The Shale Tipping Point:

The Relationship of Drilling to Crime, Traffic Fatalities, STDs, and Rents in Pennsylvania, West Virginia, and Ohio

Unabridged Version

Multi-State Shale Research Collaborative
December 2014

See http://www.multistateshale.org/shale-tipping-point for an abridged version of this report and http://keystoneresearch.org/MSSRC/tech_app for the online technical appendix.

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Acknowledgements

This project is supported through grants from the Heinz Endowments, Stoneman Family Foundation, Hillsdale Foundation and Park Foundation. The Multi-State Shale Research Collaborative wishes to thank its funders for their ongoing support. Thanks to Frank Mauro and Michele Mattingly of the Fiscal Policy Institute in New York for their helpful comments. Thanks to Ellen Lyon, Keystone Research Center Communications Director and its Pennsylvania Budget and Policy Center (PBPC), for editorial assistance and guidance, and to Stephanie Frank, KRC Office Manager, for laying out the report and producing the charts and figures.

Table of Contents

Executive Summary

How does hydro-fracking affect the rural communities at the epicenter of drilling activity? A rich body of literature on the human impacts and lore exists from the Mountain West: of boomtowns and bar fights, and rising rents and rising crime that accompanied oil and gas development in Wyoming and Colorado in the 1980s and 1990s, and more recently in North Dakota shale oil fields.

Considerable evidence indicates that shale development has followed a similar trajectory in Pennsylvania. Work from academic researchers and advocacy groups such as Food and Water Watch, and our own in-depth examination of two high-intensity Pennsylvania drilling counties (Greene and Tioga) document increased traffic, damaged roads, rising rents, and intensified demands on police and local first responders.

These impacts are in addition to the growing environmental and public health impacts associated with hydro-fracking, from greater incidence of childhood asthma in Texas, to water contamination in Pennsylvania, to seismic activity in Ohio and Oklahoma.

In many states, regulation of drilling activity is controlled by state officials, leaving local officials with few options except to manage the consequences. A better understanding of the nature and timing of likely impacts can help local governments and residents anticipate, plan for, or avoid the inevitable negative consequences of shale development.

In this report, the Multi-State Shale Research Collaborative examined potential shale-related impacts identified in our prior work and that of others to further identify impacts and determine at what point their effects became evident. We looked at three states: Pennsylvania, Ohio, and West Virginia, dividing drilling counties in those states into three groups based on the level of drilling activity in order to better understand the relationship between the density of drilling and the severity of impacts. We used non-drilling rural and non-drilling urban counties as control groups, in order to account for relevant factors unrelated to shale development. Our analysis found impacts on housing, crime, traffic fatalities, and sexually transmitted diseases in communities with high levels of drilling. Although the impact of drilling is often localized within counties, data limitations necessitate use of county-level data (and, in the case of housing, multi-county data). As a result of this incongruity between the geography of drilling's impact and publicly available data sources, the impacts on crime, sexually transmitted diseases, traffic fatalities, and rents are likely to be underestimated.

Based on our analysis, we hypothesize that significant impacts emerge when the number of wells drilled in a given county exceeds 400 within a period of five to eight years.

Our main findings follow.

Drilling, Employment, and Population Trends

County Drilling Trends

Shale development is not evenly distributed across the states, nor across counties. Whether we see broad-based impacts depends on the level and concentration of drilling. Our analysis covered the 210 counties in

Pennsylvania, Ohio, and West Virginia. We divided these counties into five groups: low-, moderate--, and high-drilling counties; non-drilling rural counties; and non-drilling urban counties.

- Six Pennsylvania counties with more than 400 wells drilled were classified as high-drilling: Bradford, Tioga, Washington, Lycoming, Susquehanna, and Greene. As a group, they account for 52% of, or 4,515 of 8,634, new shale oil and gas wells drilled in Pennsylvania, West Virginia, and Ohio between 2005 and 2012.
- Ten West Virginia counties, one Ohio county, and six Pennsylvania counties, each with between 100 and 399 wells, were designated moderate-drilling counties. The 10 West Virginia counties account for 67% of the state's total shale oil and gas wells drilled between 2005 and 2012 (Kanawha, Logan, Ritchie, Harrison Doddridge, Boone, Upshur, Jackson, Wetzel, and Lincoln). Carroll County is the only Ohio county having more than 100 wells drilled; by 2013, 49% of all the unconventional wells in Ohio were located in Carroll County. Across all three states, the 17 moderate--drilling counties account for 30% of wells drilled from 2005 to 2012.

Employment

Consistent with our prior research (Mauro et al, 2013), we found modest employment growth in Pennsylvania, West Virginia, and Ohio from 2005 to 2012, particularly when measured as a share of total employment.

The bulk of employment impacts were found in the six high-drilling counties, where mining and natural resources employment rose by 138% (7,121 jobs) from 2005 to 2012 (compared to a decline of 2% from 1998 to 2005), and total employment across all industries grew by 10.3% (or 18,932 jobs).

In the remaining moderate- and low-drilling counties we found no statistically significant impact on total covered employment from drilling. In moderate-activity counties, mining and natural resources employment grew by 8% (1,126 jobs). Total employment actually declined in these counties, driven by a 1% total employment decline in moderate-drilling West Virginia counties that outweighed a 0.3% total employment increase in moderate-drilling Pennsylvania counties and a 6.4% employment growth in the one moderate-drilling Ohio county.. Carroll County employment trends and recent drilling activity are more similar to the six Pennsylvania high-drilling counties than to other moderate-drilling counties. In all three states, as a result of the Great Recession, total employment was down from 2005 to 2012 in both rural and urban non-drilling counties.

Population

We found little evidence in our data of significant population growth resulting from drilling.

The six high-drilling counties had a small population increase of 0.4%, or 2,040 people, between 2005 and 2012, reversing a small (0.3%) population decline during the prior seven-year period. The moderate-drilling counties in all three states have experienced a small decline in population since 2005 (0.9% in PA, 0.3% in WV, and 1.8% in OH). By contrast, since 2005, the population in non-drilling urban and

rural counties in all three states actually grew by about 3%.[1] Across county-level population data for West Virginia, Pennsylvania, and Ohio, we found that drilling did not have a positive and statistically significant impact on population growth for any grouping, including high-drilling counties.

Social and human impacts

Given the drilling, employment, and population trends described above, we would expect to observe social and human impacts (crime, traffic fatalities, sexually transmitted disease and rising rents) in high-drilling counties. In fact, across the counties studies, significant increases in the rates of crime, sexually transmitted diseases, motor vehicle fatalities, and increased housing costs were almost exclusively limited to the six high-drilling Pennsylvania counties.

Crime

- Violent crime
    - There was a statistically significant increase in violent crime of 17.7% in high-drilling counties; this increase corresponds to about 130 more violent crimes in these six counties in 2012. During this same period, the violent crime rate was down in both urban and rural non-drilling communities.
    - In moderate-drilling counties in Pennsylvania, West Virginia, and Ohio, we did not observe any statistically significant increases in violent crime or property crime over the period of this study. Carroll County, Ohio, which experienced a rapid increase in drilling only in the final year of this study (2012), will, if drilling continues apace, provide an important test of whether the increased crime rates observed in high-drilling counties in Pennsylvania also occur in other states with similar levels of drilling.

- Property Crime
    - We observed a statistically significant increase in property crime of 10.8% in high-drilling counties.
    - For the most part, we did not observe a statistically significant increase in violent crime and property crime in moderate- and low-drilling counties in West Virginia, Pennsylvania, and Ohio.[2]

- Drug and alcohol crime
    - Between 2005 and 2012, drug abuse rates rose 48% in the high-drilling counties in Pennsylvania, representing an annual increase of about 600 cases. In these same counties, DUI offenses were up 65%, compared to 42% in non-drilling rural areas, and little or no increase elsewhere across the state. The gap between the 65% and 42% increases amounts to an additional 400 cases per year across the six high-drilling counties.

[1] Some population trends in drilling areas led us to wonder whether year-to-year population statistics fully capture all of the out-of-state influx of people triggered by drilling, some of which could be temporary. Since our 2005-12 period includes data from the 2010 Census, it is unlikely that our drilling-area population estimates are substantially undercounted, but we are nonetheless consulting further with state demographers.

[2] We did, however, observe a statistically significant increase in violent crime in low-drilling counties.

Interestingly, drug abuse and DUI offenses did not increase substantially, and in some cases fell, in moderate- and low-drilling counties.

Sexually Transmitted Diseases

- Between 2005 and 2012, there was a statistically significant increase of 24% to 27% in rates of infection for chlamydia across all drilling counties (high-, moderate-, and low-) across all three states. There also was an increase in gonorrhea infection rates across all counties, but it was no higher in drilling counties than in non-drilling ones.

Motor Vehicle Fatalities

- There was a statistically significant increase of 27.8% in truck-involved motor vehicle fatalities in the high- drilling counties. In terms of all traffic fatalities (not just those involving trucks) Pennsylvania's six high-drilling counties also had about 35 more traffic fatalities in 2012 than if the number had followed the statewide trend. However this increase in overall motor vehicle fatalities between 2005 and 2012 was not statistically significant.
- We observed no increase in motor vehicle fatalities overall or in truck-involved fatalities in moderate-drilling counties in West Virginia, Pennsylvania, and Ohio.[3]

Rental Housing Markets[4]

Some of the most widely reported impacts of shale oil and gas development relate to housing shortages and rapidly rising rents.

- In high-drilling counties, we observed statistically significant increases in median, low (20th percentile) and high (80th percentile) rents of 10.2%, 7.6% and 12.3%, respectively. We observed no statistically significant impacts for moderate- or low-drilling counties.
- There is a clear pattern of rising rents in the middle and near the top (80th percentile) of the rental market in high-drilling areas.
    - Median rents rose by the indicated rates in the following groups of Pennsylvania counties (***bold italics*** denote heavy-drilling counties): 16.5% in ***Bradford***, Sullivan & ***Tioga***; 9.4% in ***Greene*** and ***Washington***; and 13.9% in Pike, ***Susquehanna***, and Wayne.
- In Ohio, low and median rents were up 3.2% and 1.7%, respectively, in ***Carroll County*** (112 wells drilled) and Stark County (7 wells drilled).

With respect to changes in the incomes of renters, in high-drilling counties we observed a statistically significant increase in renter incomes only at the 80th percentile. By contrast, in medium- and low-drilling counties we observed declines in the incomes of renters at the 20th percentile. With rising rents and no change in incomes for low- (20th percentile) and median- income renters in high-drilling counties, there was a statistically significant 14% increase in the number of renters paying 30% or more of their income in rent (a measure of housing affordability). It is also of note that, although there were rising median and

[3] We did observe a decline of 11% in low-drilling counties in motor vehicle fatalities overall.
[4] Note that we are hampered in this analysis by having to rely on data for "county groups" rather than individual counties. Grouping heavy-drilling Bradford, Tioga, and Greene counties with other counties likely masks bigger impacts of drilling on housing variables in those individual counties.

high rents in high-drilling counties, we found no evidence of an increase in new residential housing construction over the 2005-2012 period.

Conclusion

One challenge for the future is to improve data sources to get a better match between the area where drilling is occurring and the information available on human and social service impacts.

What do we know from analyzing the data that are currently available as well as our prior case studies? Summing up, our case studies of two high-drilling Pennsylvania counties, Tioga and especially Greene, revealed some positive employment and income benefits of shale development. Our assessment of the human and social impacts in this report reveals the other side of this positive-economic impacts coin: The heaviest drilling counties, as measured by number of wells and by industry and total employment impacts, also experience negative impacts. These include higher rates of crime, sexually transmitted disease, and traffic fatalities, and higher rents.

In a sense, these findings echo the old saying that “there’s no free lunch.” The communities in which the scale of shale development is sufficient to move the needle on total employment and income are also the communities likely to be faced with social challenges. Communities with shale resources where drilling has not yet occurred should understand this trade-off so that they may weigh their options in an informed way and prepare for the social impacts if drilling is undertaken.

Introduction

Unconventional shale oil and gas extraction is a high-impact industrial process, especially when considered relative to conventional oil and gas extraction, which has been present in Pennsylvania, Ohio, and West Virginia since the discovery of oil in the 19th century. Some economic and social impacts of shale development result directly from drilling itself, e.g., traffic- and road-related impacts. Other impacts result from an influx of people and income directly or indirectly associated with industry development, such as increases in crime, sexually transmitted diseases and housing costs. Because we anticipate that drilling-related social impacts are associated with the amount of drilling and with changes in industry employment, total employment, and population, we begin our analysis in Chapter 1 with a summary of county-level trends in the number of wells drilled, total employment, and population trends in each state.

Based on this analysis, we find that six Pennsylvania counties— each with more than 400 wells drilled—stand far above all the others studied for the amount of drilling and also for industry employment growth. We define these as high-drilling counties. No county in Ohio has had more than 112 wells drilled, and no county in West Virginia has had more than 200 wells drilled. To permit analysis of drilling's human service impacts in all three states, we created a second group of medium-drilling counties with between 100 and 399 wells drilled. In addition to these two categories, we also look in subsequent chapters for drilling impacts in counties with 1 to 99 wells (low-drilling) and in two control groups, rural counties without drilling and urban counties without drilling.[5]

Map 1.1, Map 1.2, and Map 1.3 in Chapter 1 identify the counties that fall into each of these categories in Pennsylvania, West Virginia, and Ohio. When possible, we examine trends in our social and economic variables prior to drilling and also present trends in these same variables in the non-drilling rural and urban portions of New York, Maryland, and Virginia.

Using these groupings, we explore in each state whether the counties with the most drilling have seen changes in job growth (Chapter 2) and population (Chapter 3) above and beyond that found in control areas.[6]

In the remaining chapters we explore trends in crime (Chapter 4), sexually transmitted diseases (Chapter 5), and traffic fatalities (Chapter 6).

In Chapter 7 we examine trends in rents, renter income, rental housing affordability, home values, and homeowner incomes. Data limitations imposed by our use of the American Community Survey for these analyses mean that observations from high-drilling counties are pooled with those from counties much less drilling, likely resulting in the underestimation of the impact of heavy drilling.

[5] Whenever possible in the subsequent chapters we also present trends in the rural and urban portions of New York, Virginia, and Maryland. These are the other states in the region that may have shale oil and gas.
[6] In an Online Technical Appendix we also present county-by-county trends in each of the areas we study for counties with 100 or more wells drilled.

In Chapter 8 we expand our analysis to four additional potential human service impact areas: early intervention for children with developmental delays or disabilities, foster care, and emergency room visits. Since data in these areas are not uniform across states, we restrict our analysis to Pennsylvania, the state with the most drilling over the period studied.

Box 1. Online Technical Appendix

Find online at http://keystoneresearch.org/MSSRC/tech_app Excel files of the tables printed in this document, as well as supplementary tables with individual county-level outcomes for each of the topics covered in this report.

Researchers interested in exploring the strength of the relationships between drilling intensity and the topics covered in this report can also find here Stata datasets containing the variables summarized in this study.

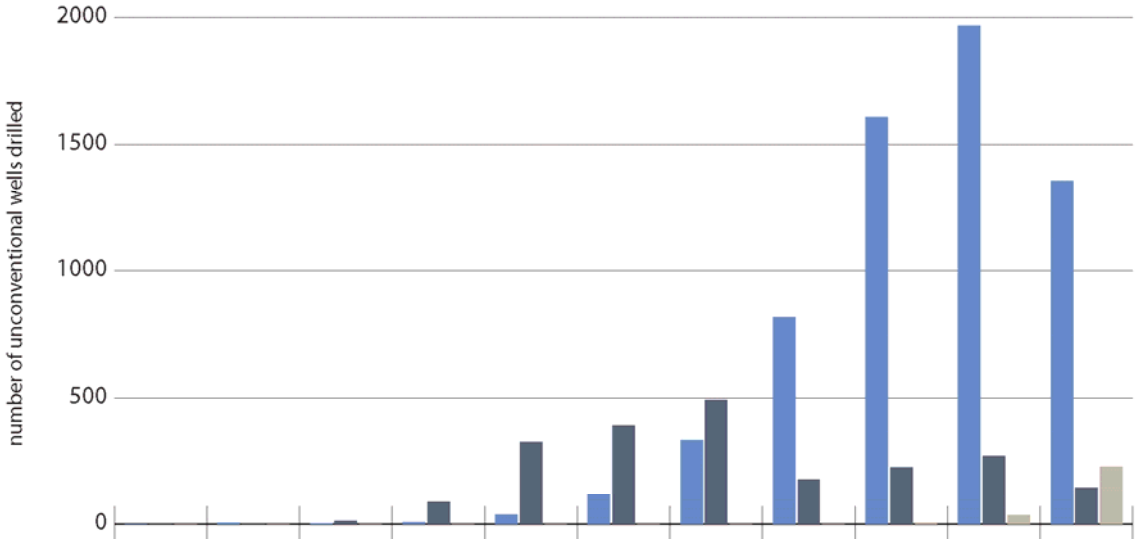
Chapter 1: State and County Trends in Drilling

To better understand the human and social impacts of drilling in Pennsylvania, West Virginia and Ohio, we need to explore where and when that drilling created changes in employment and population.

We start the process by looking at the timeline of drilling at the state level—the number of wells drilled each year in our three states (Figure 1.1). Three points stand out from this figure. First, Pennsylvania accounts for much more drilling than West Virginia and Ohio, with 72% of total wells drilled across all three states from 2005 to 2012. Second, drilling started in earnest first in West Virginia, peaking in 2008 at only one quarter the peak drilling level in Pennsylvania. Third, drilling in Ohio does not begin until 2011, and only exceeds 35 wells in 2012, the final year of this study.

Figure 1.1

Number of Unconventional Wells Drilled By Year in Pennsylvania, West Virginia, and Ohio



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Pennsylvania	1	4	2	8	37	115	335	817	1607	1968	1358
West Virginia	0	0	12	89	326	392	492	178	227	270	146
Ohio	0	0	0	0	1	0	0	1	4	35	229

Source. Multi-State Shale Collaborative based on Pennsylvania Department of Environmental Protection (DEP), the West Virginia Geological and Economic Survey (WVGES), and the Ohio Department of Natural Resources (DNR).

Table 1.1 examines the amount of drilling by county for all counties in the three states with at least 100 wells drilled from 2005 to 2012. This table reveals that the top six Pennsylvania drilling counties, each with at least 517 wells drilled, had more than two-and-a-half times as many wells drilled as any West Virginia county and nearly five times as many as any Ohio county. These six counties accounted for more than half (52%) of all wells drilled in the three states from 2005 to 2012. The table further reveals that the top two counties for total wells drilled (Bradford and Tioga in Pennsylvania) are also the top two counties for wells drilled per capita. The fifth- and sixth-ranked counties for wells drilled (Susquehanna and Greene in Pennsylvania) also ranked fifth and sixth for wells drilled per capita. The third- and fourth-

place counties for wells drilled (Washington and Lycoming in Pennsylvania) are more urban and therefore rank lower for wells drilled per capita. Meanwhile, the third- and fourth-place counties measured by wells drilled per capita are sparsely populated Doddridge and Ritchie in West Virginia, with only 16 and 12 wells drilled over the 2005-2012 period, respectively. In sum, based on drilling intensity alone, we should expect to see human and social service impacts in the top six Pennsylvania drilling counties, and especially in the four less populous of those counties because they rank in the top six BOTH for total number of wells drilled and for wells drilled per capita.

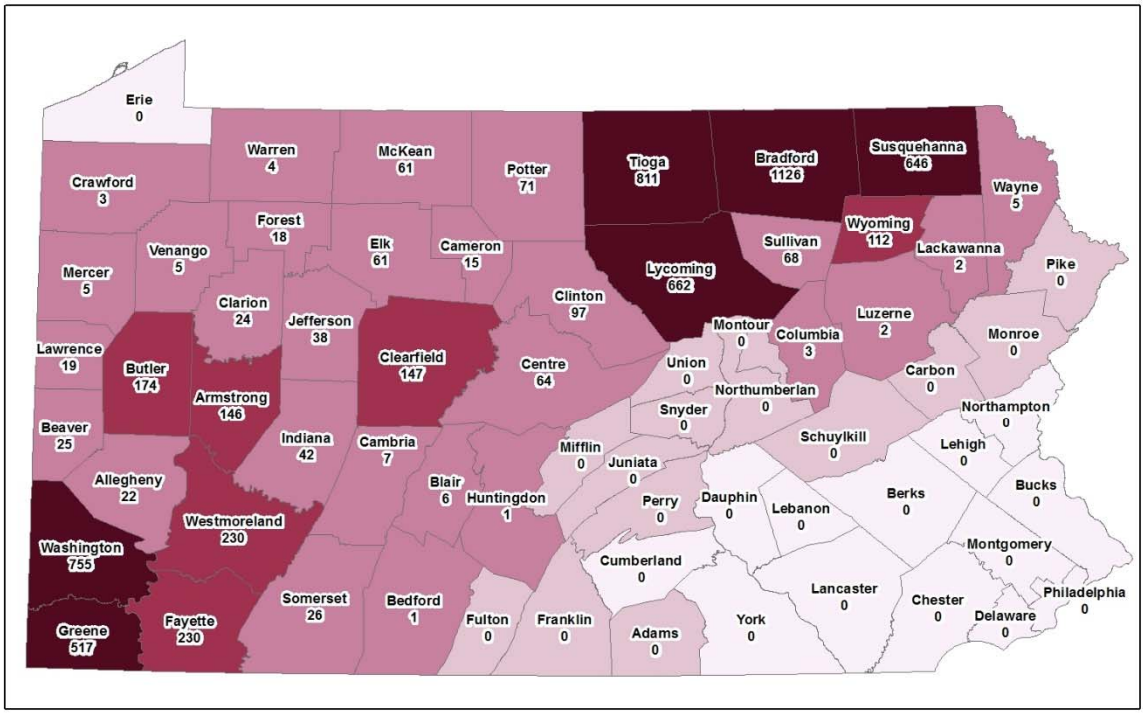
Table 1.1

The amount of drilling activity by county in Pennsylvania, West Virginia, and Ohio counties with at least 100 wells drilled from 2005 to 2012

State	county	total wells drilled	total wells drilled rank	wells drilled per capita	wells drilled per capita rank
Pennsylvania	Bradford	1126	1	0.018	2
Pennsylvania	Tioga	811	2	0.019	1
Pennsylvania	Washington	755	3	0.004	16
Pennsylvania	Lycoming	662	4	0.006	8
Pennsylvania	Susquehanna	646	5	0.015	5
Pennsylvania	Greene	517	6	0.014	6
Pennsylvania	Fayette	230	7	0.002	20
Pennsylvania	Westmoreland	230	8	0.001	23
West Virginia	Kanawha	194	9	0.001	21
West Virginia	Logan	191	10	0.005	9
Pennsylvania	Butler	174	11	0.001	22
West Virginia	Ritchie	163	12	0.016	4
West Virginia	Harrison	156	13	0.002	17
Pennsylvania	Clearfield	147	14	0.002	19
Pennsylvania	Armstrong	146	15	0.002	18
West Virginia	Doddridge	137	16	0.017	3
West Virginia	Boone	122	17	0.005	12
West Virginia	Upshur	122	18	0.005	11
West Virginia	Jackson	121	19	0.004	13
West Virginia	Wetzel	115	20	0.007	7
Ohio	Carroll	112	21	0.004	15
Pennsylvania	Wyoming	112	22	0.004	14
West Virginia	Lincoln	111	23	0.005	10

Source. Multi-State Shale Collaborative based on Ohio Department of Natural Resources, Pennsylvania Department of Environmental Protection, West Virginia Geological and Economic Survey, and Bureau of Economic Analysis data.

Map 1.1



Source. Multi-State Shale Collaborative.

Table 1.2

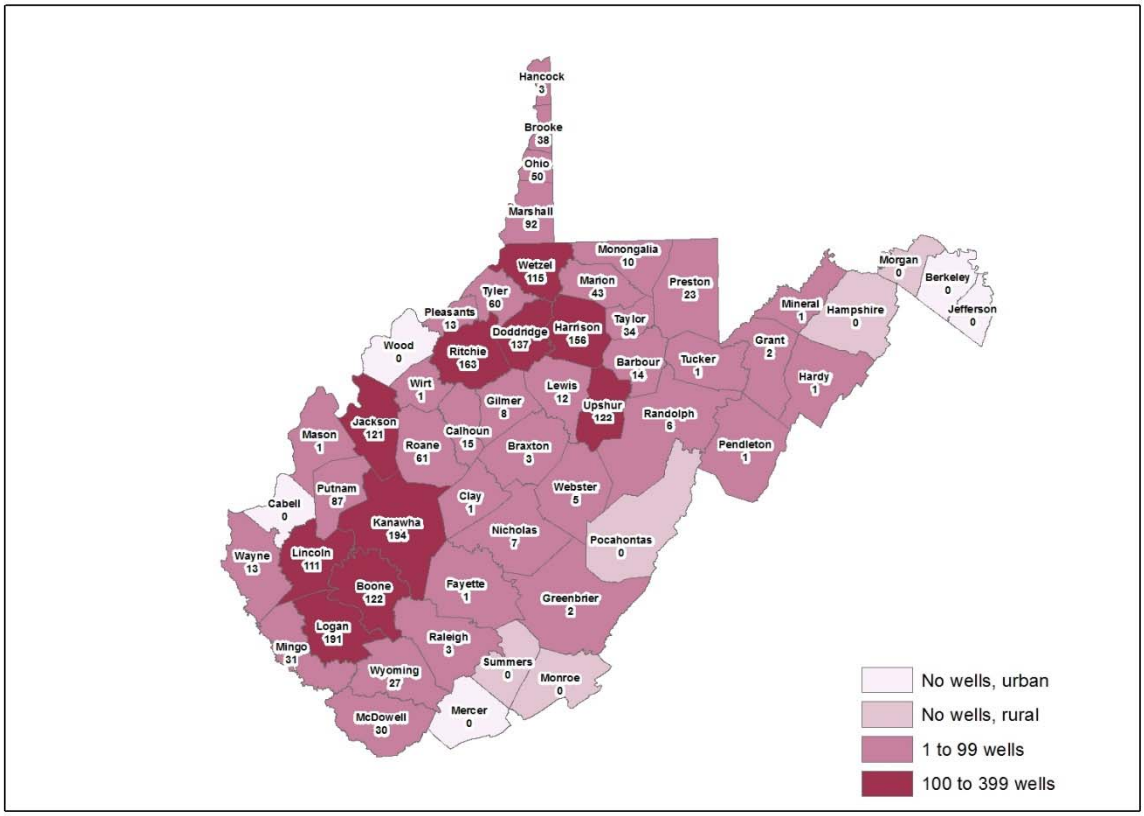
Share of total wells drilled each year for the top six drilling counties in Pennsylvania

Year	Pennsylvania (Number of Wells Drilled)	Brad-ford	Tioga	Wash-ington	Lycom-ing	Susque-hanna	Greene	Six county share of PA total
2002	1	0%	0%	100%	0%	0%	0%	100%
2003	4	0%	0%	25%	0%	0%	0%	25%
2004	2	0%	0%	0%	0%	0%	0%	0%
2005	8	13%	0%	63%	0%	0%	0%	75%
2006	37	5%	3%	51%	0%	3%	5%	68%
2007	115	2%	0%	39%	4%	2%	12%	59%
2008	335	7%	4%	20%	4%	10%	20%	65%
2009	817	19%	15%	12%	3%	11%	12%	73%
2010	1607	23%	17%	10%	7%	8%	6%	73%
2011	1968	20%	14%	8%	15%	10%	6%	74%
2012	1358	12%	9%	14%	15%	14%	8%	72%
Total wells drilled	6252	18%	13%	12%	11%	10%	8%	72%

Source. Multi-State Shale Collaborative based on Pennsylvania Department of Environmental Protection (DEP) data.

In the six top-drilling counties, Table 1.2 shows the timeline of drilling. Drilling from 2006 to 2008 was concentrated in Washington and Greene counties in the southwest corner of Pennsylvania. Drilling then expanded rapidly in the four northeast Pennsylvania counties, Bradford, Tioga, Lycoming, and Susquehanna.

Map 1.2



Source. Multi-State Shale Collaborative

In West Virginia, the 10-top drilling counties composed 67% of the state's total unconventional drilling during the 2002-12 period (Map 1.2). Table 1.3 shows that the locus of drilling within West Virginia has shifted over time, from the southwest to the northwest (Doddridge, Harrison, Upshur, and Wetzel counties). Table 1.3 show that drilling dropped off by more than two-thirds from 2008 to 2012. Thus, based on the lack of sustained drilling intensity in any part of the state, there is a question whether West Virginia should expect significant human and social impacts from drilling.

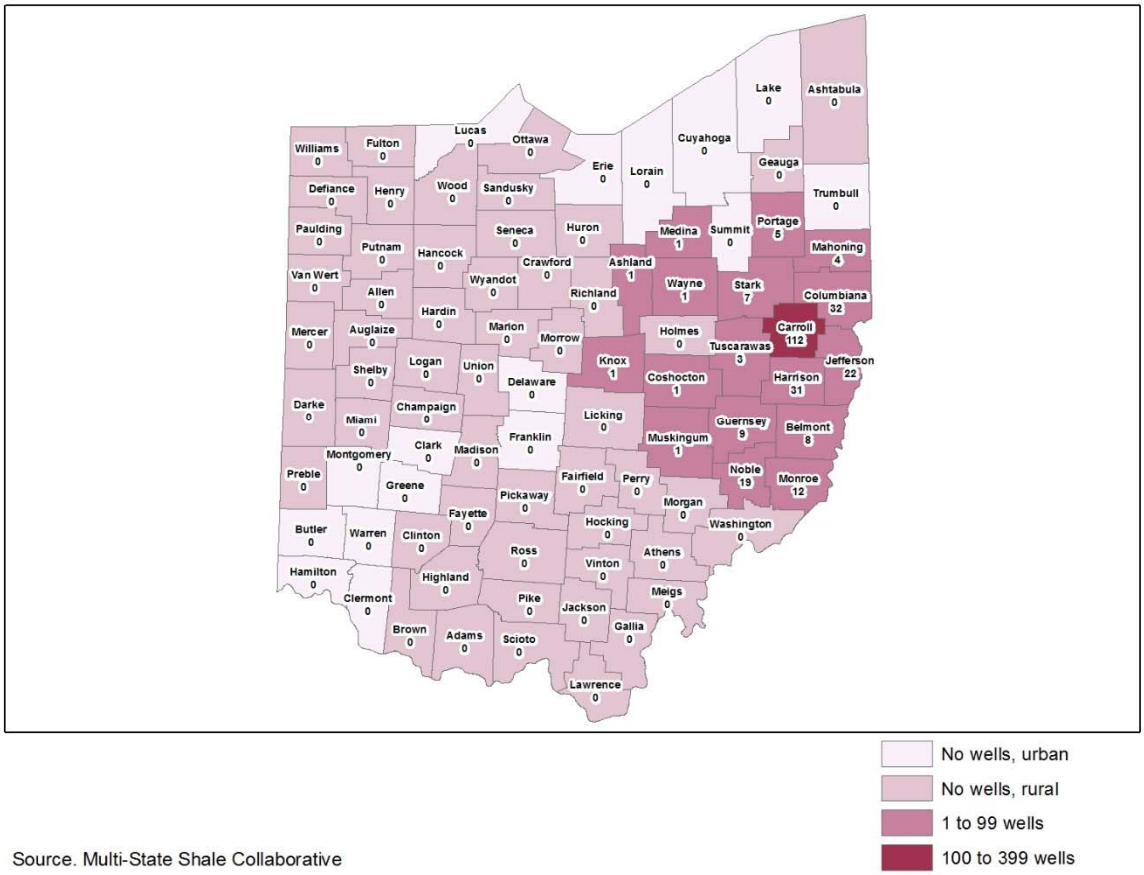
Table 1.3

Wells drilled as a share of total wells for the top ten drilling counties in West Virginia

County	year									Share of total since 2004
	2004	2005	2006	2007	2008	2009	2010	2011	2012	
Kanawha	17%	6%	18%	11%	15%	4%	0%	0%	0%	9%
Logan	0%	37%	18%	19%	5%	0%	0%	0%	0%	9%
Ritchie	0%	4%	13%	15%	7%	3%	1%	3%	3%	8%
Harrison	0%	0%	0%	0%	3%	8%	17%	19%	22%	7%
Doddridge	0%	0%	0%	0%	7%	19%	21%	1%	12%	6%
Boone	25%	13%	13%	8%	5%	0%	1%	0%	0%	6%
Upshur	0%	0%	0%	2%	3%	10%	19%	11%	5%	6%
Jackson	0%	4%	1%	13%	10%	4%	2%	0%	0%	6%
Wetzel	0%	0%	0%	1%	3%	18%	12%	8%	10%	5%
Lincoln	0%	0%	12%	8%	8%	3%	0%	0%	0%	5%
statewide total	12	89	326	392	492	178	227	270	146	2132

Source. Multi-State Shale Collaborative based on the West Virginia Geological and Economic Survey (WVGES) data.

Map 1.3



Source. Multi-State Shale Collaborative

Significant drilling started in Ohio in 2011, with 35 new wells, and then jumped to 229 new wells in 2012. That was 83 more wells than were drilled in West Virginia that same year but only about one-sixth the number of wells drilled in Pennsylvania in 2012. Drilling in Ohio, so far, is concentrated near the eastern border with West Virginia, with only one county (Carroll) having more than 100 wells drilled (See Table 1.4 and Map 1.3). Carroll County had more wells drilled in 2010 (94 wells) than any one West Virginia county has had drilled in a single year. Within all three states from 2005 to 2012, Carroll County's drilling activity in 2012 has only been exceeded in any single year by the six Pennsylvania high-drilling counties.

Table 1.4

Wells drilled in Ohio and Carroll County, Ohio

Year	Ohio total	Carroll
2006	1	0%
2007	0	0%
2008	0	0%
2009	1	0%
2010	4	0%
2011	35	51%
2012	229	41%
Total Wells Drilled	270	41%

Source. Multi-State Shale Collaborative based on the Ohio Department of Natural Resources (DNR).

Chapter 2: Job Growth

Next we consider whether drilling in individual counties translated into an impact on jobs and population. We know from our prior research that across ALL drilling counties, the relationship between drilling and employment is a weak one (Mauro et al 2013). For the heaviest drilling counties, however, this relationship could be stronger. For example, the Census Bureau (2013) finds the fastest growing communities in the country are those undergoing energy natural resource extraction booms.

In examining employment and population (discussed in detail next chapter) trends, we compare changes in the seven-year period after drilling picked up (2005-2012) with a seven-year period ending in 2005 (1998-2005) (see Table 2.1). The period from 1998 to 2005, including the 2001 recession, measures employment change roughly from peak to peak of the business cycle. The period from 2005 to 2012 includes the Great Recession and ends in a year when employment remained closer to the trough of the business cycle. Thus, unless shale-specific factors (or other local factors) outweigh the impact of the national economy, we would expect total employment gains from 1998 to 2005 but flat or declining employment from 2005 to 2012.[7]

Table 2.1 shows changes in industry employment, total employment, and population in each of the counties with at least 100 wells drilled across all three states. (We measure industry employment using "mining and natural resources employment" because narrower industry definitions are not available for all counties[8]). Four of the Pennsylvania high-activity drilling counties have industry employment increases of over a 1,000 jobs (three have increases of over 1,700 jobs); a fifth high-activity county, Tioga, also has a big mining and natural resources employment increase in percentage terms (376%). Only one county outside the "big six" has an industry employment increase of over 300% —Carroll County in Ohio.[9]

Tables 2.2 and 2.3 show industry (natural resources and mining) and total employment changes for our county groups, starting with the six Pennsylvania counties with 400 or more wells drilled (what we previously defined as high-activity). Table 2.2 shows that the high activity Pennsylvania counties saw industry employment increases of 138%, over two-and-a-half times greater than any other grouping except for Carroll County (in a group by itself). These six counties also saw an increase in employment between 2005 and 2012 of 10.3% (or 18,932 jobs), while both rural and urban Pennsylvania counties without drilling saw employment decline by 1.5% and 0.8%, respectively. Washington and Greene counties together account for 13,579 (71%) of the job gains in the high-drilling counties. As discussed in Chapter 1, these two southwestern counties accounted for a third of the wells drilled in Pennsylvania since 2005. Thus, total employment gains in Greene and Washington appear to reflect growth in both

[7] For the purposes of this paper, we will briefly focus on changes in total covered employment (hereafter referred to as employment) as measured in the Quarterly Census of Employment and Wages between 1998 and 2012.
[8] The use of this broader definition means that in some counties trends in non-shale employment, including coal mining, may drive the numbers. This may particularly impact Greene and Fayette counties in Pennsylvania and some West Virginia counties.
[9] With 93 new jobs, an increase of 291% in Wetzel County, West Virginia, just misses the 300% cutoff.

drilling and non-drilling sectors.[10] In the remaining top-six drilling counties, employment gains were modest, ranging from 4% to 8%.

Table 2.2

Mining and natural resources employment change from 1998 to 2012 in counties grouped by the amount of drilling

Wells drilled/region	Employment 2012	1998 to 2005		2005 to 2012		Total wells drilled 2005 to 2012
		Change	Percent Change	Change	Percent Change	
PA, 400 or more wells	12,284	-108	-2%	7,121	138%	4,515
PA, 100 to 399 wells	5,298	-499	-10%	971	22%	1,036
PA, 1 to 99 wells	15,632	-200	-2%	5,442	53%	693
PA, Rural*	5,158	-48	-1%	482	10%	0
PA, Urban*	16,098	2,540	17%	-1,184	-7%	0
WV, 100 to 399 wells	10,094	1,869	23%	21	0.2%	1,427
WV, 1 to 99 wells	20,704	-115	-1%	5,978	41%	693
WV, Rural*	115	-80	-34%	-40	-26%	0
WV, Urban*	736	-91	-12%	74	11%	0
OH, 100 to 399 wells (Carroll, OH)	173	-46	-54%	134	344%	112
OH, 1 to 99 wells	7,210	439	7%	694	11%	158
OH, Rural*	9,359	-1,825	-17%	148	2%	0
OH, Urban*	6,197	-815	-11%	-508	-8%	0
MD, Rural*	3,711	248	7%	116	3%	0
MD, Urban*	1,861	241	13%	-169	-8%	0
NY, Rural~	19,410	2,573	17%	1,250	7%	21
NY, Urban*	7,736	-80	-1%	-84	-1%	0
VA, Rural~	17,148	-1,901	-10%	-40	-0.2%	93
VA, Urban*	2,972	-27	-1%	-338	-10%	0

*The figures here represent employment in rural and urban counties with no wells drilled between 2002 and 2012. A county or county group is defined as rural if the 2005 population per square mile is below its corresponding statewide total population per square mile. What follows is the population per square mile for each state in this study: Pennsylvania (278); West Virginia (75); Maryland (576); New York (405); Ohio (280); Virginia (191).

~ There were 93 wells drilled in rural Virginia counties and 22 wells drilled in rural New York counties between 2002 and 2012.

Source. Multi-State Shale Collaborative based on Quarterly Census of Employment and Wages data.

[10] For instance, in this period coal production was increasing in Greene County, and casino gaming was expanding in Washington County.

Table 2.3

Employment change 1998 to 2012 in counties grouped by the amount of drilling.

Wells drilled/region	Employment 2012	1998 to 2005		2005 to 2012		Total wells drilled 2005 to 2012
		Change	Percent Change	Change	Percent Change	
PA, 400 or more wells	202,596	9,489	5.4%	18,932	10.3%	4,515
PA, 100 to 399 wells	314,582	21,437	7.3%	997	0.3%	1,036
PA, 1 to 99 wells	1,507,614	6,510	0.4%	-11,284	-0.7%	693
PA, Rural*	328,950	30,027	9.9%	-5,035	-1.5%	0
PA, Urban*	3,096,180	123,344	4.1%	-25,371	-0.8%	0
WV, 100 to 399 wells	187,367	-494	-0.3%	-1,898	-1.0%	1,427
WV, 1 to 99 wells	329,723	12,379	4.0%	10,242	3.2%	693
WV, Rural*	14,171	494	3.4%	-955	-6.3%	0
WV, Urban*	156,232	3,678	2.4%	-306	-0.2%	0
OH, 100 to 399 wells (Carroll, OH)	5,950	-871	-13.5%	359	6.4%	112
OH, 1 to 99 wells	617,112	-6,987	-1.0%	-45,585	-6.9%	158
OH, Rural*	1,017,375	7,749	0.7%	-71,910	-6.6%	0
OH, Urban*	3,321,113	-25,367	-0.7%	-187,080	-5.3%	0
MD, Rural*	608,634	98,081	19.6%	9,390	1.6%	0
MD, Urban*	1,841,543	135,958	7.9%	-12,365	-0.7%	0
NY, Rural~	1,368,950	65,329	4.9%	-30,245	-2.2%	21
NY, Urban*	7,053,753	196,580	3.0%	235,857	3.5%	0
VA, Rural~	806,703	41,373	5.2%	-25,261	-3.0%	93
VA, Urban*	2,738,630	301,631	12.7%	52,700	2.0%	0

*The figures here represent employment in rural and urban counties with no wells drilled between 2002 and 2012. A county or county group is defined as rural if the 2005 population per square mile is below its corresponding statewide total population per square mile. What follows is the population per square mile for each state in this study: Pennsylvania (278); West Virginia (75); Maryland (576); New York (405); Ohio (280); Virginia (191).

~ There were 93 wells drilled in rural Virginia counties and 22 wells drilled in rural New York counties between 2002 and 2012.

Source. Multi-State Shale Collaborative based on Quarterly Census of Employment and Wages data

In West Virginia, drilling does not appear to have been extensive enough to drive overall employment trends. Counties with 100 to 399 wells (medium-activity), which account for 67% of the state's new unconventional oil and gas wells, experienced a decline in total employment of 1% since 2005 (Table 2.3). Counties with less drilling (between 1 and 99 wells or low-activity) saw employment climb 3.2%. In

rural West Virginia counties without drilling, employment fell 6.3%, and in urban West Virginia counties without drilling, it fell 0.2%.[11]

In Ohio, only Carroll County had more than 100 wells drilled (no other Ohio county had more than 32 wells drilled) between 2002 and 2012, with total employment growing by 6.4%, or 359 jobs, since 2005 (Table 2.3). The employment picture in the rest of Ohio was grim before and after 2005.

Panel regression on employment

Using our annual data set (1998 to 2012) of total covered employment and employment in mining and natural resources (expressed in logs), we estimated using a fixed effects panel regression the relationship between employment and the amount of drilling activity by county in West Virginia, Pennsylvania and Ohio. We included three indicator variables set to 1 for counties between 2005 and 2012 (the period in which drilling occurred) that also had high-activity (400 or more wells drilled over the period), medium-activity (100 to 399 wells drilled over the period) and low-activity(1 to 99 wells drilled over the period) and zero otherwise.[12] In terms of total covered employment, we found a positive and significant elasticity for high-activity counties, implying an increase in total covered employment of 10.5%. For medium-activity counties we failed to find a statistically significant coefficient. In low-activity counties the coefficient is negative and statistically significant. The relationship between drilling and employment in natural resources and mining is stronger across all counties with an elasticity ranging from .203 in low-activity counties to 1.085 in high-activity counties. Consistent with our prior work the only places to see significant employment impacts are those six high-activity counties in Pennsylvania.

[11] Some individual counties (Kanawha, Logan, and Harrison) did in relative terms have stronger employment growth since 2005 than prior (see the Online Technical Appendix, Appendix B, Table B1 for a county-by-county breakout of employment gains in each state with 100 or more wells drilled).

[12] As reflected in the absence of a full set of controls, our intent here is not to fully explain differences in employment across counties but to assess the relationship between drilling and employment. Researchers interested in exploring the robustness of this relationship can find this dataset in the Online Technical Appendix, Chapter 2, AppendixB.dta (stata).

Table 2.4

Employment in West Virginia, Pennsylvania and Ohio by high-, medium- and low-drilling activity

Independent variables	Dependent variable = natural log of total covered employment	Dependent variable = natural log of natural resources and mining employment
	b/se	b/se
High-activity	0.105***	1.085***
	(0.026)	(0.209)
Medium-activity	0.016	0.322**
	(0.014)	(0.130)
Low-activity	-0.017**	0.203***
	(0.008)	(0.046)
Constant	9.879***	5.623***
	(0.000)	(0.001)
R-sqr-overall	0.001	0.011
N	3,149	2,688

Notes. *, ** and *** indicate significance at the 10, 5 and 1 percent levels. Standard error estimates are robust to disturbances being heteroscedastic.

Chapter 3: Population

We now turn to population. As a group high-activity counties (those with 400 or more wells) in Pennsylvania saw their population increase by 0.4%, or 2,040 people, after 2005, whereas prior to 2005 these same counties experienced a population decline of 0.3%.[13] (Recall that Table 2.1 had individual county population changes for counties with 100 or more wells drilled). Since 2005, the population in urban and rural Pennsylvania counties without drilling grew by 4.4% and 3.4%, respectively. (See the Online Technical Appendix, Chapter 3, Table C1 for a county-by-county breakout of population trends in counties with 100 or more wells drilled).[14]

Considered as a group, the heaviest drilling counties in West Virginia, those with between 100 and 399 wells (medium-activity), experienced a decline in population since 2005 of 1,365 people, or 0.3%, compared to a decline of 2.9% from 1998 to 2005.[15] In comparison, urban and rural West Virginia counties without drilling grew by 6.3% and 2.6%, respectively. In Carroll County, Ohio, despite recent gains in total employment, the county population is down by 531 people, or 1.8%, since 2005.[16]

Using data from the 2000 Census and the 2008-2012 American Community Survey, we also examined the population share of males ages 15 to 39 by county in West Virginia, Pennsylvania and Ohio. Reflecting broader demographic trends, the share of males ages 15 to 39 fell across all three states, and we could identify no clear pattern by the level of drilling activity. (See the Online Technical Appendix, Chapter 3, Table C2 and Table C3, for a county-by-county breakout of the change in the share of males ages 15 to 39 in counties with 100 or more wells drilled).

We interviewed demographers at the Penn State Data Center who acknowledged that local officials in drilling communities in Pennsylvania expressed some concern that the 2010 Census did not confirm as much population growth as they were expecting, given reports of increasing rents and shortages of local hotel rooms. To the extent that drillers use out-of-state workers, those workers may not necessarily report that they reside in the states studied here. Thus these workers would not show up in the population data summarized here. Similarly, a sizable share of employment generated by drilling is in the construction sector where it is in the nature of the industry for workers to travel long distances to find work, and this is especially true in rural regions.

[13] As a group, these Pennsylvania counties account for 72% of the 6,245 wells drilled in Pennsylvania since 2005.
[14] See Table C4 in Chapter 3 of the Online Technical Appendix for the results of a fixed-effects panel regression on population (expressed in logs) by county from 1998 to 2012 in West Virginia, Pennsylvania and Ohio. The model included no other independent variables than three indicator variables set to 1 for every year from 2005 to 2012 in high-activity counties (those with 400 or more wells), medium-activity counties(100 to 399 wells), and low-activity counties (1 to 99 wells) and 0 otherwise. None of the coefficients on the indicator variables were statistically significant for any level of drilling. If there were population impacts from drilling they were too small to be detectable in county-level population data.
[15] As a group, these West Virginia counties account for 67% of that state's 2,120 unconventional oil and gas wells.
[16] The population in Carroll County in 2012 was down by 213 individuals compared to its 2010 level.

Table 3.1

Population change 1998 to 2012 by state and by number of wells drilled

Wells drilled/region	2012	1998 to 2005		2005 to 2012		Total wells drilled 2002 to 2012
		Change	Percent Change	Change	Percent Change	
PA, 400 or more Wells	512,034	-1,698	-0.3%	2,040	0.4%	4,515
PA, 100 to 399 Wells	861,743	-7,972	-0.9%	-7,750	-0.9%	1,036
PA, 1 to 99 Wells	3,362,037	-92,214	-2.7%	-12,135	-0.4%	693
PA, Rural*	1,020,081	64,707	7.0%	33,661	3.4%	0
PA, Urban*	7,007,641	241,495	3.7%	297,730	4.4%	0
WV, 100 to 399 Wells	432,140	-12,856	-2.9%	-1,365	-0.3%	1,427
WV, 1 to 99 Wells	938,401	-8,493	-0.9%	10,258	1.1%	693
WV, Rural*	77,072	4,457	6.3%	1,947	2.6%	0
WV, Urban*	407,800	21,775	6.0%	24,081	6.3%	0
OH, 100 to 399 Wells (Carroll, OH)	28,587	481	1.7%	-531	-1.8%	112
OH, 1 to 99 Wells	1,718,010	17,729	1.0%	-5,851	-0.3%	158
OH, Rural*	2,938,175	78,777	2.8%	16,503	0.6%	0
OH, Urban*	6,859,453	54,797	0.8%	70,784	1.0%	0
MD, Rural*	1,710,001	180,039	12.5%	87,855	5.4%	0
MD, Urban*	4,174,562	207,876	5.5%	204,329	5.1%	0
NY, Rural~	3,822,058	62,491	1.7%	10,026	0.3%	21
NY, Urban*	15,748,203	314,213	2.1%	427,625	2.8%	0
VA, Rural~	2,393,746	124,590	5.7%	86,762	3.8%	93
VA, Urban*	5,792,121	551,597	11.7%	522,000	9.9%	0

*The figures here represent employment in rural and urban counties with no wells drilled between 2002 and 2012.

~ There were 93 wells drilled in rural Virginia counties and 22 drilled in rural New York counties between 2002 and 2012.

Note. A county or county group is defined as rural if the 2005 population per square mile is below its corresponding statewide total population per square mile. What follows is the population per square mile for each state in this study: Pennsylvania (278); West Virginia (75); Maryland (576); New York (405); Ohio (280); Virginia (191).

Source. Multi-State Shale Collaborative based on Bureau of Economic Analysis data

Chapter 4: Crime

Natural resource extraction booms tend to lead to an influx of out-of-state workers, including transient young men making higher-than-average wages. With this influx and the extraction activity, traffic increases, local bars and restaurants fill up, and small town life changes. Numerous studies have found that this influx corresponds to an increase in crime and a greater demand on emergency services.

The Long-Term Link between Natural Resource Extraction and Crime:

In *Long-term effects of income specialization in oil and gas extraction: the U.S. West, 1980-2011*, researchers observed that counties in the American West that derive more of their income from oil and gas extraction for a longer period of time experienced higher violent and property crime rates than other counties in the region (page 13 bottom).

To read more: http://headwaterseconomics.org/wphw/wp-content/uploads/OilAndGasSpecialization_Manuscript_2013.pdf

Several studies have documented that rising crime accompanies unconventional gas booms. Murray and Ooms (2008) found increases in population and crime during the height of gas extraction in Denton city and Wise County, Texas, and in Faulkner and White counties, Arkansas. Similar trends were found in Sublette County, Wyoming, where increases in population led to rising crime and the need for more law enforcement. Another study of Sublette County documented that arrests grew faster than the population between 1995 and 2004 and showed links between the growth in gas drilling and the growth in the crime rates (Jacquet 2005).

Research in Sweetwater County, Wyoming, revealed a sharp increase in crime, which coincided with the boom in oil and gas extraction. The county saw a particularly high increase in drug-related arrests, which increased from 90 in 2002 to 450 in 2006 (Headwaters Economics 2009).

In Pennsylvania, the influx of well-paid young men who work in (or are connected to) the gas industry has led to reports of increases in drunk-driving, assaults, domestic disturbances and prostitution (Levy 2011). In Williston, North Dakota, there has been an increase in reported rape (about one complaint each week, most often of date rape, say local police). Police rarely got these types of complaints before the gas boom (Ellis 2011).

Case Study Findings

In the spring and summer of 2013 researchers from the Multi-State Shale Research Collaborative conducted interviews with local stakeholders in Tioga and Greene Counties, Pennsylvania; Wetzel County, West Virginia; and Carroll County, Ohio, to examine the social and human service impacts of gas drilling on these local communities.

In Greene County, Pennsylvania, arrests and calls to police increased during the height of the gas boom. The police in Cumberland Township, a center of heavy drilling, reported that calls doubled between 2008 and 2011, and arrests rose for driving under the influence (DUIs), theft, bar fights, assaults, and prostitution. Serious crime[17] rose in Greene County by 31% between 1999-2001 and 2010-12, while

[17] The Pennsylvania State Police include murder, forcible rape, robbery, aggravated assault, burglary, larceny, motor vehicle theft, and arson as serious crime.

Pennsylvania's crime rate fell by 6%. This increase was concentrated in two main areas—burglary and larceny. Escorting wide-load tractor-trailers and handling traffic-related accidents, including minor things like knocked over side mirrors and mailboxes, also increased demand on police (Herzenberg, Polson, and Price 2014).

In Tioga County, Pennsylvania, drilling was associated with increased crime and increased demands on emergency service personnel. Serious crime rose 13% in Tioga County between the period 1999-2000 and 2011-12, while across Pennsylvania serious crime declined by 6%. Tioga County's rise in crime was driven by increases in aggravated assault, larceny, burglary, and motor vehicle theft. DUIs increased 40% in Tioga compared to an increase of 28% statewide between 1999-2001 and 2010-12. Higher crime has meant higher costs to the county as the number of new criminal cases jumped 25% between 2010 and 2011 at the height of the gas boom.

Mansfield and Wellsboro, Tioga County's two population hubs, also saw calls to police and arrests increase with the gas boom. Between 2009 and 2011, calls to the Mansfield Police Department tripled. Wellsboro saw a spike in traffic and other citations. Misdemeanor arrests rose 82% from 2009 to 2011. One sexual assault victim resource organization in Tioga reported seeing rises in the number of sexual assaults (some with the use of date rape drugs) and women seeking domestic violence services during the height of the boom (Ward, Polson, Price 2014).

In Wetzel County, West Virginia, interviewees did not report increases in crime or 911 calls (although data below do show an increase in violent crime, property crime, and non-serious criminal offenses between 2009 and 2012). The Sherriff's office noted a slight increase in DUI arrests and an increase in traffic citations for speeding and driving left-of-center. County commissioners reported complaints from citizens about increased traffic and hazardous driving by trucking companies. (Corroborating this claim, vehicle accidents increased from 194 in 2007 to 310 in 2012 [O'Leary 2014]).

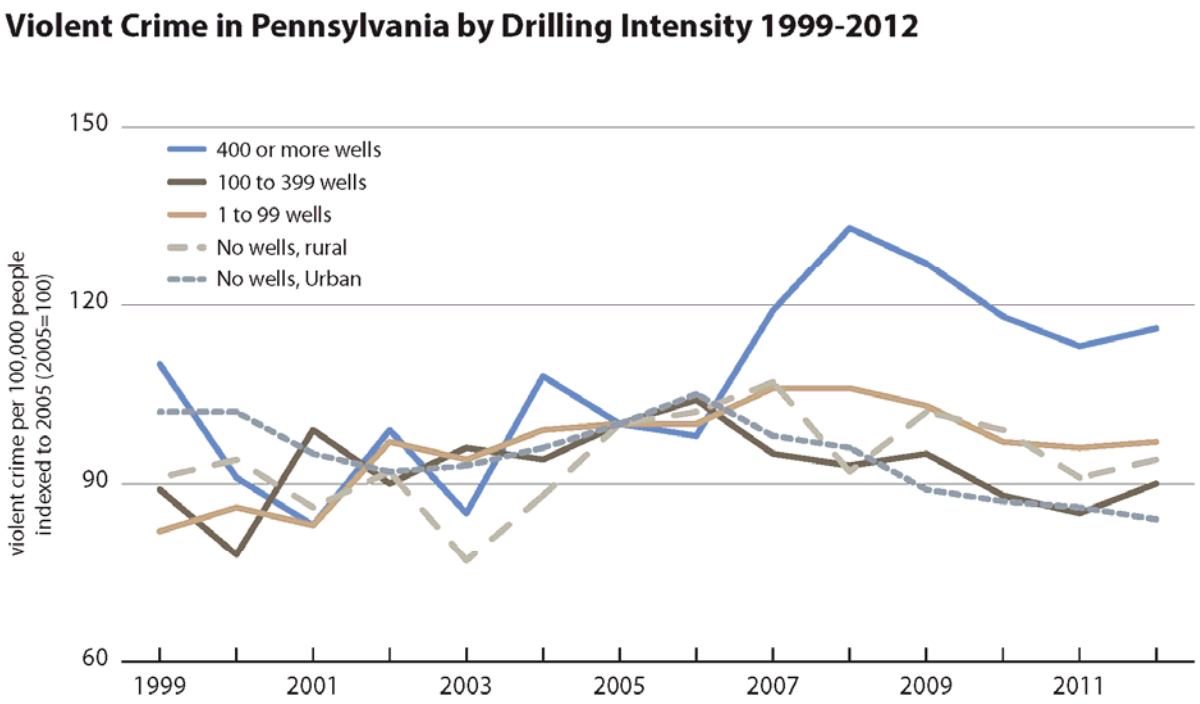
Interviewees in Ohio reported a quadrupling of calls to the sheriff between 2011 and 2013; those calls, plus a doubling of traffic accidents primarily involving heavy trucks, had reportedly increased the workload for the sheriff's office (Woodrum 2014).

Notes on Crime Data

In this chapter we used county-level crime data to more rigorously examine changes in crime by county in Pennsylvania, West Virginia, and Ohio, paying special attention to trends in counties by the number of wells drilled. Because levels of crime vary with the size of the local population, we analyzed crime per 100,000 individuals to facilitate comparisons of the crime rate by county. Our analysis in this chapter focused on reported offenses for violent and property crime. Violent crime is defined as reported offenses for murder, negligent manslaughter, rape, robbery, and aggravated assault. Property crime is defined as reported offenses for burglary, larceny, motor vehicle theft, and arson. We relied on data on criminal offenses through 2012 published by the Pennsylvania State Police (starting in 1999), the West Virginia State Police (starting in 2002), and the Ohio Department of Public Safety (starting in 2000). Reflecting the data available, we also present crime rates for lesser criminal offenses for Pennsylvania and West Virginia.

Pennsylvania:

Figure 4.1



Note. Violent crime is defined here as reported offenses for murder, negligent manslaughter, rape, robbery, and aggravated assault.
Source. Multi-State Shale Collaborative based on Pennsylvania State Police and Bureau of Economic Analysis data.

As illustrated in Figure 4.1 (see also the Online Technical Appendix, Chapter 4, Table D6), violent crime rates were rising between 2001 and 2005 in counties that would eventually see the biggest expansion of drilling, a pattern similar to the rest of the state. However, since 2005 the violent crime rate in the heaviest drilling counties has climbed by 16%, while crime rates have for the most part held steady or fallen in the rest of the state's counties (including those with fewer wells and those in urban and rural communities without wells). This rise in violent crime in the heaviest drilling counties resulted mainly from an increase in aggravated assaults.[18]

Table 4.1 presents the violent crime rate in Pennsylvania counties with 100 or more wells drilled as well as the crime rate in rural and urban counties with no wells drilled (See Map 1.1 in Chapter 1). Since 2005, violent crime was up in every county with more than 400 wells. The violent crime rate fell in all but two (Westmoreland and Clearfield) of the counties with between 100 and 399 wells. The violent crime rate was down in both urban and rural communities without wells drilled. Besides aggravated assault, the other quantitatively important major violent crime category is robbery-theft; this has not shown a

[18] Aggravated assault is one of the two largest components of violent crime, accounting for more than half of the violent criminal offenses (see the Online Technical Appendix, Chapter 4, Table D7). Between 2005 and 2012, aggravated assault has risen by 13% in counties with 400 or more wells (see the Online Technical Appendix, Chapter 4, and Table D12).

significant increase in any of the drilling areas since the emergence of major fracking activity in 2005. (The remaining violent crime categories—murder, negligent manslaughter, and rape—do not represent a large share of violent crime and have seen minimal to zero growth.)

Table 4.1

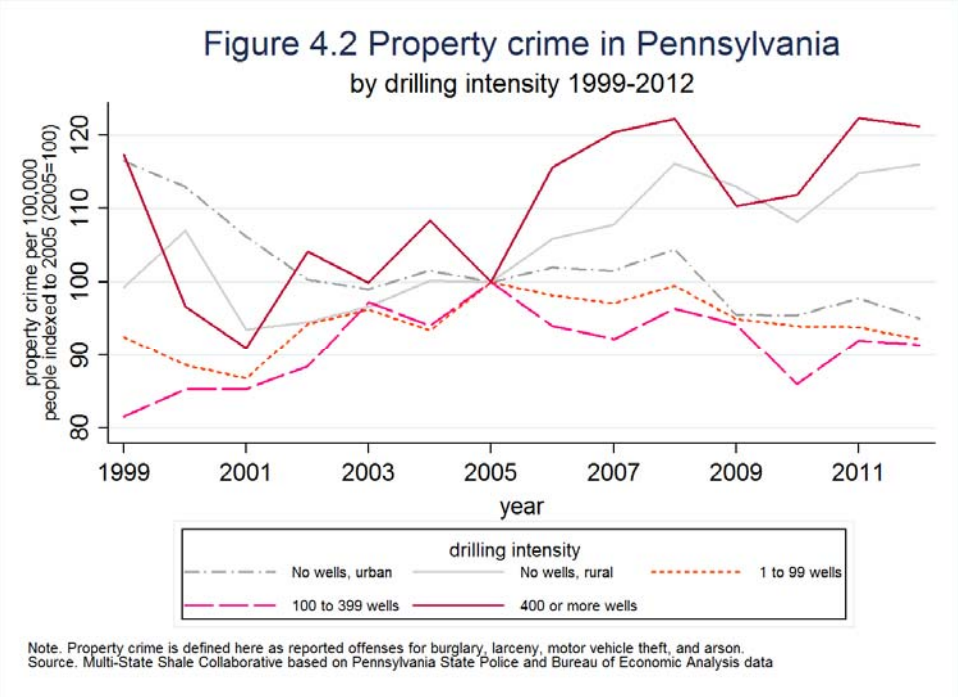
Violent crime in Pennsylvania counties with 100 or more wells drilled and in urban and rural counties with no wells

Wells drilled/region	Violent crime per 100,000 people in 2012	1999 to 2005		2005 to 2012		Total wells drilled 2005 to 2012
		Change	Percent change	Change	Percent change	
Urban, no wells	444	-10	-2%	-87	-16%	0
Rural, no wells	208	20	10%	-14	-6%	0
Bradford	145	-57	-33%	31	28%	1126
Tioga	113	-12	-19%	62	123%	811
Washington	184	4	2%	10	6%	755
Lycoming	181	7	4%	7	4%	662
Susquehanna	126	-48	-31%	18	16%	646
Greene	184	-74	-45%	93	103%	517
Westmoreland	154	-26	-15%	1	1%	230
Fayette	254	110	58%	-45	-15%	230
Butler	114	50	35%	-83	-42%	174
Clearfield	304	-18	-8%	94	45%	147
Armstrong	96	43	50%	-34	-26%	146
Wyoming	100	50	59%	-35	-26%	112

Note. Violent crimes are reported offenses for murder, negligent manslaughter, rape, robbery, and aggravated assault.

Source. Multi-State Shale Collaborative based on Pennsylvania State Police and Bureau of Economic Analysis data.

Property Crime in Pennsylvania:



The property crime rate also rose between 2001 and 2005 in counties with 400 or more wells drilled. Since 2005, property crime increased another 21% in counties with 400 or more wells (Figure 4.2 and Online Technical Appendix, Chapter 4, Table D8). Over the same period the rate of property crime was down in urban counties with no wells as well as counties with fewer than 400 wells.[19] Rural Pennsylvania counties without wells, however, saw the rate of property crime climb over the period by 16%, not far below the increase for high-drilling counties. As with violent crime, all six counties that had 400 or more wells experienced an increase in property crime. The most abrupt increases were seen in the two heaviest-drilling counties, Bradford and Tioga, with 83% and 54% increases, respectively, and in Greene County, which experienced the biggest total employment increase (Table 4.2).

Larceny thefts represent the bulk of property crime (69% to 73% of property crimes between 1999 and 2012), and the rate of larceny theft in Pennsylvania has increased 25% in counties with 400 or more wells (see the Online Technical Appendix, Chapter 4, Table D9 and Table D10). The rate of larceny theft was also up 21% in rural counties with no drilling activity. The rate of larceny theft fell in drilling counties with fewer than 400 wells as well as in urban counties with no wells.[20]

[19] The estimated number of property crimes decreased by 9% in counties with 100-399 wells, 8% in counties with 1-99 wells, and 5% in urban counties with no drilling activity.

[20] Burglary, another subcategory making up 19% of property crime on average, has also shown an increase in heavily drilled counties. In areas with the most drilling activity, there has been a 30% increase in burglary from 2005 to 2012, compared to a 13% decline between 1999 and 2005. Motor vehicle theft, which composes about 9% of property crime in Pennsylvania, has continued to plummet in counties with drilling. Arson has seen virtually no change since 1999.

Table 4.2

Property crime in Pennsylvania counties with 100 or more wells drilled and in urban and rural counties with no wells

Wells drilled/region	Property crime per 100,000 people in 2012	1999 to 2005		2005 to 2012		Total wells drilled 2005 to 2012
		change	percent change	change	percent change	
Urban, no wells	2425	-421	-14%	-126	-5%	0
Rural, no wells	1766	10	1%	244	16%	0
Bradford	1965	-630	-37%	890	83%	1126
Tioga	1444	-266	-22%	509	54%	811
Washington	1707	-147	-9%	144	9%	755
Lycoming	2170	-349	-15%	201	10%	662
Susquehanna	1204	-234	-17%	86	8%	646
Greene	2001	39	3%	694	53%	517
Westmoreland	1472	219	16%	-133	-8%	230
Fayette	2488	931	61%	34	1%	230
Butler	1281	112	7%	-409	-24%	174
Clearfield	2268	455	25%	15	1%	147
Armstrong	931	169	18%	-158	-15%	146
Wyoming	1419	55	4%	48	3%	112

Note: Property crimes are reported offenses for burglary, larceny, motor vehicle theft, and arson.

Source. Multi-State Shale Collaborative based on Pennsylvania State Police and Bureau of Economic Analysis data.

Other Categories of Crime in Pennsylvania:

Table 4.3

Drug abuse in Pennsylvania by the number of wells drilled

Wells drilled/region	Drug abuse per 100,000 people in 2012	1999 to 2005		2005 to 2012		Total wells drilled 2005 to 2012
		Change	Percent change	Change	Percent change	
400 or more wells	360	52	27%	116	48%	4517
100 to 399 wells	247	148	92%	-63	-20%	1039
1 to 99 wells	403	98	39%	51	14%	695
Rural, no wells	281	56	33%	56	25%	0
Urban, no wells	463	60	15%	3	1%	0

Source. Multi-State Shale Collaborative based on Pennsylvania State Police and Bureau of Economic Analysis data.

In addition to violent and property crime, the Pennsylvania State Police also track 18 other categories of less serious criminal offenses.[21] Of these 18 crimes, just six (vandalism, other assaults, DUI, disorderly conduct, drug abuse, and all other offenses) represent more than 80% of these less serious criminal offenses. Among these offenses, the changes in the crime rate for drug abuse and DUIs stand out in counties with 400 or more wells.[22] Prior to the start of drilling, the period from 1999 to 2005, the rate of reported criminal offenses for drug abuse rose 27% in counties that would see the biggest increase in drilling (Table 4.3 and Figure 4.3). Between 2005 and 2012 the crime rate for drug abuse rose 48% in the heaviest drilling counties, it rose 25% in rural areas without wells and just 1% in urban areas without wells . DUI offenses were up 65% since 2005 in the heaviest drilling counties in Pennsylvania. DUI offenses were up 42% over the same period in the rural counties without wells and up just 5% in urban counties without wells.

Table 4.4

DUI offenses in Pennsylvania by the number of wells drilled

Wells drilled/region	DUI cases per 100,000 people in 2012	1999 to 2005		2005 to 2012		Total wells drilled 2005 to 2012
		Change	Percent change	Change	Percent change	
400 or more wells	543	-60	-15%	214	65%	4517
100 to 399 wells	408	49	14%	2	0%	1039
1 to 99 wells	398	37	11%	22	6%	695
No wells, rural	445	-17	-5%	133	42%	0
No wells, urban	400	73	24%	21	5%	0

Source. Multi-State Shale Collaborative based on Pennsylvania State Police and Bureau of Economic Analysis data.

[21] These include reported offenses for other assaults, forgery, fraud, embezzlement, stolen property, vandalism, weapons (carrying, possession, etc.), prostitution, sex offenses, drug abuse, gambling, family offense, DUIs, liquor law violations, drunkenness, disorderly conduct, vagrancy, and all other offenses.

[22] In the remaining categories in the heaviest drilling areas, there was little change in the number of reported offenses over the period studied.

Box 4.1: Drug Abuse and Drilling

As drilling has expanded in West Virginia and Pennsylvania, local concerns that the employment boom benefited out-of-state workers have, at times, been rebuffed with claims that the local workforce was plagued by rampant drug abuse, which severely limited the pool of labor available to drillers. For example, in the city of Williamsport (Lycoming County) a recent article on the region's struggle with drug abuse led a local chamber of commerce official to note:

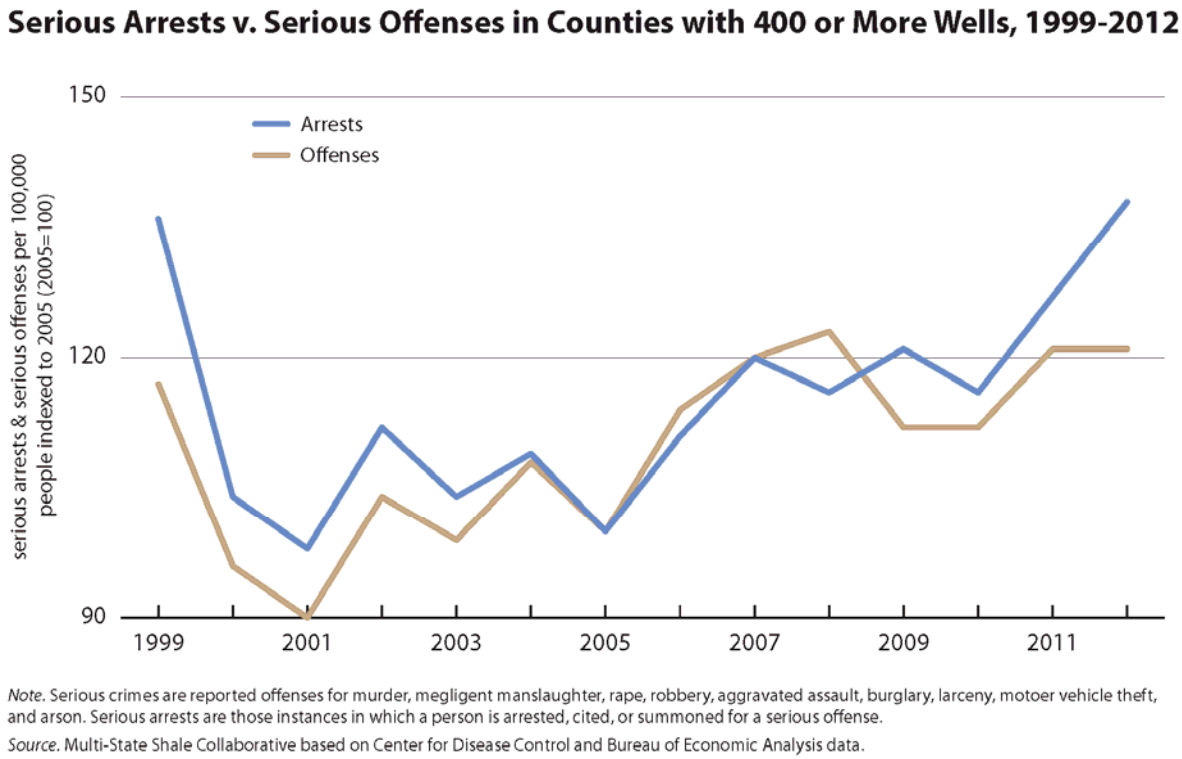
> The unemployment rate has gone down thank to jobs being created by companies involved with the natural gas exploration and drilling along the Marcellus Shale. But employers are having trouble filling certain positions because applicants can't pass a drug test, said Vincent J. Matteo, president and chief executive officer of the Williamsport-Lycoming Chamber of Commerce.[1]

These claims have never been substantiated by data on the number of workers that have failed drug tests when applying for employment with drillers. In general, the rate at which workers in Pennsylvania fail employment-related drug tests, including in drilling regions, is less than 5% (see Page 21) and, therefore, is unlikely to be an important determinant of the mix of local and out-of-state residents employed directly or indirectly in the development of shale oil and gas. As the data on drug abuse summarized in Table 4.4 make clear, the expansion of drilling and drug abuse are not phenomena independent of one another. For policymakers and communities contemplating the expansion of shale oil and gas extraction, these data point to the need for community-wide plans to address the challenges that come with increased drug abuse.

[1] A. John Beauge, "'Home of millionaires' has new meaning in Williamsport - heroin sales," *Patriot News*, June 14, 2014. http://goo.gl/vWcIIh]

Arrest Data for Pennsylvania:

Figure 4.3



Note. Serious crimes are reported offenses for murder, megligent manslaughter, rape, robbery, aggravated assault, burglary, larceny, motoer vehicle theft, and arson. Serious arrests are those instances in which a person is arrested, cited, or summoned for a serious offense.

Source. Multi-State Shale Collaborative based on Center for Disease Control and Bureau of Economic Analysis data.

The Pennsylvania State Police, in addition to tracking data on reported offenses, also track data on arrests. The arrest data corroborate our earlier analysis of violent and property crime data. In heavily drilled areas the increase in the overall rate of crime since 2005 (the sum of all violent and property crimes) has also been accompanied by a rise in the rate of arrests (Figure 5.3).

Considering arrests for all violent and property crime categories, the increase in arrests has been primarily for aggravated assault and larceny theft (see Online Technical Appendix, Chapter 4, Table D11).

West Virginia

Our analysis of West Virginia crime data reveals no clear relationship between increased drilling and crime rates. From 2005 to 2012, there was a 49% increase in violent crime rates in West Virginia rural counties with no wells. The changes in crime rates in West Virginia counties with 100 more wells over this period was above 49% in three counties and below 49% in seven counties. We also found no relationship between drilling and property and "all other" crime (see the Online Technical Appendix, Chapter 4 Table D1, Table D2 and Table D3 for crime rates in West Virginia).

Ohio

Although we do observe an increase in both property and violent crime since the start of drilling in Carroll County, the heaviest drilling county in Ohio, both crime rates prior to the start of drilling rose and fell by similar amounts, making it difficult to confidently conclude that the modest amount of drilling is the primary driver of the changes in the crime rate that have occurred since 2009.

The violent and property crime rates were up in rural areas with no drilling by 8% and 5%, respectively, since 2009 (See the Online Technical Appendix, Chapter 4, Table D4 and Table D5). In urban counties with no drilling the violent and property crime rates were down by 11% and 6%, respectively.

Panel regression on violent and property crime

Using our data set (2000 to 2012) of violent and property crime rates (expressed in logs), we estimated using a fixed effects panel regression the relationship between crime rates and the amount of drilling activity by county in West Virginia, Pennsylvania and Ohio. We included three indicator variables set to 1 for counties between 2005 and 2012 (the period in which drilling occurred) that also had high-activity (400 or more wells drilled over the period), medium-activity (100 to 399 wells drilled over the period) and low-activity (1 to 99 wells drilled over the period) and zero otherwise.[23] For both violent and property crime in high-activity counties after 2005, we found positive and statistically significant elasticities indicating violent crime was up 17.7%,and property crime was up 10.8%.. The coefficient for medium-activity counties was not statistically significant. For low-activity counties there was positive and statistically significant elasticity for violent crime but not for property crime.

[23] As reflected in the absence of a full set of controls, our intent here is not to fully explain differences in crime rates across counties but to make a first attempt at assessing the relationship between drilling and crime rates. Researchers interested in exploring the robustness of this relationship can find this dataset in the Online Technical Appendix, Chapter 4, AppendixD.dta (stata).

Table 4.5

Violent and property crime rates in drilling counties in West Virginia, Pennsylvania and Ohio by high-, medium- and low-drilling activity

Independent variables	Dependent variable = natural log of the number of violent crimes per 100,000 people	Dependent variable = natural log of the number of property crimes per 100,000 people
	b/se	b/se
High-activity	0.177***	0.108***
	(0.059)	(0.038)
Medium-activity	-0.040	-0.009
	(0.071)	(0.061)
Low-activity	0.165***	0.022
	(0.044)	(0.047)
Constant	4.801***	7.351***
	(0.011)	(0.012)
R-sqr-overall	0.002	0.006
N	2,639	2,660

Notes. *, ** and *** indicate significance at the 10, 5 and 1 percent levels. Standard error estimates are robust to disturbances being heteroscedastic.

Chapter 5: Sexually Transmitted Diseases

Sexually transmitted diseases have increased in some areas where transient workers, mostly young men, enter a new town en masse to work in the gas (or related) industries. Food and Water Watch found that in Pennsylvania the average number of cases of sexually transmitted diseases was 62 percent higher in heavily drilled counties than in counties with no drilling (Food and Water Watch 2013). The Troy Community Hospital in Bradford County, Pennsylvania (home to the highest number of wells in the three-state region), reported an increase in STDs connected to the growth of the industry (Covey 2011). A spike in sexually transmitted diseases has also been reported in highly drilled areas in other states, including Carrizzo Springs, Texas; Mesa County, Colorado; and McKenzie County, North Dakota (Vaughan 2012; Redifer et al 2007; Eligon 2013). Chlamydia rates doubled between 2010 and 2011 in McKenzie County, North Dakota (Eligon 2013).

Case Study Findings

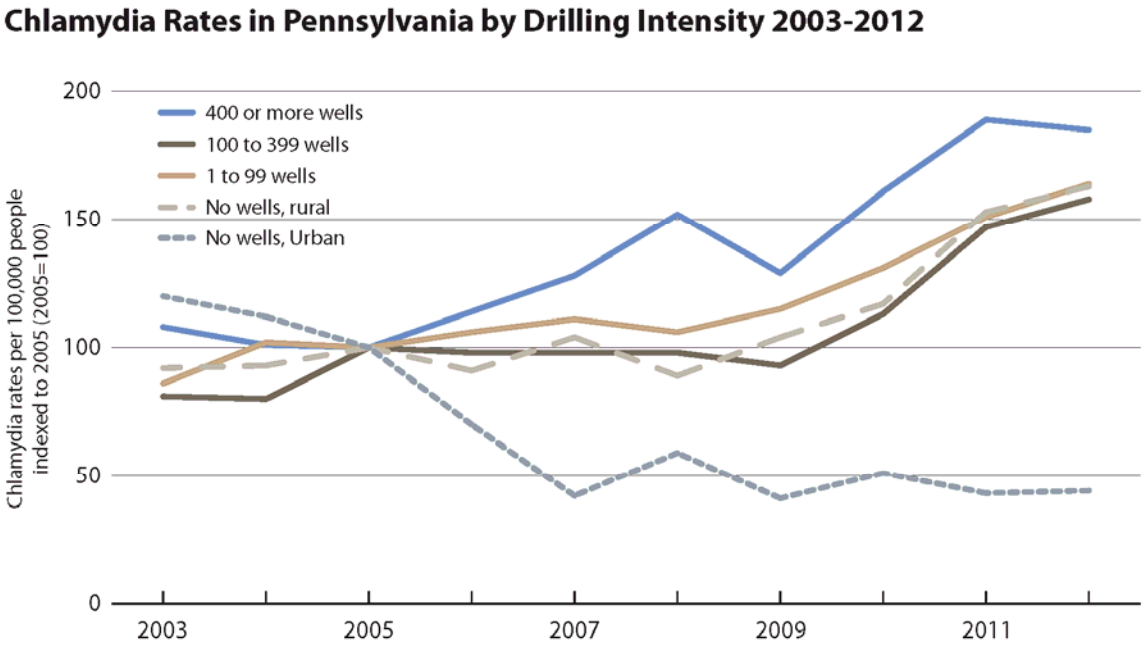
In our case studies of high-drilling counties, only Tioga County respondents reported increases in sexually transmitted diseases. In Tioga County, Pennsylvania's Soldiers and Sailors Memorial Hospital said an increase in sexually transmitted diseases was one clear impact it has seen as a result of increased drilling. Executive Vice President Ron Butler reported that the hospital traced this increase to individuals who had out-of-state home addresses, likely connected to the gas drilling industry (Ward, Polson, and Price 2014). County-level data show that chlamydia rates in Tioga County rose 93% between 2005 and 2012 (compared to rural, non-drilling counties, which saw rates rise 63%). Gonorrhea rates rose only slightly higher (46%) than statewide rates (which rose 37%).

While local Greene County, Pennsylvania, and Wetzel County, Ohio, informants did not report increased rates of STDs, county data showed that rates for chlamydia did rise 119% between 2005 and 2012 in Greene County (nearly double the rate of growth in rural non-drilling Pennsylvania counties) and 146% in Wetzel County (compared to 81% in non-drilling rural West Virginia counties). Carroll County, Ohio, has so far seen a much lower chlamydia rate increase (3%) than rural non-drilling Ohio counties (where rates rose 55%). Gonorrhea rates also rose in some of our case study counties (46% in Tioga County and 266% in Greene County, compared to 37% in rural non-drilling PA counties).[24] Wetzel County, WV, had an increase of 56% in gonorrhea rates, compared to rural, non-drilling WVA counties, where the rates rose only 11%.

[24] The exception was Carroll County, Ohio, which saw rates decrease between 2005 and 2012.

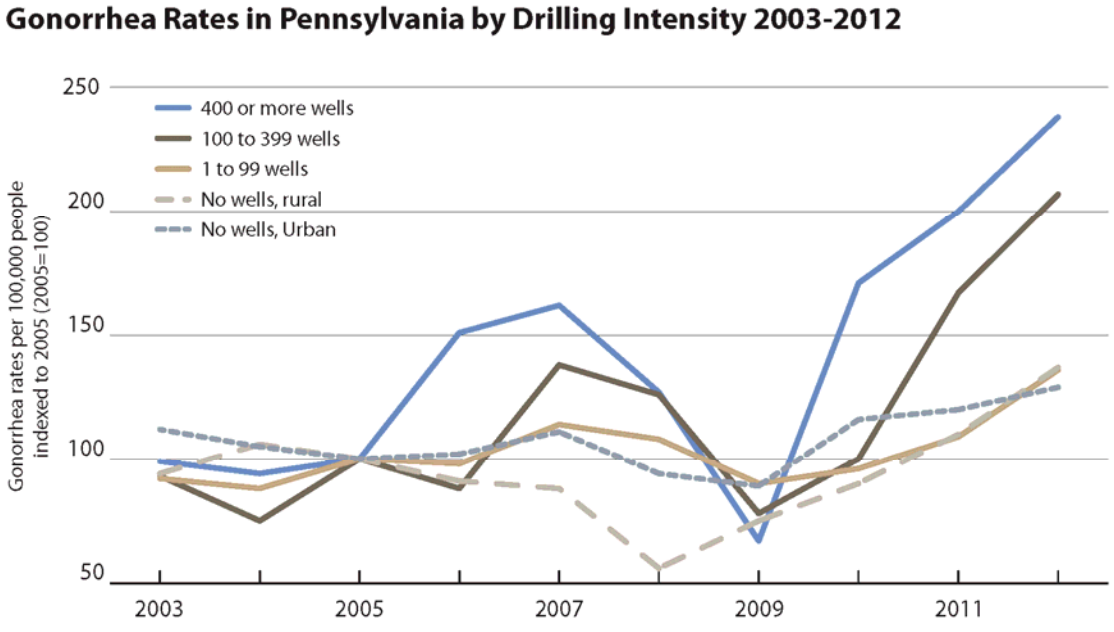
Sexually transmitted disease by county:

Figure 5.1



Source. Multi-State Shale Collaborative based on Center for Disease Control and Bureau of Economic Analysis data.

Figure 5.2



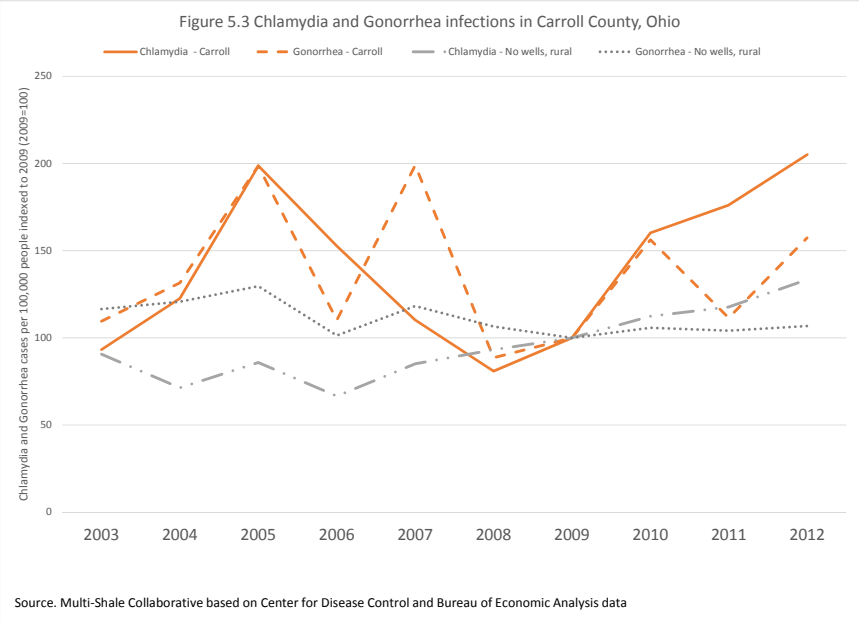
Source. Multi-State Shale Collaborative based on Center for Disease Control and Bureau of Economic Analysis data.

We looked at all six Pennsylvania high- activity drilling counties and how their STD rates compared with counties that have less drilling as well as rural and urban counties with no drilling.

For chlamydia rates (see Figure 5.1 and the Online Technical Appendix, Chapter 5, Table E1. See Table E3 for infection rates for individual Pennsylvania counties with 100 or more wells).All rural areas (with and without drilling) experienced big incidence rate increases while urban areas experienced a big reduction in incidence. High-activity drilling counties, however, experienced the biggest increase in rates (85% compared with 58% to 63% in the three other rural groupings).

For gonorrhea rates see Figure 5.2 and see the Online Technical Appendix, Chapter 5, Table E2. See Table E4 for infection rates for individual Pennsylvania counties with 100 or more wells. The gonorrhea picture was more mixed with rates of infection rising in every part of Pennsylvania (especially since 2009). The heaviest drilling counties experienced the largest increase in rate of infection from 2005 to 2012 (138%), followed by counties with 100 to 399 wells (107%). Counties with less or no drilling only experienced incidence rate increases of about 30% to 40%.

Possibly as a result of the lower level of drilling, there was no clear relationship between rates of infection for either chlamydia or gonorrhea in West Virginia and the amount of drilling (See Table E5 and Table E6 in Chapter 5 of the Online Technical Appendix).



Tables 5.1 and 5.2 show that Carroll County, Ohio, experienced, relative to the rest of the state, a larger increase in the incidence of chlamydia.[25] Gonorrhea was also up across drilling counties in Ohio. Given the low level of drilling and the volatility of data on infectious disease for a small rural county like Carroll, this data is only suggestive of a link between drilling and the spread of sexually transmitted disease in Ohio.

[25] Because drilling began later in Ohio, we analyzed changes in the number of cases of chlamydia and gonorrhea per 100,000 people before and after 2009.

Table 5.1

Chlamydia rates in Ohio by the number of wells drilled

Wells drilled/region	Chlamydia cases per 100,000 people in 2012	2003 to 2009		2009 to 2012		Total wells drilled 2009 to 2012
		Change	Percent change	Change	Percent change	
Carroll county	262	9	7%	134	105%	112
1 to 99 wells	206	6	4%	57	38%	158
No wells, rural	265	19	10%	66	33%	0
No wells, urban	57	26	54%	-18	-23%	0

Source. Multi-State Shale Collaborative based on Centers for Disease Control and Prevention and Bureau of Economic Analysis data.

Table 5.2

Gonorrhea rates in Ohio by the number of wells drilled

Wells drilled/region	Gonorrhea cases per 100,000 people in 2012	2003 to 2009		2009 to 2012		Total wells drilled 2009 to 2012
		change	percent change	change	percent change	
Carroll County	49	-3	-9%	18	57%	112
1 to 99 wells	81	-50	-49%	30	58%	158
No wells, rural	42	-6	-14%	3	7%	0
No wells, urban	195	-65	-26%	12	7%	0

Source. Multi-State Shale Collaborative based on Centers for Disease Control and Prevention and Bureau of Economic Analysis data.

Panel regression on sexually transmitted disease

Using our data set (2003 to 2012) of chlamydia and gonorrhea rates (expressed in logs), we estimated using a fixed effects panel regression the relationship between each of these sexually transmitted diseases and the amount of drilling activity by county in West Virginia, Pennsylvania and Ohio. We used three indicator variables set equal to 1 for counties between 2005 and 2012 (the period in which drilling occurred) that also had high-activity (400 or more wells drilled over the period), medium-activity (100 to 399 wells drilled over the period) and low-activity (1 to 99 wells drilled over the period) and 0 otherwise.[26] Matching the patterns we observed in the descriptive data summarized earlier in this chapter, we found evidence of a link between drilling and the incidence of chlamydia but not for the incidence of gonorrhea. Specifically, we found a positive and statistically significant elasticity for chlamydia in drilling counties after 2005 for all levels of drilling activity, indicating between a 24% and 27% increase in the incidence of chlamydia. With respect to gonorrhea, the coefficients for high- and

[26] The results here do not represent a full accounting of the factors that explain differences between counties in the incidence of sexually transmitted diseases. These results provide a first test of the association between drilling and the incidence of sexually transmitted disease. Researchers interested in further exploring the strength of this relationship can find this dataset in the Online Technical Appendix, Chapter 5, AppendixE.dta (stata).

medium-activity counties are not statistically significant. We did find for gonorrhea in low- activity counties a negative (lower incidence of infection) and statistically significant effect.

Table 5.3

Chlamydia and gonorrhea rates in drilling counties in West Virginia, Pennsylvania and Ohio by high, medium- and low-drilling activity

Independent variables	Dependent variable = natural log of the number of chlamydia cases per 100,000 people	Dependent variable = natural log of the number of gonorrhea cases per 100,000 people
	b/se	b/se
High-activity	0.260***	-0.171
	(0.051)	(0.217)
Medium-activity	0.243***	-0.099
	(0.058)	(0.131)
Low-activity	0.274***	-0.125**
	(0.046)	(0.063)
Constant	4.780***	3.281***
	(0.015)	(0.020)
R-sqr-overall	0.002	0.046
N	1,929	1,896

Notes. *, ** and *** indicate significance at the 10, 5 and 1 percent levels. Standard error estimates are robust to disturbances being heteroscedastic.

Chapter 6: Motor Vehicle Fatalities

In a study of two Barnett Shale counties, Anderson and Theodori (2009) report that "Some communities have tied increased traffic accidents and fatalities to the traffic from shale development."

In Bradford County, Pennsylvania, Stacy Covey, president of Guthrie Troy Community Hospital, found that traffic accidents, along with increases in STDs, occupational injuries, and substance abuse, put pressure on local hospitals (Covey 2011).

In Pennsylvania, local officials cited traffic, safety, and road damage as key concerns (Schaeffer 2011;Troxell 2011) (Herzenberg, Polson and Price 2014).

Case Study Findings

The Multi-State Shale Collaborative case studies in West Virginia, Pennsylvania and Ohio found an increase in heavy truck traffic due to increased industry activity. Deteriorated roads, increased noise, safety concerns, and higher road repair costs became major concerns in these areas as drilling advanced.

Interviews revealed a widely shared concern about truck drivers operating their vehicles unsafely. Truck driver safety is particularly important given the increase in trucks on the road in these rural counties. One

Pennsylvania Department of Transportation (PennDOT) official in Tioga County said that traffic volume had increased from 50 or 60 vehicles per day to 400 trucks on the same roads to accommodate the volume of gas drilling in the county (Ward, Polson, and Price 2014).

School officials in Tioga County reported concerns about children's safety. School bus drivers experienced "a number of close calls and near misses," said one school official. "Some gas trucks were going pretty fast around the buses" (Ward, Polson, Price 2014, p. 13). Greene County officials reported that truck drivers do not always adhere to speed limits and stop signs, endangering pedestrians and other drivers (Herzenberg, Polson, and Price 2014). In Wetzel County, WV, county commissioners cited road safety as their biggest concern, adding that many of the subcontractors and trucking companies violate traffic laws, including speeding and driving left-of-center (O'Leary 2014).

The case studies also provided anecdotal data on traffic fatalities. In Greene County, PA, traffic fatalities ranged from 5 to 16 per year between 2000 and 2012, but the highest number of fatalities occurred in 2012, the peak of gas drilling locally (Herzenberg, Polson, Price 2014, p 17). In Carroll County, OH, one transportation expert reported that "Before shale development, there might have been one or two accidents a year involving semi-trucks, and five years might pass without a rollover incident. Over the last year, however, there have been several large vehicle rollovers in the county; a trucker and a community member recently died." (Woodrum 2014)

Some interviewees reported the need for more emergency services personnel because of increased traffic and accidents. In Carroll County, OH, reported traffic incidents doubled, and calls to the sheriff quadrupled since the start of drilling there. To deal with the increased calls, EMS had to add extra shifts, and the county needed an assistant director of emergency management and additional deputies (Woodrum 2014). Helicopter transport has increased 200% in Tioga County, PA, due to changing protocols for medical transport, population growth, and the increased number of vehicle accidents (Ward, Polson, Price 2014).

Motor vehicle fatalities by county

We analyzed data on traffic fatalities compiled annually by the National Highway Traffic Safety Administration. In order to compare data across counties with differing populations, we expressed the number of fatalities in each county and group of counties as the number of fatalities per 100,000 people (Table 6.1).

All across Pennsylvania traffic fatalities were on the rise from 2000 to 2005. Since 2005, traffic fatalities have fallen in both urban and rural counties without wells. Counter to this trend, traffic fatalities continued to rise in the six Pennsylvania counties with 400 or more wells (see the Online Technical Appendix, Chapter 6, Table F1, for a county-by-county breakout of rates of traffic fatalities in Pennsylvania counties with 100 or more wells). Translating the continued upward trend in traffic fatality rates into actual deaths, given that these counties collectively have a population of slightly more than half a million people, Pennsylvania's six high-drilling counties experienced about 35 more traffic fatalities in 2012 than if the number of fatal accidents per 100,000 had followed the statewide trend.

In West Virginia and Ohio, the county-level data reveal no systematic relationship between drilling and traffic fatalities. (See the Online Technical Appendix, Chapter 6, Table F2, for county-by-county data).

Truck-involved motor vehicle fatalities by county

We analyzed data provided by the Center for the Management of Information for Safe and Sustainable Transportation (http://www.cmisst.org/tifa/) on trucks involved in fatal accidents. As these data are only available through 2010, we do not report trends for Ohio because there were only four wells drilled in the state in that year.

With the exception of urban counties without wells, traffic fatalities involving trucks were up from 2000 to 2005 in Pennsylvania (Table 6.2). After 2005, fatalities involving trucks were down in both urban and rural counties without wells. Truck-involved fatalities, however, rose in the six Pennsylvania counties with 400 or more wells as well as in Pennsylvania counties with 100 or more wells (see the Online Technical Appendix, Chapter 6, Table F3, for a county-by-county breakout of rates of traffic fatalities in Pennsylvania counties with 100 or more wells). In the six high-drilling counties, there were 10 more fatalities involving trucks in 2012 than if these counties had followed the statewide average.

In West Virginia, fatalities involving trucks were down since the start of drilling in both the heaviest drilling counties and in rural and urban counties without wells (see the Online Technical Appendix, Chapter 6, Table F4, for a county-by-county breakout of rates of traffic fatalities in West Virginia counties with 100 or more wells drilled). Truck-involved traffic fatalities were up slightly in West Virginia counties with fewer than 100 wells.

Table 6.1

Fatal accidents per 100,000 people by state and number of wells drilled

Wells drilled/region	Fatal accidents per 100,000 people in 2012	2000 to 2005		2005 to 2012		Total wells drilled 2005 to 2012
		Change	Percent change	Change	Percent change	
PA, 400 or more wells	19.5	2.9	21%	2.5	14%	4517
PA, 100 to 399 wells	16.2	0.6	4%	-0.3	-2%	1039
PA, 1 to 99 wells	10.7	0.5	4%	-3.4	-24%	695
PA, Rural	15.7	2.8	15%	-6.7	-30%	0
PA, Urban	7.8	0.2	2%	-2.4	-23%	0
WV, 100 to 399 wells	17.6	-6.7	-25%	-2.5	-12%	1432
WV, 1 to 99 wells	19.2	-1.1	-5%	-2.4	-11%	700
WV, Rural*	28.5	5.7	26%	0.6	2%	0
WV, Urban*	15.0	-1.1	-6%	-2.2	-13%	0
OH, 100 to 399 wells	10.5	-0.1	-1%	-3.2	-24%	112
OH, 1 to 99 wells	10.6	-2.0	-14%	-1.8	-15%	158
OH, Rural*	14.5	-1.2	-6%	-3.6	-20%	0
OH, Urban*	7.5	0.1	1%	-1.0	-12%	0
MD, Rural*	12.8	-0.6	-4%	-3.0	-19%	0
MD, Urban*	6.9	0.0	0%	-2.1	-24%	0
NY, Rural~	1.3	-0.3	-15%	-0.1	-6%	22
NY, Urban*	0.4	0.0	-7%	-0.2	-26%	0
VA, Rural~	20.1	3.6	15%	-7.6	-27%	93
VA, Urban*	14.9	-2.9	-13%	-3.8	-21%	0

*The figures here represent fatal accidents in rural and urban counties with no wells drilled between 2002 and 2012.

~There were 93 wells drilled in rural Virginia counties, and 22 wells drilled in rural New York counties between 2002 and 2012.

Note. A county or county group is defined as rural if the 2005 population per square mile in that county is below its corresponding statewide total population per square mile. What follows is the population per square mile for each state in this study: Pennsylvania (278); West Virginia (75); Maryland (576); New York (405); Ohio (280); Virginia (191).

Source. Multi-State Shale Collaborative based on National Highway Traffic Safety Administration and Bureau of Economic Analysis data.

Table 6.2

Fatal accidents per 100,000 people involving trucks by state and number of wells drilled

Wells drilled/region	Fatal accident rate per 100,000 people involving trucks in 2010	2000 to 2005		2005 to 2010		Total wells drilled 2005 to 2012
		Change	Percent change	Change	Percent change	
PA, 400 or more wells	3.7	0.8	44%	1.2	46%	4517
PA, 100 to 399 wells	3.5	0.4	20%	1.3	59%	1039
PA, 1 to 99 wells	1.2	0.1	7%	-0.5	-29%	695
PA, Rural	2.3	0.9	48%	-0.5	-17%	0
PA, Urban	0.8	-0.1	-9%	-0.4	-35%	0
WV, 100 to 399 wells	2.1	-0.9	-24%	-0.7	-25%	1432
WV, 1 to 99 wells	3.2	0.0	0%	0.3	10%	700
WV, Rural*	1.3	5.3	379%	-5.4	-81%	0
WV, Urban*	1.0	-0.3	-18%	-0.6	-37%	0
OH, Rural*	1.7	-0.9	-25%	-0.9	-33%	0
OH, Urban*	0.7	0.1	6%	-0.3	-28%	0
MD, Rural*	1.2	-0.2	-8%	-0.9	-41%	0
MD, Urban*	0.3	-0.1	-7%	-0.5	-58%	0
NY, Rural~	1.3	-0.3	-15%	-0.1	-6%	22
NY, Urban*	0.4	0.0	-7%	-0.2	-26%	0
VA, Rural~	2.8	0.7	24%	-1.1	-28%	93
VA, Urban*	1.7	0.1	3%	-0.7	-29%	0

*The figures here represent trucks in fatal accidents in rural and urban counties with no wells drilled between 2002 and 2012.

~There were 93 wells drilled in rural Virginia counties, and 22 wells drilled in rural New York counties between 2002 and 2012.

Note. A county or county group is defined as rural if the 2005 population per square mile in that county is below its corresponding statewide total population per square mile. What follows is the population per square mile for each state in this study: Pennsylvania (278); West Virginia (75); Maryland (576); New York (405); Ohio (280); Virginia (191).

Source. Multi-State Shale Collaborative based on Center for the Management of Information for Safe and Sustainable Transportation and Bureau of Economic Analysis data.

Panel regression on motor vehicle fatalities

Our data set of fatal motor vehicle accidents by county covered the period from 2000 to 2012, while our data set of fatal motor vehicle accidents involving trucks covered the period from 2000 to 2010. We examined changes in the rate of these fatalities (expressed in logs) using a fixed effects panel regression for counties in West Virginia, Pennsylvania and Ohio. We used three indicator variables set equal to 1 for counties between 2005 and the end of the period (the period in which drilling occurred) that also had high- activity (400 or more wells drilled over the period), medium-activity (100 to 399 wells drilled over

the period), and low-activity (1 to 99 wells drilled over the period), and 0 otherwise.[27] In high-activity counties, only the coefficient for truck-involved motor vehicle fatalities was statistically significant and positive, indicating a 27.8% increase in truck-involved fatalities. Both coefficients (all fatal motor vehicle accidents and truck-involved fatal motor vehicle accidents) for medium-activity counties were not statistically significant. For low-activity counties, only the coefficient for all motor vehicle fatalities was significant, and it was negative.

Table 6.3

Fatal motor vehicle accidents overall and those involving trucks in West Virginia, Pennsylvania and Ohio drilling counties by high-, medium- and low-drilling activity

Independent variables	Dependent variable = natural log of the number of motor vehicle accidents per 100,000 people (2000 to 2012)	Dependent variable = natural log of the number of fatal motor vehicle accidents involving trucks per 100,000 people (2000 to 2010)
	b/se	b/se
High-activity	0.017	0.278**
	(0.081)	(0.133)
Medium-activity	-0.030	-0.095
	(0.052)	(0.117)
Low-activity	-0.111***	-0.048
	(0.032)	(0.050)
Constant	2.809***	0.968***
	(0.008)	(0.010)
R-sqr-overall	0.004	0.000
N	2,672	1,569

Notes. *, ** and *** indicate significance at the 10, 5 and 1 percent levels. Standard error estimates are robust to disturbances being heteroscedastic.

[27] The results here do not represent a full accounting of the factors that explain differences between counties in fatal motor vehicle fatalities. These results provide a limited test of the association between drilling and fatal motor vehicle accidents. Researchers interested in further exploring the strength of this relationship can find this dataset in the Online Technical Appendix, Chapter 6, AppendixF.dta (stata).

Chapter 7: Rental Housing Markets

Ecosystems Research Group (2009) documented large population increases associated with natural resource extraction in Sublette County, Wyoming, between 2000 and 2006which, in turn, boosted housing prices and rents there relative to Wyoming as a whole. In case studies of energy development in Mesa and Garfield counties, Colorado, and Sweetwater County, Wyoming, Headwaters Economics (2008; 2009) reported a shortage of housing resulting from energy-related development. In both their reports, Headwaters found that non-energy-related employers, including local colleges and hospitals, had difficulty recruiting new workers because of the sharp rise in the cost of housing. Headwaters noted that the high wages of oil and gas companies, relative to what other employers in the region were paying, put upward pressure on rents and housing prices and potentially threatened the economic diversity of regional economies. Ecosystems Research Group raised similar concerns when comparing housing affordability and pay for energy-related and non-energy-related employment in Sublette County, Wyoming. Jacquet (2009), in summarizing literature focused on an energy boom in the western United States in the 1970s, cited similar themes of housing shortages and rising home prices and rents. Jacquet also noted evidence of an expansion of mobile home communities and an increased commute as among the responses to the housing shortages experienced in the 1970s.

Recent research has identified other potential impacts. Property values near drilling activity, particularly homes with well water, can be negatively impacted (Gopalakrishnan and Klaiber 2012; Muehlenbacks, Sipplier, and Timmins 2012; BBC Research and Consulting; Integra Realty Resources; Colorado School of Public Health 2011).

Case Study Findings

Our case studies of four drilling counties revealed findings consistent with other research on housing impacts of booms in extractive industries. Out-of-state drilling industry workers created increased demand for temporary housing in Carroll, Greene, and Tioga counties (Woodrum 2014; Herzenberg, Polson, and Price, 2014; Ward, Polson, and Price, 2014). Hotels filled up and new hotels were added or planned. For example, the hotel in Carrollton, Ohio, had been solidly booked for two years, and there were plans to build a new one (Woodrum 2014). The most pronounced housing impact in Wetzel County was a 700% increase in collections from a New Martinsville hotel room occupancy tax, primarily in 2011 and 2012 (O'Leary 2014). Tioga and Greene counties each built two new hotels. Their hotel occupancy tax does not apply to stays over 30 days, so the counties lost significant revenue to long stays. (Coolidge 2011; Herzenberg, Polson, and Price 2014). An informant in Tioga County said the hotel shortage hurt the county's tourism business, and an informant in Greene County said tourists often spend their lodging dollars outside the county because of a lack of available rooms (Coolidge 2011; Herzenberg, Polson, and Price 2014).

In Tioga, Greene, and Carroll counties, empty lots were being turned into RV sites, sometimes without adequate connections to water, sewer, or electrical systems (Woodrum 2014, Herzenberg, Polson, and Price, 2014; Ward, Polson, and Price, 2014). According to a local joke in Greene County, "$900 will get you a pond-side view."

Large housing stipends for oil and gas workers and limited supplies of housing translated into a doubling, tripling, or even quadrupling of rental rates since the start of drilling Carroll County, Ohio, according to local interviews (Woodrum 2014). In Tioga County, classified ads in the *Wellsboro Gazette* documented a

doubling or tripling of rents for comparable housing between 2007-08 and 2012 (Ward, Polson, and Price, 2014).

Rising rents, in turn, created a shortage of affordable housing in Carroll County (Boyd 2013). In Greene County, increased demand exacerbated a pre-existing shortage of affordable housing (Herzenberg, Polson, and Price, 2014). Some residents had to move out of the county or live in substandard housing that lacked running water. Some landlords rented unlivable properties for high prices.

Sources in Tioga, Greene, and Carroll counties reported increased homelessness (Woodrum 2014; Herzenberg, Polson, and Price, 2014; Ward, Polson, and Price, 2014). The Tioga County Department of Human Services reported a four- to five-fold increase in households seeking help with housing (after it started tracking this number in August 2008) (Ward, Polson, and Price, 2014). Tioga County also reported a four-fold increase in the share of Head Start families that were homeless (from 6% in 2010-11 to 24% in 2012-13). Similarly, Greene County saw a jump in the number of children in foster care because of "inadequate housing," from 12 in 2008-09 to 36 in 2012-13. Even in 2009-10, before the boom peaked, Greene County had Pennsylvania's highest rate of homelessness assistance:45 clients per 1,000 residents compared to the state average of seven clients per 1,000 residents.

In Greene County, a local domestic violence organization reported that some clients have found it more difficult to leave abusive situations because of the lack of affordable housing (Herzenberg, Polson, and Price 2014).

Notes on county-level housing data derived from the American Community Survey

The rest of this chapter complements our case studies with quantitative analysis of the impact of drilling on trends in rents, renter incomes, and rental housing affordability.[28]

Our analysis of rental housing and owner-occupied housing relied on data from the American Community Survey (ACS), which has two key limitations.[29]

1. We were unable to identify trends prior to the start of drilling in 2005.[30] For this reason and to increase the size of our samples, we compared changes in housing variables between 2005-07 (before drilling picked up in Ohio and in most of Pennsylvania) and 2010-12.

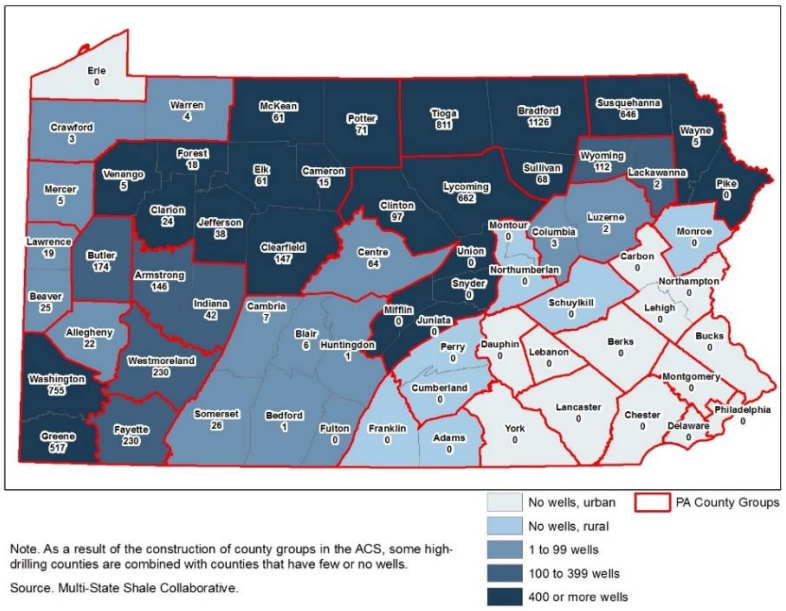
[28] In the Online Technical Appendix we also present data on trends in home prices, homeowner incomes and new housing construction (this includes all new housing construction, whether it is intended for rent or for purchase). Data on home prices and homeowner incomes is available in Chapter 7 Homeowner Incomes. Data for new housing construction is in Chapter 7 Table G15 and Table G16.

[29] We analyzed American Community Survey microdata provided by Steven Ruggles, J. Trent Alexander, Katie Genadek, Ronald Goeken, Matthew B. Schroeder, and Matthew Sobek. Integrated Public Use Microdata Series: Version 5.0 [Machine-readable database]. Minneapolis: University of Minnesota, 2010.

[30] County-level data from the American Community Survey was not available prior to 2005. County-level data from the 2000 Census is available, but differences between the design of the ACS questionnaire and the long form questions on the 2000 Census complicated the interpretation of time trends enough to leave such longer term comparisons for future research.

2. We were restricted to analyzing groups of contiguous counties, as opposed to each individual county.[31] This limitation exacerbated the fact that even county-level data was not as localized as drilling activity and impacts.
    a. In Pennsylvania, as a result of this limitation, putting all six of our high-drilling counties in a single county group would have required also including eight additional rural counties, five of which had no drilling activity (Mifflin, Juniata, Snyder, Union, and Pike). Instead of this, we focused our analysis on smaller county groups, comparing four such groups with one or two of our top drilling counties with other county groups in which less drilling occurred (see Map 7.1 below).[32]

Map 4.1



Note. As a result of the construction of county groups in the ACS, some high-drilling counties are combined with counties that have few or no wells.

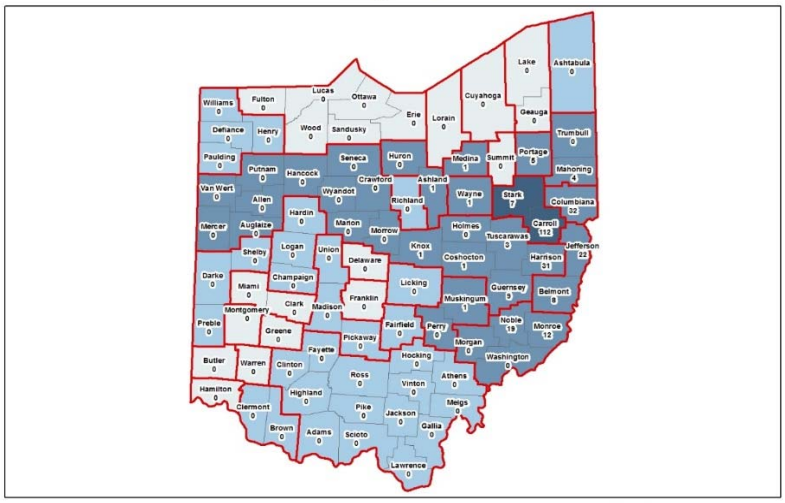
Source. Multi-State Shale Collaborative.

    b. In Ohio (see Map 7.2), observations from Carroll County, which had the most wells, were combined with observations from Stark County (which had just seven wells drilled).

[31] In public use data from the American Community Survey it is not always possible to identify observations from sparsely populated individual counties. Instead, data for these counties are reported in Public Use Microdata Areas (PUMAs), which combine in whole or part smaller counties. For more information see: information https://usa.ipums.org/usa-action/variables/PUMA#description_section.

[32] The sixth high-drilling county, Lycoming, is combined with five other counties: Clinton, Juniata, Mifflin, Snyder, and Union. Its housing industry impacts are, not surprisingly, attenuated, and we do not report the results of this region.

Map 4.2

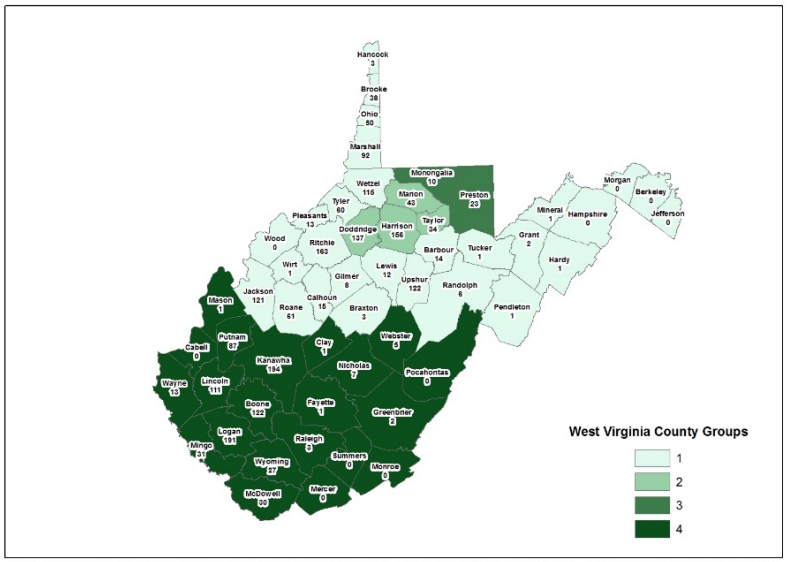


Note. As a result of the construction of county groups in the ACS, some high-drilling counties are combined with counties that have few or no wells.

Source. Multi-State Shale Collaborative

c. Data limitations are most severe in West Virginia, where the ACS includes only four county groups (the state has 55 counties) (Map 7.3). These groups, which do not sharply differentiate drilling and non-drilling regions, also fail to reveal any clear link between drilling and changes in any of the categories analyzed here. Therefore, we do not report the West Virginia data in the text (see the Online Technical Appendix, Chapter 7 West Virginia, for the results of our West Virginia housing analysis).

Map 4.3



Note. As a result of the construction of county groups in the ACS, some high-drilling counties are combined with counties that have few or no wells.

Source. Multi-State Shale Collaborative

Rents by county[33]

In Pennsylvania, from 2005-07 to 2010-12, we find that median rents were up 16.5% in ***Bradford***, Sullivan & ***Tioga*** counties; 9.4% in ***Greene*** and ***Washington counties***; and 13.9% in Pike, ***Susquehanna***, and Wayne counties (the counties highlighted in bold italic are top six drilling counties) (see Table 7.1 below; see the Online Technical Appendix, Appendix D, Table D18 through Table D21 for additional figures). At the 80th percentile, rents increased even more in the two county groups with the most wells.[34]

By contrast, urban and rural county groups with no wells (and most groups with just a few wells) experienced rent increases at the median and the 80th percentile of only 4% to 7% in this five-year span, an increase below the rate of inflation. This reflects the impact of the Great Recession. Drilling did not have as consistent an impact on rents at the 20th percentile.

Table 7.1

Change in rents by amount of drilling in Pennsylvania county/county groups (2012 dollars)

PA county/county group/region	Percent change in rents (2005-2007 to 2010-2012)			Change in wells drilled (2005-2007 minus 2010-2012)
	20th	50th	80th	
Urban*	3.3%	3.4%	6.1%	0
Rural*	6.5%	6.5%	4.1%	0
Bradford, Sullivan & Tioga	4.1%	16.5%	21.6%	1671
Greene & Washington	11.2%	9.4%	13.4%	765
Clinton, Juniata, Lycoming, Mifflin, Snyder, & Union	11.7%	3.8%	7.0%	701
Pike, Susquehanna, & Wayne	4.7%	13.9%	10.7%	523
Cameron, Clarion, Clearfield, Elk, Forest, Jefferson, McKean, Potter, & Venango	2.1%	1.7%	-1.1%	304
Westmoreland	-5.4%	-3.7%	-4.1%	145
Armstrong & Indiana	0.3%	0.7%	3.5%	140
Fayette	1.5%	6.5%	10.7%	137
Butler	-2.2%	-1.5%	2.4%	123
Lackawanna & Wyoming	14.0%	5.4%	4.3%	111

*Rural and urban counties with no wells drilled

[33] In this section we present data on monthly rents for all rental units. Typically, rents are subdivided by the number of bedrooms, but sample size prevents us from doing this. In our summary of trends, we present changes in rents at the 20th percentile (low), 50th percentile (median) and 80th percentile (high).

[34] It's of note that despite these trends, as illustrated in Table G15 and Table G16 (see the Online Technical Appendix, Chapter 7), there was a 26% decline in the number of new housing permits issued in the high-drilling counties from the number issued in 1998-2004. This decline was, however, smaller than the 29% decline observed in rural Pennsylvania counties without wells.

Note. A county or county group is defined as rural if the 2005 population per square mile in that county or county group is below its corresponding statewide total population per square mile of 278.

Source. Multi-State Shale Collaborative based on the American Community Survey microdata provided by Steven Ruggles, J. Trent Alexander, Katie Genadek, Ronald Goeken, Matthew B. Schroeder, and Matthew Sobek. Integrated Public Use Microdata Series: Version 5.0 [Machine-readable database]. Minneapolis: University of Minnesota, 2010.

Overall, given the data limitations, the Pennsylvania data corroborate the case study findings, with differences in rent increases found in drilling county groupings even though virtually all these groupings include either significant urban populations (e.g., Washington and Greene counties) and/or areas with little drilling. Both these data limitations dilute the observed impact of drilling on rents and suggest more detailed data would reveal much greater impacts of drilling on rents.

In Carroll and Stark counties,[35] the only Ohio grouping with more than 100 wells drilled, low and median rents also rose between 2005-07 and 2010-12 by 3.2% and 1.7%, respectively (see Online Technical Appendix, Chapter 7, Table G1). Low and median rents were also up slightly in the remaining Ohio counties with some drilling but not elsewhere in the state.[36]

Renter incomes by county

Rising economic activity would normally be associated with rising incomes in a region. In this section we explore trends in the incomes of renters. In Table 7.2 we present the percent change from 2005-07 to 2010-12 in the household income of renters at the 20th, 50th (median), and 80th percentile for Pennsylvania county groupings, based on the number of wells drilled since 2002 (see the Online Technical Appendix, Chapter 7, Tables G7 through G10 for percent change and levels).

Reflecting the impact of the recession, the median household income of renters was down by 7.6% and 10% in urban and rural portions of Pennsylvania, respectively, that did not see any drilling over this period. In contrast, in the high--drilling regions (***Bradford,*** Sullivan, and ***Tioga counties***), the income of renters at the median and 80th percentile rose about 16.6% and 11.2%, respectively. In the next heaviest-drilling region (which unlike the other groups only high drilling counties), both median and 80th percentile rental incomes in ***Washington and Greene*** counties rose about 20%. Importantly, increases in income in drilling regions were not as consistent at the 20th percentile of the rental income distribution, with a decline in ***Bradford,*** Sullivan, and ***Tioga counties***, for example, that was close to the decline for rural areas with no drilling. If rental rates of properties coming on the market were going up, but the incomes of lower-income renters were not consistently increasing, that could help explain the reports of homelessness problems in our case studies.

[35] Stark County had just seven wells drilled prior to 2013.

[36] Rents were down by between 1.4% and 2.8% over the period analyzed in urban Ohio counties with no wells (Erie, Fulton, Lucas, Ottawa, Sandusky, Wood, Lorain, Cuyahoga, Geauga, Lake, Summit, Delaware, Clark, Miami, Franklin, Greene, Montgomery, Warren, Butler, and Hamilton) and rural counties with no wells (Defiance, Henry, Paulding, Williams, Ashtabula, Champaign, Hardin, Logan, Richland, Madison, Pickaway, Union, Darke, Preble, Shelby, Licking, Fairfield, Adams, Athens, Clinton, Fayette, Gallia, Highland, Hocking, Jackson, Lawrence, Meigs, Pike, Ross, Scioto, Vinton, Brown, and Clermont).

In Carroll and Stark counties, Ohio (see Online Technical Appendix, Chapter 4, Table G7), the median income of renters was down 3% between 2005-07 and 2010-12. Renter incomes were down 6.1% in rural non-drilling counties and 8.7% in urban non-drilling counties.

Table 7.2

Change in the household income of renters in Pennsylvania counties/county groups (2012 dollars)

PA county/county group/region	Percent change in the household incomes of renters (2005-2007 to 2010-2012)			Change in wells drilled (2005-2007 minus 2010-2012)
	20th	50th	80th	
Urban no wells	-0.1%	-10.0%	-1.9%	0
Rural no wells	-6.7%	-7.6%	-4.0%	0
Bradford, Sullivan & Tioga	-5.2%	16.6%	11.2%	1671
Greene & Washington	7.3%	20.0%	20.2%	765
Clinton, Juniata, Lycoming, Mifflin, Snyder, & Union	-10.5%	-5.9%	0.0%	701
Pike, Susquehanna, & Wayne	6.4%	-1.4%	6.0%	523
Cameron, Clarion, Clearfield, Elk, Forest, Jefferson, McKean, Potter, & Venango	-4.5%	-14.5%	-4.9%	304
Westmoreland	-0.4%	0.4%	9.3%	145
Armstrong & Indiana	-9.2%	-6.4%	-1.6%	140
Fayette	-4.0%	5.3%	-1.6%	137
Butler	9.0%	-1.4%	-12.5%	123
Lackawanna & Wyoming	9.4%	-0.1%	7.2%	111

Note. A county or county group is defined as rural if the 2005 population per square mile in that county is below 278.

Source. Multi-State Shale Collaborative based on the American Community Survey microdata provided by Steven Ruggles, J. Trent Alexander, Katie Genadek, Ronald Goeken, Matthew B. Schroeder, and Matthew Sobek. Integrated Public Use Microdata Series: Version 5.0 [Machine-readable database]. Minneapolis: University of Minnesota, 2010.

Rental housing affordability

In Table 7.3 we summarize the percentage of renters paying 30% or more of their income for rent by Pennsylvania drilling county/grouping. In all of the groupings , the number and share of households paying at least 30% of their income in rent climbed from 2005-07 to 2010-12, 3.8% more in ***Bradford***, Sullivan, and ***Tioga counties,*** and 15% more in ***Washington*** and ***Greene counties***. Reflecting the impact of the Great Recession, however, the share of renters paying more than 30% of their income in rents rose even more in the rest of the state: 24% in urban non-drilling areas and 30% in rural non-drilling areas.

In Ohio, the share of households paying at least 30% of their income in rents increased by similar amounts in the drilling counties (Carroll and Stark:17.2%), non-drilling rural counties (15.2%) and non-drilling urban counties (16.8%) (See Online Technical Appendix, Chapter 7, Table G11).

Table 7.3

Percent of renters paying 30% or more of their income in rent for Pennsylvania counties/county groups

PA county/county group/region	Percent of all households	Change in households	Percent change in number of households	Change in wells drilled (2005-2007 minus 2010-2012)
Urban*	42.9%	9,244	29.9%	0
Rural*	51.1%	80,713	23.8%	0
Bradford, Sullivan & Tioga	41.5%	160	3.8%	1671
Greene & Washington	40.8%	1,259	15.0%	765
Clinton, Juniata, Lycoming, Mifflin, Snyder, & Union	41.5%	859	6.6%	701
Pike, Susquehanna, & Wayne	48.5%	1,566	36.9%	523
Cameron, Clarion, Clearfield, Elk, Forest, Jefferson, McKean, Potter, & Venango	41.1%	400	3.2%	304
Westmoreland	42.3%	-5,277	-18.0%	145
Armstrong & Indiana	45.3%	-61	-0.8%	140
Fayette	38.8%	-2,093	-16.7%	137
Butler	42.8%	703	10.6%	123
Lackawanna & Wyoming	39.0%	-89	-0.7%	111

*Rural and urban counties with no wells drilled

Note. A county or county group is defined as rural if the 2005 population per square mile in that county is below 278.

Source. Multi-State Shale Collaborative based on the American Community Survey microdata provided by Steven Ruggles, J. Trent Alexander, Katie Genadek, Ronald Goeken, Matthew B. Schroeder, and Matthew Sobek. Integrated Public Use Microdata Series: Version 5.0 [Machine-readable database]. Minneapolis: University of Minnesota, 2010.

Panel Regression on Rents, Renter Income and Rental Housing Affordability

As discussed in the beginning of this chapter, our data set on housing is drawn from the American Community Survey (ACS) and thus, unlike for our previous analysis, we lack a period prior to the start of drilling in that we are comparing rents, renter incomes and rental housing affordability in West Virginia, Pennsylvania and Ohio in two three-year periods 2005-07 and 2010-12. Furthermore, due to the aggregation of counties in the ACS, we have fewer observations than when analyzing data with observations for each county in the region.

We examined each of our housing variables of interest (expressed as logs) using a fixed effects panel regression and only three indicator variables as independent variables. Our indicator variables were set equal to 1 in 2010-12 in county groups that had high activity (400 or more wells drilled over the period), medium activity (100 to 399 wells drilled over the period), low activity (1 to 99 wells drilled over the

period) and 0 otherwise (the reference group thus includes counties without wells drilled in both periods and all drilling counties in 2005-07).[37] Table 7.4 reports the coefficients for each level of drilling activity for median rents, 20th percentile rents, and 80th percentile rents. In high-drilling counties the coefficient is statistically significant, with median rents up 10%, 20th percentile rents up 7.6%, and 80th percentile rents up 12.3%. None of the coefficients for medium- or low-drilling counties was statistically significant.

Table 7.4

Median, 20th percentile, and 80th percentile rents in West Virginia, Pennsylvania and Ohio by high-, medium- and low-drilling activity

Independent variables	Dependent variable = natural log of median rents	Dependent variable = natural log of 20th percentile rents	Dependent variable = natural log of 80th percentile rents
	b/se	b/se	b/se
High-drilling	0.102***	0.076***	0.123***
	(0.022)	(0.017)	(0.024)
Medium-drilling	0.015	0.027	0.011
	(0.012)	(0.017)	(0.015)
Low-drilling	0.012	0.008	0.019
	(0.013)	(0.014)	(0.016)
Constant	6.545***	6.201***	6.843***
	(0.002)	(0.002)	(0.002)
R-sqr-overall	0.015	0.035	0.005
N	144	144	144

Notes. *, ** and *** indicate significance at the 10, 5 and 1 percent levels.
Standard error estimates are robust to disturbances being heteroscedastic.

With respect to renter incomes at the median, 20th percentile, and 80th percentile (expressed in logs) in high-drilling counties, the coefficient for median renter incomes and 20th percentile renter incomes is not statistically significant (Table 7.5). In contrast, the coefficient for 80th percentile renter incomes was significant, indicating that these renters' incomes were up 8.7% in the high-drilling counties. The coefficients for renter incomes in medium-drilling counties were not statistically significant. In low-drilling counties/county groups, the coefficient on median and 20th percentile renter incomes was both significant and negative, indicating a decline in median incomes of 5.6%, and in 20th percentile incomes of 4%.

[37] The results for rents, renter income and housing affordability do not represent a full accounting of the factors that explain differences between counties in these variables. These results provide a limited test of the association among drilling, rising rents, and declining housing affordability. Researchers interested in further exploring the strength of these relationships can find this dataset in the Online Technical Appendix, Chapter 7, AppendixG.dta (stata).

Table 7.5

Median, 20th percentile and 80th percentile renter incomes in West Virginia, Pennsylvania and Ohio by high-, medium- and low-drilling activity

Independent variables	Dependent variable = natural log of median renter income	Dependent variable = natural log of 20th percentile renter income	Dependent variable = natural log of 80th percentile renter income
	b/se	b/se	b/se
High-drilling	-0.008	0.065	0.087**
	(0.039)	(0.053)	(0.034)
Medium-drilling	-0.011	-0.044**	-0.012
	(0.021)	(0.021)	(0.027)
Low-drilling	-0.056*	-0.040**	0.019
	(0.031)	(0.019)	(0.018)
Constant	9.373***	10.205***	10.881***
	(0.004)	(0.003)	(0.003)
R-sqr-overall	0.082	0.079	0.003
N	144	144	144

Notes. *, ** and *** indicate significance at the 10, 5 and 1 percent levels. Standard error estimates are robust to disturbances being heteroscedastic.

Given evidence that rents were up, but renter incomes were not in high-drilling counties over the period, it was not surprising that when examining the number of renters paying at least 30% of their income in rent we found a statistically significant and positive coefficient (Table 7.6). Specifically, we found a 13.9% increase in the number of renters paying at least 30% of their income in rent.

Table 7.6

Number of renters paying at least 30% of their income in rent in West Virginia, Pennsylvania and Ohio by high-, medium- and low-drilling activity

Independent variables	Dependent variable = natural log of number of household paying 30% or more of their income in rent
	b/se
High activity	0.139**
	(0.055)
Medium activity	0.025
	(0.048)
Low activity	0.137***
	(0.030)
Constant	9.404***
	(0.005)
R-sqr-overall	0.008
N	144

Notes. *, ** and *** indicate significance at the 10, 5 and 1 percent levels. Standard error estimates are robust to disturbances being heteroscedastic.

Chapter 8: Other Pennsylvania Specific Impacts

This chapter considers four additional human service impacts identified in our case studies but for which no standard data source exists across multiple states: emergency room visits, early intervention services for children with developmental delays, foster care, and prison populations. Given our reliance on state-specific data, we restricted our analysis to Pennsylvania: This made our task more manageable. Our three-state analysis of other social impacts also consistently documented that most impacts occurred in the six Pennsylvania counties with the most wells drilled from 2005 to 2012. In this chapter, the link we found between drilling and demand for these additional human/social services was not a tight one. Whether that would change with better data remains an open question.

Emergency Room Visits

Some research has explored the link between increased gas drilling and emergency room visits. Hessert (2012) found some increase in emergency room visits in the Marcellus Shale region, although researchers were unsure how much of this was due to gas drilling. Jersey Shore Hospital in Lycoming County, PA, reported an operating budget deficit for the first time in 2013, which it attributed to uncompensated care costs for uninsured sub-contractors in the gas industry (*Republican Herald* 2013). The county government in Sublette County, WY, had substantial fiscal impacts due to needed expansion of medical clinics in the region to deal with the incoming population connected to the gas industry (Ecosystems Research Group 2009). Ecosystems Research Group and Headwaters (2008) also found an increase in patients without health insurance, which coincided with more gas drilling in the area that could lead to increased emergency room visits (although these researchers did not document such a connection).

Our case studies found increases in emergency room visits in Tioga and Greene counties, PA. In Tioga County, PA, Soldiers and Sailors Memorial Hospital saw an increase in emergency room visits between 2006-07 and 2011-12, with the largest increase occurring between 2010-11 and 2011-12, during the height of the gas boom. The hospital has also seen some uptick in uncompensated care coinciding with the gas boom (Ward, Polson, and Price 2014). In Greene County, the Southwest Regional Medical Center saw a sharp rise in emergency room visits between 2005-06 and 2010-11, coinciding with increased drilling (Herzenberg, Polson, and Price 2014).

Looking at Pennsylvania as a whole, no strong correlation exists between increased gas drilling and increases in emergency room visits. For example, in counties with 400 or more wells, ER visits increased 12%, compared to counties with no drilling in which visits increased by 11% (Table 8.1).

Table 8.1

ER visits in Pennsylvania by number of wells drilled

Wells drilled/region	ER visits per 100,000 people in 2012	2001 to 2005		2005 to 2012		Total wells drilled 2005 to 2012
		Change	Percent change	Change	Percent change	
400 or more wells	54618	2543	6%	6028	12%	4517
100 to 399 wells	38483	3478	10%	-899	-2%	1039
1 to 99 wells	53682	4080	9%	4634	9%	695
No wells, rural	43993	3288	9%	4275	11%	0
No wells, urban	46375	4663	13%	5305	13%	0

Source. Multi-State Shale Collaborative based on Pennsylvania State Police and Bureau of Economic Analysis data.

Looking at individual counties, four of the six high-drilling counties saw increases in emergency room visits of more than 10%, with Greene County leading the way (66% increase between 2005 and 2012). The relationship between the level of drilling and the increase in emergency room visits, however, was not a consistent one: Two counties that had 230 wells drilled each experienced small decreases in visits, and two counties with between 100 and 200 wells saw decreases of more than 10% (Butler and Wyoming (Table 8.2).

Table 8.2

ER visits in counties with 100 or more wells drilled

Wells drilled/region	ER visits per 100,000 people in 2012	2001 to 2005		2005 to 2012		Total wells drilled 2005 to 2012
		Change	Percent change	Change	Percent change	
Pennsylvania, Urban*	46375	4663	13%	5305	13%	0
Pennsylvania, Rural*	43993	3288	9%	4275	11%	0
Bradford	78005	1502	2%	7846	11%	1126
Tioga	42690	1022	3%	6866	19%	811
Washington	50158	1996	5%	5630	13%	755
Lycoming	64834	5294	9%	1610	3%	662
Susquehanna	19831	1555	9%	53	0%	646
Greene	61402	2624	8%	24317	66%	517
Westmoreland	51046	5892	12%	-3347	-6%	230
Fayette	33254	2259	7%	-474	-1%	230
Butler	25475	2127	7%	-5314	-17%	174
Clearfield	71977	7567	15%	12687	21%	147
Armstrong	38246	4861	15%	1552	4%	146
Wyoming	34880	3305	9%	-5905	-14%	112

*limited to counties with no wells drilled between 2002 and 2012

Source. Multi-State Shale Collaborative based on Pennsylvania State Police and Bureau of Economic Analysis data.

Looking forward, better data could help more definitively settle whether drilling contributes to ER visits and increases in the costs of health care.

Early Intervention

Case Study Findings

Early intervention services are designed to serve children with developmental delays or disabilities from birth. to school age. . Our case study research revealed potential links between drilling and an increased need for early intervention services for kids 0-5, and special education for school-age kids. To our knowledge, such a link has not been reported previously in the research literature.

In Greene County, Pennsylvania, human service staff reported that a November 2012 assessment found that one-quarter of the children receiving early intervention services were the children of drillers. Human service personnel did not offer an explanation for this (Herzenberg, Polson, and Price 2014).

In Tioga County, the Southern Tioga School District experienced an increase in students requiring special education services, including emotional and learning supports. The superintendent reported the district had 320 special needs students out of a total enrollment of 2,100 students before drilling began. After the gas boom, the number of special needs students increased to 404, even though the student population had decreased to 1,900 (Ward, Polson, Price 2014).

Quantitative Analysis of Demand for Early Intervention Services

We analyzed early intervention data collected from the Pennsylvania Office of Child Development and Early Learning by the Kids Count initiative. These data include early intervention services for infants/toddlers (0-2) and preschool-aged kids (3-5).

Table 8.3 shows early intervention enrollment (rates per 100,000 people) over time in counties with and without drilling. Early intervention services grew across the state between 2004-2006 and 2010-2012. Services in drilling counties (both those with more than 400 wells, and those with 100-399 wells) grew at more than twice the rate of services in rural counties with no wells. For example, counties with 400 or more wells saw early intervention services increase by 32%, compared to a 15% increase in rural non-drilling counties. Except for this lower increase in rural non-drilling areas, however, all other parts of the state experienced similar increases in early intervention services, independent of the amount of drilling. It could be possible that some factor independent of drilling was driving increases across all of these areas, but that this factor is less influential in rural non-drilling counties. It could also be that drilling was driving increases in rural areas with wells, and a different causal factor was driving increases in urban areas.

Table 8.3

Early intervention rate (early interventions per 100,000 people) in Pennsylvania by the number of wells drilled

Wells drilled/region	2004-06	2007-09	2010-12	Percent Change 2004-06 to 2010-12	Total wells drilled
Pennsylvania, 400 or more wells	443	551	583	32%	4517
Pennsylvania, 100 to 399 wells	458	539	616	35%	1039
Pennsylvania, 1 to 99 wells	497	575	626	26%	695
Pennsylvania, No wells, rural	467	520	538	15%	0
Pennsylvania, No wells, urban	528	620	705	34%	0

Source. Multi-State Shale Collaborative based on Pennsylvania Office of Child Development and Early Learning.

What link might exist between increased early intervention services and drilling requires more research. Are gas drillers' families more likely to need early intervention services? If so, why? Are pregnant women and young children in the area impacted by environmental factors related to increased gas drilling that lead to disabilities, developmental delays, etc.? One study reported that specific chemicals used in unconventional gas drilling can affect the endocrine system (Song 2012). The lead researcher reported that endocrine-disrupting chemicals have been linked to a variety of health issues – obesity, diabetes, fetal development problems and infertility. Babies and young children are especially vulnerable – "during fetal development, if you don't have the right level of hormones in the thyroid, you can have severe mental retardation." Another study identified 649 chemicals used during gas drilling, of which 130 could affect the endocrine system (Vandenberg et al. 2012).

Foster Care

Our case study research found that in Greene County, PA, the number of kids going into foster care due to inadequate housing more than doubled during the gas boom between 2008-09 and 2009-10 (from 15% to 36%) and has remained nearly as high since. Increased cost of foster care has put a financial strain on the Greene County Human Services Department (Herzenberg, Polson, and Price 2014).

Analysis of foster care data across all Pennsylvania counties, however, does not show a consistent relationship between children entering foster care and drilling activity. Greene County is one of only two top drilling counties that saw an increase in foster care rates between 2008 and 2011 (Table 8.4 and Table 8.5). Between 2008 and 2012, the foster care rate grew by 8% in Greene County and by 4% in Fayette County. In every other Pennsylvania county with 100 or more wells drilled, the number of kids in foster care decreased during this time period. And in rural counties with no drilling the number decreased by 19%. Analysis by county groupings based on the amount of drilling also shows no relationship between drilling and demand for foster care.

Table 8.4

Foster care rates (foster care cases per 100,000 people) in Pennsylvania counties with 100 or more wells drilled

Wells drilled/region	Total foster care rates reported per 100,000 people				Change 2008 to 2011	Percent change 2008 to 2011	Total wells drilled
	2008	2009	2010	2011			
Pennsylvania, Urban*	268	235	198	177	-91	-34%	0
Pennsylvania, Rural*	197	177	178	159	-38	-19%	0
Bradford, PA	393	332	335	248	-146	-37%	1126
Tioga, PA	336	289	236	252	-84	-25%	811
Washington, PA	284	254	219	201	-83	-29%	755
Lycoming, PA	187	157	109	88	-99	-53%	662
Susquehanna, PA	191	161	189	174	-17	-9%	646
Greene, PA	202	188	184	219	16	8%	517
Fayette, PA	116	104	111	120	4	4%	230
Westmoreland, PA	198	154	138	198	-1	0%	230
Butler, PA	194	178	152	116	-77	-40%	174
Clearfield, PA	226	189	165	195	-31	-14%	147
Armstrong, PA	126	114	116	100	-26	-21%	146
Wyoming, PA	173	134	106	92	-81	-47%	112

*Limited to counties with no wells drilled between 2002 and 2012

Source. Multi-State Shale Collaborative based on Kids Count Data and Bureau of Economic Analysis data.

Table 8.5

Total foster care rates in Pennsylvania by the number of wells drilled

Wells drilled/region	Total foster care rates reported per 100,000 people				Change 2008 to 2011	Percent change 2008 to 2011	Total wells drilled
	2008	2009	2010	2011			
Pennsylvania, 400 or more wells	265	232	204	184	-81	-31%	4517
Pennsylvania, 100 to 399 wells	159	137	129	136	-22	-14%	1039
Pennsylvania, 1 to 99 wells	250	218	192	187	-63	-25%	695
Pennsylvania, Rural*	197	177	178	159	-38	-19%	0
Pennsylvania, Urban*	268	235	198	177	-91	-34%	0

*Limited to counties with no wells drilled between 2002 and 2012

Source. Multi-State Shale Collaborative based on Kids Count Data and Bureau of Economic Analysis data.

In light of our case study findings in Greene County, we also looked specifically at the impact of drilling on children placed into foster care due to inadequate housing. Only three of 12 counties with more than 100 wells drilled saw increases in foster care placements due to inadequate housing: Westmoreland (21%), Greene County (129%), and Armstrong County (272%). All other heavily drilled counties saw a decrease in foster care rates due to inadequate housing between 2008 and 2012.

Chapter 9: Conclusion

What is the takeaway from our analysis of data on human and social impacts of drilling and our prior case studies?

Both our case studies and our statistical analysis of employment revealed some positive employment and income benefits of shale development in high-drilling counties, especially in Greene County, Pennsylvania.

This report reveals the other side of the coin: The high-drilling counties, measured by number of wells and by industry and total employment impacts, also experienced negative community impacts, such as higher rates of crime, STDs, and traffic fatalities, and less affordable housing.

Our findings are consistent with the qualitative picture of drilling impacts from case studies in Wyoming and other drilling states. High levels of drilling lead to an increase in employment, some of it as a result of an influx of transient out-of-state workers making higher-than-average wages. Drilling activity itself, out-of-state workers, and the increase in income and valuable (and portable) equipment and materials on drilling sites, contribute to increases in crime, traffic accidents, STD rate, and rents. Some of these impacts may have been mitigated in the Marcellus and Utica Shale regions by the lack of apparent increase in overall population; this may reflect, in addition to data limitations, the fact that rural drilling counties in Pennsylvania, West Virginia, and Ohio are more densely populated than parts of the west. As a result, drilling counties in the east may have more pre-existing infrastructure and social services than their counterparts in Wyoming and North Dakota. Regardless, our research indicates that Marcellus and Utica Shale communities in which the scale of shale development is sufficient to move the needle on total employment and income are also communities likely to be faced with social challenges as a result of the drilling intensity. Communities with shale deposits where drilling has not yet occurred should understand this trade-off so that they can weigh their options in an informed way and prepare for the social impacts if drilling does expand to them.

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