RAND CORPORATION

Wages, Employment, and STEM Education in Ohio, Pennsylvania, and West Virginia

Report No. 2 (2017)

Gabriella C. Gonzalez, Kyle Siler-Evans, Gerald Paul Hunter, Nicholas Broten

Since 2000, the combination of horizontal drilling and hydraulic fracturing has provided access to large volumes of oil and natural gas that were previously unprofitable or impossible to extract (U.S. Energy Information Administration, 2016d).[1] These new technologies and techniques, in turn, produced a boom in supply of new energy sources: As illustrated in Figure 1, dry gas shale production in the United States increased from 2.3 billion cubic feet per day in 2002 to 42.3 billion cubic feet per day in 2016. The increase in natural gas production was most pronounced in the Marcellus and Utica shale plays, which extend under the states of Maryland, New York, Ohio, Pennsylvania, and West Virginia. From 2010 to 2015, the natural gas extraction industry in the Marcellus and Utica shale plays grew from a half billion cubic feet per day to over 19 billion cubic feet per day. From January through September 2016, the output remained

Key findings

- Working-age population decline was persistent and pervasive within the Appalachia Partnership Initiative (API) region. Twenty of the 27 counties registered declines between 2000 and 2014.
- However, the population was virtually unchanged in size, as population growth in a few counties offset decline in the others.
- Workers in traditional science, technology, engineering, and mathematics (STEM) fields commanded the highest pay in the API region, but STEM pay levels in the region lagged national average pay levels.
- Regional workers in extraction and construction fields commanded pay substantially above the national average in these fields. Workers in extraction industries' median wages were comparatively high and rose 6 percent in the past five years.
- Both nationally and within the API region, real wages have declined across all education levels in the past five years. Workers with the least education were hardest hit: their real wages declined around 6 percent.
- Most new hires in oil and gas extraction jobs were drawn from labor pools in Ohio, Pennsylvania, and West Virginia. Most open jobs were filled by local workers switching from other industries, not by oil and gas workers from outside the region.
- High school graduation rates rose in Ohio, Pennsylvania, and West Virginia, following a national trend.
- Institutions of higher education appeared to be graduating students with the needed STEM skills. Local institutions exceeded the national average in the percentage of students gaining certificates, associate degrees, and bachelor's degrees in STEM fields. Across all institutions, 16 percent of graduates were in STEM-related fields, as compared to 12 percent nationwide.

steady at about 20 billion cubic feet per day. Pennsylvania, Ohio, and West Virginia's abundant fossil fuel resources have long shaped the tristate economy. The increase in the extraction of natural gas from the Utica and Marcellus shale plays has propelled the region to become a leader in supplying energy to the nation.

In Ohio, natural gas production from the Utica shale was 12 times greater in 2015 than in 2011, rising from 1 percent of the nation's total to 3 percent. The eastern part of Ohio contains reserves of coal, crude oil, and natural gas fields. Several interstate natural gas pipelines cross Ohio. The state is the tenth-largest coal-producing state in the nation and the sixth-largest producer of bituminous coal. The primary fuel for electricity generation in Ohio is coal (Energy Information Administration, 2016b).

Pennsylvania is the leading east coast supplier of coal, natural gas, and refined petroleum products. It is the second-largest natural gas producer in the nation (after Texas), producing more than 4.7 trillion cubic feet in 2014 (more than eight times the production in 2010). It is also the nation's fourth-largest coal producer. New pipelines are being built to transport the increased natural gas output. Pennsylvania's production of natural gas liquids, such as ethane and propane, grew more than five-fold from 2010 to 2014; processing plants to extract natural gas liquids and pipelines to transport them to markets around the country are being built. Pennsylvania's first ethane cracker, which makes feedstocks for plastics manufacturing from ethane, is in development (Energy Information Administration, 2016c).

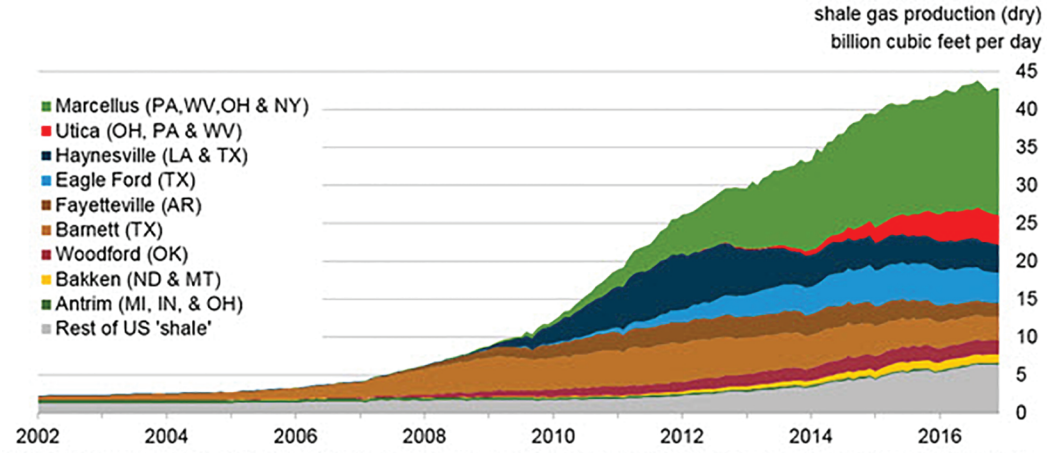
West Virginia remains the fourth-largest energy producing state in the United States, producing 4.6 percent of the nation's energy. In 2014, it was the second-largest coal producing state (after Wyoming), accounting for 11 percent of U.S. coal production. In 2015, it ranked eighth in the nation's natural gas production, producing more than 1.3 trillion cubic feet (Energy Information Administration, 2016g).

Some economic theories suggest that resource abundance may increase local economic development through higher demand for labor in the energy sector and spillover spending in the local economy. An analysis of the early boom in the natural gas industry in nine states in the central United States found that local labor market conditions (employment and wages at the county level) responded positively to the rapid expansion of natural gas production from 2001 to 2011 (Brown, 2014). The increased extraction of natural gas, coupled with already-strong output from traditional energy sources, could therefore create an economic revitalization in many areas in Ohio, Pennsylvania, and West Virginia.

Yet employment and earnings in the energy sector have proven volatile because the energy sector is notoriously unstable. This volatility and instability are caused by fluctuating prices (strongly dependent on supply and demand), resource stocks that are primarily nonrenewable, inadequate energy storage facilities, and technological change that determines where drilling and extraction are viable (Kelsey, Partridge, and White, 2016). Regional economies that are heavily dependent on energy extraction—such as the tristate region of Ohio, Pennsylvania, and West Virginia— therefore may be particularly subject to employment and earnings volatility.

Indeed, the 2000–2015 energy boom created an oversupply in natural gas, resulting in a marked decrease in prices: Henry

Figure 1. U.S. Dry Gas Shale Production, 2000–2016



SOURCE: U.S Energy Information Administration, 2016d.

Hub Natural Gas Spot Price fell to $2.62 per million British thermal units (BTU) in 2015, down from $4.37 in 2014 and the 2008 peak of $8.86 (U.S. Energy Information Administration, 2016a). The 2015 fall in gas prices prompted a reduction in new extraction efforts in the tristate region. Some well sites were closed, and few new sites were opened (U.S. Energy Information Administration, 2016e and 2016f).

Despite falling prices, production remained steady in 2016, as illustrated in Figure 1. Also, the national demand for workers to fill jobs requiring science, technology, mathematics, and engineering (STEM) skills (hereafter referred to as STEM jobs) has grown steadily over time (National Academies of Sciences, Engineering, and Medicine, 2016). Between 2008 and 2014, the number of workers employed in STEM jobs rose by 500,000 nationwide, whereas the total workforce stayed relatively stable (National Science Board, 2016, pp. 3–5). STEM jobs have become a large and growing part of the U.S. economy, comprising 20 percent of all U.S. jobs in 2013 (National Research Council, 2013; Rothwell, 2013). The most recent analyses from the U.S. Bureau of Labor Statistics project that STEM employment will grow about 13 percent between 2014 and 2024—twice the 6.5-percent projected growth rate for all occupations over that decade (U.S. Bureau of Labor Statistics, 2015). Indeed, these projections suggest that while STEM job growth has been somewhat offset by 2015 layoffs caused by the decline in oil and natural gas prices, the need for STEM workers is expected to resume over the medium and longer term as oil and gas prices recover (Porter, Gee, and Pope, 2015; Lendel et al., 2015).

Bolstering those expectations, a 2016 analysis of demand for jobs and skills in high-priority occupations in the ten counties surrounding Pittsburgh, Pennsylvania, estimated that 34,000 jobs could go unfilled in the next decade given a forthcoming wave of impending retirements and insufficient supply of school-age children to fill those jobs. This analysis found that key skills for the jobs examined included technology skills and digital fluency, as well as cross-cutting skills. Cross-cutting skills are applicable to a range of roles and occupations, not just one particular occupation. For example, drafting is a cross-cutting skill; while demand for drafting jobs themselves is expected to decline in Pittsburgh over the next ten years, drafting *skills* remain essential for mechanical engineers and machinists, two fast-growing occupations in advanced manufacturing. Moreover, employers are increasingly demanding hybridization of skills, in which jobs and skills that were once distinct specialties are merging into single roles. For example, a person in a non-technology-focused job will still be expected to have technology knowledge (Burning Glass Technologies, Council for Adult and Experiential Learning, and Allegheny Conference on Community Development, 2016).

THE APPALACHIA PARTNERSHIP INITIATIVE

While the volatile nature of the energy and advanced manufacturing sectors may cause short-term rises and falls in employment rates, in the long term, the tristate region has a strong need for workers with STEM-related, technological, cross-cutting skills; in addition, employers are increasingly expecting skills hybridization among their workers. It is therefore important for the tristate region to work toward ensuring that the supply of labor in STEM occupations is keeping pace with demand. Recognizing the challenge of meeting STEM workforce demands in Ohio, Pennsylvania, and West Virginia, the Social Investment Team of the Chevron North American Appalachian Mountain Business Unit launched the Appalachia Partnership Initiative (API) in 2014.

The stated goal of API is to produce a long-term, sustainable effort to build the pool of local workers for jobs in the energy and advanced manufacturing sectors in the Marcellus and Utica shale region. To meet this goal, API has committed to investing $20 million to support STEM education for kindergarten through the 12th grade and STEM workforce development programs to educate and train local adult workers. These programs increase preparedness for and access to STEM

> In the long term, the region has a strong need for workers with STEM-related skills—a person in a non-technology job will still be expected to have technology knowledge.

jobs in the energy and advanced manufacturing sectors. API is also working to bring stakeholders in the region (e.g., education and training institutions, industry and business leaders, nonprofits, and government entities) together to collaborate on issues related to STEM education and the workforce (RAND Corporation, 2016). RAND's role is to provide objective evidence to assess API's progress toward its goals.[2]

API focuses its investments in the 27 counties in Ohio, Pennsylvania, and West Virginia illustrated in Figure 2.

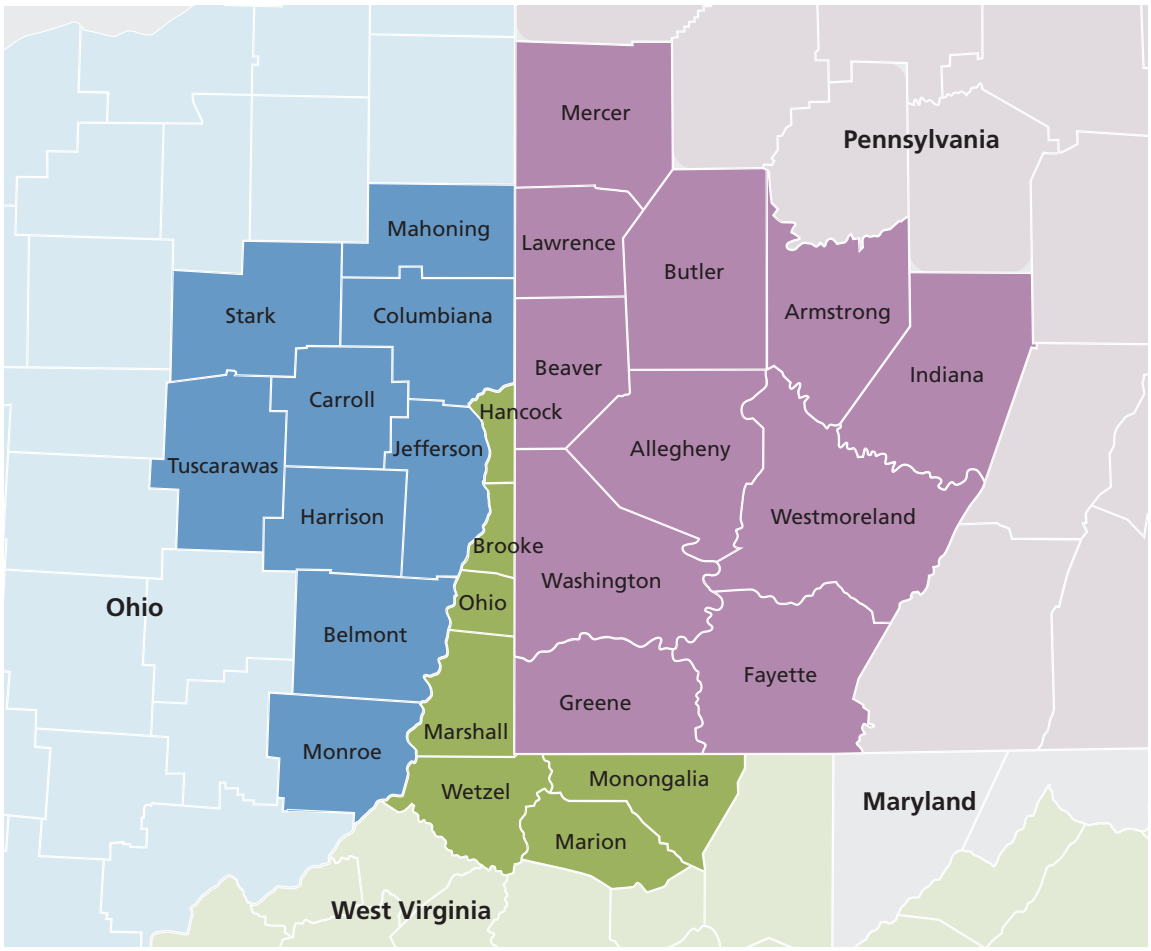
OBJECTIVES AND USES OF THIS REPORT

Given the ongoing economic transformations brought about by natural gas extraction and production in the API region and the shifting skill sets in demand in energy and advanced manufacturing, it is important to gauge and monitor the region's economic vitality and well-being. What types of jobs and occupations are in high demand? Is there sufficient talent with the requisite skills to fill those jobs? Are education and training providers producing a qualified workforce that will find employment in the region's evolving STEM labor market?

To answer these questions, RAND, as the monitoring and evaluation lead of API, was asked to produce five successive annual descriptive reports documenting and summarizing the 27-county region's STEM workforce, employment, and wages in energy and advanced manufacturing–related industries, as well as STEM education intended to shed light on transformations under way in the 27-county region. This is the second of the five reports. (For the initial report, see Gonzalez et al., 2016.)

These descriptive portraits of the 27 counties fill important gaps in knowledge and current measurement, which can guide long-term policy decisions and investment in the region's future.[3] Each regional report tracks year-to-year progress and clarifies trends in the region's energy and advanced manufacturing sectors. This information can be used to inform the regional stakeholder community across the 27-county region

Figure 2. The 27 Counties Composing the API Region



about which localities may be generating employment demand for local talent in STEM careers and where that local talent is being produced. In turn, API can use the reports to guide investments and collaborative work, helping pinpoint where collaborations across government, education providers, and nonprofits could be enhanced or promoted.

This second report in the series updates analyses undertaken in the first report (Gonzalez et al., 2016) to answer the following questions:

- What are the characteristics of the API region's STEM labor market?
  - Which areas within the region are registering growth in working-age population, employment, and wages or earnings?
  - Which STEM occupations and jobs are garnering the highest wages?
- Is the local talent pool graduating from high schools and colleges equipped with skills and trained in fields that could be utilized in the region's STEM labor market?

This report also includes new analyses to answer questions about the flow of workers into oil and gas extraction jobs in the region.

- Who are new hires in the extraction industry?
  - Do these new entrants originate locally or from outside the region?
  - When workers enter or leave the industry, which industries are they coming from or going to?

As descriptive snapshots, our analyses are intended to highlight regional balances or imbalances in supply and demand of STEM workers. They are not suited to making causal inferences about relationships between or among indicators or to drawing conclusions about how well a particular county is meeting employers' skill demands.

DATA SOURCES

To inform the analyses presented in this report, we used publicly available data from the U.S. Census Bureau's Decennial Census, American Community Survey (ACS), and Local Employment Dynamics (LED); the U.S. Department of Education's National Center for Education Statistics (NCES) National Assessment of Educational Progress (NAEP) and Integrated Postsecondary Education Data System (IPEDS); and each state's Department of Education. From these sources, we documented trends in regional working-age populations, real wages, employment, eighth-grade assessment scores, high school graduation rates, and the number of higher-education degrees granted in STEM-related fields.[4]

In many instances, these indicators track slow-moving trends, registering gradual changes over a single year. Furthermore, several of the indicators are necessarily based on a five-year average from the ACS, which mutes year-to-year changes (e.g., the 2014 data are based on data from 2010 through 2014). The appendix provides more details on data and methods.

WORKFORCE, WAGES, AND EMPLOYMENT TRENDS IN THE ENERGY AND ADVANCED MANUFACTURING SECTORS

This section documents API regional trends in the working-age population and in wages and employment in the energy and advanced manufacturing sectors. We first provide a one-year update of metrics that were introduced in the first report (Gonzalez et al., 2016) using the most recent census data available. Next, we broaden our analysis beyond that of the first report to add (1) an in-depth look at earnings and employment across education levels in mining, quarrying, and oil and gas extraction (referred to here as *extraction industries*), and (2) an analysis of the movement of workers into and out of the extraction industries.

Consistent with trends described in the first report, 20 of the 27 counties in the API region registered a decline in the working-age (ages 18–64) population between 2000 and 2014. The size of the region's overall working-age population has remained virtually unchanged, though, due in part to healthy growth in Butler and Washington Counties (Pennsylvania) and Monongalia County (West Virginia). The U.S. working-age population, in comparison, grew by roughly 14 percent during this one-year period (based on successive five-year ACS measures). About 53 percent of the counties in the United States lost working-age population between 2010 and 2014 (40 percent lost population between 2000 and 2004).

The extraction industries offer relatively high median wages within the API region (over $60,000), and these wages have registered a 6-percent increase over the past five years. In manufacturing, in contrast, median wages have declined slightly from

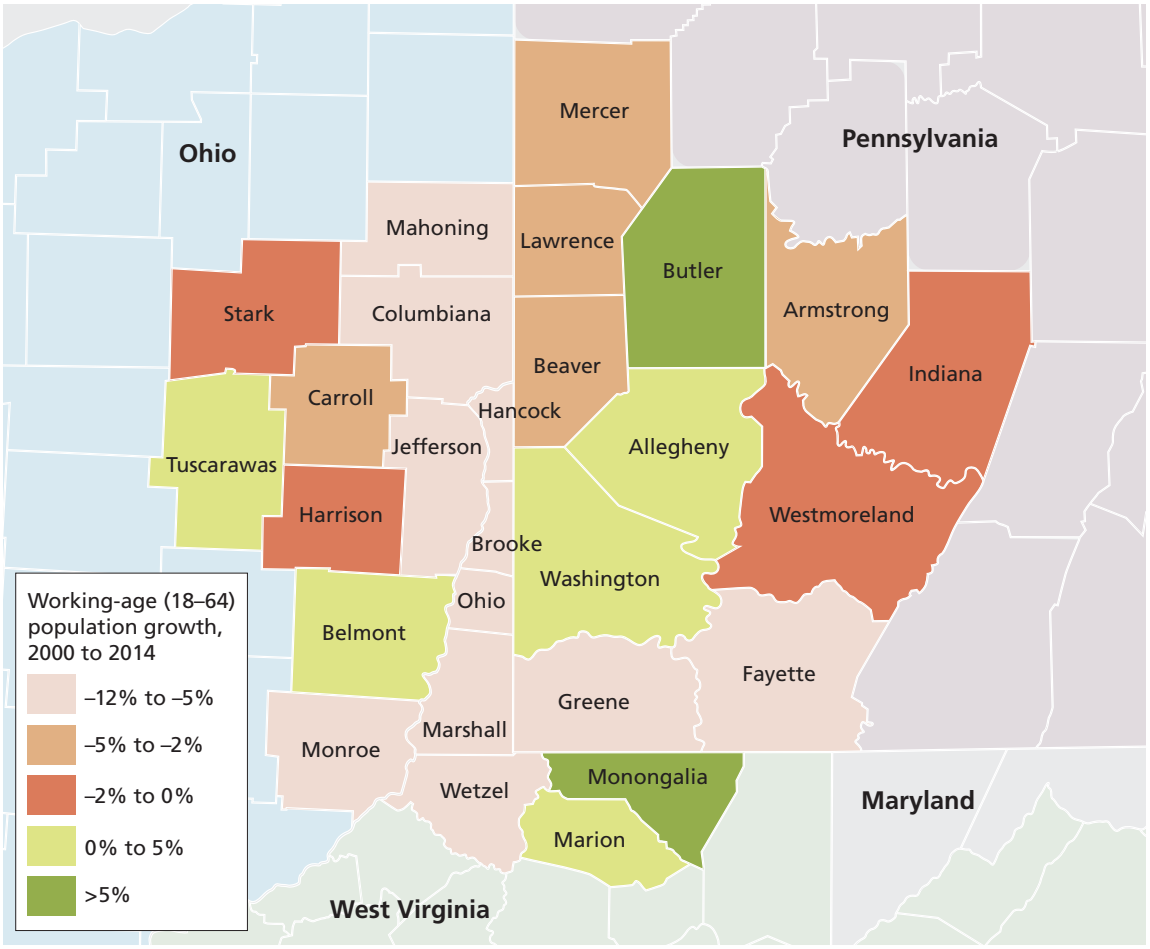
the 2006–2010 to the 2010–2014 time periods, but there is wide variation across API counties. Both nationally and within the API region, real wages have declined across all education levels in the past five years. Less-educated workers were hardest hit, with declines in real wages of around 6 percent in both the API and the nation.

Working-Age Population

Figure 3 illustrates changes in the working-age population in each of the 27 API counties from 2000 to 2014. It is important to track the size of the working age population in the API region. A shrinking pool of residents in their prime working age would have noteworthy implications for a region's economy: a smaller talent pool could strain a workforce; an increasing number of older residents likely means greater demand for public services; and, depending on tax structures, state and local revenues could be impacted. The figure is based on data from the 2000 Decennial Census and the 2010–2014 five-year estimate from the ACS. The patterns shown here are consistent with those highlighted in the first API report. Recall that year-to-year changes are muted, because we must compare successive measures based on five-year ACS estimates (i.e., change registered from 2006–2010 to 2010–2014).

From 2000 to 2014, the national working-age population grew by 14.3 percent, compared with virtually no increase in the API region. Twenty of the API region's 27 counties, approximately 75 percent, experienced a decline in working-age population. Between 2010 and 2015, about two-thirds of U.S. counties—mostly rural and suburban—experienced a decline in their working-age population (Lombard, 2016). Several API counties, however, bucked that trend. Monongalia County, West Virginia, registered a 30.2 percent gain in working-age population, over double the national rate. Pennsylvania's Butler County and Washington County both registered moderate growth (8.7 and 5.0 percent, respectively). Four other counties

Figure 3. Change in Working-Age Population by County, 2000–2014



SOURCE: U.S. Census Bureau, 2000; and U.S. Census Bureau, undated b.

gained no more than 5 percent: Marion County, West Virginia; Allegheny County, Pennsylvania; Belmont County, Ohio; and Tuscarawas County, Ohio.

Median Wages

Figure 4 shows median wages by census tract for the API region over the five-year period from 2010 to 2014. Consistent with the first report, census tracts with the higher median wages are clustered in or near Allegheny County and Monongalia County, home to the region's largest higher-education institutions (Gonzalez et al., 2016). Census tracts with the lowest median wages—$0 to $5,700 per year—are in inner-city Pittsburgh. The majority of the census tracts in the API region have median wages of $16,000 to $37,000 per year.

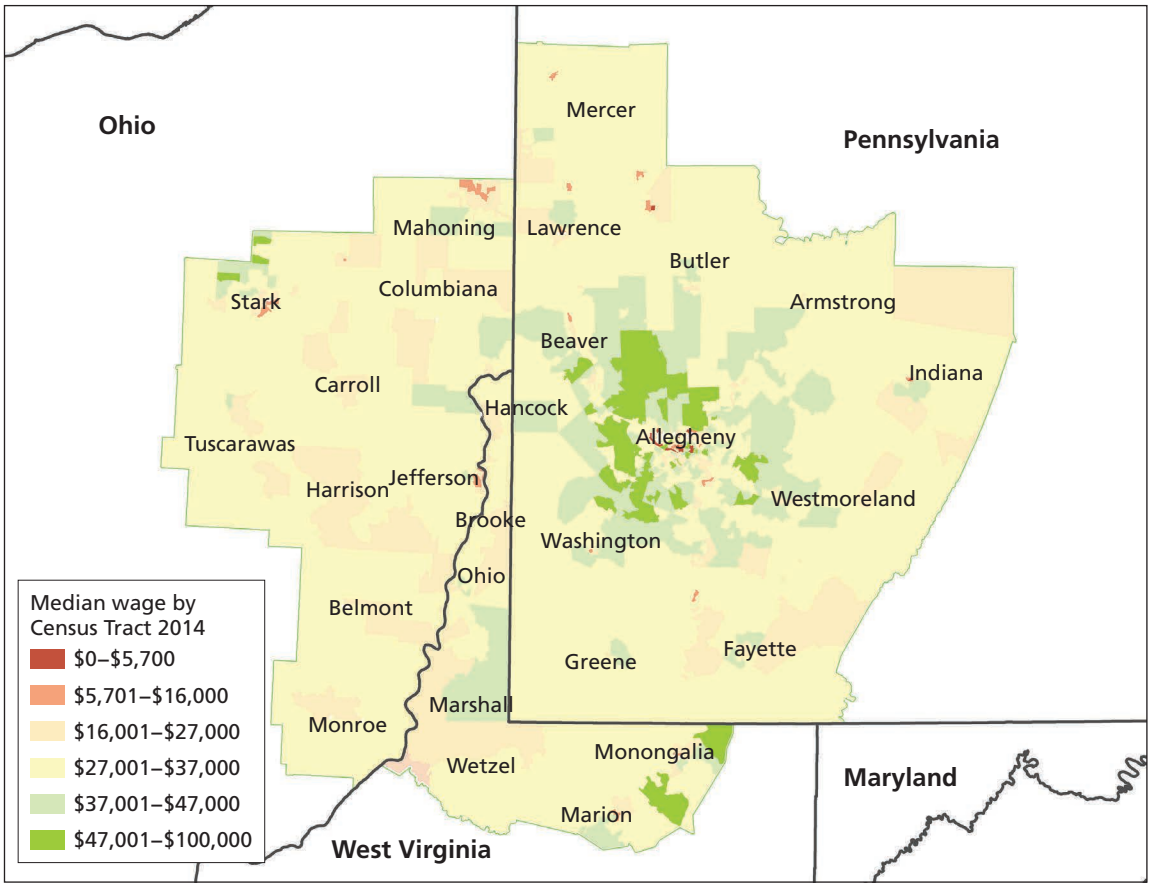
Wages for STEM-Related Industries and Occupations and Educational Attainment

To better understand and define the local makeup of the region's labor force, we examined wages by STEM-related industry, STEM-related occupation, and education level. For both industry and occupation, we focused on the six occupational and five industry STEM-related categories that are most relevant for the region. Our occupational focus encompasses 20 percent of all jobs in the region; our industry focus encompasses 41 percent of all jobs in the region.

Table 1 shows median county-level wages for STEM industries, STEM occupations, and levels of educational attainment.[5] Median wages are derived from the 2010–2014 five-year ACS estimates, affording us a one-year update from last year's report. The education categories include the entire workforce over the age of 25, while the industry and occupation categories include employed civilians ages 16 and older. We compare the lowest and highest county-level median wages in the 27-county API region, as well as the simple arithmetic average of all 27 county median wages ("Average County Median Wage"). For comparison, we also include the national median wage for each category.

Among the five STEM-related industries examined, the utilities industry registered the highest average median wage ($62,464), but it had a wide range of salaries by county (from

Figure 4. Median Wages by Census Tract, 2010–2014



SOURCE: U.S. Census Bureau, undated b.

$86,818 to $41,402). Jobs in the utilities industry typically involve production and installation, maintenance, and repair. Examples of such jobs include installing and maintaining pipelines and powerlines, operating and fixing plant machinery, and monitoring treatment processes. Mining and extraction also registered high average median wages ($58,290), over twice the average for health care and social services ($28,690).

The table includes six STEM-related occupations ranging from engineering to health care support. The highest average median wages in the region were in the traditional STEM fields. However, the regional median lagged the national median in each of these occupations. By contrast, workers in the extraction and construction fields within the API region *exceeded* the national median, and did so by nearly $10,000 ($43,217 vs. $32,605). This difference may reflect stronger demand for workers in these jobs by employers in the API region than their counterparts elsewhere.

Average median wages by educational attainment (measured for all workers) mirrors the national pattern: Workers with more years of schooling tend to have higher wages. At all levels of education, average median wages within the region were lower than national median wages. However there was a wider range throughout the region for workers with a bachelor's degree (ranging from $33,780 to $54,386) and a graduate or professional degree (ranging from $30,313 to $71,402) than less educated workers.

Table 1. Median Annual Wages by STEM-Related Industry, Occupation, and Educational Attainment for All Workers in the API Region and the United States, 2010–2014

Industry, Occupation, or Educational Attainment	Lowest County Median Wage ($)	Average County Median Wage ($)	Highest County Median Wage ($)	National Median Wage ($)
Industry				
Mining, quarrying, and oil and gas extraction	34,696	58,290	77,014	61,563
Utilities	41,402	62,464	86,818	62,514
Manufacturing	34,961	43,967	67,054	42,274
Health care and social assistance	18,634	28,690	35,981	33,426
Professional, scientific, management, and administrative	23,568	31,311	46,883	41,415
Occupation				
Computer and mathematics	29,063	51,751*	71,491	73,455
Life, physical, and social science	32,321	51,917	103,542	55,463
Architecture and engineering	41,932	67,300	88,542	73,762
Health care practitioners and technical	37,222	44,671*	51,742	53,881
Health care support	12,713	20,123	26,771	22,336
Construction and extraction	32,139	43,217*	56,094	32,605
Educational attainment (ages 25 and over)				
Less than high school graduate	12,361	18,360	24,835	19,954
High school graduate (includes equivalency)	23,108	27,008	30,213	27,868
Some college or associate degree	26,065	31,045	36,549	33,988
Bachelor's degree	33,780	43,024	54,386	50,515
Graduate or professional degree	30,313	54,284	71,402	66,944

SOURCE: U.S. Census Bureau, undated b.
NOTE: Education-attainment categories include the entire workforce over the age of 25; industry and occupational categories are specific to that category's working-age population (ages 25–64).
* Average county median wage is statistically significantly different from national median wage ($p < 0.05$).

Figure 5 shows county-level median earnings by industry, occupation, and educational attainment, as measured by the 2014 ACS five-year estimate. Each bubble represents a county, and the size of the bubble is proportional to the working-age population (ages 18 to 64) in the county. The solid black dot indicates the median wages nationally for each category. Similarly, Figure 6 illustrates the change in county-level median wages during the 2006–2010 and 2010–2014 periods.[6] Both figures reflect a one-year update from results reported in the preceding year's report. As noted above, year-to-year changes will tend to be muted due to the use of the ACS five-year estimates (i.e., wages are based on data from 2010 through 2014, whereas the first report presented wages using data from 2009 through 2013 [Gonzalez et al., 2016]).

Regional wages in the manufacturing, utilities, and extraction industries are on pace with the national medians in the respective sectors. In these industries, roughly half of the API counties are outperforming the national median, and half are underperforming. By contrast, within the health care and social service industries, only Allegheny and Butler Counties outperform the national median. The extraction industries and utilities have the highest wages, both nationally and regionally, although those industries make up only 2 percent and 1 percent of total nationwide employment in 2014, respectively. Nationally, median wages in mining increased by 6.0 percent over the five-year period, and manufacturing wages decreased nationally by 2.4 percent. Allegheny and Armstrong Counties experienced increases of 7.1 percent and 12.3 percent, respectively, in median wages in manufacturing.

Among STEM-related fields, the API region registered lower-than-national median wages in computer and mathematics and health care technical occupations, but higher-than-national wages in extraction and construction occupations. Median wages for computer and mathematics occupations were lower in each API county than the national median of $73,455 in the 2010–2014 estimate. Wages in these occupations did not increase nationally or regionally between the 2006–2010 and 2010–2014 time periods. While median wages dropped 5.3 percent nationally in extraction and construction occupations, 20 counties within the API region saw increases in median wages. All counties' extraction and construction median earnings were higher in the 2010–2014 estimate than the national median of $32,605. However, almost every county has lower health care support and health care practitioner wages compared to the national medians in those occupations; both nationally and within the API region (on average), median wages have stayed the same or slightly declined for health care support and health care practitioners.

As expected, national median wages are significantly higher for more-educated workers: roughly $20,000 for those without a high school diploma, $28,000 for those with a high school diploma, $50,000 for those with a bachelor's degree, and $67,000 for those with a graduate or professional degree. The API region's wages are comparable with national median wages at the lower education levels (no high school diploma, high school diploma, or some college). For those with bachelor's or advanced/professional degrees, median wages in the API region are, on average, roughly 15 percent and 19 percent below the national median, respectively. Only Butler County has median earnings significantly above the national median at every education level.

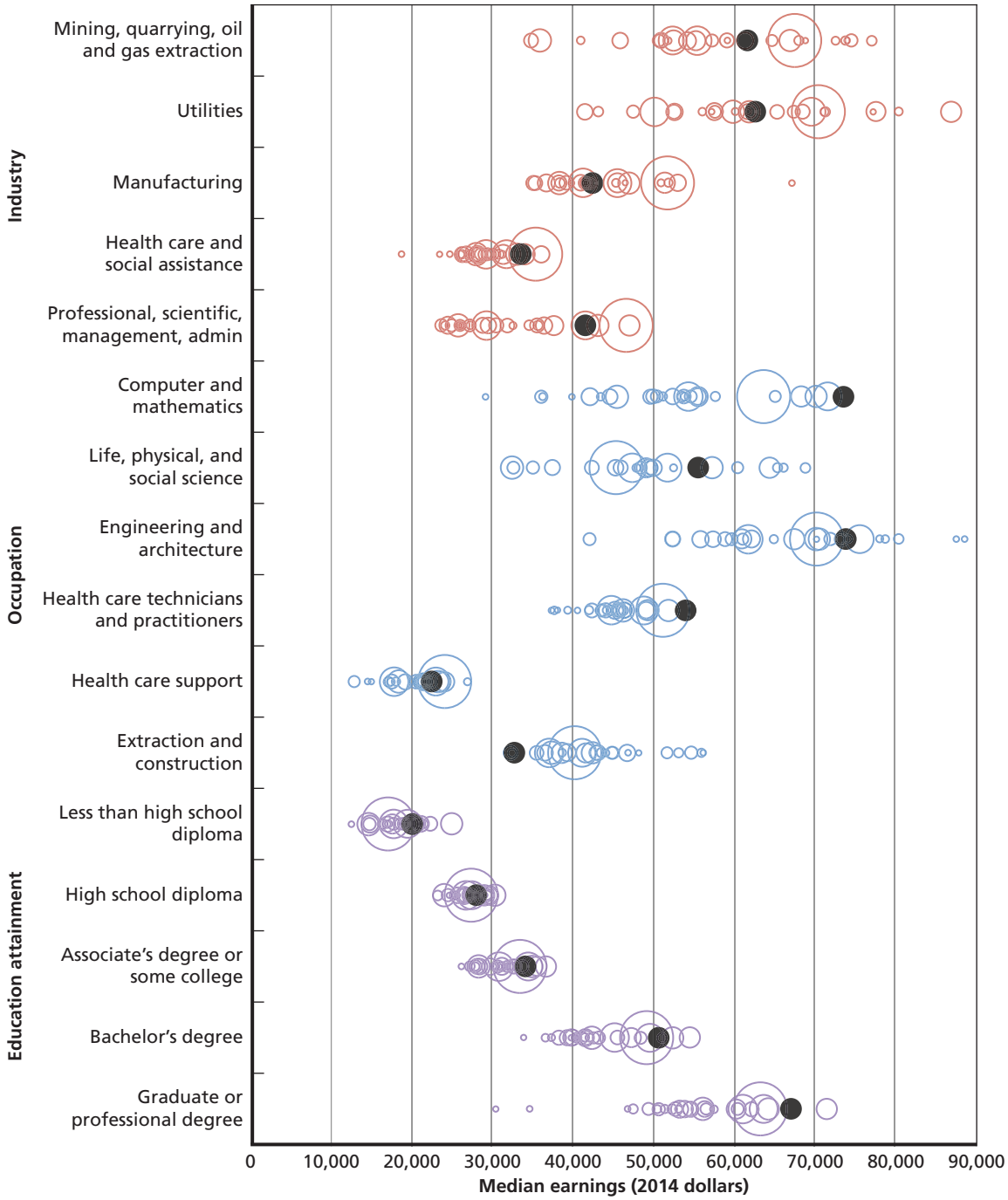
Consistent with trends presented in last year's API report, real wages, both nationally and within the API region, have declined across all education levels from the 2006–2010 to the 2010–2014 time frames.[7] The largest percentage declines nationally were for workers with a high school diploma and those with an associate degree or some college (6.4 percent decline in real wages for both) and for those who did not have a high school diploma (6.0 percent decline). Nationally, median wages for those with a bachelor's degree or an advanced or professional degree decreased by 4.0 and 3.2 percent, respectively.

Earnings by Education Level Within Industries

Table 1 and Figures 5 and 6 compared wages across select industries, occupations, and education levels. Here, we draw upon and analyze the Quarterly Workforce Indicators (QWI) from the U.S. Census Bureau's Longitudinal Employment Dynamics (LED) data series. This data series reports earnings for different education levels within each industry. A distinctive feature of the QWI data is that they provide average monthly earnings for stable jobs, defined as those in which the employee remains employed with the same employer for the duration of the quarter.

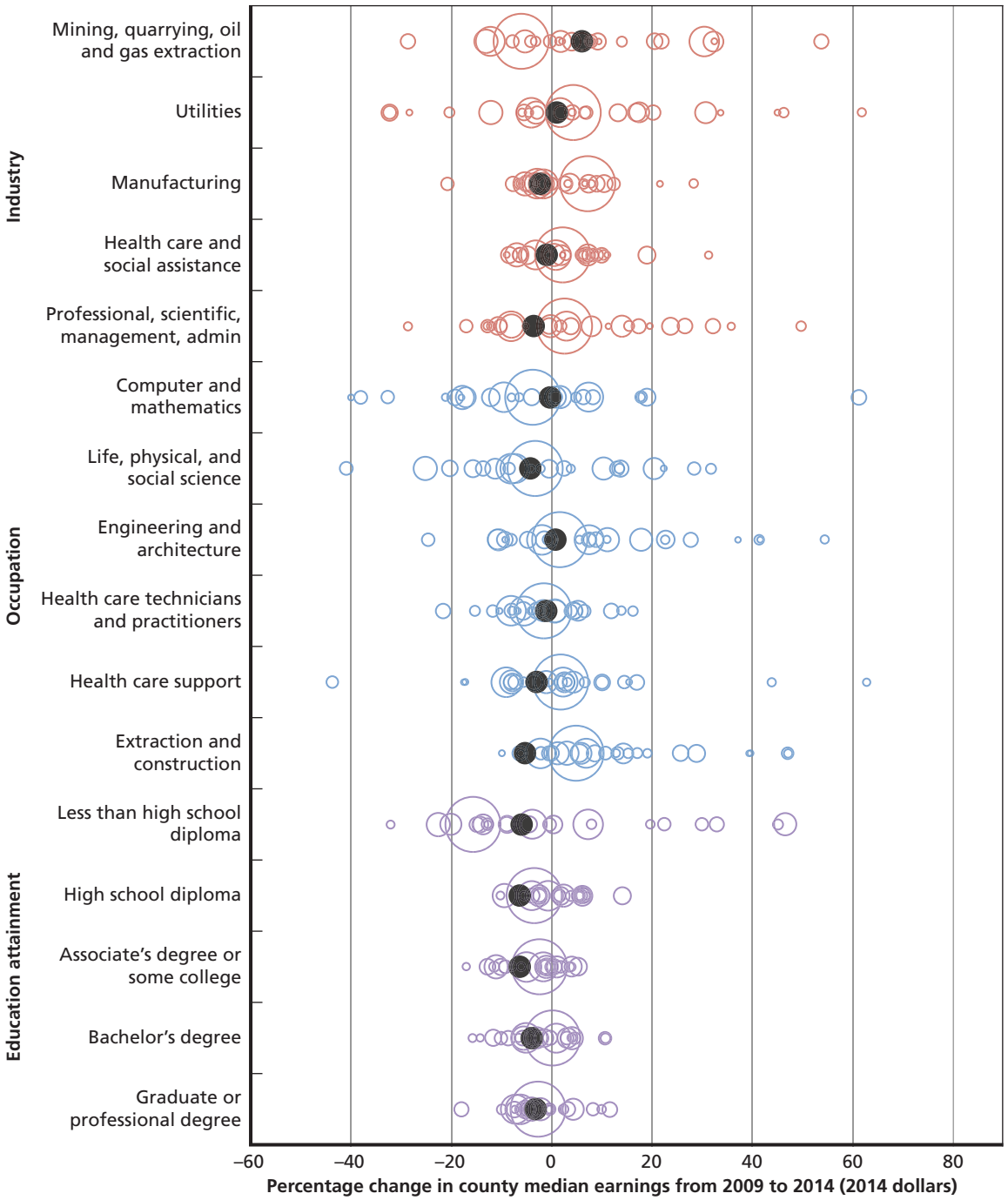
Figure 7 shows mean monthly earnings by education level in Ohio, Pennsylvania, and West Virginia for four industries: mining, quarrying, and oil and gas extraction (extraction industries); utilities; manufacturing; and health care and social assistance industries. Each column represents a weighted average of earnings across the three states in the API region, where weights are determined by the share of total employees in the region who reside in each state (see the appendix for a discussion of the differences between average monthly earnings from the QWI and median wages from the ACS).

Figure 5. Median Wages by STEM-Related Industry, Occupation, and Educational Attainment for Workers (Ages 25 and Above) in the API Region, 2010–2014



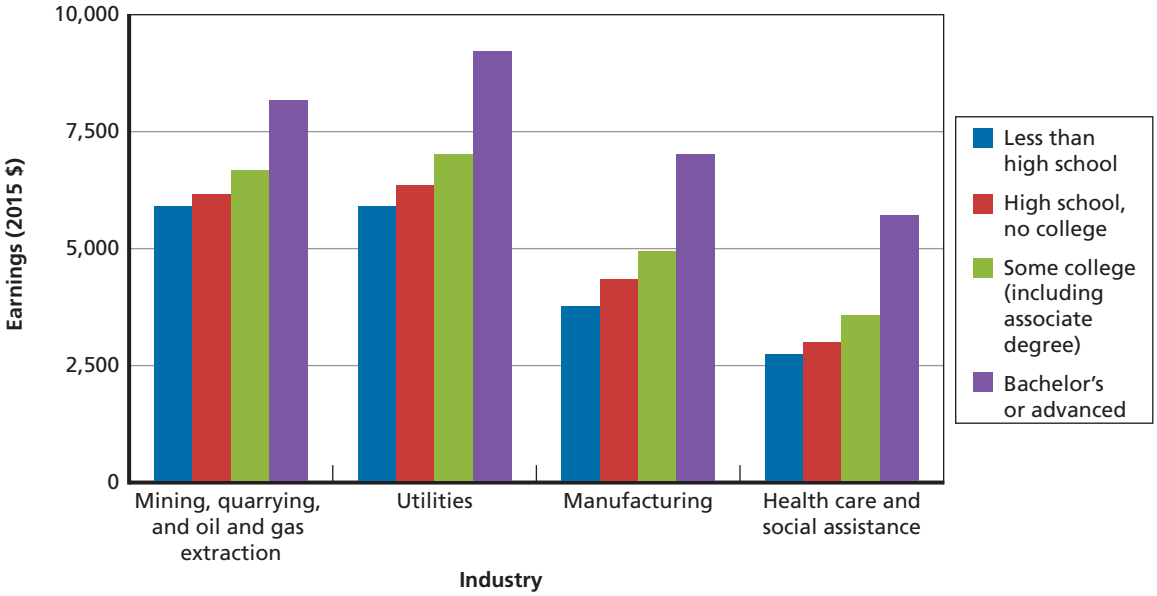
SOURCE: U.S. Census Bureau, undated b.
NOTES: The size of the colored bubbles corresponds to the size of the working-age population in each of the API region's 27 counties. The black bubble represents the U.S. average. Education-attainment categories include the entire workforce over the age of 25; industry and occupational categories are specific to the working-age population (ages 25–64).

Figure 6. Change in Median Wages by STEM-Related Industry, Occupation, and Educational Attainment for Workers (Ages 25 and Above) in the API Region, 2006–2014



SOURCE: U.S. Census Bureau, undated a; and U.S. Census Bureau, undated b.
NOTES: The size of the colored bubbles corresponds to the size of the working-age population in each of the API region's 27 counties. The black bubble represents the U.S. average. Education-attainment categories include the entire workforce over the age of 25; industry and occupational categories are specific to the working-age population (ages 25–64).

Figure 7. Average Monthly Earnings by Education Level and Industry in Pennsylvania, Ohio, and West Virginia, 2015 (Quarter One and Quarter Two)



SOURCE: U.S. Census Bureau, 2015a.
NOTE: Each column represents a weighted average of earnings across Ohio, Pennsylvania, and West Virginia; weights are determined by the share of total employees in the region who reside in each state.

Figure 7 documents the relatively advantageous circumstances of workers in the region's extraction and utilities industries and the disadvantageous circumstances of workers in manufacturing and health care. Across education levels, mean monthly earnings in the extraction industries and utilities exceed those in manufacturing and in health care and social assistance. Workers with only a high school education have higher average monthly earnings in the extraction industries than their more highly educated counterparts in the health care and social assistance industries. The utilities industry offers the highest average earnings overall, particularly for those with bachelor's or advanced degrees.

In the extraction industries, college graduates (including workers with advanced degrees) earn, on average, 37 percent more than workers with less than a high school education—a relatively narrow spread compared to other industries. In the manufacturing and health care industries, those with a bachelor's or advanced degree earn 86 percent and 111 percent more than those with less than a high school education, respectively.

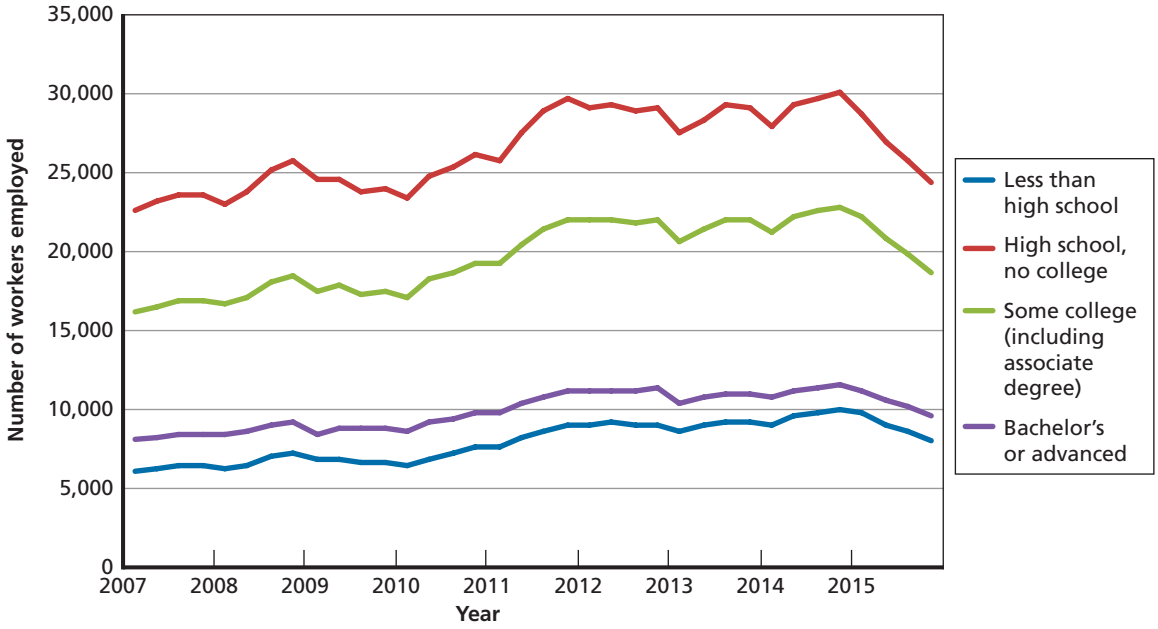
One interpretation of this pattern is that the return on education is higher for workers in manufacturing and health care than in the extraction industries, where everyone's wages are high and less tightly linked to further years of education; a worker in the extraction industry need not be highly educated to reap relatively high earnings.[8] While this has positive implications for workers who are not interested in or able to pursue higher education, one possible negative consequence is that workers might not benefit from longer-term returns on education; there is ample evidence that more education is associated with higher earnings over one's lifetime (for a detailed review of this literature, see Card, 1999).[9]

Employment in Mining and Oil and Gas Extraction Over Time

Figure 8 shows total employment in the extraction industries by education level from 2007 through 2015 in Pennsylvania, Ohio, and West Virginia. Workers whose education status was unknown are not shown. The educational makeup of this workforce was relatively steady in the time frame examined: in 2015, nearly 50 percent of the workforce had a high school education or less, 28 percent had some college (including associate degrees), and 14 percent had a bachelor's or advanced degree (8 percent had unknown education).

Across the three states, total employment in the extraction industries stood at approximately 60,000 in 2007, peaked at slightly over 82,000 in 2014, then declined to 65,000 by the end of 2015. The 2010–2011 period of rapid growth, when over 20,000 jobs were added, documents the types of workers added in an expanding market. The data

Figure 8. Employment by Education Level in the Extraction Industries in Pennsylvania, Ohio, and West Virginia, 2007–2015



SOURCE: U.S. Census Bureau, 2015a.
NOTE: Data shown from Quarter One, 2007, through Quarter Four, 2015.

show that 13 percent were non-high school graduates, 32 percent were high school graduates, 25 percent had some college, and 13 percent were college graduates. Total payroll in the industry (not shown) exhibited similar trends; payroll rapidly increased between 2009 and 2012, plateaued at roughly $1.75 billion per quarter, and then experienced a steep decline (28 percent) from late 2014 to the end of 2015. Note that the economic downturn in 2008 and the subsequent recession appear to have had relatively little impact on employment. The decline in employment in 2015 coincided with falling gas prices, despite the region's continued growth in gas production (see Figure 1).

Insights into Workers Entering and Exiting Extraction Industry Jobs

To gain a better understanding of the trends in the supply of workers in STEM-related fields, we examined employment flows: who is entering or exiting jobs in the extraction industry? In this section we examine two employment transitions—geographic movement and cross-sector movement. Are those who enter the industry local or from outside the region? When workers enter or leave the extraction industry, which other occupational sectors do they come from or go to?

Our objective in undertaking this new inquiry was to overcome the limitations in simple measures of net changes in workers holding extraction industry jobs. Such measures may convey a misleading impression of the underlying migration process and hence the dynamics of employment change. Employment mobility within a region entails enormous slippage (King, Burke, and Pemberton, 2005), and net migration does not take into account the region's economic context (Briscoe et al., 2012) or a specific industry cluster's employment context (Sullivan and Arthur, 2006) that could impact individuals' decisionmaking processes (Sullivan and Arthur, 2006; Culié, Khapova, and Arthur, 2014; Zacher, 2014). That is, a workforce may remain essentially the same size over a given interval, but the people making up that workforce may change.

To gain these insights, we analyzed data from the Longitudinal Employer-Household Dynamics (LEHD) series from the LED. An important limitation of the LEHD data is that they only track job-to-job flows, excluding those who are first entering the workforce (e.g., recent college graduates) and those who have an extended delay between leaving one job and entering the next. A second limitation is that the data are only provided at the state level. Accordingly, the job flows discussed below are totals for entire states (Pennsylvania, Ohio, and West Virginia),

not the specific counties in the API region (see the appendix for more information about the LEHD and its limitations).

Figure 9 shows the origins of workers entering the extraction industry in Ohio, Pennsylvania, and West Virginia from 2009 to 2015. The LEHD data series refers to workers who left one job and began another job in the same quarter or in the following quarter. We focused on three types of workers: (1) job switchers local to the region who entered the extraction industries from another sector of the economy (green); (2) job switchers from outside the API states who entered the extraction industries from another sector of the economy (red); and (3) job switchers from outside the API states who had held extraction industry jobs in their origin state and moved to an extraction industry job within the API states (blue). We do not consider intraregional flows from extraction jobs to extraction jobs within the API states.

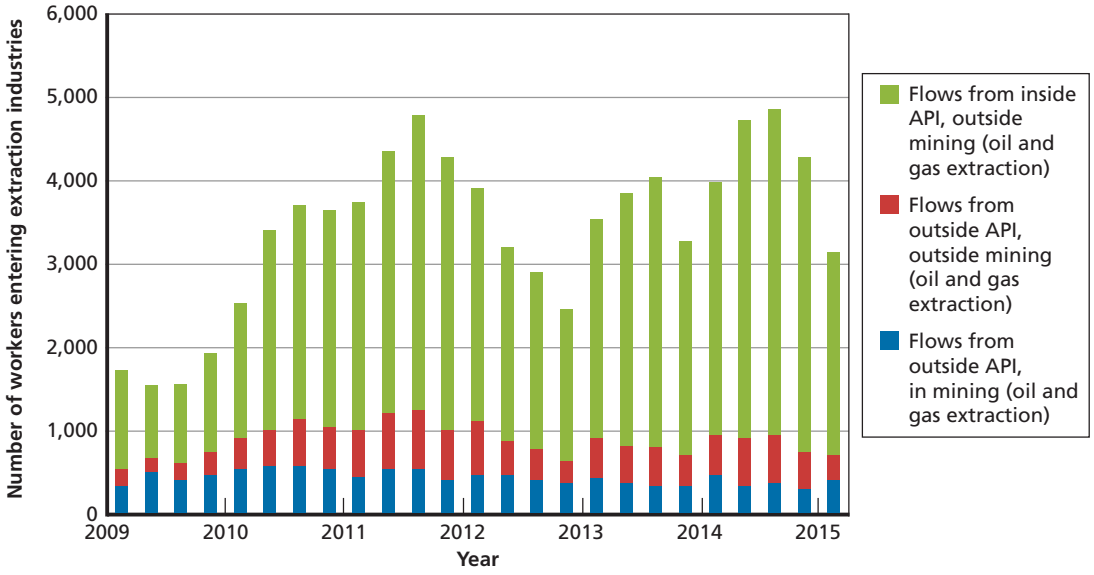
These data reveal that workers entering the extraction industries in Pennsylvania, Ohio, and West Virginia are primarily locals from within these states who are typically transitioning from other sectors of the economy. For example, across all the quarters in 2014 and the first quarter of 2015, approximately 73 percent of workers entering mining were local to the region, approximately 19 percent were out-of-state workers transitioning from a different industry, and approximately 8 percent were out-of-state mining or oil and gas workers moving into the region. These data afford an important insight: Even during the 2009–2011 employment boom, employers succeeded in attracting workers from other industries within the API region to fill open jobs; out-of-region oil and gas workers made up a small share of new hires.

Figure 10 shows the origin and destination industries for workers who entered and exited the extraction industries in Pennsylvania, Ohio, and West Virginia from the first quarter of 2007 to the first quarter of 2015. The data were aggregated over time, so workers who regularly moved between jobs during this period may have been counted more than once. Thus, the unit of analysis here is an event (the job *transition*), not a person (the job *transitioner*).

Workers move between sectors of the economy to switch to a job that better matches one's skills or that offers higher pay, or to embark on a new career in a different industry. Over the period examined here, the data record over 90,000 instances of a worker entering a new extraction industry job from a former job in some other industry. The largest share of incoming workers came from construction (22 percent), waste management and administration (15 percent), and manufacturing (12 percent). Conversely, roughly 60,000 workers left the extraction industries. This leaves a net growth of roughly 30,000 workers from 2007 to 2015.

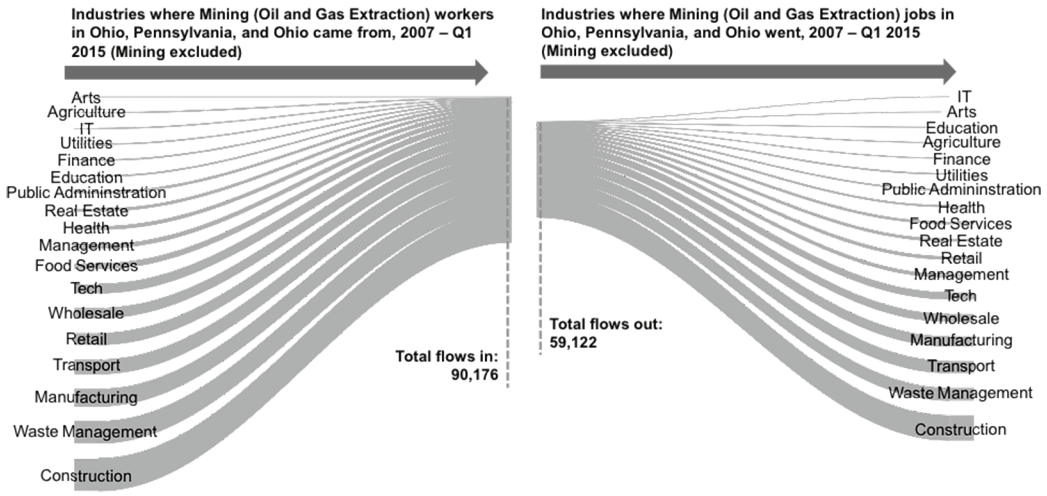
The industries with the highest ratio of inflows to outflows—an indicator of the extent to which worker flows were driven by greater opportunity in the destination industry—were retail trade (2.42) and food services (2.31). In other words,

Figure 9. Sources of New Hires into the Extraction Industries in Pennsylvania, Ohio, and West Virginia, 2009–2015



SOURCE: U.S. Census Bureau, 2015a.
NOTE: Data shown are from Quarter One, 2009, through Quarter Four, 2015. Data do not include those who are new to the workforce or those who entered a job after not working for more than two quarters.

Figure 10. Source and Destination Industries for Workers Moving into and out of the Extraction Industries in Pennsylvania, Ohio, and West Virginia, 2007–2015



SOURCE: U.S. Census Bureau, 2015b.
NOTES: Analysis excludes those whose industry classification was "other." Data set does not include those who are new to the workforce and those who enter a job after not working for more than two quarters.

nearly two and a half workers left a retail job in favor of work in the extraction industries for every one worker who left an extraction job in favor of retail. The industry with the lowest ratio of inflows to outflows was utilities (0.88), indicating a net loss of workers from the extraction industries to utilities. The three largest source/destination industries—construction, waste management, and manufacturing—all have positive inflow-to-outflow ratios, indicating net movement into the extraction industries between 2007 and 2015 from those industries.

EDUCATION PATHWAYS TO STEM CAREERS

This section summarizes analyses of three important educational stepping-stones along the path to STEM careers in order to measure the supply of talent that is entering or readying itself to enter the regional workforce. We update eighth-grade math and science assessment scores and high school graduation rates. Each of these measures is based on state-average performance from Ohio, West Virginia, and Pennsylvania, benchmarked against the national-average performance as a point of comparison. In addition, this section provides an in-depth analysis of post-secondary education trends for all colleges and universities located within the 27-county API footprint. The indicators reflect the most-recent available data (see the appendix for more information about the data used in this section).

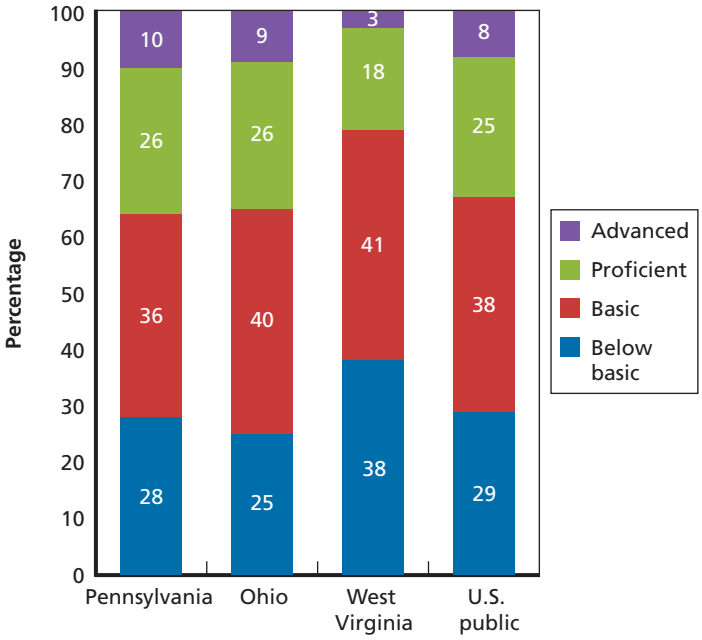
Eighth-Grade Mathematics and Science Proficiency

Figures 11 and 12 show eighth-grade mathematics and science proficiency, respectively, based on the 2015 NAEP, updating 2013 mathematics and 2011 science scores reported in the previous report (Gonzalez et al., 2016). [10]

2015 NAEP scores register a decline in eighth-grade mathematics performance across the API states as well as nationally. While Ohio and Pennsylvania outperform the national average, with 35 and 36 percent of students scoring at or above proficiency, these rates have both fallen by at least 5 percentage points from 2013. Nationally, proficiency has dropped by one percentage point, from 34 percent scoring at or above proficiency in 2013 to 33 percent in 2015. West Virginia remains below the national average, with 21 percent of students at or above proficiency, a 3 percentage-point drop from 2013.

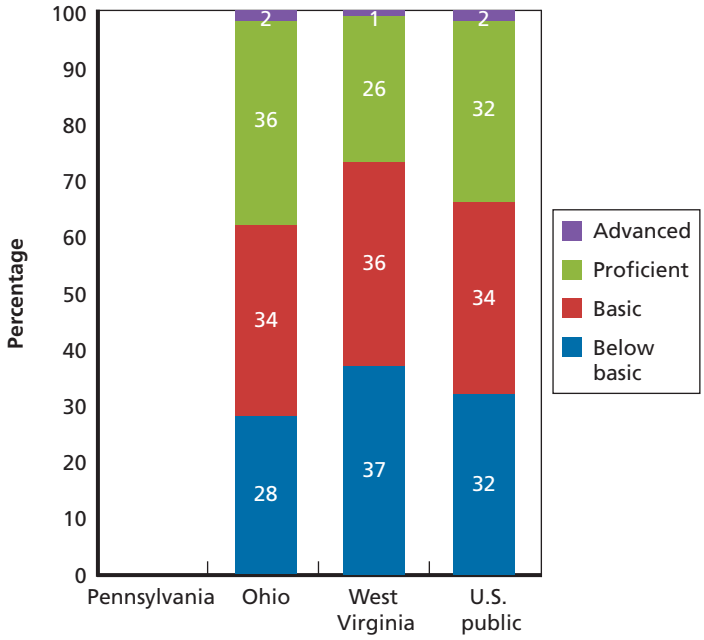
Science proficiency scores show a more encouraging trend. Nationally, 34 percent of eighth-grade students scored as proficient or advanced on the 2015 NAEP science assessment, up from 32 percent in 2011 and 30 percent in 2009. Performance in Ohio remained unchanged from 2011, with 36 percent of students scoring at or above proficiency. West Virginia eighth-graders' scores improved by 3 percentage points from 2011, though scores still lagged the national average by 7 percentage points.

Figure 11. NAEP Eighth-Grade Math Proficiency, 2015



SOURCE: NCES, undated b.

Figure 12. NAEP Eighth-Grade Science Proficiency, 2015



SOURCE: NCES, undated b.
NOTE: State-level scores are not available for Pennsylvania.

High School Graduation Rates

Table 2 compares the statewide high school graduation rates for the four-year cohort of the three API states, as well as for the United States.[11] Nationally, high school graduation rates have continued to climb, with an 82-percent cohort graduation rate for the 2013–2014 academic year. Pennsylvania graduate rates were above the national rate by 3 percentage points, at 85 percent, after a 1-percentage-point drop from the previous year. Ohio saw a 2-percentage-point increase in the three years between 2010–2011 and 2013–2014. As of 2013–2014, Ohio was on par with the national average. West Virginia, which in 2013–2014 had graduation rates 3 percentage points above the national average, registered a noteworthy 4-percentage-point increase between 2012–2013 and 2013–2014 and a 7-percentage-point increase between 2010–2011 and 2013–2014.

Overall, there has been a marked improvement in high school graduation rates, especially in West Virginia. This bodes well for increasing employment and enrollment in higher education across the region. However, there is cause for concern: Those students are not graduating with the mathematics or science skills or content knowledge—as measured in NAEP exams—needed for employment in STEM careers or to pursue STEM majors in higher education.

In the following section, we explore the extent to which the talent pool in the region is graduating from higher education institutions in STEM-related fields.

Table 2. Four-Year Cohort Graduation Rate, 2010–2011 to 2013–2014

Region	2010–2011 (%)	2011–2012 (%)	2012–2013 (%)	2013–2014 (%)
U.S. average	79	80	81	82
Pennsylvania	83	84	86	85
Ohio	80	81	82	82
West Virginia	78	79	81	85

SOURCE: U.S. Department of Education, undated.

Post-Secondary Graduation in STEM-Related Fields

Post-secondary education is an important component in the STEM-workforce pipeline. Our first API report summarized the percentage of post-secondary graduates who earned credentials in STEM fields (Gonzalez et al., 2016). Here we take an in-depth look at post-secondary education in the API region to gain a better understanding of the local talent pool potentially available for employment in STEM careers in the region. We analyzed IPEDS data to gauge the number of 2014 graduates of institutions of higher education, the percentage of 2014 graduates who earned a degree or certificate in a STEM-related field, and the cohort graduation rate in the API footprint.

In the 27 API counties, there were 148 post-secondary educational institutions with more than 45,000 total graduates in 2014. Table 3 shows the type of institutions operating within the API 27-county footprint, along with the number of graduates in 2014 and the percentage of those graduates who earned a degree or credential in a STEM-related field. Note that these values include only bachelor's degrees, associate degrees, and certificates requiring less than two years; master's, doctoral, and other postgraduate degrees are not included.

In 2014, over 28,000 graduates earned bachelor's degrees in the API footprint, roughly twice the number of graduates from two-year institutions (14,432) and 10 times the number of graduates from institutions classified as "less than 2 years" (2,816). The data indicate that four-year institutions generally had a higher share of STEM-related graduates (17 to 19 percent) as compared to two-year institutions (11 to 14 percent). Institutions classified as "less than two years" had a minuscule share of STEM graduates (0 to 1 percent).

Overall, in 2014, institutions of higher education within the API footprint exceeded the national average in the percentage of students gaining certificates, associate degrees, and bachelor's degrees in STEM fields. Across all institution types, 16 percent of graduates in the API footprint were in STEM-related fields as compared to 12 percent nationally. Note that two-year institutions in the API footprint have a significantly higher share of STEM graduates relative to their national peer institutions.

Table 3 also shows the cohort graduation rate.[12] Cohort graduation rates for four-year institutions include only bach-

Table 3. Post-Secondary Education Outcomes by Institution Type Within API 27-County Footprint, 2014

Institution Type	Number of Institutions	Number of Graduates[a]	STEM % (U.S. average %)	2013–2014 % (U.S. average %)
Public, four-year or above	19	17,631	18 (18)	57 (58)
Private not-for-profit, four-year or above	29	10,140	19 (14)	68 (65)
Private for-profit, four-year or above	4	593	17 (10)	26 (28)
Public, two-year	9	8,106	14 (8)	12 (22)
Private not-for-profit, two-year	13	796	12 (4)	63 (54)
Private for-profit, two-year	34	5,530	11 (4)	62 (60)
Public, less than two-year	17	1,167	1 (5)	
Private not-for-profit, less than two-year	5	139	0 (2)	
Private for-profit, less than two-year	18	1,510	1 (3)	
All	148	45,612	16 (12)	51 (48)

SOURCE: NCES, undated a.
NOTE: Numbers in parentheses are the nationwide average.
[a] This category includes associate degrees and certificates classified by IPEDS as "less than one year" or "one to two years." This includes certificates granted by four-year institutions, which are not included in the totals displayed.

elor's degrees or equivalent (post-baccalaureate degrees are not included), and rates for two-year institutions include degree- and certificate-seeking students. IPEDS does not provide graduation rates for "less than two-year" institutions. Graduation rates for four-year institutions in the API footprint were generally comparable with their nationwide peers, with cohort graduation rates of 57 percent for public four-year institutions and 68 percent for private, not-for-profit four-year institutions.

Both nationally and within the API footprint, graduation rates at private, for-profit four-year institutions were significantly lower (26 percent) than those of public and private, not-for-profit institutions. Public two-year institutions in the API region had the lowest graduation rate—12 percent, which also lags the national average (22 percent). Private, not-for-profit two-year institutions in the API footprint outperformed the national average by nearly 10 percentage points, with a graduation rate of 63 percent.

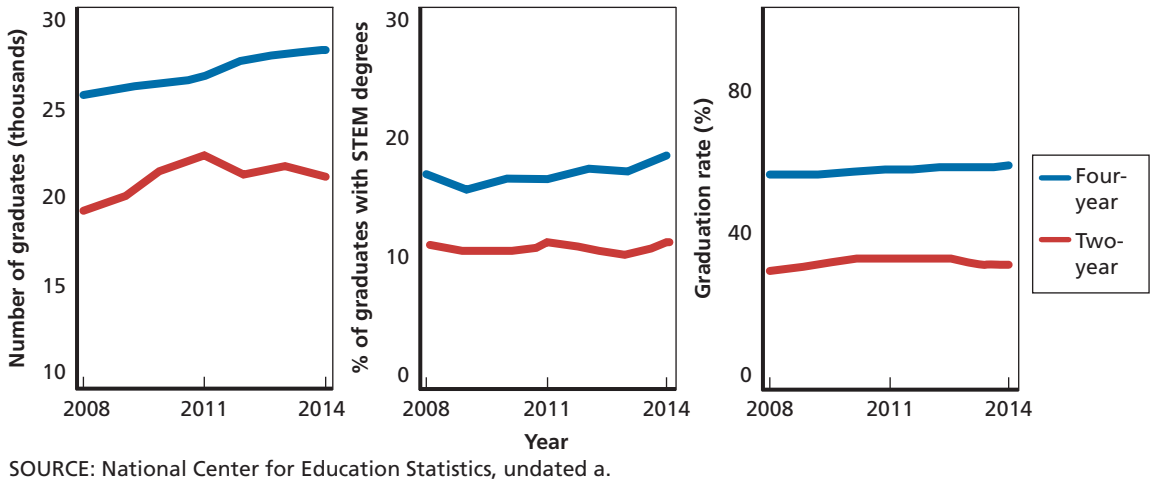
Figure 13 shows trends from 2008 through 2014 for post-secondary education in the API footprint. The figure tracks changes in the three indicators discussed above: the number of graduates (on the left), the percentage of graduates earning a degree or certificate in a STEM-related field (in the middle), and the cohort graduation rate (on the right). The blue line shows trends for bachelor's degrees, and the red line shows trends for associate degrees and certificates. As shown on the left of Figure 13, the number of graduates with bachelor's degrees from four-year institutions steadily increased, from roughly 26,000 in 2008 to 28,300 in 2014 (an average annual increase of 400 graduates). The number of associate degrees and certificates declined slightly from a peak of 22,500 in 2011 to 21,300 in 2014. As shown in the middle of Figure 13, there has been very modest growth in the share of bachelor's degrees awarded in STEM-related fields, rising from 17 percent in 2008 to 18.6 percent in 2014. The share of associate degrees and certificates in STEM fields has remained steady—at just over 10 percent—over the past eight years. The right side of Figure 13 illustrates that cohort graduation rates have remained steady, with very modest increases for bachelor's degrees (2.5 percentage points in eight years) and associate degrees and certificates (1 percentage point in eight years). Note that the cohort graduation rate for bachelor's degrees—roughly 60 percent—is nearly twice as high as the graduation rate for associate degrees and certificates.

Taken together, Table 3 and Figure 13 suggest that the post-secondary education institutions in the API footprint are producing more STEM graduates than the U.S. average. Further, high school graduation rates have increased through the years, with an 82 percent cohort graduation rate for the 2013–2014 academic year, with strong improvement in Pennsylvania, Ohio, and West Virginia. And while math and science scores in West Virginia, as presented in Figures 11 and 12, did not keep pace with Ohio, Pennsylvania, or the national average, scores did improve between 2015 and 2011 (for science) and 2013 (for math).

CONCLUSION

This annual report is the second in a series of five planned regional indicator reports tracking and analyzing the state of the local STEM labor market and the production of local tal-

Figure 13. Trends in Post-Secondary Education Graduation, Graduates with a STEM Degree, and Graduation Rate Within API 27-County Footprint, 2008–2014



SOURCE: National Center for Education Statistics, undated a.

ent through education in the 27-county API region. Given the volatility of the region's energy and advanced manufacturing sector, it is imperative to monitor and assess the strengths and weaknesses of the STEM economy and the capacity of the local talent pool, which contribute to the API region's continued economic vitality.

Three questions guided the descriptive analysis presented in this report:

- What are the characteristics of the API region's STEM labor market?
- Who are the new hires in the extraction industry?
- Is the local talent pool graduating from high schools and colleges equipped with skills and trained in fields appropriate to the region's STEM labor market?

Below we summarize our key findings.

Trends in STEM labor market indicators for the API region were broadly similar to national averages, although certain counties' characteristics varied by industry or occupation. The working-age population continued to shrink for most of the API region's counties. As noted in last year's report, the API region is at a demographic disadvantage, and that disadvantage persists (Gonzalez et al., 2016). Our latest data show that 20 of its 27 counties registered declines in their working-age population, in sharp contrast to the 14.3-percent national growth in working-age population between 2000 and 2014. Monongalia County, West Virginia, continued to stand out as the exception. By our latest measures, it registered a 30.2-percent increase in working-age population.

An important question to consider is *why* the working-age population is shrinking across most of the region. Is interregional migration replacing working-age residents with retirees? Are the cohorts of youth coming into working age smaller than before? Are youth moving out of the region once they are old enough to work? Further, little is known about the workforce participation of this population. Are they employed? In which industries or occupations? Are their wages commensurate with their education and training? These are questions to be explored in future analyses, as we accumulate additional years of data that will support such inquiries.

About half of the counties in the API region outperformed the nation in median wages in extraction, utilities, and manufacturing industries. Our current data and analyses showed continuity with trends in wages noted in last year's report: for some STEM industries and occupations, average median wages in the 27-county API region were higher or on pace with national averages, but some counties' wages remained stubbornly below the national average (Gonzalez et al., 2016). The extraction industries and utilities boasted the highest wages, both nationally and regionally. Regional wages in the manufacturing, utilities, and extraction industries remained on pace with the national median wages. In these industries, roughly half of the API counties were outperforming the national median wage, and half were underperforming. Census tracts with the highest median wages in the region clustered around Allegheny County, Pennsylvania, and Monongalia County, West Virginia.

The differences in median wages observed across counties by occupation and industry may have occurred for several reasons. Among these are shifts in supply and demand for the types of workers needed in each industry (driven at least in part by shifts in supply and demand for the products in each industry, such as oil); shifts in the types of workers and use of physical capital within firms in each industry; changes in productivity of workers through education or training; and labor migration patterns into and out of the region. This study is unable to conclude which of these factors, among others, drive median wage levels and changes in this region.

Real wages, both nationally and within the API region, declined across most education levels from 2005 to 2014. However, in a handful of API counties, there was a marked increase in median wages for workers with less than a high school degree. There was less regional variation in wages for employees with less than a bachelor's degree. This suggests that an employer's location could have had an impact on salaries for the workforce with a bachelor's degree or higher, but the impact was much less for a workforce with less than a bachelor's degree. Workers with fewer years of education could therefore expect to move across county lines and receive comparable wages.

Across education levels in Ohio, Pennsylvania, and West Virginia, mean monthly earnings in the extraction industries and utilities continued to exceed those in manufacturing and health care and social assistance in 2015. Even for workers with only a high school education or less, average monthly earnings in the extraction industries exceeded average earnings for highly educated workers in the health care and social assistance industries. The utilities industry offered the highest average earnings overall, particularly for those with bachelor's or advanced degrees.

Within the API region, the relative makeup of the workforce in extraction industries, by education level,

The local talent pool graduated from colleges with skills and in fields that could be utilized in the STEM labor market, but high school graduates lagged the nation in math and science assessment scores.

remained essentially unchanged from 2007 to 2015. Nearly 50 percent of the workforce had a high school education or less, 28 percent had some college (including associate degrees), and 14 percent had a bachelor's or advanced degree (8 percent had unknown education). The 2008 economic downturn and the recession that followed had relatively little impact on employment in the extraction industry: Overall, employment rose from approximately 60,000 in 2007 to slightly more than 82,000 in 2014. However, by the end of 2015, employment in the extraction industry declined by roughly 20 percent, to 65,000 (the decline corresponded to falling gas prices). For the extraction industry, the decrease in production and extraction in 2015 had a direct impact on short-term employment.

New hires in the extraction industry tend to be local to the region. In this year's report, we analyzed new hires in the extraction industry from 2007 to 2015 to document (1) whether they were coming from outside Ohio, Pennsylvania, or West Virginia and (2) their previous sectors of employment. This information can indicate the extent to which local talent has been employed in the industry. We found that workers entering the extraction industries in Pennsylvania, Ohio, and West Virginia in this time period were primarily locals from within their respective states; they typically were transitioning from other sectors of the economy. Over the period examined here, roughly 90,000 workers entered a new extraction job from a different industry. The largest share of incoming workers came from construction (22 percent), waste management and administration (15 percent), and manufacturing (12 percent). There were roughly 60,000 cases of workers exiting the extraction industries, leaving a net growth of roughly 30,000 workers from 2007 to 2015.

Taken together, these findings suggest that in the years examined, the local supply of talent has kept pace with the employment demands in the extraction industry. Moreover, even during the 2009–2011 employment boom, out-of-region oil and gas workers composed a small share of new hires. Rather, employers turned to workers from other industries in the API region to fill open jobs. This finding is critical to sustaining an economically vibrant region, as talent must be retained within the region to encourage steady growth of STEM jobs going forward.

The local talent pool graduated from colleges with skills and in fields that could be utilized in the STEM labor market, but high school graduates lagged the nation in math and science assessment scores. The analyses presented in this report examined three educational stepping-stones along the path to STEM careers to measure the supply of talent that is entering or readying to enter the regional workforce.

West Virginia continued to lag behind Pennsylvania, Ohio, and the national average in mathematics and science assessment scores. Across the nation and in Ohio, Pennsylvania, and West Virginia, average eighth-grade mathematics NAEP test scores declined from 2013 to 2015. Science scores improved nationally and for West Virginia from 2011 to 2015 (Ohio remained about the same, and Pennsylvania scores were unavailable). However, West Virginia continued to lag behind the national average science score by 7 percentage points in 2015.

High school graduation rates in the region continued to improve. Pennsylvania and West Virginia had high school graduation rates about 3 percentage points above the national average, while Ohio's rate was on par with the national average. Graduation rates in West Virginia experienced the greatest change: from 78 percent in 2010–2011 to 85 percent in 2013–2014.

The number of STEM degrees earned in the API region is higher than the national average. Institutions of higher education within the API footprint exceeded the national average in the percentage of students gaining certificates, associate degrees, and bachelor's degrees in STEM fields. Across all institution

types, 16 percent of graduates in the API region were in STEM-related fields, as compared to 12 percent nationally. Note that two-year institutions in the API footprint had a significantly higher share of STEM graduates relative to their national peer institutions. The number of graduates with bachelor's degrees from four-year institutions has steadily increased from 2008 through 2014, whereas the number of associate degrees and certificates has declined slightly from the peak of 22,500 in 2011 to 21,300 in 2014. There was very modest growth in the share of bachelor's degrees awarded in STEM-related fields. The share of associate degrees and certificates in STEM fields has remained steady—at just over 10 percent—over the past eight years. Graduation rates have remained steady, with very modest increases for bachelor's degrees (2.5 percentage points gained in eight years) and associate degrees and certificates (1 percentage point gained in eight years).

By and large, our expanding slate of indicators—the size of the working-age population, median wages and earnings by industry, occupation, and education level, and employment by education level in the extraction industries—reflects market processes gradually adjusting to the shifts in demands for workers and the STEM skills needed in the energy and advanced manufacturing workplace. Although the working-age population is declining in most counties in the region, the three counties experiencing growth (Monongalia County, West Virginia, and Butler and Washington Counties, Pennsylvania) are also those where workers in STEM fields garner higher wages than in other fields, especially workers with few years of formal schooling. Further, employers in the extraction industries have relied mostly on local labor within Ohio, Pennsylvania, and West Virginia. This finding that worker mobility is predominantly intraregional suggests that employers and policymakers can continue to channel talent from within the region to fill STEM jobs. Future policies might therefore focus on enhancing the attractiveness of STEM jobs toward the local talent pool.

Analyses of the supply of the STEM workforce are also modestly encouraging: A steady supply of STEM-focused students continues to enter the workforce. While we cannot conclude whether the supply is sufficient for the demand, our educational indicators highlight areas where the pipeline of potential talent might not be keeping pace with potential future or long-term demand. Specifically, scores on the NAEP eighth-grade assessments suggest that students in West Virginia are lagging in math and science proficiency, compared with students nationwide and with students in Ohio and Pennsylvania. For those looking to invest in the region's future economic prosperity, this is one area where such investment may be warranted.

APPENDIX

The indicators presented in this report relied on the following data sources.

Data Sources for Wages and Employment Indicators

Wage, employment, and population data are from the 2000 Decennial Census, the Population Estimates Program (PEP), and the ACS five-year estimates. Data from the ACS were found in Tables B01001, B20004, B24011, C24010, C24013, S1903, S2402, and S2403.

Data on population growth (Figure 3) are based on a comparison between the 2000 Decennial Census and the 2010–2014 ACS five-year estimates, which reflect data collected between January 2010 and December 2014. Median wages (Figures 4, 5, and 6 and Table 1) are all based on the 2010–2014 ACS five-year estimates. Figure 6 shows the percentage change in wages, which is based on data from the ACS 2014 five-year estimates (2010–2014) and the ACS 2010 five-year estimates (2006–2010).

The ACS has well-documented limitations (U.S. Census Bureau, 2009). First, the ACS reports employment levels by occupation and industry, using major occupational and industrial groups but not more-granular categories. For example, the ACS reports management, business, science, and arts occupations together. We reported industry employment separately from occupation employment because these two categories are not mutually exclusive. Second, while the ACS permits the reporting of median wages by education level, it does not permit the reporting of wages by industry, occupation, or education level within age groups. Such information, if available, could help us better understand differences in age-cohort wages or employment. Third, the ACS does not report wages by occupation and education concurrently. Note that Figures 4, 5, and 6 and Table 1 present a one-year update from data shown in the first API report (Gonzalez et al., 2016). However, the reliance on the ACS five-year estimates will tend to mute year-to-year changes.

To broaden our slate of employment indicators, we accessed several data sets this year for the first time and incorporated new measures derived from them. These new data sets are the QWI and LEHD data, which are applications of the U.S. Census Bureau's LED Partnership. Data in these series are tabulated quarterly and are based on employer- and firm-level administrative data shared through the LED Partnership. The primary sources for this series are unemployment insurance earnings data; the Quarterly Census of Employment and Wages; the Business Dynamics Statistics database; and demographic information from several sources, including the Census and Social Security Administration records. These micro-level data enable us to track employees across firms, industries, and states and to identify important labor market measures across several dimensions, including worker education, gender, age, and firm age.

Note that the mean stable earnings (Figures 7 and 8) reported in the QWI are constructed in a fundamentally different way from median wages in the ACS (Figures 4 through 6, and Table 1). A worker is included in the QWI earnings calculation if he or she received positive earnings in a reference quarter and remained employed with that firm for the duration of the quarter. The mean earnings metric is then calculated by adding together the total earnings of all workers in a given reference group, dividing by stable employment in that reference group, and dividing by three to produce a monthly average. This measure differs from the ACS median wage in three important ways. First, it includes all monetary compensation, including bonuses, but excludes benefits (such as health insurance). Second, it tends to underweight short-term workers, since it includes only those workers who were employed in a firm for at least two consecutive quarters. Third, the mean stable earnings are systematically higher than the median, due to the influence of very high earners.

The analysis of workers' movement into and out of industries (Figures 9 and 10) is based on our newly accessed LEHD Job-to-Job origin-destination data series. Data for each of the three states that compose the API region were downloaded and merged to create a single integrated data set of directional flows. This data set measures two kinds of flows into and out of each state for each quarter and for each two-digit NAICS code: (1) direct job flows and (2) main job accessions following a brief period of nonemployment. A direct job flow is defined as a worker who leaves one job and begins a different job within the same quarter. A main job accession is defined as a worker who leaves one job and begins a different job during the subsequent quarter.

For our purposes, we combined these two into a single set of flows with reference to the API region. Inflows into the region were defined as workers who left a job outside Ohio, Pennsylvania, or West Virginia and moved to a job in one of those states. Outflows from the region were defined as work-

ers who left a job in Ohio, Pennsylvania, or West Virginia and moved to a job outside those states.

An important limitation of the LEHD data is that they only track job-to-job flows, which exclude a portion of the workforce. Specifically, the data do not include persons first entering the workforce (e.g., new college graduates) nor those who had an extended spell of nonemployment between leaving one job and starting the next one. A second limitation is that the data are only provided at the state level, so the job flows we measure necessarily refer to all of Pennsylvania, Ohio, and West Virginia, not just the portions of each state within the API region.

Data Sources for STEM-Education Indicators

The NAEP is a nationally representative assessment well suited for making comparisons across states. The NAEP is administered to a national sample of students in fourth, eighth, and 12th grades. Mathematics assessments are administered every two years, and science assessments are administered every four years. In this report, we used the latest available data: the 2015 science assessments and 2015 mathematics assessments. Further technical details about the NAEP are accessible at its website (see NCES, 2015).

We used the 2015 NAEP data from the NCES. For ease of interpretation, we present the original scaled scores in terms of NAEP achievement levels—"below basic," "basic," "proficient," and "advanced."[13]

We used high school graduation rates from data compiled by the U.S. Department of Education and available at the department's EDFacts web site (see U.S. Department of Education, undated). EDFacts centralizes data provided by state education agencies, local education agencies, and schools. The four-year adjusted cohort graduation rate is calculated based on the number of first-time ninth graders in a given year who graduate within four academic years, after accounting for those who transferred into or out of the cohort.

The IPEDS is a compilation of surveys conducted by the NCES. IPEDS gathers information from every college, university, and technical and vocational institution that participates in federal financial aid programs for students. Results presented in the body of the report give the average share of degrees granted in STEM fields, as defined by Classification of Instructional Programs codes. More than 200 areas of study fall under the STEM umbrella, including computer and information sciences, engineering and engineering technologies, biological and biomedical sciences, mathematics and statistics, physical sciences, and sciences technologies. The complete list of STEM Classification of Instructional Programs codes is available from the U.S. Department of Education (NCES, 2011). Graduates include those who completed a degree or certificate between July 1, 2013, and June 30, 2014, from an institution within the 27-county API region. The share of STEM degrees is simply the total number of graduates from STEM fields divided by the grand total of graduates from the relevant institutions.

NOTES

[1] During hydraulic fracturing, high-pressure water, mixed with sand and other compounds, is pumped into a borehole to crack layers of a shale rock formation, releasing trapped oil and gas.

[2] RAND does not make investment decisions. Rather, as the monitoring and evaluation lead, RAND produces these regional indicator reports (of which this is the second in a series of five) and evaluates the extent to which API's portfolio of program investments meets Chevron's goals in the region. The result of the latter evaluation will be published in a separate report. For details, see Dougherty, 2014.

[3] To date, this type of descriptive portrait of the 27 counties does not exist, although there is ample published information specific to each state, metropolitan areas within each state, and the broader Appalachian region. For information on the population, employment, and labor force in the 420-county, 12-state Appalachian region, see Pollard and Jacobson (2015) and Center for Regional Economic Competitiveness and West Virginia University (2015).

[4] The wages reported here are real wages; they have been adjusted for inflation.

[5] ACS reports median wages by education level, but not wages by industry, occupation, or education level within age groups. Further, the ACS does not report county-level wage data by educational attainment for specific industries or occupations.

[6] The growth is represented as (2014 median earnings in 2014 dollars – 2009 median earnings in 2014 dollars)/2009 median earnings in 2014 dollars. Using the Consumer Price Index to adjust for inflation, $100 in 2009 had the same buying power as $110.35 in 2014.

[7] The 2010 five-year ACS earnings data were collected between 2006 and 2010, while the 2014 five-year ACS earnings data were collected between 2010 and 2014. The Great Recession lasted from December 2007 to June 2009, so data in the 2010 ACS product reflect almost two years of pre-recession earnings. While the earnings may have grown from 2009 (the end of the recession) to 2014, the earnings comparison illustrated in the charts reflects a multiyear period making it difficult to observe a definitive trend.

[8] Average monthly earnings in the extraction industries are slightly below those in other notable oil extraction states, such as Texas, Oklahoma, and North Dakota, but remain well above national averages across education levels (analyses not shown, but available from the authors by request).

[9] For example, on average, a bachelor's degree is worth $2.8 million over a lifetime. There is also a premium for people with associate degrees who earn, on average, one-third more than those with only a high school diploma (Carnevale, Rose, and Cheah, 2011), and, post-secondary certificate holders earn 20 percent more than high school graduates without any postsecondary education (Carnevale, Rose, and Hansen, 2012).

[10] As explained in the appendix, NAEP does not test all students in a state. It therefore does not report results at the district level (or county level). For more information on how proficiency in a NAEP subject is defined, see NCES, 2012b. State-level science scores for the 2015 NAEP are not available for Pennsylvania.

[11] The four-year cohort graduation rate is calculated based on the number of first-time ninth graders in 2009–2010 who graduated within four academic years (by 2013–2014), after accounting for those who transferred into or out of the cohort.

[12] The post-secondary cohort graduation rate is the percentage of an original cohort that completed the degree within 150 percent of the target time (i.e., within six years for a bachelor's degree, three years for an associate's degree).

[13] For more information on the expectations for eighth-grade students to perform proficiently in the mathematics and science NAEP tests, refer to NCES, 2015, and NCES, 2012a.

BIBLIOGRAPHY

Briscoe, J. P., S. C. Henagan, J. P. Burton, and W. M. Murphy, "Coping with an Insecure Employment Environment: The Differing Roles of Protean and Boundaryless Career Orientations," *Journal of Vocational Behavior*, Vol. 80, No. 2, 2012, pp. 308–316.

Brown, Jason, "Production of Natural Gas from Shale in Local Economies: A Resource Blessing or Curse?" *Economic Review*, Vol. 99, No. 1, 2014, pp. 119–147. As of November 18, 2016: https://www.kansascityfed.org/publicat/econrev/pdf/14q1Brown.pdf

Burning Glass Technologies, Council for Adult and Experiential Learning, and Allegheny Conference on Community Development, *Inflection Point: Supply, Demand and the Future of Work in the Pittsburgh Region,* 2016. As of November 18, 2016: http://www.alleghenyconference.org/wp-content/uploads/2016/08/InflectionPoint.pdf

Card, David, "The Causal Effect of Education on Earnings," in Orley Ashengelter and David E. Card, eds., *Handbook of Labor Economics*, Vol. 3A, Amsterdam: Elsevier, 1999, pp. 1801–1863.

Carnevale, Anthony P., Stephen J. Rose, and Ban Cheah, *The College Payoff: Education, Occupations, Lifetime Earnings*, Washington, D.C., Georgetown University Center on Education and the Workforce, 2011. As of December 14, 2016: https://cew.georgetown.edu/cew-reports/the-college-payoff/

Carnevale, Anthony P., Stephen J. Rose, and Andrew R. Hansen, *Certificates: Gateway to Gainful Employment and College Degrees*, Washington, D.C., Georgetown University Center on Education and the Workforce, 2012. As of December 13, 2016: https://cew.georgetown.edu/cew-reports/certificates/

Center for Regional Economic Competitiveness and West Virginia University, *Appalachia Then and Now: Examining Changes in the Region Since 1965*, Washington, D.C.: Appalachian Regional Commission, February 2015. As of December 23, 2015: http://www.arc.gov/assets/research_reports/AppalachiaThenAndNowCompiledReports.pdf

Chevron, "Chevron Launches Appalachia Partnership Initiative," press release, October 21, 2014. As of January 25, 2017: https://www.chevron.com/stories/chevron-launches-appalachia-partnership-initiative

Culié, Jean-Davis, Svetlana N. Khapova, and Michael B. Arthur, "Careers, Clusters and Employment Mobility: The Influences of Psychological Mobility and Organizational Support," *Journal of Vocational Behavior*, Vol. 84, No. 2, April 2014, pp. 164–176.

Dougherty, Joseph, "RAND to Evaluate New STEM Initiative in Appalachia Region," blog post, RAND.org, October 21, 2014. As of October 9, 2015: http://www.rand.org/blog/2014/10/rand-to-evaluate-new-stem-initiative-in-appalachia.html

Gonzalez, Gabriella C., Kyle Siler-Evans, Gerald Paul Hunter, and Matthew D. Baird, *Wages, Employment, and STEM Education in Ohio, Pennsylvania, and West Virginia: Report No. 1 (2016),* Santa Monica, Calif.: RAND Corporation, RR-1357-CHC, 2016. As of January 26, 2017: http://www.rand.org/pubs/research_reports/RR1357.html

Kelsey, Timothy W., Mark D. Partridge, and Nancy E. White, "Unconventional Gas and Oil Development in the United States: Economic Experience and Policy Issues," *Applied Economic Perspectives and Policy,* 2016, pp. 1–24.

King, Z., S. Burke, and J. Pemberton, "The 'Bounded' Career: An Empirical Study of Human Capital, Career Mobility and Employment Outcomes in a Mediated Labour Market," *Human Relations*, Vol. 58, No. 8, 2005, pp. 981–1007.

Lendel, Iryna, Andrew R. Thomas, Bryan Townley, Thomas Murphy, and Ken Kalynchuk, *Economics of Utica Shale in Ohio: Workforce Analysis*, Cleveland, Ohio: Center for Economic Development and Energy Policy Center, Cleveland State University, September 2015. As of January 26, 2017: http://engagedscholarship.csuohio.edu/urban_facpub/1330/

Lombard, Hamilton, "In Most of the United States the Working Age Population Is Now Shrinking," *Stat Chat*, November 2, 2016. As of December 20, 2016: http://statchatva.org/2016/11/02/in-most-of-the-united-states-the-working-age-population-is-now-shrinking/

National Academies of Sciences, Engineering, and Medicine, *Promising Practices for Strengthening the Regional STEM Workforce Development Ecosystem.* Washington, D.C.: The National Academies Press, 2016. As of January 31, 2017: https://www.nap.edu/download/21894

National Center for Education Statistics, "Integrated Postsecondary Education Data System," data set, undated a. As of January 31, 2017: https://nces.ed.gov/ipeds/

———, "State Profiles," Washington, D.C., undated b. As of January 31, 2017: http://nces.ed.gov/nationsreportcard/states/

———, *Postsecondary Awards in Science, Technology, Engineering, and Mathematics, by State: 2001 and 2009*, Washington, D.C., April 2011. As of January 26, 2017: https://nces.ed.gov/pubs2011/2011226.pdf

———, "The NAEP Science Achievement Levels," web page, March 24, 2012a. As of January 31, 2017: https://nces.ed.gov/nationsreportcard/science/achieveall.asp

———, "NAEP Achievment Levels," web page, July 17, 2012b. As of February 14, 2017: https://nces.ed.gov/nationsreportcard/achievement.aspx

———, "The NAEP Mathematics Achievement Levels," web page, October 21, 2015. As of February 1, 2017: https://nces.ed.gov/nationsreportcard/science/achieveall.asp

National Research Council, *Emerging Workforce Trends in the U.S. Energy and Mining Industries: A Call to Action,* Washington, D.C.: National Academies Press, 2013.

National Science Board, *Science and Engineering Indicators*, Arlington, Va.: National Science Foundation, MSB-2016-1, 2016. As of November 29, 2016: https://www.nsf.gov/statistics/2016/nsb20161/uploads/1/nsb20161.pdf

NCES—*See* National Center for Education Statistics.

Pollard, Kelvin, and Lenore Jacobson, *The Appalachian Region: A Data Overview from the 2009–2013 American Community Survey*, Washington, D.C.: Appalachian Regional Commission, February 2015. As of December 23, 2015: http://www.arc.gov/assets/research_reports/DataOverviewfrom2009-2013ACS.pdf

Porter, Michael E., David S. Gee, and Gregory J. Pope, *America's Unconventional Energy Opportunity: A Win-Win Plan for the Economy, the Environment, and a Lower-Carbon, Cleaner-Energy Future*, Cambridge, Mass.: Harvard Business School and Boston Consulting Group, June 2015. As of December 23, 2015: http://www.hbs.edu/competitiveness/Documents/america-unconventional-energy-opportunity.pdf

President's Council of Advisors on Science and Technology, *Engage to Excel: Producing on Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics.* Washington, D.C.: Executive Office of the President, 2012.

Rothwell, Jonathan, *The Hidden STEM Economy*, Washington, D.C.: Brookings Institution, June 2013. As of October 5, 2015: http://www.brookings.edu/research/reports/2013/06/10-stem-economy-rothwell

Sirkin, Harold L., Michael Zinser, and Justin Rose, " The U.S. Skills Gap: Could It Threaten a Manufacturing Renaissance?" *BCG Perspectives*, August 28, 2013. As of December 23, 2015: https://www.bcgperspectives.com/content/articles/lean_manufacturing_us_skills_gap_could_threaten_manufacturing_renaissance

Sullivan, S. E., and M.B. Arthur, "The Evolution of the Boundaryless Career Concept: Examining Physical and Psychological Mobility," *Journal of Vocational Behavior*, Vol. 69, 2006, pp. 19–29.

U.S. Bureau of Labor Statistics, *Employment of Major Occupational Group, 2014 and Projected 2024,* December 8, 2015. As of November 29, 2016: http://www.bls.gov/news.release/ecopro.t04.htm

U.S. Census Bureau, 2006–2010 American Community Survey Five-Year Estimates, undated a. As of February 1, 2017: https://factfinder.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t

———, 2010–2014 American Community Survey Five-Year Estimates, undated b. As of February 1, 2017: https://factfinder.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t

———, Decennial Census, 2000. As of February 1, 2017: http://www.census.gov/main/www/cen2000.html

———, *A Compass for Understanding and Using American Community Survey Data: What Researchers Need to Know*, Washington, D.C.: U.S. Government Printing Office, May 2009. As of January 31, 2017: https://www.census.gov/content/dam/Census/library/publications/2009/acs/ACSResearch.pdf

———, Longitudinal-Employer Household Dynamics Program, Job-to-Job Flows (J2J) Data (Beta), 2015a. As of February 6, 2017: https://lehd.ces.census.gov/data/j2j_beta.html

———, Longitudinal-Employer Household Dynamics Program, Quarterly Workforce Indicators Data, 2015b. As of February 1, 2017: https://lehd.ces.census.gov/data/

U.S. Department of Education, "EDFacts Data Files," web page, last updated January 24, 2017. As of January 31, 2017: http://www2.ed.gov/about/inits/ed/edfacts/data-files/index.html

U.S. Energy Information Administration, "Henry Hub Natural Gas Spot Price," web page, November 16, 2016a. As of November 18, 2016: https://www.eia.gov/dnav/ng/hist/rngwhhdA.htm

———, "Ohio State Energy Profile," web page, last updated April 21, 2016b. As of November 18, 2016: http://www.eia.gov/state/print.cfm?sid=OH

———, "Pennsylvania State Energy Profile," web page, last updated July 21, 2016c. As of November 18, 2016: http://www.eia.gov/state/print.cfm?sid=PA

———, "Shale in the United States," web page, October 19, 2016d. As of November 18, 2016: http://www.eia.gov/energy_in_brief/article/shale_in_the_united_states.cfm

———, "Natural Gas Gross Withdrawals and Production," web page, October 31, 2016e. As of November 18, 2016: http://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_FGW_mmcf_m.htm

———, "Number of Producing Gas Wells," web page, October 31, 2016f. As of November 18, 2016: http://www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm

———, "West Virginia State Energy Profile," web page, last updated July 21, 2016g. As of November 18, 2016: https://www.eia.gov/state/print.cfm?sid=WV

Zacher, Hannes, "Individual Difference Predictors of Change in Career Adaptability over Time," *Journal of Vocational Behavior*, Vol. 84, No. 2, April 2014, pp. 188–198.

About This Report

The research was conducted within RAND Education and RAND Justice, Infrastructure, and Environment, units of the RAND Corporation. The authors would like to thank RAND colleagues Matthew Baird and Catherine Augustine, who reviewed early drafts of this report and provided important commentary. We would also like to thank our two objective peer reviewers, Peter Morrison and Troy Smith, for their insights and suggested changes, which greatly improved the report. However, any errors within are the responsibility of the authors alone.

This research was sponsored by the Appalachia Partnership Initiative (API). As the Research and Analysis lead of API, RAND was asked to produce annual descriptive portraits of employment and wages in energy and advanced manufacturing–related industries and STEM education indicators in the API region. This is the second of five annual reports. These reports should be of interest to regional education, business, and community leaders interested in STEM education and the career readiness of workers in the energy and advanced manufacturing sectors.

The Appalachia Partnership Initiative

Chevron North America Exploration and Production (CNAEP) Appalachian Mountain Business Unit's Social Investment Team was established to strengthen science, technology, engineering, and mathematics (STEM) education in middle and high schools and improve pathways for high school graduates and adult learners interested in careers in oil and gas industries and in advanced manufacturing in the Pennsylvania, West Virginia, and Ohio region. As part of these efforts, in 2014, Chevron's Social Investment Team launched API, a partnership of businesses, nonprofit organizations, and education institutions in the region. As of 2015, API consisted of representatives from Chevron, the Claude Worthington Benedum Foundation, the Grable Foundation, Allegheny Conference for Community Development, and the RAND Corporation.

Appalachia Partnership Initiative
MAKING OUR NEW ENERGY ECONOMY WORK

About the Authors

Gabriella C. Gonzalez is a senior sociologist whose work focuses on career and technical education, workforce development, school-to-work transitions, and program evaluation. She is the RAND lead of the API.

Kyle Siler-Evans is an associate engineer at RAND, where his research interests span several disparate fields, including education policy, college and career readiness, energy and infrastructure policy, and cost and risk assessments.

Gerald Paul Hunter is a research programmer at RAND.

Nicholas Broten is an assistant policy analyst at RAND and a doctoral candidate at the Pardee RAND Graduate School.

Limited Print and Electronic Distribution Rights

This document and trademark(s) contained herein are protected by law. This representation of RAND intellectual property is provided for noncommercial use only. Unauthorized posting of this publication online is prohibited. Permission is given to duplicate this document for personal use only, as long as it is unaltered and complete. Permission is required from RAND to reproduce, or reuse in another form, any of our research documents for commercial use. For information on reprint and linking permissions, please visit www.rand.org/pubs/permissions.html.

For more information on this publication, visit www.rand.org/t/RR1863

© Copyright 2017 RAND Corporation

www.rand.org

RAND CORPORATION

The RAND Corporation is a research organization that develops solutions to public policy challenges to help make communities throughout the world safer and more secure, healthier and more prosperous. RAND is nonprofit, nonpartisan, and committed to the public interest.

RAND's publications do not necessarily reflect the opinions of its research clients and sponsors. **RAND**® is a registered trademark.

RR-1863-CHC