Only leases matched to rural residents in the early 2000s are depicted in the figure above, as this is the sample of leases used in the analysis. Monthly county production data are from North Dakota Department of Mineral Resources.

Figure 3: County demographics by fracking region

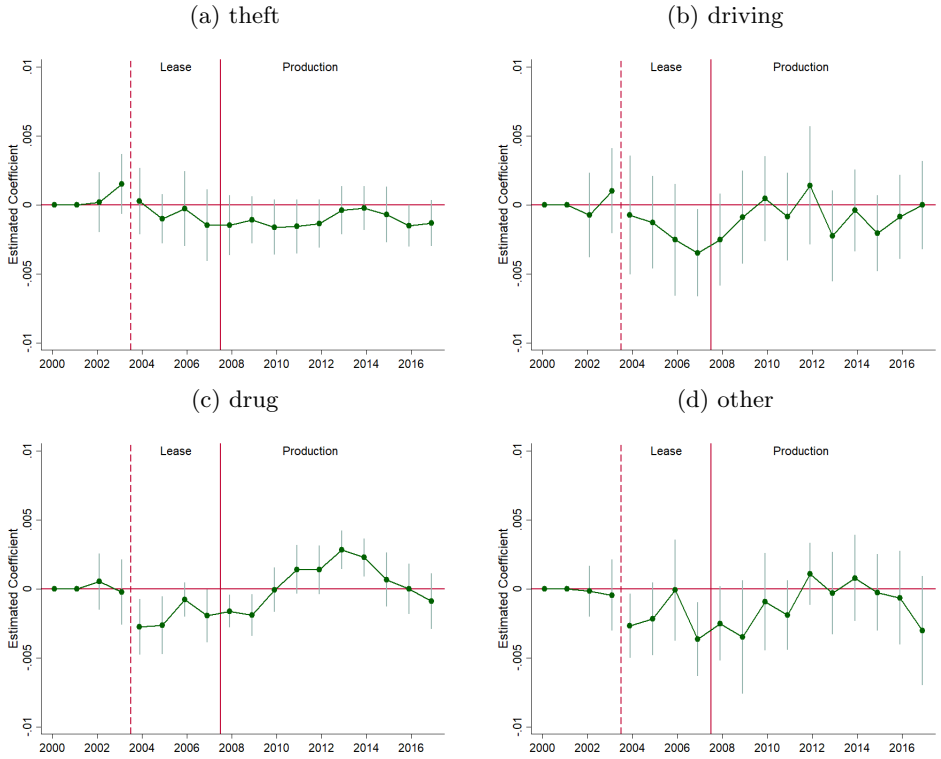


Notes: Data on income and jobs are from Bureau of Economic Analysis. Population is calculated using the number of migrant and non-migrant tax exemptions from the Internal Revenue Service. Police employment data are from the Uniform Crime Reporting Program: Police Employee (LEOKA) Data.

Figure 4: Dynamic difference-in-difference estimates of the effect of fracking on crime

Notes: Dynamic difference-in-differences estimates from equation 1. Standard errors are clustered at the county-level and 95% confidence intervals are shown. Data are from the State of North Dakota Judicial Branch from 2000-2017.

Figure 5: Dynamic difference-in-difference estimates of the effect of fracking on crime, by crime type



Notes: Dynamic difference-in-differences estimates from equation 1 with household and year fixed effects. Standard errors are clustered at the county-level and 95% confidence intervals are shown. Data are from the State of North Dakota Judicial Branch from 2000-2017.

Figure 6: Dynamic difference-in-difference estimates of the effect of fracking on police and population

(a) population

(b) total officers

Notes: Dynamic difference-in-differences estimates from equation 1 at the county-level. Standard errors are clustered at the county-level and 95% confidence intervals are shown. Data are from Internal Revenue Service and Uniform Crime Reporting Program Data [United States]: Police Employee (LEOKA).

Figure 7: Estimates of the effect of fracking on out-migration

Notes: Dynamic difference-in-differences estimates from Equation 1 with county and year fixed effects. Standard errors are clustered at the county-level and 95% confidence intervals are shown. Outcome is defined as total number of out-migration exemptions. An exemption is classified as a migrant if it is filed in a different county than in the the previous year. The exemption would be an out-migrant for the county of filing in the previous year and an in-migrant for the county of filing in the current year. Data on all exemptions is from the Internal Revenue Service.

9 Tables

Table 1: Summary Statistics

	All	Fracking County	Non-Fracking County	Lease Holder	Non-Lease Holder
Panel A: Household					
Case ever filed	0.20	0.20	0.20	0.22	0.19
Lease holder	0.21	0.42	0.08	1.00	0.00
Monthly Payment	6,848	6,109	681	36,154	0.00
	(119989.88)	(165432)	(21437)	(273796)	(0.00)
Number of months	4.89	6.78	0.79	25.80	0.00
	(21.31)	(24.16)	(8.53)	(43.11)	(0.00)
Observations	31169	6964	21394	6436	24733
Panel B: Household-Year					
Case filed	0.0232	0.0219	0.0238	0.0283	0.0218
Drug charge	0.0047	0.0035	0.0050	0.0060	0.0043
Driving charge	0.0132	0.0129	0.0134	0.0166	0.0124
Theft charge	0.0043	0.0041	0.0045	0.0048	0.0042
Other charge	0.0085	0.0081	0.0088	0.0105	0.0080
Observations	561042	125352	385092	115848	445194
Panel C: Charges					
Charges per case	1.14	1.11	1.15	1.15	1.14
	(0.60)	(0.50)	(0.64)	(0.58)	(0.61)
Felony charge	0.10	0.09	0.11	0.11	0.10
Driving charge	0.44	0.45	0.42	0.44	0.44
Drug charge	0.17	0.13	0.18	0.18	0.17
Theft charge	0.17	0.17	0.17	0.15	0.17
Assault charge	0.04	0.03	0.04	0.04	0.04
Other charge	0.30	0.30	0.30	0.31	0.30
Male	0.78	0.77	0.79	0.78	0.79
Age	34.38	33.86	34.37	33.90	34.55
	(14.30)	(14.02)	(14.35)	(13.81)	(14.47)
Observations	23091	4746	16583	6076	17015

Table 2: Estimates of the effect of fracking on crime

	1	2	3	4
Fracking Co X Post Lease	-0.0044***	-0.0048***	-0.0050***	-0.0050**
	(0.0015)	(0.0017)	(0.0017)	(0.0019)
Fracking Co X Post Prod	-0.0027	-0.0031*	-0.0043*	-0.0018
	(0.0020)	(0.0019)	(0.0025)	(0.0022)
Pre Lease		-0.0009		
		(0.0014)		
Observations	561078	561078	561078	561078
Mean Dependent Variable	0.02	0.02	0.02	0.02
Household & Year FE	Y	Y	Y	Y
Lead	N	Y	N	N
County Trends	N	N	Y	N
Pre-Period County Controls X Year	N	N	N	Y

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. Standard errors are in parentheses and clustered at the county level. County controls include per capita income, total jobs, population, total officers, and production in 2000.

Table 3: Estimates of the effect of fracking on crime, by crime type

	1	2	3	4
Panel A: Property Case Filed				
Fracking Co X Post Lease	-0.0011	-0.0006	-0.0012	-0.0016**
	(0.0008)	(0.0010)	(0.0009)	(0.0007)
Adjusted FDR Q-values	[0.316]	[0.519]	[0.242]	[0.119]
Fracking Co X Post Prod	-0.0016**	-0.0011	-0.0020*	-0.0016*
	(0.0007)	(0.0007)	(0.0011)	(0.0009)
Adjusted FDR Q-values	[0.076]	[0.316]	[0.191]	[0.211]
Pre Lease		0.0008		
		(0.0008)		
Observations	561078	561078	561078	561078
Mean Dependant Variable	0.004	0.004	0.004	0.004
Panel B: Driving Case Filed				
Fracking Co X Post Lease	-0.0021*	-0.0020	-0.0020*	-0.0022
	(0.0012)	(0.0015)	(0.0012)	(0.0016)
Adjusted FDR Q-values	[0.188]	[0.374]	[0.195]	[0.292]
Fracking Co X Post Prod	-0.0009	-0.0008	-0.0008	-0.0002
	(0.0012)	(0.0012)	(0.0017)	(0.0015)
Adjusted FDR Q-values	[0.535]	[0.519]	[0.651]	[0.879]
Pre Lease		0.0001		
		(0.0013)		
Observations	561078	561078	561078	561078
Mean Dependant Variable	0.013	0.013	0.013	0.013
Panel C: Drug Case Filed				
Fracking Co X Post Lease	-0.0021**	-0.0020***	-0.0028***	-0.0024***
	(0.0009)	(0.0007)	(0.0010)	(0.0009)
Adjusted FDR Q-values	[0.076]	[0.049]	[0.062]	[0.052]
Fracking Co X Post Prod	0.0003	0.0004	-0.0015	-0.0001
	(0.0005)	(0.0005)	(0.0012)	(0.0005)
Adjusted FDR Q-values	[0.535]	[0.519]	[0.254]	[0.875]
Pre Lease		0.0001		
		(0.0008)		
Observations	561078	561078	561078	561078
Mean Dependant Variable	0.005	0.005	0.005	0.005
Panel D: Other Case Filed				
Fracking Co X Post Lease	-0.0020**	-0.0022**	-0.0025**	-0.0015
	(0.0009)	(0.0011)	(0.0010)	(0.0011)
Adjusted FDR Q-values	[0.076]	[0.192]	[0.062]	[0.292]
Fracking Co X Post Prod	-0.0010	-0.0011	-0.0022	-0.0004
	(0.0012)	(0.0012)	(0.0014)	(0.0012)
Adjusted FDR Q-values	[0.535]	[0.519]	[0.208]	[0.875]
Pre Lease		-0.0003		
		(0.0009)		
Observations	561078	561078	561078	561078
Mean Dependant Variable	0.008	0.008	0.008	0.008
Household & Year FE	Y	Y	Y	Y
Lead	N	Y	N	N
County Linear Trends	N	N	Y	N
Pre-Period County Controls X Year	N	N	N	Y

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. Standard errors are in parentheses and clustered at the county level. County controls include per capita income, total jobs, population, total officers, and production in 2000.

Table 4: Estimates of the effect of fracking on crime, by intensity

	1	2	3	4
Minor Fracking County X Post Lease	-0.0039**	-0.0044***	-0.0039**	-0.0044**
	(0.0015)	(0.0016)	(0.0017)	(0.0021)
Major Fracking County X Post Lease	-0.0055*	-0.0060*	-0.0075***	-0.0070**
	(0.0030)	(0.0032)	(0.0028)	(0.0032)
Minor Fracking County X Post Prod	-0.0035*	-0.0040**	-0.0036	-0.0019
	(0.0021)	(0.0019)	(0.0030)	(0.0023)
Major Fracking County X Post Prod	-0.0007	-0.0012	-0.0062**	-0.0016
	(0.0034)	(0.0035)	(0.0026)	(0.0032)
Pre Lease		-0.0009		
		(0.0014)		
Observations	561078	561078	561078	561078
Mean Dependent Variable	0.02	0.02	0.02	0.02
Household & Year FE	Y	Y	Y	Y
Lead	N	Y	N	N
County Linear Trends	N	N	Y	N
Pre-Period County Controls X Year	N	N	N	Y

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. Standard errors are in parentheses and clustered at the county level. County controls include per capita income, total jobs, population, total officers, and production in 2000.

Table 5: Estimates of the effect of fracking on crime, by lease status

	1	2	3	4
Lease HH X Post Lease	-0.0021	-0.0026	-0.0028	-0.0023
	(0.0019)	(0.0021)	(0.0020)	(0.0023)
Lease HH X Post Prod	-0.0008	-0.0012	-0.0027	0.0007
	(0.0023)	(0.0021)	(0.0026)	(0.0026)
Non-Lease HH X Post Lease	-0.0066***	-0.0070***	-0.0070***	-0.0068***
	(0.0018)	(0.0020)	(0.0020)	(0.0020)
Non-Lease HH X Post Prod	-0.0046**	-0.0050**	-0.0059**	-0.0034
	(0.0021)	(0.0021)	(0.0027)	(0.0021)
Pre Lease		-0.0009		
		(0.0014)		
Observations	561078	561078	561078	561078
Mean Dependent Variable	0.02	0.02	0.02	0.02
Household & Year FE	Y	Y	Y	Y
Lead	N	Y	N	N
County Linear Trends	N	N	Y	N
Pre-Period County Controls X Year	N	N	N	Y

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. Standard errors are in parentheses and clustered at the county level. County controls include per capita income, total jobs, population, total officers, and production in 2000.

A Appendix

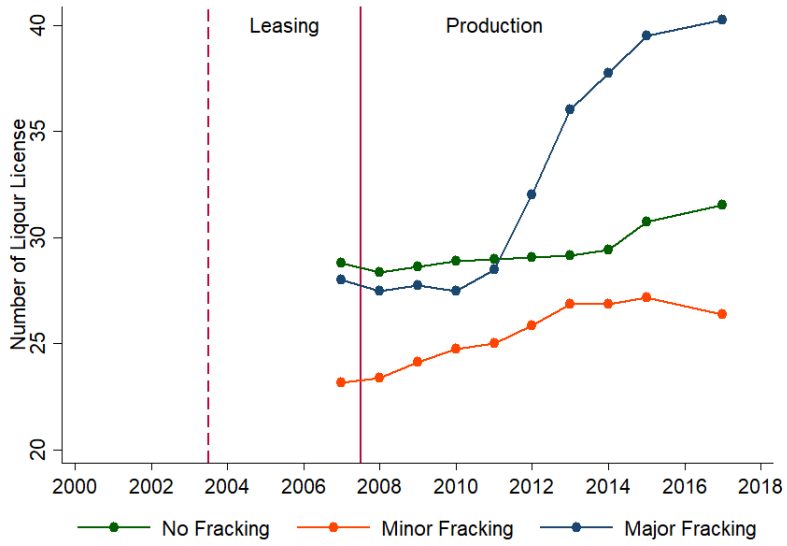
Figure A.1: Estimates of the effect of fracking on real estate

(a) total sales

(b) price

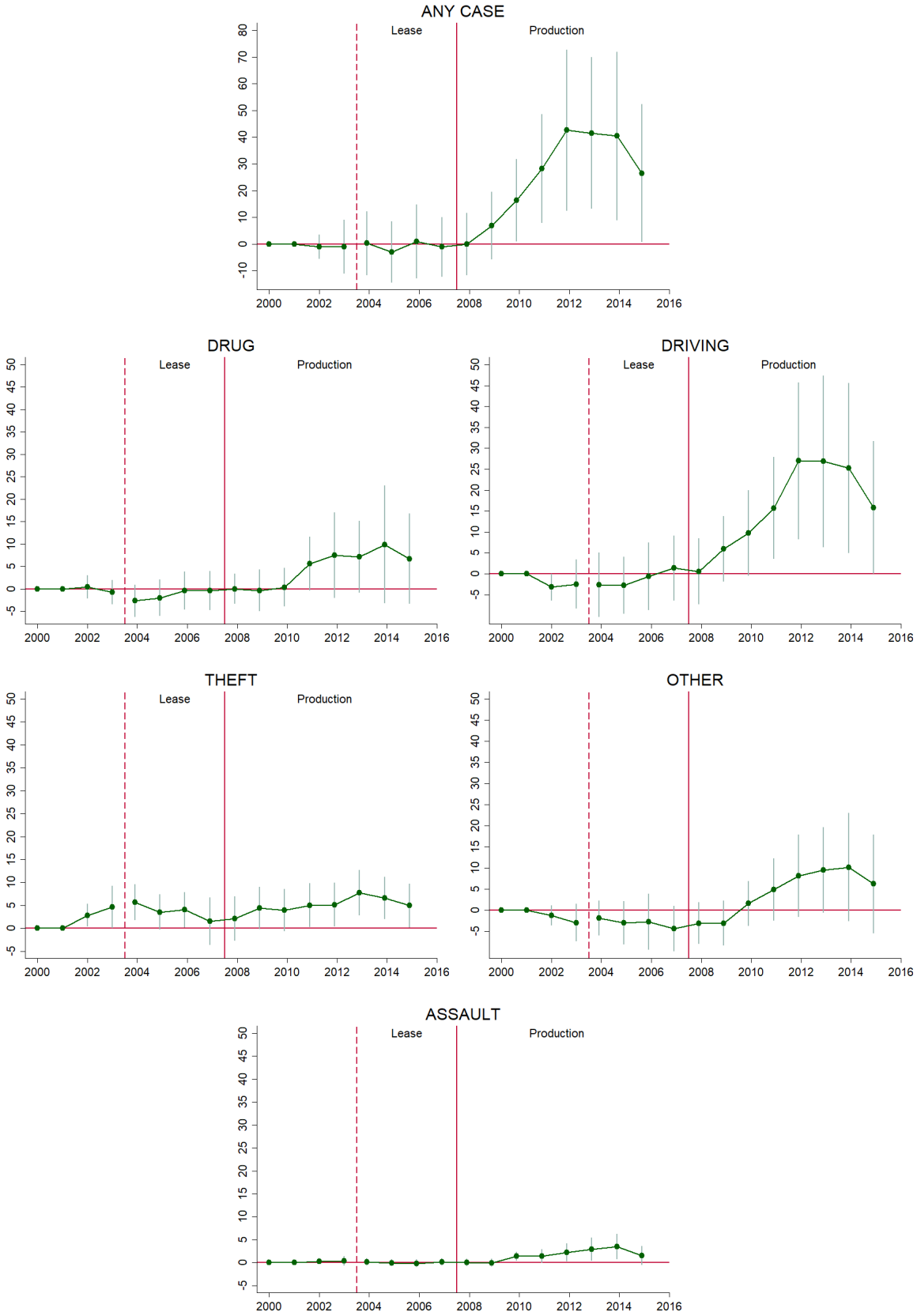
Notes: Dynamic difference-in-differences estimates from Equation 1 with county and year fixed effects. Standard errors are clustered at the county-level and 95% confidence intervals are shown. Outcome is defined as total sales in each county and total sale values. Data on all property sales are from the North Dakota State Board of Equalization.

Figure A.2: Average total number of liqour license per county by fracking region



Notes: Data on all liqour licenses in the State of North Dakota are provided by the North Dakota Attorney General's office from 2007-2018. Average total number of of licenses per county by fracking region are plotted.

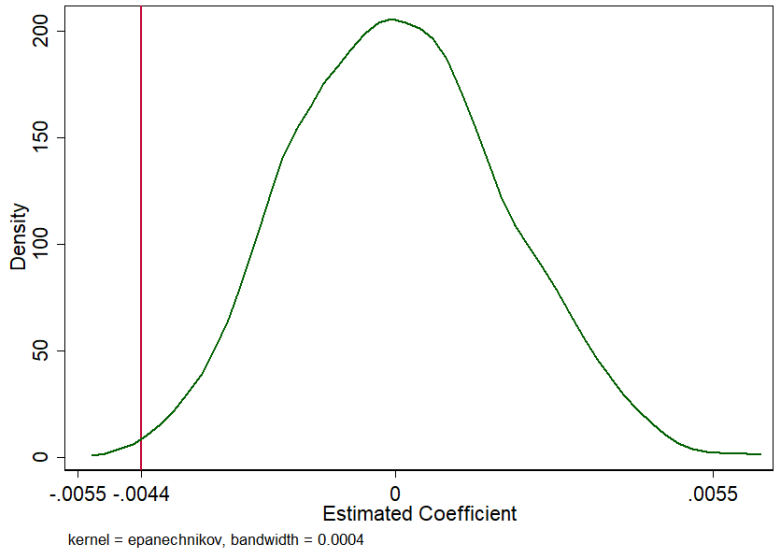
Figure A.3: Estimates of the effect of fracking on aggregate crime, residents and non-residents



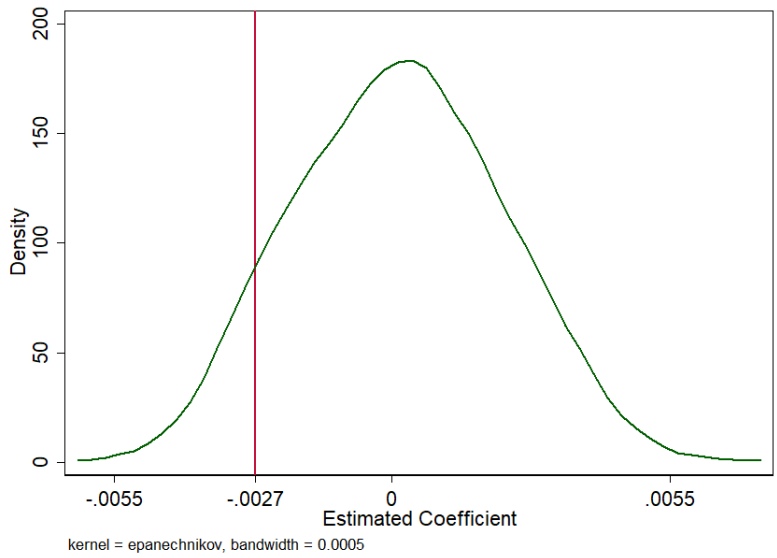
Notes: Dynamic difference-in-differences estimates from equation 1 with county and year fixed effects. Standard errors are clustered at the county-level and 95% confidence intervals are shown. Outcome is defined as cases filed per 1000 persons with population measured using IRS tax exemptions in each year.

Figure A.4: Placebo tests

(a) Placebo estimates for any case during leasing period



(b) Placebo estimates for any case during production period



Notes: Figure plots the density of 1000 estimates from equation 1 with fracking status randomly assigned to 17 counties. The red line in Figure A.2a depicts the main estimate during leasing period, -0.0044, with 1 estimate less than or equal to it. Similarly, in Figure A.2b the estimate during production period, -0.0027, is drawn in red with 88 estimates less than or equal to it.

Table A.1: Case Filed, robustness to Levenshtein Index

	1	2	3	4
Fracking Co X Post Lease	-0.0044***	-0.0044***	-0.0035**	-0.0031**
	(0.0015)	(0.0015)	(0.0013)	(0.0012)
Fracking Co X Post Production	-0.0009	-0.0027	-0.0032*	-0.0032*
	(0.0026)	(0.0020)	(0.0018)	(0.0016)
Observations	562500	561132	560592	560340
Mean Dependent Variable	0.02	0.02	0.02	0.02
Household & Year FE	Y	Y	Y	Y
Levenshtein Distance	3	2	1	0

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. Standard errors are in parentheses and clustered at the county level. Levenshtein Distance is the number of string edits permitted when match households using last name, street number, city, and zip code. Column 1 allows for three string edits when matching households, which is one more than what is used throughout the paper. Column 2 replicates Column 1 from Table 2 with two string edits as a baseline specification. Column 2 and 3 restrict to matches with a string distance of one or zero, respectively.

Table A.2: Estimates of the effect of fracking on crime, robust to functional form and intensive margin

Dependant Variable	Any Case		Number of Cases		Number of Charges	
	1	2	3	4	5	6
Fracking Co X Post Lease	-0.0044***	-0.2102***	-0.0059***	-0.2399***	-0.0059***	-0.1927***
	(0.0015)	(0.0781)	(0.0019)	(0.0768)	(0.0019)	(0.0671)
Fracking Co X Post Prod	-0.0027	-0.1476	-0.0036	-0.1823**	-0.0039*	-0.1517*
	(0.0020)	(0.1052)	(0.0022)	(0.0877)	(0.0022)	(0.0852)
Observations	561042	110034	561042	110052	561042	110052
Mean Dependent Variable	0.02	0.02	0.04	0.04	0.04	0.04
Household & Year FE	Y	Y	Y	Y	Y	Y
Ordinary Least Squares	Y	N	N	N	N	N
Logit	N	Y	N	N	N	N
Inverse Hyperbolic Sine	N	N	Y	N	Y	N
Poisson	N	N	N	Y	N	Y

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. Standard errors are in parentheses and clustered at the county level. Column 1 replicates the main findings from Table 2 using a linear probability model. Column 2 estimates the effect of fracking on whether or not a case was filed in a given year using a logistic regression. Columns 3 and 4 show results for the number of cases filed using the Inverse Hyperbolic Sine (IHS) transformation and Poisson model, respectively. Similarly, in columns 5 and 6 the effect on number of charges filed is shown for both IHS and Poisson models.