RFF REPORT

Economic Impacts of Unconventional Oil and Gas Development

Alan J. Krupnick and Isabel Echarte

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

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RESOURCES FOR THE FUTURE

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Summary

The localized impacts of shale gas and tight oil development are often framed in terms of income, employment, and economic development. These impacts may take various forms: royalty payments to mineral rights owners, the potential for increased direct and indirect job opportunities, increased sales for local businesses, and possible growth in wages for both extraction-related sectors and others due to an increase in the demand for labor. All of these benefits then have indirect and induced benefits to other sectors and the regional economy.

Landowners with active leases earn royalties, but their neighbors and other landowners who do not own their mineral rights may receive no compensation, experience negative externalities, and even see property values drop. Workers see new opportunities but, at least initially, much of the workforce comes in from outside the community, particularly in areas that do not have prior experience with oil and gas development. Likewise, local businesses that support oil and gas operations see increased demands and income growth, but residents may see higher prices for goods and housing. The overall economic changes to a local area are therefore not necessarily clear cut, though the literature generally finds an overall increase in employment and income.

- We examine 32 studies, focusing on studies that analyze these effects at a local level, such as townships and counties, as opposed to national changes, though a few studies look at state-wide effects.
- Twenty-two of these studies analyze wages and earnings in some capacity, and fewer (17) analyze other sources of income such as lease payments and royalties. Three-quarters of the studies assess employment changes, while over one-third address the potential for a resource curse. Few studies assess the distributional effects of shale development, and those that do measure these impacts indirectly, such as through analysis of rental rates and other metrics.
- We conclude that there is strong evidence for local employment gains during a growth period of unconventional oil and gas development, though the magnitude of these benefits vary from study to study. Particularly, we find that some studies overestimate the employment effects of oil and gas development. Furthermore, the size of the estimates in these studies can depend on the source of data. For example, some employment data include out-of-state or out-of-county workers.
- We also find that there is strong evidence of an increase in wages (though a few studies find that this increase may be temporary), and increases in royalty income, though the share of local residents that owns the mineral rights varies greatly by area, with royalty benefits to the community varying accordingly.
- The literature on long-term growth and economic development effects provides less consistent evidence, with several studies finding evidence of a "resource curse," or a negative long-term impact, and others finding no evidence of such an effect.

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 economic 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 the set of 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: Economic Impacts of Unconventional Oil and Gas Development

Employment

Impact	Findings	Results
Local	↑	Several studies see increases, with large variation in magnitude across studies. Limited growth for local workers in regions without existing oil and gas workforce.
Regional	↑	Several studies see modest increases at the state- or shale play-levels; variation across studies, with some finding only short-term effects.

Income

Impact	Findings	Results
Wages	↑	Most studies see increases, some find no association; large variation in magnitude across studies
Other income	↑	Several studies note increases in bonuses and royalties prior to and during production for those with mineral rights.

Economic Development

Impact	Findings	Results
Long-term growth	~	A number of studies report evidence for and against the resource curse.

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

Growth in oil and gas development, like any major economic change, comes with positives and negatives for a local community. The localized impacts of unconventional oil and gas development are often framed in terms of income, employment, and economic development. These impacts (from a boom, for example) take various forms: royalty payments to mineral rights owners, the potential for increased direct and indirect job opportunities, increased sales for local businesses, and possible growth in wages for both extraction-related sectors and others due to an increase in the demand for labor. All of these benefits then have indirect and induced benefits to other sectors and the regional economy. New revenue streams to the public sector are welcomed, but new service demands are made of government and education systems.[1]

Landowners with title to the resources see their income rise, but their neighbors and landowners who do not own their mineral rights experience negative externalities without direct compensation. Workers see new opportunities but, at least initially, much of the workforce comes in from outside the community, particularly in areas that do not have prior experience with oil and gas development. Likewise, local businesses that support oil and gas operations see increased demands and income growth, but residents may see higher prices for goods and housing.

Any examination of the gains during a boom therefore needs to also consider the losses during that time. Further, because the industry is characterized by a boom-bust cycle, studies of a bust (a period where output is declining significantly) are also needed (but are largely absent due to the recent timing of the bust). Finally, beyond the near-term effects of booms and busts, the long-run effects of resource development also need to be examined, including the longer-term dynamics as economies adjust to newfound resource wealth.

Resource-based economic development creates the potential for a "resource curse," or decreased long-term economic growth as a result of natural resource development, and a local "Dutch disease" effect, in which certain sectors may become less competitive as a result of oil and gas development.[2] Thus, it is no small task to sort out what the net effect of oil and gas development is, under what conditions the gains outweigh the losses (and vice-versa), and over what period of time these effects manifest. Indeed, there is much disagreement surrounding the size of these benefits, as well as how to measure them. As new data on shale-producing regions become available, we see a difference in findings from the recent empirical studies conducting statistical analysis of ex post data (such as Weber 2012; Feyrer, Mansur, and Sacerdote 2017; Maniloff and Mastromonaco 2014; Paredes, Komarek, and Loveridge 2015) compared to impact studies using input-output models (Considine 2010; Considine, Watson, and Blumsack 2010, 2011; Deck et al. 2008).

Below, we review the large literature that has taken up these questions (Table 1). We start with studies that have taken very broad looks at these impacts, then focus on those

[1] For a more in-depth discussion of this issue, see our related literature reviews on the local government impacts and public education impacts of unconventional oil and gas development.

[2] *The Economist* coined the term in 1977 to describe the decline in the manufacturing sector in the Netherlands following the discovery of large gas reserves in 1959 (see "What Dutch disease is, and why it's bad" for more information).

that have closely examined specific effects, predominantly employment and income. We also consider a specialized literature on the resource curse, with implications for longer-term impacts. We examine 28 studies, with many that analyze these local impacts nationally (for all oil- and gas- or shale-producing regions) and a large number that analyze Pennsylvania specifically. Of these studies, 19 analyze wages and earnings in some capacity; fewer, 15, analyze other sources of income such as lease payments and royalties. Three-quarters of the studies assess employment changes, whereas only about one-third address the potential for a resource curse. Few studies assess the distributional effects of shale development, and those that do so address them indirectly, such as through analysis of rental rates and other metrics.

Overall, we conclude that there is strong evidence for positive local economic impacts during a growth period of unconventional oil and gas development, though the magnitude of these benefits varies from study to study. The literature on the resource curse provides less conclusive evidence.

Table 1. Overview of Literature Reviewed

Study	Years	Location	Methodology	Wages and Earnings	Other Income	Employment	Resource Curse
Bartik et al. (2017)	1992–2013	US	Econometric analysis	✓	✓	✓	
Weber (2012)	1999–2007	WY, CO, TX	Econometric analysis	✓	✓	✓	
Feyrer , Mansur, and Sacerdote (2017)	2004–2014	US	Econometric analysis	✓	✓	✓	
Maniloff and Mastromonaco (2014)	2000–2010	US	Econometric analysis	✓		✓	✓
DeLeire, Eliason, and Timmins (2014)	2000–2010	PA	Econometric analysis	✓		✓	✓
Munasib and Rickman (2014)	2000–2011	ND, AR, PA	Econometric analysis		✓	✓	
Brundage et al. (2011)	2011–2014	PA	Ex ante model			✓	
Komarek (2016)	2001–2013	OH, PA, WV, NY	Econometric analysis	✓		✓	✓
Weinstein (2014)	2001–2011	US	Econometric analysis	✓		✓	✓
Wrenn, Kelsey, and Jaenicke (2015)	2005–2011	PA	Econometric analysis			✓	
Considine (2010)	2009	PA	Input-output			✓	
Considine, Watson, and Blumsack (2010)	2009	PA	Input-output			✓	
Considine, Watson, and Blumsack (2011)	2010	PA	Input-output			✓	

Deck, Riiman, and Jebaraj. (2012)	2008–2011	AR	Input-output			✓	
IHS (2012)	2010	US	Input-output			✓	
Loren C. Scott and Associates (2009)	2008	LA	Input-output	✓	✓	✓	
Kelsey et al. (2012)	2010	Bradford	Input-output	✓	✓	✓	
Kelsey, Metcalf, and Salcedo (2012)	2010–2011	Several Marcellus counties, PA	Tax data and GIS analysis		✓		
Paredes, Komarek, and Loveridge (2015)	2004–2011	PA, NY	Econometric analysis	✓	✓	✓	
Hardy and Kelsey (2015)	2007–2010	PA	Tax data analysis	✓	✓		
O'Coonahern, Hardy, an dKelsey (2014)	2004–2013	PA	Tax data analysis	✓	✓		
Allcott and Keniston (2014)	1969–2014	US	Econometric analysis	✓			✓
Jacobsen (2015)	2006–2014	US	Econometric analysis	✓	✓	✓	
Brown, Fitzgerald, and Weber (2017)	2000–2014	US	Econometric analysis	✓	✓		
Brown, Fitzgerald, and Weber (2016)	2014	US	Econometric analysis		✓		
Haggerty et al. (2014)	1980–2011	CO, MT, NM, ND, UT, WY	Econometric analysis	✓	✓		✓
Tsvetkova and Partridge (2015)	1993–2013	US	Econometric analysis			✓	✓
Brown (2014)	2001–2011	AR, LA, CO, OK, WY, TX, NM, KS, NE	Econometric analysis	✓	✓	✓	✓
Weber (2014)	1995–2010	AR, LA, OK, TX	Econometric analysis	✓		✓	✓
James and Aadland (2011)	1980–1995	US	Econometric analysis	✓	✓		✓
Miljkovic and Ripplinger (2016)	1992–2014	ND	Econometric analysis	✓		✓	✓
Weinstein, Partridge, and Tsvetkova (2017)	2001–2013	US	Econometric analysis	✓		✓	✓

2. Overall Community Welfare

Only two studies address the overall welfare of communities experiencing unconventional oil and gas development quantitatively (Allcott and Keniston 2014; Bartik et al. 2017). Allcott and Keniston (2014) assessed population changes in counties with one standard deviation of additional oil and gas endowment compared to other, comparable counties in order to infer the social welfare impacts of oil and gas development. Bartik et al. (2017) analyzed data from nine shale plays and found that counties in the top quartile of unconventional resource potential benefit on net from shale development compared to non-top quartile counties after fracking was initiated. The study also measures the willingness to pay for changes in amenities while also analyzing some specific measures—unemployment, salaries, government revenue, crime, housing prices, population, and housing rental rates.

Allcott and Keniston (2014) assessed the local welfare benefits of oil and gas resource booms from 1969 to 2014. First, the study found no statistically significant long-term impacts on productivity, population, or wages from the oil and gas boom and bust of the 1970s and 1980s. But the study did find that average real earnings increased 1 percent in counties with one standard deviation of additional oil and gas endowment relative to other counties. This increase would equate to social welfare gains in a county only if resource booms did not impact amenities. Thus, the authors measured changes in population controlling for other factors for counties with one standard deviation of additional endowment over the full sample (including the recent boom in unconventional oil and gas development), with the intuition that "people migrate to producer counties if and only if their utility is higher there." The authors found that population averaged 0.8 percent higher in counties with one standard deviation of additional endowment over this period, indicating that these endowments have increased relative welfare over this period.

The welfare measure used Bartik et al. (2017), on the other hand, is a willingness to pay for amenities as a whole, measured as the "difference between the change in population, adjusted for the magnitude of moving costs, and the change in real wages" (Bartik et al. 2017, 4). The authors state that the intuition for this measure is that "in spatial equilibrium, the marginal resident must be indifferent to relocating, which means that local housing prices will respond to changes in local wages," with the elasticity of local housing supply and moving costs affecting this response (Bartik et al. 2017, 5). If the willingness to pay for amenities is zero, for example, the change in income (normalized) is equal to the adjusted change in population, but when the adjusted populated change is larger than the change in real income, people are exchanging reductions in income for higher amenity levels (at the margin). Furthermore, as the study was conducted at the county level, the distribution of benefits among groups or individuals cannot be investigated. In particular, individuals not participating in the labor market, homeowners without mineral rights, and renters are unlikely to benefit on net. The interpretation of these willingness to pay results is more complicated if households are misinformed or uninformed about changes caused by fracking, as the model assumes households have knowledge and rational expectations of these changes.

The study measured the valuation of the changes in amenities overall in a community for those who reside in the community prior to the start of fracking, and therefore measured the willingness to pay to allow fracking. This measure is best suited for differentiating the impacts on the community in which fracking takes place, rather than estimating the effects on the community including those that migrated in due to shale development. The study found the costs of decreases in local amenities to be on average $1000 to $1,600 per household annually depending on the model (1.9 percent to 3.1 percent of mean household income). The net of this cost and the benefits, or the willingness to pay to allow fracking (which includes the reduction in amenity value), are estimated to be $1,300 to $1,900 per household annually (2.5 percent to 3.7 percent of mean household income). These findings indicate a net positive impact for homeowners. Nevertheless, there is quite a bit of heterogeneity across the shale plays, with three regions (the Haynesville, Woodford Anadarko, and Eagle Ford) showing a net benefit below zero, though none of these estimates are statistically significantly different from zero.

The study also looked at a number of economic and social indicators individually. In the top quartile fracking potential counties, total income increased 4.4 percent to 6.9 percent, employment increased 3.6 percent to 5.4 percent, and salaries increased 7.6 percent to 13 percent compared to non-top quartile counties in the shale plays after the initiation of fracking. The study has several other notable findings. For example, local government revenues had a greater increase (of 15.5 percent) than the increase in expenditures (12.9 percent); the economic position (debt minus cash and securities as a share of annual revenue) of these counties, however, did not change despite an increase in revenues.

Although the study is comprehensive, there are a number of shortcomings with this design. First, the data used for some of these measures are not ideal. The US Census Bureau reports local public finance data every five years; the crime reports of local police agencies to the FBI are not mandatory and therefore are not complete; and the housing price data come from the decennial census, with an average reported for 2009–2013 (during much of the fracking boom) from the American Community Survey. Furthermore, using the top quartile of fracking potential counties as the treatment group could introduce bias, and counties with fracking but not in the top quartile of fracking potential might also experience benefits or costs from fracking. It is also important to note that the study is not able to include health or environmental impacts due to a lack of information and incomplete data, respectively, though the willingness to pay for decreased amenities may capture at least some of the households' perceived (not measured) health and environmental effects.

Overall, Bartik et al. (2017) provided the most comprehensive look at the net impact of fracking on US counties of any of the studies we reviewed. Despite its shortcomings, Bartik et al. (2017) stands out for its breadth. And the findings of Allcott and Keniston (2014) on welfare likewise support the finding that oil and gas booms (and the recent boom in unconventional oil and gas development) have increased local welfare in these communities. Below we contrast findings from these studies with those of more detailed studies of these various impacts.

3. Summary of Employment and Income Impacts

Table 2 provides an overview of the results from the ex post studies of employment and income effects. The studies found a wide range of impacts, ranging from increases in wages or earnings of 0.3 percent to 16.7 percent, and increases in employment from 0.16 percent to 23 percent. The range likely reflects differences in the studies' scopes—some looked at a few states, whereas others examined the entire United States, and all studied different time periods. Additionally, the studies all define their treatment effects differently—some compared counties in the top quartile of fracking potential, while others looked at counties in the top 20 percent of production, and others used well counts. Table 2, though it shows a wide range of estimated impacts, shows that unconventional oil and gas development has the potential to be economically significant—particularly in more rural counties where the impacts are generally larger in percentage terms. These effects—particularly those for employment—are much smaller than originally estimated earlier in the boom by input-output and/or industry-funded studies.

TABLE 2. OVERVIEW OF WAGE AND EMPLOYMENT IMPACTS

Study	Location	Time Period	Treatment for spatial unit	Wages/Earnings	Employment
Feyrer, Mansur, and Sacerdote (2017)	US	2004–2014	Counties with $1 million of oil and gas production	$42,000- $80,000	0.85 jobs
			$1 million of oil and gas production within 100 miles	$130,000- $257,000	2.13 jobs
Weber (2012)	CO, TX, WY	1999–2007	Counties with $1 million of gas production	$91,000‡	2.35 jobs
			Counties in the top 20% of production	2.6%‡	1.5% annually
Allcott and Keniston (2014)	US	1969–2014	Counties with one standard deviation greater oil and gas endowments than other counties during a boom that increases national oil and gas employment by 100 log points	1.79%	2.82%
Bartik et al. (2017)	US	1992–2013	Top quartile fracking potential counties	4.4% - 6.9% ‡	3.6% - 5.4%
DeLeire, Eliason, and Timmins (2014)	PA	2000–2010	New wells installed in PA counties	Minimal effects‡	2% for average county, over 10% for some
Jacobsen (2015)	US	2006–2014	Non-metropolitan areas with increase of $500 million or greater of oil and gas extraction	16.7%	13.6%
Komarek (2016)	OH, WV, PA	2001–2013	Counties with at least 50 wells	Temporary increase in some sectors	~7% temporary increase
Maniloff and Mastromonaco (2014)	US	2000–2010	Top 25% of counties with increased shale well count	10%	24%
Paredes, Komarek, and Loveridge (2015)	PA and NY	2004–2011	Counties with shale development	Minimal effects‡	0.16% to 0.4% for the average county†
Wrenn, Kelsey, and Jaenicke (2015)	PA	2005–2011	Shale development impact for local residents	N/A	1.53%
Weinstein (2014)	Lower 48 States	2001–2011	Counties that experience ≥ 10% increase in oil and gas employment and ≥ 20 additional oil and gas workers during boom period	7.2% initial increase, returns to original growth rate in ~5 years‡	3.3% initial increase, returns to original growth rate in ~5 years

*This study found larger impacts within a 100-mile radius and heterogeneity for different counties and areas.
†Calculated based on average county employment for the entire sample and average employment effect per county for the sample.
‡ This figure includes non-wage income (earnings or other sources of income).

Another issue concerns employment estimates, for which different data sources may count employment in ways that overestimate the number of local residents employed by the shale boom, as Wrenn, Kelsey, and Jaenicke (2015) show in their study comparing results from local tax data, US Bureau of Economic Analysis (BEA), US Bureau of Labor Statistics (BLS) data (discussed further below).

What is most apparent from Table 2 is that direct comparison of the estimates is difficult due to varying treatment effects, as mentioned earlier. Komarek (2016) defines "boom" counties, the treatment, as counties with at least 50 wells during the study period. Paredes, Komarek, and Loveridge (2015), however, define a "boom" county as any with shale development. Some studies provide more specific definitions: Weinstein (2014) defines boom counties as those that experience an increase in oil and gas employment of ≥10 percent and ≥ 20 additional oil and gas workers during boom period. Although the wage and employment results for these studies are reported in the table, they are provided for convenience—an apples-to-apples comparison is not possible.

The differences in the treatment effect are likewise important for the validity of the results, as they must allow for a proper counterfactual. For example, the treatment effect used by Paredes, Komarek, and Loveridge (2015), which compares counties with any level of shale development, provides the less precise counterfactual—counties without any shale development. Counties that do not have shale development may not provide an accurate reflection of what would have happened without shale development, as these counties might differ in unobservable ways from counties that do have shale development. Even comparing counties that have shale development activities above a certain threshold (such as those with the top 20 percent of production) and counties with less development may bias the results for the same reasons. The treatment effect of Bartik et al. (2017)—using an estimation of the fracking potential in a county—minimizes this issue. Most of the studies, including Bartik et al. (2017), however, are unable to control for spillover effects—in which shale development in neighboring counties could affect the treated counties, meaning the results are often biased for this reason. Feyrer, Mansur, and Sacerdote (2017) conducted an analysis assessing the impacts within a 100-mile radius, as opposed to at the county level, and found much larger impacts. In all, the results provide strong statistical evidence of positive impacts that often affect various localities differently. The variation in the magnitude of these findings is likely due to varying treatment effects, time periods, and conditions in the locations analyzed.

Below, we discuss in more detail the studies in Table 2, as well as those that reported impacts not readily translatable to percent changes in wages or employment.

3.1. Employment Impacts

Though various studies produce vastly different results regarding employment changes due to shale development, most agree that the recent boom in unconventional oil and gas development has led to an increase in employment on statewide as well as local levels. What differs among studies is how large this effect has been. The estimated effects vary within the statistical studies using ex post data (many of which are listed in the table above), but these statistical estimates differ dramatically from impact studies using input-output methods in that the results are much smaller. The ex post studies find that the impact studies, several of which are industry-funded, largely exaggerate the employment impacts of shale development because they do not account for the true counterfactual of what would have happened without shale development (Partridge and Weinstein 2011). Economists find other study types that use econometric data analysis to be more credible (Partridge and Weinstein 2011). The methodologies of both of these types of studies will be discussed in detail below, beginning with ex post, statistical studies.

3.2. Statistical, Ex Post Models

Not surprisingly, statistical studies using ex post data found these impacts to be far smaller than all the studies using input-output models. These studies, through the use of data and rigorous econometric methods, do not assume economies are static and are better able to control for previously existing trends and exclude the aforementioned questionable assumptions regarding economic spillovers. Furthermore, these studies are able to use these methods to focus on county-level and localized employment effects. Such methods are better able control for spillover effects (in which development in one county may benefit a neighboring county) and within-state or within-shale play variation and are therefore less likely to overestimate the impacts of shale development.

Weber (2012) studied counties in Wyoming, Colorado, and Texas, finding that every $1 million of gas production leads to 2.35 jobs in the producing county. Using these estimates, the study found that total jobs created in 2009 associated with the Marcellus shale region would have been just below 2,200 jobs—almost 10 times smaller than the 2009 Marcellus employment estimate of 21,000 in Considine's (2010) impact study. Feyrer, Mansur, and Sacerdote (2017) studied counties throughout the United States, finding even lower within-county estimates: every $1 million of extraction of gas and oil produced 0.85 jobs within the county of production and 2.13 jobs within a 100-mile radius.

Several studies differentiate between counties with low or no shale development and counties experiencing high amounts of (or increases in) production, making it clear that more rigorous shale development yields higher employment benefits. Weber (2012) found that several counties that experienced a boom (defined as a county in the top 20 percent for gas production) from 1999 to 2007 had an annual increase in employment of 1.5 percent compared to non-boom counties in several states. Maniloff and Mastromonaco (2014), controlling for geographic spillovers, found results larger than those of Weber (2012), though the former study defined boom counties as those in the top 25 percent of unconventional oil and gas wells from 2000 to 2010 throughout the United States. These counties experienced a 24 percent growth in employment throughout this period. The same study found that a doubling of the number of wells in a county would increase the number of jobs by 3 percent.

DeLeire, Eliason, and Timmins (2014) found that on average, fracking contributed to only 2 percent of job growth from 2000 to 2010 in Pennsylvania, though it was responsible for more than 10 percent of total job growth in a number of counties (such as Susquehanna, Tioga, Bradford, Green, and Sullivan). Looking at the effect of each well on employment, the study found that an additional well brought 3 new mining jobs on average, with 1.4 remaining after two years, though the authors note heterogeneous effects with wells in the 90th percentile creating 5.8 mining jobs. Munasib and Rickman (2014) looked at the impact of oil and gas development on non-metropolitan counties in three states from 2000 to 2011, and found a large increase in wage and salary employment of 19 percent, in North Dakota, while Arkansas' 2011 wage and salary employment was 8.2 percent higher than they would be without oil and gas development. In Pennsylvania, their results are not statistically significant, though they do become positive after 2009, which is in line with the timing of development the state. Bartik et al. (2017), for comparison, saw an increase in employment ranging from 3.6 percent to 5.4 percent for counties in the top quartile of fracking potential compared to other counties within the shale play.

One study assessing employment changes from 1992 to 2014 in the Bakken region specifically used time series analysis to quantify the relationship among the oil and gas sector, agricultural sector, and the rest of the economy (Miljkovic and Ripplinger 2016). The Bakken region differs from many other areas with unconventional oil and gas development in its rurality, the dominance of agriculture (rather than manufacturing) in the economy, and the fact that few skilled oil and gas workers were in the area prior to the boom.

The study found that, for a one-rig increase, the oil and gas sector saw a 0.3 percent increase in employment, the agricultural sector saw a 0.2 percent increase in employment, and the rest of the economy saw a 0.1 percent increase in employment—for context, the state had 217 rigs in 2012 around the peak of the boom. The study notes that, although these other sectors saw increases in employment on a per-rig basis, the findings indicate that labor transfers from the rest of the economy to the oil and gas sector: every 1 percent increase in oil and gas sector employment caused a 0.02 percent decrease in employment elsewhere (though this finding was not noted for the agricultural sector). The authors hypothesize that much of the non-seasonal agricultural labor is specialized and not directly substitutable, so it is more difficult to have marginal changes in agricultural employment than in other sectors.

Two studies found effects that were positive, but temporary. Komarek (2016) studied counties in Ohio, West Virginia, and Pennsylvania, finding that counties with 50 wells or more (compared to counties in these states with no fracking and also to New York counties, which have no fracking) from 2001 to 2013 found that employment increased, but with the bust returned to pre-fracking levels after four years. Specifically, the study found that in these counties, employment increased 4 percent above pre-boom levels in the first year after the start of fracking and 7 percent above pre-boom levels three years after the start, but that employment moved toward pre-boom levels in the fourth year during the bust. Weinstein (2014) found that boom counties throughout the United States—those with an increase of at least 10 percent in oil and gas employment and 20 oil and gas workers during the boom period—from 2001 to 2011 experienced an initial 3.3 percent increase in employment that decreased by 0.65 percent each year, returning to original growth rates after five years.

Even when conducting these more rigorous ex post analyses, accurately measuring these benefits on a local level presents some difficulties. Many studies use data from the Bureau of Labor Statistics (BLS) or the Bureau of Economic Analysis (BEA), neither of which draws a distinction between jobs going to residents living permanently within the county of production or non-local workers residing temporarily in the community (Hardy and Kelsey 2015). To correct for this flaw, Wrenn, Kelsey, and Jaenicke (2015) used local tax data linking workers to residences and found that the employment impact of Marcellus shale development over a six-year period, from 2005 to 2011, resulted in 7,346 to 9,602 additional jobs for local residents in Pennsylvania, or a 1.53 percent employment increase. These employment effects were found to be significant only for counties with 90 wells or more. Their results were two to almost three times larger when using BEA and BLS data, indicating employment effects for local residents are likely more modest than many studies predict using datasets that do not identify local residents.

3.3. Ex Ante Estimates

The Marcellus Shale Education and Training Center (MSETC) provided ex ante estimates of direct drilling, full time employment jobs in Pennsylvania based on the workers and days of work needed per well and the efficiency of drilling rigs, or the number of wells drilled by a single rig in a given year (Brundage et al. 2011). Depending on the amount of drilling that occurs, the MSETC model predicted that from 2011 to 2014, Marcellus development would create between 9,800 to 15,900 new jobs over 2010 levels. This number is smaller than the per-year direct employment estimates of input-output studies analyzing earlier years.

3.4. Impact Studies

The impact studies discussed in this review use several types of input-output models in order to estimate direct and indirect employment impacts from shale development, with estimates noticeably larger than the above statistical and ex post studies. As discussed above, economists do not consider these studies to be as credible as the ex post studies for a number of reasons.

Considine (2010), an industry-funded study using the IMPLAN input-output model, estimated that the increase in Marcellus shale development in Pennsylvania added over 21,000 jobs directly, as well as about 8,700 indirect and 13,600 "induced" jobs (those created throughout an economy by spending from jobs directly and indirectly created) in 2009. This estimate amounts to a state-wide share of just 0.74 percent of jobs that year in the state, though this impact is likely greater in the counties actually experiencing shale production.[3] The study also found that for every $1 million of gross output from natural gas production, 6.2 jobs are created in the state, with $3.9 billion in value added. Considine, Watson, and Blumsack (2010), using the same model, found similar employment results. Considine (2010) also found large employment benefits in West Virginia as well as the potential for such benefits in New York should the state lift its moratorium on fracking.

Deck et al. (2008), in an industry-funded study also using the IMPLAN model, found that Fayetteville shale development in 2007 created 9,533 jobs. This estimate accounts for a share of 0.74 percent of employment within the state.[3] In an update to this study, Deck, Riiman, and Jebaraj (2012) found the direct, indirect, and induced employment associated with Fayetteville shale activities to be above 20,000 in 2009 and 2010, and almost 22,500 in 2011. In 2011, this employment estimate would account for 13.3 percent of jobs in the nine "core" counties—assuming every job remains within the county of production—and 1.8 percent statewide.[3] An IHS (2012) study, using the same model, estimated state employment from unconventional oil and gas to be up to 288,222 in Texas and 56,884 in Pennsylvania in 2010—2.6 percent and 0.97 percent of state employment, respectively.[3]

Another study, Loren C. Scott and Associates (2009), using the RIMS II model (which is similar to IMPLAN), reported that 431 employees and contract workers on the Haynesville shale in Louisiana were associated with an indirect increase of 32,311 jobs in the state in 2008, or 1.71 percent of total employment in the state in 2008.[3] This

[3] Percentages are the authors' calculations using Bureau of Labor Statistics employment data.

estimate of indirect employment implies an extremely high employment multiplier of 76, an issue that will be discussed below. The authors state that this “lower bound” is due to $3.2 billion in lease and royalty payments combined with indirect income effects as a result of spending, even when only 5 percent of those payments are spent. One factor contributing to this high estimate, however, is the extremely high leasing bonuses in the area, with some bonuses documented being up to $30,000 per acre in Caddo Parish (supplemented by a 30 percent royalty rate share) (Raimi and Newell 2014). Whether such high bonuses and royalty rates are widespread enough to account for a substantial amount of the size of this multiplier, however, would require further study.

Other studies, however, find that these numbers are overstated for various reasons, even when using the similar input-output methods. For instance, Kelsey et al. (2011), using the IMPLAN model and aggregating information from GIS analysis and individual surveys, found that the employment impact of Marcellus shale development in Pennsylvania in 2009 to be closer to 23,385 to 23,884 jobs—around 0.4 percent of jobs statewide[3] This estimate is almost half of what Considine (2010) found using the same model. The estimates of Kelsey et al. (2011) are better able to address some assumptions made in the other studies, such as the fact that many workers, especially at the start of shale development, were from other states and a large share of mineral rights owners live outside the county of production. For context, Weber (2012), an ex post, statistical study discussed above using more accurate assumptions, found results about 10 times less than the input-output estimates of Kelsey et al. (2011) and 20 times less than those of Considine (2010) (these studies are discussed in depth below).

The input-output approach is problematic because it does not take into account the counterfactual of what would have happened without shale development (Partridge and Weinstein 2011). These studies also do not estimate continuous employment numbers, meaning Considine’s (2010) estimated 44,000 jobs does not indicate 44,000 employed workers throughout the entirety of 2009 (Partridge and Weinstein 2011). Furthermore, input-output studies depend on assumptions regarding economic multipliers—estimates of the additional or indirect economic benefit of an activity—that overstate the impact of shale development (Weber 2012), which Considine, Watson, and Blumsack (2011) applied after the indirect and induced jobs are already accounted for—effectively double counting those jobs (Partridge and Weinstein 2011).

Lee (2015) highlights a few more issues with input-output methodologies. First, these methods assume that the economy operates with excess capacity (an elastic labor supply) with no crowding out or leakage effects. Second, these studies ignore the fact that lease and royalty income materialize as windfalls in income, meaning they are more likely to be saved. Direct spending is also likely overstated, as input-output studies ignore supply constraints that might be issues in small economies.

Table 3 illustrates the differences in multipliers, one reason why input-output studies and ex post, statistical studies differ so much in their estimates. The table summarizes the differences in employment multipliers across these studies, which indicates how many total jobs are produced for each direct oil and gas job. Using the IHS (2012) estimate of an employment multiplier of five, for example, each oil and gas job would create four non–oil and gas jobs (a total of five). The employment multipliers are noticeably larger in the studies using input-output models (Deck et al. 2008; Considine, Watson, and Blumsack

2010, 2011; IHS 2012). One study, Loren C. Scott and Associates (2009) reported an exceptionally high multiplier, even in comparison to other input-output studies. Out of the studies using ex post data, only Munasib and Rickman (2014) report an employment multiplier above two (3.37 for North Dakota). The authors are not concerned that this number is so high, as North Dakota oil and gas counties are more isolated and contain fewer types of other economic activity than other states experiencing shale development. The distinctly lower multipliers reported by ex post studies indicate that employment spillovers to the rest of the economy are likely more muted than previously assumed.

Despite these discrepancies in the magnitude of employment benefits, the studies, regardless of model, are unanimous in finding a positive impact on employment and employment growth in counties that experienced shale development, though the ex post, data-intensive studies find significantly lower benefits than do the impact studies. One area that is important for further study is the temporal aspect of employment impacts. The results of two studies (Komarek 2016; Weinstein 2014) indicate that these job gains may not hold in the long run, an issue that is discussed further in the long-term impacts section below. Furthermore, if out-of-state or out-of-county workers are occupying the majority of these jobs, this has large implications for local, regional, and state policymakers who likely prefer long-term job growth for local residents, rather than short-term jobs or employment for transient worker.

TABLE 3. EMPLOYMENT MULTIPLIERS FOR STUDIES REVIEWED

Study	Employment Multiplier	Methodology	Focus
Loren C. Scott and Associates (2009)	76	Input-output	Estimates 2008 Haynesville shale impacts, Louisiana [a]
IHS (2012)	5	Input-output	Predicts US employment from oil and gas, 2012–2035 [b]
Munasib and Rickman (2014)	3.37 in ND; 1.77 in AR	Statistical	Estimates impact of shale in North Dakota, Arkansas, and Pennsylvania, 2000–2011
Deck et al. (2008)	2.5-2.64	Input-output	Predicts Arkansas shale employment, 2008–2012
Considine, Watson, and Blumsack (2011)	2.07	Input-output	Estimates 2010 Marcellus impacts for Pennsylvania [c]
Considine, Watson, and Blumsack (2010)	2.02	Input-output	Estimates 2009 Marcellus impacts for Pennsylvania [d]
Brown (2014)	1.7	Statistical	Analyzes county-level natural gas boom in 9 central US states, 2001–2011
Weinstein, Partridge, and Tsvetkova (2017)	1.5	Statistical	Analyzes county-level income and employment in US, 2001-2013
Weber (2014)	1.4	Statistical	Analyzes non-metropolitan counties in AR, LA, OK, TX from 1995-2010.
Weinstein (2014)	1.3	Statistical	County-level analysis of shale boom in lower 28 states from 2001-11.
Tsvetkova and Partridge (2015)	1.26	Statistical	Examines oil and gas specialization in 6 Western states, 1980-2011.

a Multiplier calculated from study estimates: 32,742 total jobs with 431 direct jobs from shale development.
b Multiplier calculated from study estimates: direct employment accounts for 20% of total jobs associated with oil and gas boom 2012-2035.
c Multiplier calculated from study estimates: 139,889 total jobs with 67,739 direct jobs from shale development.
d Multiplier calculated from study estimates: 44,098 total jobs with 21,778 direct jobs from shale development.

3.5. Earnings and Income

Residents of communities that produce shale gas and tight oil can experience an increase in income from several sources. The first is from leasing and royalty payments to the owner of the mineral rights—these are sometimes separated from the surface property (termed split estates) and can be divided among several owners. Natural gas royalties usually cover at least 12.5 percent of the value of gas removed for a period of five years (Weber, Brown, and Pender 2013)—this rate is the minimum required federally by the 1982 Federal Oil and Gas Royalty Management Act of 1982, though Brown, Fitzgerald, and Weber (2016) found the average royalty rate was generally higher, ranging from an average of 13.2 in the Marcellus to 21.2 in the Permian in an analysis of oil and gas leases. These gains for the most part materialize as windfalls rather than long-term income augmentation, as most wells experience a 50 percent to 70 percent decrease in output within the first three years of production (Paredes, Komarek, and Loveridge 2015).

The increase in wages and earnings that results from the sudden increase in labor demand can also provide another form of local income. The direct increase in earnings for those in extraction and related industries, as well as the increased royalty income, may also have indirect or induced effects due to the larger economic changes resulting from unconventional oil and gas development.

Lastly, incomes can be affected by changing home values—an issue which is discussed in a separate report.[4] Although changes in home values can increase or decrease a resident's income, much of the literature uses changes in home prices to estimate how disamenities (the expectations or experiences of the impact of development, such as noise or truck traffic) and benefits (such as royalties) are valued by residents.

The local impact of these income benefits, however, could be diminished if workers are commuting to a community, living temporarily in a community, or if mineral rights owners are non-local, spending their income outside of the community producing gas and oil. Kelsey et al. (2011), for example, found that just over half of land in Marcellus counties is owned by local residents, and that over 37 percent of workers were not Pennsylvania residents. Furthermore, income changes in the earlier years of development (2007 to 2010) in Pennsylvania, for example, have been shown to result mostly from increases in royalty or leasing income, rather than increases in wages or increased job opportunities (Hardy and Kelsey 2015). Furthermore, some local sectors, such as manufacturing, can become less competitive or decrease employment as a result of these higher wages and increased labor demand, again potentially diminishing the local benefits (Brown 2014).

Studies using ex post data attempt to address these estimation and geographic spillover issues through various methods in order to accurately measure local income effects. Feyrer, Mansur, and Sacerdote (2017), for example, used data aggregated at the state level to control for spillovers in benefits from production in neighboring counties in addition to conducting analysis for a 100-mile radius surrounding the center of a county to pick up benefits that might extend outside county borders. This analysis might better measure the benefits that commuters see.

Maniloff and Mastromonaco (2014), on the other hand, use county-level data and instrumental variables in order to estimate the effects of endogenous factors such as

[4] Housing Market Impacts of Unconventional Oil and Gas Development

geographic spillovers and existing trends. Paredes, Komarek, and Loveridge (2015) used two methods, though this review focuses on one method that compares counties with and without fracking wells in Pennsylvania and New York (which banned fracking and thus provides a natural experiment). The authors also allowed for differentiation between short-term and long-term impacts. While input-output models could estimate employment impacts, most estimate gross output by the state or changes in state-wide taxable income and not the effects of development on individual incomes.

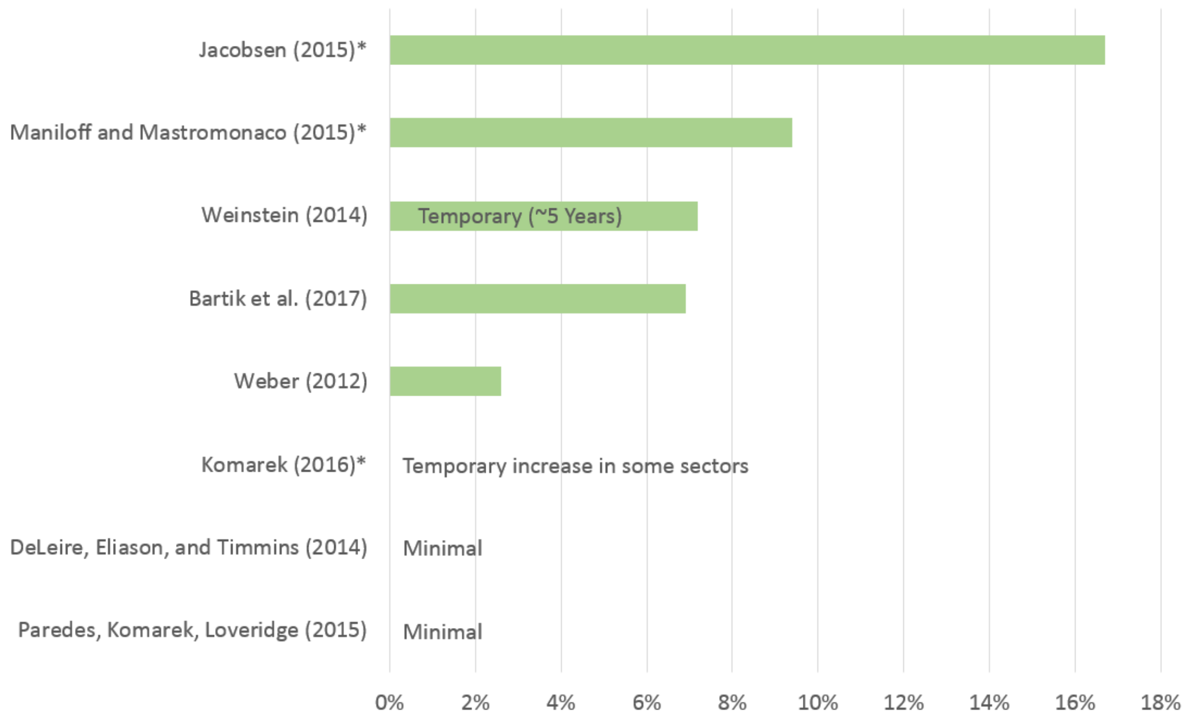
Some studies use Pennsylvania tax data to give an overview of changes in income on the county level for those with shale development, such as Hardy and Kelsey (2015) and O'Coonahern, Hardy, and Kelsey (2014). The benefit of these data and the methodology, though not using econometric methods, is that the study can isolate income changes for county residents directly, as opposed to estimating these changes.

Many of these income studies, even when correcting for the aforementioned issues in calculating income benefits, find a modest to large positive increase in local income. Feyrer, Mansur, and Sacerdote (2017), for example, studying several US shale plays from 2004 to 2014, estimated that for every $1 million of oil and gas production, $80,000 in wage income, $132,000 in royalty and business income, and 0.85 jobs are produced within the county using BLS data. About 60 percent of the wage estimate is direct payments to oil and gas workers, with the rest being spillover to workers in other industries. Expanding this area of study to a 100-mile radius, every $1 million of new oil and gas production creates $257,000 in wages, $286,000 in royalty and business income, and 2.13 jobs. The study notes that two-thirds of the wage income increase persists for two years.

Using data from the Internal Revenue Service (IRS) from 2004 to 2012, however, the study found smaller effects, with $42,000 in increased wages at the county level and $130,000 within a 100-mile radius. IRS data are better suited to assess the impacts of unconventional oil and gas development on local communities, as BLS data calculate employment based on the employer's location (reflecting economic activity in a local area), whereas the IRS data are based on the location of the tax filer. The difference in estimates between the two data sources suggests that "itinerant workers are capturing a substantial portion of the wage increase in comparison with long-time residents" (Feyrer, Mansur, and Sacerdote 2017, 1323). This discrepancy is an issue in other studies as well, as many use BLS data.

The direct wage effects imply that 20 percent of the total value of oil and gas extracted remains in the county (using BLS data), and 54 percent of the value of production remains within the 100-mile radius. The study notes that royalty and business income is "ephemeral" (Feyrer, Mansur, and Sacerdote 2017, 1323). The study also notes that counties with larger populations are more likely to see these gains; counties with more rural populations will have to rely on workers commuting in from other areas.

FIGURE 1. ESTIMATED PERCENT CHANGE IN WAGES AND EARNINGS FOR STUDIES REVIEWED



Notes: Asterisks indicate that a study analyzed wages. Those without asterisks studied earnings. Different shades of color indicate a range (e.g., Bartik et al. reported an impact of 4.4% to 6.9%).

Maniloff and Mastromonaco (2014) found that US counties with shale development had 6 percent higher wages than counties that did not. Boom counties (those in the top 25 percent of counties experiencing an increase in wells) had 10 percent higher wages than non–oil and gas producing counties. Allcott and Keniston (2014) find that resource booms in the United States (both the recent boom in unconventional gas and tight oil and the oil boom of the 1970s and early 1980s) that increase national oil and gas employment by 100 log points increase relative earnings per worker by 1.79 percent for counties with one standard deviation of additional oil and gas endowment. Jacobsen (2015), analyzing nonmetropolitan areas (which, on average, comprise 12 counties) in the United States found that "boom" nonmetropolitan areas—those that experienced an increase of oil and gas extraction of $500 million or greater between 2006 and 2014—saw a 7 percent increase in wages in that time. Analyzing such large areas does not allow for analysis of local variation, which no doubt occurs during booms. Results comparing 2014 boom county outcomes to 2001 income saw even larger impacts—increases of 11.8 percent for income and 16.7 percent for wages.

Heterogeneity across counties and local areas is an important issue. Hardy and Kelsey (2015), analyzing Pennsylvania tax data from 2007 to 2010 for county residents, found that increases in total taxable income were the greatest for counties with high levels of shale development, 90 or more wells—which saw increases in taxable income of 6 percent compared to 8.1 percent decreases in counties without wells. Increases for rural counties were the greatest, at 21.6 percent in Tioga, 19.1 percent in Bradford, and 16 percent in Susquehanna. And O'Coonahern, Hardy, and

Kelsey (2014) found heterogeneity in changes to taxable income across counties depending on the level of Marcellus activity. Counties that had 90 or more Marcellus wells saw an increase in taxable income of 4.3 percent from 2007 to 2011, while counties with less development saw decreases. Counties with 10 to 89 Marcellus wells saw a decrease of 1.5 percent (less than the state average decrease of 4.4 percent) and those with 1 to 9 or no Marcellus wells saw decreases larger than the state average, of 6.3 percent and 8.1 percent, respectively. The study noted that Bradford and Tioga Counties saw average increases in taxable income of over 25 percent, and Susquehanna and Greene Counties saw increases above 12 percent. Miljkovic and Ripplinger (2016) analyzed employment and income changes from 1992 to 2014 in the Bakken region, where the impacts of unconventional oil and gas development have differed for a number of reasons (discussed in the employment section above). The study finds that wages increased in the oil and gas sector and to a smaller degree in other sectors of the economy (save for the agricultural sector). The oil and gas sector saw a 0.2 percent increase in wages for every new oil rig, while the rest of the economy saw an increase in wages of 0.01 percent for every new oil rig.

One study, Weinstein, Partridge, and Tsvetkova (2017), assessed income multipliers across counties throughout the lower 48 states, comparing counties in different regions as well as metropolitan and nonmetropolitan counties. The study found that an increase of a dollar in oil and gas earnings was associated with an increase in earnings of 30 cents in nonmetropolitan counties and 10 cents in metropolitan counties across all other industries. Brown, Fitzgerald, and Weber (2017) found a larger multiplier for royalty income of 1.52. Weinstein, Partridge, and Tsvetkova (2017), comparing this wage multiplier to the larger nonmetropolitan employment multiplier (in which each job created 0.5 extra jobs in nonmetropolitan counties), found "relatively little" of these earnings remain within counties (12). Furthermore, "as a share of direct energy earnings, the increase in total residential earnings beyond the direct energy earnings only equals 10 percent in nonmetro counties and actually declines by 13 percent in the metro sample" (Weinstein, Partridge, and Tsvetkova 2017, 22). The authors believe the reason why money does not stay within a county is due to the use of commuters in the industry. The authors also found that neighboring counties, particularly metropolitan counties, benefit from being adjacent to oil- and gas-intensive counties, with heterogeneity across plays.

Some studies find positive, but temporary, effects on income. Komarek (2016) found a temporary (about 3-year) increase in wages at the county level in Ohio, West Virginia, and Pennsylvania. Analyzing data from 2001 to 2013, the study found that in counties with at least 50 wells, wages grew in sectors such as construction (up to 52 percent) and retail (up to 10 percent), but returned to pre-boom levels by the fourth year of the initiation of fracking. DeLeire, Eliason, and Timmins (2014), analyzing the effect of an additional well on income in Pennsylvania from 2000 to 2010 found that a very small increase in income even for wells at the high end of the distribution for income effects—a well at the 90th percentile—caused a 1.12 percent increase in earnings. These income effects disappear over time. The authors believe this may be due to "slack" in the market following the recession and out-of-state workers looking for fracking jobs. Weinstein (2014) found that US boom counties (those with a 10 percent increase in oil and gas employment and at least 20 oil and gas workers) from 2001 to 2011 experienced an initial 7.2 percent increase in earnings, which decreased 1.23 percent each year; after about five years, the counties return to their original growth rates. The study found that neighboring counties receive a small boost in earnings as well.

These income benefits, however, are not unanimously supported by the literature. Paredes, Komarek, and Loveridge (2015) studied the effects of unconventional gas production in Pennsylvania in comparison with counties in New York (which banned fracking), and found only weak evidence that production increases local incomes in the long run, with such activities having minimal indirect or induced income effects within Pennsylvania counties. The authors of the study concluded that, despite substantial employment effects, income effects might be smaller because jobs are taken by out-of-county workers who spend incomes elsewhere, in addition to the fact that mineral rights may not necessarily be owned by local residents. Kelsey, Metcalf, and Salcedo (2012) found that county residents receive around 60 percent of leasing and royalty dollars from shale development in Pennsylvania counties experiencing Marcellus shale production, meaning much of the income is being spent outside the county, supporting some estimates of small impacts.

Furthermore, the prevalence of split estates—where mineral, or subsurface, rights are not owned by the same person who owns the surface property—could potentially dampen how much a region benefits from shale development, as the benefits of unconventional oil and gas development could potentially leave the local development area. Brown, Fitzgerald, and Weber (2017) analyzed county-level income effects of counties in 17 states where oil and gas production increased from 2000 to 2014 (accounting for 90 percent of onshore production in 2014) using data from 2.2 million private leases. Due to their methodology, some of the estimates include the effects of conventional oil and gas development, though the majority of the development analyzed is unconventional.

The study found that, by 2014, residents in the counties with the top quartile of well-count increases over the study period had $1,792 higher per capita incomes than residents in non-growth counties. Non-wage income (royalty income as well as other sources of income such as from rental properties) was responsible for more than two-thirds of the total income effect from extraction in 2014. According to their estimates, $1 in royalty income led to 52 cents in non-royalty income ($0.36 in additional wage income and $0.16 in non-wage non-royalty income) associated with additional wage income that results from increased demand for goods and services and non-wage income, such as investment. The extent of mineral rights ownership varied widely across counties, with some having nearly absentee ownership while some had nearly complete local ownership of mineral rights. Because royalties accounted for almost three-quarters of the income effects in this analysis, the extent of mineral rights ownership is key—counties with average mineral rights ownership had an income effect 2.5 times greater than counties with complete absentee mineral rights ownership. The input-output analysis of Kelsey et al. (2012) likewise found a large income effect related to royalties—with royalty income increasing 611 percent—and a smaller effect for wages, with this source of income increasing only 2.8 percent in Bradford county.

Brown, Fitzgerald, and Weber (2016), analyzing private lease data in 16 states in 2014, studied how mineral rights owners capitalize on the potential benefits. The study found that an increase in production, rather than negotiating higher royalty rates, was the main way homeowners could benefit from royalties and leasing. Doubling the estimated ultimate recovery of a typical well led to an increase of 1 to 2 percentage points in the royalty rate. The estimate implies a 6 percent to 11 percent increase from that original rate.

Like employment estimates, comparing income and earnings estimates across studies is difficult due to these varying treatment effects and methodologies. What is clear is that there is a generally positive impact on earnings and income, with other sectors sometimes seeing increases in wages as well, though the extent of these impacts varies substantially across studies. It is important to note that a few studies indicate that there is large variation in these impacts across local areas. Hardy and Kelsey's (2015) results show a significantly larger percentage impact in the more rural counties in Pennsylvania. More studies focusing on within-state or within-county variation would aid in painting a more accurate picture of how local areas are affected by shale development.

4. Long-Term Growth

While discussions of the economic impact of shale development often surround the short-term benefits of a boom (such as wage increases, immediate employment growth, and income from leasing and royalties), counties that develop natural resources, especially those that do so intensively, may experience negative economic impacts in the long run, quite apart from those stemming from a bust. These impacts can be summed up as the "resource curse."

Several studies have examined whether the curse exists and how large it might be (Allcot and Keniston 2013; Haggerty et al. 2014; Weber 2014; Brown 2014; Maniloff and Mastromonaco 2014; Tsvetkova and Partridge 2015; and Komarek 2016). With a resource curse, economies experience decreased long-run growth and worse development outcomes than they otherwise would without developing natural resources (Kelsey, Partridge, and White 2016). These impacts are often studied in the context of a country's economy, yet similar concepts can apply to local economies as well. There are many explanations offered for why countries or regions could become worse off, ranging from poor handling of revenues to dependence on a volatile energy sector.

Kelsey, Partridge, and White (2016), a paper discussing policy issues related to unconventional oil and gas development, is one of many papers that discusses the potential causes of such an effect. The boom and bust cycle itself can deter businesses in other sectors due to increased risks and volatility. Additionally, natural resource development may lead an economy to be less diverse than it otherwise would be for various reasons, though other sectors may simply be crowded out due to the increase in labor and land costs during booms. One specific form of crowding out, called "Dutch disease," can occur when increased labor costs due to higher wages cause the tradable goods sector to become less competitive in export markets, in part due to a strengthening local currency. Long-term specialization can lead to weaker economic outcomes, though the effect on national economies has been better studied than the local effects (Haggerty et al. 2014). Even educational outcomes can suffer through labor competition with the public sector.[5]

The findings from the literature covering these issues specifically in the context of oil and gas development are mixed. Several studies find no evidence of a resource curse. Allcott and Keniston (2014; also discussed in the section on overall community welfare, above) is one of the most comprehensive Dutch disease/resource curse studies due to its temporal breadth—analyzing booms and busts from 1969 through the unconventional oil and

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gas development boom of 2014—as well as the variety of metrics used to assess long-term local welfare and economic impacts. The authors, though they found a necessary condition for Dutch disease (wages rise during booms), did not find evidence of a resource curse. Manufacturing is not crowded out, and grows during booms and contracts during busts. Total factor productivity is likewise pro-cyclical with booms, a change driven by locally traded subsectors with upstream or downstream links to oil and gas development. And though metrics such as wages, employment, and population increase with booms, they also decrease with busts, but remain net neutral in the long term (as noted above).

Weber (2014), studying non-metropolitan counties in Arkansas, Louisiana, Oklahoma, and Texas, found that the increases in population mitigated an increase in earnings per job and crowding out; additionally, population changes did not result in a less educated population. Such changes were able to mitigate the development of a resource curse in these counties.

Komarek (2016) also did not find evidence of Dutch disease—while wages and employment in Ohio, West Virginia, and Pennsylvania counties with 50 or more wells increased in the three years following the start of fracking, wages in manufacturing did not rise and employment in the sector was not crowded out. This finding would indicate that the cost of production has not increased and the sector is therefore not less competitive. Weber (2014), on the other hand, posits that the increased labor costs and the resulting crowding-out effects could be offset by increases in population in nonmetropolitan counties in Arkansas, Louisiana, Oklahoma, and Texas. Miljkovic and Ripplinger (2016), analyzing employment and wage impacts of unconventional oil and gas development in the Bakken region, did not find evidence of a Dutch disease effect on agriculture, the dominant sector in the area. The authors posit that the sector may have been unaffected for several reasons. Agricultural sector labor is not directly substitutable with that of the energy sector, and the low unemployment rate in the region as well as the migration of oil and gas workers from other regions have dampened this effect.

Weinstein, Partridge, and Tsvetkova (2017) noted no evidence of Dutch disease in their findings on sectoral impacts of the recent oil and gas booms in counties in the lower 48 states, but the authors noted that the three-year delay in the analysis is likely not enough time to assess the long-term impacts of unconventional oil and gas development on long-term economic outcomes. The authors caution of negative impacts during a bust:

"Given the pronounced cycle-like development of the energy sector, the benefits from the recent boom are likely to disappear as the cycle goes into a bust, leaving many communities suffering economically, especially in remote and rural areas that lack alternative engines of growth. Our analysis suggests that overreliance on the oil and gas industry in economic development might be detrimental to future growth prospects. A more holistic approach that targets a multitude of industries appears to be more likely to yield sustainable positive results" (Weinstein, Partridge, and Tsvetkova 2017, 15).

Other studies, however, found evidence supporting a resource curse. While Maniloff and Mastromonaco (2014) did not find evidence of a possible resource curse in most regions of the United States, the authors did find that manufacturing wages jumped in the Census Bureau's Mid-Atlantic (containing Pennsylvania) and West North Central (containing North Dakota and Kansas) census divisions, which had low levels of unemployment in the oil and gas sector prior to the boom in unconventional oil and gas development. The increased wages can negatively impact the businesses in this area that are not related to oil and gas extraction, as these firms become less competitive due to increased costs. This study, however, conducted its analysis of sectoral impacts at too broad a geographic level to be useful in looking for community impacts. Tsvetkova and Partridge (2017) find that oil and gas development tends to crowd out local self-employment and entrepreneurship, particularly in more rural areas.

DeLeire, Eliason, and Timmins (2014) exploited temporal variation in development activity to analyze the heterogeneous effects of fracking in Pennsylvania from 2000 to 2010 and found the potential for Dutch disease—though these findings do not necessarily prove it has occurred. The authors found that at the time of drilling, a well has no effect on employment in the manufacturing sector, but two years out estimated a loss of 5.7 jobs in manufacturing (a necessary condition for Dutch Disease). Assessing heterogeneity within the impacts of fracking, the study finds a small but positive effect on manufacturing wages (the second necessary condition) for wells at the 75th and 90th percentiles of distribution (of income effects). Due to the nature of the analysis, the authors cannot say that these two effects occur in the same county, meaning the potential for Dutch disease cannot be proven or disproven in this study. Weinstein (2014) likewise found evidence of the potential for a resource curse. The study found that crowding out is not occurring in the tradeable goods sector, but the increase in wages in that sector could indicate longer-term impacts. Additionally, the initial positive employment and earnings shocks in boom counties decrease in the years following, and could evidence a resource curse if these indicators continue to decrease past the original employment and earnings levels.

Haggerty et al. (2014) found evidence supporting the existence of a resource curse as well as diminishing benefits over time studying the county-level impact of overall oil and gas development from 1980 to 2011 in Colorado, Montana, New Mexico, North Dakota, Utah, and Wyoming. This study takes a unique approach to measuring long-term impacts: one variable of interest is the sum of the number of years from 1980 to 2011 in which a county experienced above-average personal income from oil and gas production. The authors found that long-term oil and gas specialization has negative effects on the change of per capita income, crime, and educational outcomes. If one county with 8.1 percent of income from oil and gas production (a high level) continued to experience above-average income from oil and gas production for 10 years longer than another otherwise-similar county, it would see a $340 to $7,000 lower per capita income from 1980 to 2011 than what it would experience without the extra 10 years of high levels of oil- and gas-related income. These findings question whether, following the initial benefits such as income windfalls and employment increases, localities continue to benefit from resource extraction in the long run.

Though James and Aadland (2011), studying US counties from 1980 to 1995, focused their analysis in a period prior to the shale boom, their county-level analysis of resource extraction dependence can elucidate aspects of shale development and its potential trajectory in the long run. The authors found that an increase of 1 percentage point in “natural resource specialization” reduced real income per capita by 0.02 percentage points. The authors argue that though this metric may appear small, applying it to a county’s growth over time can yield economically significant results. Applying this number by comparing two counties—one receives 1 percent of its income from natural resources (similar to a 1980 Maine county) and another receives 25 percent of its income from natural resources (like 1980 Wyoming counties)—the resource-intensive county would see 0.5 percent less growth than the other. With an average growth rate across counties in the study of 1.3 percent, the resource-intensive county would see 0.8 percent growth. Assuming both counties begin with a $20,000 per capita income, after 25 years, the Wyoming-like county would see about $3,200 less in per capita income. Over longer periods, the differences compound, though these effects decrease over time.

Tsvetkova and Partridge (2015) also estimate longer-term impacts in addition to analyzing sectoral impacts, finding more mixed results depending on sector and time frame. This study looked at counties throughout the United States, analyzing the impacts of oil and gas shocks on 1-, 3-, 6-, and 10-year time periods for various sectors in addition to comparing these results to equal-sized shocks in other parts of the economy. The study finds that growth in oil and gas employment has positive impacts on total county employment, which increases up to 6-year horizons, where it peaks and continues to decrease thereafter in nonmetropolitan counties. For these counties, the study also found a stimulating effect on non-traded goods employment for the longer horizons. The results also suggest that the average metropolitan county lost about 0.3 jobs in other sectors for each additional energy job. These employment effects from energy booms, however, are estimated to be smaller than those of equal-sized shocks in the rest of the economy, leading the authors to conclude that counties would benefit more from diversified development. The authors also found some evidence of crowding out for employment in traded goods in the long run for non-metropolitan areas, which provides some evidence for a Dutch disease effect.

Studies that include temporal analysis are better suited to address questions regarding the impacts of oil and gas development on economic growth issues, as short run impacts may not be indicative of net impacts over longer time periods. Both Tsvetkova and Partridge (2015) and Haggerty et al. (2014) studied these long-run impacts directly. Though the studies conducted different analyses and reported differing results, they both show that impacts are heterogeneous over time, and Tsvetkova and Partridge found that impacts are heterogeneous according to the sector within and metropolitan status of a county.

Overall, the varying results of this literature on long-run economic development show that outcomes are heterogeneous over locations and time. The reason for these inconsistent outcomes is possibly related to the large number of socioeconomic variables that affect resource dependence locally as well as the difficulty inherent in measuring resource dependence on a local level, an outcome that is less concrete than, say, a change in employment. This literature reports conflicting evidence for the resource curse related to earlier oil and gas booms as well, though with more time the longer term effects of shale development may become more clear.

Literature not specific to shale development argues that the potential for a resource curse can be mitigated through a slower pace of development and increased diversification (Stevens 2003; Christopherson and Rightor 2012), and some studies assessing other oil and gas booms in the United States, such as Freeman (2009), did find negative longer-term impacts. These findings imply that some regions may, to some extent, be exposed to the potentially negative long-term consequences of resource development booms—the economic impacts can therefore not be assumed to be entirely positive for an area given this (albeit mixed) evidence of a resource curse in the current context of the unconventional oil and gas boom.

5. Conclusion

Economic impacts are one of the more well-studied subjects in terms of the various local impacts of unconventional oil and gas development. While the results of the fracking boom on natural gas and electricity prices, for instance, are easy to see at the national or regional level, it is more difficult to sort out the economic effects locally. And it is easy to develop stories about how overall economic impacts can be positive or negative both in the short and long runs. Fortunately, the literature is relatively united in showing that short-run benefits to wages, jobs, and economic development are significant during a boom and overall that concerns about a resource curse (quite apart from a bust) are probably small. Nevertheless, the newer statistically based employment studies show that many of the earlier impact study estimates of employment opportunities taken from input-output studies were overblown, although there is a relatively wide variation in estimates of wage impacts among statistical studies. Overall, the literature shows the economic benefits of unconventional oil and gas development to be positive.

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