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 activities. 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 14 percent reduction in criminal cases filed. Effects continue once the fracking boom escalates into to production period. These results are in contrast to the observed aggregate increase in crime from fracking activities and consistent with improved economic opportunity reducing crime, highlighting the important role of compositional changes.

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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 activities. 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 disentangle 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 because people tend to leave as labor market conditions worsen and migrate to areas during economic expansions. I use 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 changes in individual criminal behavior.

I identify effects using a difference-in-differences framework, comparing counties located in the shale play, a geological area with oil and natural gas, to counties not located in the shale play over time. Importantly, I measure the impact on residents, separating out migration effects, by 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, 2015; 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 research design.[1] Third, hydraulic fracturing was large enough to affect the entire local economy in many areas. Finally, the shock affected

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

predominately low-skill jobs, a population of policy interest.

Studying the effects at the individual level requires detailed data on hydraulic fracturing activities, criminal behavior, and local residents in North Dakota.[2] I obtained detailed administrative data on the universe of criminal cases filed in the state from 2000 to 2017. I identify a subset of residents in each county from printed directories in the early 2000s before the in-migration associated with production activities. I also observe which residents signed a mineral 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 on residents who received large, non-labor income shocks and those who did 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, 2020).

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 0.28 percentage point (14%) reduction in criminal behavior by local residents. The effects are most pronounced for drug-related crimes, though I also see some less precisely estimated declines in other crimes. The effect continues as production ramped up, with a 0.35 percentage point decrease in the likelihood of committing a crime. This includes changes during the production period, such as increased income or changes in peer composition. These results do not appear to be primarily driven by changes in the police force, addressing concerns about detection and deterrence.

In addition, I exploit variation in mineral rights ownership and royalty income to assess the extent to which the 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 the hypothesis that those not receiving income through alternative means are more responsive to increased job opportunities.

To my knowledge, this is the first paper to identify the effects of economic shocks on individuals' criminal behavior separate from the effect of migration. In doing so, it contributes to two bodies of literature. 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, 2018; Axbard, 2016; Grinols and Mustard, 2006; Gould, Weinberg and Mustard, 2002; Raphael and Winter-Ebmer, 2001; Evans and Topoleski, 2002; Montolio,

[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.

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. They also find that crime is more likely to be committed by individuals with a prior criminal record, who are 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 and shifts in the population can explain the puzzling finding that aggregate crime often rises 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 (James and Smith, 2017; Andrews and Deza, 2018; Komarek, 2017; Bartik, Currie, Greenstone and Knittel, 2019), along with riskier sexual activity Cunningham et al. (2020).[3] However, the aggregate 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. Indeed James and Smith (2017) provide evidence in line with both of these channels, showing an increase in income inequality in fracking counties and an increase in felony sex offenders moving into these areas, as two potential mechanisms. I measure a similar increase in aggregate cases filed in fracking counties, and show that local residents in the county are 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]

Finally, while the primary purpose of this study is to examine the impact of economic expansions on

[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 economic conditions (e.g., Agan and Makowsky, forthcoming; Yang, 2017; Galbiati, Ouss and Philippe, 2021; Schnepel, 2017; Raphael and Weiman, 2007) and in the fracking context specifically (Eren and Owens, 2019), as well as increased lifetime criminal behavior for cohorts graduating high school in harsher economic conditions (Bell, Bindler and Machin, forthcoming)

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 opportunities 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 suggest that the fracking induced in-migration of mostly young, American men, documented by Wilson (2020), may have led to the 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 (Energy Information Administration, 2016). Fracking suddenly became more profitable due to a breakthrough in directional drilling, hydraulic fracturing technologies, and seismic imaging (Wang and Krupnick, 2015; Crooks, 2015). Hydraulic fracturing involves injecting fluids at a high pressure into a shale play 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.

One such area is the Bakken formation in North Dakota. It is smaller only than the Permian and Eagle Ford formations in Texas in crude oil production. Figure 1 shows the 17 counties that produce oil and gas in North Dakota, each classified by production levels as either a core (major) or balance (minor) county by Labor Market Information Center, Job Service North Dakota. Four counties make up the major fracking counties producing 80% of North Dakota's oil from 2000–2017, with the remaining 13 producing 20%.

[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.

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 first 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, ramping up in 2008. From 2008 to 2017, North Dakota produced oil valued at an estimated $2,904,191 million.[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 0.85 jobs and $80,000 in wages in counties with a shale play across the United States.[8] Similarly, in response to the stronger labor markets, Wilson (2020) 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% of production revenues through royalty payments. As I show in the next section, I estimate that the average leaseholder earned a royalty of $12,500 per month, which is a substantial non-labor income shock.

Figure 3 shows that before the fracking boom, counties in North Dakota were relatively similar in terms of per capita income, total jobs, population, and total police officers.[9] 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). Actual oil production typically lags roughly two years from lease signing as it takes time for the well to be constructed and operational, which is reflected in the timing of lease signing and barrels of oil produced in Figure 2. Notably, work begins during the leasing period with total jobs increasing by 23.6% in major fracking counties between 2004 and 2008 during the initial construction period. Oil production began ramping up in 2008, as the initial wells began producing oil, along with a rapid construction of more wells to accompany the new leases signed. The production period is when companies began 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

[7]This estimate is calculated based on total monthly oil production in North Dakota (Department of Mineral Resources, 2018) and the monthly North Dakota oil first purchase price (Energy Information Administration, 2018a).

[8]Other papers estimating increases in wages and employment from fracking activities include Bartik, Currie, Greenstone and Knittel (2019); Allcott and Keniston (2017); Fetzer (2014); Maniloff and Mastromonaco (2014); Weber (2014) and Gittings and Roach (2020) to name a few.

[9]County-level data on income and total jobs are obtained from the Bureau of Economic Analysis. The population is calculated using the number of personal tax exemptions from the Internal Revenue Service. The number of personal exemptions provides a year to year estimate of the population for counties based on the address listed on the tax return. The number of exemptions is used rather than the number of tax filings as many individuals may be reported on a single tax filing with one exemption per person on the filing. Thus, the number of tax filings approximates the number of households while the number of exemptions approximates the number of persons.Police employment data are from the Uniform Crime Reporting Program: Police Employee (LEOKA) data.

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, 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, I will estimate the effect of the expected economic opportunity that occurs after signing but before production, as well as the effect during the heavy production period. 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 other 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. Lower criminal behavior could also operate through a beliefs about better jobs or a better life, or through a practical incapacitation effect of being on a job (Galbiati et al., 2021; Case and Deaton, 2015; 2017; Autor et al., 2020). Alternatively, the large cash transfers—via royalty payments—to some households may lead to more crime through increased income inequality and opportunity of crime (Freedman and Owens, 2016; Mejia and Restrepo, 2016; Cook, 1986; James and Smith, 2017). 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, such as alcohol, or create conflict within the home (e.g., Carr and Packham, 2019; Dobkin and Puller, 2007; Carr and Packham, 2021). Finally, the large migration effects observed in the production period may affect crime through population increases and compositional changes (Glaeser, Sacerdote and Scheinkman, 1996; James and Smith, 2017).

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 can distinguish the effect on crime by the existing population from the 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 before the large in-migration spurred by the fracking boom. To do this, I collected a list of all rural residents for each county in North Dakota prior to 2008 from the Great Plains Directory Service.[10,11] Households listed in these directories cover roughly 20% of all households in North Dakota during this time, which is half of all rural households.[12] The directory information includes the name, address, and city of all rural residents. In total, there are 30,909 households defined by last name, street number, city, and zip code. This is considered the sample of households for the analysis, which I match to lease and crime data using a Levenshtein Index.[13,14]

One potential concern with identifying residents is that some people may have moved into fracking counties before 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.

A second concern is that household composition could be changing over time. Even if households are not moving into fracking counties, it is possible that some members of the household move in response to the local economic shock. Specifically, younger men may move either to or from a resident household address as jobs enter the county. In this case, if they officially change their address, their criminal behavior may be assigned to a household differentially during treatment periods. Thus, the results could be picking up a change in household composition, rather than a change in household criminal behavior. If this were the case, I should not see the same effects when limiting the analysis to the criminal behavior of more stable household members, those 25 or older by

[10] The Great Plains Directory Service obtains their information from property tax records reported by each county, and then verify and record who resides at the property. Residents living within city limits are not included in the directories and thus are not able to be considered in this analysis.

[11] Notably, the directories are created for a county every few years and directories for all counties were not created in the same year. All counties are included except Cass, Grand Forks, Pembina, and Traill, which were not covered by the Great Plains Directory Service. Moreover, I show results are robust to the restriction of directory years in Table A.3.

[12] All rural households are not covered since the directories cover areas outside of the city limits; however, many cities in North Dakota are officially classified as rural by Census.

[13] I allow matches with a string distance of one or less. In practice, this means two strings are matched across datasets if there is only one change that needs to be made to the concatenated string of last name, street number, city, and zip code in order for them to be exact matches. While the court records include date of birth, it is not possible to use for matching since it is not also in the residential directories. In Table A.4, I show that the main results are robust to this index.

[14] Among individuals receiving a criminal charge between 2000 and 2003, the rural residents identified by the Great Plains Directory service look remarkable similar to the rest of the population (Table A.1).

the start of the sample. However, in Section 5.1, I show results are robust to this sample restriction in Figure A.2 and Table A.2, suggesting that it is changes in criminal behavior that are driving my results.

I identify which households also have a mineral lease by collecting all leases signed from 2000 to 2017 in North Dakota 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, the company listed as grantee, the number of acres leased, the royalty rate, and the date of record.[15] 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. I dollarize this amount using the North Dakota Crude Oil First Purchase Price to estimate the amount leaseholders receive in the form of royalty payments.[16]

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 contain identifying information, including 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, cases filed are considerably more serious than 911 calls or arrests, as an individual has been charged with a crime. As a result, charges filed are arguably a less noisy measure of criminality than the other possible alternatives. 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.[17] 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

[15] Address information beyond matching and identifying county is not used, as rural addresses have higher geocode error rates (e.g., U.S. Census geocoding, Ruhnke, 2003). Thus, designs using within county variation of residences are problematic.

[16] Each well in North Dakota is assigned a spacing unit that 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 the recommendations 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. I subtract $10/barrel to account for post-production costs, namely, transportation. I deduct 10% for the severance tax since 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 depending on their negotiated royalty rate, typically 12–18%.

[17] This estimate is based on numbers produced by the North Dakota Attorney General's Office, received September 2018

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 ($\sim$90%), with driving-, drug-, and property-related charges making up roughly 44%, 17%, and 17% of all charges, respectively. Smaller crime categories representing less than 10% of all charges, such as assault (3%), are grouped together in other charges. Of the households in my sample, roughly 15% sign a lease and may receive royalty payments during this period. Close to 40% of leaseholders in my sample do not receive payments during this period, with the average leaseholder receiving $12,500 per month with the median leaseholder receiving $2,300 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 provides a plausibly exogenous shock to local economic conditions. Using a generalized difference-in-differences framework, I compare the criminal behavior of resident households in counties within the shale play to residents in counties outside the shale play, before and after the fracking boom. 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 local household's criminal behavior using the following linear probability model:

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

where criminal behavior is a binary indicator for whether a case was filed for household h in year t.[18] 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 of 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, 2004 to 2008, and during the production period, 2008 to 2017, respectively. The coefficients of interest, θ_1 and θ_2, measure 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, absent hydraulic fracturing activities, residents' criminal behavior in fracking counties would have changed similarly over time with residents' criminal behavior in non-fracking counties. 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 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. To do this, I randomly assign treatment to 17 counties and compare the estimated coefficient to 1000 placebo estimates to compute two-sided p-values. In addition, I report Adjusted False Discovery Rate (FDR) Q-values when estimating effects separately by crime type (property, driving, drug, and other) following Anderson (2008). Adjusted FDR 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 experience 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

[18] Since the dependent variable is binary, I additionally show results using a logistic regression in Table A.5. 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.

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:

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

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 mutually exclusive periods: leasing starting in 2004 and production beginning in 2008. Notably, leaseholders receive a small signing bonus upfront, with royalty payments closely following production.

4.3 Aggregate effects on crime and other outcomes at the county level

Throughout the paper, it is useful to show how counties change in response to the hydraulic fracturing activities. Notably, it is useful to highlight the aggregate increase in crime. It is also important to understand how the police force and population changes in these counties in response to the fracking boom, and the extent that these changes may be driving the main findings (Section 6). I present these results graphically using the following equation:

$$y_{ct} = \alpha_c + \gamma_t + \sum_{s=2002}^{2017} \theta_s FrackingCounty_{c,t=s} + \varepsilon_{ct} \tag{3}$$

where y_{ct} is the outcome of interest including aggregate charges filed per 1000 persons, population, number of police officers, number of houses sold, price of houses sold, and out-migration for county c in year t. County fixed effects, α_c, account for any static differences in outcomes, such as crime or population, across counties. Year fixed effects, λ_t, control for factors that affect outcomes across all counties in a given year, such as the Great Recession. The set of indicator variables, $FrackingCounty_{c,s}$, are equal to 1 for fracking counties in year s. The coefficients of interest, θ_s, measure the difference in the outcome in fracking counties relative to non-fracking counties in each of the sample periods relative to 2000 and 2001.

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 the population of residents before the fracking boom in North Dakota. In doing so, I can exclude 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 figure 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 and continues during the production process, with the drop most notable during the time when counties are ramping up work leading into the production period. This suggests economic opportunity reduces crime for those already living these areas despite the aggregate increase in crime that has been documented. I report the average treatment effects for each period in Table 2.

Starting with the leasing period, Column 1 indicates an initial drop of 0.28 percentage points in overall crime by residents in fracking counties relative to residents in non-fracking counties. This translates to a 13.5% drop in cases filed and is statistically significant at the 5% level. Moreover, the permutation-based p-value is less than 4.3%, with 43 out of 1,000 placebo estimates greater in absolute magnitude than 0.0028, 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, -0.0012, 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 -0.29 percentage points. Finally, counties with different baseline populations, total jobs, police 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 baseline characteristics, observed in 2000, to differentially affect criminal behavior each year. The magnitude remains stable at -0.36 percentage points. Notably, all coefficients are statistically significant at the 10% level with 3 of the 4 significant at the 5% 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 the relative drop in criminal behavior continues through the production period. Column 1 indicates a 0.35 percentage point reduction in cases filed for residents in fracking counties compared to residents in non-fracking counties. The permutation-based p-value is significant at 5.1%, with 51 of the 1000 placebo estimates greater in absolute value than the estimated coefficient. Moving across Columns 2 through 4, coefficients remain negative ranging from -0.36 to -0.41 percentage points.

Given that estimates are at the household level, a potential concern is that effects are being driven by

changes in household composition rather than changes in criminal behavior. For example, the results could be driven by composition if young men, a more crime-prone demographic, were more likely to move out during the leasing period and then move back during the height of the production period in fracking counties.[19] I examine this concern by restricting the sample to crime committed by household members that are older than 25 years at the start of my period in January 2000. The results for the older, more stable sample are shown in Figure A.2 and Table A.2. They are the same as the results in Figure 4 and Table 2, respectively, suggesting that it is changes in criminal behavior rather than household composition that are driving this pattern of results. Moreover, I do not find evidence of differential moving out of fracking counties, see Figure 10, or moving within fracking counties, see Figure **??**, at least until towards the end of the sample when you expect churning of migratory workers.[20]

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 reductions in driving, drug, and other offenses in the leasing period. However, this reduction is diminished once production starts.

Similar to Table 2, Table 3 reports average treatment effects for each period, with panels for each crime type and adjusted FDR Q-values for statistical inference. Panel A indicates a -0.06 to -0.11 percentage point decrease in property cases filed during the leasing period, and a -0.13 to -0.16 percentage point decrease during the production period. Similarly, estimates are negative for driving-related cases during the leasing (-0.10 to -0.22 percentage points) and production period (-0.12 to -0.18 percentage points). Panel C shows a decrease in drug cases filed of -0.19 to -0.28 percentage points during the leasing period, and a reduction of 0.00 to -0.25 percentage points during the production period. Finally, all other crimes have a similar negative effect during the leasing period ranging from -0.05 to -0.16, with a smaller effect once production begins ranging from -0.08 to

[19] Importantly, even if some household members move, they would have to officially change their address for their crime to no longer be attributed to the household.

[20] Both of these figures represent information for all individuals in the county for the given year, thus does not only represent the local residents used in the analysis.

-0.26 percentage points. All coefficients are fairly robust to the inclusion of controls and a lead term.

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, property, and other 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 0.027 0.028, 0.01, 0.01, respectively. There is no statistical effect on drug cases during the production period.

It is possible that the reduction in criminal behavior from the boost in economic activity may be somewhat offset by additional effects on criminal behavior during the production period, particularly for drug-related crime, shown above, and in major fracking counties, shown in the next section (5.2). 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. Indeed, Cunningham, DeAngelo and Smith (2020) document an increase in risky sexual behavior and prostitution markets in fracking counties. Moreover, I show descriptive evidence of a large increase in the number of liquor licenses per county in counties with major fracking activity, graphically depicted in Figure A.3.[21]

For comparison, I also report the effect of hydraulic fracturing activities on aggregate changes in cases filed per 1000 persons. Figure 6 plots the dynamic coefficients from the county level model in equation 3, 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.

Finally, I do a back of the envelope calculation to see whether the migrants entering the fracking counties were committing crimes at higher rates than the local population. To do so, I use county personal tax exemptions as an estimate of the annual population for each county and the number of in-migrants each year (defined by filing in a new county than in the previous year). This enables me to shed light on a question of interest in the immigration literature of whether those moving into an area are more criminogenic in general. For this exercise, the local population is all North Dakotians and the migrant population are those from other US states moving

[21] Data on all liquor licenses in the State of North Dakota are provided by the North Dakota Attorney General's office from 2007-2018.

to North Dakota, as measured by the address on the court records. I measure the propensity to commit crime for a subset of those moving into fracking counties, as those moving within state are counted as a part of the local population in the exercise. 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 (i.e., number of in-migrants). 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; this is a rough estimate, but can be thought of as a conservative estimate of the difference in criminal propensity between groups. 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. To be conservative, the denominator for the out-of-state crime rate is the total of all inflows from 2000 through 2015. 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 evidence of a reduction in residents' criminal behavior during the leasing period and into the production period. While I observe reductions in all crime types, results are most pronounced for drug-related crimes. This is in contrast to 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 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, particularly the four major oil and gas producing counties, as defined by the Labor Market Information Center in North Dakota, experience much larger economic shocks than others. The oil production in each of these four counties was greater than the amount produced in the other 13 counties combined over the sample period. These four counties, namely Williams, McKenzie, Mountrail and Dunn, experience the largest percent increase in

total jobs from 2004-2015 relative to their 2000-2003 baseline of all 53 counties in the North Dakota with over a 50% increase.

To estimate the differential effect by treatment intensity, I report estimates from equation 1 separately for major and minor fracking counties in Table 4. For the leasing period, 2004 to 2008, estimates in Column 1 indicate a 0.29 percentage point decrease in cases filed by residents in counties with minor fracking activity and a 0.24 percentage point decrease in the major fracking counties. This represents a 14.5% reduction in cases filed in counties with minor fracking activity and a 12% 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 0.29 to 0.37 percentage point decline in minor fracking counties and 0.24 to 0.33 in major fracking counties. All estimates in minor fracking counties are significant at conventional levels with imprecise, although similar in magnitude, estimates for the four major counties.

During the production period, estimates for minor fracking counties are larger in magnitude to the leasing period, ranging from a 0.40 to 0.48 percentage point reduction in cases filed, all significant at conventional levels. Estimates for major fracking counties are smaller in magnitude during the production period relative to the leasing period (-0.15 to -0.36 percentage points), and not significant at conventional levels.

The effect is similar in magnitude for the major and minor fracking counties initially, and 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, as well as spillovers, 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 roughly $12,500 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 (-0.05 to -0.12 percentage points) and production (-0.26 to -0.34 percentage points), although none are significant at conventional levels. Estimates for non-lease-holders range from -0.42 to -0.48 percentage points during the leasing period and are all significant at the 5% level and 3 of the 4 significant at the 1% level. During the production period, estimates range from -0.41 to -0.47 for non-lease holders, with three of the four estimates significant at the 5% level. Estimates during the leasing period are statistically different from each other at the 5% level. Although not statistically different from each other during the production period, estimates remain larger for non-leaseholder, indicating that the overall reductions in crime shown in Table 2 are primarily driven 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 (0.28 percentage point reduction), and that the effect continues once drilling activities escalate throughout the production period (0.35 percentage point reduction). Effects are largest and most consistent for drug-related crimes with a decrease of 0.19 percentage points in drug-related cases filed during the leasing period, although estimates are negative for all other crime categories as well. Additionally, the effect is not solely driven by the four largest oil-producing counties. During the leasing period, there is a 0.24 percentage point crime reduction in the four major fracking counties, as compared to a 0.29 percentage point reduction in the minor fracking counties. The effects diminish more in the major fracking counties, which suggests 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 (0.42 percentage point reduction during the leasing period), and persist into the production period (0.41 percentage point reduction). 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 officers. Becker (1968) and others highlight that the probability of detection

factors into an individual's decision to commit a 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 plot the raw data by fracking county type in Figure 7 and estimate the main model at the county level with total police officers as the outcome of interest in Figure 9. Panel A of both figures indicate that the change in the number of police officers was negligible until 2010 when it started increasing in fracking counties. As a result, changes in the police force are unlikely to be driving the significant reduction in crime observed during the leasing period, although potentially part of the treatment during the production period. Similarly, reductions in police resources from population increases may lead to fewer reported cases filed (Vollaard and Hamed, 2012). Panel B shows little evidence of changes in the population initially, with larger increases during the more labor-intensive production period. Again, population changes are less of a concern during the leasing period but are a part of the treatment effects after 2008. Consistent with this, James and Smith (2017) find negligible changes in police per capita in fracking counties and rule it out as a driving mechanism behind the observed aggregate changes in crime. However, it may still be the case that police resources are strained due to the nature of new offenses making them less likely to detect lower-level offenses of residents, which is more difficult to rule out but does not seem to be driving effects, especially early on in the sample. First, aggregate crime does not increase in a meaningful way until after 2008 (see Figure 6). Second, the ratio of felony charges to all charges is consistent if not falling until 2010 and the subsequent observed increase matches non-fracking counties (Panel D), suggesting serious offenses are not crowding out detection of other offenses. Additionally, while data prior to 2008 is not available, I show that even traffic infractions experience an uptick in fracking areas for both overall and for in-state drives, suggesting detection is not likely driving the results presented above (Figure 8a). A similar concern relates to charges filed, but the share of felony charges to index crimes is also relatively stable during the entire period (Panel E).

Relatedly, a concern may be that individuals 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 differentially not observing the criminal behavior of individuals that move out of the state. Anecdotally, it seems improbable that residents would disproportionately move out of fracking counties as economic conditions improved. It is also worth noting that households in the residential directories are more likely to have stable residences than the general population. 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. I find signs of out-migration only toward the end of the production period when presumably workers who had moved into the county begin leaving, as shown in Figure 10. Additionally, I show in Figure A.1 that there does not seem to be a large change in home sales or the price of homes sold in fracking counties, at least not until much later in the sample. While the American Community Survey does not cover counties in North Dakota until 2009, it again does not seem as though people are moving more often *within* the county except for in the major fracking counties near the end of the sample, shown in Figure **??**. Notably, this survey reflects the population of the county rather than those in the residential directories and might be capturing the transitory workers moving between temporary housing. Finally, I restrict to the population that is more likely to have a stable residence, crime committed by those 25 or older as of the start of the sample, in Figure A.2 and get similar results. Together, these results suggest that differential moving does not account for the main results presented above.

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 the incapacitation effect of school 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, given their improved economic outlook. This is consistent with work by Case and Deaton (2015; 2017) and Autor, Dorn and Gordon (2020), who document an increasing number of deaths from drugs, alcohol and suicide associated with deteriorating economic conditions. Moreover, Galbiati, Ouss and Philippe (2021) show a decrease in recidivism when there is more media coverage of job creation, holding constant job vacancies, highlighting the role of beliefs about economic opportunities related to criminal activity. 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 charges 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 production period. However, local residents actually engage in less criminal activity during the hydraulic fracking boom. Effects are most pronounced for drug offenses, and are observed across all counties with fracking activity. Additionally, I show that effects are largest for residents that do not also receive royalty payments. Taken together, these results are consistent with economic opportunities reducing crime and highlights the role of compositional changes on the aggregate effects on crime.

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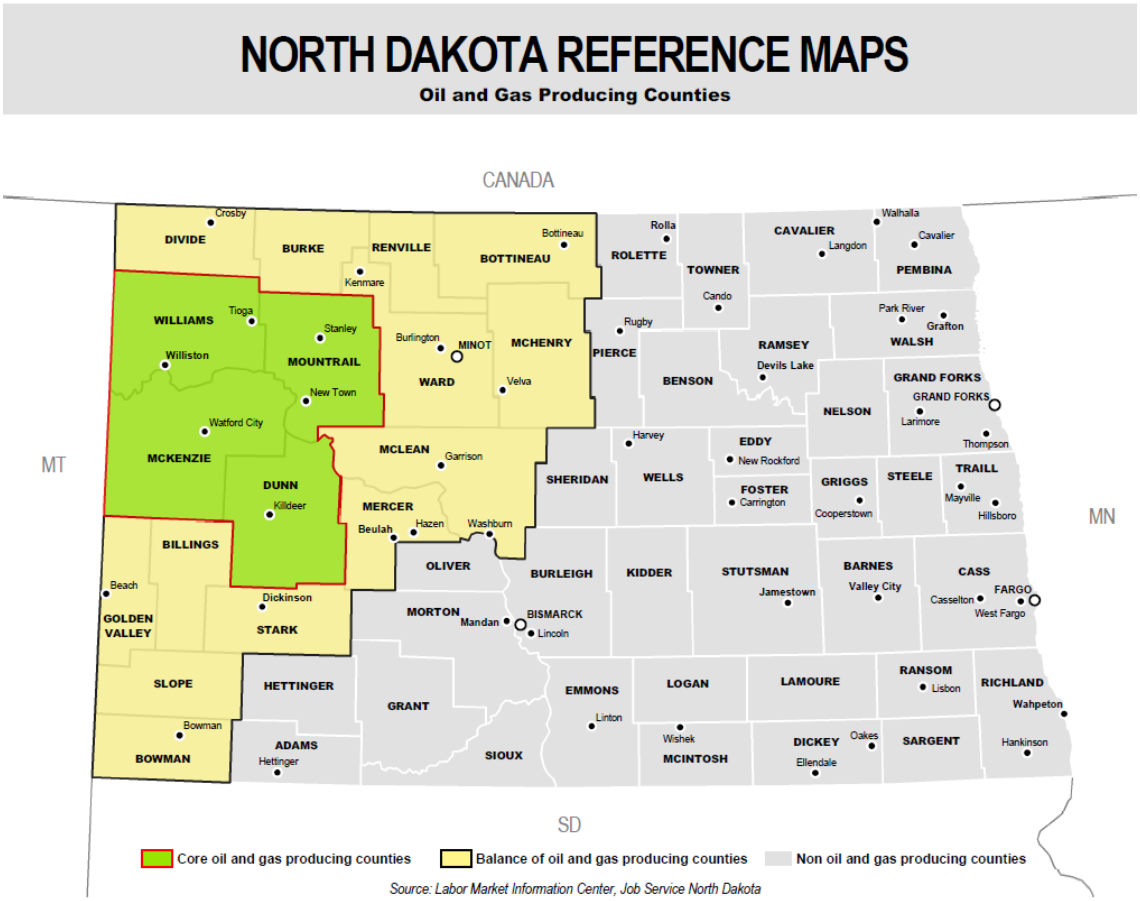
Yang, Crystal, "Local Labor Markets and Criminal Recidivism," *Journal of Public Economics*, 2017, *147*, 16–29.

Figure 1: Fracking counties in North Dakota

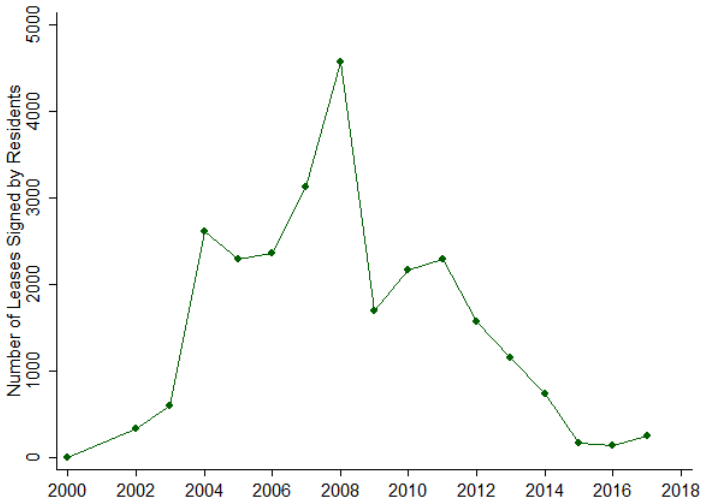


Source: Labor Market Information Center, Job Service North Dakota

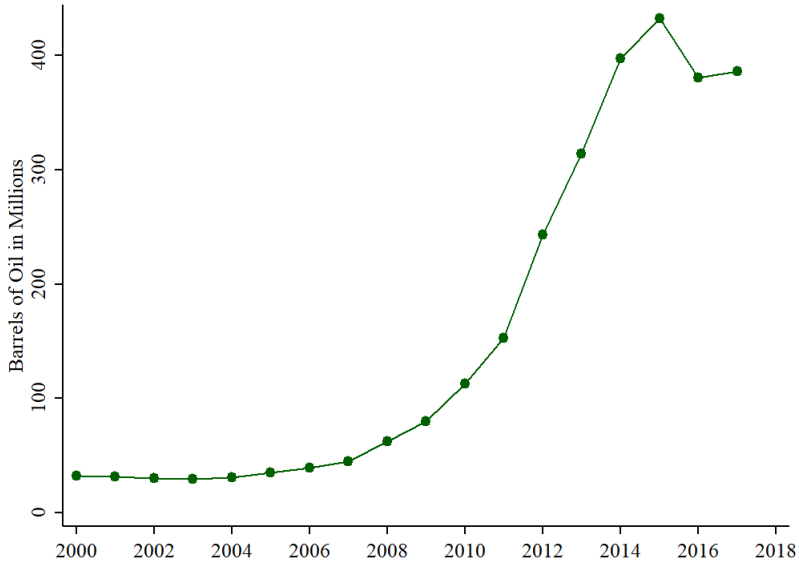
8 Figures

Figure 2: Leasing and production

(a) leases

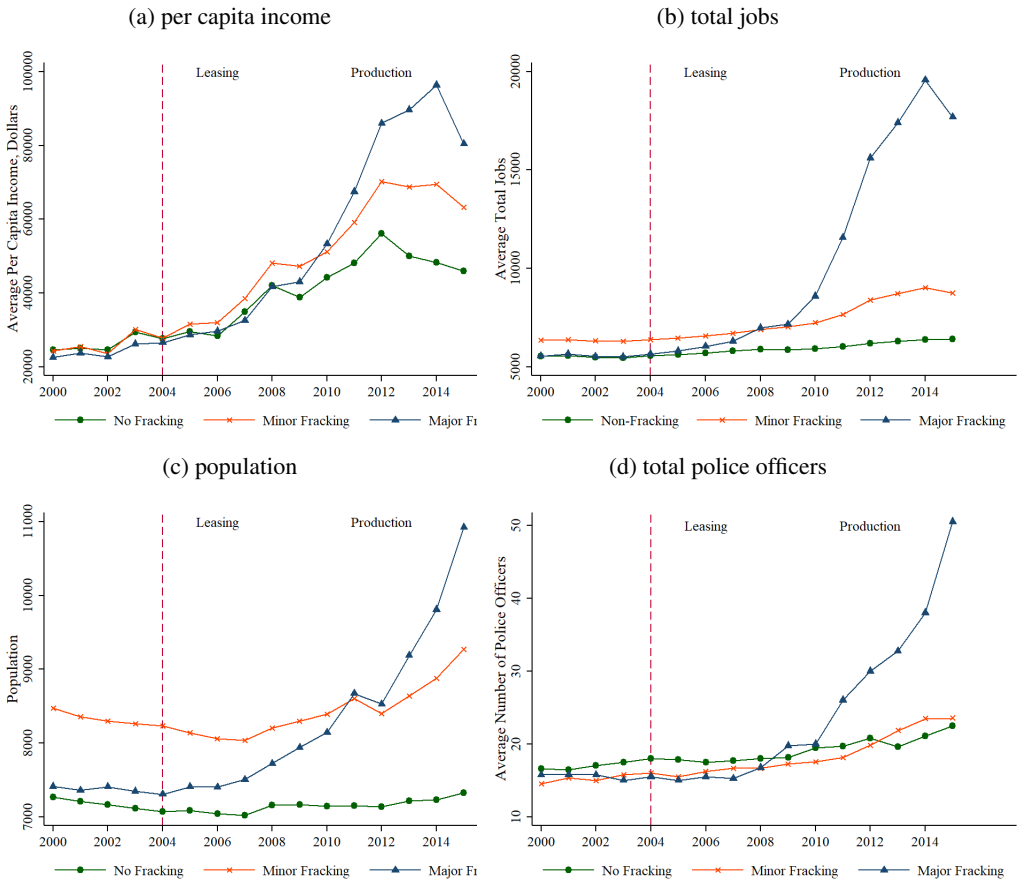


(b) production



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 characteristics by fracking region

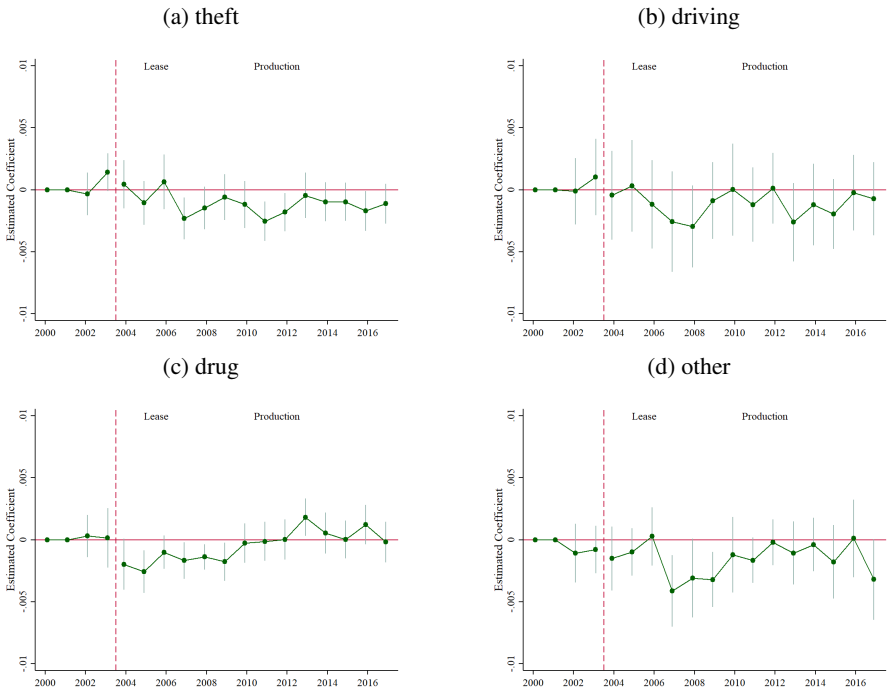


Notes: County-level data on income and total jobs are obtained from the Bureau of Economic Analysis. Population is calculated using the number of migrant and non-migrant tax exemptions from the Internal Revenue Service. The number of personal exemptions provides a year to year estimate of the population for counties based on the address listed on the tax return. The number of exemptions is used rather than the number of tax filings as many individuals may be reported on a single tax filing with one exemption per person on the filing. Thus, the number of tax filings approximates the number of households while the number of exemptions approximates the number of persons. Migrant and non-migrant status is determined based on whether the person filed in a different county in the prior year. 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

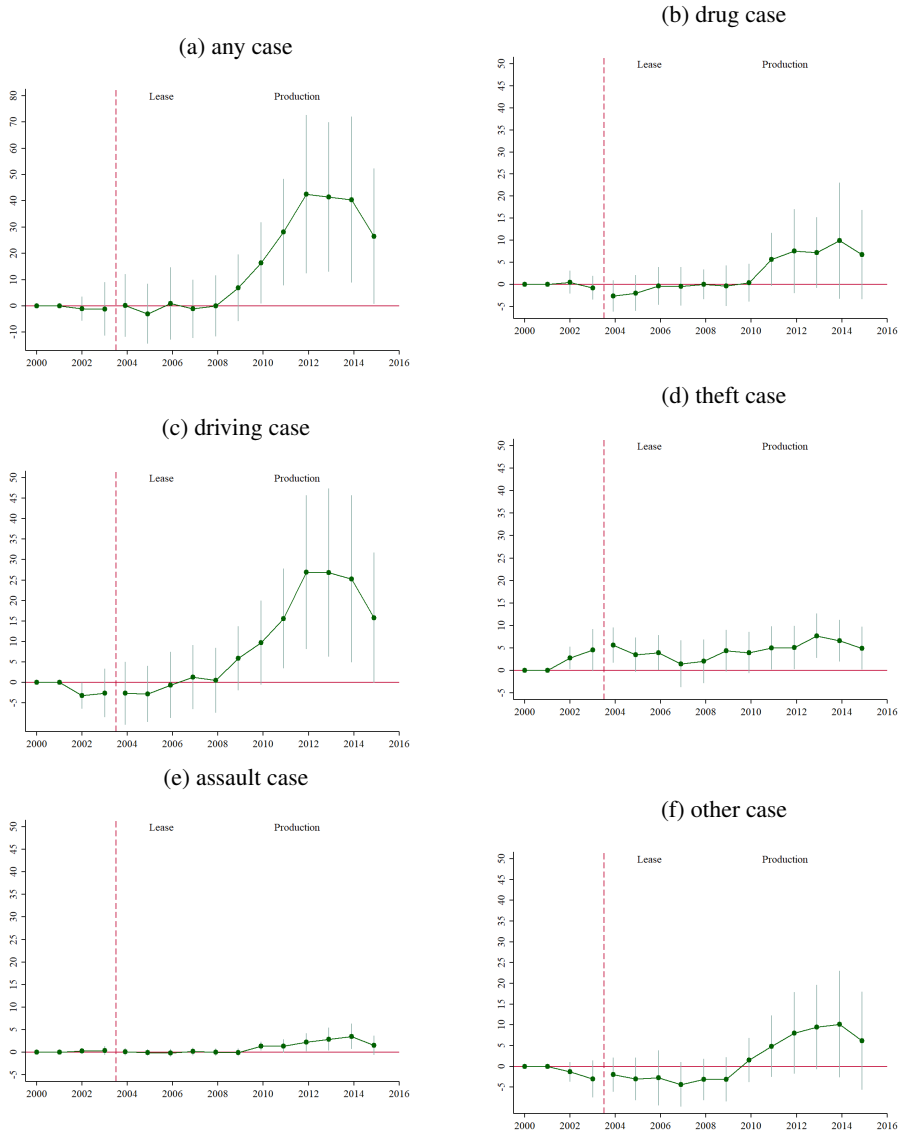
Notes: Dynamic difference-in-differences estimates from equation 1. Standard errors are clustered at the county-level and 95% confidence intervals are shown. Data are from the State of North Dakota Judicial Branch from 2000–2017. The sample is all local households defined by last name, street number, city, and zip code identified in each county from the Great Plains Directory Service.

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 on charges filed are from the State of North Dakota Judicial Branch from 2000–2017. The sample is all local households defined by last name, street number, city, and zip code identified in each county from the Great Plains Directory Service.

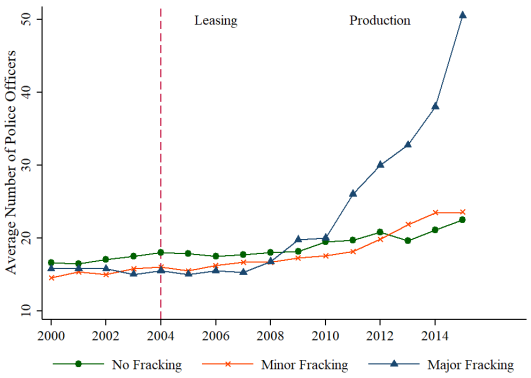
Figure 6: Estimates of the effect of fracking on aggregate crime, residents and non-residents



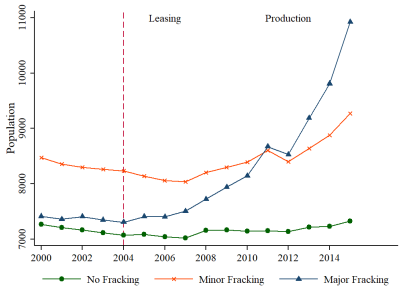
Notes: Dynamic difference-in-differences county-level estimates from equation 3 with county and year fixed effects. Standard errors are clustered at the county-level and 95% confidence intervals are shown. Data on charges filed are from the State of North Dakota Judicial Branch from 2000–2017. The sample is all cases filed in North Dakota Counties (except the four that are not covered by the residential directories, namely Cass, Grand Forks, Pembina and Traill). Outcome is defined as cases filed per 1000 persons with population measured using IRS tax exemptions in each year.

Figure 7: Raw data of the effect of fracking on police and population

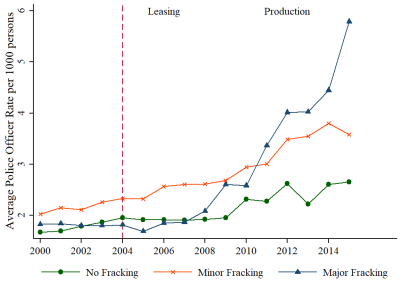
(a) total officers



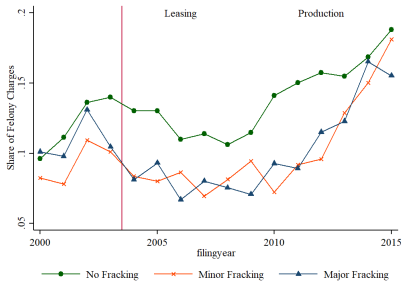
(b) population



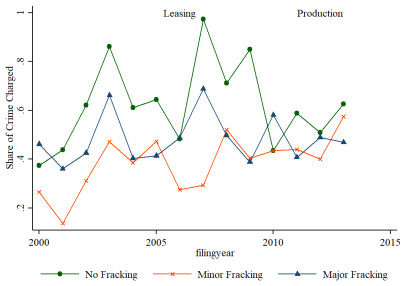
(c) officers per 1000s person



(d) share of felony charges among all charges



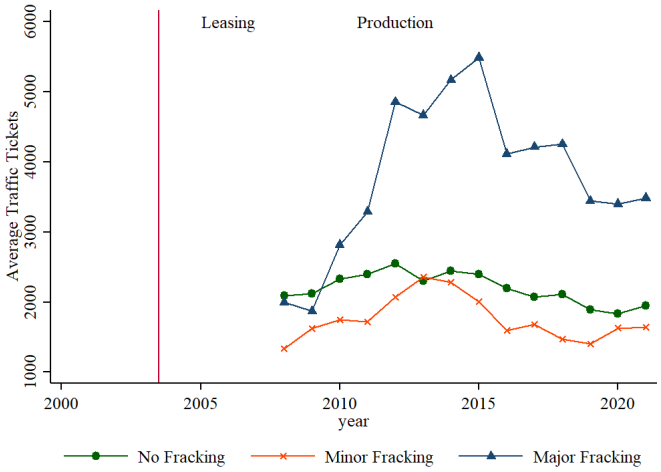
(e) ratio of felony charges to index crimes



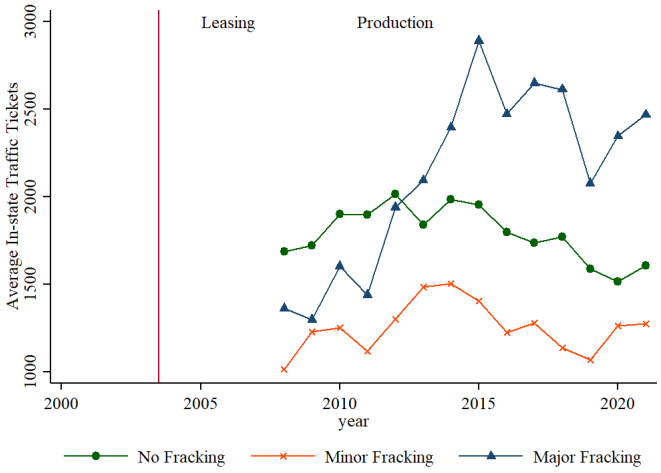
Notes: Dynamic difference-in-differences county-level estimates from equation 3 with county and year fixed effects. Standard errors are clustered at the county-level and 95% confidence intervals are shown. Data are from Internal Revenue Service and Uniform Crime Reporting Program Data [United States]: Police Employee (LEOKA). Charge data are from the State of North Dakota Judicial Branch from 2000–2017.

Figure 8: Trends in traffic tickets by fracking region

(a) total number of tickets



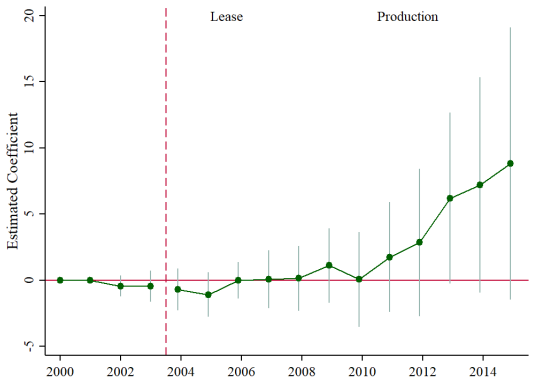
(b) average number of tickets instate



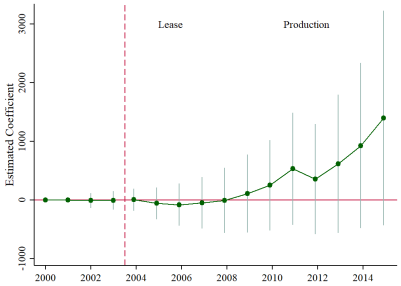
Notes: Traffic data are from the State of North Dakota Judicial Branch from 2008–2021.

Figure 9: Dynamic difference-in-difference estimates of the effect of fracking on police and population

(a) total officers

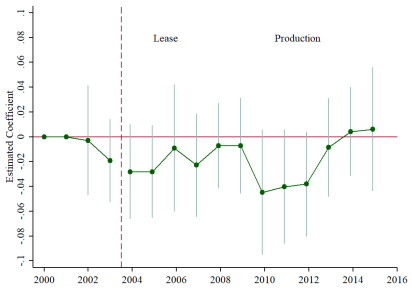


(b) population

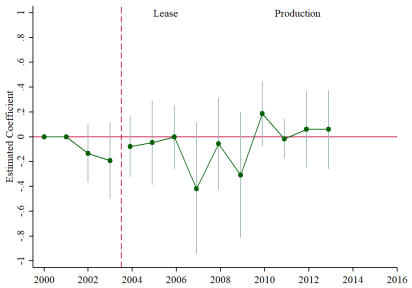


(c) officers per 1000 persons IRS

(d) share felony charges among all charges

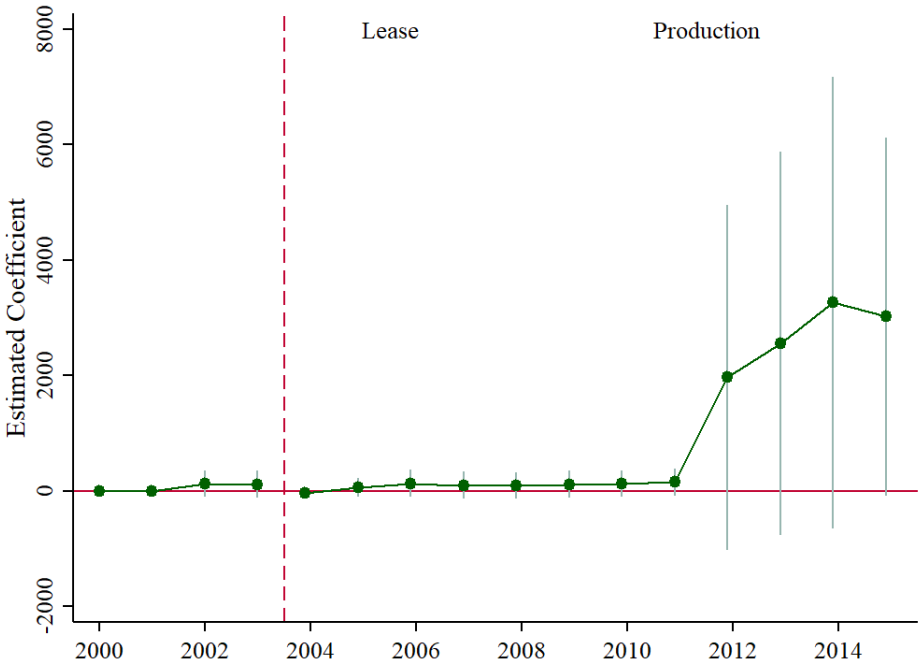


(e) ratio of felony charges to index crimes



Notes: Dynamic difference-in-differences county-level estimates from equation 3 with county and year fixed effects. 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). Charge data are from the State of North Dakota Judicial Branch from 2000–2017. Data on the number of index crimes by county are from the North Dakota Office of Attorney General, Bureau of Criminal Investigation 2000-2013. -

Figure 10: Estimates of the effect of fracking on out-migration



Notes: Dynamic difference-in-differences county-level estimates from equation 3 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 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. These data are not necessarily represent only the local residents used in the analysis, rather it is represents all tax filers in the county in a given year.

9 Tables

Table 1: Summary statistics for residents, 2000-2017

	All	Fracking County	Non-Fracking County	Lease Holder	Non-Lease Holder
Panel A: Household					
Case ever filed	0.17	0.17	0.17	0.18	0.17
Lease holder	0.15	0.39	0.03	1.00	0.00
Number of royalty months	9.58	24.64	1.96	64.34	0.00
	(32.26)	(48.11)	(14.96)	(58.90)	(0.00)
Monthly royalty payment	1873.54	5033.89	274.90	12586.26	0.00
	(13367.60)	(22122.99)	(3730.56)	(32646.55)	(0.00)
Observations	30909	10383	20526	4601	26308
Panel B: Household-Year					
Case filed	0.0176	0.0180	0.0173	0.0189	0.0173
Drug charge	0.0035	0.0033	0.0036	0.0036	0.0035
Driving charge	0.0100	0.0106	0.0097	0.0113	0.0097
Theft charge	0.0032	0.0031	0.0032	0.0030	0.0032
Other charge	0.0062	0.0063	0.0062	0.0065	0.0062
Observations	556362	186894	369468	82818	473544
Panel C: Charges					
Charges per case	1.13	1.10	1.14	1.14	1.13
	(0.58)	(0.47)	(0.62)	(0.58)	(0.59)
Felony charge	0.10	0.08	0.10	0.10	0.09
Driving charge	0.44	0.46	0.43	0.47	0.44
Drug charge	0.17	0.15	0.18	0.17	0.17
Theft charge	0.17	0.17	0.17	0.14	0.17
Assault charge	0.03	0.03	0.04	0.03	0.04
Other charge	0.30	0.30	0.31	0.30	0.30
Male	0.80	0.80	0.80	0.79	0.80
Defendant's age	35.64	34.86	35.85	36.25	35.52
	(15.16)	(14.85)	(15.31)	(14.86)	(15.22)
Observations	16093	4045	10615	2651	13442

Notes: Data on charges filed are from the State of North Dakota Judicial Branch from 2000–2017. The sample is all local households defined by last name, street number, city, and zip code identified in each county from the Great Plains Directory Service. Leaseholders are identified from leases signed between 2000-2017 and collected by DrillingInfo, a private company. The gender of the offender is predicted based on first name using an API and is reported as a continuous variable.

Table 2: Estimates of the effect of fracking on crime

	1	2	3	4
Fracking Co X Post Lease	-0.0028**	-0.0034**	-0.0029**	-0.0036*
	(0.0014)	(0.0016)	(0.0014)	(0.0018)
Fracking Co X Post Prod	-0.0035**	-0.0041**	-0.0040*	-0.0036*
	(0.0017)	(0.0017)	(0.0021)	(0.0021)
Pre Lease		-0.0012		
		(0.0014)		
Observations	556362	556362	556362	556362
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. Data on charges filed are from the State of North Dakota Judicial Branch from 2000–2017. The sample is all local households defined by last name, street number, city, and zip code identified in each county from the Great Plains Directory Service.

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	-0.0008	-0.0006	-0.0008	-0.0011
	(0.0005)	(0.0006)	(0.0006)	(0.0007)
Fracking Co X Post Prod	-0.0016**	-0.0013*	-0.0016*	-0.0016*
	(0.0006)	(0.0007)	(0.0008)	(0.0008)
Pre Lease		0.0005		
		(0.0007)		
Observations	556362	556362	556362	556362
Mean Dependent Variable	0.004	0.004	0.004	0.004
Panel B: Driving Case Filed				
Fracking Co X Post Lease	-0.0012	-0.0010	-0.0013	-0.0022
	(0.0013)	(0.0015)	(0.0013)	(0.0014)
Fracking Co X Post Prod	-0.0014	-0.0012	-0.0018	-0.0017
	(0.0011)	(0.0012)	(0.0017)	(0.0014)
Pre Lease		0.0005		
		(0.0011)		
Observations	556362	556362	556362	556362
Mean Dependent Variable	0.013	0.013	0.013	0.013
Panel C: Drug Case Filed				
Fracking Co X Post Lease	-0.0019***	-0.0018***	-0.0028***	-0.0021***
	(0.0006)	(0.0006)	(0.0008)	(0.0006)
Fracking Co X Post Prod	-0.0001	-0.0000	-0.0025**	-0.0006
	(0.0005)	(0.0004)	(0.0012)	(0.0006)
Pre Lease		0.0002		
		(0.0008)		
Observations	556362	556362	556362	556362
Mean Dependent Variable	0.005	0.005	0.005	0.005
Panel D: Other Case Filed				
Fracking Co X Post Lease	-0.0011	-0.0016*	-0.0013	-0.0005
	(0.0008)	(0.0009)	(0.0008)	(0.0010)
Fracking Co X Post Prod	-0.0011	-0.0016	-0.0017	-0.0008
	(0.0010)	(0.0010)	(0.0012)	(0.0009)
Pre Lease		-0.0009		
		(0.0006)		
Observations	556362	556362	556362	556362
Mean Dependent Variable	0.009	0.009	0.009	0.009
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. Data on charges filed are from the State of North Dakota Judicial Branch from 2000–2017. The sample is all local households defined by last name, street number, city, and zip code identified in each county from the Great Plains Directory Service.

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

	1	2	3	4
Minor Fracking County X Post Lease	-0.0029*	-0.0035**	-0.0029*	-0.0037*
	(0.0015)	(0.0016)	(0.0014)	(0.0020)
Major Fracking County X Post Lease	-0.0024	-0.0030	-0.0031	-0.0033
	(0.0023)	(0.0026)	(0.0027)	(0.0023)
Minor Fracking County X Post Prod	-0.0042**	-0.0048***	-0.0041*	-0.0040*
	(0.0019)	(0.0018)	(0.0023)	(0.0022)
Major Fracking County X Post Prod	-0.0015	-0.0021	-0.0036	-0.0021
	(0.0025)	(0.0027)	(0.0027)	(0.0026)
Pre Lease		-0.0012		
		(0.0014)		
Observations	556362	556362	556362	556362
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. Data on charges filed are from the State of North Dakota Judicial Branch from 2000–2017. The sample is all local households defined by last name, street number, city, and zip code identified in each county from the Great Plains Directory Service.

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

	1	2	3	4
Lease HH X Post Lease	-0.0005	-0.0011	-0.0008	-0.0012
	(0.0019)	(0.0020)	(0.0020)	(0.0021)
Non-Lease HH X Post Lease	-0.0042***	-0.0048***	-0.0042***	-0.0047**
	(0.0014)	(0.0016)	(0.0014)	(0.0018)
Lease HH X Post Prod	-0.0026	-0.0032	-0.0034	-0.0026
	(0.0022)	(0.0022)	(0.0024)	(0.0020)
Non-Lease HH X Post Prod	-0.0041**	-0.0047**	-0.0043**	-0.0041*
	(0.0018)	(0.0018)	(0.0020)	(0.0023)
Pre Lease		-0.0012		
		(0.0014)		
Observations	556362	556362	556362	556362
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

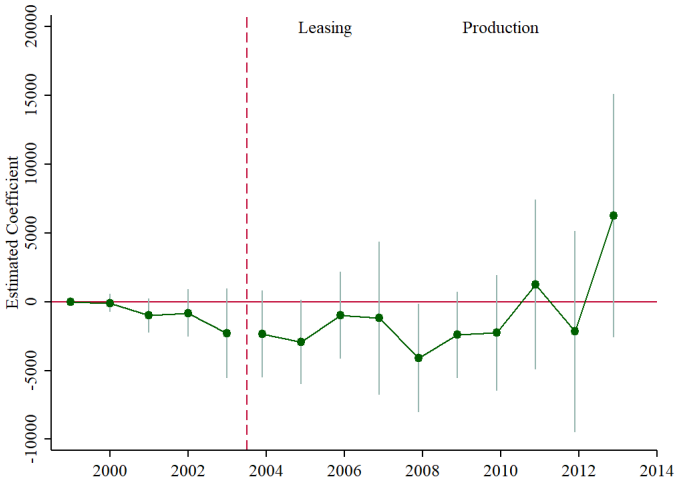
Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. Standard errors are in parentheses and clustered at the county level. County controls include per capita income, total jobs, population, total officers, and production in 2000. Data on charges filed are from the State of North Dakota Judicial Branch from 2000–2017. The sample is all local households defined by last name, street number, city, and zip code identified in each county from the Great Plains Directory Service. Leaseholders are identified from leases signed between 2000-2017 and collected by DrillingInfo, a private company.

A Appendix

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

(a) total sales

(b) price

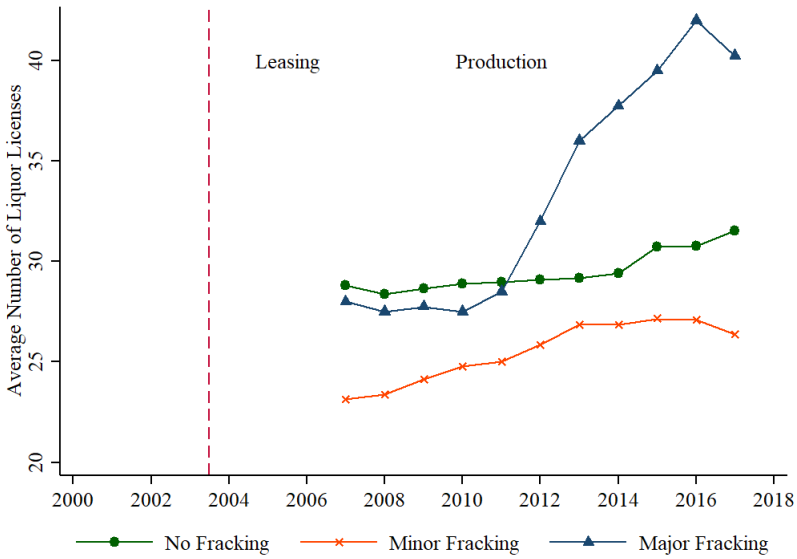


Notes: Dynamic difference-in-differences county-level estimates from equation 3 with county and year fixed effects. Standard errors are clustered at the county-level and 95% confidence intervals are shown. Outcome is defined as total sales in each county and total sale values. Data on all property sales are from the North Dakota State Board of Equalization.

Figure A.2: Estimates of the effect of fracking for older household members

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 on charges filed are from the State of North Dakota Judicial Branch from 2000–2017. The sample is all local households defined by last name, street number, city, and zip code identified in each county from the Great Plains Directory Service. Leaseholders are identified from leases signed between 2000-2017 and collected by DrillingInfo, a private company. The outcome is restricted to crimes committed by household members that were 25 years or older as of January 2000.

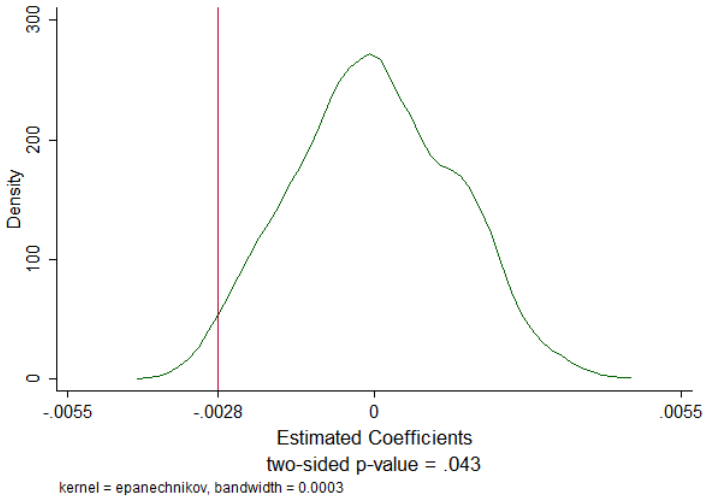
Figure A.3: Average total number of liquor license per county by fracking region



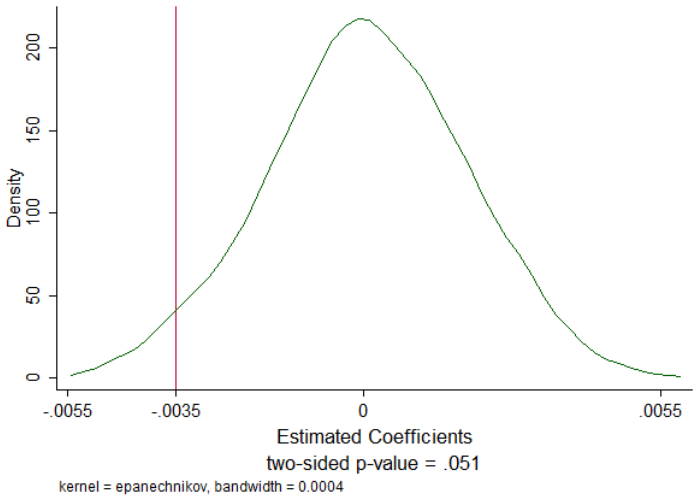
Notes: Average total number of licenses per county are plotted by fracking region. Data on all liquor licenses in the State of North Dakota are provided by the North Dakota Attorney General's office from 2007–2018.

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, -0.0028, with 19 estimates less than or equal to it and 43 estimates greater than the coefficient in absolute magnitude. Similarly, in Figure A.2b the estimate during production period, -0.0035, is drawn in red with 27 estimates less than or equal to it and 51 estimates greater than the coefficient in absolute magnitude.

Table A.1: Summary statistics for all charges by group, 2000-2003

	All	Resident	Non-Resident	Lease Holder	Non-Lease Holder
Male	0.709	0.745	0.705	0.703	0.758
Defendant's age	30.16	31.29	30.03	31.84	31.11
Felony	0.099	0.078	0.102	0.062	0.083
Drug offense	0.137	0.148	0.136	0.136	0.152
Driving offense	0.362	0.379	0.360	0.400	0.372
Theft offense	0.268	0.260	0.269	0.253	0.262
Assault offense	0.042	0.036	0.043	0.034	0.036
Other offense	0.288	0.289	0.2882	0.275	0.294
Observations	101762	9731	92031	2352	7379

Notes: Data on charges filed are from the State of North Dakota Judicial Branch from 2000–2003. The sample is all local households defined by last name, street number, city, and zip code identified in each county from the Great Plains Directory Service. Leaseholders are identified from leases signed between 2000-2017 and collected by DrillingInfo, a private company. The gender of the offender is predicted based on first name using an API and is reported as a continuous variable.

Table A.2: Estimates of the effect of fracking on crime for household members with stable residences, 25 years or older at start of sample

	Any Charge	Any Charge	Any Charge	Any Charge
Fracking Co X Post Lease	-0.0028**	-0.0034**	-0.0029**	-0.0036*
	(0.0014)	(0.0016)	(0.0014)	(0.0018)
Fracking Co X Post Prod	-0.0035**	-0.0041**	-0.0040*	-0.0036*
	(0.0017)	(0.0017)	(0.0021)	(0.0021)
Pre Lease		-0.0012		
		(0.0014)		
Observations	556362	556362	556362	556362
Mean Dependent Variable	0.02	0.02	0.02	0.02
Household & Year FE	Y	Y	Y	Y
Lead		Y		
County Trends			Y	
Base Level Controls X Year				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. Data on charges filed are from the State of North Dakota Judicial Branch from 2000–2017. The sample is all local households defined by last name, street number, city, and zip code identified in each county from the Great Plains Directory Service and the outcome is restricted to crimes committed by household members that were 25 years or older as January 2000.

Table A.3: Case filed, robustness to residential directory years

	1	2	3	4
Fracking Co X Post Lease	-0.0028**	-0.0025*	-0.0030*	-0.0027
	(0.0014)	(0.0014)	(0.0015)	(0.0021)
Fracking Co X Post Prod	-0.0035**	-0.0031*	-0.0037**	-0.0034
	(0.0017)	(0.0018)	(0.0018)	(0.0024)
Observations	556362	465966	383454	269028
Mean Dependent Variable	0.02	0.02	0.02	0.02
Household & Year FE	Y	Y	Y	Y
Residential Directories before	2008	2007	2006	2005

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. Standard errors are in parentheses and clustered at the county level. Residential directory years correspond to the year of the county records that the directories are include. Column 1 replicates Column 1 from Table 2 with all residential directories prior to 2008. Column 2, 3, and 4 restrict to all residential directories prior to 2007, 2006, and 2005, respectively. There are not enough residential directories sourced prior to 2004 alone to conduct the analysis. Data are from the State of North Dakota Judicial Branch from 2000–2017. The sample is all local households defined by last name, street number, city, and zip code identified in each county from the Great Plains Directory Service.

Table A.4: Case filed, robustness to Levenshtein Index

	1	2	3	4
Fracking Co X Post Lease	-0.0025	-0.0032*	-0.0028**	-0.0025*
	(0.0020)	(0.0016)	(0.0014)	(0.0014)
Fracking Co X Post Production	-0.0019	-0.0027	-0.0035**	-0.0033**
	(0.0037)	(0.0022)	(0.0018)	(0.0017)
Observations	556362	556362	556362	556362
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 and 2 allow for more string edits than what is used throughout the paper for matching with a string distance of three and two, respectively. Column 3 replicates Column 1 from Table 2 with one string edit as a baseline specification. Column 4 restricts to exact matches with a string distance zero. Data are from the State of North Dakota Judicial Branch from 2000–2017. The sample is all local households defined by last name, street number, city, and zip code identified in each county from the Great Plains Directory Service.

Table A.5: Estimates of the effect of fracking on crime, robust to functional form and intensive margin

Dependent Variable	Any Case		Number of Cases		Number of Charges	
	1	2	3	4	5	6
Fracking Co X Post Lease	-0.0028**	-0.1931**	-0.0037**	-0.2298**	-0.0037**	-0.1933**
	(0.0014)	(0.0867)	(0.0017)	(0.0958)	(0.0017)	(0.0831)
Fracking Co X Post Prod	-0.0035**	-0.2345**	-0.0042**	-0.2504**	-0.0043**	-0.2209**
	(0.0017)	(0.1123)	(0.0020)	(0.1121)	(0.0021)	(0.1069)
Observations	556362	93204	556362	93204	556362	93204
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. Data are from the State of North Dakota Judicial Branch from 2000–2017. The sample is all local households defined by last name, street number, city, and zip code identified in each county from the Great Plains Directory Service.