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BLS publishes experimental state-level labor productivity measures

The U.S. Bureau of Labor Statistics recently published experimental data on state-level labor productivity for the private nonfarm sector, including state-level output per hour, output, hours, unit labor costs, hourly compensation, and real hourly compensation data series. These annual data series, covering 2007−17, provide insights into the variation in productivity across states. Over this period, average annual productivity growth ranged from 3.1 percent in North Dakota to −0.7 percent in Louisiana. However, California, whose productivity grew at an average annual rate of 1.7 percent, was the largest contributor to national productivity growth due to the large size of its economy. This article describes the data and methodology used to estimate this new experimental state-level labor productivity series. In addition, it examines the compensation-productivity gap, the relationship between productivity growth and the share of output in the information and communications technology producing sector, and whether state-level labor productivity was converging in the postrecession period.

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U.S. Bureau of Labor Statistics (BLS) data users have long sought state-level productivity measures for public and private policy planning and for economic research. These measures may vary substantially given the variation in industrial composition by state. By analyzing state-level productivity trends over the long term, data users may learn more about regional business cycles; the persistence of regional income inequality; which states are driving productivity growth at the national level; and the role of regulations and taxes on growth.

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Numerous researchers have attempted to produce time-series data that measure state-level productivity growth. In most cases, they have used employment for the labor input rather than hours worked.[1] Hours worked, however, are preferred for productivity measurement because they more accurately capture the time available for production.[2] In addition, hours worked data are used for BLS national productivity estimates. Using data from its establishment survey, the Current Employment Statistics (CES), in 2007, BLS began producing a state-level average weekly hours series for all employees, making an output-per-hour-worked series possible.[3] In June 2019, BLS published for the first time an experimental state-level labor productivity data series, measured as output per hour worked, for the private nonfarm sector.[4] BLS also published measures of state-level output, hours, unit labor costs, hourly compensation, and real hourly compensation. These new annual measures cover all 50 states and the District of Columbia from 2007 to 2017. When the underlying state output and hours data are aggregated to produce an aggregate labor productivity measure, the resulting sum-of-states estimates closely track the BLS official measures of productivity for the nonfarm business sector, although the sectoral coverage and the hours methodology used to produce the estimates differ somewhat. Thus, we can infer the amount the states contribute to national productivity growth.

This article first discusses the data sources and methodology used to construct these new state-level estimates and then presents some preliminary findings. Over the current business cycle (2007–17), nonfarm business sector labor productivity grew an average of 1.3 percent annually. However, these new measures show that productivity growth rates varied substantially across states. For example, average annual productivity growth ranged from 3.1 percent in North Dakota to −0.7 percent in Louisiana.[5] In the last section, we explore several potential uses of these new state-level data. We examine the contribution of states to national and regional productivity estimates, the growing compensation-productivity gap, the relationship between productivity growth and the share of output in the information and communications technology (ICT) producing sector, and whether state-level productivity levels are converging.

Data and methodology

Labor productivity is measured as the difference between the percentage growth in output and the percentage growth in hours worked. In order to measure productivity accurately, one must ensure that the sectors of the economy covered by the output and hours measures are consistent. It is also important that one uses measures of the hours worked to produce the output rather than the hours paid, which are reported in most U.S. establishment-level surveys. Hours worked more accurately measure the intensity of labor due to variations in paid leave practices across industries. For one to create accurate subnational measures, measures of hours worked must be recorded for the same place (in this case the state) in which the worker produced the output. Thus, caution should be exercised when data are used from household surveys, such as the Current Population Survey (CPS) or the American Community Survey, in which the place of residence does not necessarily equal the place of production. Finally, the output and hours measures should be independent of each other. Output measured primarily using employee compensation data will trend similarly to hours data over time, resulting in labor productivity estimates being biased toward zero. For this reason, official national labor productivity statistics cover the nonfarm business sector and exclude general government, private households, the Armed Forces, and nonprofit institutions.[6]

Because of limitations in the state-level data, the new BLS state-level labor productivity measures cover the private nonfarm sector, which differs in coverage from the nonfarm business sector by including nonprofit institutions serving households and excluding government enterprises. Any bias introduced with nonprofits included would be more prevalent in states with large nonprofit sectors. The state-level labor productivity measures are calculated by combining real gross domestic product (GDP) by state, produced by the U.S. Bureau of Economic Analysis (BEA), with BLS state-level measures of hours worked for all people. Unit labor costs are calculated as BEA nominal compensation per unit of output. Hourly compensation is constructed with BEA compensation data and BLS hours worked for all people. In the following sections, we describe in detail the data sources and methodology BLS uses to construct state-level output and hours worked and how these estimates differ from those used for the national-level productivity measures.

Output

BLS creates state-level measures of output for the private nonfarm sector using BEA's GDP by state and industry-level detail.[7] BEA uses two procedures for estimating current-dollar GDP by state and its components. These procedures differ depending on whether the industry is a goods-producing industry or a service-providing industry.[8] For nonfarm goods-producing industries, GDP by state is measured primarily with the use of industry value-added data classified by establishment location from the U.S. Census Bureau.[9] For private service-providing industries, GDP by state is measured as the sum of three income components, which include labor income, capital income, and business taxes less subsidies (i.e., the gross domestic income [GDI] approach).

In theory, the value-added approach and the income approach to measuring GDP should be identical. However, in practice, the two approaches do not result in equal measures because of the different data sources used. At the national level, the difference between these two GDP measures (usually 0.5 percent to 1.0 percent) is reported in the National Income and Product Accounts as a statistical discrepancy.[10] At the state level, BEA reconciles the GDP by state components for each industry to be consistent with BEA's definition of value added and then scales the components to the national-level industry estimates.

Using the GDI approach for state-level productivity measures has several potential limitations that scaling to the total national industry level may not resolve. Labor income is composed of wages, salaries, and other benefits earned by workers.[11] Because labor income and hours trend closely together, states with a relatively large service sector with output based on a high percentage of labor income may lead to somewhat biased productivity measures. Capital income less fixed investment comprises three components: (1) proprietors' income, (2) nontax payments to the government, and (3) corporate capital charges.[12] Proprietors' income earned in other states are reported in the proprietors' state of residence or tax-filing address of the firm. Therefore, bias is introduced when output produced in one state is improperly credited to another state. However, Daveri and Mascotto concluded that the bias would be very small, except for in small states and states in which a large portion of their economies extend across state boundaries (Connecticut, Delaware, Rhode Island, New Jersey, Virginia, and the District of Columbia).[13] Another potential limitation of the BEA capital income methodology is that not all the components are built up with state and local data. Instead, national data are distributed to states on the basis of various state indicator series.

To get real GDP, BEA uses price deflators to deflate current-dollar GDP. For states, state-specific producer price indexes (PPIs) would be preferred because they would more accurately represent prices in that state. However, because state PPIs do not exist, BEA prepares real measures of GDP by state by applying national-level chain-type price indexes to the current-dollar values of GDP by state for detailed industries.[14] “To the extent that a state’s output is produced and sold in national markets at relatively uniform prices . . . , real GDP by state captures the relative differences in the mix of goods and services that states produce.”[15] However, the measure cannot account for the differences in prices of goods and services that are produced and sold locally.

BEA does not produce a private nonfarm sector measure of real output by state. To create the necessary output series, BLS uses the Fisher ideal index formula to subtract several industry components—the farm sector, private households, and owner-occupied housing—from GDP by state for all private industries.[16] Owner-occupied housing and private household data are removed because there are no comparable data on hours. Because GDP by state does not include a separate breakout for private households (North American Industry Classification System [NAICS] 814), BLS estimates output for private households using BEA state employee compensation and the national chain-type price index for private households. Similarly, the GDP by state dataset includes real estate (NAICS 531), but it does not have a separate breakout for owner-occupied housing. To estimate the value of owner-occupied housing by state, BLS applies the owner-occupied housing’s share of the national real estate industry to each state’s value of real estate.[17] BLS then deflates this estimate using the BEA national chain-type price index for owner-occupied housing.

Hours worked

BLS creates estimates of state-level hours worked for all people as shown in equation (1):

$$\text{Hours worked} = [N * \text{AWH} * \text{HWHP} * 52] + \text{SEUFWhours}, \qquad (1)$$

where *N* is wage and salary employment, AWH is all-employee average weekly hours paid, HWHP is the hours-worked-to-hours-paid ratio, and SEUFWhours is unincorporated self-employed worker (also referred to as proprietors) and unpaid family worker hours. For wage and salary workers, employment is based primarily on the CES state-level employment series, with supplemental employment counts for the nonfarm portion of the agricultural sector coming from the Quarterly Census of Employment and Wages (QCEW).[18] In some instances in which QCEW data are suppressed, employment is imputed using a variety of methods, such as linear interpolation, ratios of the missing industry to the total in different years, or ratios based on establishment counts. In total over the period, approximately 25 percent of the state-year observations contain imputed data. However, the imputed estimates average only 0.005 percent of total wage and salary employment.

The all-employee average weekly hours paid series is based on payroll records of business establishments and covers the private nonagricultural sector (excluding private households).[19] For productivity estimates at the national level, BLS converts hours paid to hours worked primarily using HWHP ratios developed from employer-leave practices recorded in the BLS National Compensation Survey. Thus, changes in paid vacation granted and sick leave taken do not affect hours growth.[20] To create HWHP ratios for each state, BLS weights national industry-level all-employee HWHP ratios by their respective state’s industry employment shares and then sums the weighted ratios. The level of industry detail used for the ratios depends on whether the industry employment is publicly available. For most states, two-digit-level industry ratios are used; however, in a few less populated states, ratios for the goods-producing and service-providing sectors are used.[21]

State-level hours-worked estimates for the SEUFW come from the CPS as they do for national hours estimates. In many cases, the unincorporated self-employed work from their place of residence; however, as always, exceptions exist, and a substantial amount of work conducted outside the state of residence could bias hours estimates.

Hourly compensation

To compute hourly compensation, BLS divides BEA nominal private nonfarm compensation less private household compensation by BLS hours worked. BLS imputes compensation for SEUFW by assuming that hourly compensation is the same for both SEUFW and the average wage and salary worker. Real hourly compensation reflects the adjustment of hourly compensation for changes in prices. To calculate real compensation, BLS first divides nominal compensation by the BEA regional price parities. These price parities are spatial price indexes that compare state-level price levels in 1 year to the U.S. average, which is indexed to 100 in each year.[22] Next, this result is scaled so that the sum of all states matches the sum of total nominal compensation for all states because data precision issues allow for small differences to arise. Then, BLS converts the result to constant dollars using the BLS Consumer Price Index for all Urban Consumers Research Series (CPI-U-RS). BEA uses a similar methodology to convert personal income to real personal income, although it uses the BEA Personal Consumption Expenditures Price Index to convert to constant dollars. For state-level hourly compensation, BLS uses the CPI-U-RS to be consistent with the national-level productivity statistics.

Differences between state and national productivity measures

Two important differences exist between the way BLS constructs the experimental state-level labor productivity measures and the way BLS constructs the official national-level labor productivity measures. First, average weekly hours worked for wage and salary workers are measured differently. The national measure of average weekly hours worked is constructed separately for production workers and nonproduction workers.[23] Average weekly hours worked by production workers are the product of production worker average weekly hours paid and the production worker hours-worked-to-hours-paid ratio. Average weekly hours worked by nonproduction workers are the product of the average weekly hours worked by production workers and the ratio of nonproduction worker hours to production worker hours estimated with the CPS (also referred to as the CPS ratio). The CPS ratio was introduced in 1994 to improve estimates of average weekly hours for nonproduction and supervisory workers.[24] The state measures use average weekly hours data for all employees because the CES state-level data do not capture average weekly hours separately for production workers at the private nonfarm level. BLS is currently evaluating whether to use all-employee average weekly hours for national-level productivity statistics as well.

Second, two differences exist in sectoral coverage. State-level measures of output and hours include coverage of nonprofit institutions because data at the state level are insufficient for measuring nonprofit institutions accurately. As previously mentioned, removing nonprofits is desirable when productivity is measured. At the national level, BEA produces nonfarm business estimates and separate estimates for nonprofits serving households. Thus, nonprofit institutions at the national level can be excluded from output. For national major sector hours measures, BLS removes nonprofits using nonprofit factor ratios for certain three-digit NAICS industries, primarily on the basis of Economic Census data.[25] State-level hours estimates from CES are available at the two-digit NAICS level for some states, not the three-digit level; therefore, the same nonprofits cannot be removed from the state data.

Although other state-level data exist on nonprofit employment, these data do not cover all nonprofits. For example, the National Center for Charitable Statistics covers 501(c)3s and 501(c)4s only and the BLS Business Employment Dynamics (BED) covers 501(c)3s only.[26] According to the BED, in 2017, the share of state employment working in 501(c)3s was 11 percent, on average, ranging from 3 percent in Nevada to 26 percent in the District of Columbia. Between 2016 and 2017, the change in the share of employment in 501(c)3s ranged from −0.4 percent in the District of Columbia to 0.5 percent in Alaska. This change implies that productivity growth estimates excluding nonprofits would differ slightly from the new series year over year.

For productivity measures, removing general government is desirable because its output is primarily estimated with the use of labor compensation. In the National Income and Product Accounts, value added for government enterprises is recorded in the business sector.[27] At the state level, however, GDP measures include government enterprise data in general government, and the activity of government enterprises cannot be clearly separated from the data to add its activity to the private nonfarm sector. Therefore, when government is removed from GDP by state, the output of government enterprises is also removed.

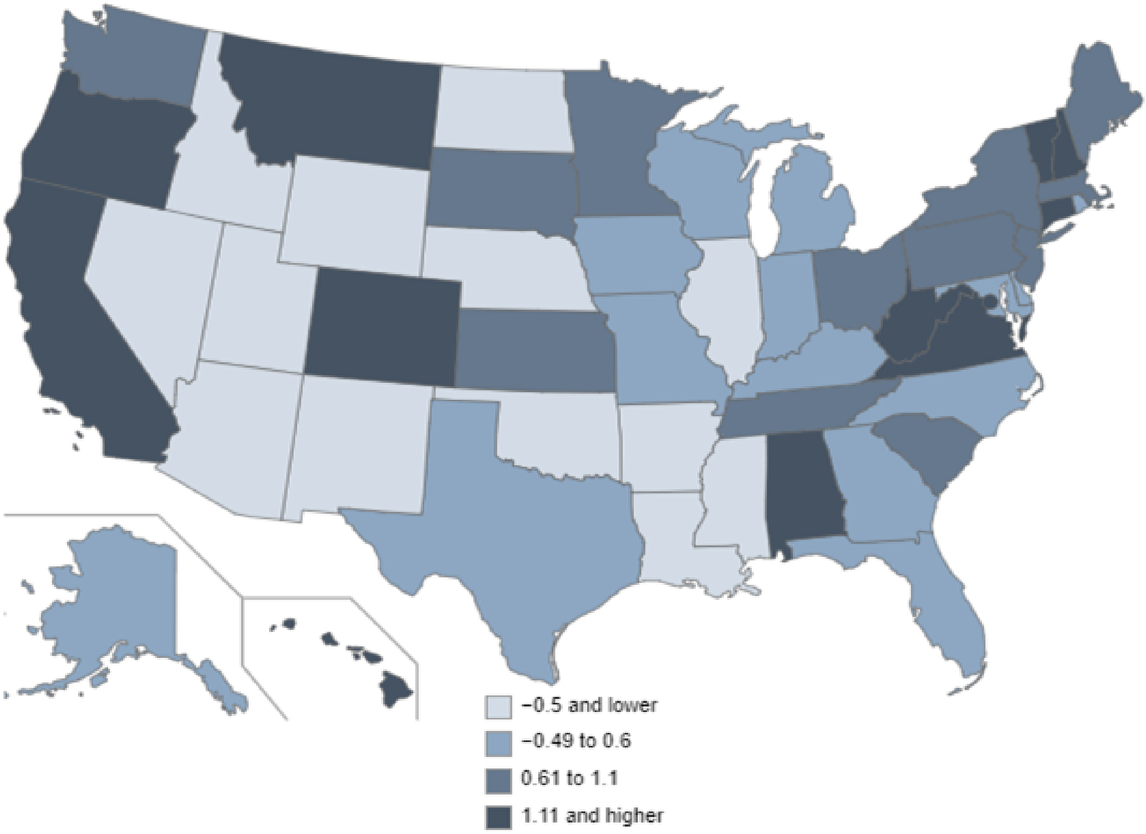
When nonprofit hours are added back to the hours worked data used to produce the nonfarm business productivity measures and when government enterprises are removed from these data, the resulting hours differ slightly from the sum-of-states hours estimates. The largest differences in the estimates were in 2009 and 2016. In 2009, hours worked declined 6.5 percent in the adjusted official productivity data but declined 6.8 percent for the sum-of-states hours. In 2016, hours worked increased 1.6 percent in the adjusted official productivity data but increased only 1.3 percent for the sum-of-states hours. The differences can primarily be attributed to two factors. First, as just described, differences exist in the methods used for estimating average weekly hours worked for employed people. Second, there are inconsistencies between employment estimates published by the CES state and area program and the CES national program because of differences in benchmarking schedules that affect the versions of data available for use to establish the benchmark levels. In 2009, CES national employment for private nonfarm industries declined 5.2 percent while the CES state and area sum-of-states employment for private nonfarm industries declined 5.4 percent.

Findings

Most recent data, 2016–17

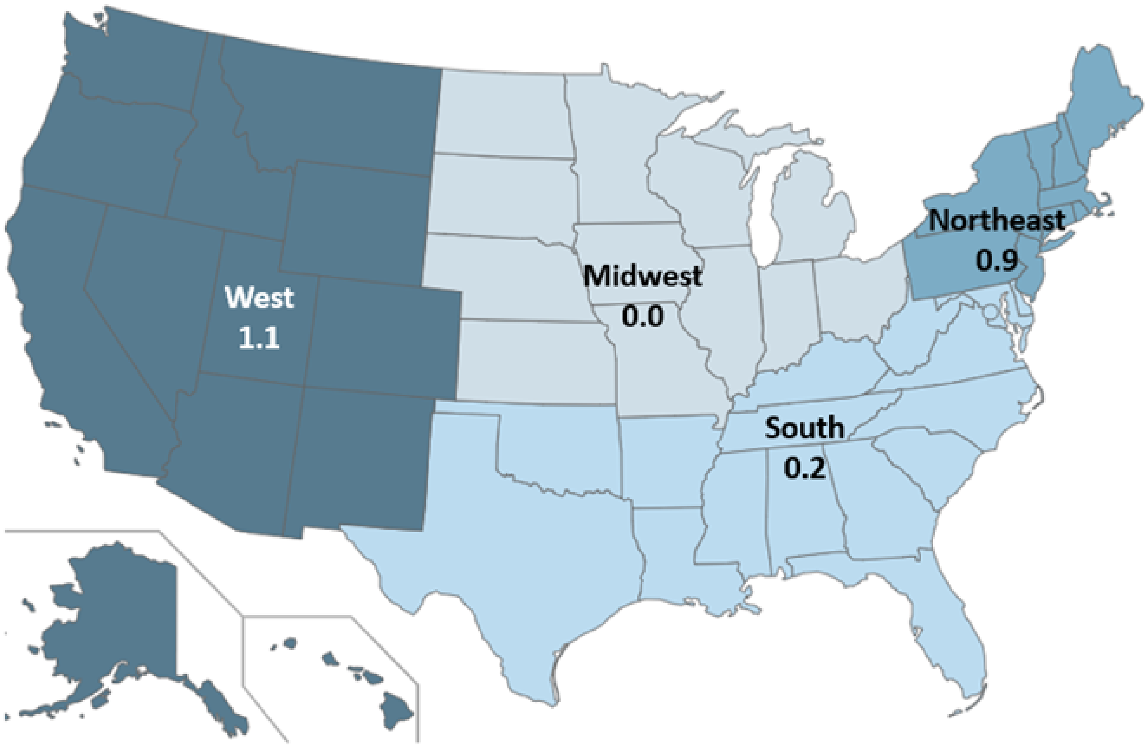
Figure 1 shows that in 2017, state-level labor productivity growth rates ranged from 2.0 percent in Montana to −2.2 percent in Arkansas, a 4.2-percentage point difference. Growth was fastest in Montana (2.0 percent), West Virginia (1.9 percent), California (1.8 percent), and Hawaii (1.7 percent). The two leaders, Montana and West Virginia, are states with relatively large shares of GDP coming from energy-producing industries. Overall, productivity grew in 31 states and the District of Columbia. Figure 2 shows the labor productivity growth rates for the four Census regions, which show that the West region was growing the fastest, with a growth rate of 1.1 percent. See data in appendix table A-1 for 2016–17 growth rates in productivity and other series for all states and regions.

Figure 1. State-level labor productivity (percent change), 2016–17 (U.S. sum of states = 0.5 percent)



Source: U.S. Bureau of Labor Statistics.

Figure 2. Labor productivity (percent change), by Census region, 2016–17

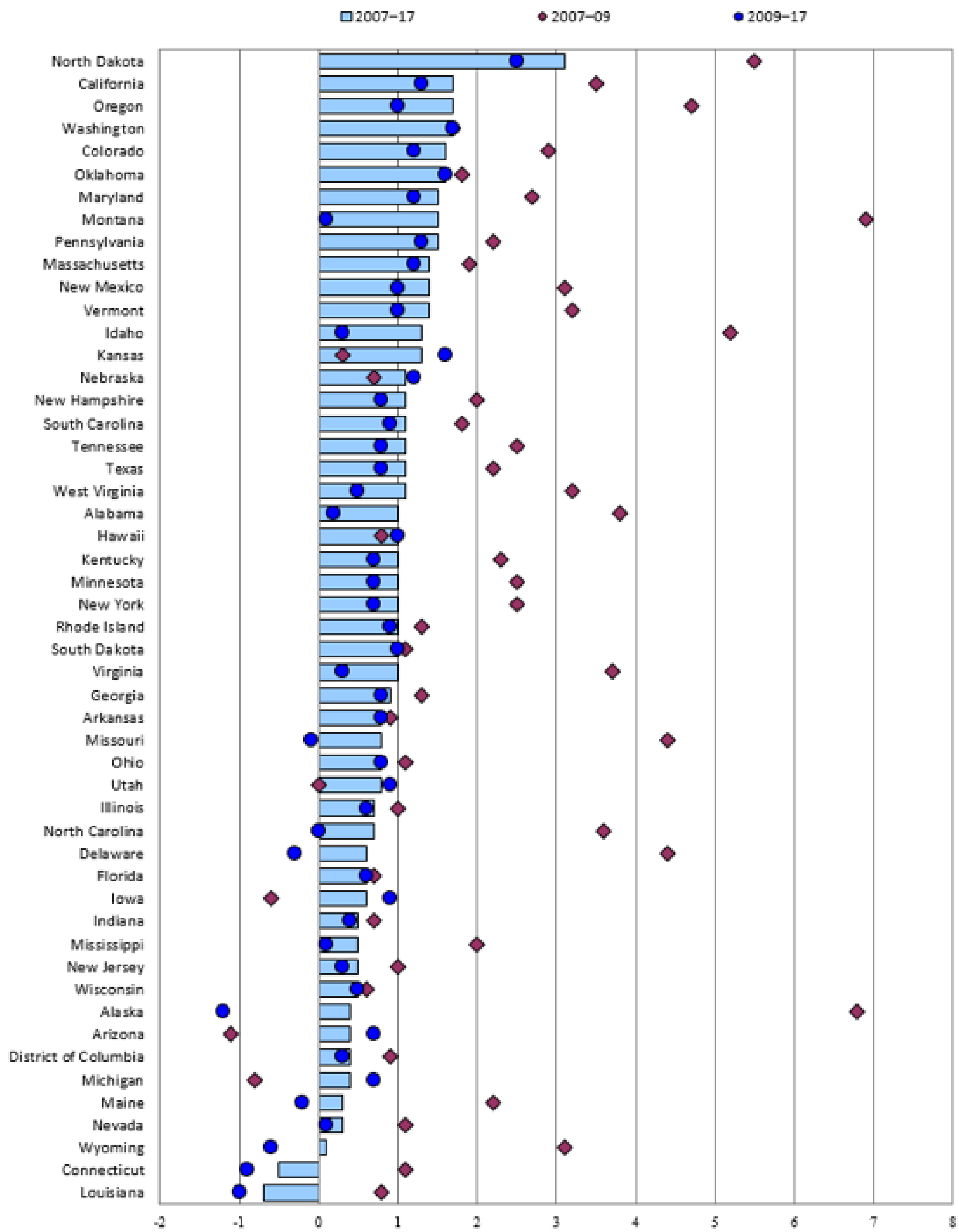


Hover over a region to see data.
Source: U.S. Bureau of Labor Statistics.

Long-run trends

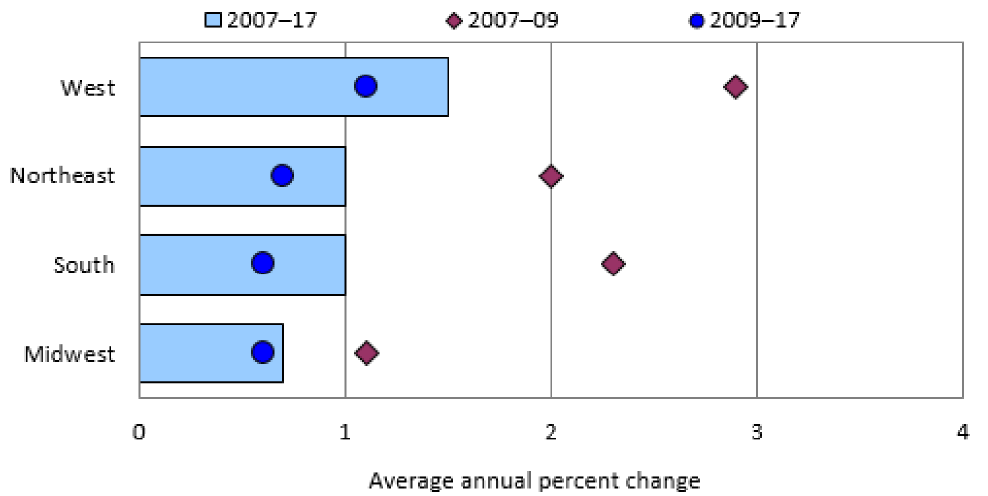
Figure 3 shows the average annual state-level labor productivity growth over the current business cycle (2007–17), during the Great Recession (2007–09), and in the postrecession period (2009–17). Over the 2007–17 period, the fastest growing states were North Dakota, California, Oregon, and Washington. Because of the shale oil boom, North Dakota's labor productivity growth was substantially higher than the growth in the rest of the states.[28] The slowest growing states were Louisiana, Connecticut, Wyoming, Maine, and Nevada. However, growth varied over the period. During the recession, labor productivity grew in 46 states and the District of Columbia, led by Montana, Alaska, North Dakota, and Idaho. Productivity gains were mostly the result of hours falling faster than output, with all states and the District of Columbia recording declines in hours worked and only nine states and the District of Columbia recording gains in output. In the postrecession period, North Dakota, Washington, Oklahoma, and Kansas experienced the largest gains. Figure 4 shows the growth rates for the four Census regions. The average annual growth rate ranged from 1.5 percent in the West region to only 0.7 percent in the Midwest region. See data in appendix table A-2 for growth rates in productivity and other series for all states and regions over the period 2007–17.

Figure 3. Labor productivity, by state, average annual percent change, 2007–17



Source: U.S. Bureau of Labor Statistics.

Figure 4. Labor productivity, by Census region, average annual percent change, 2007–17

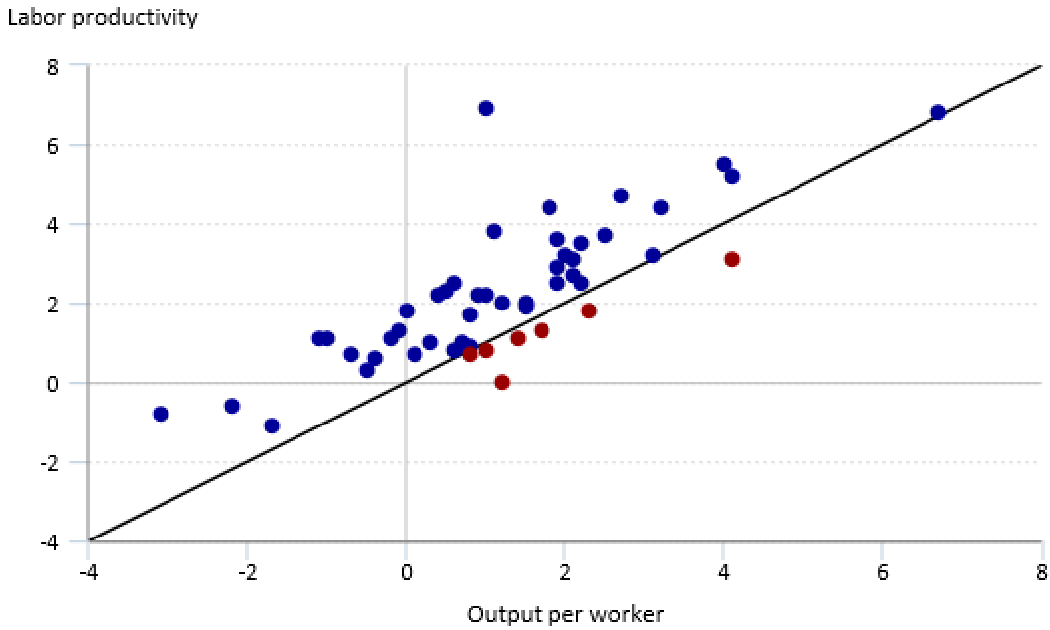


Source: U.S. Bureau of Labor Statistics.

Output per hour versus output per worker

Most of the prior literature on state-level labor productivity used output per worker as a measure of labor productivity. Using these new data, we compare output-per-worker and output-per-hour-worked (labor productivity) estimates. The simple correlation between the two series differs significantly by period, with the correlation very high in the postrecession period (correlation = 0.93) but less so during the Great Recession (correlation = 0.79). During the recession, labor productivity growth was higher than output-per-worker growth in 43 states and the District of Columbia (figure 5). Thus, studies relying on output per worker would understate state-level labor productivity during recessions.

Figure 5. Labor productivity versus output per worker, by state, average annual percent change, 2007–09



Note: Angled line represents equal growth line.
Source: U.S. Bureau of Labor Statistics.

This finding that output per hour grew faster than output per worker is consistent with employers cutting back on hours at a faster rate than employment. During the Great Recession, the average workweek of employees fell by 0.9 hours.[29] Using output per worker as the productivity measure, we find that the productivity growth ranking over the entire period (2007−17) changes slightly, with North Dakota, Oklahoma, Oregon, California, and Washington growing the fastest and Louisiana, Connecticut, Nevada, and Wyoming growing the slowest. Although the difference between the growth rates for the two measures is only a couple tenths of a percentage point for most states, estimates for Nevada, Montana, Kentucky, North Dakota, and Wyoming differ by half a percentage point or more. Thus, using these new output-per-hour-worked measures could lead to new findings on the sources of productivity growth.

Analyses

We conduct several brief analyses to show users how our data might be used to explore some popular topics in the productivity literature. In these analyses, we compute the national estimate by aggregating the state-level data.

State contributions to national and regional productivity

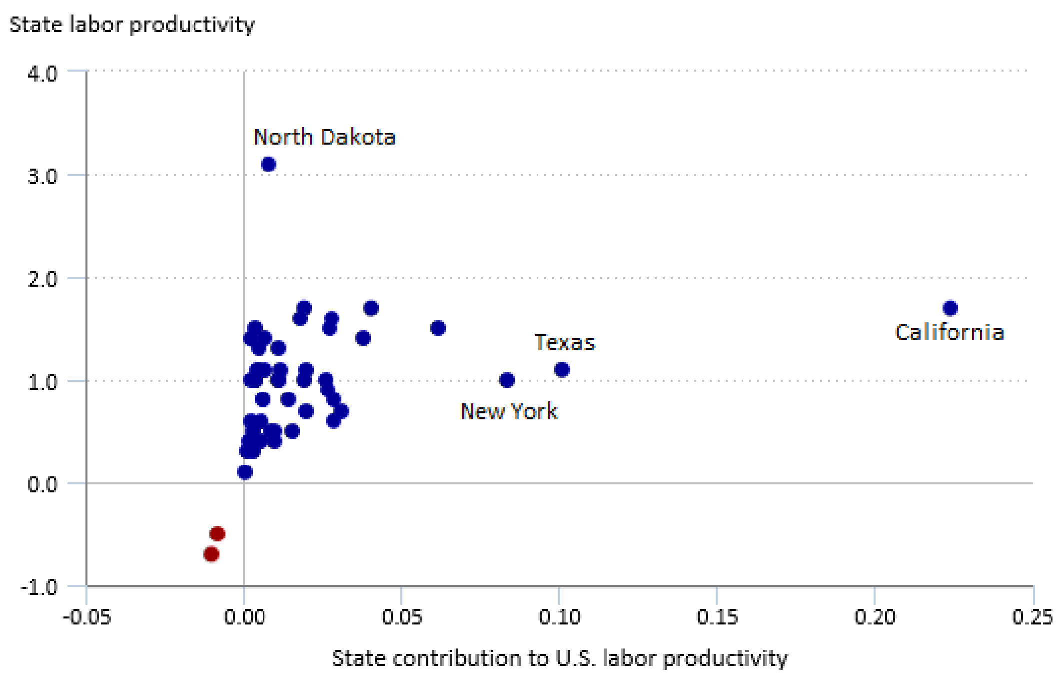
In the first analysis, we examine the contribution of states to both national and Census regional productivity trends. Because states are not all the same size, two states with the same individual growth rates will have differing impacts on aggregate productivity measures. For each year, we estimate each state's contribution to national productivity growth by multiplying the state's productivity growth rate by its average share of total current dollar national output, as shown in equation (2):

$$C_{it} = (\ln LP_{it} - \ln LP_{i,t-1}) * ((W_{it} + W_{i,t-1})/2), \qquad (2)$$

where C_{it} is the annual contribution for state i in time t to national productivity growth, lnLP is the natural logarithm of the state's labor productivity, and W is the state's share of national current dollar output.[30]

Figure 6 compares each state's average annual labor productivity growth rate with its average contribution to national productivity growth from 2007 to 2017.[31] Of all the states, California with 1.7-percent growth made the largest contribution (0.22 percent) to national productivity growth (1.0 percent), followed by Texas (0.10 percent) and New York (0.08 percent). North Dakota, despite having the largest productivity growth rate, only ranks 28th in terms of its contribution to national productivity growth.

Figure 6. Labor productivity versus contribution to national labor productivity, by state, average annual percent change, 2007–17



Source: U.S. Bureau of Labor Statistics.

In a similar fashion, we calculate each state's contribution to its respective geographic region. As seen with the national contribution analysis, the economic size of each state influences its contribution to regional estimates. As shown in table 1, the states with the largest growth rates are not always the same states with the greatest positive influence on regional labor productivity growth. Across the regions, the range in state labor productivity growth rates varies from 2.7 percent in the Midwest region to 1.6 percent in the West region.

Table 1. State contributions to regional labor productivity growth (average annual percent change), 2007–17

Region	Regional productivity growth	State with largest contribution	State with largest growth	State with smallest contribution	State with smallest growth	Range of state productivity growth
Midwest	0.7	Illinois (0.15)	North Dakota (3.1)	South Dakota (0.01)	Michigan (0.4)	2.7
Northeast	1.0	New York (0.39)	Pennsylvania (1.5)	Connecticut (–0.04)	Connecticut (–0.5)	2.0
South	1.0	Texas (0.30)	Oklahoma (1.6)	Louisiana (–0.03)	Louisiana (–0.7)	2.3
West	1.5	California (0.94)	California, Oregon, and Washington (1.7)	Wyoming (0.00)	Wyoming (0.1)	1.6

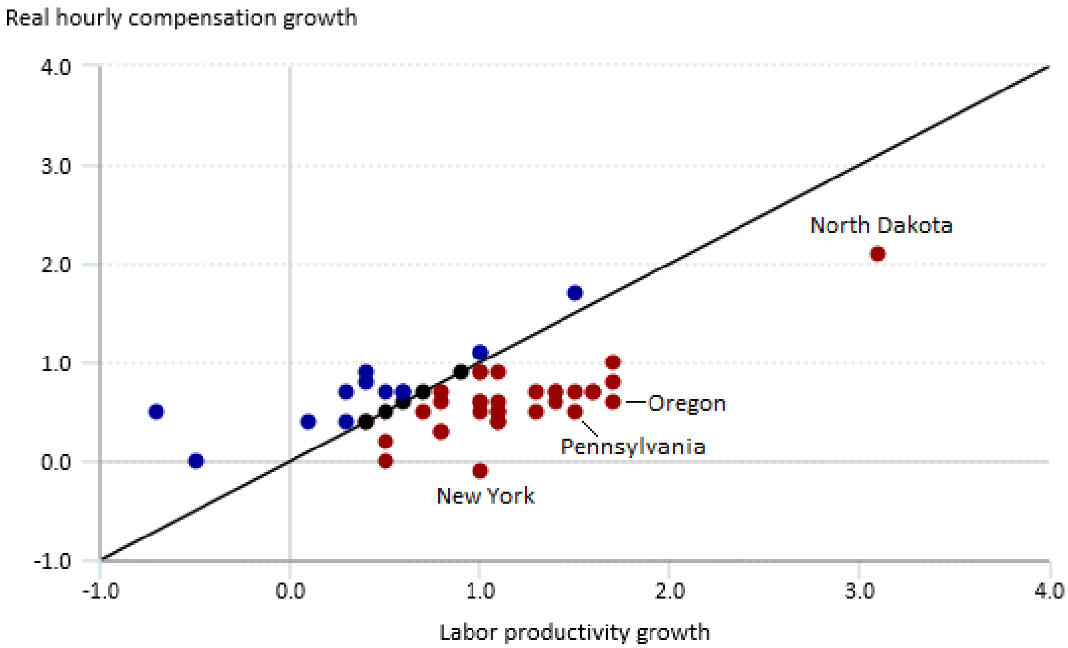
Source: U.S Bureau of Labor Statistics.

Compensation-productivity gap

Economists have recently focused on the growing gap between the growth rates in labor productivity and real hourly compensation (and the consequent fall in labor share).[32] During the 2007–17 period, nonfarm business sector labor productivity for the nation grew at an average rate of 1.3 percent per year while real hourly compensation only grew at an average rate of 0.5 percent per year. As a second analysis, we examine these same trends at the state level.

During the period studied, 32 states saw labor productivity increase faster than real hourly compensation (figure 7). This included four states (New York, North Dakota, Oregon, and Pennsylvania) where the difference was 1 percentage point or greater.

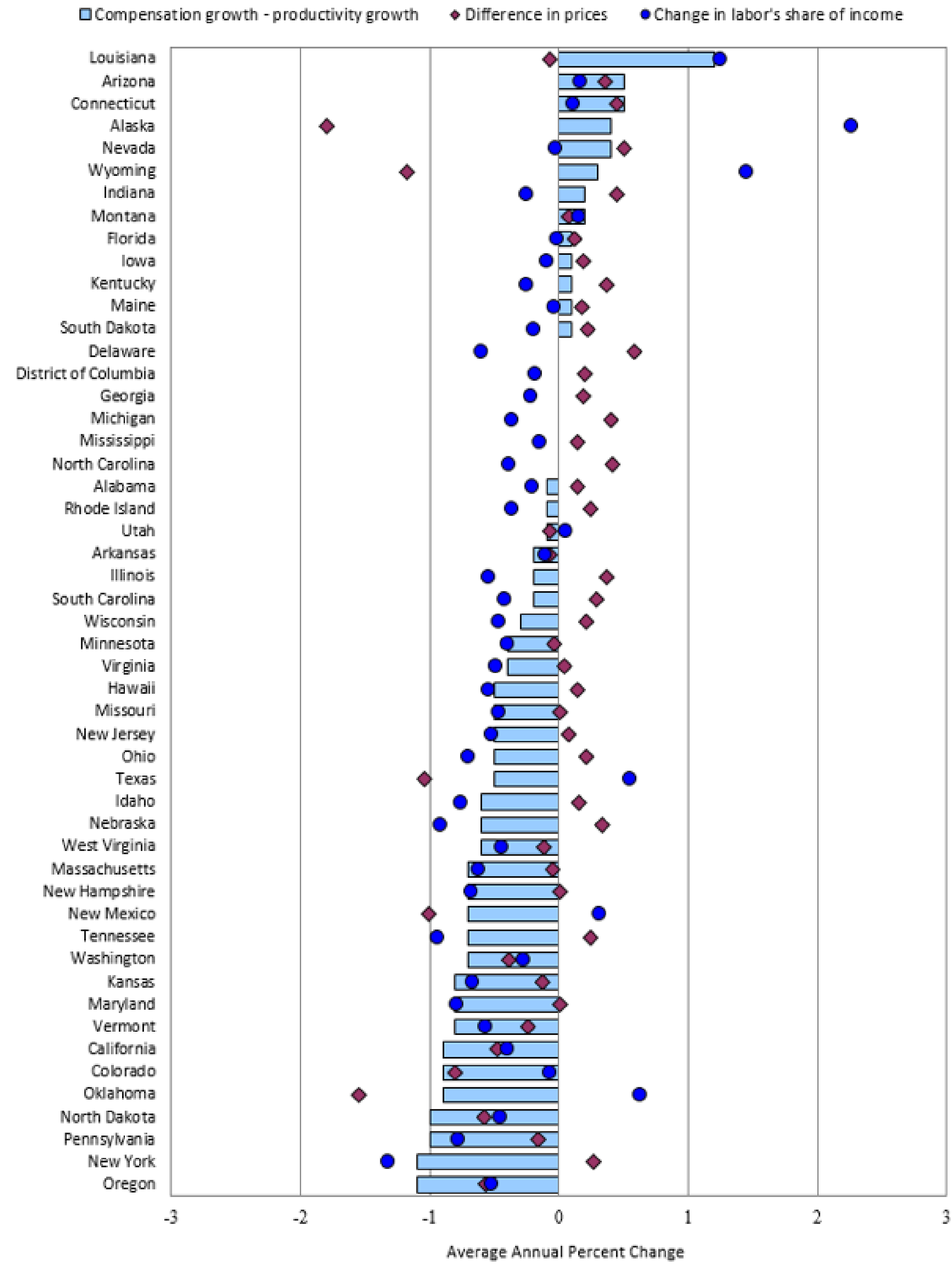
Figure 7. Labor productivity versus real hourly compensation, by state, average annual percent change, 2007–17



Note: Angled line represents equal growth line.
Source: U.S. Bureau of Labor Statistics.

Two components account for the gap between real hourly compensation growth and productivity growth. The first is the difference between the price indexes used to account for inflation in the productivity and hourly compensation measures. Over the period 2007–17, the compensation price index grew at a quicker pace than that of the implicit output deflator in 19 states, widening the gap in these states. The difference in the deflator growth rates was largest in Alaska, Oklahoma, Wyoming, and Texas, all states which have a substantial share of their economy concentrated in oil and gas extraction. The second component is the change in labor share, which measures the fraction of output that accrues to workers as compensation and is a closely tracked metric at the national level. Over the period 2007–17, the labor share decreased in 40 states and the District of Columbia. The labor share declined the most in New York and Tennessee (by −7.9 percent and −5.7 percent, respectively). It increased the most in Alaska, Louisiana, and Wyoming (by 9.9 percent, 6.2 percent, and 6.1 percent, respectively). Figure 8 shows the composition of the gap for all 50 states and the District of Columbia.

Figure 8. Composition of the compensation-productivity gap, by state, average annual percent change, 2007–17



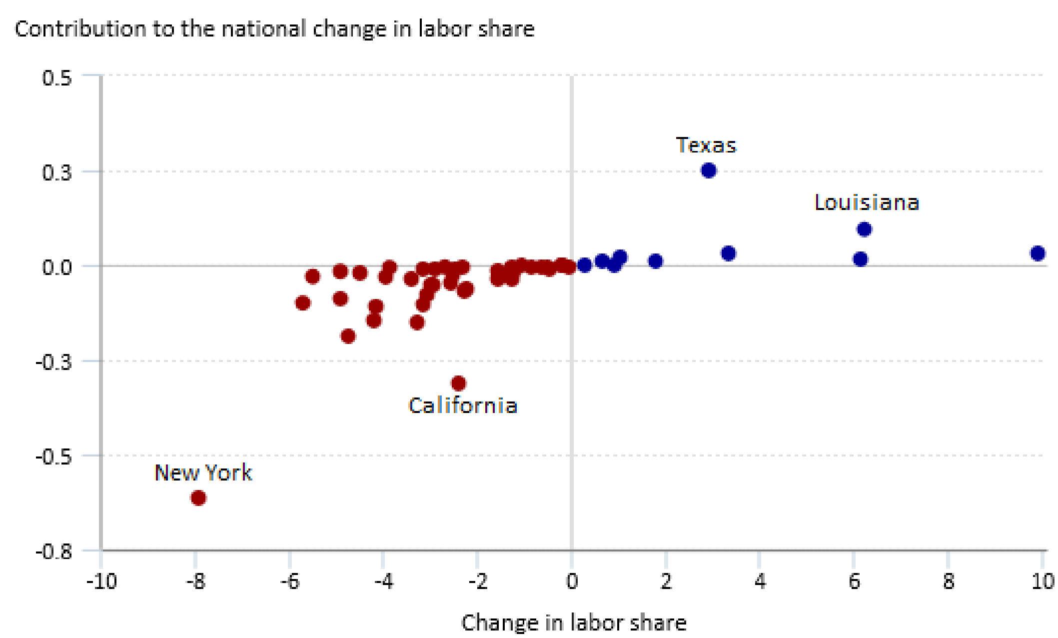
Source: U.S. Bureau of Labor Statistics.

The sum-of-states labor share declined 2.1 percentage points from 60.6 percent to 58.5 percent over the period 2007–17. However, the contribution to this decline was not the same across all states because the average state decline was 1.5 percentage points. The contribution of each state's change in labor share to the change in the national labor share can be calculated as equation (3) shows:

$$\text{Contribution to the change in the national labor share for state } i \ (07-17) = (S_{i2017} - S_{i2007}) * W_{i2007}, \quad (3)$$

where S_i is the labor share in state i and W_i is the share of national current dollar output in state i.[33] In terms of contributions to the change in the national labor share, New York and California had the largest negative influence. These two states jointly accounted for approximately 0.94 percentage point of the 2.1-percentage-point reduction in the national labor share. Texas and Louisiana had the largest positive influence on labor share (figure 9).

Figure 9. Change in labor share versus its contribution to the national change in labor share, by state, percentage points, 2007–17



Source: U.S. Bureau of Labor Statistics.

ICT-producing sector and state-level labor productivity

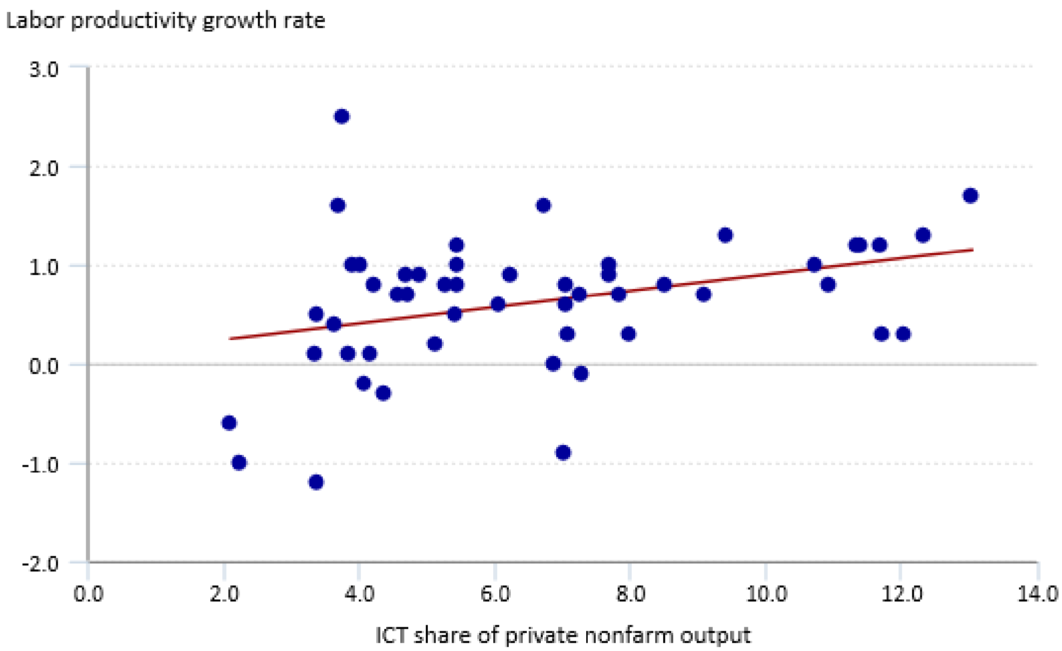
The state-level labor productivity dataset also allows for testing of the relationship between key economic variables and labor productivity growth. As seen previously, significant variation exists in state-level labor productivity growth rates. Therefore, determining which particular economic factors contribute to this variation is likely to interest many researchers. Although we do not have state-level productivity by industry estimates, we can examine the impact of industrial composition on labor productivity growth rates. We use linear regression to estimate the relationship between a state's labor productivity growth and the share of the state's output that comprises particular ICT-producing industries using BEA GDP by state industry measures.

At the national level, the ICT-producing sector has been a primary driver of productivity growth for some time.[34] Does the ICT sector drive productivity growth in only a small set of influential states, or does a relationship exist between the size of a state's ICT sector and average annual productivity growth? We examine the correlation by estimating the following simple equation (4):

$$\text{Labor productivity growth}_{i,2009\text{–}17} = a + b \text{ Average ICT sector share of output}_i + \varepsilon, \qquad (4)$$

where α is a constant term, β is the correlation between average annual state-level labor productivity growth and the average ICT-producing sector share of state output, and ε is an error term. Over the postrecession period (2009–17), we find a positive correlation between labor productivity growth and the average ICT sector share of output ($\beta = 0.35$). In figure 10, we show that 8 of the top 10 states in terms of their ICT-producing sector share saw labor productivity growth exceed the state average (0.6 percent) over the period. Similarly, labor productivity growth in 7 of the 10 states with the lowest shares in the ICT sector saw labor productivity growth fall below the average. As this dataset expands to include more years and greater industry detail, tests and analyses such as these can be expanded on.

Figure 10. Labor productivity (average annual percent change) versus average information and communications technology share of private nonfarm output (in percent), by state, 2009–17



Source: U.S. Bureau of Labor Statistics.

State-level productivity convergence

In our final analysis, we examine whether state-level labor productivity levels are converging among states in the postrecession period (2009–17). Consistent with the neoclassical growth model, seminal work by Barro et al. and Barro and Sala-i-Martin on income convergence using state GDP per capita showed unconditional convergence among U.S. states using pre-2000 data.[35] More recent work by Chanda and Panda, Khandrika, and Kinfemichael and Morshed, for example, find productivity convergence among U.S. states using employment as the labor input.[36] Kinfemichael and Morshed find differences in convergence even among disaggregated subsectors of the economy; therefore, a finding of convergence at the state-level is unlikely due solely to variations in industrial composition across states.

Using ordinary least squares, we estimate equation (5) to determine whether state-level labor productivity levels are converging:

$$\ln LP_{i2017} - \ln LP_{i2009} = a + \beta \ln LP_{i2009} + \varepsilon_{it}\,. \qquad (5)$$

A negative coefficient on the initial labor productivity level (β) represents unconditional convergence.

Regression results are reported in table 2. The unconditional convergence coefficient is −0.13 and statistically significant. Thus, we find evidence that states with a lower labor productivity level in 2009 grew faster over the postrecession period. Figure 11 plots each state's labor productivity growth rate against the natural logarithm of its initial labor productivity level.

Table 2. Convergence of state labor productivity in the United States, 2009–17

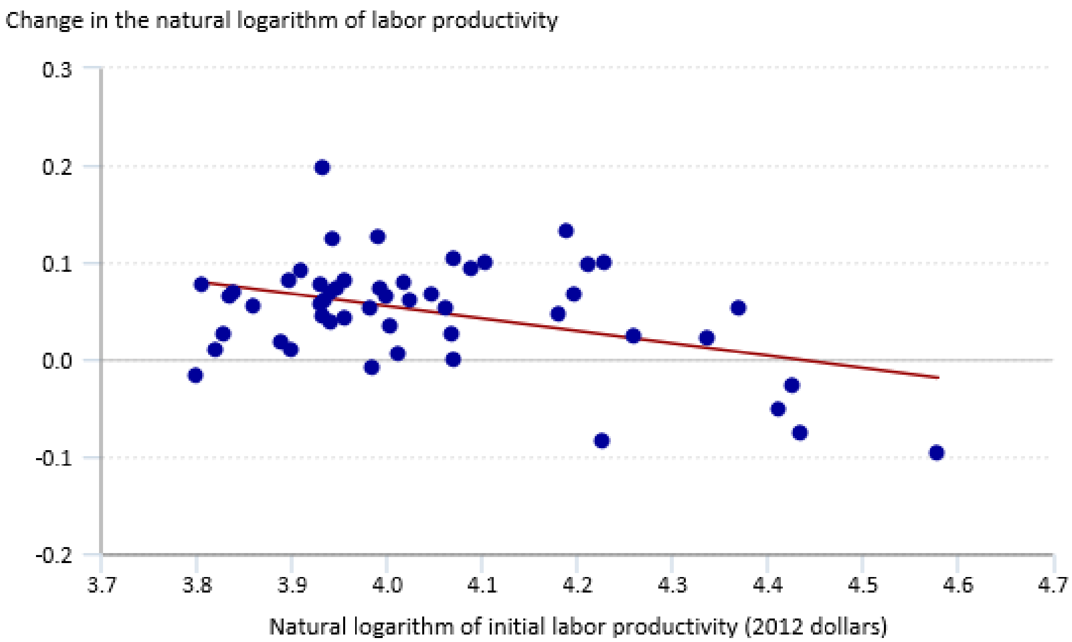
Variable	$\ln LP_{i2017} - \ln LP_{i2009}$
$\ln LP_{i2009}$	–0.13*(0.04)
R-squared	0.18
Number of states	51

*$p < 0.05$ indicates significance level.

Notes: A constant term is included in the model. Standard error is in parentheses.

Source: U.S. Bureau of Labor Statistics.

Figure 11. Change in the natural logarithm of labor productivity versus natural logarithm of initial labor productivity (2012 dollars), by state, 2009–17



Source: U.S. Bureau of Labor Statistics.

Conclusion

The release of a new state-level output-per-hour-worked series shows substantial variation in labor productivity across the nation and improves on previous efforts that measured state-level labor productivity as GDP per worker. We have discussed several limitations of the data in this article, such as the lack of state-level PPIs and proprietors' output and hours worked reported in the state of residence rather than reported in the state of production. In addition, we emphasize that the data do not sum to the BLS published national totals for the nonfarm business sector. However, they can still provide insights into national statistics because almost the same methods are followed and the sum-of-states productivity measures tracks the official national measures closely. BLS welcomes feedback on these new measures as we continue to look for ways to improve our products and expand coverage to major industry groups and metropolitan areas. Comments can be submitted by emailing productivity@bls.gov.

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Appendix: Supplementary tables

Appendix table A-1. Percent change in labor productivity and related series, by region and state, 2016–17

Region and state	Labor productivity	Output per worker	Output	Hours	Employment	Real hourly compensation	Unit labor costs
Midwest	0.0	0.6	1.4	1.4	0.8	0.6	2.6
Illinois	–0.5	0.0	0.7	1.2	0.7	0.6	3.0
Indiana	0.0	0.9	1.9	1.9	1.0	0.4	2.5
Iowa	–0.2	0.4	–0.1	0.1	–0.5	1.0	3.3
Kansas	0.7	1.0	2.0	1.2	1.0	–0.1	1.2
Michigan	0.1	1.2	1.8	1.8	0.6	0.0	2.0
Minnesota	1.0	1.0	2.5	1.5	1.4	1.0	2.4
Missouri	–0.1	0.3	1.1	1.1	0.7	0.2	2.4
Nebraska	–1.8	–0.1	1.5	3.4	1.5	0.5	4.1
North Dakota	–1.3	0.1	–0.8	0.5	–0.9	1.5	3.9
Ohio	0.7	0.7	1.8	1.1	1.0	1.3	2.5
South Dakota	0.9	0.3	–0.1	–1.0	–0.4	1.7	3.2
Wisconsin	–0.3	0.7	1.8	2.1	1.1	0.3	2.6
Northeast	0.9	0.7	1.5	0.7	0.9	1.6	2.6
Connecticut	1.2	1.1	–0.7	–1.9	–1.8	–0.6	–0.1
Maine	1.1	1.0	1.9	0.8	0.9	1.3	1.9
Massachusetts	0.7	0.6	2.5	1.7	1.9	1.8	3.0
New Hampshire	1.2	1.7	2.4	1.2	0.6	0.8	1.4
New Jersey	0.9	0.4	1.5	0.6	1.1	0.6	1.5
New York	0.7	0.2	1.4	0.7	1.2	2.5	3.7
Pennsylvania	1.1	1.3	1.9	0.8	0.6	1.7	2.1
Rhode Island	0.4	0.4	0.8	0.4	0.4	1.6	1.9
Vermont	1.6	1.5	1.6	0.0	0.1	–0.2	0.8
South	0.2	0.5	2.2	2.0	1.7	0.4	2.4
Alabama	1.4	0.6	1.9	0.5	1.3	1.5	2.3
Arkansas	–2.2	–0.1	1.1	3.4	1.2	–0.4	3.4
Delaware	0.4	–0.4	–0.4	–0.8	0.1	2.7	4.4
District of Columbia	1.2	0.9	2.2	1.0	1.2	0.2	2.5
Florida	0.6	1.5	3.0	2.4	1.5	–0.1	1.5
Georgia	0.6	0.5	3.2	2.6	2.7	1.0	2.6
Kentucky	0.1	0.4	1.2	1.2	0.9	0.5	2.5
Louisiana	–1.9	–0.8	0.1	2.0	0.9	–0.5	3.1
Maryland	–0.4	–0.2	2.3	2.8	2.5	0.2	2.8
Mississippi	–1.5	–1.1	0.6	2.1	1.7	0.6	3.3
North Carolina	0.4	1.3	2.1	1.7	0.9	0.3	2.3
Oklahoma	–1.4	0.0	0.4	1.8	0.4	–0.5	3.0
South Carolina	1.0	1.4	3.1	2.1	1.7	0.8	1.9
Tennessee	1.0	0.2	2.5	1.4	2.3	0.9	2.1
Texas	–0.2	0.1	2.2	2.4	2.1	–0.1	2.5
Virginia	1.3	0.1	2.1	0.8	2.0	2.2	3.0
West Virginia	1.9	2.9	2.0	0.1	–0.8	2.4	1.9
West	1.1	1.5	3.9	2.7	2.3	1.1	2.4
Alaska	0.6	1.5	–0.1	–0.7	–1.6	–2.3	–1.5
Arizona	–0.7	1.4	3.5	4.2	2.1	–0.5	2.7

See footnotes at end of table.

Appendix table A-1. Percent change in labor productivity and related series, by region and state, 2016–17

Region and state	Labor productivity	Output per worker	Output	Hours	Employment	Real hourly compensation	Unit labor costs
California	1.8	2.0	4.2	2.3	2.2	1.7	2.2
Colorado	1.5	1.0	3.6	2.1	2.6	1.6	2.7
Hawaii	1.7	2.3	2.4	0.6	0.0	–0.2	0.2
Idaho	–1.8	0.4	3.3	5.2	3.0	–0.6	3.5
Montana	2.0	2.1	1.9	–0.1	–0.2	0.1	0.8
Nevada	–1.3	–0.9	2.7	4.0	3.7	–1.3	2.6
New Mexico	–2.0	–1.7	0.4	2.4	2.1	–0.5	3.6
Oregon	1.6	2.2	3.9	2.2	1.7	1.0	1.6
Utah	–1.2	–0.6	2.9	4.1	3.5	–0.1	3.1
Washington	0.7	0.8	4.9	4.2	4.0	1.5	3.5
Wyoming	–0.7	1.9	1.0	1.7	–0.9	–0.1	1.1

Source: U.S. Bureau of Labor Statistics.

Appendix table A–2. Average annual percent change in labor productivity and related series, by region and state, 2007–17

Region and state	Labor productivity	Output per worker	Output	Hours	Employment	Real hourly compensation	Unit labor costs
Midwest	0.7	0.7	1.0	0.2	0.2	0.5	1.4
Illinois	0.7	0.6	0.7	0.0	0.1	0.5	1.4
Indiana	0.5	0.3	0.7	0.2	0.4	0.7	1.7
Iowa	0.6	0.7	0.9	0.3	0.2	0.7	1.9
Kansas	1.3	1.1	1.2	–0.1	0.1	0.5	1.0
Michigan	0.4	0.3	0.6	0.2	0.2	0.4	1.5
Minnesota	1.0	1.1	1.6	0.6	0.5	0.6	1.3
Missouri	0.8	0.5	0.5	–0.3	0.0	0.3	1.4
Nebraska	1.1	1.3	1.6	0.5	0.4	0.5	1.1
North Dakota	3.1	3.6	5.5	2.4	1.9	2.1	0.9
Ohio	0.8	0.9	1.1	0.2	0.1	0.3	1.1
South Dakota	1.0	1.2	1.7	0.7	0.5	1.1	1.9
Wisconsin	0.5	0.7	1.1	0.6	0.3	0.2	1.4
Northeast	1.0	0.8	1.4	0.4	0.5	0.2	1.0
Connecticut	–0.5	–0.8	–0.9	–0.4	–0.1	0.0	2.0
Maine	0.3	0.2	0.4	0.1	0.2	0.4	1.9
Massachusetts	1.4	1.3	2.1	0.8	0.8	0.7	1.0
New Hampshire	1.1	1.3	1.6	0.5	0.3	0.4	0.9
New Jersey	0.5	0.4	0.6	0.1	0.2	0.0	1.3
New York	1.0	0.8	1.8	0.8	1.0	–0.1	0.7
Pennsylvania	1.5	1.4	1.6	0.1	0.2	0.5	0.7
Rhode Island	1.0	0.8	0.7	–0.3	–0.1	0.9	1.4
Vermont	1.4	1.3	1.1	–0.3	–0.1	0.6	1.1
South	1.0	0.8	1.5	0.5	0.7	0.7	1.4

See footnotes at end of table.

Appendix table A–2. Average annual percent change in labor productivity and related series, by region and state, 2007–17

Region and state	Labor productivity	Output per worker	Output	Hours	Employment	Real hourly compensation	Unit labor costs
Alabama	1.0	0.6	0.4	–0.6	–0.2	0.9	1.6
Arkansas	0.8	0.8	1.0	0.1	0.1	0.6	1.5
Delaware	0.6	0.2	0.4	–0.2	0.2	0.6	1.5
District of Columbia	0.4	0.1	1.6	1.2	1.5	0.4	1.8
Florida	0.6	0.3	0.9	0.3	0.7	0.7	1.7
Georgia	0.9	0.7	1.4	0.5	0.8	0.9	1.6
Kentucky	1.0	0.5	0.7	–0.3	0.2	1.1	1.7
Louisiana	–0.7	–0.8	–0.4	0.3	0.4	0.5	2.8
Maryland	1.5	1.4	1.7	0.3	0.4	0.7	0.8
Mississippi	0.5	0.2	0.0	–0.4	–0.2	0.5	1.6
North Carolina	0.7	0.6	1.1	0.4	0.4	0.7	1.7
Oklahoma	1.6	1.8	2.3	0.7	0.5	0.7	0.8
South Carolina	1.1	0.7	1.4	0.4	0.7	0.9	1.5
Tennessee	1.1	1.1	1.6	0.5	0.5	0.4	1.0
Texas	1.1	0.9	2.6	1.5	1.7	0.6	1.3
Virginia	1.0	0.7	0.9	–0.1	0.2	0.6	1.2
West Virginia	1.1	1.1	0.6	–0.4	–0.5	0.5	1.2
West	1.5	1.3	2.0	0.6	0.7	0.8	1.2
Alaska	0.4	0.1	0.2	–0.2	0.0	0.8	1.9
Arizona	0.4	0.2	0.6	0.3	0.4	0.9	1.8
California	1.7	1.6	2.4	0.7	0.8	0.8	1.0
Colorado	1.6	1.2	2.2	0.6	1.0	0.7	1.1
Hawaii	1.0	1.1	1.3	0.3	0.2	0.5	1.3
Idaho	1.3	1.1	1.6	0.3	0.5	0.7	0.9
Montana	1.5	0.7	0.9	–0.5	0.2	1.7	1.9
Nevada	0.3	–0.6	–0.2	–0.5	0.4	0.7	1.9
New Mexico	1.4	1.1	0.7	–0.7	–0.4	0.7	0.9
Oregon	1.7	1.6	2.2	0.5	0.6	0.6	0.7
Utah	0.8	0.7	2.1	1.3	1.4	0.7	1.7
Washington	1.7	1.6	2.7	1.0	1.0	1.0	1.4
Wyoming	0.1	–0.4	–1.0	–1.1	–0.6	0.4	1.9

Source: U.S. Bureau of Labor Statistics.

SUGGESTED CITATION

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NOTES

1 For a recent example, see Bhavani Khandrika, “Essays on economics of technical change & effect of R&D on non-farm business labor productivity of the U.S. States” (Ph.D. diss., The New School, 2014). In addition, most previous researchers excluded the hours

worked by unincorporated self-employed workers, even though their output is included in gross domestic product (GDP) by state measures.

2 Hours worked also include paid time necessary for production such as time for traveling between work sites, short breaks, machine downtime, and maintenance activities.

3 The Bureau of Economic Analysis (BEA) began publishing GDP by state measures in 1985; however, the series began in 1963.

4 Data are accessible at https://www.bls.gov/lpc/state-productivity.htm.

5 Over the same period, average annual productivity growth was 1.0 percent for a sum-of-the-states measure.

6 See "Overview of output measures used by BLS to construct productivity statistics for major sectors of the US economy" (U.S. Bureau of Labor Statistics, September 29, 2014), https://www.bls.gov/mfp/outputnote.pdf.

7 GDP by state is the BEA state equivalent of the national GDP. See "Gross domestic product by state estimation methodology" (U.S. Bureau of Economic Analysis, 2017), p. i, https://www.bea.gov/sites/default/files/methodologies/0417_GDP_by_State_Methodology.pdf.

8 GDP by state covers many three-digit North American Industry Classification System (NAICS) industries (81 NAICS industries in total) and BEA supersectors (two-digit NAICS industry classification).

9 The Census value-added data include the value of purchased services, which does not conform to the BEA definition of value-added data. BEA treats purchased services as an intermediate cost of production and, therefore, removes these costs using the national ratio for purchased services to value added by industry.

10 The National Income and Product Accounts "present the value and composition of national output and the types of incomes generated in its production." For more information, see U.S. Bureau of Economic Analysis website https://www.bea.gov/resources/methodologies/nipa-handbook.

11 These data are reported at the place of production and are based primarily on the BLS Quarterly Census of Employment and Wages (QCEW), with some adjustments for workers not covered by unemployment insurance.

12 Capital income is also referred to as gross operating surplus in BEA's methodology.

13 See Francesco Daveri and Andrea Mascotto, "The IT revolution across the United States," *Review of Income and Wealth*, vol. 52, no. 4, November 2006, pp. 569–602, https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1475-4991.2006.00205.x.

14 The BLS Producer Price Index (PPI) program produces regional indexes for only a few industries (NAICS 221122, 212321, 221210, 236400, 236500, 327320), which are published in the monthly PPI detailed report within table 11, accessible at https://www.bls.gov/web/ppi/ppitable11.pdf. These regional indexes were constructed because PPI program research indicated regional pricing variation for these industries and sufficient price quotes were available to support their calculation and publication.

15 "Gross domestic product by state estimation methodology," p. 16.

16 Fisher's ideal index is the geometric mean of the Laspeyres and Paasche indexes. See Organisation for Economic Co-operation and Development (OECD) website, https://stats.oecd.org/glossary/detail.asp?ID=989.

17 BLS is currently investigating alternative ways to remove owner-occupied housing.

18 The average weekly hours estimates are applied to the total employment counts, with the assumption that average weekly hours for employees in the nonagricultural sector are similar to those of employees in the nonfarm agricultural sector.

19 Average weekly hours are also available for many states at the CES supersector level but not at a more detailed industry level.

20 For NAICS 113–115 industries, HWHP ratios are constructed using CPS data. These ratios are calculated as the number of workers at work divided by the number of workers paid.

21 For Delaware and the District of Columbia, the HWHP ratios for the goods-producing and service-providing sectors are weighted by employment. For Hawaii, the HWHP ratios for the goods-producing sector and two-digit service-providing industries are weighted by employment. The HWHP ratios for two-digit goods-producing industries and the service-providing sector are weighted by employment for Arkansas, Louisiana, Montana, Nebraska, New Mexico, Rhode Island, South Dakota, Vermont, and West Virginia.

22 Because the regional price parities are available beginning in 2008, the 2008 values are applied to the 2007 data. For a description of the methodology used to create the regional price parities, see "Real personal income and regional price parities" (U.S. Bureau of Economic Analysis, July 2016), https://www.bea.gov/sites/default/files/methodologies/RPP2016_methodology.pdf.

23 By production workers, we are referring to production and nonsupervisory workers in which production workers are those employed in goods-producing industries and nonsupervisory workers are those employed in service-providing industries. By nonproduction workers, we are referring to nonproduction and supervisory workers in which nonproduction workers are those employed in goods-producing industries and supervisory workers are those employed in service-providing industries.

24 This method of measuring hours is described in detail in Lucy P. Eldridge, Marilyn E. Manser, and Phyllis Flohr Otto, "Alternative measures of supervisory employee hours and productivity growth," *Monthly Labor Review*, April 2004, pp. 9–28, https://www.bls.gov/opub/mlr/2004/04/art2full.pdf.

25 The CPS indicates that there is more nonprofit employment than for which BLS currently removes from major sector national measures. However, the CPS data are based on state of residence rather than on state of employment. Thus, its use for removing nonprofits could bias the estimates and would not bring about further consistency with existing national measures.

26 See Erik Friesenhahn, "Nonprofits in America: new research data on employment, wages, and establishments," *Monthly Labor Review*, February 2016, https://doi.org/10.21916/mlr.2016.9.

27 Government enterprises are "government agencies that cover a substantial portion of their operating costs by selling goods and services to the public and that maintain their own separate accounts." For more information, see U.S. Bureau of Economic Analysis website at https://www.bea.gov/help/glossary/government-enterprises.

28 See Mark Muro, Jacob Whiton, Robert Maxim, and Ross DeVol, "The state of the heartland: factbook 2018" (Metropolitan Policy Program at Brookings and Walton Family Foundation, October 2018), https://www.brookings.edu/research/heartland-factbook; and Lorenzo Caliendo, Fernando Parro, Esteban Rossi-Hansberg, and Pierre-Daniel Sarte, "The impact of regional and sector productivity changes on the U.S. economy," *Review of Economic Studies*, vol. 85, no. 4, October 2018, pp. 2042–2096, https://www.princeton.edu/~erossi/RSSUS.pdf.

29 Steven Kroll, "The decline in work hours during the 2007–09 recession," *Monthly Labor Review*, April 2011, pp. 53–59, https://www.bls.gov/opub/mlr/2011/04/art10full.pdf.

30 Evsey D. Domar, "On the measurement of technological change," *Economic Journal*, vol. 71, no. 294, December 1961, pp. 709–729, http://www.jstor.org/stable/2228246?seq=1#page_scan_tab_contents.

31 Over this period, the official productivity growth was 1.3 percent while the sum-of-the states productivity growth was 1.0 percent.

32 See Michael Brill, Corey Holman, Chris Morris, Ronjoy Raichoudhary, and Noah Yosif, "Understanding the labor productivity and compensation gap," *Beyond the Numbers*, vol. 6, no. 6, June 2017, https://www.bls.gov/opub/btn/volume-6/pdf/understanding-the-labor-productivity-and-compensation-gap.pdf; Michael D. Giandrea and Shawn Sprague, "Estimating the U.S. labor share," *Monthly Labor Review*, February 2017, https://www.bls.gov/opub/mlr/2017/article/estimating-the-us-labor-share.htm; and Susan Fleck, John Glaser, and Shawn Sprague, "The compensation-productivity gap: a visual essay," *Monthly Labor Review*, January 2011, pp. 57–69, https://www.bls.gov/opub/mlr/2011/01/art3full.pdf.

33 This equation holds each state's share of national output constant, thus isolating the "within-state" effect. Accounting for shifts in a state's relative size can distort this analysis because a state with a declining labor share can end up having a positive contribution to the national change. When rounded, the sum of the within-state contributions and the total change in the national labor share are both equal to 2.1 percent.

34 See Dave Byrne and Carol Corrado, "ICT prices and ICT services: What do they tell us about productivity and technology," *International Productivity Monitor*, vol. 33, Fall 2017, pp. 150–181, https://ideas.repec.org/a/sls/ipmsls/v33y20178.html and https://ideas.repec.org/s/sls/ipmsls.html; Bart van Ark, Robert Inklaar, and Robert H. McGuckin, "The contribution of ICT-producing and ICT-using industries to productivity growth: a comparison of Canada, Europe and the United States," *International Productivity Monitor*, vol. 6, Spring 2003, pp. 56–63, https://ideas.repec.org/a/sls/ipmsls/v6y20035.html and https://ideas.repec.org/s/sls/ipmsls.html. BEA defines the information and communications technology (ICT) sector as computer and electronic product manufacturing (excluding navigational, measuring, electromedical, and control instruments manufacturing); software publishers; broadcasting and telecommunications; data processing, hosting and related services; internet publishing and broadcasting and web-search portals; and computer systems design and related services. Because not all of these detailed industries exist in the GDP by state data, we impute certain industries using national GDP by industry data.

35 Robert J. Barro, Xavier Sala-i-Martin, Olivier Jean Blanchard, and Robert E. Hall, "Convergence across states and regions," *Brookings Papers on Economic Activity*, no. 1, 1991, pp. 107–182, https://www.brookings.edu/bpea-articles/convergence-across-states-and-regions/; and Robert J. Barro and Xavier Sala-i-Martin, "Convergence," *Journal of Political Economy*, vol. 100, no. 2, April 1992, pp. 223–251, https://www.journals.uchicago.edu/doi/10.1086/261816?mobileUi=0.

36 Areendam Chanda and Bibhudutta Panda, "Productivity growth in goods and services across the heterogeneous states of America," *Economic Inquiry*, vol. 54, no. 2, April 2016, pp. 1021–1045; Khandrika, "Essays on economics of technical change & effect of R&D;" and Bisrat Kinfemichael and A.K.M. Mahbub Morshed, "Convergence of labor productivity across the US states," *Economic Modelling*, vol. 76, 2019, pp. 270–280.

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