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Shale gas production and labor market trends in the U.S. Marcellus–Utica region over the last decade

The advent of unconventional oil and natural gas production in the United States, made possible by improvements in horizontal drilling and hydraulic fracturing technologies in recent years, has increased total dry natural gas production. This article analyzes trends in shale gas production and labor market data in the Marcellus–Utica region, which consists of Ohio, Pennsylvania, and West Virginia, where much of the increase in U.S. natural gas production has occurred. Production data are analyzed at both the county and state level, whereas labor market data are primarily analyzed at the state level, examining metrics such as employment, number of establishments, and wages. This article also addresses several questions regarding shale gas production and labor market trends of the Marcellus–Utica region, as well as the size of shale gas industries in relation to the overall economy.

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The maturation of unconventional technologies in the United States for resource development has led to a renaissance in domestic oil and natural gas (O&G) production. Improved O&G resource development requires supporting infrastructure and utilization options, such as power generation, ethane crackers, and polyolefin plants, which spur additional employment within a region. The advent of unconventional O&G production in the United States in recent years, made possible by improvements in horizontal drilling and hydraulic fracturing technologies,[1] increased total dry natural gas production from 19.3 trillion cubic feet (Tft^3) in 2007 to 26.5 Tft^3 in 2016, an overall increase of 7.2 Tft^3.[2] During the same period, U.S. shale gas production increased by 14.5 Tft^3, from 1.3 Tft^3 to 15.8 Tft^3.[3] A larger increase in shale gas production than in total dry natural gas production implies that without the advent of shale gas production, overall U.S. natural gas production would have declined during the last decade.

Much of the growth in U.S. natural gas production has occurred in the Marcellus and Utica shale plays in Ohio, Pennsylvania, and West Virginia (also known as the Marcellus–Utica region), with shale gas accounting for most of the increase. This article analyzes trends in shale gas production and labor market data in Ohio, Pennsylvania, and West Virginia, the three states with active Marcellus and Utica production and drilling over the last decade. Production data are analyzed at both the county and state level, whereas labor market data are primarily analyzed at the state level, examining metrics such as employment, number of establishments, and wages. This article addresses a number of key questions regarding the Marcellus–Utica region, such as What proportion of natural gas production does shale gas production represent? The article also examines questions concerning recent trends, such as How much has shale gas production grown over the last decade? and How has growth in shale gas industry labor metrics compared with growth in other industries? A comparison between salaries in shale industries and other industries is also made. Another area examined includes the correlation between trends in labor market metrics with shale gas production and short-term trends that departed from overall decade-long trends.

Data and terminology

The analysis in this article uses available 2007–16 annual data at the county, state, and national levels, with most analysis occurring at the state level. At the state and county levels, Ohio, Pennsylvania, and West Virginia shale gas production data for 2016 were sourced from the Pennsylvania Department of Environmental Protection (DEP),[4] the Ohio Department of Natural Resources,[5] and the West Virginia DEP.[6] U.S. Energy Information Administration (EIA) shale gas and natural gas production data at the state and national level were used in the analysis for 2007–16, with the exception of Ohio, Pennsylvania, and West Virginia 2016 shale gas production data, which are sourced from the respective state agencies noted in the previous sentence.

State-level and county-level data on employment, number of establishments, total wages, and average annual pay (i.e., wages) in the Marcellus–Utica region were taken from the U.S. Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages database.[7] The U.S. Bureau of Economic Analysis (BEA) implicit gross domestic product (GDP) price deflator (annual) is used to convert total wage and average annual pay data to real 2016 dollars.[8]

The annual spot price data of Henry Hub natural gas are sourced from EIA.[9] Annual spot prices of Dominion South, however, are calculated based on S&P Global Market Intelligence monthly data and converted from dollars per million British thermal units to dollars per thousand cubic feet (kft^3) with the use of an EIA conversion factor.[10] The annual average natural gas spot price of Dominion South is calculated by averaging the monthly price over the year. Annual natural gas spot prices of Henry Hub and Dominion South are converted to real 2016 dollars with the use of the BEA Implicit GDP Annual Price deflator.[11]

Unless otherwise stated, all dollar figures in this article are in real 2016 dollars. State-level GDP data are sourced from the BEA Regional Economic Accounts.[12] Occupational statistics come from the BLS Occupational Employment Statistics program.[13] The current article refers to shale gas-related industries as “shale industry” or “shale industries” throughout and defines the shale industry using the following North American Industry Classification System (NAICS) codes:[14]

- O&G extraction (NAICS 211)

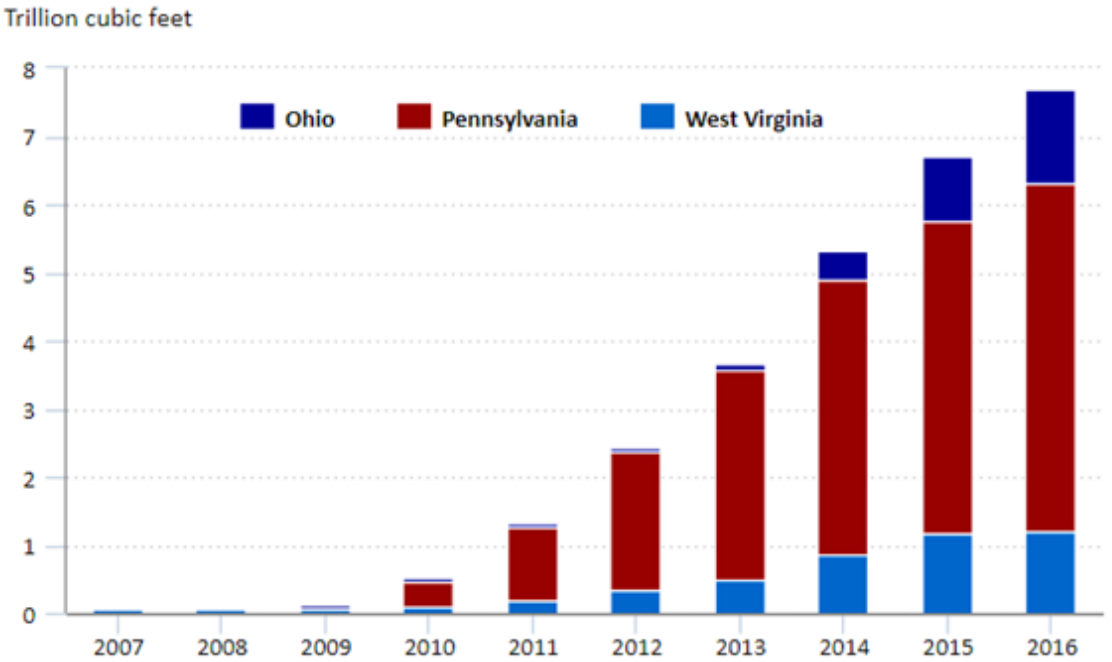
- Drilling O&G wells (NAICS 213111)
- Support activities for O&G operations (NAICS 213112)
- O&G pipeline construction (NAICS 23712)
- Pipeline transportation of natural gas (NAICS 4862)

“All industries” or “all industry” includes every industry in a region’s economy, regardless of whether it is a shale industry. One study lists 30 ancillary shale gas industries (e.g., petrochemical manufacturing). However, ancillary shale gas industries are not examined in this article.[15] The term “establishment” is defined as the “physical location of a certain economic activity” (e.g., a mine or office).[16] A private company may consist of more than one establishment.

Production

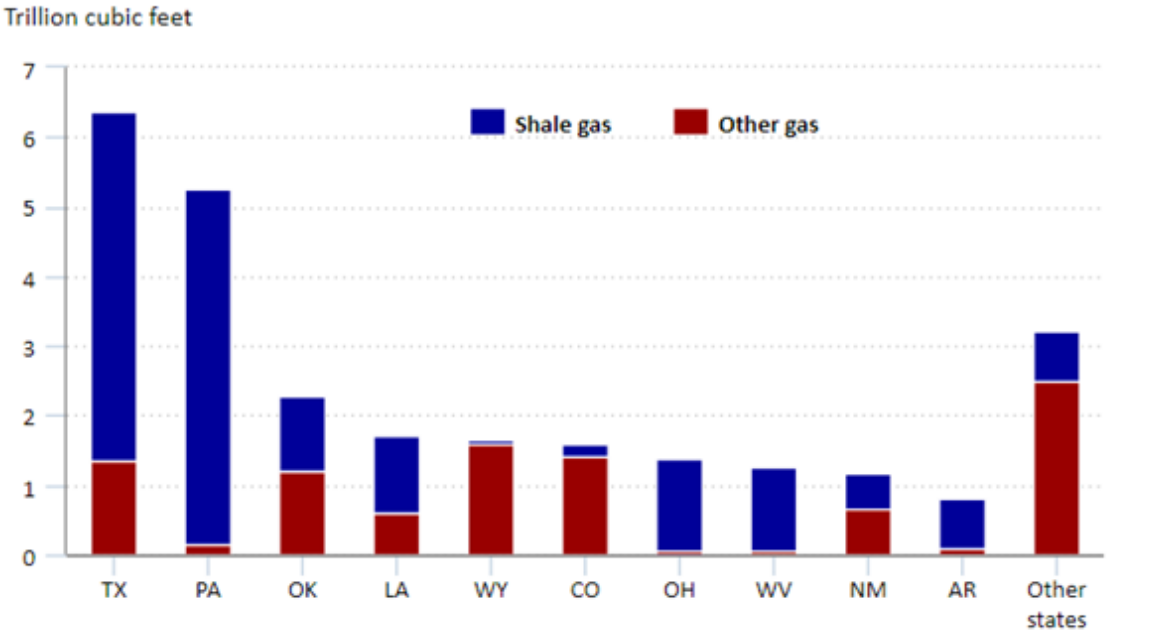
The recent growth in shale gas production in the Marcellus–Utica region is portrayed in figure 1. In 2007, shale gas production was 0.001 Tft^3 in Pennsylvania, with West Virginia production beginning in 2009 and Ohio production beginning in 2012 (0.014 Tft^3). Pennsylvania (4.6 Tft^3) overtook Texas (4.4 Tft^3) as the leading state in U.S. shale gas production in 2015. By 2016, Pennsylvania shale gas production had grown to 5.10 Tft^3, compared with 1.21 Tft^3 in West Virginia and 1.39 Tft^3 in Ohio. Figure 2 depicts the top 10 states in overall 2016 natural gas production and provides a breakout of total gas production into shale gas production and all other production. In 2016, shale gas production accounted for over 90 percent of natural gas production for each of the three states in the Marcellus–Utica region.

Figure 1. Marcellus–Utica state-level shale gas production, 2007 through 2016 (in trillion cubic feet)



Click legend items to change data display. Hover over chart to view data.
Note: Details may not sum to total because of rounding.
Sources: U.S. Energy Information Administration, Pennsylvania Department of Environmental Protection, West Virginia Department of Environmental Protection, and Ohio Department of Natural Resources.

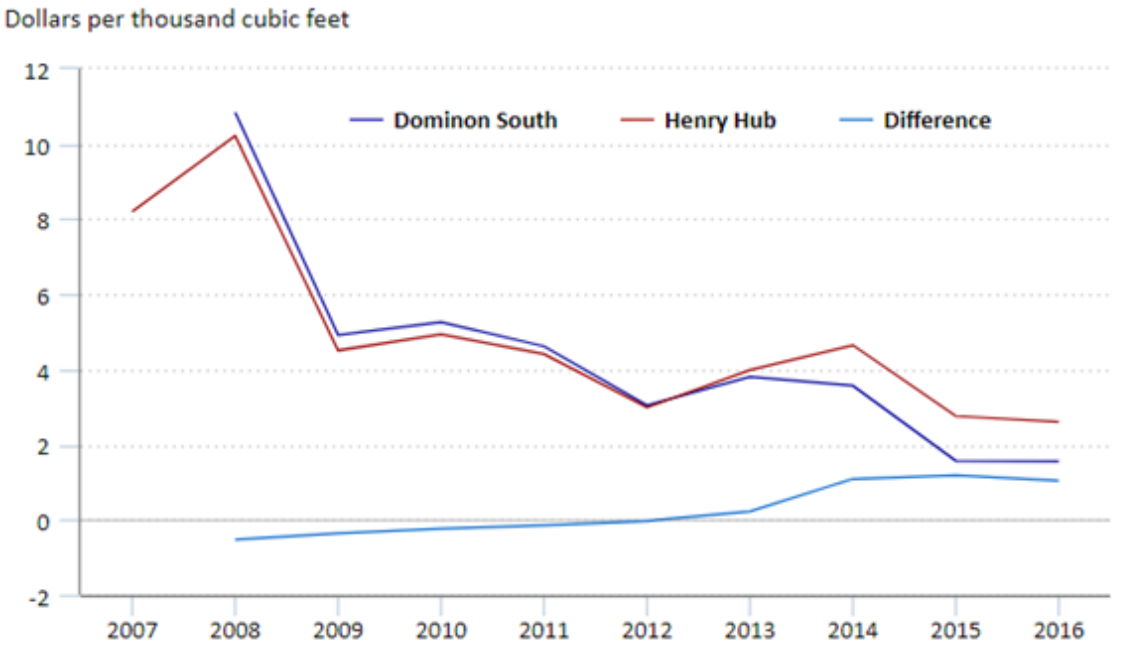
Figure 2. Dry natural gas production by top-10-producing states (in trillion cubic feet), 2016



Click legend items to change data display. Hover over chart to view data.
Note: TX = Texas, PA = Pennsylvania, OK = Oklahoma, LA = Louisiana, WY = Wyoming, CO = Colorado, WV = West Virginia, NM = New Mexico, AR = Arkansas.
Sources: U.S. Energy Information Administration, Pennsylvania Department of Environmental Protection, West Virginia Department of Environmental Protection, and Ohio Department of Natural Resources.

The value of 7.69 Tft^3 of total shale gas production in Ohio, Pennsylvania, and West Virginia in 2016 is estimated at $12 billion based on the Dominion South natural gas spot price average of $1.56 per thousand cubic feet (kft^3). (See figure 3.) This $12 billion compares with the combined GDP of $1.424 trillion (current dollars) of these three states in 2016. This result suggests that the direct value of shale gas production was about 0.84 percent the size of the overall economy of these states. One should note that prices could substantially vary within a region, depending on contract terms and the market in which the gas is sold. The Dominion South price has recently been lower than the national benchmark (Henry Hub) spot price; in 2016, the Henry Hub spot price averaged $2.61/kft^3 (figure 3).[17]

Figure 3. Spot price comparison (in real 2016 dollars per thousand cubic feet) of natural gas: Henry Hub versus Dominion South, 2007–16

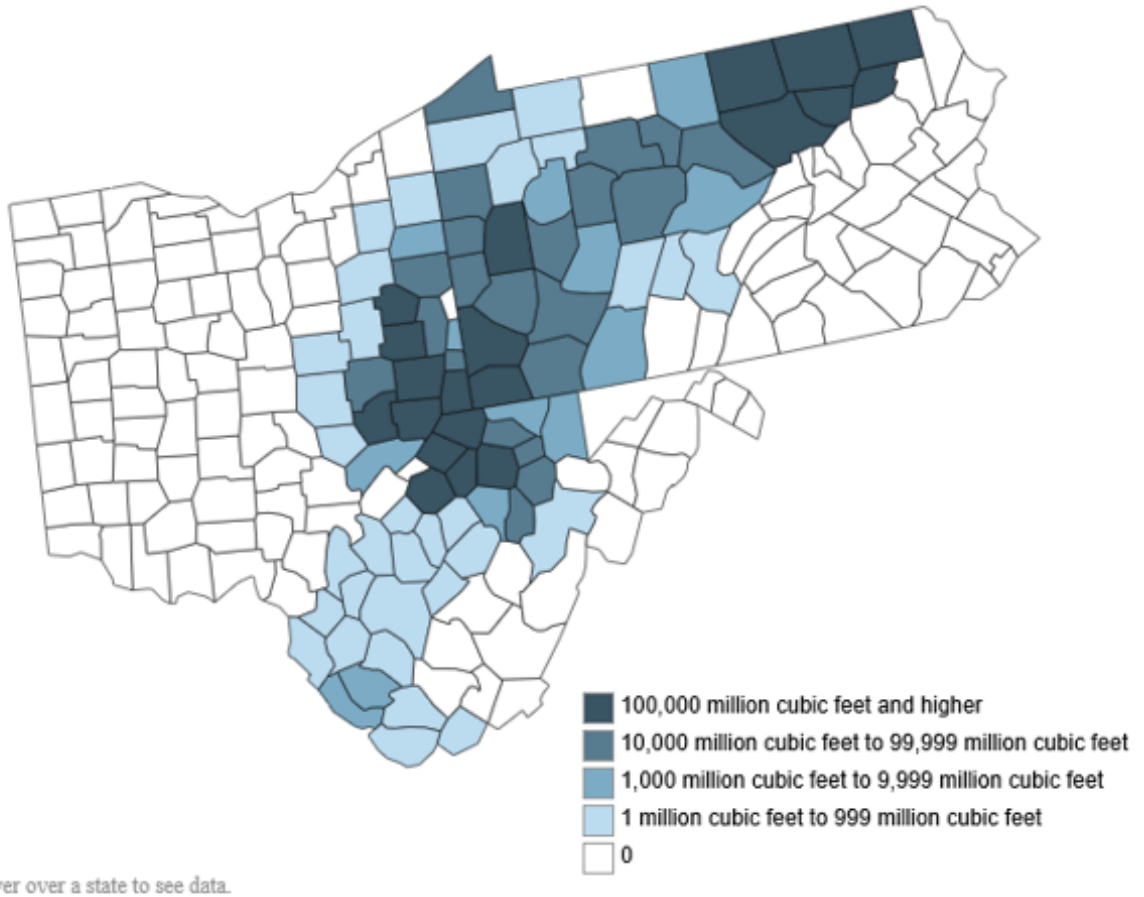


Click legend items to change data display. Hover over chart to view data.
Note: Data of Dominion South were not available until mid-2007 year. Therefore, calculations begin with 2008 to prevent calculation based on a partial year.
Sources: U.S. Energy Information Administration, U.S. Bureau of Economic Analysis, and S&P Global Market.

Both the Marcellus and Utica plays are major contributors to shale gas production. For instance, according to EIA, total monthly November 2016 natural gas production was 0.55 Tft^3 in the Marcellus region and 0.12 Tft^3 in the Utica region.[18]

As figure 4 shows, 2016 shale gas production varies widely by county within the Marcellus–Utica region. Of the 210 counties in the three states, 124 did not produce shale gas in 2016. Of the 86 shale gas-producing counties, 20 produced over 100,000 million cubic feet (Mft^3) (or 0.1 Tft^3). The four largest producing counties were all in Pennsylvania, with each producing over 500,000 Mft^3 (or 0.5 Tft^3) of shale gas.

Figure 4. Marcellus–Utica shale gas production of Ohio, Pennsylvania, and West Virginia by county in 2016 (in million cubic feet)



Hover over a state to see data.
Hover over legend items to see states in a category.
Sources: Pennsylvania Department of Environmental Protection, West Virginia Department of Environmental Protection, and Ohio Department of Natural Resources.

Employment

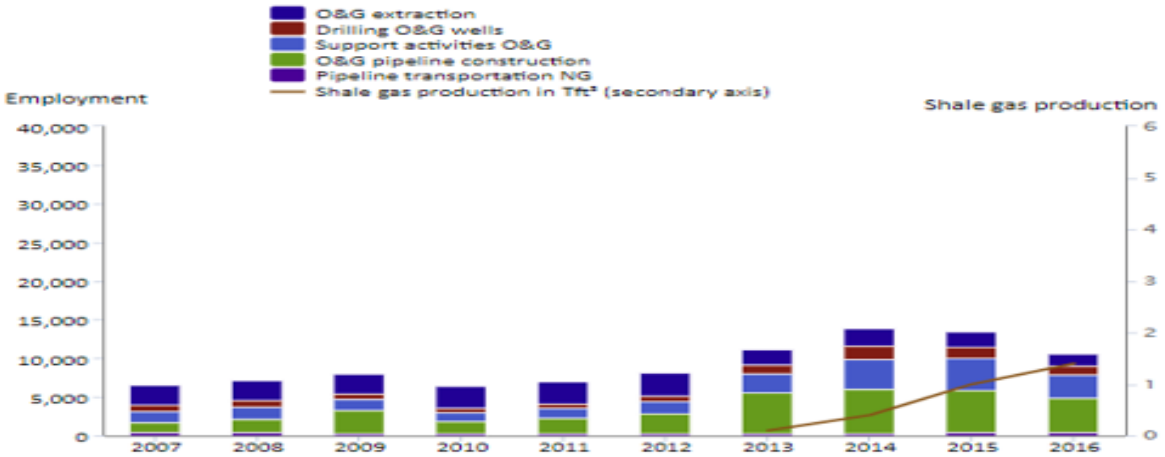
Employment data in industries directly associated with shale gas production in the Marcellus–Utica region were examined. The employment data, which include information on full-time, part-time, temporary, and permanent employees, are estimated from quarterly contribution reports filed by most U.S. employers.[19]

Analysis in the remainder of this article is done at the state level. Data at the state level are more likely to meet BLS or state agency disclosure standards than data at the county level.[20] Importantly, note that the nondisclosure of county-level data does not prevent an accurate total at the state level.

Employment in shale industries over the 2007–16 period is plotted against shale gas production (figure 5). The number of employees in the region employed in shale industries increased by 80 percent since 2007, which outpaced the 1.5-percent growth seen for the average of all industries in the region. From 2007 to 2016, overall growth in shale gas production was largest in Pennsylvania, while Ohio slightly outpaced West Virginia production in 2016 (figure 1). The same state rank order applies for employment as it does for shale gas production (figure 5). Over the last decade, Pennsylvania led employment growth in the shale industry, growing 121 percent from 2007

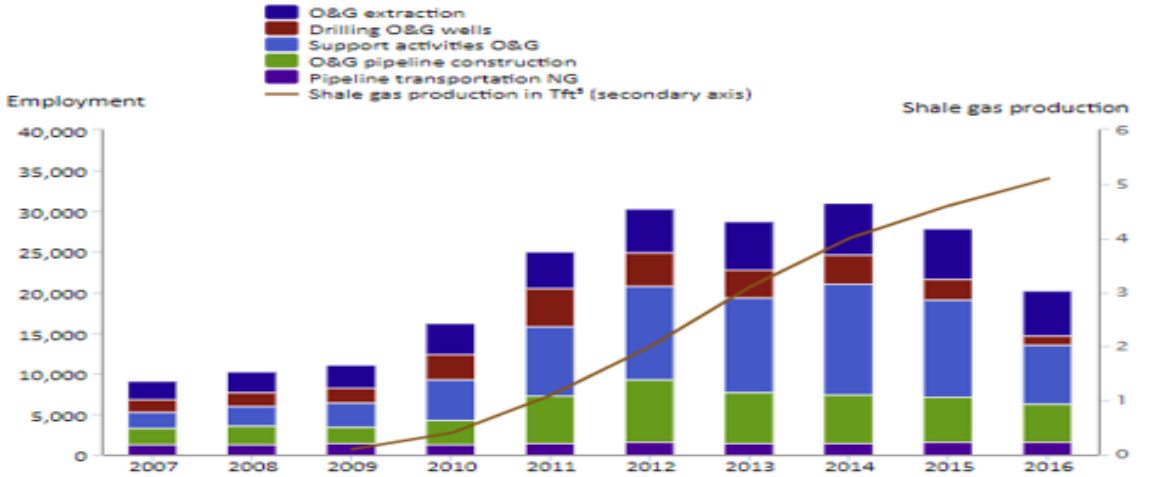
to 2016, while Ohio employment in shale industries grew 62 percent over the last decade, compared with West Virginia's 41-percent growth.[21]

Figure 5a. Employment by industry versus shale gas production (in trillion cubic feet [Tft³]), Ohio, 2007–16



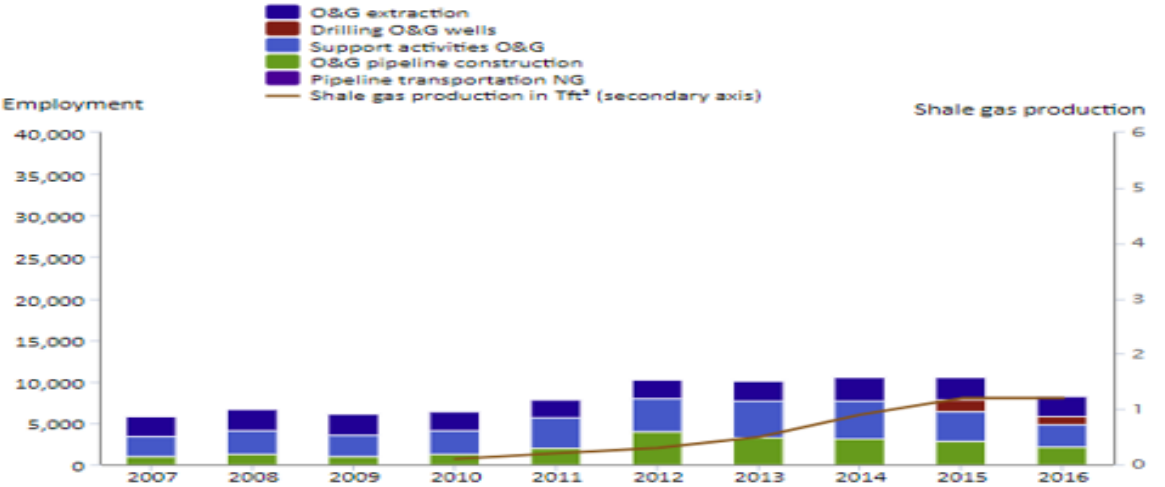
Note: NG = natural gas and O&G = oil and natural gas.
Click legend items to change data display. Hover over chart to view data.
Sources: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages; U.S. Energy Information Administration; and Ohio Department of Natural Resources.

Figure 5b. Employment by industry versus shale gas production (in trillion cubic feet [Tft³]), Pennsylvania, 2007–16



Note: NG = natural gas and O&G = oil and natural gas.
Click legend items to change data display. Hover over chart to view data.
Sources: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages; U.S. Energy Information Administration; and Pennsylvania Department of Environmental Protection.

Figure 5c. Employment by industry versus shale gas production (in trillion cubic feet [Tft³]), West Virginia, 2007–16

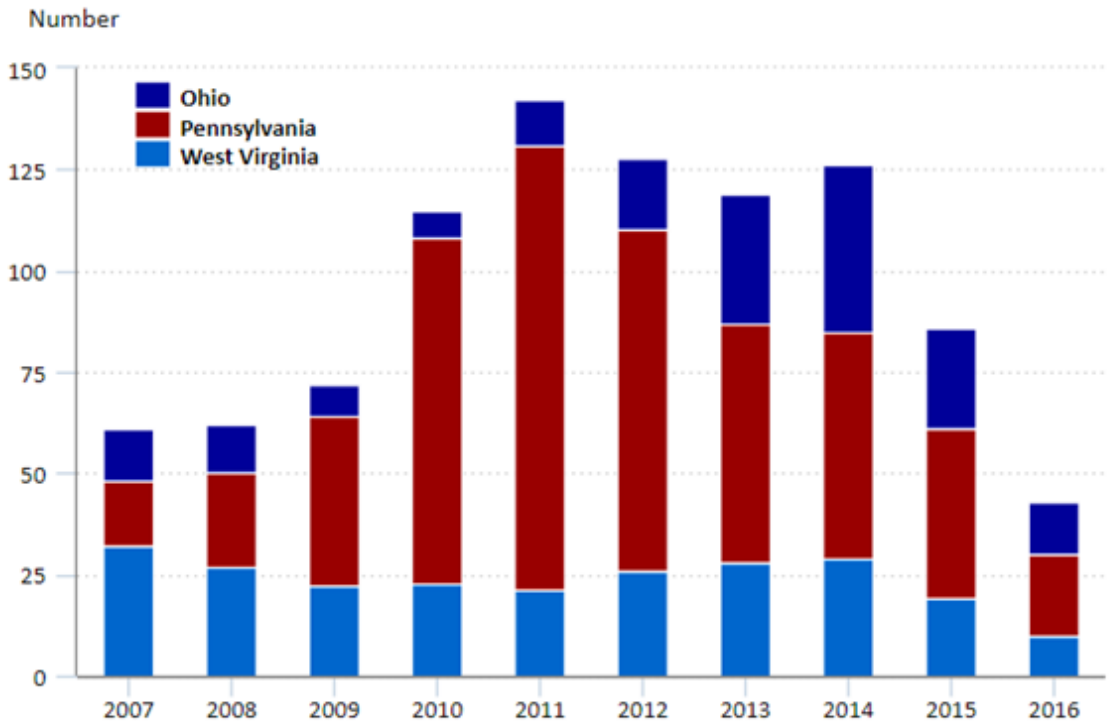


Note: NG = natural gas and O&G = oil and natural gas.
Click legend items to change data display. Hover over chart to view data.
Sources: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages; U.S. Energy Information Administration; and West Virginia Department of Environmental Protection.

In Pennsylvania, both shale gas production and employment in shale industries increased through 2014. However, while employment in these industries subsequently declined 35 percent since 2014, shale gas production continued to increase in 2015 and 2016. Shale industry employment of West Virginia saw most of its growth from 2010 to 2012. Then from 2012 to 2015, employment leveled off before falling in 2016. Shale gas production, however, trended upward from 2010 to 2016. (Note that West Virginia shale employment may have peaked between 2012 and 2014, because employment data of drilling O&G wells were not disclosed for West Virginia until 2015.) In Ohio, both shale gas production and shale employment increased from 2012 to 2014. However, the two metrics moved in opposite directions in 2015 and 2016 (figure 5), with shale employment falling 23 percent.

Continued low natural gas prices may have had a downward effect on employment. For instance, the real average annual price of Henry Hub natural gas reached $10.2/kft^3 in 2008 but has not exceeded $4.70/kft^3 annually since 2010. In addition, the price more recently fell from $4.65/kft^3 in 2014 to $2.61/kft^3 in 2016 (its lowest annual level during the last decade).[22] The Dominion South spot price has plummeted more quickly than the Henry Hub in recent years (figure 3). The timing of the employment decline over the last 2 years appears to be in line with the recent drop in the number of rotary rigs in each of the states (figure 6), with the number of rigs in the three states declining 66 percent from 2014 to 2016.[23]

Figure 6. Average number of rotary rigs by state, 2007 through 2016



Click legend items to change data display. Hover over chart to view data.
Source: "North America rig count" (Baker Hughes, 2017).

Employment in shale industries for these three states was 39,076 in 2016. During 2016, combined private sector employment in the three states was 10.2 million. This result implies that these shale industries made up about 0.4

percent of overall employment in the Marcellus–Utica region. Keep in mind that most counties in the region do not produce shale gas (figure 4).

Regarding the decade-long employment trend (2007–16) in shale industries in these states, two outliers are noticeable in figure 5:

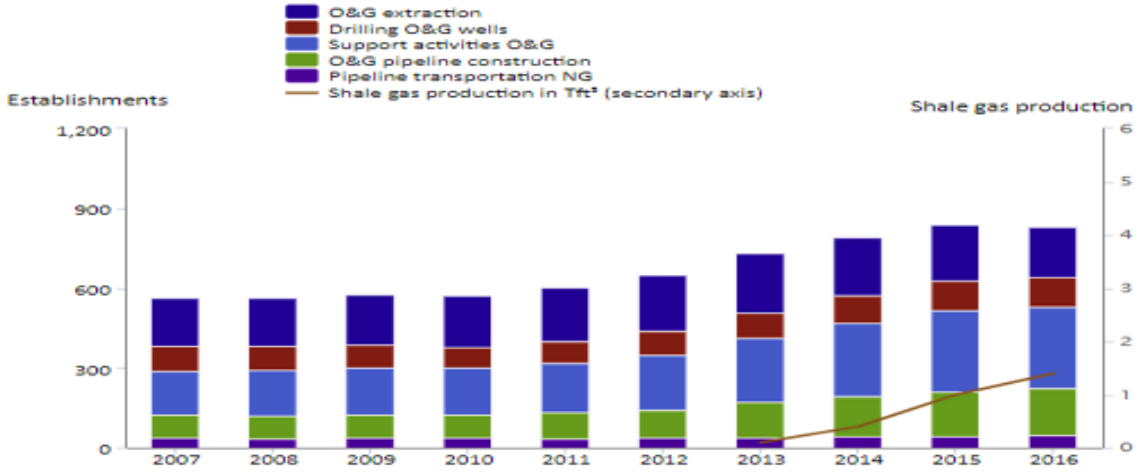
Outlier 1: Ohio employment in the O&G extraction (NAICS 211) industry decreased 36 percent from 2007 to 2016. According to an Ohio report, in 2013, some establishments were reclassified to a different industry after a review of classifications.[24] This reason seems likely, given that shale gas production in Ohio had just begun to occur during the 2012–13 period and that employment in other shale industries in Ohio increased during the same period. The timing of the reclassification is consistent with the observation that Ohio O&G extraction employment peaked in 2012 at 3,086 employees, with employment falling to 2,002 the following year in 2013. BLS provides several possible reasons for major changes in employment and wages, including changes in the dominant economic activity of an establishment, as well as multiunit employers changing to reporting as multiple units after reporting as a single unit in previous years.[25]

Outlier 2: Pennsylvania employment in the drilling O&G wells (NAICS 213111) industry declined 21 percent from 2007 to 2016. From 2015 to 2016, employment in this industry declined for each of the three states, with Pennsylvania showing the largest year-over-year decline. The timing of the decline from 2015 to 2016 in employment appears to be consistent with the continued decline in the number of rotary rigs in the state.[26] During this time, continued low (and falling) natural gas prices may have had a downward effect. In addition, employment declined 19.5 percent in the industry from 2012 to 2013, which would be consistent with the potential reclassification of industries.[27]

Number of establishments

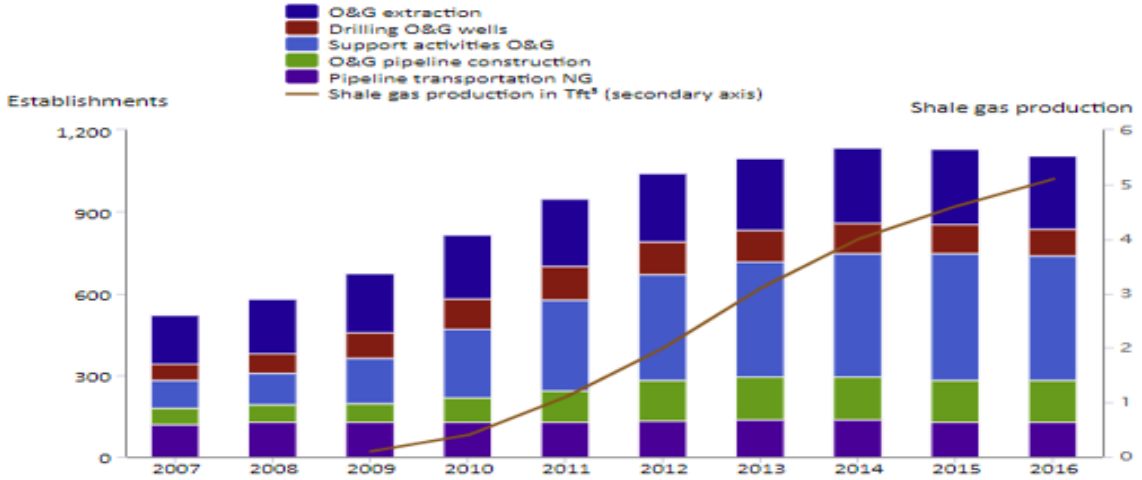
The number of shale establishments in the region over the 2007–16 period is plotted against shale gas production (figure 7). This number increased 62 percent over the last decade, outpacing the growth in all industries in the region, which totaled 3 percent. However, the number of shale establishments trended downward in the last year. Also worth noting, unlike the employment data, no state-level observations occurred for which data were not disclosed.

Figure 7a. Number of establishments by industry versus shale gas production (in trillion cubic feet [Tft³]), Ohio, 2007–16



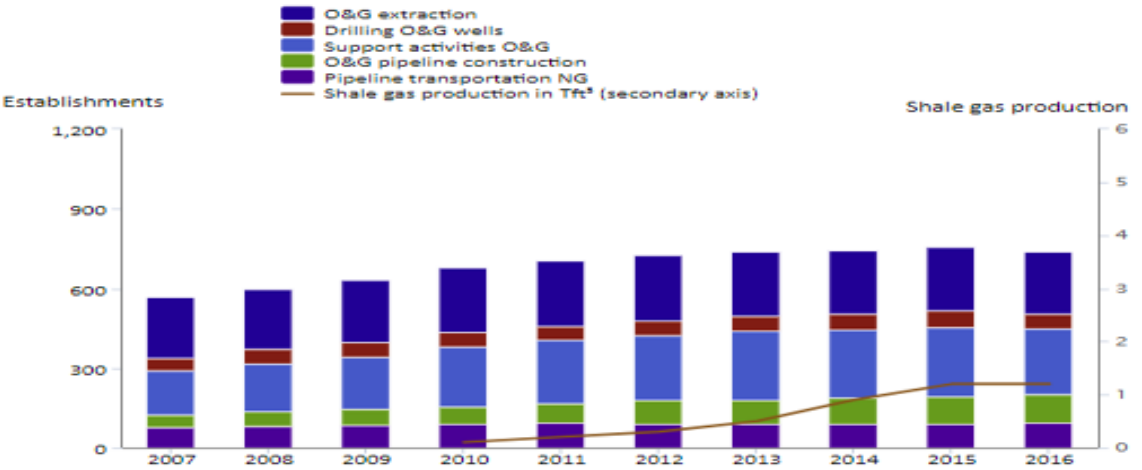
Note: NG = natural gas and O&G = oil and natural gas.
Click legend items to change data display. Hover over chart to view data.
Sources: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages; U.S. Energy Information Administration; and Ohio Department of Natural Resources.

Figure 7b. Number of establishments by industry versus shale gas production (in trillion cubic feet [Tft³]), Pennsylvania, 2007–16



Note: NG = natural gas and O&G = oil and natural gas.
Click legend items to change data display. Hover over chart to view data.
Sources: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages; U.S. Energy Information Administration; and Pennsylvania Department of Environmental Protection.

Figure 7c. Number of establishments by industry versus shale gas production (in trillion cubic feet [Tft³]), West Virginia, 2007–16



Note: NG = natural gas and O&G = oil and natural gas.
Click legend items to change data display. Hover over chart to view data.
Sources: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages; U.S. Energy Information Administration; and West Virginia Department of Environmental Protection.

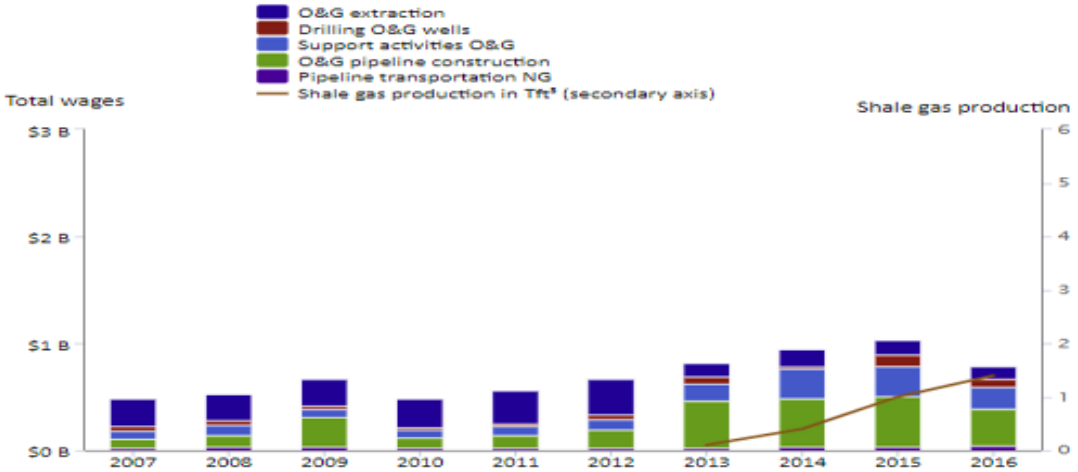
In 2016, the total number of shale establishments was higher in Pennsylvania than either Ohio or West Virginia. Pennsylvania also experienced the most growth, with the number of establishments more than doubling over the last decade, reaching a peak level in 2014, while the other two states peaked in 2015. In Pennsylvania, both shale gas production and number of shale establishments increased through 2014. However, although the number of shale establishments fell 2.5 percent since 2014, shale gas production continued to increase in 2015 and 2016. The number of West Virginia shale establishments grew through 2015, before declining in 2016. Shale gas production, on the other hand, trended upward from 2010 to 2016, but production appeared to slow in growth from 2015 to 2016, growing 4 percent year over year. In Ohio, both shale gas production and the number of shale establishments increased from 2012 to 2015. However, the two diverged in 2016, with the number of shale establishments decreasing 1 percent from 2015 to 2016. The all-industry number of establishments grew relatively slowly, with each state experiencing less than 5-percent growth over the decade.

In terms of largest industry growth in number of shale industry establishments within each state, Ohio and West Virginia experienced their largest growth in O&G pipeline construction. Pennsylvania saw its largest growth in support activities for O&G operations.

Total employment wages

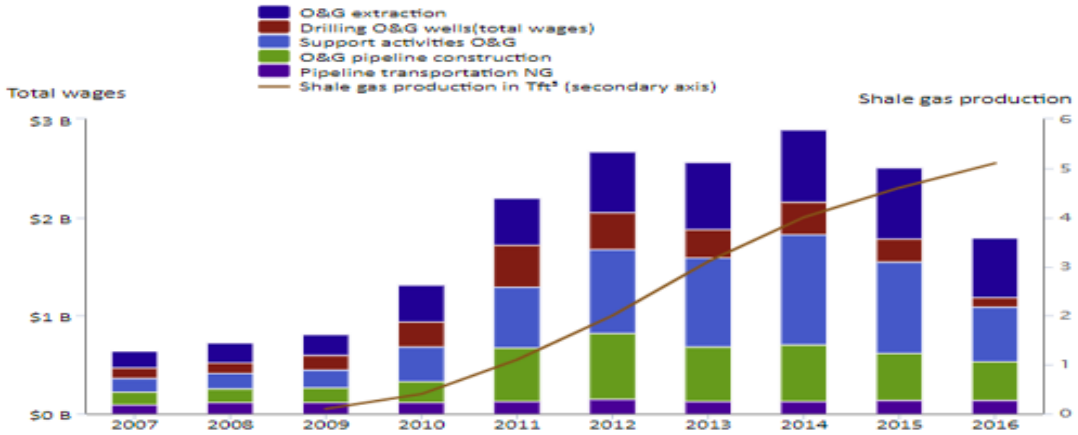
Shale industry total wages are compared with shale gas production (figure 8). In addition to salaries, most BLS wage data include other forms of compensation, such as bonuses and stock options.[28] Total wages in shale industries in the Marcellus–Utica region increased $1.7 billion (118 percent) over the decade, which was a larger increase than the all-industry average in the region, which increased 7 percent. Shale industry wages in the region totaled $3.2 billion during 2016, or approximately 0.6 percent of the region's all-industry total wages of $502.5 billion. Total wages in shale industries in the region fell $1.6 billion (33 percent) from 2014 to 2016, while total wages for all industries increased 3.0 percent. As discussed in the employment section, natural gas prices and rig counts declined during the 2014–16 period, which placed downward pressure on total wages in these industries.[29] (Note the following caveats for West Virginia total wage data at the state level: Drilling O&G wells [NAICS 213111] data were only disclosed in 2015 and 2016, whereas pipeline transportation of natural gas [NAICS 4862] data were not disclosed in any year over the last decade.)

Figure 8a. Total wages (in real billion 2016 dollars) by industry versus shale gas production (in trillion cubic feet [Tft³]), Ohio, 2007–16



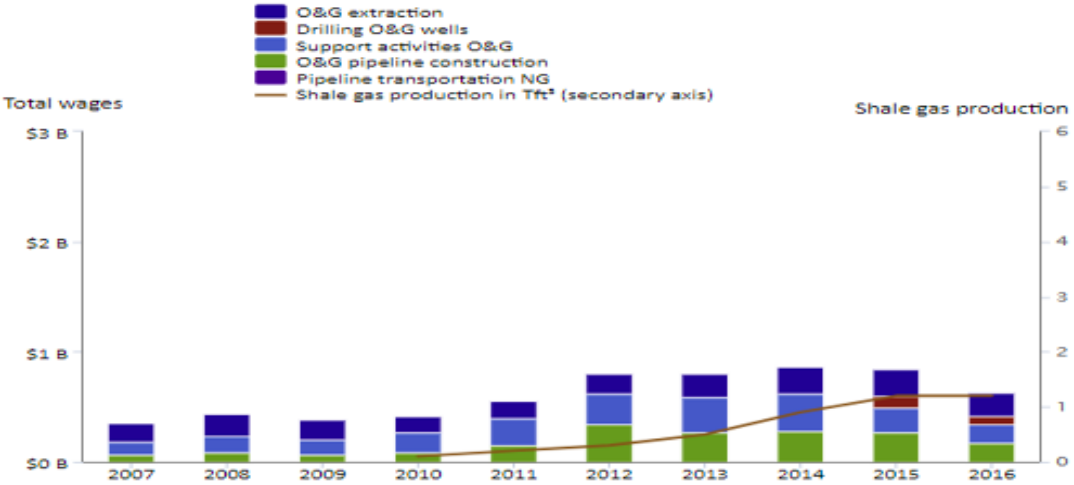
Note: NG = natural gas and O&G = oil and natural gas.
Click legend items to change data display. Hover over chart to view data.
Sources: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages; U.S. Bureau of Economic Analysis; U.S. Energy Information Administration; and Ohio Department of Natural Resources.

Figure 8b. Total wages (in real billion 2016 dollars) by industry versus shale gas production (in trillion cubic feet [Tft³]), Pennsylvania, 2007–16



Note: NG = natural gas and O&G = oil and natural gas.
Click legend items to change data display. Hover over chart to view data.
Sources: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages; U.S. Bureau of Economic Analysis; U.S. Energy Information Administration; and Pennsylvania Department of Environmental Protection.

Figure 8c. Total wages (in real billion 2016 dollars) by industry versus shale gas production (in trillion cubic feet [Tft³]), West Virginia, 2007–16



Note: NG = natural gas and O&G = oil and natural gas.
Click legend items to change data display. Hover over chart to view data.
Sources: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages; U.S. Bureau of Economic Analysis; U.S. Energy Information Administration; and West Virginia Department of Environmental Protection.

In Pennsylvania, both shale gas production and total wages in shale industries increased through 2014. However, while wages in these industries subsequently declined after 2014, shale gas production continued to increase in 2015 and 2016. West Virginia shale gas production and shale industry wages both trended upward from 2010 to 2014; the two metrics drifted in opposite directions in 2015 and 2016, similar to Pennsylvania shale gas production and shale industry wages. In Ohio, shale gas production and shale industry wages increased from 2012 to 2014. However, shale industry wages fell in 2015 and 2016, while production continued to grow.

In 2016, shale industry wages were highest in Pennsylvania, with greater total shale industry wages than West Virginia and Ohio combined. Pennsylvania also experienced the most growth, with total real wages in shale industries nearly tripling during the last decade, while wages in these industries almost doubled over the decade in Ohio and West Virginia.

Average annual pay

Some additional questions concerning average annual pay in the Marcellus–Utica region include the following:

1. How do average employees in shale industries fare in compensation relative to those in other industries?

2. How has average annual pay in shale industries changed over the last decade?

BLS calculates average pay by dividing total annual pay by average monthly number of employees. In addition to salaries, most BLS wage data includes other forms of compensation, such as bonuses and stock options.[30] Table 1 provides a summary of the data. In terms of growth over the last decade, the only average annual pay decline for shale industries is O&G extraction (NAICS 211) in Ohio. As noted in the employment section, some establishments may have been reclassified to a different industry in 2013 after a review of classifications. More closely examining the BLS data shows that the average pay of Ohio O&G extraction peaked in 2012 at $109,539 and then fell to $66,183 the following year, which would be consistent with the timing of the reclassification. (Note that the average annual pay data in West Virginia for drilling O&G wells [NAICS 213111] were only disclosed in 2015 and 2016. However, for pipeline transportation of natural gas [NAICS 4862) in West Virginia, the average annual pay data were not disclosed in any year at the state level.)

Table 1. Average annual pay (in real 2016 dollars), difference 2016 versus 2007, and percent difference 2016 versus 2007 by industry and state, 2007–16

NAICS industry and code	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Difference 2016 versus 2007	Percent difference 2016 versus 2007
O&G extraction, code 211												
Ohio	101,074	93,441	92,309	97,275	107,062	109,539	66,183	70,903	68,550	73,816	–27,258	–27.0
Pennsylvania	72,156	78,182	75,837	96,886	107,756	114,887	113,958	116,200	115,010	111,999	39,843	55.2
West Virginia	66,328	75,139	74,553	70,516	75,753	81,159	85,452	87,493	87,650	86,805	20,477	30.9
Drilling O&G wells, code 213111												
Ohio	47,038	48,136	45,182	42,851	46,876	53,489	62,561	73,459	72,350	69,444	22,406	47.6
Pennsylvania	68,345	68,178	77,585	80,721	88,386	91,283	89,249	92,181	91,824	86,570	18,225	26.7
West Virginia	ND	ND	ND	ND	ND	ND	ND	ND	77,149	77,375	—	—
Support activities for O&G operations, code 213112												
Ohio	54,413	59,346	57,608	60,915	62,409	60,172	63,898	73,563	66,272	64,801	10,388	19.1
Pennsylvania	67,880	60,882	62,905	70,584	72,769	74,022	77,692	82,537	77,861	74,750	6,870	10.1
West Virginia	50,492	52,813	54,227	60,177	65,057	67,702	70,992	75,682	65,336	60,096	9,604	19
O&G pipeline construction, code 23712												
Ohio	59,822	63,847	93,809	59,203	62,340	67,531	82,605	79,999	87,548	80,094	20,272	33.9
Pennsylvania	62,922	66,506	67,947	73,215	92,817	88,314	87,583	95,371	86,292	86,729	23,807	37.8
West Virginia	61,609	68,273	60,204	71,307	77,422	86,140	83,581	87,678	90,748	83,267	21,658	35.2
Pipeline transportation of NG, code 4862												
Ohio	71,765	72,356	87,084	78,121	77,510	79,422	79,475	81,147	89,068	87,403	15,638	21.8
Pennsylvania	79,365	86,002	88,854	88,423	90,484	91,335	88,708	90,807	86,900	85,947	6,582	8.3
West Virginia	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	—	—
All industries (including nonshale gas industries)												
Ohio	45,153	45,160	44,721	45,185	45,570	46,183	45,930	46,576	47,195	46,983	1,830	4.1
Pennsylvania	49,169	49,528	49,476	49,903	50,336	50,998	50,862	51,516	52,535	52,106	2,937	6
West Virginia	38,143	39,511	40,157	40,727	41,601	41,583	41,189	41,470	41,470	40,750	2,607	6.8

Notes: NAICS = North American Industry Classification System, ND = not disclosable (data do not meet BLS or state agency disclosure standards), NG = natural gas, and O&G = oil and natural gas. Dash indicates no data available.

Sources: U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages, and U.S. Bureau of Economic Analysis, Table 1.1.9, Implicit price deflators for gross domestic product.

Average annual pay for 2016 was highest in Pennsylvania in four of the five shale industries, while Ohio had the highest average annual pay in pipeline transportation of natural gas (NAICS 4862). Over the last decade, Ohio saw greater percent growth in average annual pay than the Pennsylvania and West Virginia in three shale industries, whereas Pennsylvania saw the greatest percent growth in the region in the other two shale industries.

One of the questions this section seeks to answer is How do average employees in shale industries fare in compensation compared with those in other industries? Average annual pay in Ohio, Pennsylvania, and West Virginia shale industries compare favorably with the all-industry average. During 2016, the average annual pay for all private industries was $46,983 in Ohio, $52,106 in Pennsylvania, and $40,750 in West Virginia. However, at the same time, the average pay in the shale industry ranged from $64,801 to $87,403 in Ohio, $74,750 to $111,999 in Pennsylvania, and $60,096 to $80,805 in West Virginia.

In addition to shale industries having higher average annual pay than the all-industry average, the percent growth in shale industry pay in these three states was larger than that of the all-industry average. Increases in the average annual pay of all industries in these three states during the 2007–16 period were between 4 and 7 percent, while many of the shale industries exceeded 20 percent growth during the decade.

Conclusion

Shale gas production in the United States increased dramatically during the 2007–16 period, outpacing the overall growth in U.S. natural gas production. This article examined shale gas production and labor trends for shale industries in the Marcellus–Utica region (Ohio, Pennsylvania, and West Virginia), which has accounted for much of the overall growth in U.S. shale gas production over the 2007–16 decade. The article addresses a number of key questions for the Marcellus–Utica region, such as What proportion of natural gas production does shale gas production represent? The article also examines questions concerning recent trends, such as How much has shale gas production grown over the last decade? and How has growth in shale gas industry labor metrics compared with growth in other industries? A comparison between salaries in shale industries and other industries is also made. Other areas examined include the correlation between trends in labor market metrics with shale gas production and short-term trends that departed from overall decade-long trends.

Shale gas production accounted for over 90 percent of natural gas production in the region and has grown from 0.001 Tft^3 in 2007 to 7.69 Tft^3 in 2016. Shale gas production varies substantially at the county level, with most counties in the three-state region not producing shale gas and four of the counties producing over 0.5 Tft^3 in 2016. At the state level in the region, Pennsylvania led the way in shale gas production (5.1 Tft^3) in 2016, while West Virginia and Ohio each produced over 1.0 Tft^3. The value of this production represented $12 billion in 2016, based on the average sale spot price of natural gas in the region. Similar to shale gas production growth, growth in employment and total wages in shale industries in Pennsylvania was the largest in the region, while Ohio and West Virginia also witnessed substantial growth. Pennsylvania had higher 2016 total annual wages in most shale industries than the other two states, whereas Ohio saw the fastest growth in average annual pay (i.e., wages) over the last decade in most of these industries.

Shale industries made up about 0.4 percent of overall employment in the region, and wages in these industries totaled $3.2 billion during 2016 or approximately 0.6 percent of the region's total wages of $502.5 billion. These industries experienced faster employment and wage growth over the last decade than the all-industry average.

The average wage in the region for shale industry employees is greater than the average wage for employees in other industries. In addition, the rate of increase in both total and average wages has been greater for shale industry employees than the rate for those employed in other industries during the last decade. In addition to the decade-long trends examined, trends that are more recent were also examined because employment and wages in shale industries have decreased since 2014 in the region, while shale gas production has continued to increase. Since 2014, both natural gas prices and the number of rigs in the region have declined, exerting downward pressure on employment and wages.

Future research may consider exploring other areas, such as improvements to productivity of natural gas extraction, by examining measures such as production per labor hour, production per well, and production per dollar of expenditures. Depending on data availability, future analyses could focus more on county-level metrics, as opposed to state-level metrics. In addition, depending on data availability, an analysis of occupation by industry at the state or county level could be done. Another potential future analysis could examine the impact of the shale gas boom on service industries in the Marcellus–Utica region. For instance, industries such as tourism, hotels, restaurants, and other service industries could be studied. Future research could also examine ancillary shale gas industries, such as petrochemical manufacturing and fossil fuel electric power generation, which rely heavily on shale gas production as an input in their production process.

SUGGESTED CITATION

Gavin C. Pickenpaugh and Justin M. Adder, "Shale gas production and labor market trends in the U.S. Marcellus–Utica region over the last decade," *Monthly Labor Review,* U.S. Bureau of Labor Statistics, August 2018, https://doi.org/10.21916/mlr.2018.20.

NOTES

1 “Shale gas: applying technology to solve America’s energy challenges” (U.S. Department of Energy, National Energy Technology Laboratory, March 2011), https://www.netl.doe.gov/file%20library/research/oil-gas/Shale_Gas_March_2011.pdf.

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3 The 2007–15 national shale gas production data are sourced from “Shale gas production” (Washington, DC: U.S. Energy Information Administration, updated about every 8 months), https://www.eia.gov/dnav/ng/ng_prod_shalegas_s1_a.htm; and the 2016 national shale gas production estimate comes from “Frequently asked questions: How much shale gas is produced in the United States?” (Washington, DC: U.S. Energy Information Administration), https://www.eia.gov/tools/faqs/faq.php?id=907&t=8.

4 “2016 oil and gas annual report” (Harrisburg, PA: Pennsylvania Department of Environmental Protection, 2016), http://www.depgis.state.pa.us/oilgasannualreport/index.html.

5 For 2017 quarterly reports on horizontal shale production, see “Oil and gas well production” (Ohio Department of Natural Resources, 2016), http://oilandgas.ohiodnr.gov/production.

6 “Oil and gas production data” (West Virginia Department of Environmental Protection, 2016), http://www.dep.wv.gov/oil-and-gas/databaseinfo/Pages/default.aspx.

7 For more information, see U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages (QCEW), https://www.bls.gov/cew/. Note that all the 2016 QCEW data were preliminary at the time of this article; therefore, the numbers are subject to change. Also worth noting is that the location (i.e., county or state) the data represent is that of the establishment, which can differ from the location of the residence of the employees.

8 National Data, table 1.1.9, "Implicit price deflators for gross domestic product" (Washington, DC: U.S. Bureau of Economic Analysis, updated monthly), https://www.bea.gov/iTable/iTable.cfm?reqid=19&step=2#reqid=19&step=3&isuri=1&1921=survey&1903=13.

9 "Short-term energy outlook" (Washington, DC: U.S. Energy Information Administration, 2017, updated monthly), https://www.eia.gov/outlooks/steo/.

10 S&P Global Market Intelligence provides news, data, and analytics for various sectors. For more information on S&P Global Market Intelligence, go to https://www.spglobal.com/marketintelligence/en/. More information on conversion factors can be found at "Energy units and calculators explained" (Washington, DC: U.S. Energy Information Administration), https://www.eia.gov/energyexplained/index.cfm?page=about_energy_conversion_calculator.

11 National Data, table 1.1.9, "Implicit price deflators for gross domestic product."

12 "Regional economic accounts, GDP by state" (Washington, DC: U.S. Bureau of Economic Analysis), https://www.bea.gov/regional/.

13 "OES research estimates by state and industry" (U.S. Bureau of Labor Statistics, May 2017), https://www.bls.gov/oes/current/oes_research_estimates.htm.

14 The industries are virtually identical to those defined as "core shale-related" industries in "2016 Annual Ohio Shale Report" (Columbus, OH: Ohio Department of Job and Family Services, 2016). The difference in industry scheme is the 2016 Annual Ohio Shale Report breaks out O&G extraction (NAICS 211) into crude petroleum and natural gas extraction (NAICS 211111) and natural gas liquid extraction (NAICS 211112). Industries considered shale gas industries vary by study. For instance, see Jennifer Cruz, Peter Smith, and Sarah Stanley, "The Marcellus shale gas boom in Pennsylvania: employment and wage trends," *Monthly Labor Review*, February 2014, https://www.bls.gov/opub/mlr/2014/article/the-marcellus-shale-gas-boom-in-pennsylvania.htm. Cruz et al. define the following three industries as shale gas industries: O&G extraction (NAICS 211), drilling O&G wells (NAICS 21311), and support activities for O&G operations (NAICS 213112).

15 "Ohio shale: quarterly economic trends for Ohio oil and gas industries" (Ohio Department of Job and Family Services, 2015).

16 "Glossary" (U.S. Bureau of Labor Statistics), https://www.bls.gov/bls/glossary.htm#E.

17 "Short-term energy outlook" (Washington, DC: U.S. Energy Information Administration, 2017, updated monthly), https://www.eia.gov/outlooks/steo/.

18 "Drilling productivity report" (Washington, DC: U.S. Energy Information Administration, November 2016) http://www.eia.gov/petroleum/drilling/#tabs-summary-2.

19 Quarterly Census of Employment and Wages, "Frequently asked questions" (U.S. Bureau of Labor Statistics, June 2018), https://www.bls.gov/cew/cewfaq.htm.

20 For instance, O&G extraction (NAICS 211) employment data for the three states were not disclosed at the county level in 79 of the 210 counties. Positive levels of employment, ranging from 10 employees to 1,291 employees, were disclosed in 36 of the counties.

21 2013 annual Ohio shale report" (Ohio Department of Job and Family Services, 2013). Note the following caveats for West Virginia employment data at the state level: drilling O&G wells (NAICS 213111) data were only disclosed in 2015 and 2016, whereas pipeline transportation of natural gas (NAICS 4862) data were not disclosed in any year over the last decade.

22 "Short-term energy outlook" (EIA, 2017).

23 "North America rig count" (Houston, TX: Baker Hughes, 2017), http://phx.corporate-ir.net/phoenix.zhtml?c=79687&p=irol-reportsother.

24 "2013 annual Ohio shale report" (Ohio Department of Job and Family Services, 2013).

25 Quarterly Census of Employment and Wages, "Frequently asked questions."

26 "North American rig count" (Baker Hughes).

27 “2013 annual Ohio shale report” (Ohio Department of Job and Family Services).

28 Quarterly Census of Employment and Wages, “Frequently asked questions.”

29 “2013 annual Ohio shale report” (Ohio Department of Job and Family Services).

30 “County employment and wages technical note,” Economic News Release (U.S. Bureau of Labor Statistics, May 2018), https://www.bls.gov/news.release/cewqtr.tn.htm.

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