RFF REPORT

Local Government Impacts of Unconventional Oil and Gas Development

Alan J. Krupnick, Isabel Echarte, and
Lucija Muehlenbachs

This report was produced as part of **The Community Impacts of Shale Gas and Oil Development***, an RFF initiative.*

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Summary

This report reviews the academic literature analyzing the effect of unconventional oil and gas development on local public finance outcomes, including a review on the truck traffic literature, a specific subset of these local government outcomes (Table 1). We first examine several studies that conduct surveys and/or interviews of local government officials as well as analyze some financial data, such as tax revenue, in order to assess the changes in various cost and revenue sources for local governments, as well as any other challenges associated with unconventional oil and gas development. We additionally analyze two studies that assess effective tax rates across oil- and gas-producing states using two different methods. Several of these studies focus on Pennsylvania, whereas the rest focus on oil- and gas-producing areas across the United States.

In all, we review 19 studies. Eight studies focus on the impacts of unconventional oil and gas development on local public finances, specifically, with one study analyzing financial effects as part of a larger study and another looking at stated gas tax rates as part of a larger study. Nine studies we discuss assess truck traffic impacts, including surveys, traffic, road damages, and accidents.

The majority of the local public finance studies are qualitative in nature, with two studies conducting statistical analysis. The majority of the truck traffic studies reviewed conduct statistical analysis.

The findings of these studies show that local areas, even within the same state, can see a wide variety of effects related to unconventional oil and gas development, often dependent on preexisting local factors and capacity. The studies assessing effective tax rates show that this rate varies widely as well.

The truck traffic literature shows that development increases the number of accidents as well as road damages, which become quite costly to local areas, as revealed by the local finance literature and as measured by the truck traffic literature.

Overall, the literature shows that municipalities and counties are generally able to meet the increased demand for services and increased costs related to shale development (including costs associated with truck traffic), though some regions—particularly rural areas with rapid development—are less able to effectively respond to these changes.

Community Risk-Benefit Matrix

The Community Risk-Benefit Matrix identifies specific areas of concern related to impacts addressed by the team's literature review (left column of the matrix), as well as impacts for which RFF experts have conducted original research and analysis. (See page 3 for the section of the matrix related to this review, on the local government impacts of unconventional oil and gas development.)

The matrix indicates the quality of the literature for each impact, judged subjectively with the color indicating whether we find the studies analyzing an impact to be, on average, of a certain quality. Impacts may be assessed by multiple low-quality studies and a medium-quality study, for example, and we would consider this body of literature to be low quality. A high-quality classification indicates that we trust the results of such studies, including the accuracy, magnitude, and direction of the results—meaning, in a practical sense, that it has no serious or fatal flaws (such as inadequate methodologies) that would lead us to question the results. A study is considered low quality if we believe we cannot trust the results because the study has multiple, serious flaws (e.g., methodology, data, focus, or study design are inadequate to reliably estimate outcomes). A study is considered medium quality if it does not fit in the other two categories. A study is therefore medium quality if it has any such major flaw or if either the methodology, data, focus, or study design lead to questionable results for a number of reasons. Generally, we find the magnitude and direction of these results to be informative, but question the precision.

Lastly, we summarize the findings reported by the literature for each impact—whether the studies as a whole report increases, decreases, or no relationship between the impact and an increase in unconventional oil and gas development. The "heterogeneous" classification indicates that the literature reports different outcomes across areas. The "inconsistent" classification indicates that the literature reports contradictory results (i.e., two studies find an increase or decrease for a certain impact in the same context).

View or download the entire matrix, including all sections that correspond with each of the literature reviews by topic produced as part of this initiative:

WHIMBY (What's Happening in My Backyard?): A Community Risk-Benefit Matrix of Unconventional Gas and Oil Development

Community Risk-Benefit Matrix Literature Review: Local Government Impacts of Unconventional Oil and Gas Development

Fiscal Impacts and Infrastructure for Counties and Cities

Impact	Findings	Results
State revenue sharing	↑	Several studies note that in most states, allocation of state severance taxes, state lease revenues, and federal lease revenues to local governments increases.
Local tax receipts	↑Ø	Several studies find increases in local sales taxes and property taxes in jurisdictions that collect them. Large variation exists across regions.
Donations	↑Ø	Several studies note collaboration between operators and local governments in select regions, notably on road repair.
Water and sewage infrastructure	↑Ø	One higher-quality study finds that particularly in rural regions, increased population can strain existing infrastructure.
Expenditures	↑	Several studies note that increased demand for government services requires higher expenditures. Increased revenues allows higher expenditures and improved services.
Debt	↑↓	Studies note that in rural regions experiencing rapid growth, debt loads have increased. In other regions, increased revenues have allowed debt to be paid off, while some studies note no changes.
Government staffing	↑	Several studies note staff growth in law enforcement, fire and emergency services, social services, and clerk/recorder. Increased compensation is often required to grow/retain staff.

Key

(green)	Higher quality: The majority of studies reviewed for an impact are of higher quality. Where there is one study of higher quality, it is marked as such.
(blue)	Medium quality: The majority of studies reviewed for an impact are of medium quality. Where there is one study of medium quality, it is marked as such.
(orange)	Lower quality: The majority of studies reviewed for an impact are of lower quality. Where there is one study of lower quality, it is marked as such.
(grey)	Not reviewed: Research on an impact was not reviewed.
↑	Increase: Studies show a positive, robust association with an impact (an increase in incidence or magnitude).
↓	Decrease: Studies show a negative, robust association with an impact (a decrease in incidence or magnitude).
↑↓	Heterogeneous: Across regions or areas, studies report robust results that differ.
Ø	No association: Studies report results that showed no association.
~	Inconsistent: Studies report differing (contradictory) results.

1. Introduction

Local governments in municipalities and counties across the United States can benefit from oil and gas production in their regions through a number of revenue streams, including local taxes, greater property taxes, and enhanced economic development. Many states also share revenues with local governments from severance taxes as well as state and federal leases. In some cases, states have directed one-time monies to communities hard hit by a boom, when costs to local government are likely to increase—often as a result of road damages or the expansion of sewer and water systems, as well as increased demand for other public services, such as law enforcement.

Communities can suffer if new local government revenues do not keep pace with needs. Even if revenues offset local government operating expenses (e.g., staff costs), localities can go into debt due to increased infrastructure spending to support increased populations and economic activity. One of the greatest costs to local areas is the various impacts related to truck traffic. Unconventional oil and gas operations require large numbers of trucks that have the potential to not only increase traffic accidents and congestion but also cause road damages. Avenues to offset costs are, however, available. Some counties and municipalities reach agreements with industry to fix road damages directly (or pay to fix them), as well as build recreation or education infrastructure in order to mitigate costs to the community overall and help balance the impacts of oil and gas production more broadly in a region.

2. Fiscal Impacts and Infrastructure for Counties and Cities

Much of the literature assessing local fiscal impacts assesses the impacts of unconventional oil and gas development impacts by analyzing local and/or state revenue data, local and state laws, and methods of distributing revenues within various jurisdictions. Some studies conduct surveys of local governments, others conduct interviews with local officials, and several conduct simple numerical analysis of local financial data. The combination of surveys and analysis of local financial data, including tax receipts, can characterize sources of revenue for local governments, their expenditures, and also the challenges they experience related to shale development. Two studies in our review, Weber et al. (2016) and Bartik et al. (2017), use econometric analysis to estimate the effective tax rate on oil and gas throughout the United States.

This report reviews the literature, documenting and analyzing these local public finance changes qualitatively as well as quantitatively, highlighting a number of best practices for local areas and states to consider.[1] In all, we look at ten studies, listed in Table 2 below. These were the only studies we could find that directly assessed local government fiscal impacts from shale gas and oil development, with all but two focusing solely on this area. Of these, four conduct surveys and interviews, while the rest analyze tax revenues and/or tax rates. Only two of the studies in our review use statistical analysis—one to analyze local expenditures and revenues; the other, effective tax rates. Only one (Weber et al. 2016) has been published in a peer reviewed journal—partly a consequence of the newness of this literature and in part related to difficulty in developing papers that are rigorous and novel enough to be journal material.

[1] Though changes related to education may also affect public finances, we review the literature on education and unconventional oil and gas development in a separate report: Public Education Impacts of Unconventional Oil and Gas Development.

TABLE 2. SUMMARY OF LOCAL PUBLIC FINANCE STUDIES REVIEWED

Study	Period	Methodology	Location
Bartik et al. (2017)	1992–2012	Econometric analysis of local public finance data as part of a larger study	Counties in nine US shale plays
Costanzo and Kelsey (2012)	2007–2011	Analysis of tax revenues	PA
Headwaters Economics (2014)	2014	Analysis of effective tax rates	CO, MT, NM, ND, OK, TX, WY
Penn State Cooperative Extension (2011a)	2010	Interviews and analysis of tax revenues	Susquehanna and Washington counties, PA
Penn State Cooperative Extension (2011b)	2010	Survey of municipal governments	PA
Raimi and Newell (2014)	2007–2013	Interviews and analysis of tax revenues	AR, CO, LA, MT, ND, PA, TX, WY
Raimi and Newell (2016a)	2007–2015	Interviews and analysis of tax revenues	AK, CA, KS, OH, OK, NM, UT, WV
Raimi and Newell (2016b)	2013	Analysis of tax revenues and effective tax rates	AK, AR, CA, CO, KS, LA, MT, ND, NM, OH, OK, PA, TX, UT, WV, WY
Richardson et al. (2013)	2013	Stated gas tax rates as part of a larger study	31 states with actual or potential shale production
Weber et al. (2016)	2004–2013	Econometric analysis of effective tax rates	23 oil and gas producing states, excluding AK and AZ

Overall, this body of literature is smaller than others assessing the community impacts of shale development. Due to the potential for large amounts of heterogeneity, larger studies that assess variation across different shale plays, states, counties, and/or municipalities are needed. Studies such as Raimi and Newell's several papers are useful in that they can assess the impacts on local areas through both interviews and analysis of financial data, both of which capture information the other cannot. A more local scope, such as analyzing municipalities within several counties or within a state, can provide the level of detail necessary to capture such impacts.

2.1. Surveys and Interviews

Studies that conduct surveys or interviews with local officials enable assessment of not only changes in the financial position of local governments but also how these changes have materialized, as well as highlight what local officials believe to be their greatest challenges as a result of a boom in unconventional oil and gas development. The most comprehensive of these studies in our review are Raimi and Newell (2014) and Raimi and Newell (2016a). Each describes local revenue and cost changes in eight shale-producing states based on extensive interviews and analysis of financial data. An accompanying study (Raimi and Newell 2016b) specifically analyzes oil and gas revenue allocation to local governments across all 16 states, which we discuss in the section below. Raimi and Newell (2014; 2016) look at different states, as shown in the above table.

It is important to note that the ways in which local governments collect tax revenue and states allocate funds to local areas vary substantially across states. Methods of allocation often has a large impact on how some local governments handle changes in their overall costs and revenues, as well as changes related to unconventional oil and gas development specifically, including road repair costs, emergency and law enforcement services, and hiring and maintaining staff. Raimi and Newell (2016a) emphasize that pre-development conditions—such as geography, demographics, and pre-existing infrastructure—are important factors in how a local government's finances might be impacted by development. Furthermore, local governments can be affected by development in neighboring areas. In Utah, a county with little oil and gas development (and therefore limited revenue) has seen negative fiscal impacts due to road damage caused by oil and gas vehicle traffic traveling to neighboring counties.

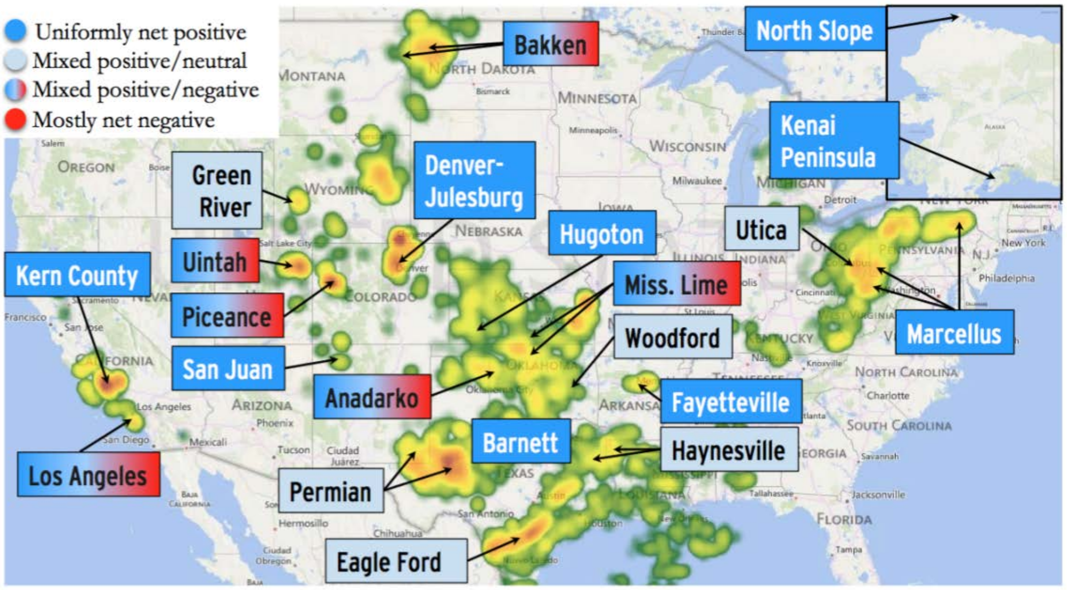
Raimi and Newell (2014) conducted over 100 interviews with local government officials from counties in the top 5 percent of oil and gas production between 2007 and 2012. They found that the majority of counties have experienced net financial benefits. Rural areas where oil and gas development expanded rapidly, such as the Bakken region, faced net negative fiscal effects. Some areas in Colorado and Wyoming additionally struggled to manage finances during "heavy phases of development" (Raimi and Newell 2014, 2).

For county governments studied in Raimi and Newell (2014), property taxes were often the largest revenue source. In the three states where local governments cannot collect property taxes on oil and gas property (Montana, North Dakota, and Pennsylvania), the largest sources of revenue were from allocations of state-collected severance taxes or impact fees. In terms of costs, road maintenance (related to oil and gas traffic) was the greatest cited cost to local governments. Staff costs—due to growing service demands from a growing population—contributed to increased costs as well. For municipal governments, sales taxes made up the largest revenue source in addition to some revenues from leasing and royalties on municipally owned land. Significant costs have resulted from upgrades to sewer and water infrastructure as well as increased staff costs. Sewer and water infrastructure can impose large costs for smaller municipalities that come under more stringent regulations once systems pass a certain size threshold.

Counties in North Dakota have not been able to keep pace with the rapid demand for road repair, for example, despite county budgets increasing as much as tenfold since 2005. Many Pennsylvania counties on the other hand, have limited costs because they have agreements with natural gas companies to repair roads.

Raimi and Newell (2016a) likewise found that most areas experienced net positive impacts, though a few highly rural areas that experienced rapid development in Kansas, New Mexico, Oklahoma, and Utah faced net negative impacts. Figure 1 illustrates both the 2014 and the 2016 findings, with some states seeing large, positive benefits, some seeing positive or neutral benefits, and others seeing a mix of positive and negative impacts across counties. Negative impacts were often associated with road repair, emergency and law enforcement services, and hiring and/or retaining government staff. No state saw wholly negative impacts across all surveyed counties or municipalities. While several western states in the 2014 report experienced strains on water systems that sometimes required costly upgrades, this issue was not observed in the counties studied in the 2016a report. Raimi and Newell (2016a) found increased costs related to roads, fire, emergency, and law enforcement services as well as government staff hiring and retention. In one area in southern California, legacy

FIGURE 1. FISCAL IMPACTS ACROSS COUNTIES AND DRILLING INTENSITY IN 16 STATES



Source: Raimi and Newell (2016c).

environmental costs exist related to early twentieth century oil production, such as unmapped and degrading oil pipelines from that period of development (Raimi and Newell 2016a).

Some local areas see issues related to the booms and busts of oil and gas development and the fiscal uncertainty and volatility accompanying that cycle. Alaska stands out for both the large, positive effects its counties experienced and also the reliance of its state and local governments on oil and gas revenues. Without a state-wide sales or income tax, 90 percent of the state's general fund revenues rely on oil and gas sources. In recent years characterized by low oil prices, the state (which provides the bulk of funding for many local governments) has faced large deficits and has begun draining its reserve funds. Across counties in all states, reliable and predictable revenue sources provided local governments with the most benefits, and more flexible funding mechanisms were able to complement those sources in some states.

Penn State Cooperative Extension (2011a) conducted several focus group interviews with municipal officials in Pennsylvania's Washington and Susquehanna counties. The study found largely neutral impacts, though some expenses did occur. The study states that "road impacts were by far the main issue municipal officials raised" in interviews, and noted that the companies had been "proactive in repairing and upgrading roads … at the company's expense" (2). Officials also reported having to spend more time on natural gas issues, resulting in less time spent on other issues. And, because Pennsylvania townships rely on state police for law enforcement, costs in this regard did not increase at the local level. Lastly, Pennsylvania municipalities reported little change to local tax revenues due to development in the Marcellus shale region, as most townships rely on a type of income tax that typically exempts royalty and leasing income. These findings are also supported by analysis of tax data from these counties, discussed below.

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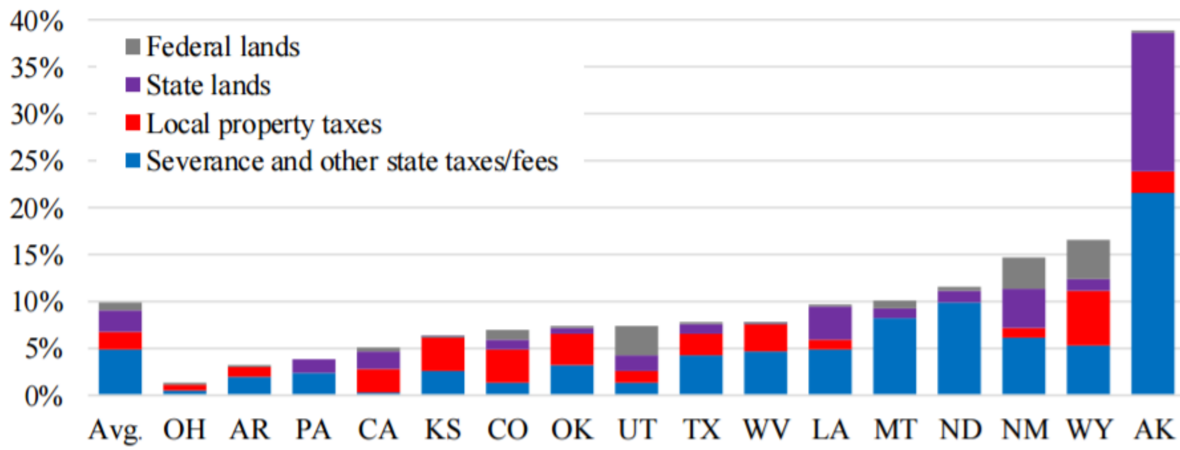
Penn State Cooperative Extension (2011b) also conducted a 12-county survey of 293 municipal governments in 2010, with half of respondents reporting shale development in their jurisdictions. Of those with shale development, three-quarters reported that shale development had not affected tax or non-tax revenue. Only 15 percent reported increased crime, and less than half reported increased property values. Notably, Pennsylvania's Act 13—which implemented the state's impact fee and began distributing oil and gas revenues to local governments—came into effect in 2011.

2.2. Analysis of Tax Revenue

Several studies, either in conjunction with surveys or separately, analyzed tax revenue to assess the impacts of unconventional oil and gas development on local public finances. Raimi and Newell (2016b) and Bartik et al. (2017) are the only studies that assess multiple states—though the latter is a larger study focusing on a number of other community issues, and Raimi and Newell's study provides much more detail. Costanzo and Kelsey (2012) look at Pennsylvania state tax collections in counties with shale development; Penn State Cooperative Extension (2011a) examined two counties within the state. Raimi and Newell (2016b) and Costanzo and Kelsey (2012) note variation across jurisdictions, with the former noting differences in the collection and allocation of revenues across states, and the latter noting differences across Pennsylvania counties related to drilling intensity.

Raimi and Newell (2016b) provide a view of the share of oil and gas revenue allocated to municipalities in 16 oil- and gas-producing states in fiscal year 2013, not including local government land leases, sales taxes, or general corporate income taxes. They found that the share of state and local government taxes on natural resources revenue—or the government "take"—ranges by state from a low of around 1 percent in Ohio to nearly 40 percent in

FIGURE 2. SOURCES OF GOVERNMENT REVENUES AS A SHARE OF OIL AND GAS PRODUCTION VALUE IN FY 2013



Source: Raimi and Newell (2016b).
Note: The average is a simple (unweighted) mean.

Alaska. The authors also find that severance taxes, on average, accounted for the largest share of state and local revenues, as illustrated by Figure 2. In Alaska, the state's "take" is large, but also volatile, as the production tax applies to an operator's profits rather than production amounts or production value, and the state also offers tax credits for certain activities. In Montana, North Dakota, and Pennsylvania, local governments do not tax oil and gas production property— these states allocate state-collected oil and gas revenues to local governments.

In California, Colorado, Kansas, Oklahoma, and Wyoming, property taxes generated more total revenue than severance taxes. Federal leases provided substantial sources of revenue for western states—the federal government maintains 65 percent of the land area in Utah, for example. Across the study, states used these revenues largely to fund their governments' current expenditures (particularly in Louisiana and Alaska), followed by allocations to local governments. States such as Colorado and Ohio allocated "only a small fraction of revenues" for current expenditures, whereas states such as Alaska, North Dakota, and Wyoming allocated funding (between 2.6 and 5.8 percent of production value) toward trust funds in order to provide a buffer during times of low oil prices and production (Raimi and Newell 2016b, 11). On average, the third largest share of revenue was allocated to education expenditures (Oklahoma and Wyoming, however, stand out in that they allocated the largest share of these revenues education).[2] Overall, Raimi and Newell (2016b) analyze, to a very detailed degree, oil and gas tax revenue sources and uses for the 16 largest oil and gas producing states; most of the other studies we review only do so for a single county or municipalities within a single state (or with much less detail).

One study focused solely on the revenue received by municipalities or townships (as opposed to counties) and found little to no impacts of Marcellus shale development (Penn State Cooperative Extension 2011a). The study analyzed audit data from a third of the

[2] We explore the impacts of unconventional oil and gas development on education in another report: [Public Education Impacts of Unconventional Oil and Gas Development](#).

townships in Pennsylvania's Susquehanna and Washington counties—in addition to interviewing officials, as discussed above. The authors did not find any statistically significant results establishing a relationship between township revenues or costs and shale gas development, a finding supported by information gathered from interviews with local officials. While this finding may be counterintuitive, it is not an unreasonable result considering that impact fee revenues were not yet flowing to localities and road repairs were usually performed at the expense of natural gas companies. Additionally, most Pennsylvania townships depend on state police, so any changes in the crime rate would not increase law enforcement costs for these townships.

Costanzo and Kelsey (2012) analyzed Pennsylvania tax revenue from 2007 to 2011 at the county level, and grouped different counties according to differing levels of Marcellus development (by number of wells). Counties with 150 Marcellus wells or more drilled between 2007 and 2010 (the top six counties with new wells during this period) saw an increase in sales tax collections of 23.8 percent from 2007 to 2011. The largest change occurred in the number of sources of resident income, with a 441 percent increase in the number of returns for royalties, rights, and patents in counties with more than 90 Marcellus wells.

Personal income tax returns decreased between 2007 and 2009, except in counties with more than 90 wells drilled from 2007 to 2009 (the top five counties with new wells during this period). This finding might not hold true for the later years of the boom when development continued to expand and when more jobs were filled by local residents. These numbers aid in supporting reports that earlier in the Pennsylvania boom, workers and materials were often brought in from other regions, as local Pennsylvania residents did not have the skills or the local capacity to fill these needs, an issue discussed further in our review of employment literature.[3]

Bartik et al. (2017) used statistical analysis to assess the impact of unconventional oil and gas development on local public finances. [4] The study examined data from the US Census Bureau's Census of Governments (which is conducted every five years), summing values for all local governments within a county to compare top-quartile fracking potential counties to non-top quartile counties—fracking potential referring to an index of several factors such as shale deposit thickness, depth, and thermal maturity. The authors found that across counties, unconventional oil and gas development was "largely budget neutral"—expenditures increased by 12.9 percent while revenues increased 15.5 percent (Bartik et al. 2017, 23).

The study estimated that the changes were related to increases in public safety expenditures of about 20 percent, infrastructure and utility expenditures of 24 percent, and welfare and hospital expenditures of about 24 percent (with little increase found in educational expenditures). The increase in revenues resulted from increases in property tax revenues of 13 percent and other revenues of 26 percent. The overall financial position of local governments—the "debt minus cash and securities as a percentage of annual revenue"—is unchanged (Bartik et al. 2017, 23). Though such statistical analysis is useful in demonstrating the relationship between changes in local public finances and

[3] Economic Impacts of Unconventional Oil and Gas Development.

[4] We also discuss this study in a report analyzing the literature on the economic impacts of unconventional oil and gas development: Economic Impacts of Unconventional Oil and Gas Development.

unconventional oil and gas development, it cannot provide detailed assessments of variation across local governments within counties or in terms of temporal analysis, as the census is conducted every five years. Nonetheless, it is important to note that, across counties, local governments have faced largely neutral impacts during the shale boom.

2.3. Effective Tax Rates

Analyzing effective severance tax rates can provide useful insight into one important revenue source for governments, and is more informative than studying stated/statutory tax rates, as a number of incentives and deductions could reduce the rate actually levied on production and collected by the state government. This issue is particularly important in assessing severance tax rates in states such as Oklahoma that have large deductions for “unconventional” (i.e., horizontally drilled) wells. However, most analyses in this review have not included other important revenue sources for state and local governments, including local property taxes on oil and gas property as well as state and federal oil and gas leases. Notably, none of the studies discussed below assessed effective tax rates from a company’s perspective, which would include other costs such as sales taxes, corporate income taxes, and more.

Raimi and Newell (2016b) included a study of the effective tax rates of severance taxes and property taxes as well as state/federal lease revenues for the top 16 oil and gas producing states in fiscal year 2013. They found effective severance tax rates ranging from 0.5 percent (Ohio) to 21.6 percent (Alaska), with an average of 4.9 percent across all states. Local property taxes on oil and gas property in the study ranged from 0 percent (Montana, North Dakota, Pennsylvania) to 5.7 percent (Wyoming) of the value of oil and gas production, averaging 1.9 percent across states. Revenues from oil and gas leases on state and federal lands ranged from 0.02 percent (West Virginia) to 14.9 percent (Alaska), averaging 3.1 percent. In total, these three revenue sources raised an average of 10 percent of oil and gas production value for state and local governments, with a low of 1.1 percent (Ohio) and a high of 38.8 percent (Alaska).

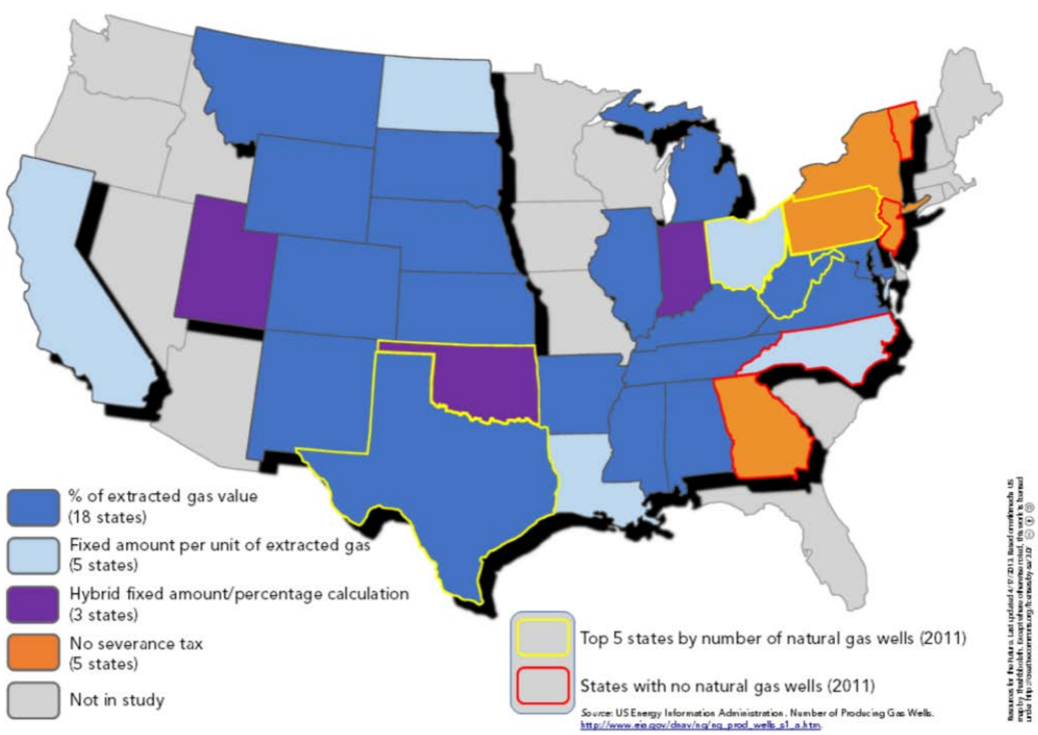
To analyze the effective oil and gas severance tax rates for 23 states, Weber et al. (2016) examined data on state oil and gas revenues and production for 2004 to 2013. The study calculated the effective rate by essentially dividing tax revenues by production, producing an average rate, production-weighted rate, and a regression-based rate. They found that whereas state taxes on oil and gas represented about 4.3 percent of receipts on average, they represented 20 percent of receipts in the states with the top 10 highest oil and gas revenues. The tax rate varied widely as well, with two states averaging 0.1 percent or less and two states averaging 8 percent or more. Montana had the highest tax rate in terms of dollars of production (8.6 cents per dollar) and North Dakota had the highest rate in terms of energy, $0.88 per MMBtu. Virginia, with no state tax on oil and gas extraction, had the lowest rate, whereas California had the lowest in per-dollar terms (0.01 cents per dollar of production).

Weber et al. (2016) found that the quantity-based rate decreased over time, likely related to lower natural gas prices, and that an increase in the average tax rate over time likely reflects policy changes such as those in Pennsylvania. They furthermore parsed out the rates for oil and gas: oil had a tax rate of 3.6 percent and gas a rate of 4.7 percent; in terms of value, however, oil pays more per unit energy because of its higher value. The study highlights that though taxes on oil and gas were responsible for $10.3 billion in revenue in 2013 (not counting property taxes on wells), these revenues declined by about 40 percent from 2008 to 2010. Despite an increase in production over this time, the decrease in natural gas prices caused revenues to decrease, as most states tax the value of oil and gas produced.

Richardson et al. (2013), as part of a larger study of state regulations, analyzed stated tax rates, using "each state's prevailing long-term tax rate for producing wells (i.e., ignoring any incentive programs or lower rates during initial production), and the highest rate charged by any county if taxes are set at the county level" (Richardson et al. 2013; 64). The study notes that taxes on gas production are calculated differently across the states with severance taxes in the study, with 18 states taxing a share of the value of gas extracted, 5 using a fixed-dollar amount for the quantity extracted, three using a hybrid approach, and five without severance taxes. These findings are illustrated in Figure 3.

A Headwaters Economics (2014) report also compares revenue return to local governments from unconventional oil and gas development but does so by studying each state's fiscal policies instead of data on revenues and production. The method of analysis differs greatly from Weber et al. (2016) in that it applies each state's fiscal policies to production from an average unconventional well to estimate tax rates and revenues over a decade for an average well in each state. The study is then able to compare the effective severance tax rates on average unconventional wells across states.

FIGURE 3. SEVERANCE TAX CALCULATION METHOD ACROSS STATES



Source: Richardson et al. (2013).

Headwaters Economics (2014) found that for a typical unconventional oil well, effective production tax rates were highly variable across states, ranging from 3.3 percent in Oklahoma to 11.7 percent in Wyoming. Additionally, the report makes clear that local governments in states with higher tax rates did not necessarily receive more allocations from state governments. Returns to counties and municipalities ranged from 14 percent of total revenue in New Mexico to 55 percent of total revenue in Wyoming.

The report also points out that there is a lag of up to a few years between the generation of revenues from production and the locality receiving revenues; many areas face costs from development booms before they receive the financial benefits, as taxes can sometimes be levied annually and often do not apply until production occurs. Drilling incentives that delay these tax collections can exacerbate this issue. Lastly, the report found that states do little to manage revenue volatility by establishing rainy day funds or other mechanisms. North Dakota and Wyoming put aside 43 percent and 19 percent of yearly revenues, respectively, while other states saved little to none. Local governments in states attempting to mitigate volatility through certain mechanisms often do not share in the investment income and are therefore are more exposed to volatility.

3. Truck Traffic

Unconventional oil and gas development requires an impressive number of trips by tanker trucks to transport water, wastewater, equipment, and sand. One shale gas well is estimated to need 400 to 1,200 one-way heavy-truck trips—and many wells may be drilled on one well pad (New York State Department of Environmental Conservation 2011; Abramzon et al. 2014; Gilmore 2013). These trips add up over time, causing damage to roadways and burdening local communities. Truck traffic related to unconventional oil and gas development can also increase the risk of traffic accidents and contribute to local air pollution. The literature examining the impacts of shale gas truck traffic has studied traffic accidents, road damages, the carbon footprint, and the perceptions of citizens and regulators, as illustrated by Table 3 on the following page.

Surveys have found that truck traffic associated with shale gas development is a concern for industry (Krupnick et al. 2013), local communities (Theodori 2009), and local public officials (Rahm et al. 2015). Adding a truck to the road poses a safety risk, because they are heavy, hard to brake and steer, and difficult to pass. The frequency therefore might increase with an influx of heavy-duty trucks on the road, though the severity of accidents might also increase. An accident involving two vehicles with very different weights results in larger total damages than an accident involving vehicles of equal weights; therefore, widening the vehicle-weight distribution of vehicles on the road (such as through increasing the number of heavy trucks on the road) leads to an increase in severity of accidents, reducing safety (Kahane 2003; White 2004).

Two studies analyze the change in accident rates and risks associated with shale gas development. First, Graham et al. (2015) found that counties in Pennsylvania with heavy drilling experienced higher vehicle crash rates as well as heavy-truck crash rates compared to counties without heavy drilling. The crashes in the heavily drilled counties in southwestern Pennsylvania also had higher rates of fatalities and injuries. One problem with a county-level analysis is that the impact would be underestimated if drilling in one county has spillovers on neighboring counties. Also, using county-level observations, it is not possible to disentangle the impact of shale gas truck traffic from demographic shifts (such as young men moving to the area). A second study, Muehlenbachs et al. (2017) gets around these issues by comparing accident rates on

TABLE 3. SUMMARY OF TRUCK TRAFFIC STUDIES REVIEWED

Study	Period	Methodology	Focus	Location
Abramzon et al. (2014)	2011	Prediction	Road Damages	Pennsylvania
Gilmore et al. (2013)	2011	Prediction	GHG emissions	Susquehanna River Basin
Graham et al. (2015)	2005–2012	Regression	Change in accident rates	Pennsylvania counties
Krupnick et al. (2013)	2012	Survey	Shale gas experts	US
Muehlenbachs et al. (2017)	1997–2014	Regression	Change in accident rates	Pennsylvania
Patterson et al. (2014)	2010–2013	Prediction	Road Damages and shale gas waste shipments	PA, NY, OH, NJ, MD, WV
Rahm et al. (2015)	2014	Survey	Public officials	Eagle Ford Shale, TX
Theodori (2009)	2006	Survey	Local communities	Wise and Johnson Counties, TX

specific roads in the same counties. Knowing the location of shale gas wells and the location of water-withdrawal and disposal points, the authors predict the route that water-hauling trucks are most likely taking. In the first three months after a well is drilled, a road connecting it to a water-withdrawal location experiences a 0.3 percent increase in truck accidents. The largest impacts are seen on highways without ramps or interchanges, which see a 0.9 percent increase in truck accidents per well.

Heavy-duty trucks also cause road damages, with the extent varying by road type—interstate highways, for example, are constructed to withstand heavier weights than local roads. Abramzon et al. (2014) predict that one well can cause up to $23,000 in road damage (assuming each well requires 1,148 truck trips, travelling 20 miles each). Patterson et al. (2014) predict the routes shale gas trucks most likely take to ship waste and then predict the resulting road damage. Over their study period (July 2010 through December 2013), the authors estimated road damages between $3 million and $18 million for the shipment of Pennsylvania shale gas waste within Pennsylvania and to New York, Ohio, New Jersey, Maryland, and West Virginia. Similarly, Gilmore et al. (2013) predict the distance that shale gas water-hauling trucks travel in the Susquehanna River basin, though the authors do so in order to calculate greenhouse gas emissions from truck transport of water, which they estimate to be 70–157 tons of carbon dioxide equivalent per gas well. With a social cost of carbon dioxide of $41 per ton (U.S. Interagency Working Group's central estimate), then, using a back of the envelope calculation, their estimate would be equivalent to $782–$1,755 in damages per gas well.

Communities have a number of options to mitigate damages from heavy truck traffic associated with unconventional oil and gas development. They can protect themselves from the damage caused by heavy trucks by imposing vehicle weight restrictions on roads, whereby only vehicles weighing less than the posted limit (typically 10 tons) can drive on a road unless the posting authority issues a permit. Heavy haulers may be able to obtain a permit by providing a security that can be used to repair the roads. However, typical security bonds are smaller than the damages. In Pennsylvania, bonds are $6,000 per mile of unpaved road and $12,500 per mile of paved road (Gaines 2013), which is less than the estimates of road damages found in the literature above. Operators do have other options for mitigation at their discretion. To avoid the expense of hauling water and fixing roads, operators may be able to build pipelines to connect water storage points to their well pads. Alternatively, operators can recycle produced water from previous wells to frack new wells.

4. Conclusion

Overall, the literature shows that municipalities and counties are generally able to meet the increased demand for services and manage increased costs related to shale development. Some regions are less able to effectively respond to these changes, particularly rural areas with rapid development, such as those in the Bakken region. A slower pace of development in addition to increased allocation of revenues to local areas might be able to mitigate these issues. Costs related to road maintenance or repair, most often the largest cost to local governments, can generally be met through agreements with oil and gas companies operating in the area. Resource booms, as the above sections on income and employment illustrate, can benefit communities in a number of ways. Ensuring that unconventional oil and gas development (and its associated benefits for local populations) does not occur to the detriment of public finances in local areas is an important factor in maximizing these gains. The above research illuminates when local governments are more likely to incur costs, as well as how some localities have sought to minimize these issues, with important implications for state and local policymakers.

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