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

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March 28, 2025

Abstract

Theory suggests crime should decrease as economic opportunities increase the returns to legal activities. However, the current literature shows crime increases when areas experience fracking, a source of increased local economic opportunity. This paper reconciles this puzzle by separating out existing residents, isolating local economic effects from changing composition. Specifically, I exploit within- and across-county variation in fracking activities in North Dakota using individual-level data on incumbent residents, mineral lease records, and criminal charges. The results rule out increases in crime for these existing residents and suggest a modest decrease. These results are consistent with theory and in contrast to the observed aggregate increases in crime from fracking, highlighting the importance of compositional changes.

JEL Classification: K42, J60, R23, H31

Keywords: Crime, Economic Opportunity, Fracking

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This research uses confidential data from the State of North Dakota Judicial Branch. I am grateful for the use of this data and pledge that that the views expressed in this manuscript are my own and not of the State of North Dakota. I would like to thank Carolina Arteaga, Panka Bencsik, Jillian Carr, Jennifer Doleac, Gopi Shah Goda, Mark Hoekstra, Emily Leslie, Elizabeth Luh, Samantha Mackley, Anita Mukherjee, Aurélie Ouss, Emily Owens, Abigail Peralta, Steve Puller, Steven Rafael, Danielle Sandler, CarlyWill Sloan, Allison Stashko, and the Center for Growth and Opportunity, as well as conference participants at the American Economic Association Conference, Society of Labor Economists Conference, Association for Public Policy & Management Conference, Southern Economic Association Conference, Midwest Economic Association-SOLE Conference, STATA TX Empirical Microeconomics Conference, and seminar participants at the Norwegian School of Economics, Temple University, Wake Forest University, Central Washington University, Louisiana State University, University of Michigan, Notre Dame University, University of Chicago - Urban Labs, RAND Corporation, Tulane University, the University of Florida, and Southern Illinois University Carbondale. Finally, I'd especially like to thank the editor and two anonymous referees for their constructive comments, which have greatly improved this paper.

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.[1] 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 local economic conditions. 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 identified in the Great Plains Directory Service prior to the economic shock.[2] 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

[1] Specifically, I estimate the average treatment effect on the treatment group, residents of fracking counties in North Dakota, which I refer to as "the effect" throughout for simplicity.

[2] The Great Plains Directory Service provides a listing of the household head for current rural residents in each county, including their address and phone number, similar to a phone book (See Figure A.1).

unrelated to prior local conditions and household behaviors, overcoming common critiques of the difference-in-differences research design.[3] Third, 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 and similar to other local stimulus via large construction or manufacturing projects.

Studying the effects at the individual level requires detailed data on hydraulic fracturing activities, criminal behavior, and local residents in North Dakota.[4] 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 show that the identified incumbent residents did not contribute to an increase in crime during the fracking boom. Rather, the start of the economic expansion — defined as the period when companies began leasing mineral rights and investing in the area — may have led to a statistically significant 0.28 percentage point (14%) reduction in criminal behavior by local residents. This modest decrease continues as production ramped up, with a 0.35 percentage point decrease in the likelihood of committing a crime. These results are statistically different from the overall results documented in the literature and replicated in my setting of an overall increase in county level crime. 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 suggest that the reduction in crime is driven by non-leaseholders, which is consistent with the hypothesis that those not receiving income through alternative means are more responsive to increased job opportunities and relative wage gains as formulated in the Becker-Ehrlich style models.

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

[4] 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.

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 local 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, 2018; Grieco, 2017). These studies generally show aggregate crime is inversely related with local 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, DeAngelo and Smith, 2020).[5] 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 are not driving the observed increase in crime. This is

[5] Alternatively, Feyrer, Mansur and Sacerdote (2017) do not find a statistically significant increase in crime across fracking counties.

consistent with predictions of the economic theory of crime when the returns to legal employment increase.[6]

Finally, while the primary purpose of this study is to examine the impact 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 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).[7] Results on aggregate crime presented here suggest that the fracking induced in-migration of mostly young, American men, documented by Wilson (2020), likely 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.[8] 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

[6]This is also consistent with empirical evidence documenting a similar inverse relationship between recidivism and economic conditions (e.g., Agan and Makowsky, 2021; 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, 2018).

[7]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.

[8]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.

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%.

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 and finally dipping in response to a drop in oil prices. Notably, it takes a significant amount of work (e.g., drilling and well set up) prior to any observed oil production as measured in barrels; thus, jobs in the area increase *prior* to the increase in oil production. Overall, North Dakota produced oil valued at an estimated $2,904,191 million from 2008-2017.[9]

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.[10] 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, and population.[11] 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,

[9]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).

[10]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.

[11]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.

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 to fill rapidly increasing jobs.[12] It is also the period when the majority of households that had signed a lease received royalty payments. This is reflected in the data, as Figure 3 shows fracking counties experienced large increases in income, jobs, and population during the post-2008 production period.[13] Prior research documents that the population increase is largely driven by young men (Wilson, 2020; James and Smith, 2017; Andrews and Deza, 2018). I also show that the majority of in-migrants to major and minor fracking counties are from other U.S. states, although a non-negligible share migrate from other counties within the state (see Figure A.10).[14] 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 local changes in educational attainment, marriage and fertility patterns, and other risky behaviors (Kearney and Wilson, 2018; Cunningham, DeAngelo and Smith, 2020; Cascio and Narayan, 2022). Moreover, I show descriptive evidence of a large increase in the number of liquor licenses per county in counties with major fracking activity during this period, graphically depicted in Figure A.7.[15]

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 (Becker, 1968; Ehrlich, 1973). 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, Ouss and Philippe, 2021; Case and Deaton, 2015; 2017; Autor, Dorn and Gordon, 2020). Alternatively, the large cash transfers—via royalty payments—to some households may lead to more

[12] Gittings and Roach (2020) show that a share of the new jobs go to those moving into the county with a much smaller share of total new jobs going to local residents; their finding is consistent with the setting in North Dakota in which local residents are brought to full employment during the initial increase in jobs and individuals must move in to fill the larger share of jobs. Notable, the unemployment rate in North Dakota was at historic lows even in the midst of the Great Recession. Specifically, North Dakota had the lowest unemployment rate of 3.9% and highest employment to population ratio at 69.8% among all 50 states with the National average unemployment rate and employment to population rate of 9.6% and 58.5%, respectively (Bureau of Labor Statistics: The Economics Daily, 2011).

[13] Interestingly, notable dips in per capita income and total jobs are observed in major fracking counties with a smaller dip in minor fracking counties likely reflecting the dip in oil prices in late 2014 / early 2015.

[14] The five highest contributing states in descending order are Minnesota, Arizona, South Dakota, California, and Montana.

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

crime through increased income inequality and opportunity of crime (Freedman and Owens, 2016; Mejia and Restrepo, 2016; Cook, 1986; James and Smith, 2017; Ehrlich, 1973). 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). These individual changes may affect the aggregate county-level of crime along with the criminal propensity of those moving into the area and how the interact with the fracking environment.

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. The directories are created for a county every few years and directories for all counties were not created in the same year.[16] 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 regardless of ownership. Residents living within city limits are not included in the directories and thus are not able to be considered in this analysis. Households listed in these directories cover roughly 20% of all households in North Dakota based on the

[16] All counties are included except Cass, Grand Forks, Pembina, and Traill, which were not covered by the Great Plains Directory Service during the relevant years. Moreover, I show results are robust to the restriction of directory years in Table A.2.

2000 Decennial Census, which is half of all of census designated rural households.[17] While I am able to identify only a subset of existing residents, these households are mostly similar in demographics and types of charges compared to those not in my sample during the pre-period (see Table A.1). For example, charges linked to the Great Plains Directory Service are more likely to be for slightly older, male offenders. The charges are less likely to be for a felony offense but have a similar distribution across offense types (e.g., drug, driving, theft, assault). While I cannot consider characteristics of those not charged or other characteristics, the types of charges for this population is particularly relevant for this context.

The directory information includes the name, address, and city of one of the household members, presumably the household head (see Figure A.1). Since all individuals are not listed for each house, I define households based on the last name, street number, city, and zipcode. In total, there are 30,909 households which is considered the sample of households for the analysis and then matched to lease and crime data using a Levenshtein Index. 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.[18]

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.2 that property sales in fracking counties remain similar to sales in non-fracking counties throughout the leasing period. Additionally, results are robust to restricting to counties with earlier directories (see Table A.2). 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. A decrease in criminal behavior, as seen in the results, could also be explained by differential out migration in fracking counties. Even if households are not moving into or out of 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

[17] The Great Plains Directory Service are not expected to cover all census designated rural households since the directories do not cover areas inside city limits and many cities in North Dakota are officially classified as rural by the U.S. Census Bureau.

[18] 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.3, I show that the main results are robust to this index.

household address as jobs enter the county. In this case, if individuals 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 composition, rather than a change in criminal behavior. If this were the case, I should see differential outmigration from fracking counties and should not see the same effects when limiting the analysis to the criminal behavior of more stable household members, those 25 or older by the start of the sample. However, in the results section (Section 5.1) and discussion (Section 6.2), I show moving is similar across different types of counties and the results are robust to the sample restriction of more stable household members, suggesting that it is changes in criminal behavior that are driving the 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.[19] 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.[20]

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

[19] 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.

[20] 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%.

five years.[21] 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.[22]

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 are grouped together in other charges, with the exception of assault charges (3%). 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 to identify the average treatment effect on the treated in North Dakota. Given the timing of fracking activities and subsequent changes in affected counties, I consider the effects separately in each period when estimating average treatment effects: leasing (2004 to 2008) and production (2008 to 2017). Again, production activities begin before any realized production in terms of barrels of oil and the tran-

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

[22] These data do not, however, allow me to observe victimization of existing residents; thus, while it is an interesting question, understanding the patterns behind victimization is beyond the scope of this paper.

sition between leasing and production periods is more gradual; thus, I show dynamic models in the accompanying figures as well. 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.[23] 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 assumptions behind this approach are 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 (parallel trends), pre-periods are not affected by treatment (no anticipation), and an individual's treatment status does not affect the potential outcome of another (stable unit treatment value assumption). I check these assumptions in several ways. First, I provide visual evidence that treated and control counties are tracking prior to any treatment, which suggests that they would have continued tracking absent treatment. Relatedly, I formally test for pre-divergence, or an Ashenfelter Dip, 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 and allow for counties to respond to year-to-year shocks based on pre-treatment characteristics. Finally, to the extent there are spillovers to neighboring control counties, the parameters of interest in the main model will be biased toward zero and can remove the eight neighboring counties, which are most prone

[23] Since the dependent variable is binary, I additionally show results using a logistic regression in Table **??**. 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.

to spillovers, as a robustness.[24]

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 Wild Bootstrapped standard errors clustered by county and permutation-based inference for approximating exact p-values in the primary specification when considering overall crime (Fisher, 1935; Imbens and Rubin, 2015). For the permutation inference, I randomly assign treatment to 17 counties and compare the estimated coefficient to 1000 placebo estimates to compute two-sided 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 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. I additionally use the logged number of jobs and the logged number of barrels of oil produced in each of the fracking counties as an alternative, continuous treatment measure. The four major fracking counties rank the highest on both of these measures.

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:

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

[24]The eight neighboring counties are Adams, Burleigh, Hettinger, Morton, Oliver, Pierce, Rollette and Sheridan.

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 as a benchmark for understanding the effects on residents. 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 6.1). 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 cases and charges filed per household population, for county c in year t. To make the aggregate analysis as similar to the incumbent resident analysis, I use the number of cases to unique households, defined by last name and address, to purge differences in the number of charges per case or repeat cases within households. Other characteristics are also considered as outcomes to highlight changes within the counties, such as number of police officers, number of houses sold, price of houses sold, and out-migration. 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. The average treatment on the treated is also estimated separately for the leasing and production periods following the above framework to have

comparable point estimates in the tables.

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 Panel A 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 in the literature and shown in Figure 4 Panel B, corresponding to the ramp up in jobs and the influx in population during the production period.

I report the average treatment effects for each period in Table 2. Column 1 indicates a decline of 0.28 (0.35) percentage points during the leasing (production) period in overall crime by residents in fracking counties relative to residents in non-fracking counties. From a baseline mean in fracking counties of 0.02, these estimates translate to a 14-17.5% drop in cases filed and is statistically significant at the 5% level. Moreover, the permutation-based p-value is less than 4.3% (5.1%), with 43 (51) out of 1,000 placebo estimates greater in absolute magnitude than estimated coefficient for the leasing (production) period, shown graphically in Figure A.3. 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 and -0.40 percentage points during the leasing and production periods. 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 in both periods, suggesting the change in criminal behavior is related to the fracking boom and not systematically responding to some other shock. Notably, all coefficients are statistically significant at the 10% level with 5 of the 8 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 Panel A in showing that the relative drop in criminal behavior continues through the production period.

Given the upper-bound of the confidence interval is 0 for both the leasing and production periods, these estimates suggest that these incumbent residents did not contribute to the aggregate increase during the production period seen in Figure 4 Panel B and Table 3, or reported in the broader literature (e.g., James and Smith, 2017). Aggregate changes in cases and charges filed per household are not detected during the leasing period with point estimates near zero at -0.0045 and -0.0018 in column 1 off of a mean of 0.083 and 0.122 per household, respectively. However, there are large increases in charges and cases filed during the production period. Specifically, Table 3 shows a 0.0371 percentage point increase in cases and a 0.0687 percentage point increase in charges per household during the production period, translating to a 44.7% and 56% increase, respectively. The increase during the production period is significant at below the 5% level. These results are in line with the literature, which finds large increases in crime rates during the production period (James and Smith, 2017; Andrews and Deza, 2018).

Given the potential for spillovers to neighboring counties, I re-estimate the main model without neighboring counties in Figure A.5 and Table A.4 for both the residents and for county crime overall. The results are qualitatively similar, although slightly larger in magnitude indicating the presence of spillovers to the control units,

a SUTVA violation in the main model. One could imagine assigning individuals in the neighboring counties as treated through increased access to economic opportunity in neighboring counties. Ultimately, the presence of spillovers to the control units attenuates the estimates from the main model as seen in Figure A.5 and Table A.4.

A potential concern is that effects are being driven by changes in household composition rather than changes in criminal behavior since estimates are at the household level. For example, the results could be driven by composition if young men, a more crime-prone demographic, were more likely to move out of the fracking counties at higher rates than the non-fracking counties.[25] 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.[26] The results for the older, perhaps more stable sample are shown in Figure A.6 and Table A.5. These results are the same as 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 5, or moving within fracking counties, see Figure A.4, at least not until towards the end of the sample when you expect churning of migratory workers.[27] Finally, I bound the extent that differential out-migration could be explaining my results by recording a random percentage of control households in the post period to 0, reflecting no criminal behavior induced migration. Table A.6 shows that over 3% of households in control areas would need to differentially move in order to make the results insignificant at conventional levels, but similar in magnitude, and coefficients remaining negative but smaller after changing 10% of control households in the post period.

Finally, I do a back of the envelope calculation to see whether out-of-state migrants entering the fracking counties were committing crimes at higher rates than North Dakotans. Since I do not observe all existing residents and cannot identify those that move into fracking counties with certainty, I make a series of conservative assumptions to shed light a question of interest in the immigration literature about whether those moving into an area are more criminogenic in general. Specifically, I assume any offense with a North Dakota address in the court records is a resident and any offense with an out-of-state address is a migrant, which will over count crimes by residents since individuals can move within the state and migrants can change their address over time.[28] To create a rate,

[25] 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.

[26] The most mobile age group in the American Community Survey is from ages 18 to 24 years old, which guides the choice in the age restriction for this exercise.

[27] 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.

[28] As seen in Figure A.4 and A.10, residents move both within the county and across counties from within North Dakota and from other states.

I consider the resident population to be fixed at the levels observed in 2000 and allow the migrant population to count *all* migrant inflows using IRS tax exemptions to account for persons moving into a new county and filing taxes; this assumption will likely under count the denominator for North Dakota residents and over count the denominator for movers since it counts migration from other counties in North Dakota and from out of state. The assumptions applied to the numerator and denominator should overstate the crime rate for North Dakotans and understate the crime rate for migrants. 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. Importantly, these results are context specific where migrants are primarily young, male, unmarried, white, and moving from other U.S. states (Wilson, 2020).

Taken together, findings provide evidence that these residents did not significantly increase their criminal behavior in response to fracking activities. 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 charge type

To better understand the type of crime affected by local economic shocks, I explore 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), other crimes (e.g., assault, resisting arrest, criminal conspiracy), and violent crimes (e.g., assault). For comparison, results are first shown for incumbent residents and then aggregate county-level results are shown. These exercises are viewed as exploratory to better understand the overall crime results and generally lack precision.

Panels A through E in Figure 6 generally show that residents in fracking and non-fracking counties do not diverge prior to the fracking boom across the crime types and that residents exposed to the fracking boom are not more likely have a criminal charge than their non-exposed counterparts. Table 4 reports average treatment effects for each period for the five crime types. Column 1 reports a -0.08 percentage point decrease in property cases filed during the leasing period, and a -0.16 percentage point decrease during the production period. Similarly, estimates are negative for driving-related cases during the leasing and production period, -0.12 and -0.14 percentage points,

respectively. Column 3 shows a decrease in drug cases filed of -0.19 percentage point during the leasing period, which is offset during the production period (0.01 percentage point). Finally, all other crimes have a similar negative effect of -0.11 during the leasing period and production periods with no effect on assault crimes. While the estimates are negative, they are mostly not significant at conventional levels.[29]

The aggregate county effects by crime types are shown dynamically in Figure 7 with aggregate effects for each period presented in Table 4. Again, counties mostly appear to track in the pre-period but now there are pronounced increases in all crime types during the production period. We do not detect effects during the leasing period across the crime groups with effects ranging from -0.35 to 0.11 percentage points and are not significant at conventional levels. The mostly negative point estimates during the leasing period likely reflect a combination of the decrease from existing residents and the gradual increase from those moving into the counties. During the production phase, I estimate percentage point increases across all crime types: 0.36 (16.2%) property, 0.82 (53.9%) drug, 3.0 (89.1%) driving, 0.26 (74.3%) assault, and 0.73 (29.1%) other cases. Here, estimates are all positive, although again mostly imprecise with the effect on driving -related cases significant at the 1% level and the effect on assault related cases significant at the 5% level.[30] The effect on driving-related cases is significant at the 1% level and the effect on assault-related cases is significant at the 5% level. These findings complement the findings in James and Smith (2017) and Andrews and Deza (2018), which documents effects across violent and property crime categories.

5.3 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, also 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.

[29] Drug cases during the leasing period and property cases during the production period are significant at the 1% and 5% levels. I also adjust for multiple testing across the five categories of crime using following Anderson (2008). The calculated FDR q-values are 0.017 for drug cases during the leasing period and 0.099 for property cases during the production period.

[30] The increase in the share of households with a driving and assault increase is significant at the 1% and 5% level, respectively The FDR q-value for driving is 0.056 and for assault is 0.144 following Anderson (2008).

To estimate the differential effect by treatment intensity, I report estimates from equation 1 separately for major and minor fracking counties in Table 5 Panel A for residents. For the leasing period, 2004 to 2008, estimates in Column 1 indicate a 0.29 and 0.24 percentage point decrease in cases filed for residents in counties with minor and fracking activity, respectively. The estimates are similar in magnitude and represents a 14.5% reduction in cases filed in counties with minor fracking activity and a 12% reduction in the major fracking counties. During the production period, estimates for minor fracking counties are larger in magnitude to the leasing period, 0.42 percentage point reduction in cases filed. Estimates for major fracking counties are smaller in magnitude during the production period relative to the leasing period (-0.15 percentage point), and not significant at conventional levels.[31] Only the coefficients for the minor fracking counties are statistically significant at 0.088 during the leasing period and 0.066 during the production period using wild bootstrapped standard errors, although the coefficients between major and minor fracking counties are not statistically different.[32] The effect grows larger in the minor fracking counties but seems to fade in the major fracking counties, which also experience larger population and income changes during the production period. I conduct a similar exercise using equation 3 for county level crime in Column 1 of Panel B. The effect is near zero during the leasing period and in minor fracking counties with a 17 percentage point (200%) increase in the major fracking counties during the production period, which is significant at the 1% level using wild bootstrapped standard errors.

I estimate alternative intensity specifications using the logged number of jobs (Columns 2 and 3) and logged number of barrels of oil produced in the county (Columns 4 and 5), offering two additional insights. First, the timing of increases in jobs closely maps to the reduction in criminal behavior among residents; in contrast, the increase in barrels of oil produced is not tied to changes in residents' criminal behavior. Increases in aggregate county-level crime related to both the increase in total jobs and actual oil production in the county. Second, specifications allowing for a linear and quadratic term for the number of jobs show that the extreme increase in jobs do not provide addition reductions in crime for residents; this is consistent with those in the county receiving initial jobs and that the excess number of jobs pulls in those from out of the county (Gittings and Roach, 2020).

[31] Importantly, if households receiving royalties were more likely to migrate out of the county and this was driving the main results discussed above, we should see larger and growing declines in the major fracking counties.

[32] I rely on wild bootstrapped standard errors for column 1 since there are 13 minor fracking counties and 4 major fracking counties.

5.4 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 6, I estimate the extent to which the fracking activities may differentially affect residents in fracking counties relative to all residents in non-fracking counties using equation 2.

Estimates for lease-holders in the fracking counties 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 in fracking counties 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: law enforcement response, out-migration, and potential mechanisms

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. In general, the offsetting effect in the production period observed for some crimes (e.g., drug-related crimes) and in the major fracking counties 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 and 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.7.[33]. Finally, 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), which is consistent with those not receiving alternative income streams being most sensitive to the job opportunities.

6.1 Law enforcement response

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 8.[34] 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 officers per capita initially, with larger increases during the more labor-intensive production period and might be 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

[33] Data on all liquor licenses in the State of North Dakota are provided by the North Dakota Attorney General's office from 2007-2018.
[34] I also estimate the main model at the county level with total police officers as the outcome of interest in Figure A.8.

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 7). 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 C), suggesting serious offenses are not crowding out detection of other offenses. A similar concern relates to the propensity for prosecutors to file charges (the outcome of interest for measuring criminal behavior), but the share of felony charges to index crimes is also relatively stable during the entire period (Panel D). While data prior to 2008 is not available, I also show that traffic infractions experience an uptick in fracking areas for both overall and for in-state drivers, consistent with the above evidence that detection is not likely driving the main results (Figure 8, Panels E and F).

6.2 Differential out-migration

Another 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 logged rate of tax exemptions filing in a new county each year, which represents out-migration rather than total population in a given year; notably, this reflects all filers in the county and not just the identified local residents.[35] 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 and filed taxes in the county begin leaving and filing taxes elsewhere, as shown in Figure 5. Additionally, I show in Figure A.2 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

[35]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. Migrant and non-migrant status is determined based on whether the person filed in a different county in the prior year.

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 likely capturing the churn of the non-resident workers and not the identified resident population, shown in Figure A.4. Nonetheless, results are similar when restricting to the population that is more likely to have a stable residence, i.e., crime committed by those 25 or older as of the start of the sample (see Figure A.5).[36] I also systematically recode control households' criminal activity to zero in the post-period mimicking differential out-migration, which I do not find strong evidence of in the above exercises. Results are stable differentially changing up to 3% of the control sample in magnitude and statistically significance. The coefficient shrinks significantly but remains negative even after differentially changing 10% of the control sample in the post-period. Together, these results suggest that differential moving does not account for the main results presented above.

6.3 Potential mechanisms

I am not able to directly test for the mechanism underlying the decrease in crime from improved economic opportunities but suggest four potential pathways. First, it is possible that residents refrain from criminal activity in order to secure the new local employment opportunities, as many jobs do not require formal education or training but do require a background check, a license, and a drug test. Second, the decreases in crime could be 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 third 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. All three mechanisms operate through access to the expanded job opportunities and increase in relative wages, rather than

[36]The most mobile age group in the American Community Survey is from ages 18 to 24 years old, which guides the choice in the age restriction for this exercise.

a pure non-labor market income shock consistent with the empirical findings loading on the timing of the increase in jobs instead of production (Table 5) and on non-leaseholders (Table 6).

While the previous channels all operate through the newly available jobs, it is also possible that effects operate through increases in school funding or other public services that likely disproportionately affect residents more than recent movers as a result of the increase in economic opportunity in the area. While, there is evidence of an increase in county revenue for school districts in fracking counties relative to non-fracking counties– a direct result of an increase in mineral leases and oil production, there is not similar evidence of a differential increase in total revenue for these schools. Rather, it seems the state reallocates funding such that all districts receive a similar increase in funding over time. School funding is one dimension that I can empirically document and it is possible that other channels exist. These other channels would need to affect fracking counties more than non-fracking counties (i.e., not allocated or balanced at the state level), disproportionately impact existing residents and those that are of criminal majority (i.e., adults).

7 Conclusion

This paper studies the effect of local economic shocks on criminal behavior separate from a migration response. Specifically, I exploit the recent boom in hydraulic fracturing activities as a plausibly exogenous shock to local economic conditions, most similar to local stimulus from large construction or manufacturing projects. Using detailed administrative data on all charges in North Dakota from 2000 to 2017, I estimate the effect of increased local 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 do not experience a similar increase but rather have a modest decrease in criminal activity during the fracking boom. Effects are observed across all counties with fracking activity and the reduction in criminal behavior is better matched to jobs in the county than oil production. 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 is the first to highlight the role of compositional changes on the aggregate effects on crime.

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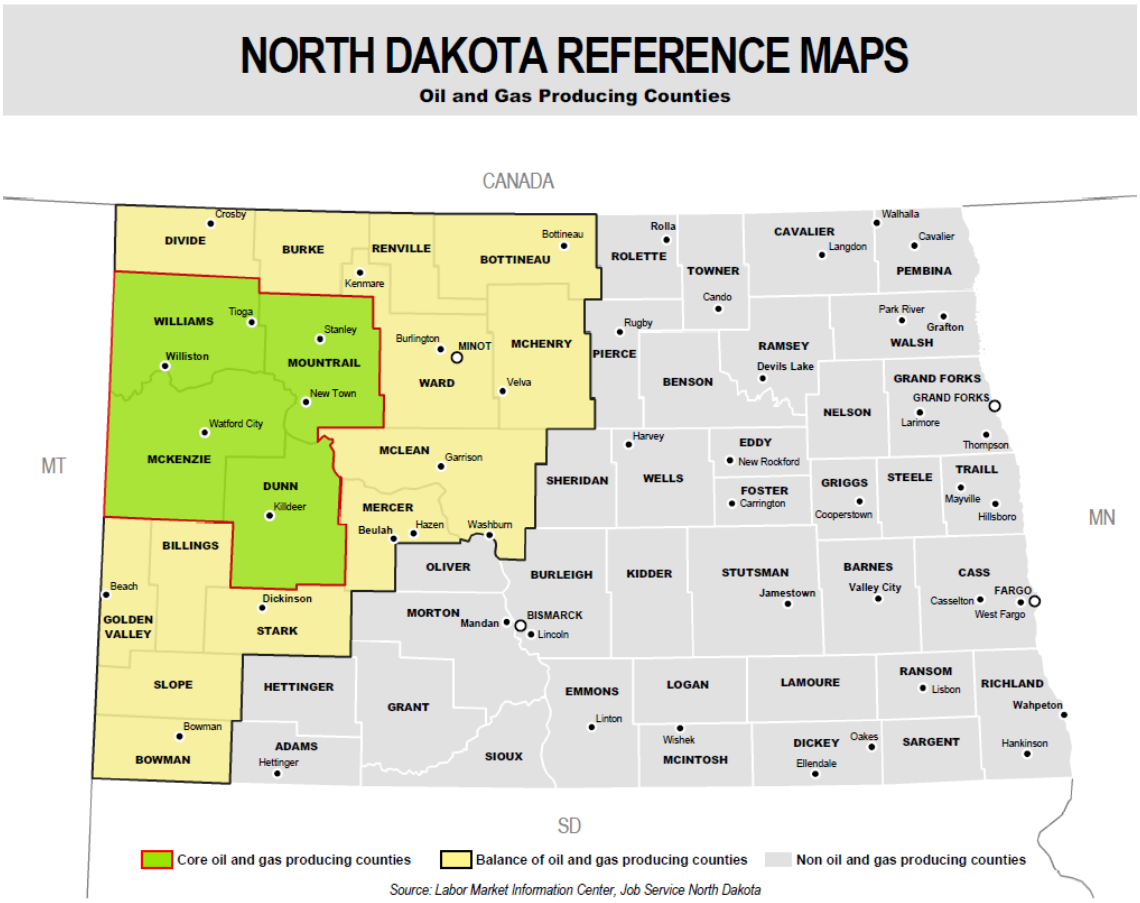
8 Figures

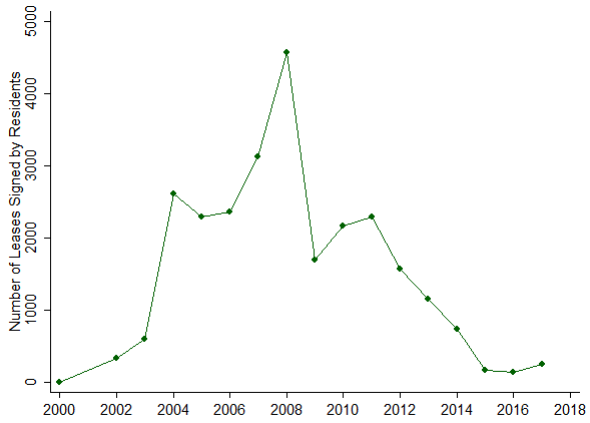
Figure 1: Fracking counties in North Dakota



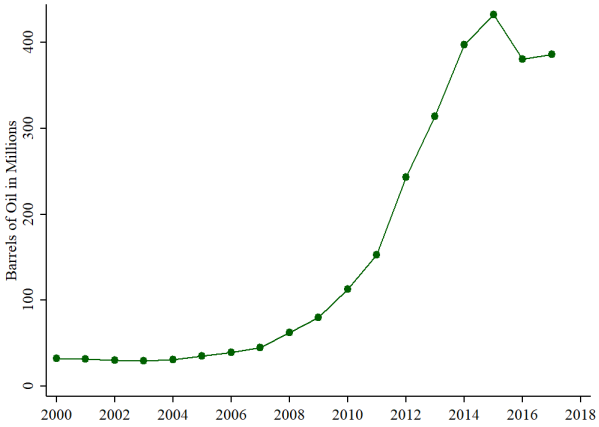
Notes: The figure is sourced from the Labor Market Information Center, Job Service North Dakota (`https://www.ndlmi.com/admin/gsipub/htmlarea/uploads/lmi_ndoilandgaseconomy.pdf`). Their definition of core and balance oil counties is used in subsequent analysis to define major and minor fracking counties, which maps to the counties with the highest oil production, number of leases, and job increases, as shown below.

Figure 2: Leasing and production

(a) leases

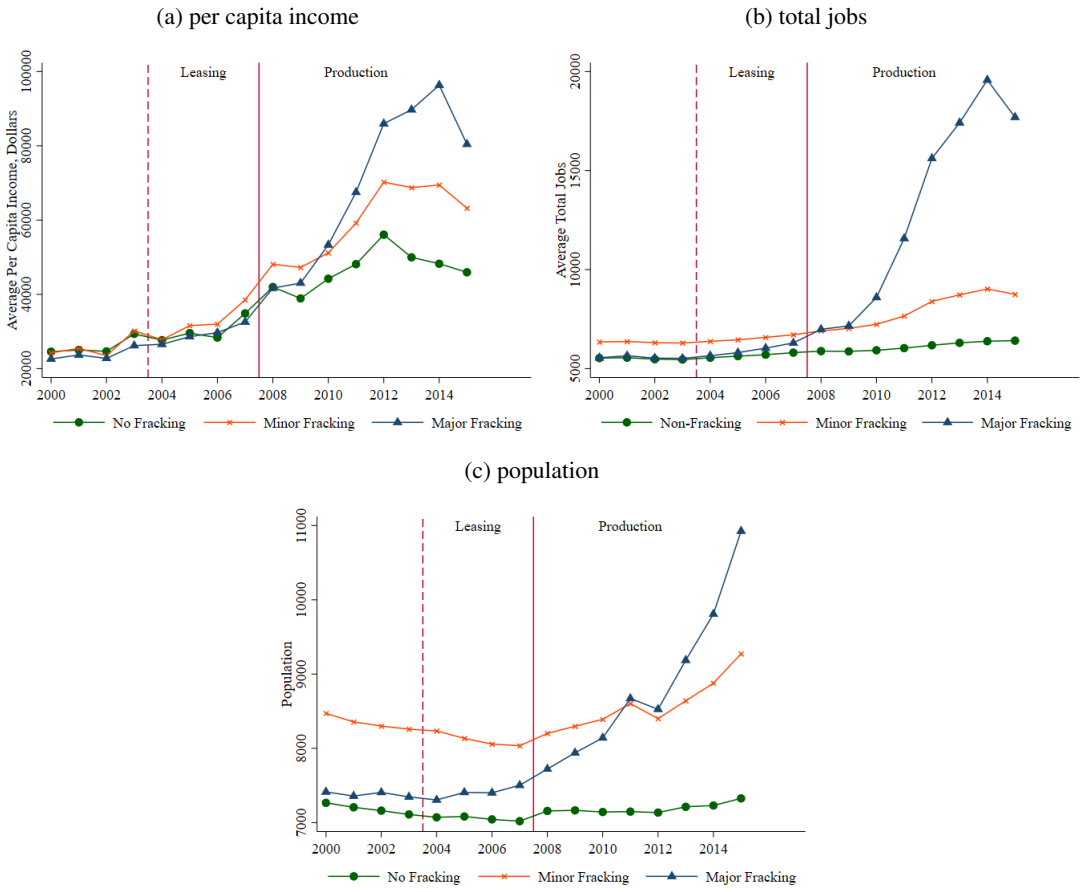


(b) production



Notes: The figure plots the total number of leases signed by identified residents from the Great Plains Directory Service (panel A) and total barrels of oil produced in North Dakota in millions (panel b) used to identify the timing of the fracking boom. All leases in North Dakota are collected from Drilling Info for 2000–2017. Monthly county production data are from North Dakota Department of Mineral Resources.

Figure 3: County characteristics by fracking region



Notes: The figure plots the average of county characteristics by fracking region (non-fracking, minor fracking, and major fracking counties), as defined in Figure 1. The dashed and solid vertical lines correspond to the start of the leasing period and production period, respectively. As seen in Figure 2, leases abruptly spike in 2004 while production gradually ramps up around 2008, which is chosen since it is the largest year-over-year percent change. 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 tax returns. 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.

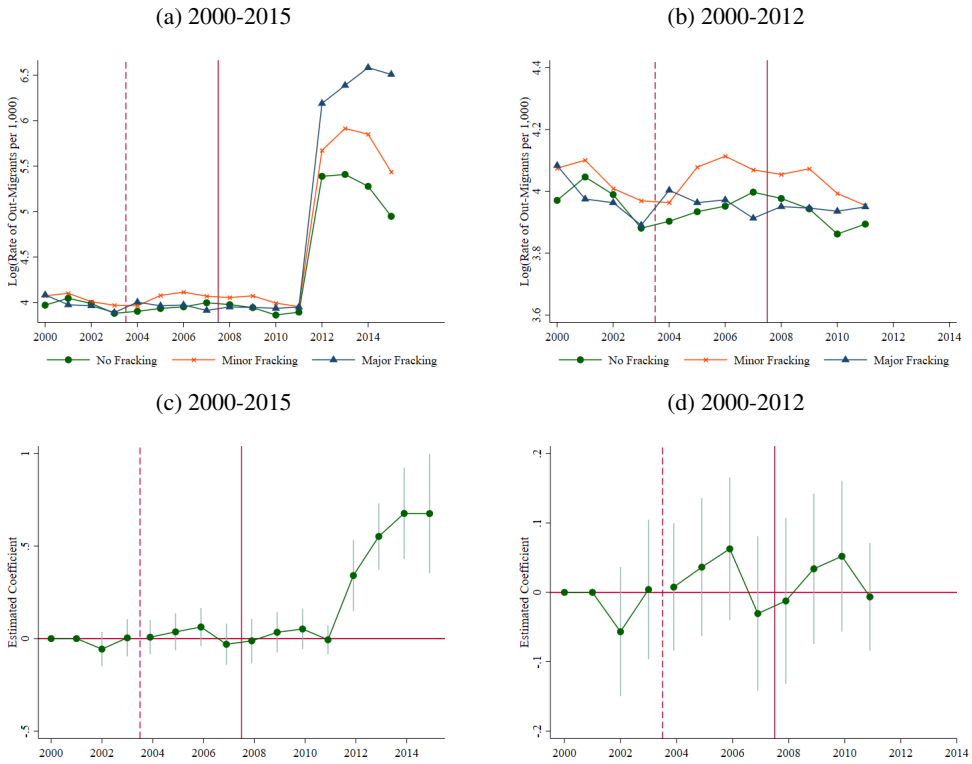
Figure 4: Dynamic difference-in-difference estimates of the effect of fracking on crime

(a) likelihood of any case filed

(b) share of households with a case filed

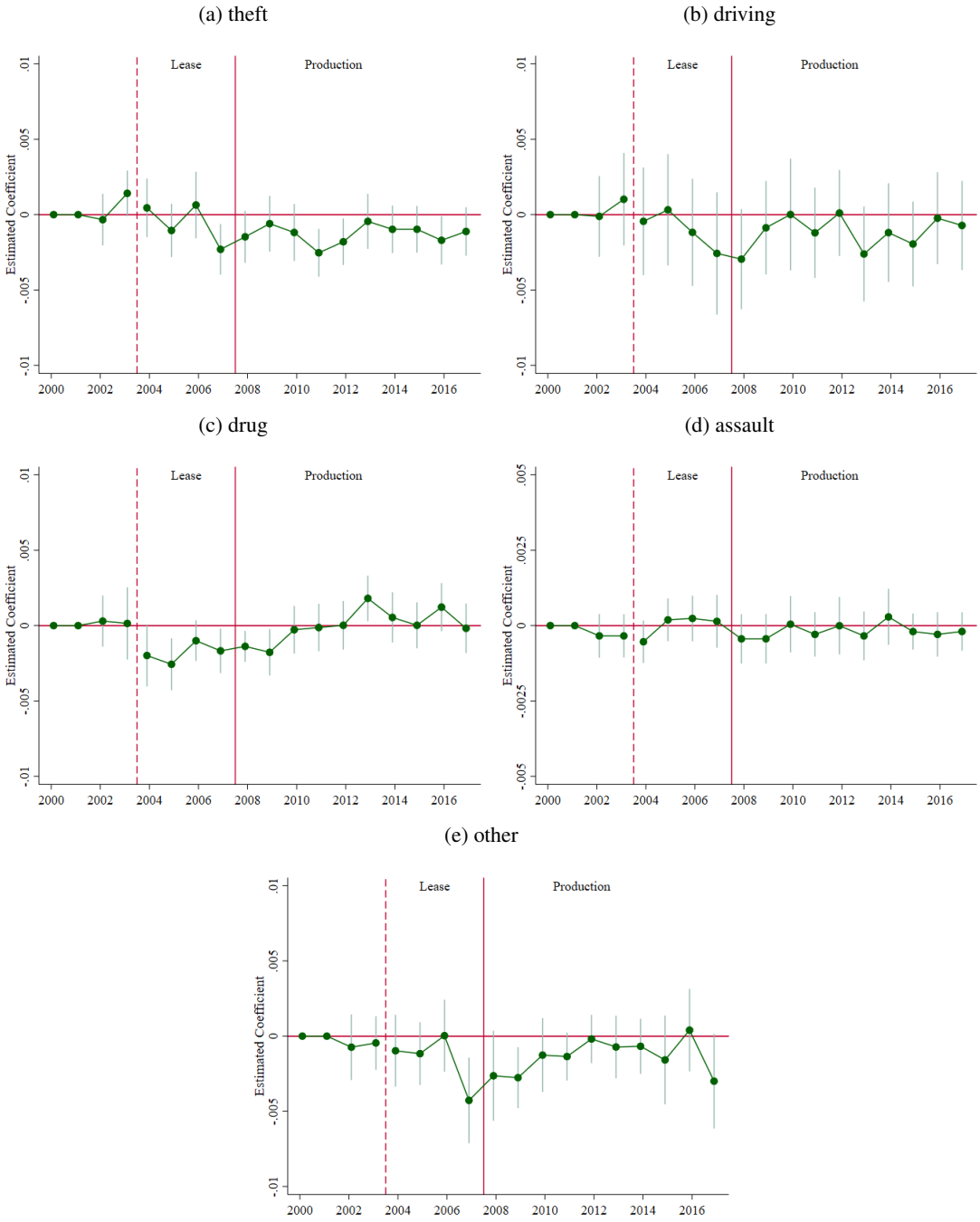
Notes: The figures plot dynamic difference-in-differences estimates on crime for fracking counties relative to non-fracking counties for incumbent households (Panel A) and the county overall (Panel B). Panel A presents coefficients from equation 1 where the outcome is an indicator for having a case filed in the household, defined by last name, street number, city, and zip code, for the sample of incumbent households in the Great Plains Directory Service. Panel B plots coefficients from equation 3 where the outcome is the share of households with a case filed in the county. The share of households is constructed as the number of cases filed to unique households in the county based on last name, street number, city, and zip code divided by the number of tax filers in the county (i.e., number of households). The dashed and solid vertical lines correspond to the start of the leasing period and production period, respectively. As seen in Figure 2, leases abruptly spike in 2004 while production gradually ramps up around 2008, which is chosen since it is the largest year-over-year percent change. 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: Trends in out-migration from the county by fracking region



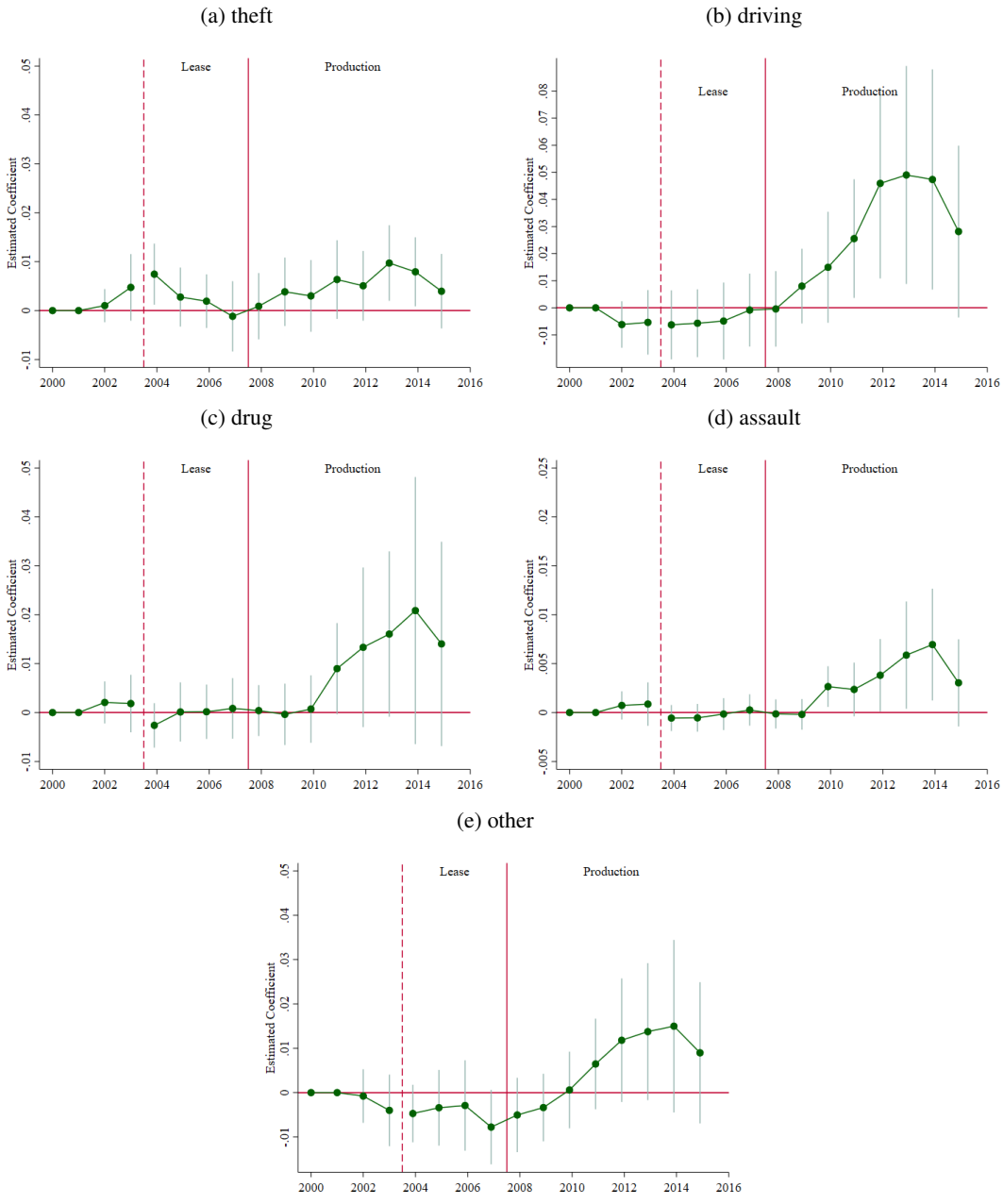
Notes: Panels A and B plot the average of county characteristics by fracking region (non-fracking, minor fracking, and major fracking). Panels C and D plot the dynamic difference-in-differences county-level estimates from equation 3 with county and year fixed effects. The dashed and solid vertical lines correspond to the start of the leasing period and production period, respectively. As seen in Figure 2, leases abruptly spike in 2004 while production gradually ramps up around 2008, which is chosen since it is the largest year-over-year percent change. Standard errors are clustered at the county-level and 95% confidence intervals are shown. Outcome is defined as the logged rate of out-migration exemptions per 1,000 persons/exemptions for each county. 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 do 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.

Figure 6: Dynamic difference-in-difference estimates of the effect of fracking on crime, by crime type



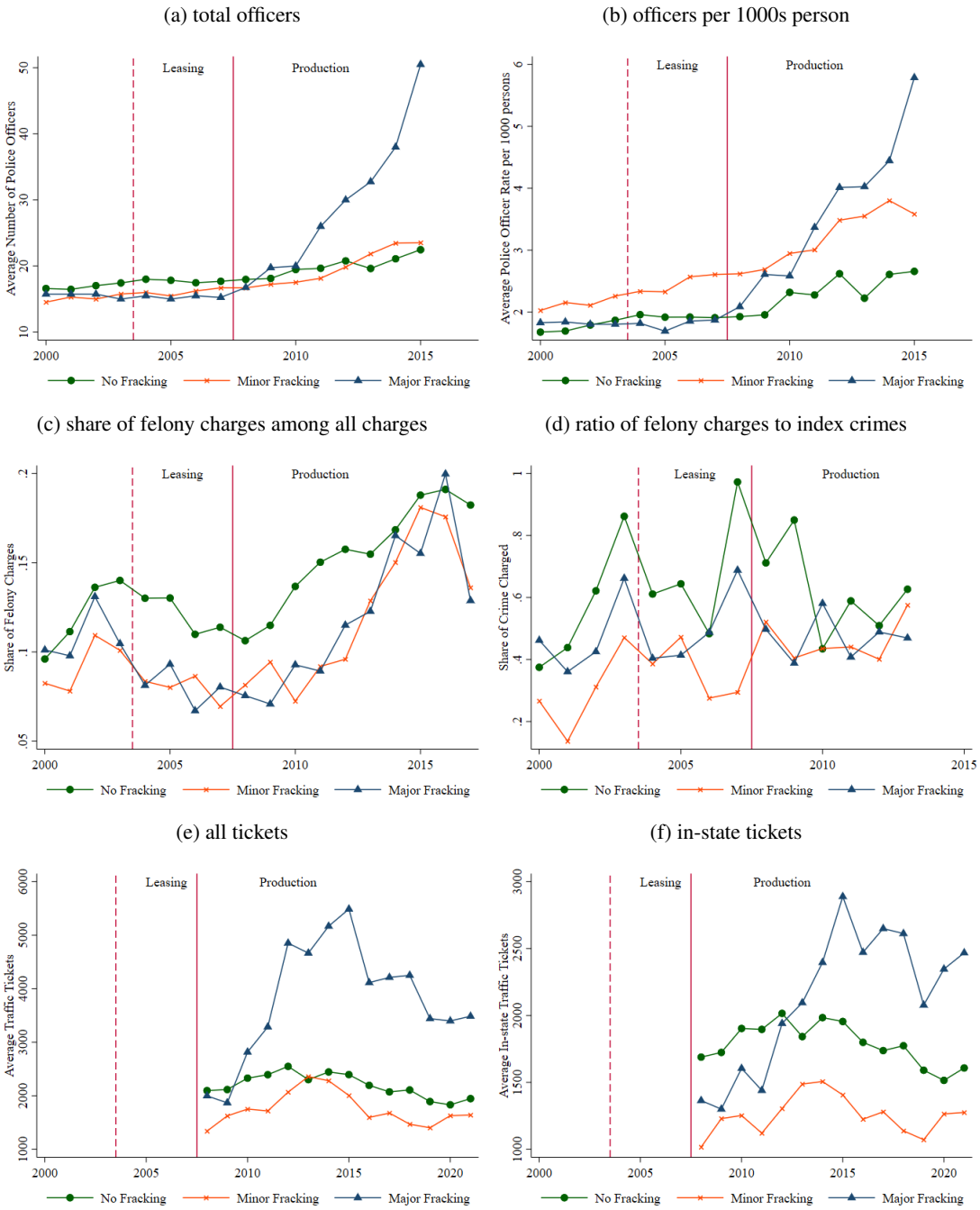
Notes: Dynamic difference-in-differences estimates on crime for fracking counties relative to non-fracking counties for incumbent households. Each panel presents coefficients from equation 1 where the outcome is an indicator for having a case filed for the designated crime category in the household, defined by last name, street number, city, and zip code, for the sample of incumbent households in the Great Plains Directory Service. The dashed and solid vertical lines correspond to the start of the leasing period and production period, respectively. As seen in Figure 2, leases abruptly spike in 2004 while production gradually ramps up around 2008, which is chosen since it is the largest year-over-year percent change. 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 7: Estimates of the effect of fracking on aggregate crime



Notes: Dynamic difference-in-differences estimates on crime for fracking counties relative to non-fracking counties for the county overall. Each panel plots coefficients from equation 3 where the outcome is the share of households with a case filed in the county. The share of households is constructed as the number of cases filed to unique households in the county based on last name, street number, city, and zip code divided by the number of tax filers in the county (i.e., number of households). The dashed and solid vertical lines correspond to the start of the leasing period and production period, respectively. As seen in Figure 2, leases abruptly spike in 2004 while production gradually ramps up around 2008, which is chosen since it is the largest year-over-year percent change. 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 8: Trends in police operations by fracking region



Notes: The figure plots the average of county characteristics by fracking regions (non-fracking, minor fracking, and major fracking counties). The dashed and solid vertical lines correspond to the start of the leasing period and production period, respectively. As seen in Figure 2, leases abruptly spike in 2004 while production gradually ramps up around 2008, which is chosen since it is the largest year-over-year percent change. Population and police data are from Internal Revenue Service and Uniform Crime Reporting Program Data [United States]: Police Employee (LEOKA) from 2000-2015. Charge data are from the State of North Dakota Judicial Branch from 2000–2015. Traffic data are from the State of North Dakota Judicial Branch from 2008–2021.

9 Tables

Table 1: Summary statistics

	All	Fracking County	Non-Fracking County	Lease Holder	Non-Lease Holder
Panel A: Incumbent households					
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 payments	9.58	24.64	1.96	64.34	0.00
	(32.26)	(48.11)	(14.96)	(58.90)	(0.00)
Monthly royalty payment	1874	5034	275	12586	0
	(13368)	(22123)	(3731)	(32647)	(0)
Observations	30909	10383	20526	4601	26308
Panel B: Household-year charges					
Case filed	0.0169	0.0191	0.0158	0.0190	0.0165
Driving charge	0.0083	0.0096	0.0077	0.0097	0.0081
DUI charge	0.0048	0.0057	0.0044	0.0058	0.0046
Drug charge	0.0034	0.0036	0.0034	0.0036	0.0034
Theft charge	0.0040	0.0046	0.0037	0.0045	0.0039
Assault charge	0.0007	0.0006	0.0007	0.0003	0.0007
Other charge	0.0056	0.0064	0.0053	0.0065	0.0055
Observations	123636	41532	82104	18404	105232
Panel C: All county charges					
Charges per case	1.13	1.11	1.14	1.15	1.13
	(0.60)	(0.50)	(0.64)	(0.60)	(0.60)
Felony charge	0.09	0.09	0.09	0.11	0.09
	(0.29)	(0.28)	(0.29)	(0.31)	(0.29)
Driving charge	0.44	0.46	0.42	0.48	0.43
	(0.50)	(0.50)	(0.49)	(0.50)	(0.50)
Drug charge	0.17	0.15	0.18	0.18	0.17
	(0.38)	(0.36)	(0.38)	(0.38)	(0.37)
Theft charge	0.17	0.16	0.18	0.14	0.18
	(0.38)	(0.37)	(0.38)	(0.34)	(0.38)
Assault charge	0.03	0.03	0.03	0.03	0.03
	(0.18)	(0.17)	(0.18)	(0.16)	(0.18)
Other charge	0.30	0.30	0.31	0.30	0.31
	(0.46)	(0.46)	(0.46)	(0.46)	(0.46)
Male	0.81	0.81	0.81	0.79	0.81
	(0.37)	(0.37)	(0.37)	(0.38)	(0.36)
Age	35.89	35.09	36.07	36.68	35.75
	(15.48)	(15.23)	(15.60)	(15.26)	(15.51)
Observations	13512	3302	8979	2114	11398

Notes: Data on charges filed are from the State of North Dakota Judicial Branch from 2000–2017. The sample in Panel A is all local households defined by last name, street number, city, and zip code identified in each county from the Great Plains Directory Service. Panel B is the sample of local households and related charges per year from 2000 to 2003. The sample in

Panel C is all charges filed in the county from 2000 to 2003. 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 incumbent residents' 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)
	[0.067]	[0.053]	[0.045]	[0.121]
Fracking Co X Post Prod	-0.0035**	-0.0041**	-0.0040*	-0.0036*
	(0.0017)	(0.0017)	(0.0021)	(0.0021)
	[0.072]	[0.040]	[0.074]	[0.125]
Pre Lease		-0.0012		
		(0.0014)		
N	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. Difference-in-differences regression estimates are from equation 1 for any case filed to the household. The Post Lease period is from 2004-2008 and Post Production period is from 2008-2017. Standard errors are in parentheses and clustered at the county level. Two-sided p-values from Wild Clustered Bootstrap are in brackets. 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 aggregate crime

	Cases per household			Charges per household		
	1	2	3	4	5	6
Fracking Co X Post Lease	-0.0045	-0.0473	-0.0674	-0.0018	-0.0335	-0.0265
	(0.0054)	(0.0758)	(0.0639)	(0.0097)	(0.0854)	(0.0708)
Fracking Co X Post Prod	0.0371**	0.2499**	0.3641***	0.0687**	0.2720**	0.4205***
	(0.0154)	(0.1220)	(0.1360)	(0.0270)	(0.1301)	(0.1463)
N	776	776	776	776	776	776
Mean Dependent Variable	0.083	0.083	0.083	0.122	0.122	0.122
County & Year FE	Y	Y	Y	Y	Y	Y
Specification	OLS	Log	Poisson	OLS	Log	Poisson

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. Difference-in-differences regression estimates are from equation 3 for the number of cases filed per the number of households in the county. Standard errors are in parentheses and clustered at the county level. Data on charges filed are from the State of North Dakota Judicial Branch from 2000–2017. The sample is all charges in North Dakota counties. The outcome is the number of unique cases per household defined by last name, street number, city, and zip code each year divided by the number of households in the county, measured by the number of IRS tax returns filed in the county.

Table 4: Estimates of the effect of fracking on crime types

	1 property	2 drug	3 driving	4 assault	5 other
Panel A: Incumbent household-level effects					
Fracking Co X Post Lease	-0.0008	-0.0019***	-0.0012	0.0002	-0.0013
	(0.0005)	(0.0006)	(0.0013)	(0.0002)	(0.0009)
Fracking Co X Post Prod	-0.0016**	-0.0001	-0.0014	-0.0000	-0.0011
	(0.0006)	(0.0005)	(0.0011)	(0.0002)	(0.0009)
Observations	556362	556362	556362	556362	556362
Mean Dependent Variable	0.0046	0.0036	0.0096	0.0006	0.0064
Household & Year FE	Y	Y	Y	Y	Y
Panel B: Aggregate county-level effects					
Fracking Co X Post Lease	0.0011	-0.0014	-0.0014	-0.0007	-0.0035
	(0.0019)	(0.0019)	(0.0043)	(0.0006)	(0.0028)
Fracking Co X Post Prod	0.0036	0.0082	0.0303**	0.0026*	0.0073
	(0.0031)	(0.0057)	(0.0115)	(0.0013)	(0.0047)
Observations	776	776	776	776	776
Mean Dependent Variable	0.0222	0.0152	0.0340	0.0035	0.0251
County & Year FE	Y	Y	Y	Y	Y

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. Panel A reports difference-in-differences estimates from equation 1 and Panel B reports estimates from equation 3. 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 in Panel A is all incumbent 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 an indicator for having a case filed associated with a given incumbent household. The sample in Panel B is all charges in North Dakota counties and the outcome is the number of unique cases per household defined by last name, street number, city, and zip code each year divided by the number of households in the county, measured by the number of IRS tax returns filed in the county.

Table 5: Estimates of the effect of fracking on crime by intensity

	1	2	3	4	5
Panel A: Incumbent household-level effects					
Minor Fracking Co X Post Lease	-0.0029*				
	(0.0015)				
Major Fracking Co X Post Lease	-0.0024				
	(0.0023)				
Minor Fracking Co X Post Prod	-0.0042**				
	(0.0019)				
Major Fracking Co X Post Prod	-0.0015				
	(0.0025)				
Fracking Co X Post X Jobs		-0.0017***	-0.0027*		
		(0.0005)	(0.0016)		
Fracking Co X Post X Jobs Sq.			0.0003		
			(0.0004)		
Fracking Co X Post X Prod				0.0004	0.0005
				(0.0005)	(0.0004)
Fracking Co X Post X Prod Sq.					-0.0001
					(0.0001)
Observations	556362	535596	535596	551295	551295
Mean Dependent Variable	0.02	0.02	0.02	0.02	0.02
Household & Year FE	Y	Y	Y	Y	Y
Panel B: Aggregate county-level effects					
Minor Fracking Co X Post Lease	-0.007				
	(0.008)				
Major Fracking Co X Post Lease	0.012				
	(0.019)				
Minor Fracking Co X Post Prod	0.016				
	(0.012)				
Major Fracking Co X Post Prod	0.170***				
	(0.033)				
Fracking Co X Post X Jobs		0.033**	0.021		
		(0.016)	(0.027)		
Fracking Co X Post X Jobs Sq.			0.004		
			(0.011)		
Fracking Co X Post X Prod				0.026***	0.026***
				(0.009)	(0.007)
Fracking Co X Post X Prod Sq.					0.006***
					(0.002)
Observations	776	776	776	769	769
Mean Dependent Variable	0.104	0.104	0.104	0.104	0.104
County & Year FE	Y	Y	Y	Y	Y

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. Panel A reports difference-in-differences estimates from variations of equation 1 and Panel B reports estimates from variations of equation 3. Standard errors are in parentheses and clustered at the county level. Major and minor fracking counties are defined by the North Dakota Labor Market Information Center. Jobs are per 1000 and measured by Bureau of Economic Analysis. Production is per 1,000,000 barrels produced measured by the North Dakota Department of Mineral Resources. The sample in Panel A is all incumbent 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 an indicator for having a case filed associated with a given incumbent household. The sample in Panel B is all charges in North Dakota counties and the outcome is the number of unique cases per household defined by last name, street number, city, and zip code each year divided by the number of households in the county, measured by the number of IRS tax returns filed in the county.

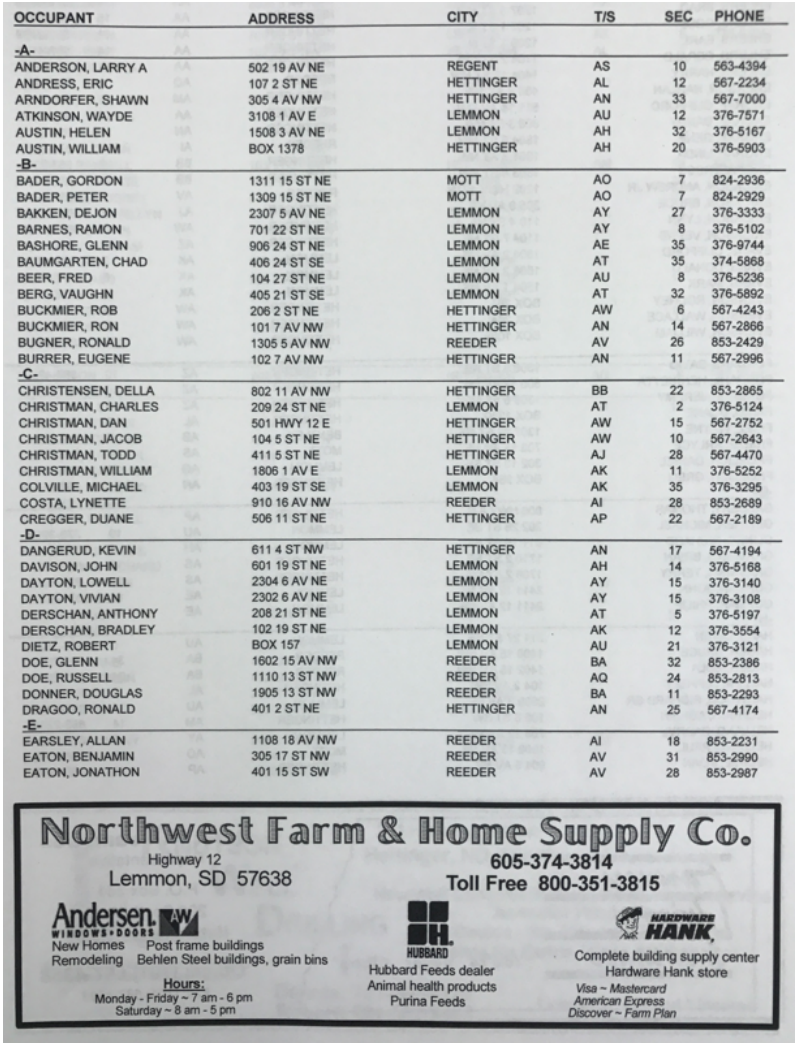
Table 6: Estimates of the effect of fracking on incumbent crime, by lease status

	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. The table reports difference-in-differences estimates from variations of equation 2, comparing leaseholders and non-leaseholders in fracking counties to all incumbent residents in non-fracking counties. 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 Online Appendix A

Figure A.1: Example page from the Great Plains Directory Service for Adams County



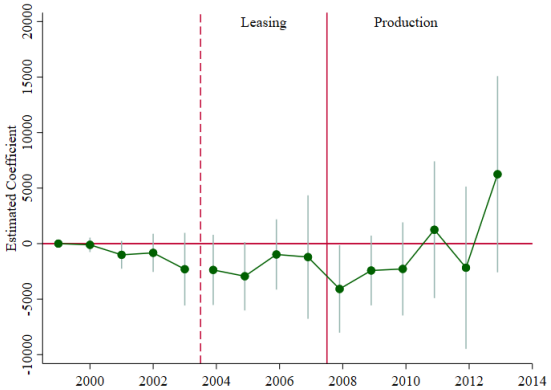
OCCUPANT	ADDRESS	CITY	T/S	SEC	PHONE
-A-					
ANDERSON, LARRY A	502 19 AV NE	REGENT	AS	10	563-4394
ANDRESS, ERIC	107 2 ST NE	HETTINGER	AL	12	567-2234
ARNDORFER, SHAWN	305 4 AV NW	HETTINGER	AN	33	567-7000
ATKINSON, WAYDE	3108 1 AV E	LEMMON	AU	12	376-7571
AUSTIN, HELEN	1508 3 AV NE	LEMMON	AH	32	376-5167
AUSTIN, WILLIAM	BOX 1378	HETTINGER	AH	20	376-5903
-B-					
BADER, GORDON	1311 15 ST NE	MOTT	AO	7	824-2936
BADER, PETER	1309 15 ST NE	MOTT	AO	7	824-2929
BAKKEN, DEJON	2307 5 AV NE	LEMMON	AY	27	376-3333
BARNES, RAMON	701 22 ST NE	LEMMON	AY	8	376-5102
BASHORE, GLENN	906 24 ST NE	LEMMON	AE	35	376-9744
BAUMGARTEN, CHAD	406 24 ST SE	LEMMON	AT	35	374-5868
BEER, FRED	104 27 ST NE	LEMMON	AU	8	376-5236
BERG, VAUGHN	405 21 ST SE	LEMMON	AT	32	376-5892
BUCKMIER, ROB	206 2 ST NE	HETTINGER	AW	6	567-4243
BUCKMIER, RON	101 7 AV NW	HETTINGER	AN	14	567-2866
BUGNER, RONALD	1305 5 AV NW	REEDER	AV	26	853-2429
BURRER, EUGENE	102 7 AV NW	HETTINGER	AN	11	567-2996
-C-					
CHRISTENSEN, DELLA	802 11 AV NW	HETTINGER	BB	22	853-2865
CHRISTMAN, CHARLES	209 24 ST NE	LEMMON	AT	2	376-5124
CHRISTMAN, DAN	501 HWY 12 E	HETTINGER	AW	15	567-2752
CHRISTMAN, JACOB	104 5 ST NE	HETTINGER	AW	10	567-2643
CHRISTMAN, TODD	411 5 ST NE	HETTINGER	AJ	28	567-4470
CHRISTMAN, WILLIAM	1806 1 AV E	LEMMON	AK	11	376-5252
COLVILLE, MICHAEL	403 19 ST SE	LEMMON	AK	35	376-3295
COSTA, LYNETTE	910 16 AV NW	REEDER	AI	28	853-2689
CREGGER, DUANE	506 11 ST NE	HETTINGER	AP	22	567-2189
-D-					
DANGERUD, KEVIN	611 4 ST NW	HETTINGER	AN	17	567-4194
DAVISON, JOHN	601 19 ST NE	LEMMON	AH	14	376-5168
DAYTON, LOWELL	2304 6 AV NE	LEMMON	AY	15	376-3140
DAYTON, VIVIAN	2302 6 AV NE	LEMMON	AY	15	376-3108
DERSCHAN, ANTHONY	208 21 ST NE	LEMMON	AT	5	376-5197
DERSCHAN, BRADLEY	102 19 ST NE	LEMMON	AK	12	376-3554
DIETZ, ROBERT	BOX 157	LEMMON	AU	21	376-3121
DOE, GLENN	1602 15 AV NW	REEDER	BA	32	853-2386
DOE, RUSSELL	1110 13 ST NW	REEDER	AQ	24	853-2813
DONNER, DOUGLAS	1905 13 ST NW	REEDER	BA	11	853-2293
DRAGOO, RONALD	401 2 ST NE	HETTINGER	AN	25	567-4174
-E-					
EARSLEY, ALLAN	1108 18 AV NW	REEDER	AI	18	853-2231
EATON, BENJAMIN	305 17 ST NW	REEDER	AV	31	853-2990
EATON, JONATHON	401 15 ST SW	REEDER	AV	28	853-2987

Notes: The figure is one of the over one thousand images taken from the Great Plains Directory Service housed in the Bismarck Public Library. Optimal Character Recognition is used to digitize the information and accuracy is verified manually.

Figure A.2: Estimates of the effect of fracking on real estate

(a) total sales

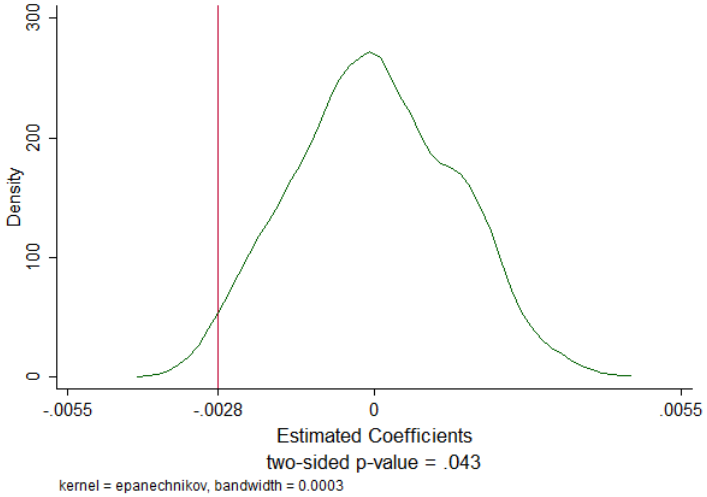
(b) price



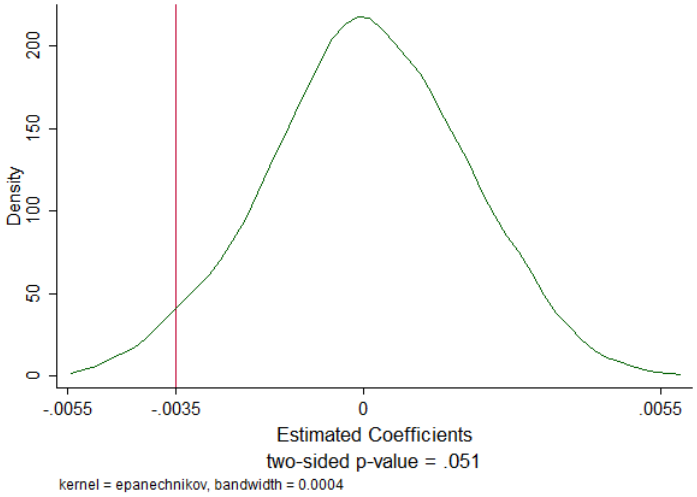
Notes: Dynamic difference-in-differences county-level estimates from equation 3 with county and year fixed effects. The dashed and solid vertical lines correspond to the start of the leasing period and production period, respectively. As seen in Figure 2, leases abruptly spike in 2004 while production gradually ramps up around 2008, which is chosen since it is the largest year-over-year percent change. Standard errors are clustered at the county-level and 95% confidence intervals are shown. The outcomes are defined as total sales in each county (Panel A) and total sale values (Panel B). Data on all property sales are from the North Dakota State Board of Equalization.

Figure A.3: Placebo tests

(a) Placebo estimates for any case during leasing period



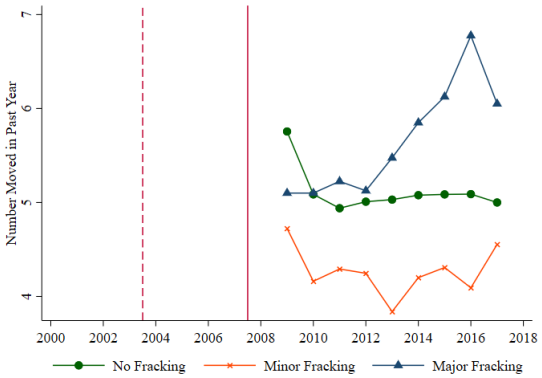
(b) Placebo estimates for any case during production period



Notes: The figure plots the density of 1000 estimates from equation 1 with fracking status randomly assigned to 17 counties. The red line in Panel A 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 Panel B 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.

Figure A.4: Moves within a county in a given year by fracking region for all persons in the county

(a) number moved within the county



(b) proportion moved within county

Notes: The average number of people that move within each county are plotted by type of fracking region (non-fracking, minor fracking, and major fracking counties). The dashed and solid vertical lines correspond to the start of the leasing period and production period, respectively. As seen in Figure 2, leases abruptly spike in 2004 while production gradually ramps up around 2008, which is chosen since it is the largest year-over-year percent change. Data are from the American Community Survey from 2009–2017. These data are not necessarily representative of the incumbent residents used in the analysis, rather it is representative of the population of the county in that year.

Figure A.5: Estimates of the effect of fracking without neighboring counties

(a) residents

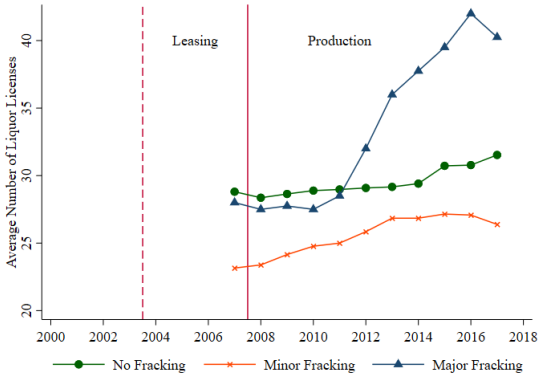
(b) aggregate county level

Notes: The figures plot dynamic difference-in-differences estimates on crime for fracking counties relative to non-fracking counties for incumbent households (Panel A) and the county overall (Panel B), excluding the eight spillover counties (Adams, Burleigh, Hettinger, Morton, Oliver, Pierce, Rollette and Sheridan). Panel A presents coefficients from equation 1 where the outcome is an indicator for having a case filed in the household, defined by last name, street number, city, and zip code, for the sample of incumbent households in the Great Plains Directory Service. Panel B plots coefficients from equation 3 where the outcome is the share of households with a case filed in the county. The share of households is constructed as the number of cases filed to unique households in the county based on last name, street number, city, and zip code divided by the number of tax filers in the county. The dashed and solid vertical lines correspond to the start of the leasing period and production period, respectively. As seen in Figure 2, leases abruptly spike in 2004 while production gradually ramps up around 2008, which is chosen since it is the largest year-over-year percent change. 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 A.6: 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. The dashed and solid vertical lines correspond to the start of the leasing period and production period, respectively. As seen in Figure 2, leases abruptly spike in 2004 while production gradually ramps up around 2008, which is chosen since it is the largest year-over-year percent change. Standard errors are clustered at the county-level and 95% confidence intervals are shown. 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. A charge is only matched to a household if the offender is 25 years or older at the start of the sample. Data on charges filed are from the State of North Dakota Judicial Branch from 2000–2017.

Figure A.7: Average total number of liquor license per county by fracking region



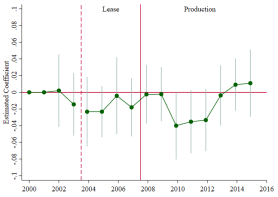
Notes: The figure plots the average total number of licenses per county by fracking region, non-fracking, minor fracking, and major fracking counties. The dashed and solid vertical lines correspond to the start of the leasing period and production period, respectively. As seen in Figure 2, leases abruptly spike in 2004 while production gradually ramps up around 2008, which is chosen since it is the largest year-over-year percent change. 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.8: Dynamic difference-in-difference estimates of the effect of fracking on police

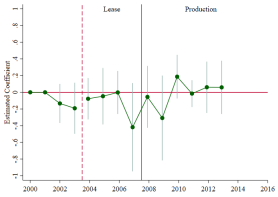
(a) total officers

(b) officers per 1000 persons IRS

(c) share felony charges among all charges



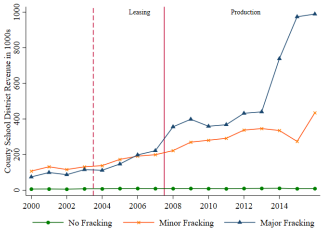
(d) ratio of felony charges to index crimes



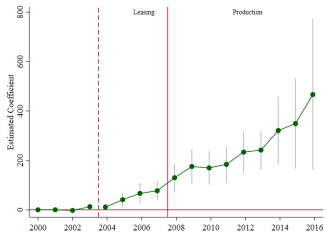
Notes: Dynamic difference-in-differences county-level estimates from equation 3 with county and year fixed effects. The dashed and solid vertical lines correspond to the start of the leasing period and production period, respectively. As seen in Figure 2, leases abruptly spike in 2004 while production gradually ramps up around 2008, which is chosen since it is the largest year-over-year percent change. 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 A.9: Changes in school funding

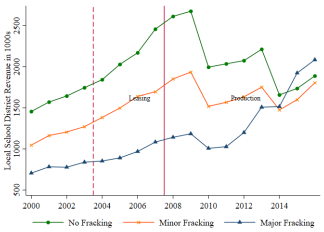
(a) County revenue for school districts



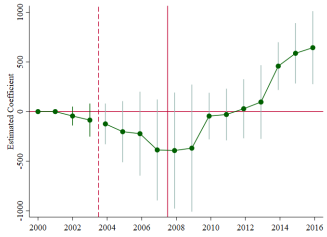
(b) County revenue for school districts



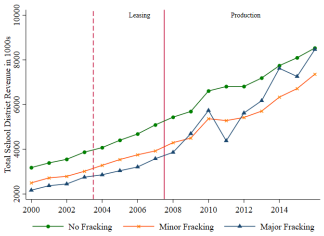
(c) Local revenue for school districts



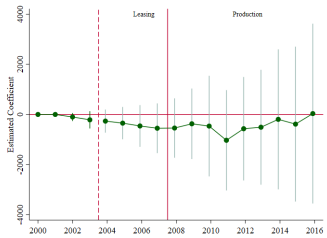
(d) Local revenue for school districts



(e) Total revenue for school districts



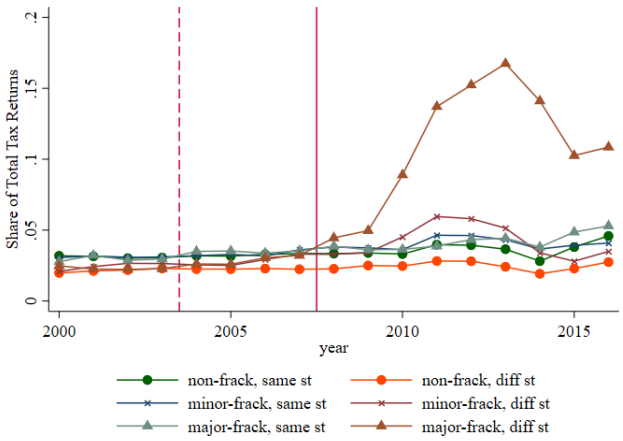
(f) Total revenue for school districts



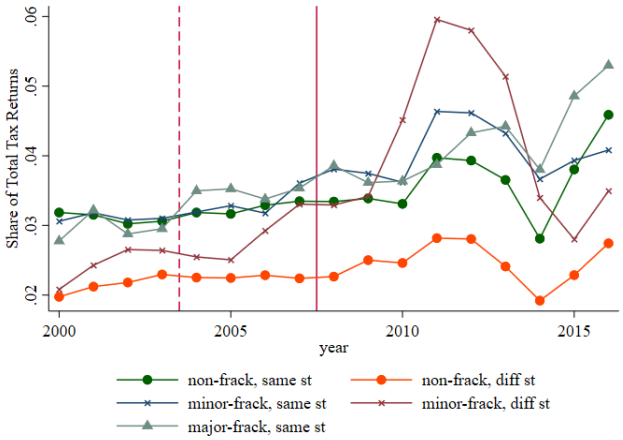
Notes: Panels A, C and E plot the average county, local and total school district revenue in 1000s across non-fracking, minor fracking, and major fracking counties from 1998 to 2016. Panels B, D, and F plot the dynamic difference-in-differences county-level estimates from equation 3 with county and year fixed effects for the same three outcomes. The dashed and solid vertical lines correspond to the start of the leasing period and production period, respectively. As seen in Figure 2, leases abruptly spike in 2004 while production gradually ramps up around 2008, which is chosen since it is the largest year-over-year percent change. County revenue is from mineral taxes and local revenue is primarily property taxes but also includes interest on investments, proceeds from sales, student participation fees, and local foundations. The dashed and solid vertical lines correspond to the start of the leasing period and production period, respectively. As seen in Figure 2, leases abruptly spike in 2004 while production gradually ramps up around 2008, which is chosen since it is the largest year-over-year percent change. Standard errors are clustered at the county-level and 95% confidence intervals are shown. Data on school funding are from the North Dakota Department of Public Instruction. Dollars are in 1000s.

Figure A.10: Migration from in-state and out-of-state counties by fracking region

(a) All six categories



(b) Five categories with smaller changes



Notes: The figure plots the average share of tax returns from in-migrants from other North Dakota counties and from out-of-state counties in each year for non-fracking, minor fracking, and major fracking counties. The dashed and solid vertical lines correspond to the start of the leasing period and production period, respectively. As seen in Figure 2, leases abruptly spike in 2004 while production gradually ramps up around 2008, which is chosen since it is the largest year-over-year percent change. Tax returns are a proxy for the number of households in the county, measured by the IRS tax statistics. Migration is measured by changing address from one county to another between tax years. Panel A plots in-state and out-of-state migration for all three county types. Panel B removes out-of-state migration for major fracking counties.

Table A.1: Summary statistics for all charges in North Dakota, 2000-2003

	All charges in North Dakota	Charges in Great Plains directory	Charges not in Great Plains directory
Male, API	0.708	0.745	0.705
Defendant's age	30.157	31.284	30.029
Felony charge	0.099	0.078	0.102
Drug charge	0.137	0.148	0.136
Driving charge	0.362	0.379	0.360
Theft charge	0.268	0.260	0.269
Assault charge	0.042	0.035	0.043
Other charge	0.246	0.254	0.245
Observations	101762	9731	92031

Notes: The table reports the characteristics of charges in North Dakota from 2000 to 2003 overall and based on whether they are identified in the Great Plains directory service (i.e., sample of incumbent residents). Data on charges filed are from the State of North Dakota Judicial Branch from 2000–2003. Charged individuals are matched to the Great Plains Directory Service based on last name, street number, city, and zip code. The gender of the offender is predicted based on first name using an API and is reported as a continuous variable.

Table A.2: 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. The table reports difference-in-difference estimates from equation 1. 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.3: 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. The table reports difference-in-difference estimates from equation 1. 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.4: Estimates of the effect of fracking on crime without spillover counties

	1	2	3	4
	Household level		County level	
	all counties	no neighboring	all counties	no neighboring
Fracking Co X Post Lease	-0.0028**	-0.0033**	-0.0045	-0.0041
	(0.0020)	(0.0014)	(0.0014)	(0.0063)
Fracking Co X Post Production	-0.0035**	-0.0037**	0.0371**	0.0423**
	(0.0017)	(0.0437)	(0.0018)	(0.0155)
Observations	556362	466902	776	648
Mean Dependent Variable	0.02	0.02	0.083	0.083
Household & Year FE	Y	Y	N	N
County & Year FE	N	N	Y	Y

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The table reports difference-in-differences estimates on crime for fracking counties relative to non-fracking counties for incumbent households (Columns 1 and 2) and the county overall (Columns 3 and 4). Columns 1 and 2 present coefficients from equation 1 where the outcome is an indicator for having a case filed in the household, defined by last name, street number, city, and zip code, for the sample of incumbent households in the Great Plains Directory Service. Columns 3 and 4 report coefficients from equation 3 where the outcome is the share of households with a case filed in the county. The share of households is constructed as the number of cases filed to unique households in the county based on last name, street number, city, and zip code divided by the number of tax filers in the county. Columns 2 and 4 exclude the eight spillover counties: Adams, Burleigh, Hettinger, Morton, Oliver, Pierce, Rollette and Sheridan. 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.Standard errors are in parentheses and clustered at the county level. Data are from the State of North Dakota Judicial Branch from 2000–2017. The sample in columns 1 and 2 are all local households defined by last name, street number, city, and zip code identified in each county from the Great Plains Directory Service. The sample in columns 3 and 4 are all cases in a county for unique households defined by last name, street number, city, and zip code.

Table A.5: Estimates of the effect of fracking on crime for household members with stable residences, 25 years or at the start of the 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	N	Y	N	N
County Trends	N	N	Y	N
Base Level Controls X Year	N	N	N	Y

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The table reports difference-in-difference estimates from equation 1. 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 of January 2000.

Table A.6: Estimates of the effect of fracking on crime, switching control households to "movers" in post period

	Any Charge	Any Charge	Any Charge	Any Charge	Any Charge	Any Charge	Any Charge	Any Charge	Any Charge	Any Charge	Any Charge
Fracking Co X Post Lease	-0.0028**	-0.0026*	-0.0022	-0.0021	-0.0017	-0.0016	-0.0015	-0.0014	-0.0015	-0.0010	-0.0006
	(0.0014)	(0.0014)	(0.0014)	(0.0014)	(0.0014)	(0.0014)	(0.0014)	(0.0014)	(0.0014)	(0.0014)	(0.0013)
Fracking Co X Post Prod	-0.0035**	-0.0034*	-0.0031*	-0.0031*	-0.0026	-0.0027	-0.0026	-0.0022	-0.0023	-0.0021	-0.0020
	(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0018)	(0.0017)
Observations	556362	556362	556362	556362	556362	556362	556362	556362	556362	556362	556362
Mean Dependent Variable	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Household & Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Number of Control HHs	0	200	400	600	800	1000	1200	1400	1600	1800	2000
≈% of Control HHs	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. The table reports difference-in-difference estimates from equation 1. Standard errors are in parentheses and clustered at the county level. 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. In each column, the outcome is set to zero for a random set of households in the control counties for all post-period years (2004-2017) to assess how differential migration would affect the main results for incumbent residents identified in the Great Plains Directory Service.

B Online Data Appendix

I use the Great Plains Directory Service to identify existing residents prior to the large immigration associated with hydraulic fracturing activities. These directories are produced on a rolling basis with a handful of counties being updated each year. There are four counties that do not have a directory in the early 2000s and are thus excluded from the analysis, namely Cass, Grand Forks, Pembina, and Traill counties. Hardcopies of the directories were accessed through the Bismark Public Library, scanned, and used optical character recognition (OCR) along with manual review to create the sample of households. An example page from one of the directories is shown in Figure A.1.

The directory uses county property records and then verifies the household head living at the address, regardless of if they are owning or renting. Only rural residents are included, meaning individuals in cities' downtown areas are not able to be included in the sample. Ultimately, I observe 20% of all households in North Dakota and 50% of households living in census designated rural areas. The Great Plains Directory Service are not expected to cover all census designated rural households since the directories do not cover areas inside city limits and many cities in North Dakota are officially classified as rural by the U.S. Census Bureau. While I am able to identify only a subset of existing residents, these households are mostly similar in demographics and types of charges compared to those not in my sample during the pre-period (see Table A.1). For example, charges linked to the Great Plains Directory Service are more likely to be for slightly older, male offenders. The charges are less likely to be for a felony but have a similar distribution across offense types (e.g., drug, driving, theft, assault). While I cannot consider characteristics of those not charged or other characteristics, the types of charges for this population is particularly relevant for this context.

Only one member of each household is recorded, presumably the household head. Since the household head is recorded in the directories, I use the last name, street number, city name and five-digit zip code to match all residents of the households to court and leasing records. The leasing data is from DrillingInfo, a private company that has granted access to their data for research purposes. The leasing data contains information on the names and address of leaseholders and the date of the mineral lease. The crime data is from the State of North Dakota Judicial Branch and includes first and last name, date of birth, and address from the driver's license.

The matching is done using a Levenshtein index with a distance of 1 between the concatenated strings. For example, in Figure A.1, there are two individuals, Rob and Ron Buckmier but at different addresses. Individuals receiving a charge with the last name of Buckmier and street number 206 in Hettinger would be considered in the same household as Rob but not Ron who is listed at street number 101. To consider these two households the same, there would need to be two edits to the street number in the first and last digit. Similarly, the five Christman, two Derschann, two Doe, and two Eaton households would not be matched together. However, the two Dayton households would be considered the same since the last name is the same and the address needs only one edit from 2302 to 2304 to be the same. Notably, the individuals in the Great Plains Directory Service are more likely to have similar last names and addresses since extended families are likely to be incumbent households, reside near each other, and appear in the directories.