Education, Employment, and Wages in the Appalachia Region

Final Report (2020)

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This report is the final in a three-part series. The first two reports provided initial examinations of the science, technology, engineering, and mathematics (STEM) education and labor market in the Appalachia Partnership Initiative (API) region. Here, we address the same questions as the first two reports but devote more attention to examining whether and how any of the indicators have changed over time. This third report also tightens some of our analysis specifically to the API region and introduces a few new

Key findings

- Middle school students in the Appalachia Partnership Initiative (API) states have outperformed the students on the nation level in mathematics, and trends are improving over time.
- Career and technical education (CTE) in the API region has room for growth. Although there were almost 75,000 CTE concentrators in secondary school in the three API states, only about 3,500 of those were in science and technology.
- High school graduation rates are high and improving. Not only did the API counties increase the graduation rate from 90 percent in 2013–2014 to 93 percent in 2017–2018, all of the 27 API counties had a graduation rate in 2016–2017 that exceeded the national rate of 85 percent (the most recent year for which national rates were available).
- Although postsecondary enrollment decreased in the API region over time, the percentage of students graduating in STEM has been increasing and outstripping the national average.
- The working-age population declined within the API region. Although the United States has continued to see increases in the number of working-age individuals, the API region has instead seen decreases from 2013 to 2018.
- Median earnings were higher in suburban areas of the API region and lowest in parts of the urban centers, but there was no clear geographic pattern of growth in median earnings.
- Earnings were high and growing in the mining and utilities industry in the API region. In 2018, average monthly earnings in mining and extraction was about $8,500, up from less than $7,000 in 2001 (in 2018 dollars).
- The mining and extraction industry was particularly successful at compensating workers who held high school degrees or had less education. While the API region mirrored the national trend of higher-educated workers being paid more on average, the gap was smaller in the mining and extraction industry.
- New hires from outside the extraction industry in API states primarily came from within the region but from other industries and enjoyed large earnings increases.

measures, such as participation in career and technical education (CTE). We consider the following questions:

- Are education and training providers producing a qualified workforce that will find employment in the region's evolving STEM labor market?
- What types of jobs and occupations have the highest employment and earnings?
- Where do workers in the mining and extraction industry come from?

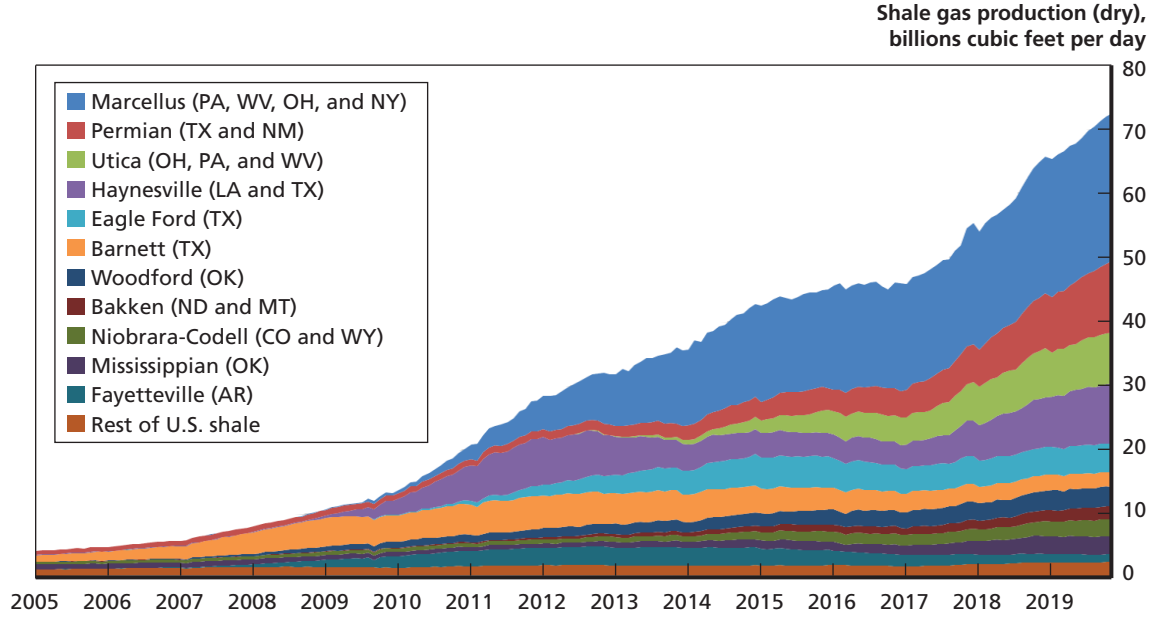
These descriptive portraits of the 27 counties fill important gaps in knowledge and what has been measured, which can provide data points that are helpful for long-term policy decisions and investment in the region's future.[1] Each regional report tracks year-to-year progress and clarifies trends in the region's energy and advanced manufacturing sectors. This information can be used to inform stakeholders across the 27-county 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, the 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.

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 [EIA], 2019e).[2] 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 more than 72.4 billion cubic feet per day in 2019. 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 2019, the natural gas extraction industry in the Marcellus and Utica shale plays grew from one-half billion cubic feet per day to more than 30 billion cubic feet per day, a 60-fold increase in less than a decade.

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 28 times greater in 2018 than in 2012, increasing from less than 1 percent of the nation's total to 6.5 percent. The eastern part of Ohio contains reserves of coal, crude oil, and natural gas fields. Several interstate natural gas pipelines cross Ohio. As of 2018, the state is the 16th largest coal-producing state in the nation and the 10th largest producer of bituminous coal (U.S. EIA, 2019c, 2019d). The primary fuel for electricity generation in Ohio

Figure 1. U.S. Dry Gas Shale Production, 2000–2019



SOURCE: U.S. EIA, 2019e.

is natural gas, which outpaced coal in electricity generation in 2017 (U.S. EIA, 2019d).

- Pennsylvania is the leading East Coast supplier of coal, natural gas, and refined petroleum products combined. It is the second-largest natural gas producer in the nation (after Texas), producing more than 6.2 trillion cubic feet in 2018 (more than 11 times the production in 2010). It is also the third-largest coal producer (U.S. EIA, 2019c) in the United States. 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 twentyfold from 2010 to 2019 (U.S. EIA, 2020d); processing plants to extract natural gas liquids and pipelines to transport them to markets around the country are currently being built. Pennsylvania's first ethane cracker, which makes feedstocks for plastics manufacturing from ethane, is in development (U.S. EIA, 2019a).
- West Virginia remains the fourth largest energy-producing state in the United States, making 5 percent of the nation's energy. In 2018, it was the second largest coal-producing state (after Wyoming), accounting for 12 percent of U.S. coal production (U.S. EIA, 2019c). As of 2019, it ranked seventh in the nation's natural gas production, producing more than 5 percent of the nation's natural gas (U.S. EIA, 2019b and 2020c).

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 Hub Natural Gas Spot Price fell to $2.62 per million British Thermal Unit (BTU) in 2015, down from $4.37 in 2014 and the 2008 peak of $8.86 (U.S. EIA, 2020a). From 2015 to 2019, prices fluctuated but remained low, residing at $2.22 per BTU as of December 2019. 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. Through 2019, well site numbers in the region have either remained steady or fallen (U.S. EIA, 2020b, 2020c).

Despite falling prices, production has increased 75 percent since the beginning of 2015 (Figure 1). Moreover, the national demand for workers to fill jobs requiring STEM skills 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 8 percent between 2018 and 2028—greater than the 5-percent projected growth rate for all occupations over the same period (U.S. Bureau of Labor Statistics, 2019). Of course, not all STEM workers are in the oil and natural gas industry (3.2 percent of workers are in the industry overall, with 5 percent of workers with STEM bachelor's degrees in the oil and natural gas industry; Baird, Bozick, and Harris, 2017). Because of this, despite the 2015 layoffs caused by the decline in oil and natural gas prices, the need for STEM workers is expected to continue to grow over the medium and longer term, especially if oil and gas prices recover (Porter, Gee, and Pope, 2015; Lendel et al., 2015).

THE APPALACHIA PARTNERSHIP INITIATIVE

Although the volatile nature of the energy sector 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, and cross-cutting skills. In addition, employers are increasingly expecting skills hybridization—meaning that workers have multiple, adaptable skills (Burning Glass Technologies, Council for Adult and Experiential Learning, and Allegheny Conference on Community Development, 2016). It is important for the tristate region to work toward ensuring that the supply of labor in STEM occupations is keeping pace with demand, both in the energy sector and other industries that rely on a strong STEM workforce.

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 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 (See Gonzalez et al., 2016, for more information about the API). To meet this goal, the 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 as a way to increase preparedness for and access to STEM jobs in the energy and advanced manufacturing sectors. The API is also working to bring stakeholders in the region (e.g., education and training institutions, industry and business leaders, nonprofits, government entities) together to collaborate on issues related to STEM education and the workforce (Gonzalez, Culbertson, and Nanda, 2017). In this capacity, the RAND Corporation provided objective evidence to assess the API's progress toward its goals.[3] This report focuses on the energy sector and not the advanced manufacturing sector, despite API's interest in both industries. Advanced manufacturing in the region is both more nascent and more difficult to define in existing data sets, which would require disentangling the industry from traditional manufacturing.

The API focuses its investments in the 27 counties in Ohio, Pennsylvania, and West Virginia illustrated in Figure 2. These counties encapsulate the footprint that the API has selected to focus its investment efforts.[4]

RESEARCH QUESTIONS, DATA SOURCES, AND LIMITATIONS

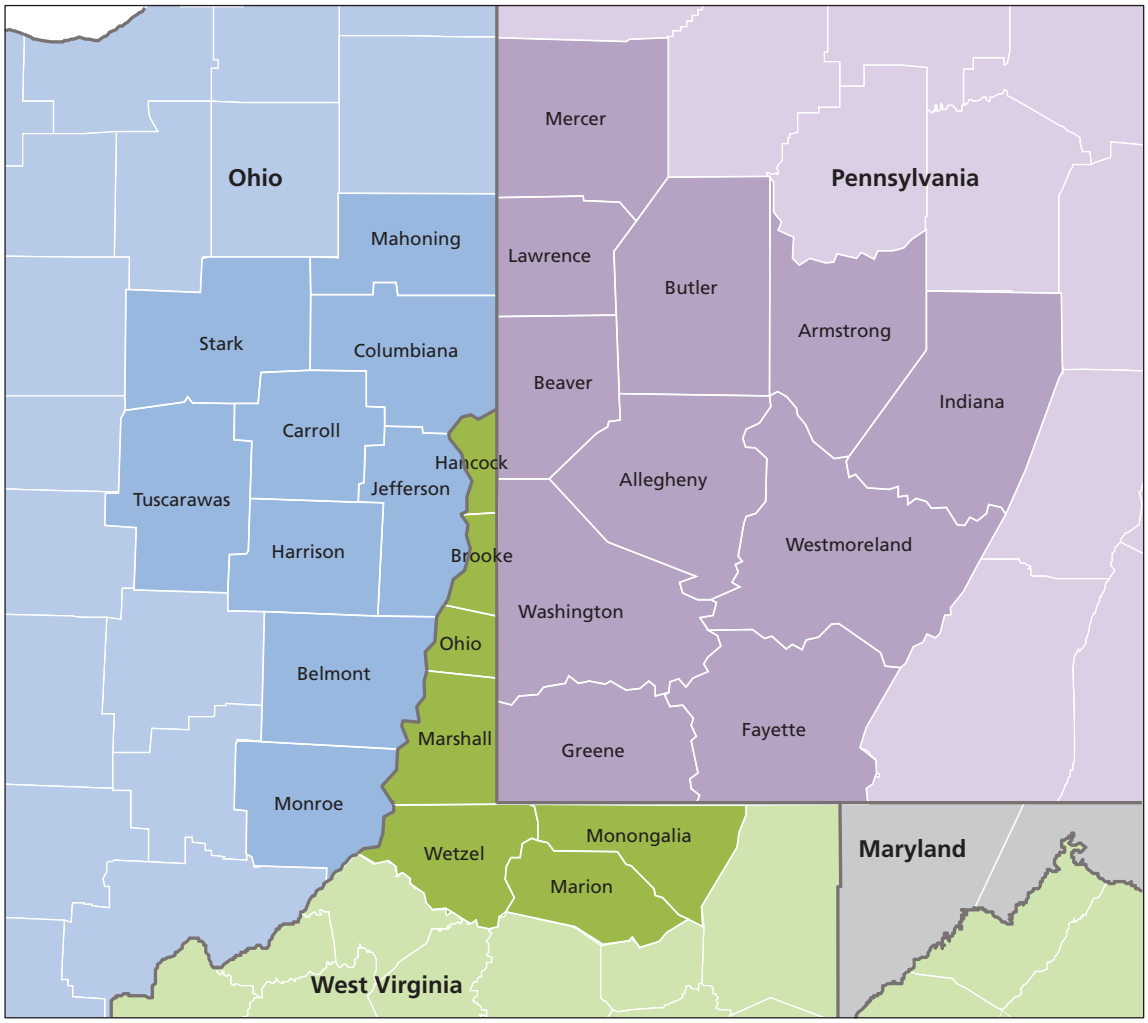
This final report in the series answers the following questions:

- What are the trends in secondary and postsecondary education in the API region, and how do they compare with the nation?
  - 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?
  - Is there expansion in the number or quality of students finishing their education?
- 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?
- 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, how does their change in earnings compare with other key industries?

To inform the analyses presented in this report, we used publicly available data from several sources: the U.S. Census Bureau's Decennial Census, American Community Surveys (ACSs), and Longitudinal Employment-Household Dynamics (LEHD) from the 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. To account for changes in nominal dollar values because of inflation, for any measure of earnings, we create real earnings measured in 2019 by adjusting using the Consumer Price Index.

In many instances, the indicators captured by each of these data sets track slow-moving trends, registering gradual changes over a single year. Furthermore, several of the indicators are necessarily based on a three-year or five-year average from the ACS, which mutes year-to-year changes (e.g., the 2018 data

Figure 2. 27 Counties Composing the API Region



SOURCE: Gonzalez, Culbertson, and Nanda, 2017, p. 3.

are based on data from 2014 through 2018). The indicators reflect the most-recent available data (see the appendix for more information about the data used in this section). The appendix provides more details on data and methods.

There are several limitations with this report. As descriptive investigations, our analyses are intended to highlight regional educational and employment trends, as well as 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 the region or a particular county is meeting employers' skill demands. As such, they are also not well suited, without additional evidence, to make policy recommendations about best practices to mitigate regional shortcomings or to buttress areas of strength. Another limitation is that, for the three specific analyses just described (NAEP mathematics scoring, CTE, and flows in and out of mining industry), we do not have access to data at the level necessary to isolate these regions (e.g., county or smaller) and must rely on state-level data. Given that the API region represents between 14 to 18 of the three API states (depending on the population, such as eighth-grade students or working population), the conclusions we draw may not accurately reflect the API region specifically.

EDUCATION PATHWAYS

This section summarizes analyses of five important educational stepping stones along the path to STEM careers to measure the supply of talent that is entering, or readying itself to enter, the regional workforce:

- eighth-grade mathematics achievement on the NAEP examinations
- overall and STEM CTE participation rates

- high school graduation rates
- postsecondary enrollment and graduation rates
- percentage of postsecondary graduates from a STEM major or field.

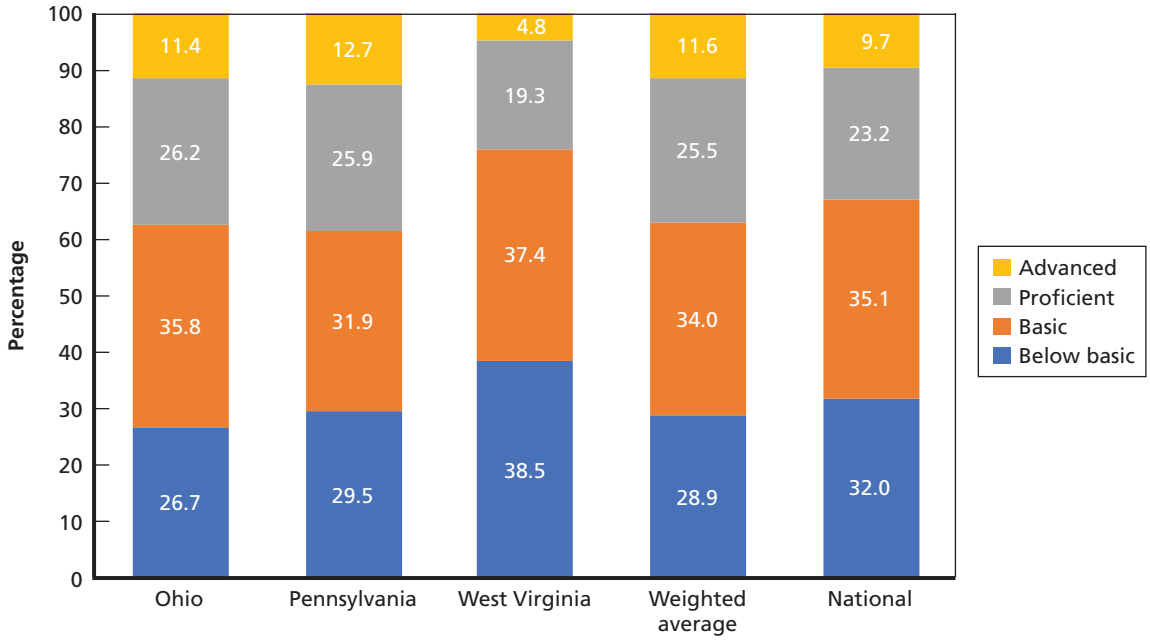
Postsecondary trends include two-year institutions (such as community colleges offering associate's degrees), four-year institutions (such as universities offering bachelor's and graduate degrees), and less-than-two-year institutions (such as vocational schools offering credentialing through certifications and licenses).

Eighth-Grade Mathematics Proficiency

A healthy pipeline of STEM workers requires early preparation in mathematics and science. Figure 3 shows eighth-grade mathematics proficiency, based on data from the NAEP, whose assessments are constructed to allow for across-time and -geography comparisons. As a reminder, for NAEP scores, we only have data available for the API states altogether and not the specific API region.[5] For eighth graders (what the analysis is based on), the API region represents approximately 14 percent of all students in the three states. Overall, the API states are performing better than the nation on this test. Ohio and Pennsylvania both have higher proportions of students scoring advanced and proficient than national levels, while West Virginia underperforms nationally. We also create an API-weighted average of the three states using the 2018 number of eighth graders in each state. The API-weighted average shows that the region is scoring better than the national average, with more than 37.1 percent of students scoring proficient or advanced, in contrast to 32.9 percent at the national level. Another way of viewing this difference is in the raw numbers of students predicted to be scoring below basic. With 39,242 eighth graders in the API footprint, Figure 3's results would predict that about 11,300 would be in the below-basic category for mathematics. If the API states had scored at the overall national level, the predicted number of students below basic would increase to about 12,500. This difference of about 1,200 students not in the below-basic category signifies the real impact that the better scoring in the API region is having on the students.

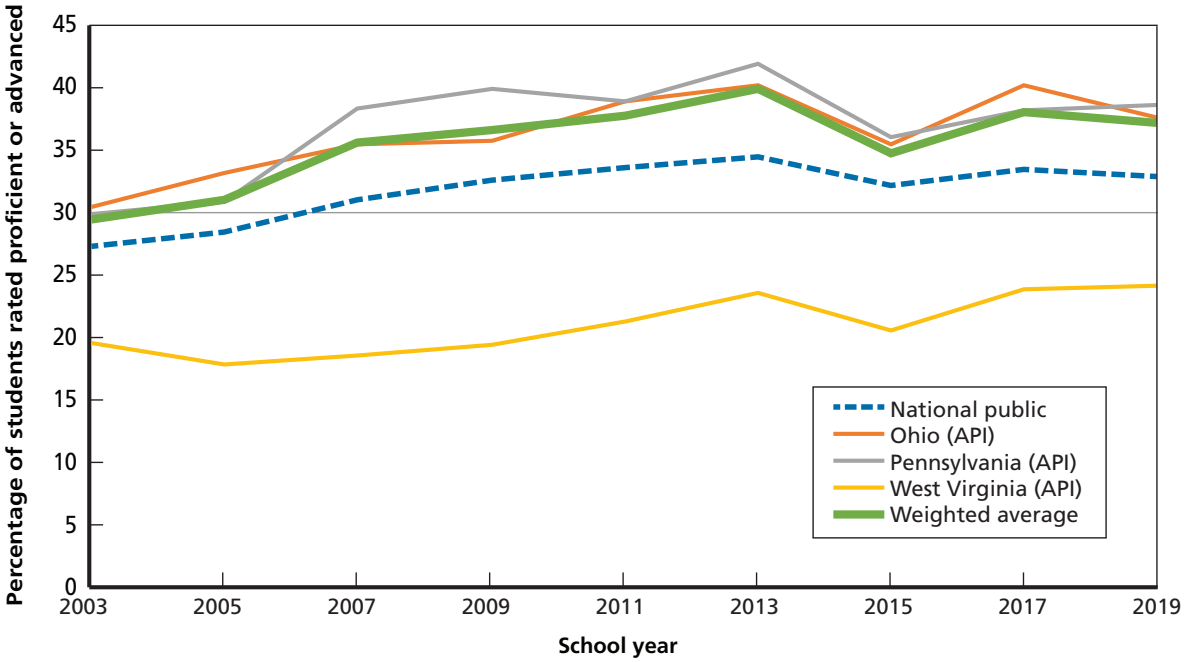
Figure 4 shows the trend lines over time in the percentage of students who scored proficient or advanced. As was true in 2019 as shown in Figure 3, over the last 16 years, Ohio and Pennsylvania have outperformed the national average in each year, while West Virginia has underperformed. When we take the weighted average of the three states, we find that, overall, the three API states together outperformed the national average, but followed a very similar trend, with a somewhat better recovery from the common dip from 2013 to 2015. Along the longer horizon since 2003, all geographies have

Figure 3. NAEP Eighth-Grade Mathematics Proficiency Rates, 2019



SOURCE: NCES, undated(a).

Figure 4. NAEP Eighth-Grade Mathematics Proficiency Over Time



SOURCE: NCES, undated(a).

shown an increase in the percentage proficient or advanced, with the three API states seeing a larger proportional increase over that time than the nation.

Although there is still room for improvement, the change over time and the comparison with the national averages both are encouraging for the performance of the eighth-grade students in the API states in mathematics. There has not been a new science assessment since our prior reporting based on the 2015 NAEP. There, we found that Ohio eighth-grade students outperformed the national levels, while West Virginia eighth grade students underperformed the same (with Pennsylvania students not having been administered the test; see Gonzalez et al., 2017).

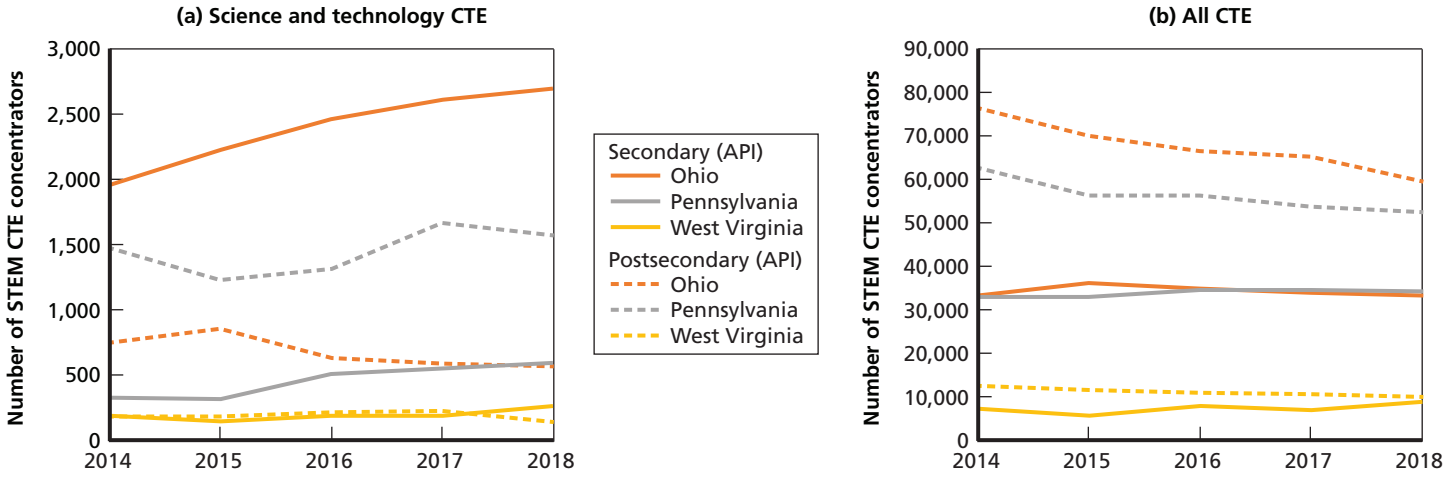
Career and Technical Education Participation

CTE is another important pathway toward labor participation in STEM fields, including in the energy and advanced manufacturing sectors. CTE are sets of courses typically offered in high school, two-year postsecondary institutions, and nondegree programs in all postsecondary institutions that focus on developing technical skills that are in demand in the workforce. Higher CTE participation may beneficially position a region to meet the increasing needs of the local labor market.

Figure 5 shows the total count of CTE concentrators in each state, both for all CTE and science and technology CTE. Concentrators have slightly different definitions in each of the states, but generally imply meaningful student engagement in several CTE courses. On one hand, there was an increase in secondary-school science and technology CTE across time in all three states, amid no changes in postsecondary CTE in these states. On the other hand, there was relatively stable science and technology postsecondary concentrators amid decreases in postsecondary overall CTE. The 3,500 high school concentrators in science and technology CTE between the three states may be a small overall number, but the growth is encouraging.

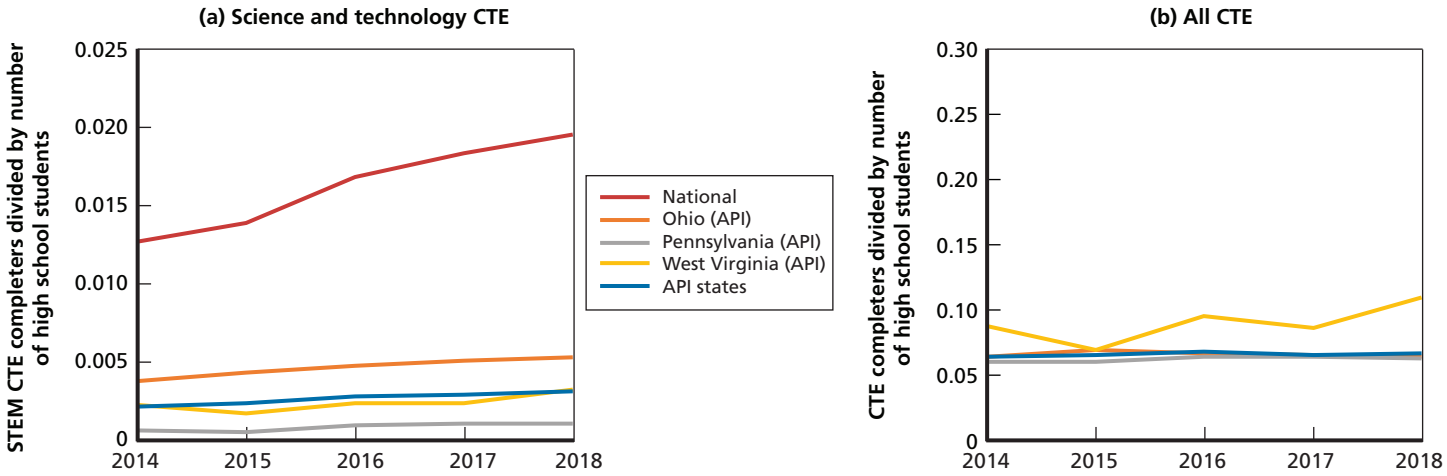
Another way to view CTE participation is as a fraction of all high school students. This allows us to control for shifts in population and compare them with national participation levels. Figure 6 presents these results. For all CTE and for science and technology CTE, the national trends are substantially higher than in the API states. Nonetheless, while the participation rates are different between the API states and the nation, the trends are relatively similar for science and technology: Both API and national participation rates are increasing an average of about 10 percent per year. Overall, CTE growth is about 5 percent per year nationally but only about 1 percent growth per year for the API states. Although evidence of growth is positive, there is room for improvement

Figure 5. CTE Concentrator Counts in API States



SOURCE: RAND analysis of CTE concentrator data set (U.S. Department of Education, 2020b).

Figure 6. CTE Concentrator Rates in API States



SOURCE: RAND analysis of CTE concentrator data set (U.S. Department of Education, 2020b).

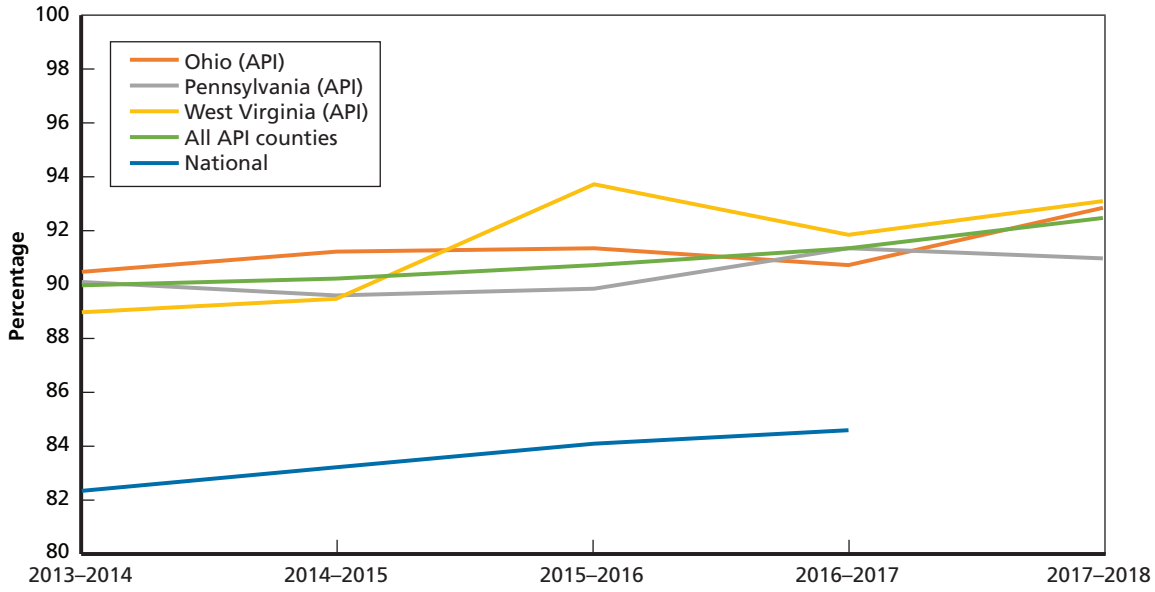
for the API states for CTE participation. Whether that growth is desirable depends on the quality of the CTE relative to what experience the students are having otherwise. There is a limited evidence base for CTE in the United States, although researchers are working on the problem. Evidence from other countries seems to suggest that secondary vocational education can make the transition into employment more easily and may improve wages, especially for low-scoring youth and those least likely to complete schooling (Eichorst et al., 2015). There is less evidence for STEM CTE, which may more successfully lead to even higher earnings or postsecondary schooling. In these cases, it would be desirable to see improvements in CTE from the low levels in API states, especially for STEM CTE.

High School Graduation Rates

We next examine graduation rates for high school students in the API footprint. Figure 7 provides the change in graduation rates over time. Counties in the API region for all three API states have had higher high school graduation rates than the national average. Graduation rates have also been increasing over time, a fact that is true both for the API county average (driven especially by West Virginia) and the nation.

Figure 8 shows the graduation rates across the API counties in 2018. Although there is reasonable variation, with a high of 96 percent in Ohio County, West Virginia, and a low of 86 percent in Fayette County, Pennsylvania, every county has a graduation rate above the 2017 national level of 85 percent

Figure 7. High School Graduation Rates



SOURCES: Ohio Department of Education, 2019; Pennsylvania Department of Education, 2019; U.S Department of Education, 2018; West Virginia Department of Education, 2019.
NOTES: West Virginia 2013–2014 API data is approximate; national-level data for 2017–2018 has not been released.

(shown in Figure 7). Thus, the trends in Figure 7 are in spite of high disparities across geographies, and the vast majority of counties (rural and urban areas) have graduation rates of 90 percent or higher. Figure 9 shows the percentage point change in graduation rates by county from 2014 to 2018. Twenty-two of the 27 counties experienced an increase in graduation rates across this time frame. Some of these involved substantial gains and, importantly, were experienced among some of the lowest graduation rate counties in the API footprint. For example, although Fayette County, Pennsylvania, had the lowest graduation rate of the counties in 2018 at 86 percent, this was a marked improvement from 2014; they have experienced an increase of almost 8 percentage points since then. A similar trend is true for Greene County, Pennsylvania.

Postsecondary Enrollment and Graduation

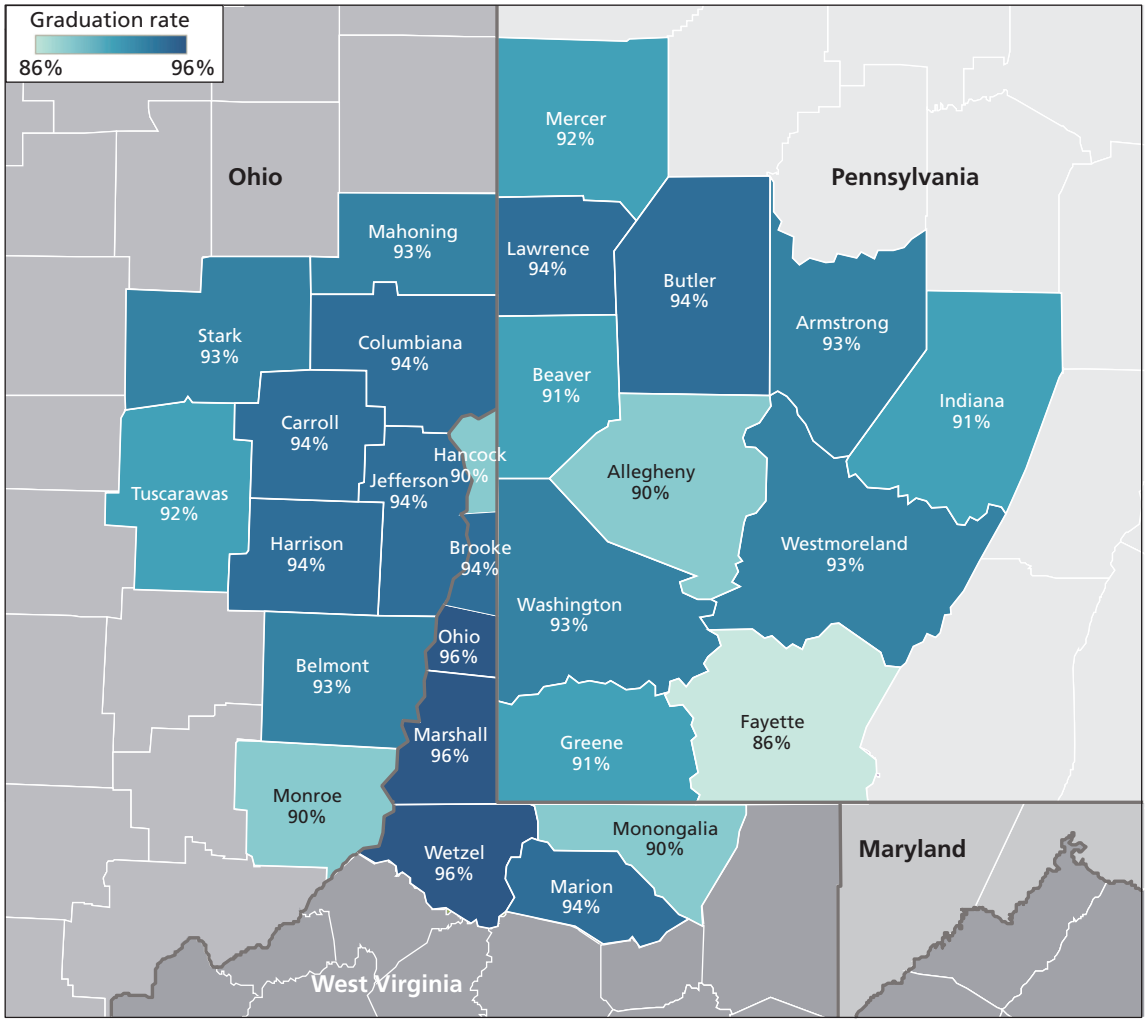
Postsecondary education is an important component of the STEM workforce pipeline. In this section, we take an in-depth look at postsecondary education in the 27 counties in the API region to gain a better understanding of the local talent pool potentially available for employment in STEM careers. In the 27 API counties in 2018, there were 135 postsecondary educational institutions with more than 23,934 total graduates.

We first examine the enrollment counts by type of institution, shown in Figure 10. In 2018, there were about 170,000 students enrolled in four-year institutions in the 27 counties in the API region, along with about 95,000 additional students enrolled in less-than-four-year institutions. However, both four-year and less-than-four-year institutions in the API region have experienced a decrease in student enrollment since the Great Recession. This is the case across the country; only four-year institution enrollment has increased (slightly) over this time.

Figure 11 shows the number of annual postsecondary graduates by API county (based on location of the postsecondary institution). The patterns between four- and two-year graduate locations are roughly similar. Although the highest number of graduates are in the population centers around Pittsburgh, Pennsylvania (Allegheny County), and Morgantown, West Virginia (Monongalia County), only four of the 27 counties had no postsecondary graduates, and 19 of the 27 counties had more than 100 graduates. Thus, there are important sources of postsecondary training spread—and noticeable gaps—throughout the API region.

Figure 12 presents the postsecondary graduation rates in the 27 counties in the API footprint and for the United States. We separate it out by four-year institutions (i.e., those offering bachelor's degrees) and two-year-or-less institutions (i.e., those

Figure 8. High School Graduation Rates in the 27 API Counties, 2018



SOURCES: Ohio Department of Education, 2019; Pennsylvania Department of Education, 2019; West Virginia Department of Education, 2019.

offering associate's degrees or nondegree credential programs). For this report, with the exception of Figure 14, we pool together two-year and less-than-two-year institutions. We also do not include postbaccalaureate degree students (i.e., masters degrees, Ph.D.s, and professional degrees) in any of the analysis.

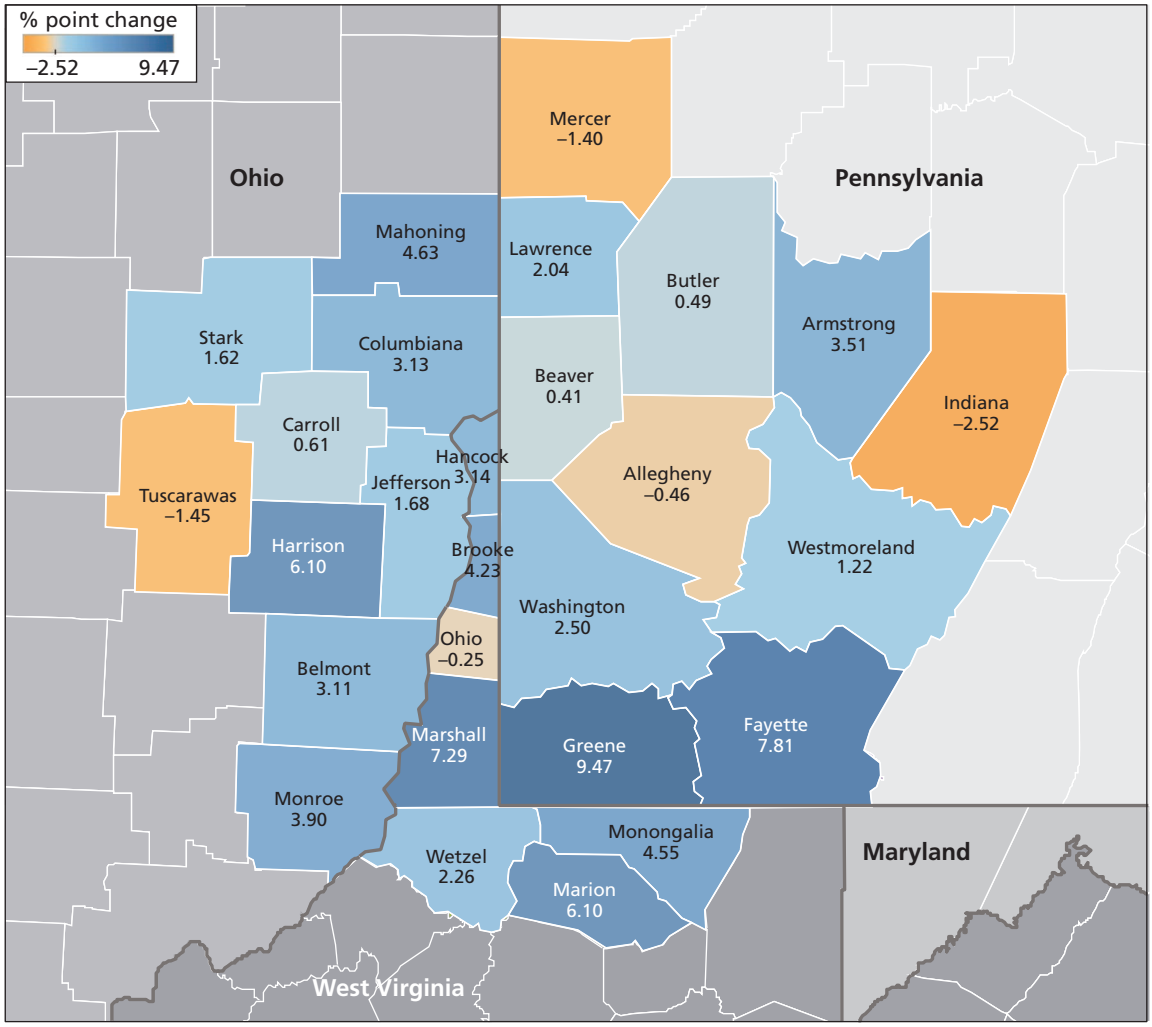
For Figure 12, graduation rates are calculated for within 150 percent of typical time (i.e., graduation rates for four-year institutions is the proportion of enrollees that graduate within six years). For the four-year institutions, the graduation rates in the API region are slightly higher than those for the nation overall; both trends have seen a modest increase over time. For the two-years-or-less institutions, graduation rates have tended to be higher in the API region than for the nation overall, although converging almost together in 2018.

Postsecondary STEM Graduation

Figure 13 presents the percentage of awards that are in a STEM field for the API region and the United States. Overall, the proportion of awards that are in a STEM field is increasing, and this is particularly true for four-year institutions, in which the increases have been relatively dramatic. On average, four-year institutions also award a higher proportion of STEM degrees than two-year institutions. Institutions in the API region tend to award a higher proportion of degrees in STEM fields compared with the nation overall, both for four- and two-year or less institutions. These trends are encouraging for the API region.

Figure 14 shows the percentage of awards that are in a STEM field specifically in the API region by type of institution. The trends are favorable for nonprofit institutions and not

Figure 9. Percentage Point Change in High School Graduation Rates in the 27 API Counties, 2014–2018



SOURCES: Ohio Department of Education, 2019; Pennsylvania Department of Education, 2019; West Virginia Department of Education, 2019.

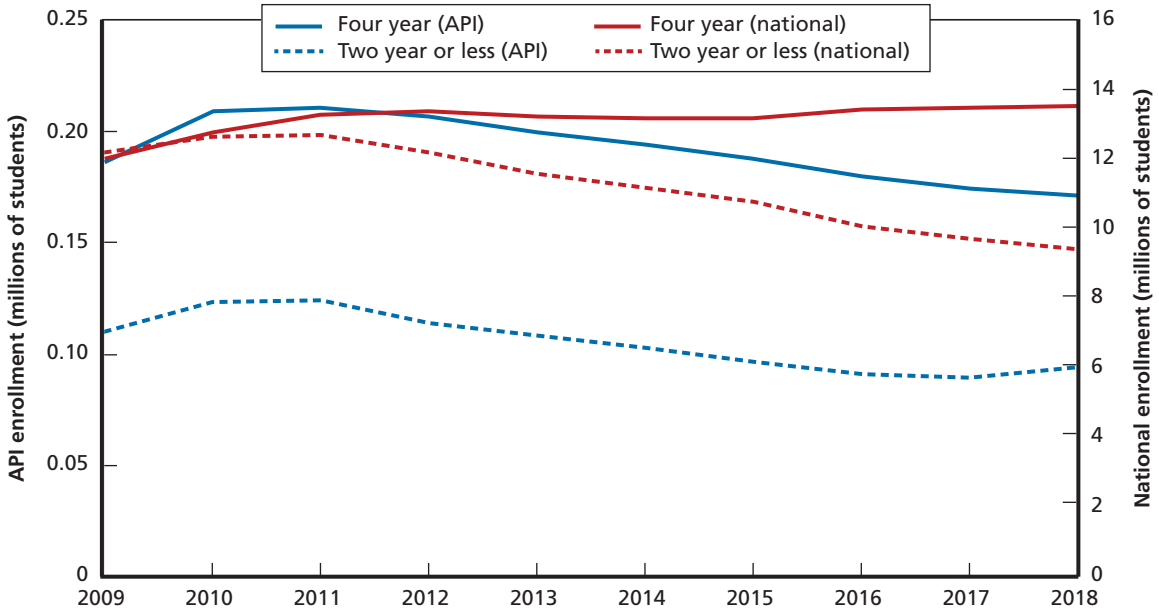
favorable for for-profit institutions. Currently, nonprofit four-year or more colleges have been most likely to yield STEM graduates at nearly 30 percent of their graduating class; and the rate is increasing, this 30 percent number is up from below 20 percent in 2009. Meanwhile, for-profit graduates have been decreasingly likely to be in STEM fields across all types of institutions; the most dramatic decrease being for for-profit four-year or more institutions, decreasing from a high of 30 percent of the graduating class in 2010 down to 5 percent in 2018.

Figure 15 shows the counties that have the highest proportion of STEM graduating postsecondary students. There is significant variation in the proportion of graduates coming out with STEM awards with, for example, Indiana County, Pennsylvania, graduating a substantially smaller fraction of students in STEM than Allegheny County, Pennsylvania, or Monongalia County, West Virginia. It is worth noting that Indiana County was third in graduating the most students, after Allegheny and Monongalia Counties.

WORKFORCE, WAGES, AND EMPLOYMENT TRENDS

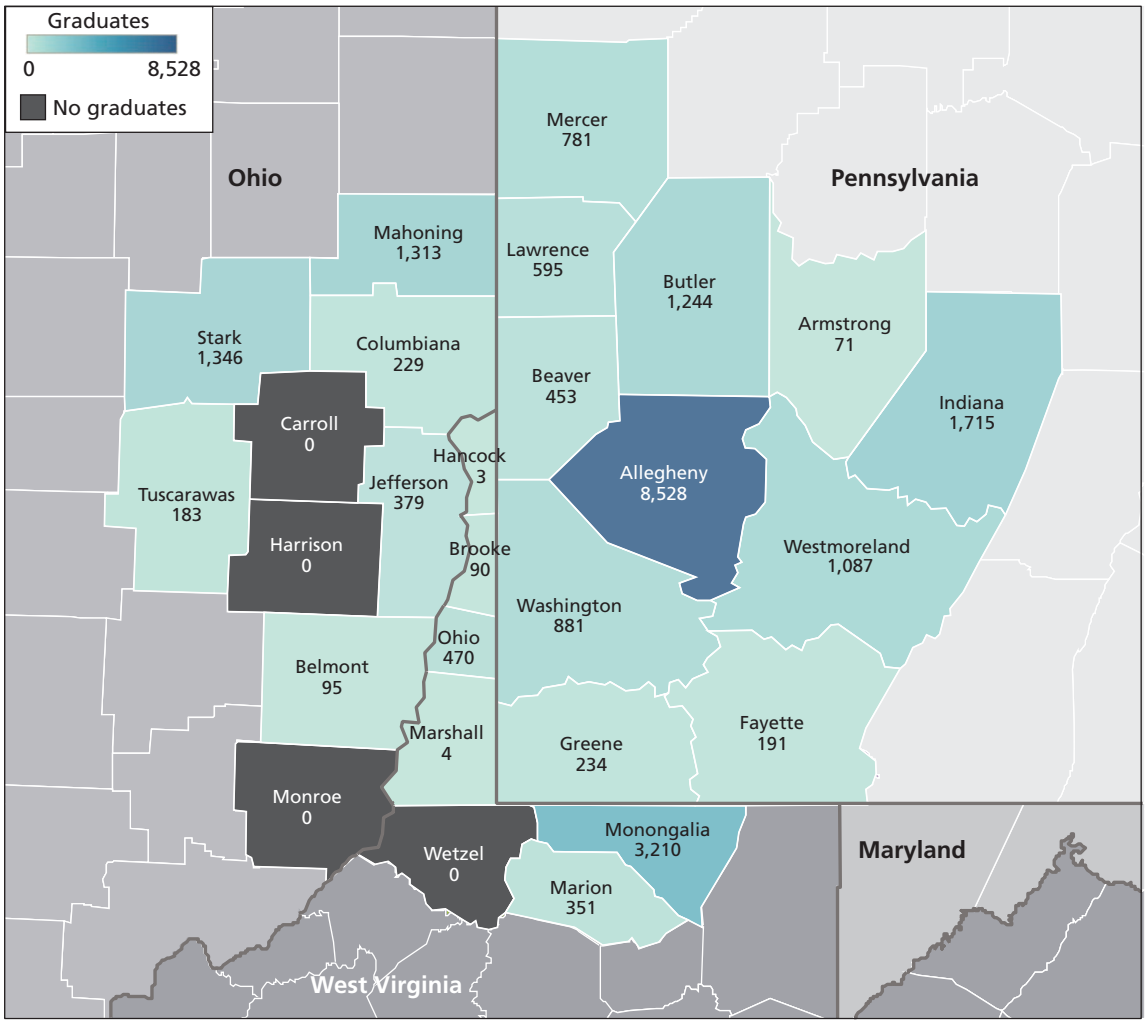
The educational patterns examined in the previous section suggest evidence about the health of the pipeline—or flow—of potential workers in the region. This section documents trends in the working-age population and in employment and earnings, both overall and in selected industries. In doing so,

Figure 10. Postsecondary Enrollment in the 27 API Counties and U.S. by Institution Type, 2018



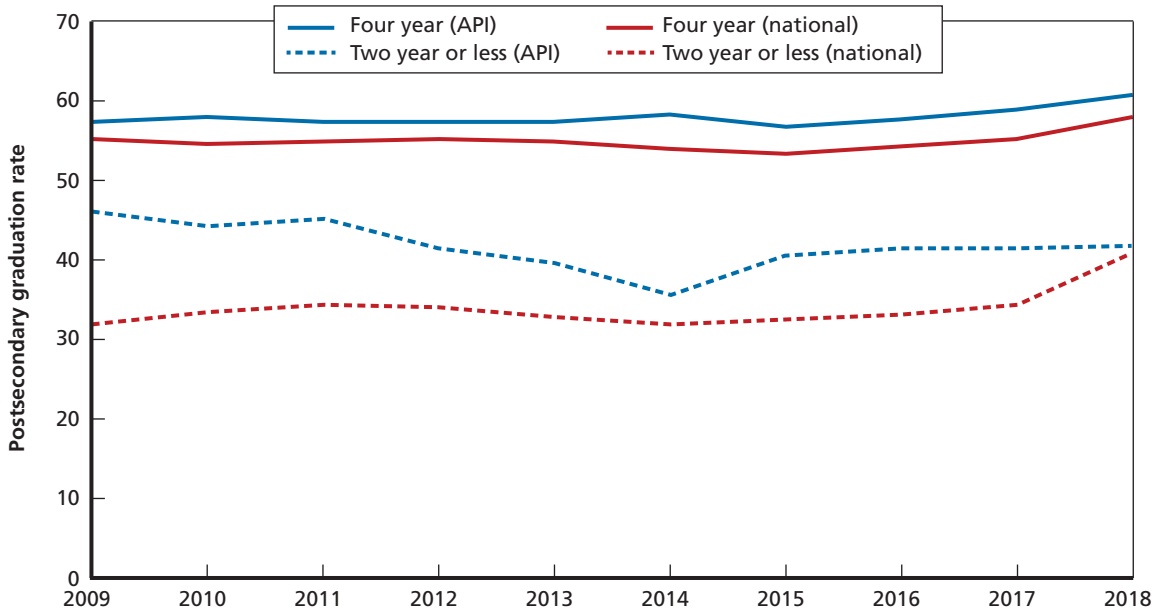
SOURCE: RAND analysis of IPEDS (NCES, undated[b]).

Figure 11. Total Postsecondary Graduates by API County, 2018



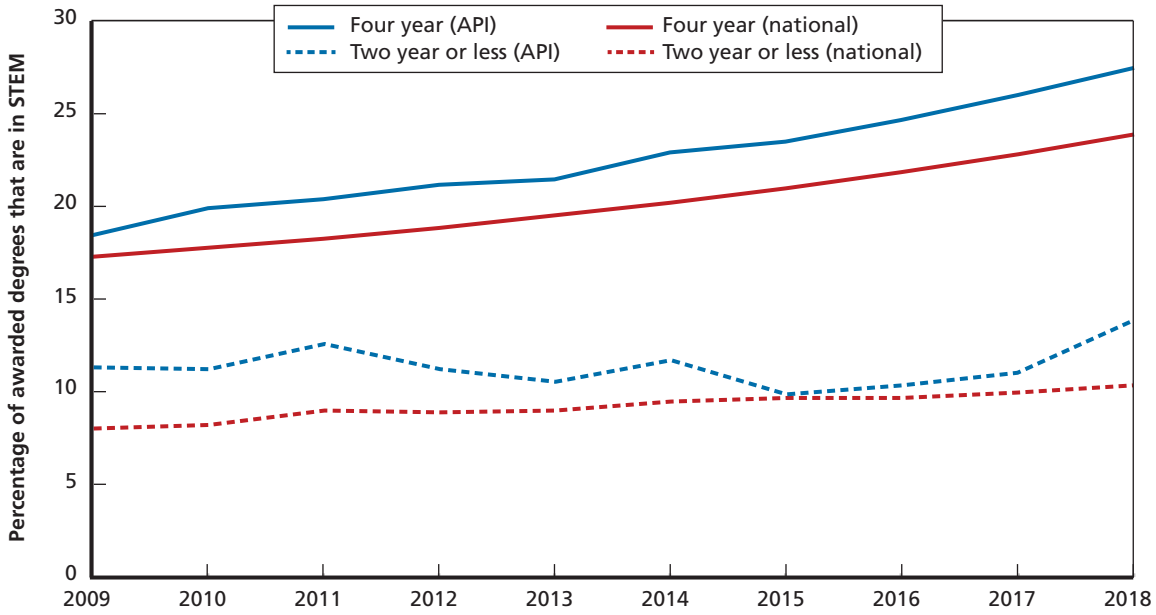
SOURCE: RAND analysis of IPEDS (NCES, undated[b]).

Figure 12. Postsecondary Graduation Rates in the 27 API Counties and United States by Institution Type, 2018



SOURCE: RAND analysis of IPEDS (NCES, undated[b]).

Figure 13. Percentage of Postsecondary Degrees in STEM in the 27 API Counties and United States by Institution Type, 2018



SOURCE: RAND analysis of IPEDS (NCES, undated[b]).

these results primarily examine the realized outcomes of the stock of workers in the region.

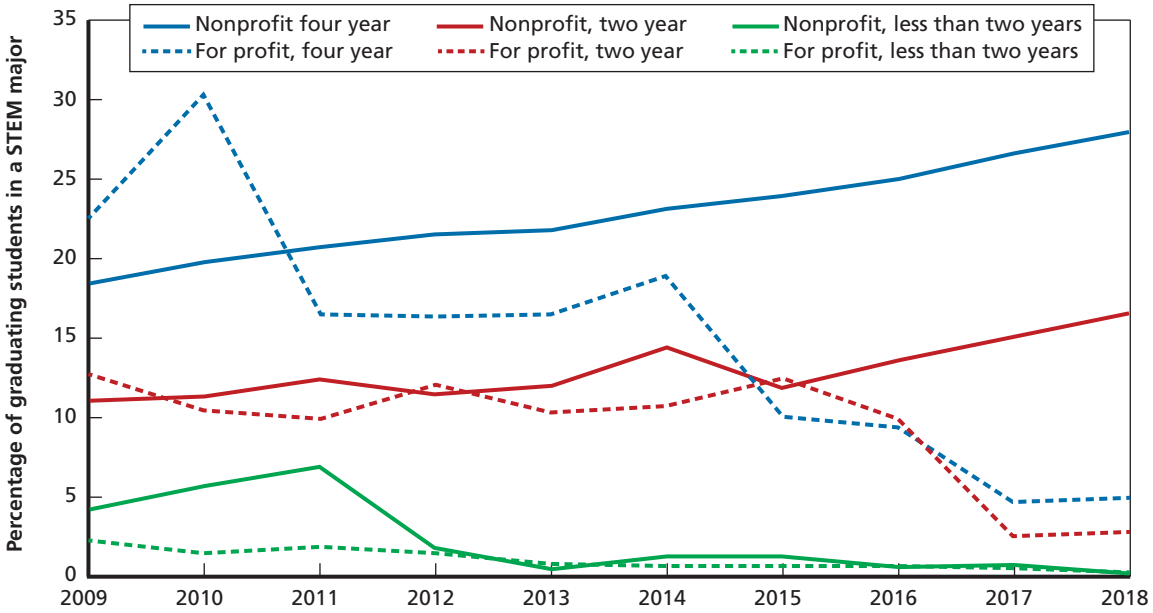
We specifically examine the following indicators of the health of the local labor market:

1. changes in the working age population
2. employment and job entry and exit trends
3. earnings trends.

Working-Age Population

It is important to track the size of the working-age population (ages 18–64) 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

Figure 14. Percentage of Postsecondary Degrees That Are in STEM Fields in the 27 API Counties, by Institution Type, 2018



SOURCE: RAND analysis of IPEDS (NCES, undated[b]).

greater demand for public services; and, depending on tax structures, state and local revenues could be impacted.

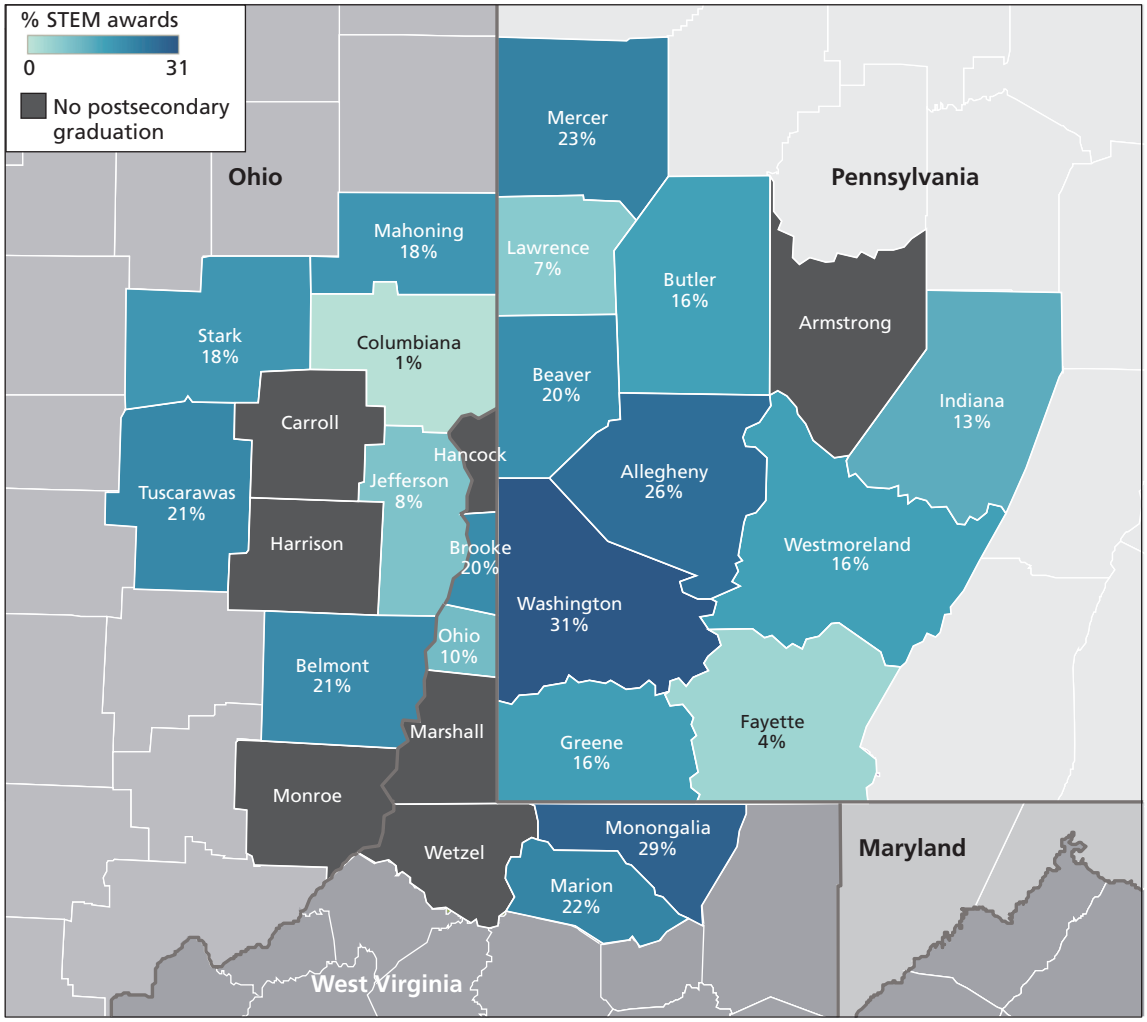
Figure 16 shows the change in the working-age population for the API region and for the United States. From 2000 to 2018, the national working-age population has been consistently increasing, with over a 13 percent increase from 2000 to 2018. The API region, however, has had a relatively stable working-age population across these two decades, with a slight downtick from 2013 to 2018. The API region had a 2-percent population loss from 2000 to 2018.

Figure 17 illustrates changes in the working-age population in each of the 27 API counties from 2010 to 2018. Twenty-four of the API region's 27 counties experienced a decline in working-age population across these years. 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). These patterns seem to be followed in the API region, with most of the counties, including more-rural ones, experiencing decreases in the working-age population. Only three API counties saw increases in the working population. Monongalia County, West Virginia, saw the largest gain in its working-age population. Pennsylvania's Butler and Allegheny Counties both registered moderate working-age population growth. All three of these counties have a Rural-Urban Continuum (RUC) code designating them as counties in a metropolitan area (U.S. Department of Agriculture, 2019). Meanwhile, the two counties with the largest decreases, Monroe, Ohio, and Wetzel, West Virginia, are substantially more rural, with Monroe County having the lowest RUC Code of the API region (8: completely rural or less than 2,500 urban population, adjacent to a metro area) and Wetzel, West Virginia, being one of the three counties in the region with the next-lowest RUC code (6: urban population of 2,500 to 19,999, adjacent to a metro area).

Employment in Mining and Oil and Gas Extraction Over Time

Figure 18 shows total employment in the extraction industries by education level from 2001 through 2018 in the API region. Workers whose education status was unknown, who accounted for approximately 7.3 percent of workers in this sample, are not shown. The education groups shown in the graph exhibit qualitatively parallel trends, although the share of workers with a high school diploma fell from 44.5 percent at the beginning of 2001 to 36.5 percent at the end of 2018. The largest educational group represented is high school graduates, at about 40 percent of the workers in 2018. There was a steady increase in employment from 2001 through 2015 as part of the shale boom, with no visible drop from the Great Recession. However, there was a sharp decrease from the first quarter of 2015 through the third quarter of 2016. Since 2016, there have been

Figure 15. Percentage of Postsecondary Degrees That Are in STEM, by County, 2018



SOURCE: RAND analysis of IPEDS (NCES, undated[b]).

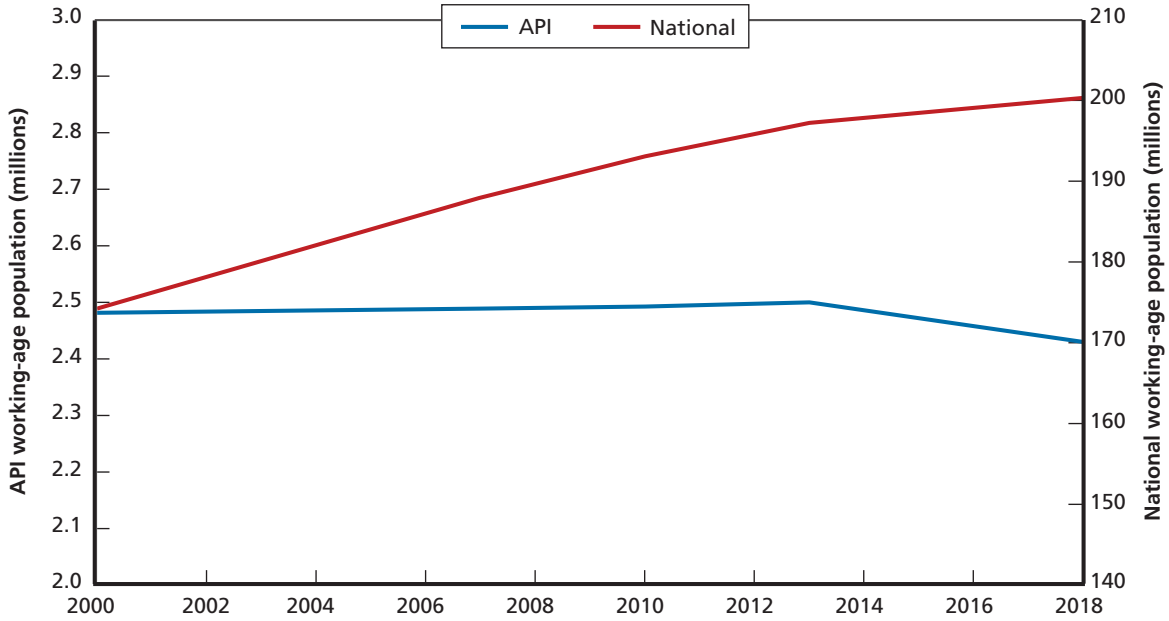
modest increases in employment levels, but they have not come close to reaching their 2015 peaks. The decline in employment in 2015 coincided with falling gas prices, despite the region's continued growth in gas production (see Figure 1).

To gain a better understanding of the trends in the demand and supply of workers in STEM fields, we examined employment flows by asking who is entering the extraction industry? We examine two employment transitions—geographic movement and cross-sector movement. Are those who enter the industry local or from outside the region?

Our objective in undertaking these new inquiries 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 comprising that workforce may change.

To gain these insights, we analyzed data from the 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.

Figure 16. Number of Working-Age Population in the API Region and in United States, 2000–2018



SOURCE: U.S. Census Bureau, 2019d.

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). In these three states, 17.8 percent of the working age population reside in the 27 counties in the API footprint.

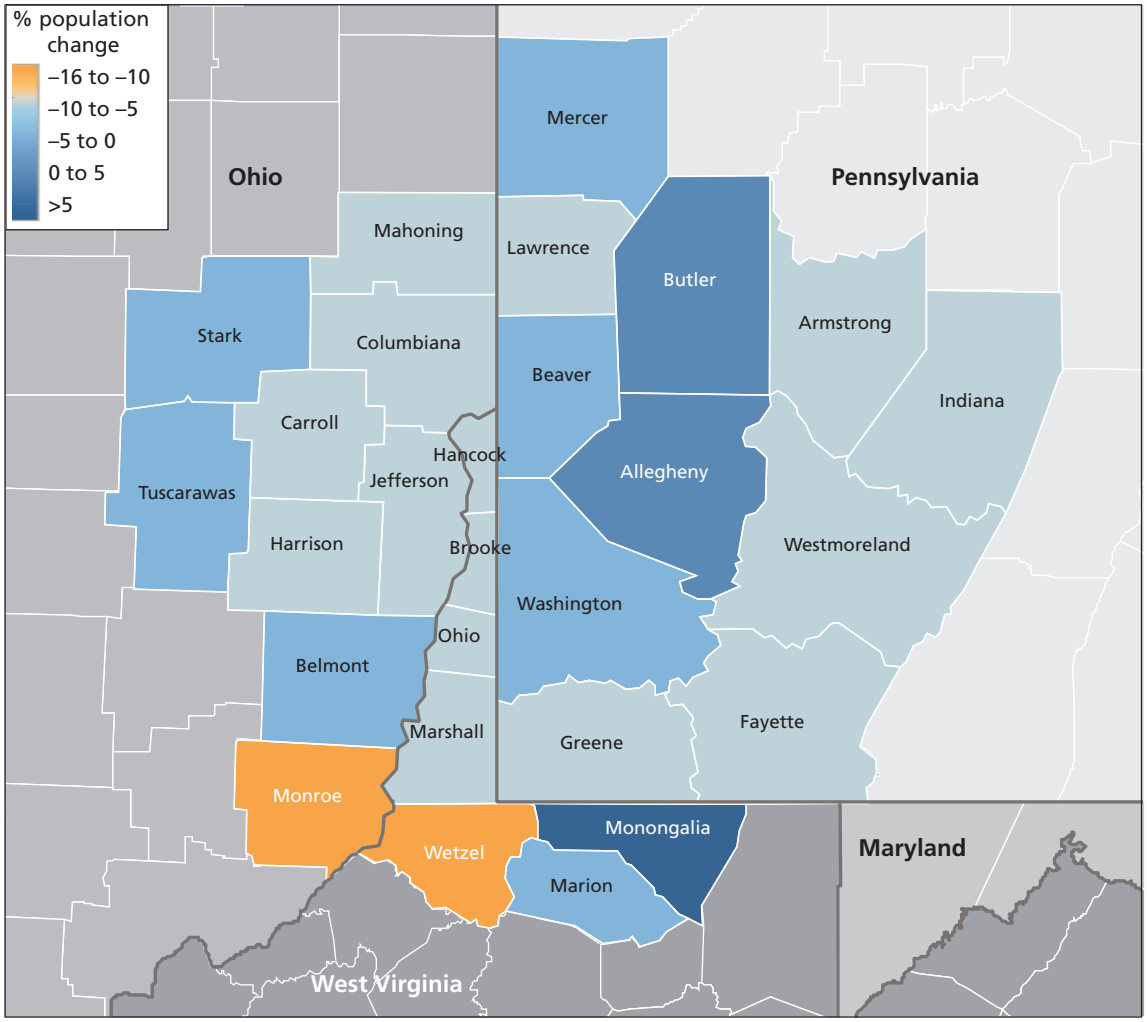
Figure 19 shows the origins of workers *entering* the extraction industry in Ohio, Pennsylvania, and West Virginia from 2001 to 2018. Flows are divided into three categories: flows from within the API states but from nonmining industries; flows from mining industries outside the API states; and flows from nonmining industries outside the API states. Across the entire period, the most common source of new hires in the extraction industry is from within the API states but from other industries. Hires from outside of the API states were slightly more likely to come from other industries than they were to come from mining work in most quarters in this period. One way to interpret these shares is a representation of how integrated the mining industry is with others in the region, which may reflect the extent to which workers in other industries have relevant skills to work in mining.

Note that there is one large shift in the shares that happened during the Great Recession, during which hires coming from within the API states but not from the mining industry dropped from the pre-recession average of 80 percent of new hires down to a low of below 60 percent in the second quarter of 2009. This share was offset entirely by flows from outside of the API states but within the mining industry. Given that there was no decrease in employment in the industry across this period (see Figure 18), this suggests that although the Great Recession did not mark decreased employment in the mining industry in the API region, it did cause a shift in where new hires came from, as the industry was more likely to hire workers coming from the mining industry in other states. Also, job churn may have fallen in the recession, reducing overall flows and disproportionately reducing flows from other industries.

Trends in Earnings

We next examine trends in earnings across geographies, subgroups, and time. Figure 20 shows median earnings by census tract for the API region in 2018. Consistent with the earlier reports, census tracts with the higher median wages are clustered near Allegheny County, suburbs of the largest city in the region, Pittsburgh. Census tracts with the lowest median earnings (less than $20,000) are concentrated in such areas as

Figure 17. Change in Working-Age Population in API Region by County, 2010–2018



SOURCE: U.S. Census Bureau, 2019d.

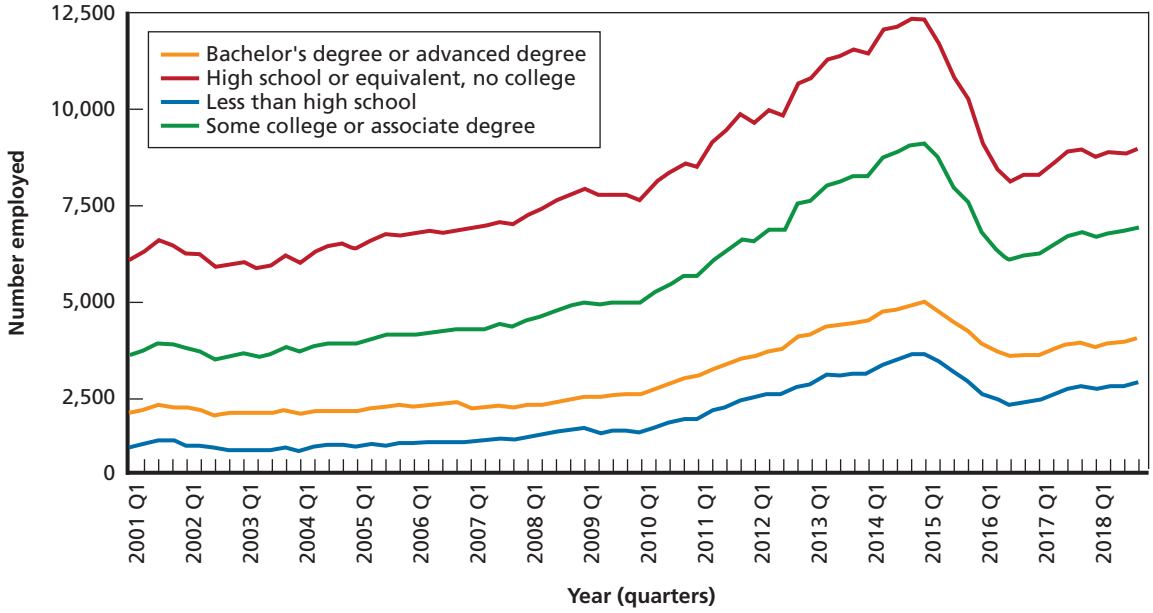
metropolitan Pittsburgh, Canton, and Youngstown, Ohio. The vast majority of the census tracts in the API region have median wages of $20,000–$50,000 per year, including throughout the more rural regions. This is in line with median U.S. earnings, which were $33,439 for the same period.

We next look at changes in median earnings by census tract, shown in Figure 21. We gray out any tract that does not have statistically significant changes, as determined by whether the margins of error in the two periods overlap. Most of the counties do not have a statistically significant change. Meanwhile, approximately 60 census tracts saw statistically significant positive real earnings growth, while about 20 saw statistically significant decreases. There is no strong geographic clustering of where the positive or negative earnings decreases were experienced.

We next examine the trends in earnings in the industries of interest for this report. Figure 22 shows year-to-year trends. Although the real value of earnings in health care and manufacturing have been growing only modestly, there has been substantial earnings growth in mining and utilities. The mining and extraction industry has experienced the strongest growth in earnings over the last two decades, even seeing some of its fastest wage growth through the recession years.

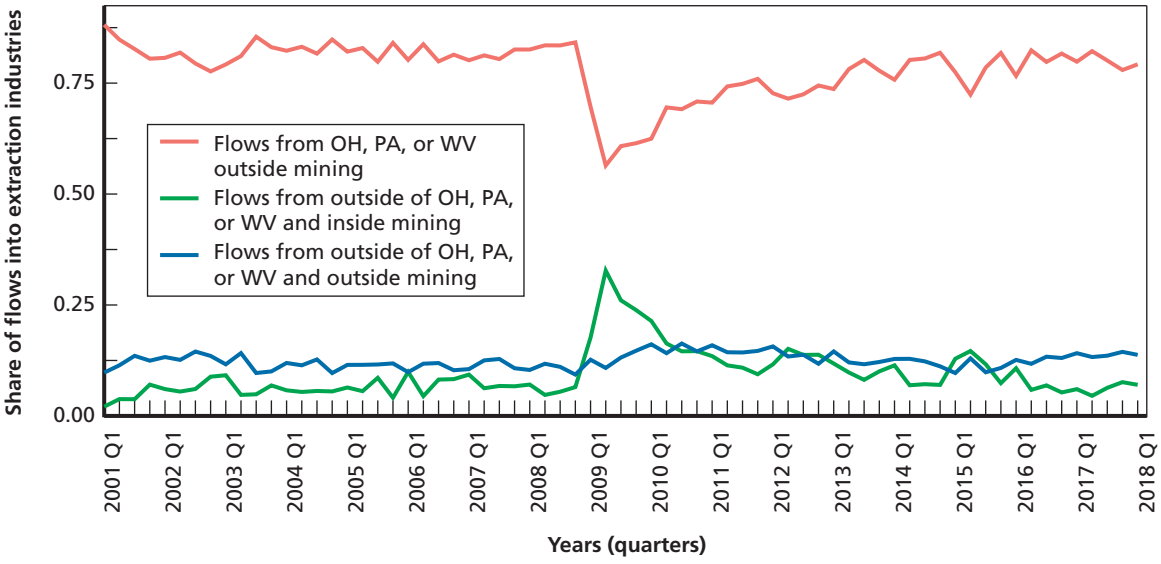
To better understand and define the local makeup of the region's labor force, we next examine wages by STEM-related industry, STEM-related occupation, and education level. For both industry and occupation, we focused on the six occupational and five industry STEM-related categories that are most relevant 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 (as determined in the two prior reports in this series (Gonzalez et al., 2016 and 2017).

Figure 18. Employment by Education Level in the Extraction industries in the API region, 2001–2018



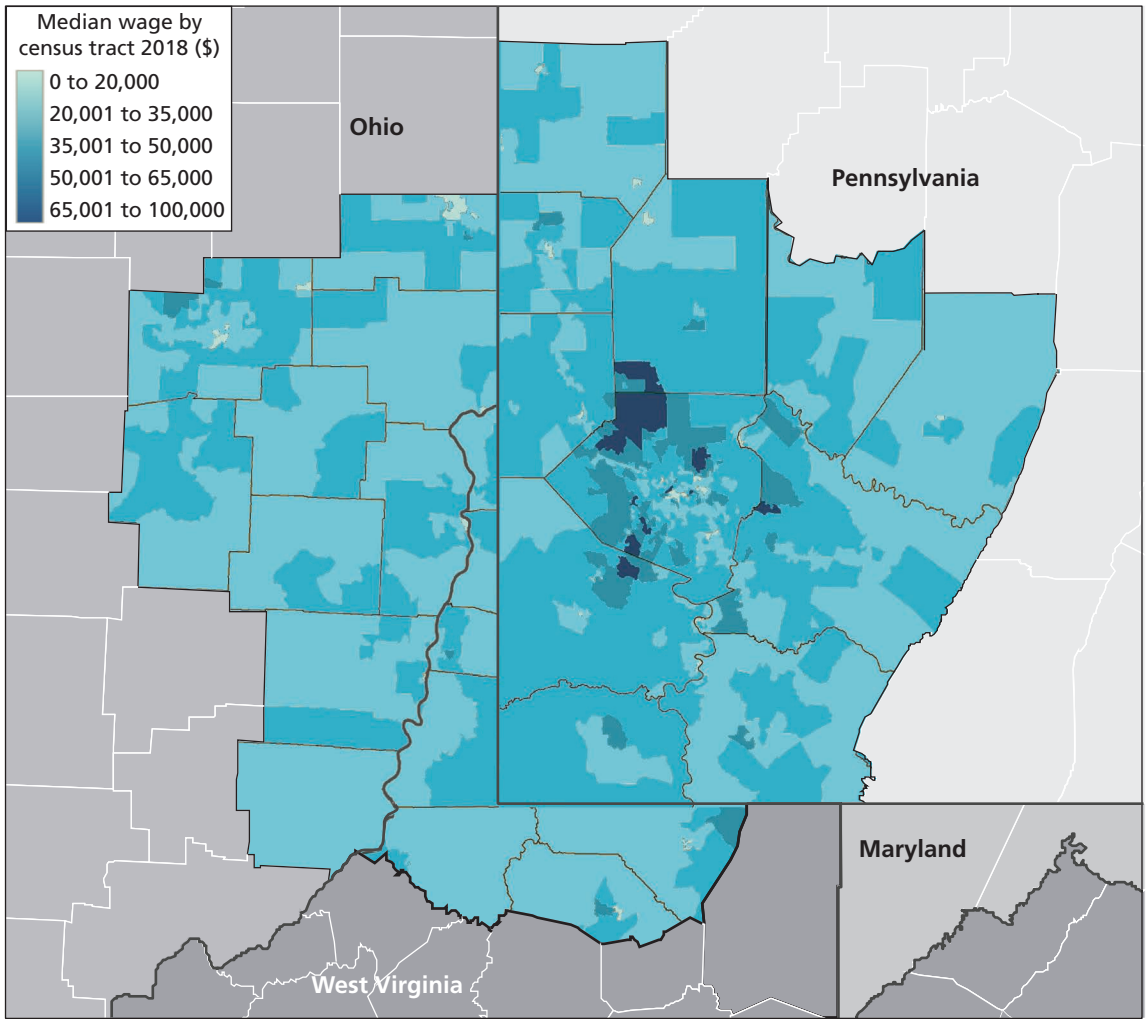
SOURCE: U.S. Census Bureau, 2019b.

Figure 19. Sources of New Hires into the Extraction Industries in Pennsylvania, Ohio, and West Virginia, 2001–2018



SOURCE: U.S. Census Bureau, 2019a.
NOTE: Data shown are from the first quarter of 2001 through the first quarter of 2018. 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 20. Median Wages Within the API Region by Census Tract, 2014–2018



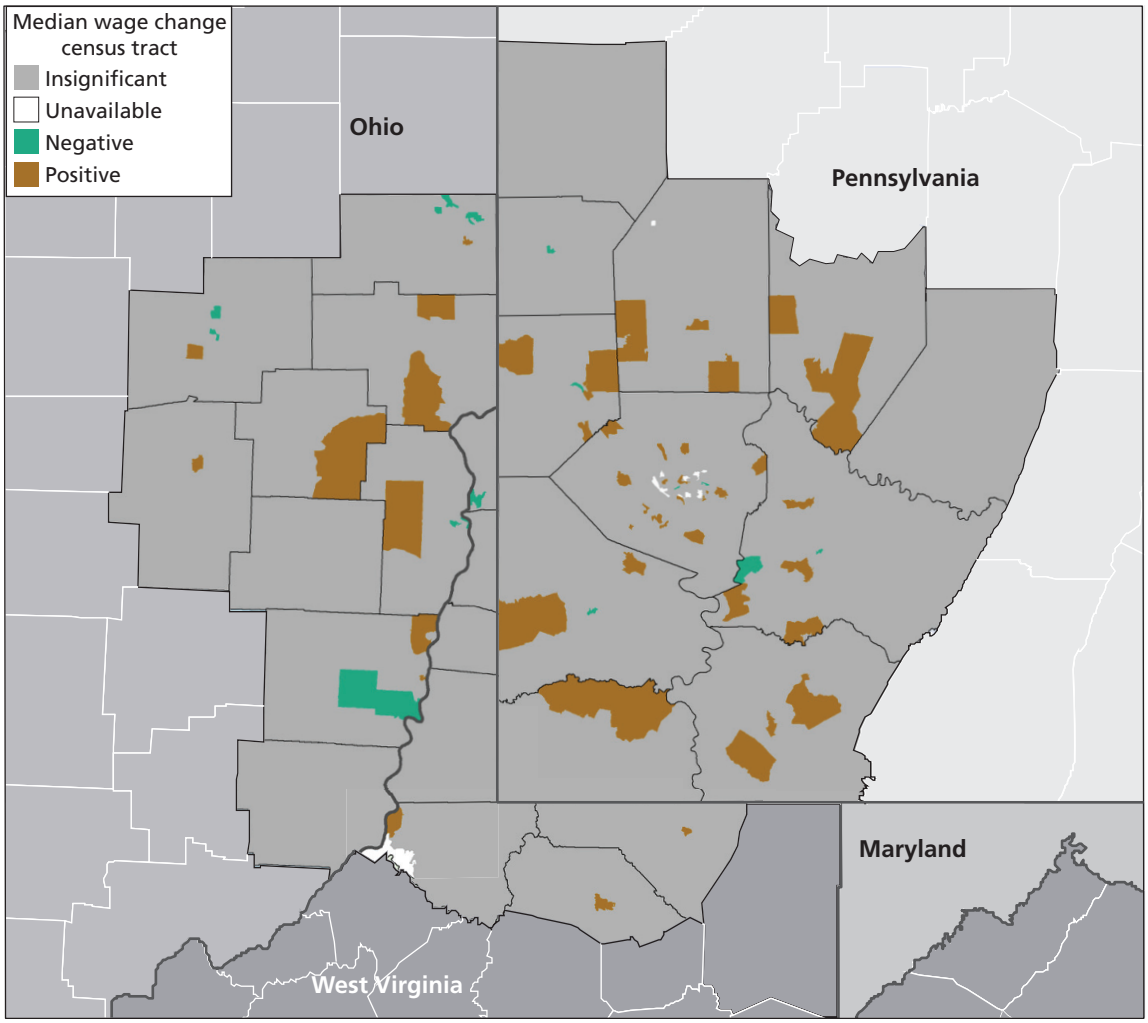
SOURCE: U.S. Census Bureau, 2019d.

Figure 23 presents changes in wages for these subgroups, both for the national median and the average county median in the API region. We find a number of interesting trends. First, in looking at the industries, we see that the API had lower median earnings than the nation for three of the five target industries, including in mining. Among the five STEM-related industries examined, the utilities industry registered the highest average median wage across the counties at just more than $70,000. 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 at about $65,000, more than twice the average for health care and social services at around $31,000. Utilities and mining and extraction average median wages are close to the national median wages in the same industries, while health care and social services average median earnings in the API region is lower than the national median earnings in the same industry, at around $36,000. The trends over time across these industries are relatively similar for the API region and the nation.

As for occupations, the API region has higher average median earnings in construction and extraction than the nation and is increasing over time, in contrast to a slight decrease in the median national earnings in the occupation.

As for education level, we find that lower educational attainment groups in both the API and the United States have relatively similar earnings, while those in higher educational attainment groups in the nation have higher median earnings than the average median API region levels.

Figure 21. Change in Median Wages Within the API Region by Census Tract, 2010–2018



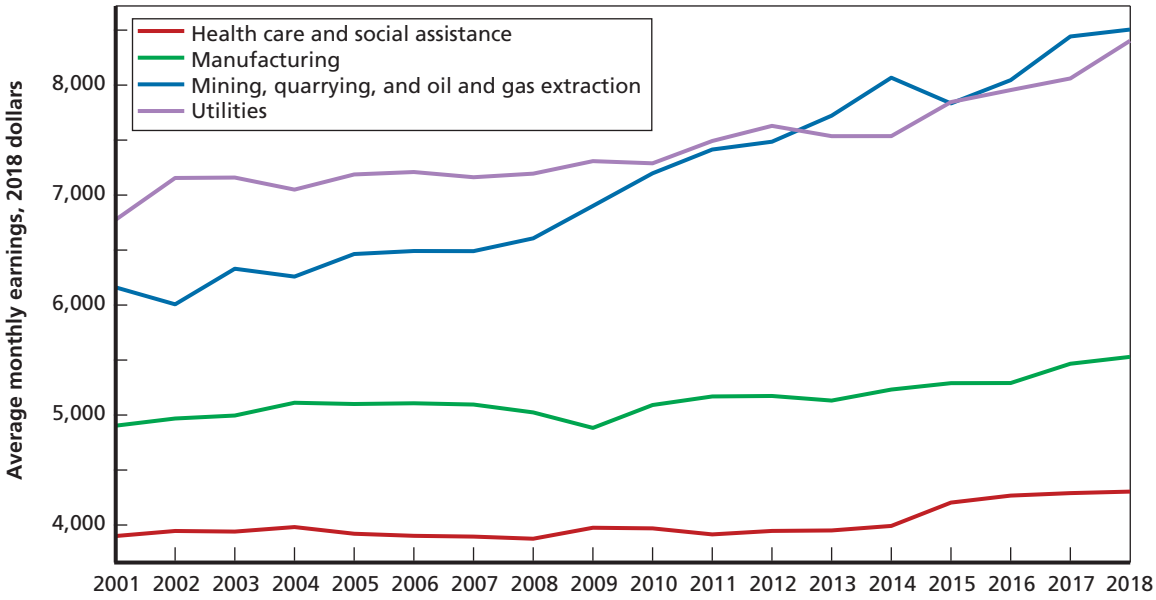
SOURCE: U.S. Census Bureau, 2019d.

However, while there are slight decreases in earnings over time for each of these educational groups at the national median level, the lower educational attainment groups in the API region show an increase. For example, the less-than-high-school education group at the national level saw a 2-percent decrease in the median earnings from 2007 to 2018, while, for the API region, the same group experienced an increase of 15 percent. For high school graduates, the national median earnings went down by 5.5 percent while the average median in the API region grew by 1.5 percent over the period.

Figure 24 shows median county-level wages for the same groupings.[6] This allows us to see the degree of variation across the 27 API counties. Each bubble represents a county, and the size of the bubble is proportional to the working-age population in the county. The education categories include the workforce between ages 26 and 64, while the industry and occupation categories include employed civilians ages 16 to 64. For comparison, we include the national median wage for each category as a black solid circle.

Although we earlier showed that the average median earnings in the API region was lower in each of the five examined industries than the national median, there are several counties for which this is not true, including in every case for the most populous county, Allegheny County, Pennsylvania. Across the investigated occupations, all of the 27 API counties had lower median earnings than the national median in computer and mathematics occupations, although every county also had a higher median earning in extraction and construction than the national median. This difference may reflect stronger demand for workers in these jobs by employers in the API region than their counterparts

Figure 22. Change in Average Earnings in the API Region, by Industry, 2001–2018



SOURCE: U.S. Census Bureau, 2019b.

elsewhere. The educational groupings show tighter clustering, such that there are few occurrences of some API counties differing greatly from the overall regional trend. Despite this tight clustering, there are several counties above and below the national median such that there is not a uniform experience here, especially for lower educational attainment groups.

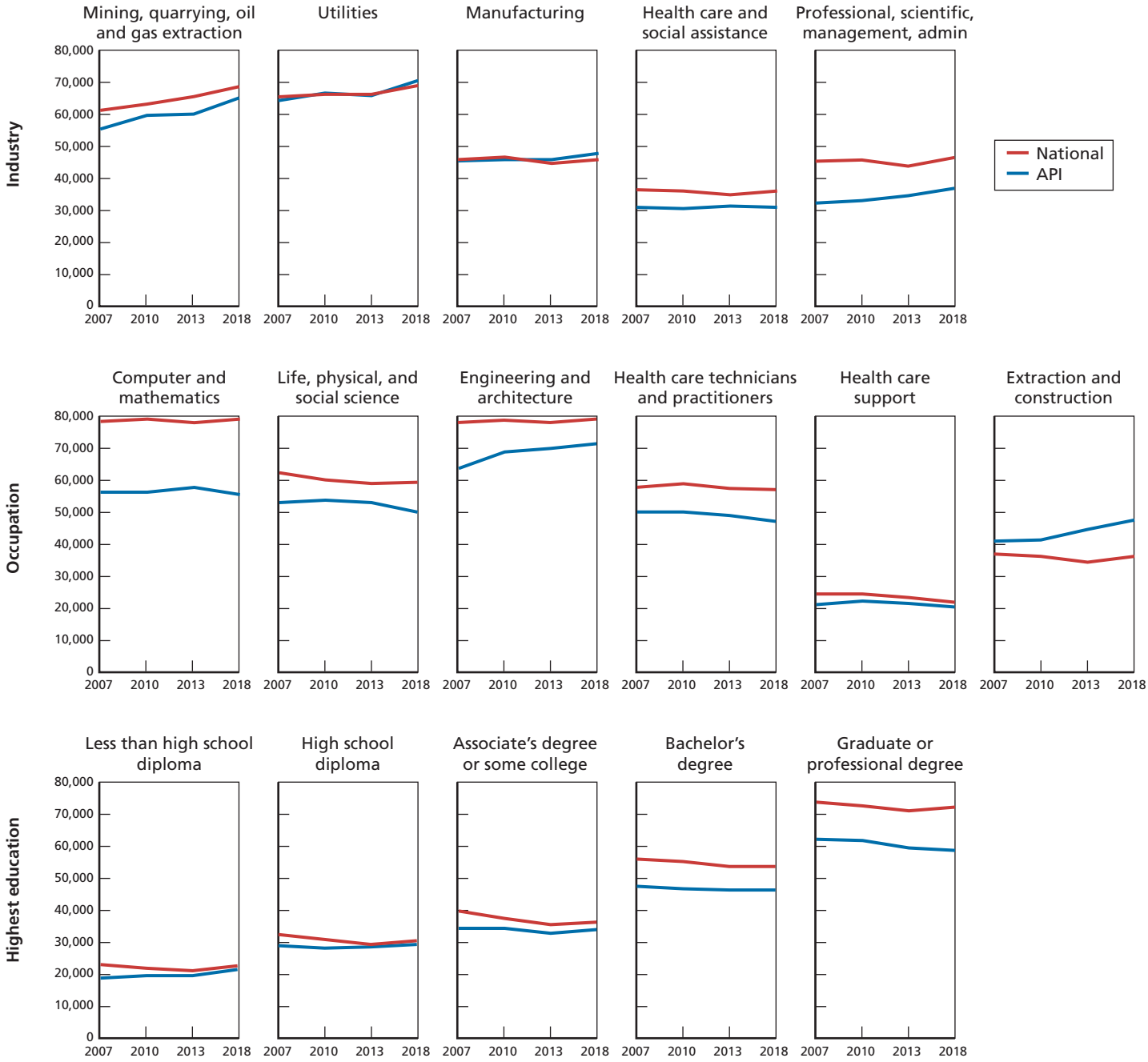
Figure 25 presents the change in median wages from 2010 to 2018, again for each county. Across all of the examined industries (as well as the other subgroups), there is again substantial variation across the counties in the change in median earnings, with some counties experiencing decreases in earnings.

While the national median change and API region average median change were similar for the first four examined occupations, the growth in earnings was more favorable in the API counties for health care support and the extraction and construction occupations; for the latter, while the national median experienced virtually no real change across the decade, the API region saw an increase of more than $5,000, or over 10-percent increase in real earnings.

Consistent with trends presented in prior API reports, real national median earnings have declined across all education levels across this time frame, with the exception of those with less than a high school degree, who had a very small positive change over time (0.7 percent).[7] However, the same cannot be said for the API region, particularly for workers with less than a high school degree or a high school degree. These workers experienced increases in the average median of about $2,000 and $1,000 for less than high school and high school degree, respectively. While these are modest increases, this stands in contrast to the lack of change for the former group and a loss of about $1,000 for the latter group at the national level.

Figure 26 compares wages across select industries by education levels. Here, we draw on and analyze the Quarterly Workforce Indicators (QWI) from the U.S. Census Bureau's LED data series. 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. We find a similar education pattern to the overall earnings, with average earnings ordered by level of education. However, the gap between earnings for those with bachelor's or higher degrees versus those with a high school diploma is the smallest for the mining and utilities industries, with about 35–40 percent higher average earnings for those with bachelor's or higher degrees, compared with 65 percent higher in manufacturing and more than 100 percent higher in health care. This is despite mining and utilities having higher overall earnings—in fact, the average earnings in the mining industry for those with a high school degree or for

Figure 23. Change in Median Wages by Industry, Occupation, and Education Level for the API Region and the United States, 2007–2018

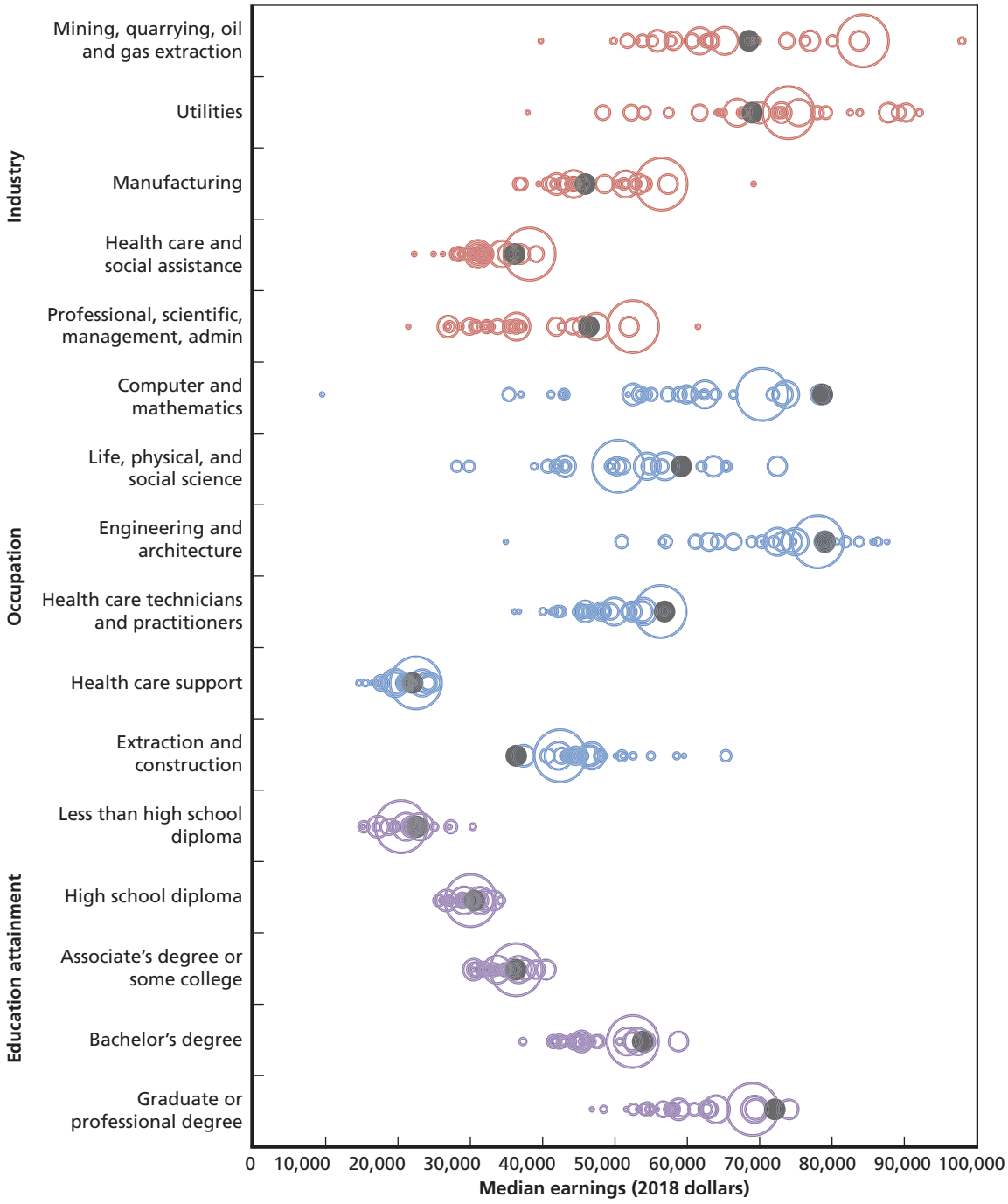


SOURCES: U.S. Census Bureau, 2019c and 2019d.

those with less than a high school degree exceed the average earnings in the health care industry for those with bachelor's or higher degrees.

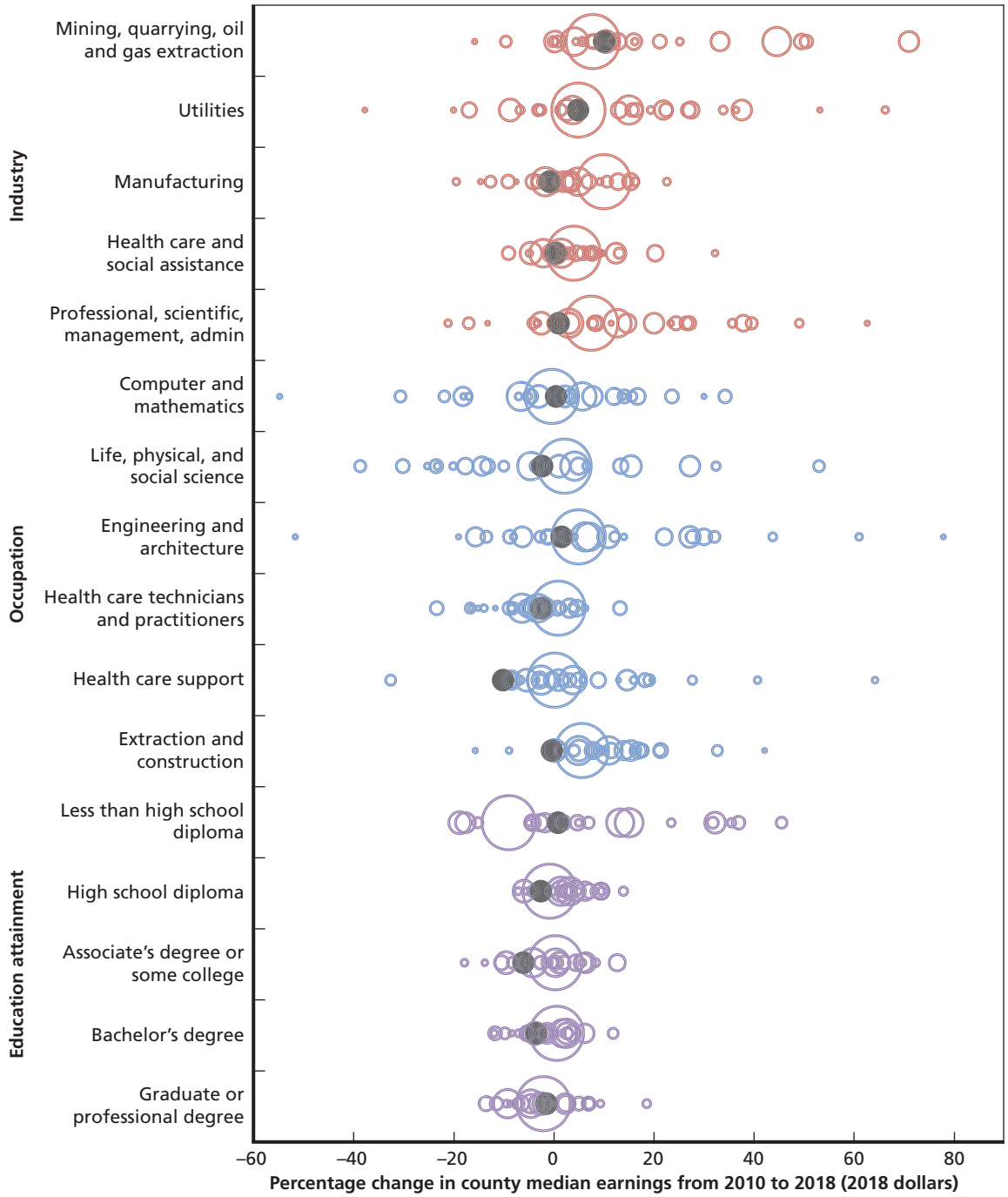
One interpretation of this pattern is that the return on education is higher for workers in manufacturing and health care than in the extraction industries, where everyone's wages are high and less tightly linked to additional years of education; a worker in the extraction industry need not be highly educated to reap relatively high earnings.[8] Although 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 and that individuals in higher-paying skilled occupations who have low educational requirements may

Figure 24. Median Wages by STEM-Related Industry, Occupation, and Educational Attainment for Workers (Ages 25 and Above) in the API Region, 2014–2018



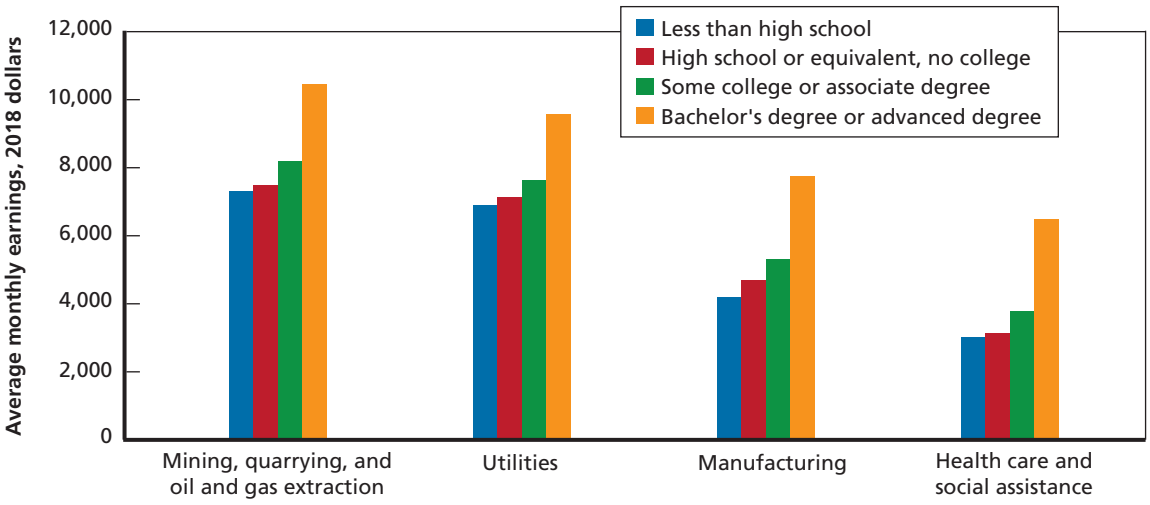
SOURCES: U.S. Census Bureau, 2019f.
NOTE: The size of the colored bubbles corresponds to the size of the working-age population in each of the API region's 27 counties. The black bubble represents the U.S. average.

Figure 25. Change in Median Wages by STEM-Related Industry, Occupation, and Educational Attainment for Workers in the API Region, 2006–2018



SOURCE: U.S. Census Bureau, 2019c and 2019e.
NOTE: 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.

Figure 26. Average Monthly Earnings by Education Level and Industry in API Region, 2015–2018



SOURCE: U.S. Census Bureau, 2019b.
NOTE: Each column represents a weighted average of earnings across the API counties in the 2015–2018 period; weights are determined by the share of total employees who reside in each county in each period.

have adverse employment outcomes later in life as the labor market shifts demand and they have difficulty pivoting into new occupations (Hanushek et al. 2017; Forster, Bol, and van de Werfhorst, 2016; for detailed review of the returns to education literature, see Card, 1999).[9]

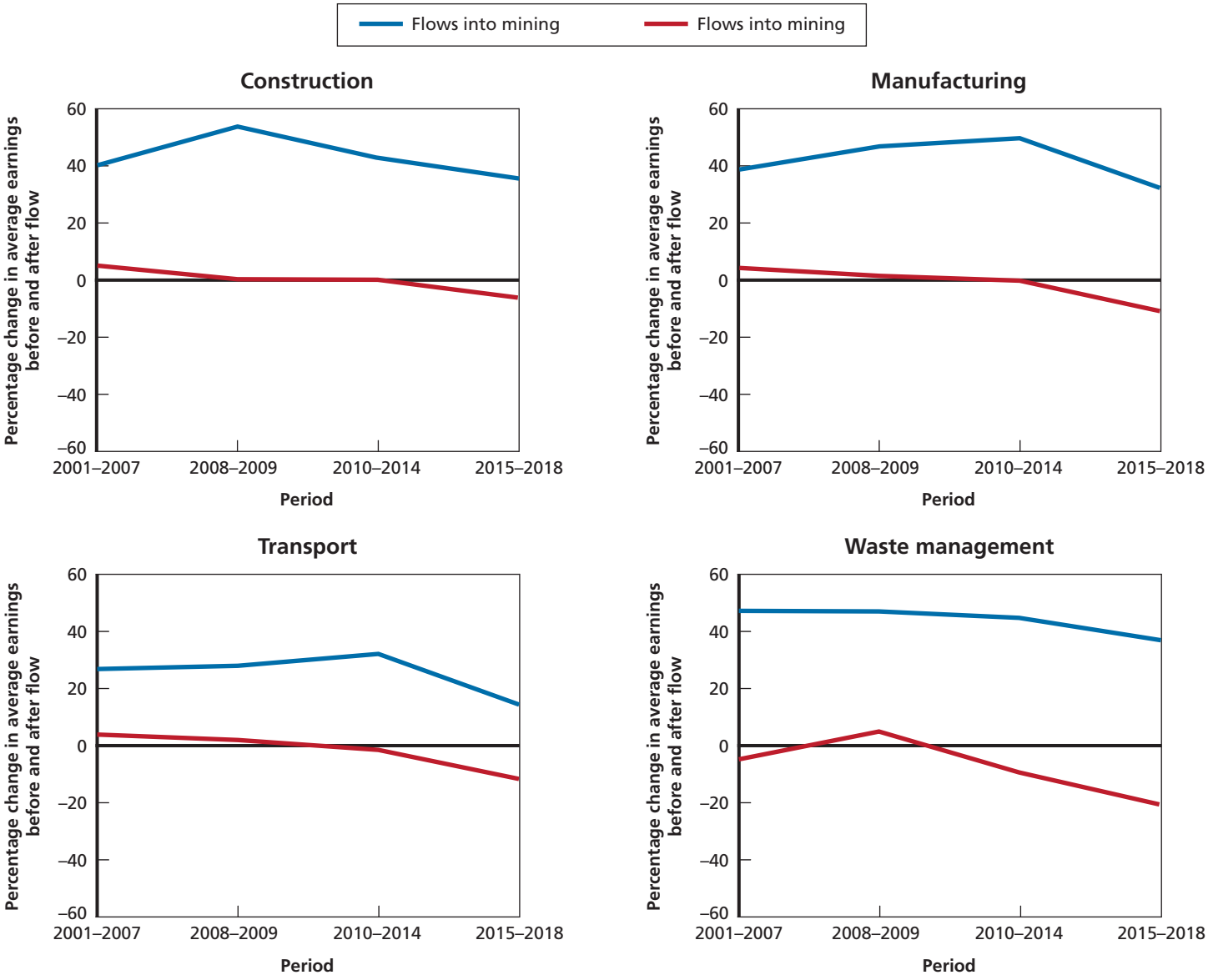
We next examine how individuals' earnings change as they move from or into other similar industries. Figure 27 shows the average percentage by which earnings changed as individuals moved in and out of the mining and extraction industry. We note that there were not significant differences over time in how earnings changed on average for those entering mining, while there was a slight worsening of earnings for those leaving mining over time. We also found striking and consistent larger increases for individuals moving into mining from these comparison industries (averaging increases between 20 and 40 percent) than those leaving mining (no average change).

Figures 28 and 29 show changes in average monthly earnings over four time periods: (2001–2007, 2008–2009, 2010–2014, and 2015–2018) for workers experiencing two kinds of job-to-job transitions: those leaving a job in an industry closely attached to mining, quarrying, and oil and gas extraction and starting a job in mining in the subsequent quarter (i.e., flows into mining) and those leaving a mining job and starting a job in a closely attached industry in the subsequent quarter (i.e., flows out of mining). For this analysis, we look only at continuous transitions—or those without a significant period of unemployment between jobs. A few observations can be drawn from the figure. First, for each educational group, the average earnings are always higher in mining than in the source industry. In contrast, the average earnings changes for people leaving mining are sometimes negative and sometimes positive. Second, for many categories of workers, the wage premium in mining—measured here as the percentage change in average earnings for people transitioning into mining jobs—has fallen in the most recent period but remains positive. Finally, the size of this wage premium has been largest for workers with the least education (i.e., those without a high school diploma) in nearly all periods and source industries, indicating the importance of jobs in the mining industry for this group of workers in the region.

CONCLUSION

This report is the third in a series of three regional indicator reports tracking and analyzing the state of the local STEM labor market and the production of local talent through education in the 27-county API region. They have served 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.

Figure 27. Change in Average Earnings for Flows In and Out of Mining Industry



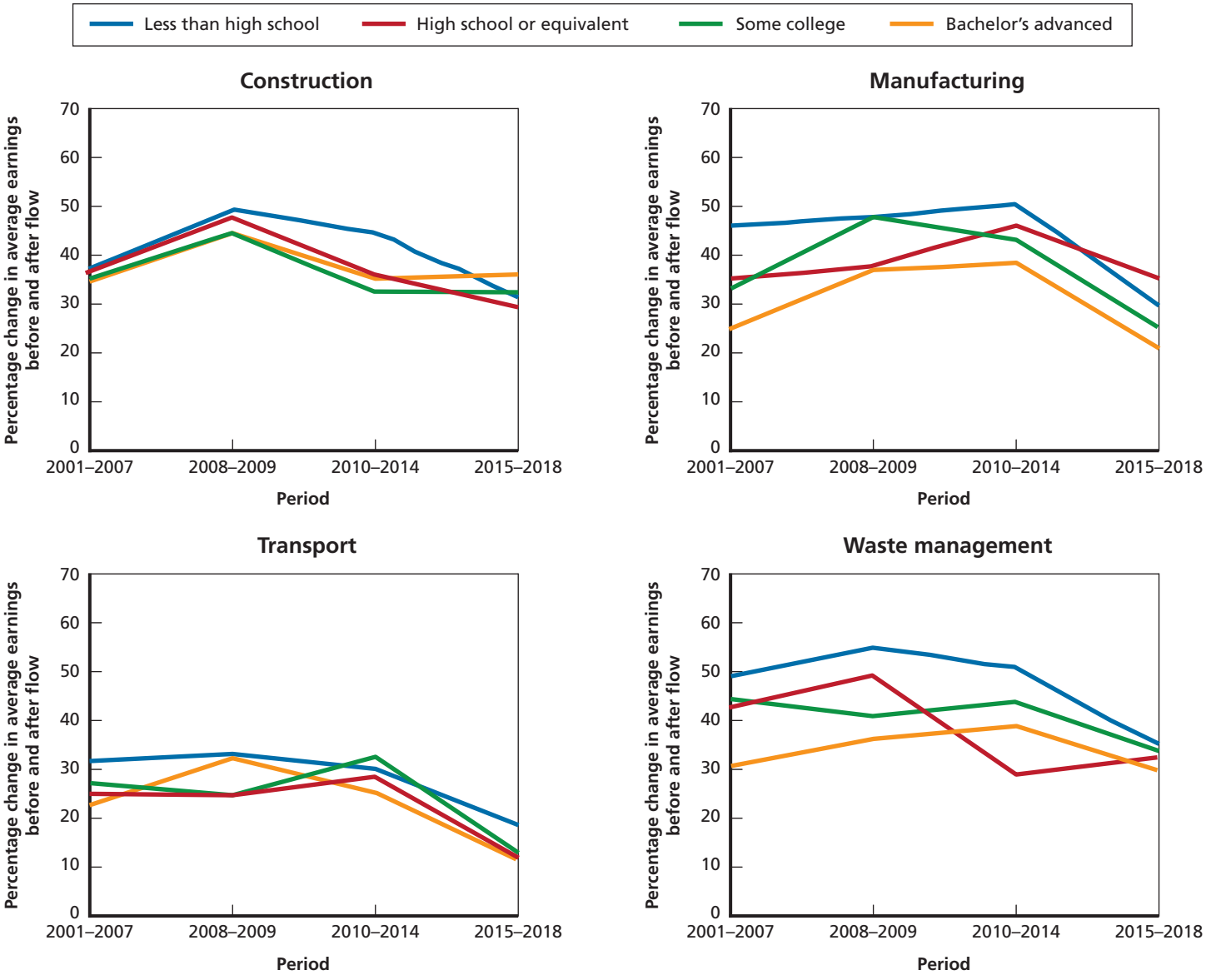
SOURCE: U.S. Census Bureau, 2019a.
NOTE: Change in average earnings is only shown for direct flows (i.e., those without a significant period of unemployment between jobs).

Three overarching questions guided the descriptive analysis presented in this report:

1. What are the trends in secondary and postsecondary education in the API region, and how do they compare with the nation?
2. What are the characteristics of the API region's STEM labor market?
3. Who are new hires in the extraction industry?

Overall, we found evidence along several metrics that education in the API region is improving over time (eighth grade mathematics scores, CTE participation for STEM and overall, high school and four-year postsecondary graduation rates, and the percentage of postsecondary awards and degrees that are in STEM). We also found that the region is doing better than the nation overall along several metrics (eighth grade mathematics scores, high school graduation rates, postsecondary graduation rates, and the percentage of postsecondary awards in STEM). However, there are still areas for improvement, namely where the

Figure 28. Change in Average Earnings for Flows into Mining by Education Level

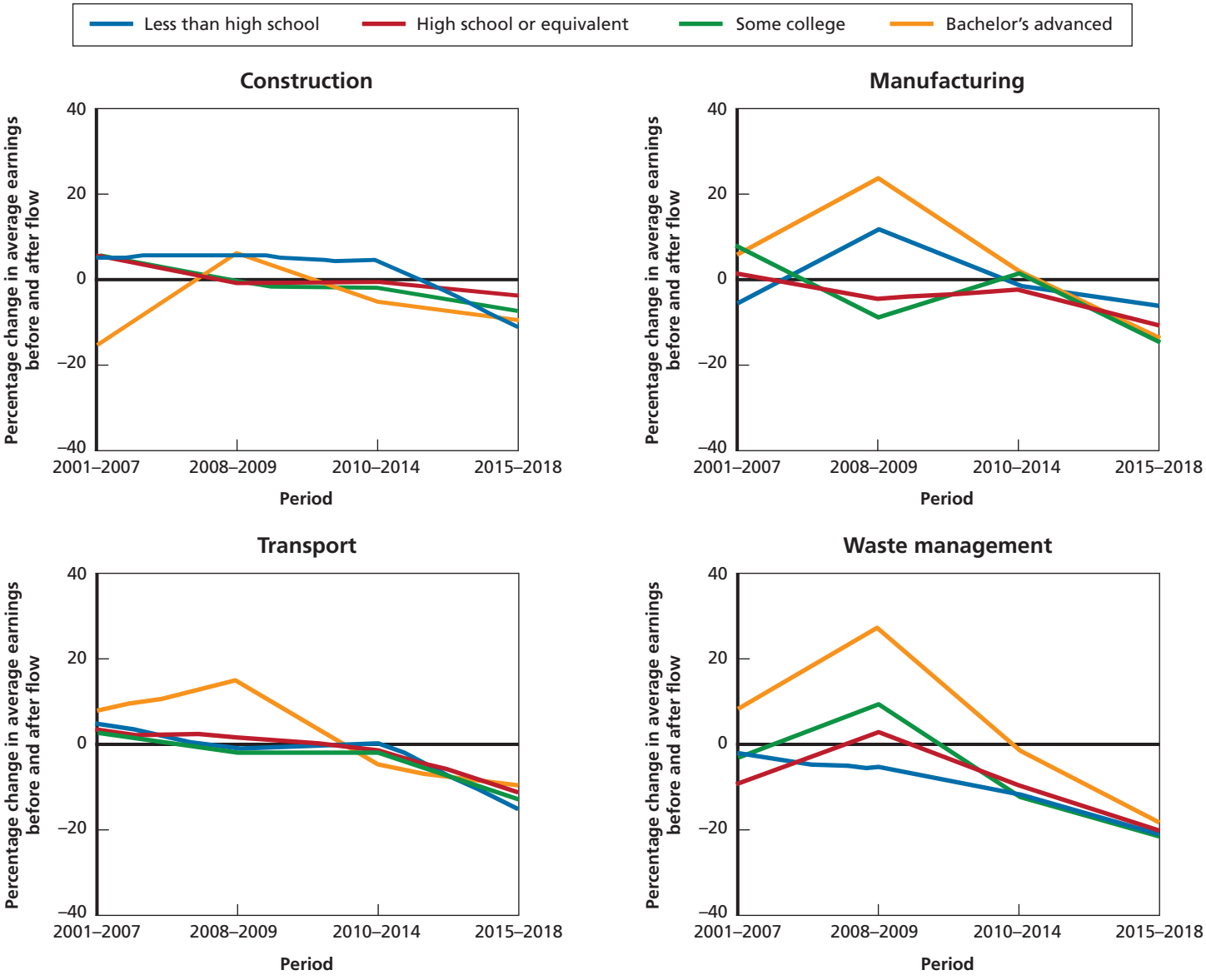


SOURCE: U.S. Census Bureau, 2019a.

metrics show worsening or are not as positive as for the nation (CTE participation rates are lower in the API region than nationwide and on a worse trajectory; postsecondary enrollment overall is decreasing, and more so than nationwide; and postsecondary graduation rates, while above the nation, are not increasing as much). We summarize our key findings in more detail.

STEM secondary education in the API region has areas of strength (mathematics achievement and high school graduation) and areas for improvement (CTE participation). Middle school students in the API states have outperformed students nationwide in mathematics assessment scores, and trends are improving over time. Although 37.1 percent of eighth graders scored proficient or advanced on the mathematics NAEP test in 2019, only 32.9 percent did for the nation overall. Furthermore, that 37.1-percent proficient or advanced in the API region represented a 7.7 percentage point improvement since 2003, compared with the national improvement over the same period of 5.6 percentage points. Mathematics and science will continue to be important for the local economy, and these trends are encouraging. So too are the rates and improvements in high school graduation. Not only did the API counties increase the graduation rate from 90 percent in 2013–2014 to 93 percent in 2017–2018, but every one of the 27 API counties had a graduation rate in

Figure 29. Change in Average Earnings for Flows Out of Mining by Education Level



SOURCE: U.S. Census Bureau, 2019a.

2016–2017 that exceeded the national rate of 85 percent (the most recent year for which national rates were available).

However, the API region has room for growth in CTE. There were almost 75,000 CTE concentrators in secondary school in the three API states; however, given that there were more than 1.1 million high school students in the three API states, this represents a relatively small fraction. Furthermore, of those 75,000 concentrators, only 3,500 were in science or technology, which is less than one-third of 1 percent of all high school students. This is far below the national rate of almost 2 percent of students that are science and technology CTE concentrators. However, the participation rates in science and technology CTE have been increasing in API, which is encouraging.

There are mixed results for STEM postsecondary education in the API region, with postsecondary enrollment decreasing in the API region and low and decreasing postsecondary CTE STEM concentrators, amid the percentage graduating in STEM increasing and outstripping the national average. Postsecondary CTE concentrators, typically in vocational schools, have decreased from about 150,000 in 2014 to about 120,000 in 2018 in the API region. Enrollment in less-than-four-year institutions in the API region decreased by about 14 percent from 2009 to 2018 and by almost 8 percent for four-year institutions.

The latter is particularly contrasted by the national increase in four-year institution enrollment over the same period by almost 13 percent. However, there is also good news for the postsecondary education sector in the API region: They continue to have higher graduation rates than the national average and have, for every year since 2009, graduated a higher fraction of students in STEM majors, both for two-year institutions and four-year institutions. In 2018, 27 percent of all postsecondary four-year degrees in the API region were in STEM, compared with 24 percent nationwide. The rates were lower for awards from two-year and less-than-two-year institutions but were still higher in the API region than the nation (14 percent versus 10 percent).

The results for employment and earnings in the API region were more neutral than the education patterns but did have some bright spots. Employment levels in the extraction industry increased throughout the early 2000s, including through the Great Recession. There was a decrease in employment starting in 2015, but the trend has been increasing steadily since 2016. Earnings tended to increase in the target industries, and more census tracts saw earnings increase overall than saw earnings decrease. There were several counties and subgroups that saw positive earnings and earning changes. Workers in extraction and construction industries had higher median earnings in every API county compared with the national median and have been experiencing better growth in earnings in the majority of counties compared with the national growth.

However, there are some areas for improvement. The API region is seeing a decrease of the working-age population amid an increase nationwide, and, for several industries and occupations, the API average median earnings is below the national median and have seen lower growth in earnings. We summarize our key findings for employment, earnings, and new hires in the extraction industry in more detail in the next paragraphs.

Working-age population declined within the API region. While the nation has experienced increases in the number of working-age individuals from 2010 to 2018, the API region continues to experience decreases. These decreases were concentrated in rural counties, consistent with national trends; three of the most urban counties in the region saw increases in the working-age population. Meanwhile, 16 of the 27 API counties had decreases of the working-age population exceeding 5 percent over this period.

Although median earnings were higher in suburban areas of the API region and lowest in parts of the urban centers, there was no clear geographic pattern for growth in median earnings. Overall, earnings in the API region were similar to the national level and followed similar trends. The vast majority of the census tracts in the API region have median wages of $20,000–$50,000 per year, including throughout the more rural regions. This is in line with nationwide median earnings, which was $33,439 for the same period. The highest-earning areas were in the suburbs of Pittsburgh, and the lowest were in the urban areas of Canton and Youngstown, Ohio, and Pittsburgh. Although most of the 1,149 total tracts in the API region did not see a statistically significant change in median earnings, 60 census tracts had statistically significant increases, while only 20 had significant decreases. These tracts were scattered across the region and did not appear to be correlated with urbanicity or location broadly.

Earnings were high and growing in the mining and utilities industry in the API region. In 2018, average monthly earnings in mining and extraction was about $8,500, up from below $7,000 in 2001 (in 2018 dollars). Although workers in several investigated occupations had lower median earnings in the API region compared with the rest of the United States, workers in construction and extraction industries had higher than national median earnings, on average and for each of the 27 API counties. They also experienced larger growth in earnings from 2010 to 2018, with all but two very small counties having median earnings for workers in extraction and construction occupations outearning the national median for change in earnings. Meanwhile, workers in health care industries or occupations had lower earnings, both relative to mining and utilities and to the national averages.

The mining and extraction industry was particularly successful at compensating workers with high school degrees or had less education. While the API region mirrored the national trends of higher educated workers being paid more on average, the gap was smaller in the mining and extraction industry: The gap between earnings for those with bachelor's or higher degrees versus those with a high school diploma is the smallest for the mining and utilities industries at about 35–40 percent higher average earnings for those with bachelor's or higher degrees, compared with 65 percent higher in manufacturing and more than 100 percent higher in health care. This is despite

mining and utilities having higher overall earnings—in fact, the average earnings in the mining industry for those with a high school degree or for those with less than a high school degree exceed the average earnings in the health care industry for those with bachelor's or higher degrees.

New hires from outside the extraction industry in API states came primarily from within the region but from other industries. They also enjoyed large earnings increases. For all new hires not already working in the extraction industry in the API states, more than 75 percent of them came from within the API region but from a different industry. In other words, the region was able to generally supply the needs of job expansion in mining. This is especially important given that these new hires coming from other industries experienced large earning increases of, on average, about 40 percent for workers coming from jobs in construction, manufacturing, or waste-management industries. This is in sharp contrast to the small earning losses on average for workers transitioning the other direction.

APPENDIX

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

Data Sources for 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 and not uniformly. In this report, we used the latest available data—the 2019 mathematics assessments. There had not been a new science administration since the last report. Additional technical details about the NAEP are accessible at its website (see NCES, 2015). For ease of interpretation, we present the original scaled scores in terms of NAEP achievement levels—below basic, basic, proficient, and advanced.[10]

We used high school graduation rates from data compiled by the U.S. Department of Education and available at the department's EDFacts website (see U.S. Department of Education, 2020a). 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 science 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, 2018, 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.

Data Sources for Wages and Employment Indicators

Wage, employment, and population data are from the 2000 Decennial Census, the Population Estimates Program, 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 and median wages are based on the 2006–2010 five-year ACS and the 2014–2018 five-year ACS estimates. 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, although 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. 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 incorporated measures derived from 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 reported in the QWI are constructed in a fundamentally different way from median wages in the ACS. 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 because of the influence of very high earners.

The analysis of workers' movement into and out of industries is based on the LEHD Job-to-Job origin-destination data series. Data for each of the three states comprising 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 North American Industry Classification System 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 to 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 workers 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 it only tracks job-to-job flows, which excludes a portion of the workforce. Specifically, the data neither 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.

NOTES

[1] 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 about 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).

[2] 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.

[3] RAND does not make investment decisions. Rather, as the monitoring and evaluation lead, RAND produces these regional indicator reports (of which this is the last in a series of three) 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.

[4] More information about the API and the process under which the footprint and programming was selected, see Gonzalez, Culbertson, and Nanda (2017). Unless otherwise noted, we will focus on this region, using terms such as the *API region*, *API footprint*, or *API counties*. For three specific analyses (NAEP mathematics scoring, career and technical education, and flows in and out of mining industry), we do not have access to data at the level necessary to isolate these regions (e.g., county or smaller). For these three, we rely on state-level data and use the terminology of API states (namely, Ohio, Pennsylvania, and West Virginia), including the counties not in the API region.

[5] 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 NAEP for mathematics is defined, see NCES (2019).

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

[7] The 2010 five-year ACS earnings data were collected between 2006 and 2010, while the 2018 five-year ACS earnings data were collected between 2014 and 2018. 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.

[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 postsecondary certificate holders earn 20 percent more than high school graduates without any postsecondary education (Carnevale, Rose, and Hansen, 2012).

[10] 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, 2012.

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About This Report

The research was conducted within RAND Education and Labor and RAND Social and Economic Well-Being Divisions of the RAND Corporation. This research was sponsored by the Appalachia Partnership Initiative (API). As the research and analysis lead of API, RAND was asked to produce descriptive portraits of employment and wages in energy and advanced manufacturing–related industries and science, technology, engineering, and mathematics (STEM) education indicators in the API region. This is the third of three 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.

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The Appalachia Partnership Initiative

Chevron North America Exploration and Production (CNAEP) Appalachian Mountain Business Unit's Social Investment Team was established to strengthen 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. API consisted of representatives from Chevron, the Claude Worthington Benedum Foundation, the Grable Foundation, Allegheny Conference for Community Development, and Catalyst Connection. RAND Corporation was the research lead for API.

Appalachia Partnership Initiative
MAKING OUR NEW ENERGY ECONOMY WORK

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