CLEVELAND FED

Regional Policy Report

# Manufacturing Wage Premiums Have Diverged between Production and Nonproduction Workers

By Joel Elvery and Julianne Dunn, Federal Reserve Bank of Cleveland

November 9, 2021 | ISSN 2770-5765 | https://doi.org/10.26509/frbc-rpr-20211109

## TABLE OF CONTENTS




The authors thank Chris Vecchio for his excellent assistance with this research.




## Abstract


A manufacturing wage premium is the average percentage difference between the wage a worker earns in manufacturing and the wage similar workers earn in industries other than manufacturing. Using standard wage regressions, we find that, between 1979 and 2018, the manufacturing wage premium declined much more for production workers (such as machine operators) than for nonproduction workers (such as managers or administrative assistants). As a result, the production-workers' wage premium was 4 percent during 2015 to 2018, while the nonproduction-workers' wage premium was 14 percent. The decline in the production-workers' wage premium is broad based, both demographically and geographically. We argue that this decline was most likely caused by the loss of manufacturing production jobs, which put downward pressure on wages for this work. The decline in manufacturing wage premiums has important implications for the difficulties associated with recruiting manufacturing workers and for public investment in training for manufacturing jobs.

## Executive Summary

Factory jobs are frequently assumed to pay good wages, and policymakers frequently use this argument to defend programs that support the sector, including subsidized training programs to address the so-called "manufacturing skills gap." However, research shows that the difference between manufacturing wages and wages in other sectors—the manufacturing wage premium—has declined over time. This report documents the decline in the manufacturing wage premium between 1979 and 2018 and compares the wage premiums of manufacturing workers in production occupations (those who operate machines and assemble products) to those of manufacturing workers in nonproduction occupations (such as sales representatives, executives, and other office workers). Using standard wage regressions, we find that the wage premium for each group has fallen during the period we study, but it fell more sharply and further for production workers. This decline was broad based, both demographically and geographically.

The wage premium for production manufacturing workers relative to all nonmanufacturing workers fell from a peak of 12 percent during 1983 to 1986 to 4 percent or less from 2003 onward. To put this in perspective, consider the case of someone who earns $600 for a 40-hour week ($15 per hour) outside of the manufacturing sector. If she were to take a production job in manufacturing, the wage premium in recent years would mean that her weekly pay should increase by $24, which is much less than the $72 she could expect if the wage premium was still as high as it was in the early 1980s. In contrast, the wage premium for nonproduction manufacturing workers fell from 18 percent (a $108 weekly premium for our hypothetical job changer) during 1983 to 1986 to 14 percent (an $84 weekly premium) during 2015 to 2018. All else equal, the nation's total wage and salary income would have been 0.6 percent higher in 2018 if these two wage premiums were still as high as they were from 1983 to 1986.

The decline in the production wage premium is most likely because fewer "factory floor" workers are needed in modern manufacturing operations, especially because of global competition and automation. This falling demand for production workers has put downward pressure on the wages they earn, which means that jobs in other sectors may be at least as attractive in terms of pay. Other research has called into question whether the manufacturing skills gap exists. The decline in the production wage premium provides an alternative explanation for why it is difficult for manufacturers to hire: They do not pay high enough relative wages to attract job seekers to a sector that is perceived as having rigid hours, a noisy work environment, and a greater chance of experiencing layoffs in an economic downturn.

Finally, we argue that policymakers should be careful when considering using public resources to support manufacturers in their search for and training of production workers. Manufacturing continues to provide significant economic benefits to the regions where it is located, which may justify policies to support and attract manufacturing facilities. However, since 2003, the production wage premium is less than one-third as large as the nonproduction wage premium, and relatively small. Thus, training workers for production jobs within manufacturing is likely to produce only modest long-term income gains. To best promote income gains, programs that train workers for manufacturing should be designed to place workers in nonproduction jobs, for which there remains a substantial manufacturing wage premium.

## Introduction

People often associate factory jobs with good wages. However, research has shown that the difference between manufacturing wages and wages in other sectors—the manufacturing wage premium—declined between 1980 and 2007 (Dupuy and Schweitzer, 1994; Lombardi and Testa, 2011).

This report provides new estimates for the manufacturing wage premium that extend up to 2018, which allows us to explore how the manufacturing wage premium has evolved since 2007. The key contribution we make to the existing literature is to compare the manufacturing wage premiums of production workers and nonproduction workers. Production workers generally work on factory floors, while nonproduction workers work in offices, laboratories, and shipping departments. Production workers hold positions that may be more analogous to the image people have in mind when they think of a factory job. The manufacturing wage premiums of production and nonproduction workers can be quite different for many reasons, so it is important to study them separately. Finally, we provide consistently defined estimates for a long period of time that control for worker attributes such as age, educational attainment, and state of residence.

While our results confirm previous work that shows the decline in the overall manufacturing wage premium between 1979 and 2007, we find that the overall manufacturing wage premium was fairly stable between 2003 and 2018. On average, between 2015 and 2018, a worker employed in manufacturing earned 10 percent more than comparable workers employed elsewhere in the economy. This is one-third less than the 15 percent manufacturing wage premium between 1983 and 1986, the peak premium during the period we study. We find that this decline is overwhelmingly due to a decline in the manufacturing wage premium for production workers, which was 12 percent during 1983 to 1986, and has been no more than 4 percent since 2003. In contrast, the manufacturing wage premium for nonproduction workers was 14 percent during 2015 to 2018, down only 4 percentage points from its peak, which was during 1983 to 1986.

The decline in the production manufacturing wage premium is broad based, falling in 47 states and for almost all groups, regardless of education level, gender, cultural group, age group, or union status. We argue that the primary reason for the decline in this wage premium is that demand for production workers within manufacturing fell dramatically during the 40 years we study, a situation which put downward pressure on the wages of these workers. Employment in the manufacturing sector as a whole fell by more than one-third during the period we study, amounting to almost 6.5 million lost jobs. As we'll show in subsequent sections, many of the jobs that were lost were in production occupations. Other studies have shown that most of this employment decline can be attributed to increased global trade, although automation has also played a role. We will elaborate on the contributors to manufacturing job loss.

The decline of the wage premium for manufacturing production workers has important implications for manufacturers and the places in which they operate, including many communities in the Fourth Federal Reserve District.[1] The decline has contributed to the slow growth of personal income in the industrial heartland, as documented by Schweitzer (2017). The loss of the production-manufacturing wage premium also adds important insight into the public discourse on the difficulty manufacturers have had recruiting workers since at least the mid-2000s, a phenomenon often attributed to the manufacturing skills gap. Our research suggests that manufacturers may have difficulty hiring qualified workers not necessarily because there is a skills gap, but because the production wage premium has become too small to attract new workers to factory jobs. A 4 percent wage premium may be insufficient to offset the unpleasant aspects of production work, such as odd shifts, physical exertion, or noisy work environments.

The decline of the production wage premium should also impact how state and local governments think about subsidizing training and providing tax advantages for manufacturers. While manufacturing provides significant economic benefits to the regions and communities in which it is located, policymakers should evaluate subsidies and training programs closely in order to promote income growth. It is difficult to justify investing public resources to increase the pool of available production workers when the income gains from entering this career are likely to be small. Therefore, we advocate that manufacturing-oriented training programs should be targeted toward nonproduction manufacturing work, for which there is still a significant wage premium. We return to these implications in the final section of this report.

## Background

There are several reasons why manufacturing jobs might pay more than other jobs that require similar levels of formal training and experience. One reason is that, overall, the manufacturing sector is more profitable than many sectors of the economy. For example, according to Compustat data, average gross profits per employee in publicly held corporations in 2019 were 37 percent higher for manufacturers than for nonmanufacturing, nonfinancial corporations (Compustat North America, 1980–2019). If the labor market is perfectly competitive, the manufacturing sector should have relatively high wages because it has high profits. If the labor market is not perfectly competitive, the degree to which these profits are reflected in the wages paid to manufacturing workers is influenced by workers' bargaining power. The more bargaining power these workers have, the higher the wages they can negotiate.

Another reason for a manufacturing wage premium is that manufacturing firms might be more likely than other firms to offer higher wages in order to have better attendance, reduce turnover, have a ready pool of applicants, and motivate their workers to be more productive. These benefits are especially salient to manufacturers, for whom worker vigilance and attendance can greatly affect productivity. Economists call wages that have been strategically set above the prevailing market wage "efficiency wages."[2]

A manufacturing wage premium might also arise because manufacturing work involves high levels of job-specific training. This is training that workers receive that is of value primarily to their current employer. Firms are loath to lose workers who have these job-specific skills and will pay a wage premium to ensure that the workers stay with the firm. Job-specific skills are especially important in manufacturing, for which production processes are often highly specialized.

A final reason a manufacturing wage premium might exist is that manufacturing jobs can have undesirable features, such as early hours, rigid schedules, and loud work environments. Manufacturers may have to offer higher wages to offset these negative job attributes and attract workers. This phenomenon is called "compensating wage differentials."

Research has documented that there has been a wage premium for manufacturing workers for many years.[3] However, the premium has fallen in recent decades. Dupuy and Schweitzer (1994) find that the percentage difference between median wages in the goods-producing sector (agriculture, forestry, fishing, and hunting; mining; construction; and manufacturing) and the service sector fell from 13 percent in the 1970s to 4 percent in 1992. Lombardi and Testa (2011) show that, for all educational groups, the manufacturing wage premium fell by more than half between 1990 and 2007.

## Data and Methodology

Data for our analysis are drawn from the Center for Economic and Policy Research's (CEPR) Outgoing Rotation Group (ORG) data from the Current Population Surveys from 1979 through 2018.[4] The Current Population Survey (CPS) is a joint program of the US Bureau of Labor Statistics and the US Census Bureau. The individual-level microdata provide data on wages, education, place of residence, and a number of demographic variables. Our sample is restricted to people aged 25 to 54.

We use these data to construct individual-level wage regressions that will estimate wage premiums for different categories of industry and occupation. We control for a number of factors associated with wages. Specifically, the regressions include state, year, and month of year fixed effects and controls for education, gender, marital status, race and ethnicity, work experience, whether one lives in a metropolitan area, whether one works overtime, and whether one is paid hourly.[5]

We categorize workers into three groups based on their industry and occupation data: nonmanufacturing, production, and nonproduction workers.[6] We use information on industry to divide workers into manufacturing and nonmanufacturing workers, then we further divide manufacturing workers by their occupation. Production workers include two occupational groups. The first is the precision-production occupations group, which includes occupations such as machinist, frontline production supervisor, tailor, and cabinet maker. The second group is the machine operators, assemblers, and inspectors group, which includes occupations such as lathe operators and welders. In general, the former group are skilled operators who use tools to make things, while the latter group are less skilled operators of machines that make things. We classify all other occupations in manufacturing as nonproduction, which includes occupations from janitor to CEO.

The regressions are designed to estimate wage premiums for three categories of manufacturing workers:

1. All manufacturing workers: The wage premium for workers in any manufacturing industry, pooling production and nonproduction workers together.
2. Production workers: The wage premium for workers in any manufacturing industry in production occupations.
3. Nonproduction workers: The wage premium for workers in any manufacturing industry whose occupation is not a production occupation.

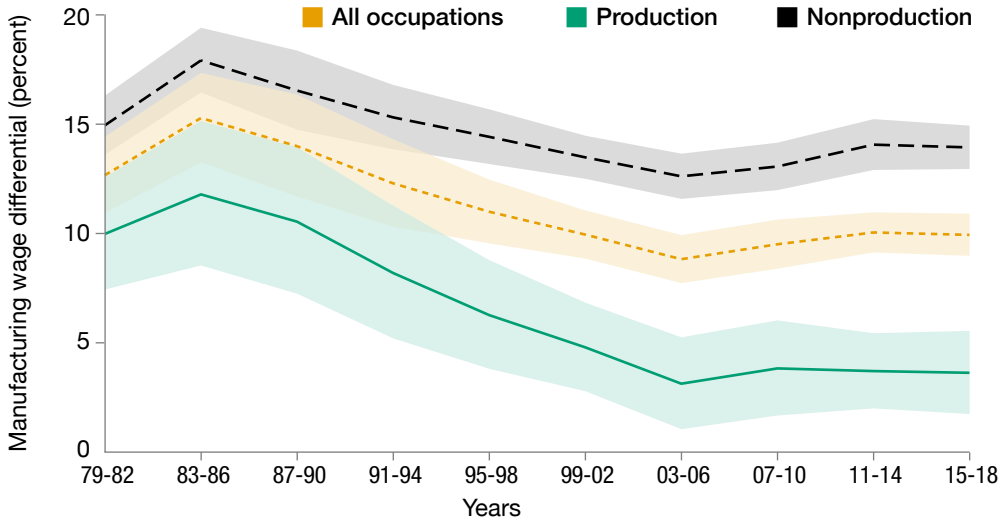
The premiums for the three categories of manufacturing workers are calculated as the percentage difference between the group's average wage and that of comparable workers who do not work in the manufacturing sector. We estimate the wage regressions separately for 10 four-year periods so we can study trends across time with reasonable precision. Because each period has a separate regression, all coefficients can vary across periods. The wage measure we use is the log of inflation-adjusted hourly wages, the standard wage measure used in regressions of this type.

We look at how these wage premiums differ across a number of dimensions, including geographic region, education level, age, and race and ethnicity. For most of these comparisons, we use separate regressions for each subgroup; therefore, all coefficients from these regressions are specific to each subgroup. The exception is that we use a combined model to look at wage premiums by union status, so that we can compare workers covered by union contracts with workers not covered by such contracts.

## Trends in Manufacturing Premiums

Figure 1 shows estimates of three different wage premiums, along with their 95 percent confidence intervals (the shaded area around each line). The orange line is the wage premium for manufacturing workers when production and nonproduction workers are pooled, as has been done in past studies. This premium fell from a peak of 15 percent from 1983 to 1986 to 9 percent from 2003 to 2006 and has stayed near 10 percent since. However, pooling production and nonproduction workers obscures significant differences between the wage premiums of these two groups. The wage premium for production manufacturing workers relative to all nonmanufacturing workers fell for most of the 40-year period, falling from a peak of 12 percent during 1983 to 1986 to 4 percent or less from 2003 onward. In contrast, the wage premium for nonproduction manufacturing workers fell only 5 percentage points between 1983 to 1986 and 2003 to 2006, and it has since risen 1 percentage point to 14 percent. Therefore, since 2003, the production wage premium is less than one-third as large as the nonproduction wage premium. Going forward, we focus exclusively on the separate wage premiums for production and nonproduction workers.

**Figure 1. Manufacturing Wage Premiums Relative to Nonmanufacturing Workers for All Occupations Together, Production Occupations, and Nonproduction Occupations**




Notes: The shaded area around each line is the 95 percent confidence interval for the wage premium. Each period is a set of four years. These wage premiums are based on hourly wage regressions that control for a variety of characteristics associated with wages. See Appendix for details.

Source: Authors' calculations from CPS ORG (CEPR 2020).

The large drop in the production wage premium has a significant effect on the earnings of production workers in manufacturing. Consider the case of a worker who earns $600 for a 40-hour week ($15 per hour) outside of the manufacturing sector. If that worker were to switch to a production job in manufacturing, the production wage premium from 2015 to 2018 would mean that the worker could expect a weekly pay increase of $24. If the wage premium was still as high as it was from 1983 to 1986, the weekly pay would increase by $72—triple the increase of the 2015 to 2018 premium. In contrast, the nonproduction wage premium fell modestly over time and remains large. If our hypothetical job changer moved from outside of manufacturing to a nonproduction job in manufacturing, the worker could expect an $84 increase in weekly pay with the nonproduction premium from 2015 to 2018, down from a $108 increase with the premium from 1983 to 1986.

The drop in the manufacturing wage premiums also affected aggregate income. All else equal, total wage and salary income in the United States in 2018 would have been approximately $17 billion more if the production wage premium were the same as it was from 1983 to 1986.[7] Similarly, if the nonproduction wage premium had remained at its 1983 to 1986 level, total wage and salary income in 2018 would have been approximately $21 billion higher. Taken together, the nation's total wage and salary income would have been 0.6 percent higher in 2018 if these two wage premiums were still as high as they were from 1983 to 1986.

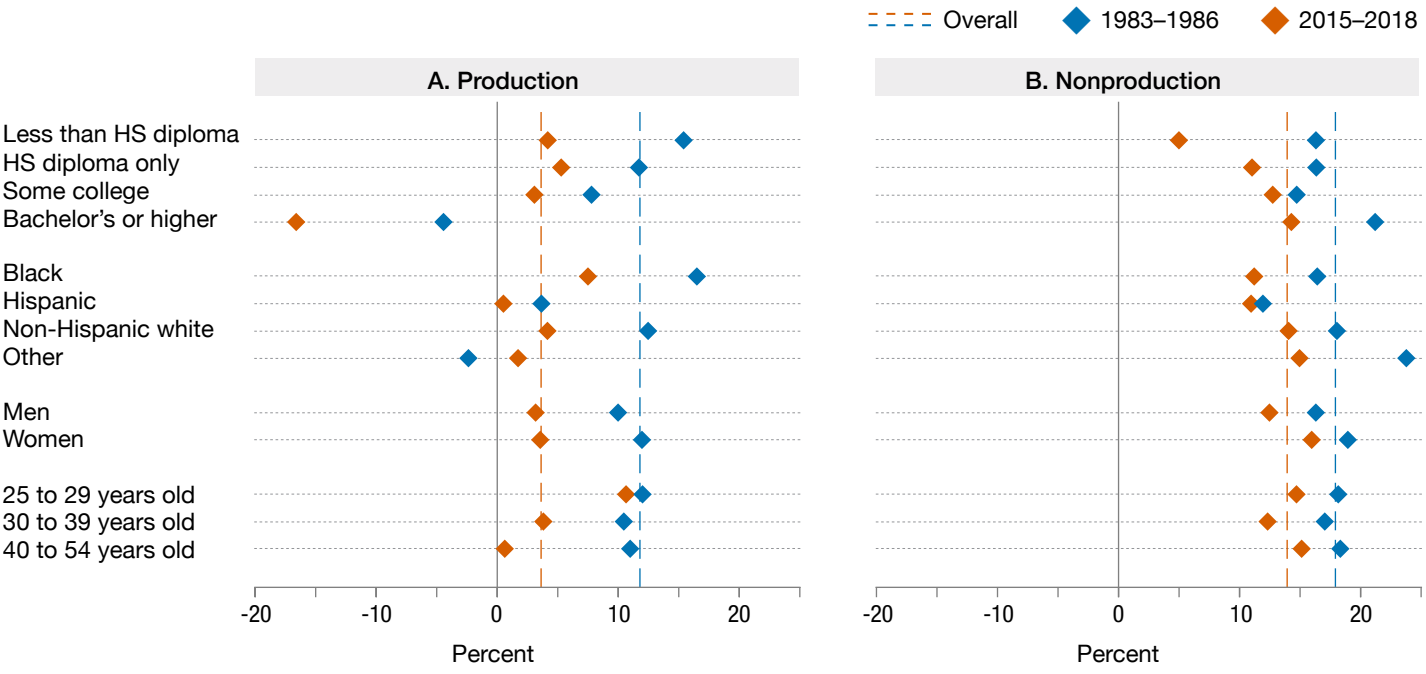
Figure 2 shows wage premiums for production and nonproduction workers by demographic subgroup for two periods: 1983 to 1986 and 2015 to 2018. As a whole, our analyses of the subgroups show that the decline in the wage premium for production workers between 1983 and 2018 is a broad-based phenomenon—the production wage premium fell regardless of age group, educational attainment, or gender, and for all but one cultural group. For most subgroups, the nonproduction wage premiums were higher and declined less than did the production wage premiums.

From 1983 to 1986, the manufacturing wage premium for production workers was greater than 7 percent for 10 of the 13 subgroups we consider. In contrast, from 2015 to 2018, only two subgroups have a production wage premium of more than 7 percent: Black workers and workers aged 25 to 29. For most subgroups, there was a substantive decline in the production wage premium—this premium declined by at least 6 percentage points for 9 of the 13 subgroups. The decline was greatest for workers with at least a bachelor's degree; their production wage premium fell 12 percentage points, ending at -17 percent. While the size of the decline varied across subgroups, only one subgroup was left unscathed: The production wage premium for the "Other" cultural group increased slightly during the period.[8] The difference in trends across age groups is notable and will be discussed later in this report.

As with the full sample, for most of the subgroups, we consider the nonproduction manufacturing wage premium was higher and experienced a smaller decline than the production wage premium. From 2015 to 2018, all but one of the subgroups of nonproduction manufacturing workers enjoyed a wage premium of more than 10 percent—the exception is workers without a high school diploma. However, this is a deterioration from earlier periods: From 1983 to 1986, only Hispanic workers had a wage premium below 15 percent, and 2 of the 13 subgroups had wage premiums higher than 20 percent. People with less than a high school diploma suffered the largest decline: The nonproduction wage premium for these workers fell from 16 percent from 1983 to 1986 to 5 percent from 2015 to 2018.

In sum, the variation in wage premiums across subgroups of workers shows that the declines during the last 40 years were broad based. The manufacturing wage premium fell for almost all groups of production and nonproduction workers, regardless of education, gender, cultural group, or age group.

**Figure 2. Manufacturing Wage Premiums Relative to Nonmanufacturing Workers for Subgroups of Workers**




Notes: These wage premiums are based on hourly wage regressions that control for a variety of characteristics associated with wages. See Appendix for details. These estimates and their confidence intervals are available in an online appendix.

Source: Authors' calculations from CPS ORG (CEPR 2020).

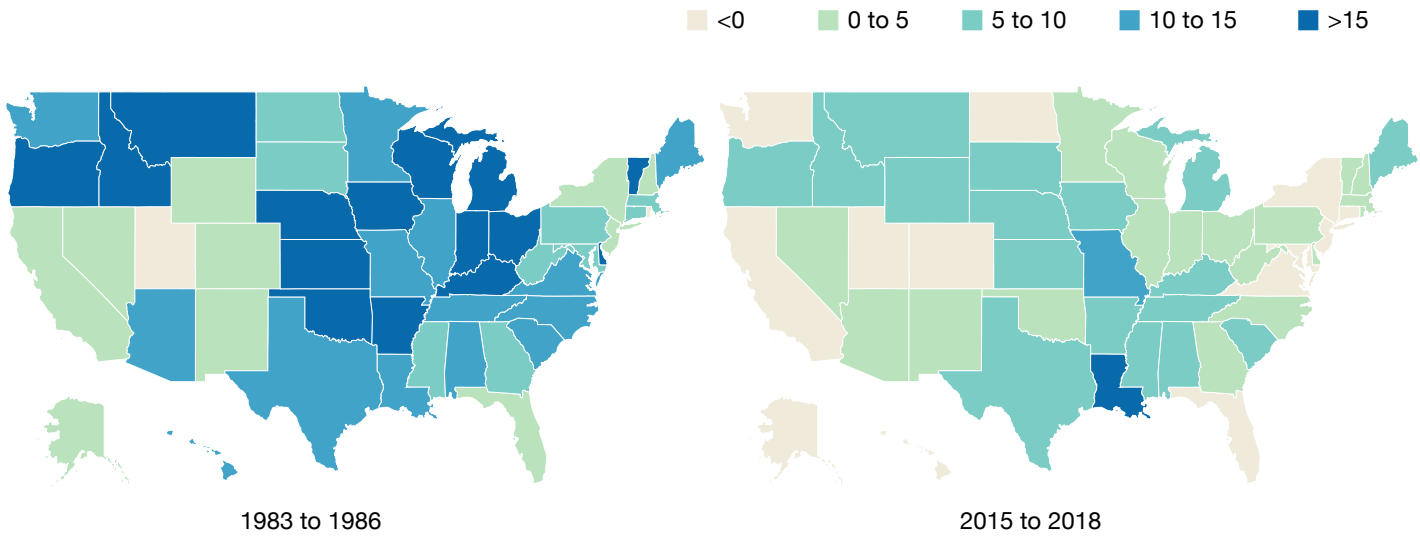
## State-Level Manufacturing Wage Premiums

Trends in the nonproduction wage premium are generally similar across states and follow the national trends discussed above. Therefore, we focus our attention on state-level production wage premiums. Because the national production wage premium peaked during 1983 to 1986, we look at the changes in the state premiums between this period and the 2015 to 2018 period. There are three notable patterns in state-level production wage premiums:

1. The production wage premium estimates declined in all but four states between 1983 and 2018.
2. Production wage premiums are more similar across states now than they were 40 years ago.
3. Several Great Lakes states that had high wage premiums during 1983 to 1986 had especially large declines in their wage premiums.

Figure 3 shows state-level production wage premiums for the periods 1983 to 1986 and 2015 to 2018. In the earlier period, 29 states and the District of Columbia had production wage premiums of more than 10 percent. During 2015 to 2018, only the District of Columbia, Louisiana, and Missouri had production wage premiums of more than 10 percent.

**Figure 3. Wage Differential between Production Workers and Comparable Nonmanufacturing Workers (Percent)**

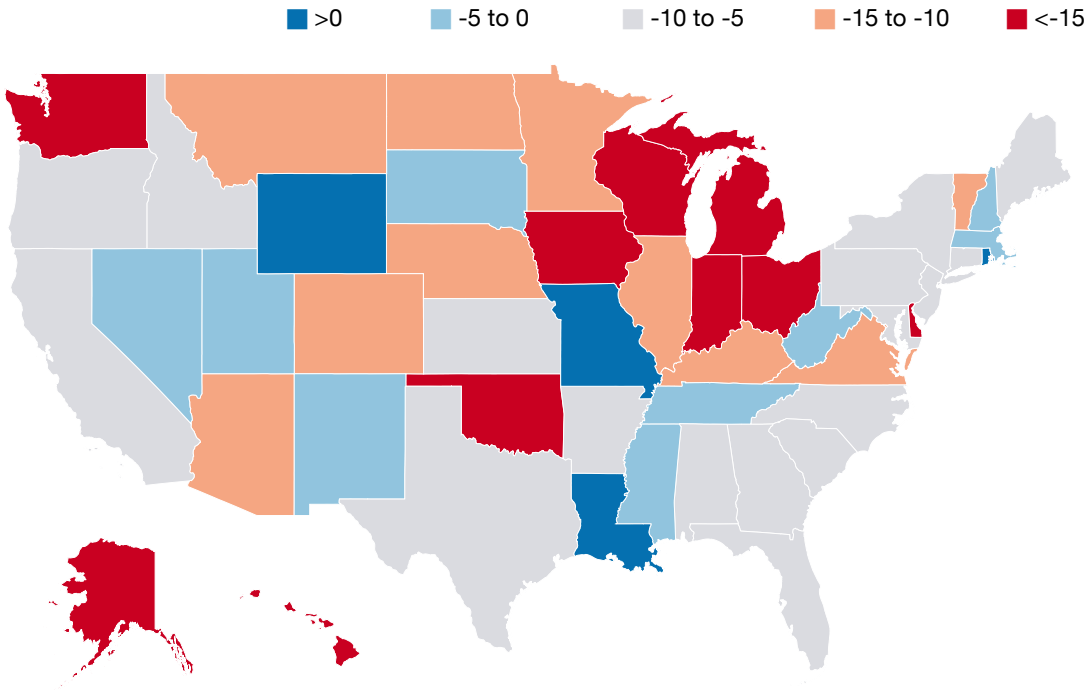



Production wage premiums were more similar across states from 2015 to 2018 than from 1983 to 1986. From 1983 to 1986, the production wage premium of the state with the tenth highest premium was 15 percentage points higher than the premium of the state with the tenth lowest premium. The comparable difference between states during 2015 to 2018 was 10 percentage points.

From 1983 to 1986, there were three clear clusters of states with production wage premiums above 15 percent.[9] The first cluster includes four Great Lakes states (Indiana, Michigan, Ohio, and Wisconsin) and Kentucky. The second cluster includes five states in the center of the country (Arkansas, Iowa, Kansas, Nebraska, and Oklahoma). The last cluster is in the Northwest (Idaho, Montana, and Oregon). From 2015 to 2018, there were no clusters of states with production wage premiums above 15 percent. The cluster with the highest production wage premiums includes Louisiana, Mississippi, Missouri, and Tennessee. There is a cluster of states along the East Coast (Connecticut, Maryland, New Jersey, New York, and Virginia) with production wage premiums below zero; in these states, production workers earn less than comparable workers outside of manufacturing.

Figure 4 is a map of the change in the production wage premium from the 1983 to 1986 period to the 2015 to 2018 period. The only states for which this wage premium did not decline between these periods were Louisiana, Missouri, Rhode Island, and Wyoming. In other states, the decline in this wage premium ranged from 0.5 percentage points (New Mexico) to 26 percentage points (Iowa). States in the Southeast, most of which had relatively low production wage premiums during the earlier period, had declines of less than 10 percentage points. The production wage premium fell by 15 percentage points or more in a cluster of states around the Great Lakes: Indiana, Michigan, Ohio, and Wisconsin.

**Figure 4. Percentage Point Change in Wage Differential for Production Workers between 1983–1986 and 2015–2018**




Since at least 1979, the decline in the production wage premium is one factor behind the slow growth of income per capita in those Great Lakes states (Schweitzer, 2017). Relative to other states, the decline in the production wage premium has had a disproportionate impact on per capita income in these states for two reasons. First, these states had especially large declines in their production wage premiums, which has slowed growth in production workers' incomes. Second, the share of all workers who are production workers has been relatively high in these states, which means that a larger share of workers have been impacted by the decline in the production wage premium.

As an example, consider how the decline in the production wage premium impacted total wage and salary income in Ohio in 2018. All else equal, Ohio's total wage and salary income would have been $2.4 billion dollars more in 2018 if the production wage premium was the same as it was during 1983 to 1986.[10] This represents a 1.1 percent increase in Ohio's total wage and salary income in 2018. Contrast this with the nation as a whole, where total wage and salary income in 2018 would be only 0.3 percent higher if the production wage premium was the same as it was during 1983 to 1986. This percentage change is approximately four times larger in Ohio because Ohio had a larger drop in its production wage premium over time and because production workers account for a larger share of total wage and salary income in Ohio than in the nation as a whole.

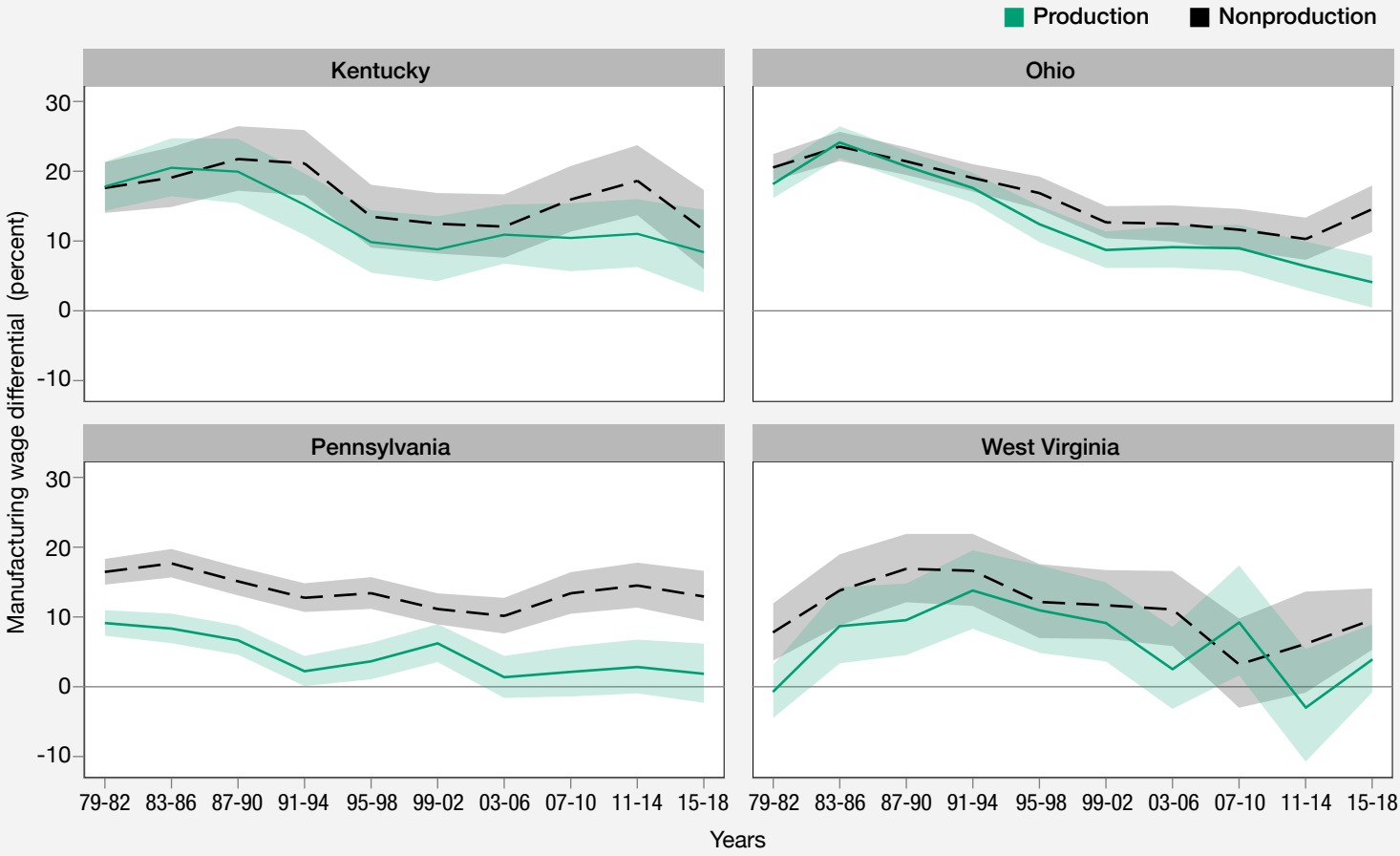
## FOURTH DISTRICT STATES

Figure 5 shows the production and nonproduction manufacturing wage premiums for the states that include a portion of the Fourth Federal Reserve District: Kentucky, Ohio, Pennsylvania, and West Virginia. Note that the estimates for West Virginia have large confidence intervals because the sample of manufacturing workers in West Virginia in the Current Population Survey is much smaller than the samples for the other three states.

Production wage premiums differed sharply across these four states from 1983 to 1986, ranging from 8 percent in Pennsylvania to 24 percent in Ohio. However, from 2015 to 2018, the production wage premiums in all four states were more similar to each other—ranging from 2 percent in Pennsylvania to 8 percent in Kentucky. The production wage premium declined between 1983 and 2018 in all four states, with the decline ranging from 5 percentage points (West Virginia) to 20 percentage points (Ohio). While all four states had statistically significant production wage premiums in the earlier period, only the premiums in Kentucky and Ohio were significantly different from zero in the later period.

The trends in the nonproduction wage premiums of Fourth District states were similar to each other, and, from 2015 to 2018, these premiums ranged from 10 percent (West Virginia) to 15 percent (Pennsylvania). All four of these premiums are significantly different from zero. The declines in the nonproduction wage premiums from 1983 to 2018 ranged from 4 percentage points (West Virginia) to 9 percentage points (Ohio).

**Figure 5. Nonproduction and Production Wage Premiums in Kentucky, Ohio, Pennsylvania, and West Virginia**




Notes: The shaded area around each line is the 95 percent confidence interval for the wage premium. Each period is a set of four years. These wage premiums are based on hourly wage regressions that control for a variety of characteristics associated with wages. See Appendix for details.

Source: Authors' calculations from CPS ORG (CEPR, 2020).

## Caveats about Estimates of Manufacturing Wage Premiums

The estimates discussed above are based on regressions that control for a number of observable differences between workers, including education, gender, cultural group, and whether one lives in a metropolitan area. However, there are a few important caveats to keep in mind.

1. **Unobservable characteristics:** While we control for observable characteristics, we cannot control for unobservable characteristics such as skills, aptitude, work ethic, and job-specific knowledge. If manufacturing workers have made fewer gains in desirable unobservable characteristics (or have seen a growing propensity toward undesirable unobservables) than nonmanufacturing workers, it could explain at least part of the decline we observe in manufacturing wage premiums. However, the fact that we see large declines in manufacturing wage premiums in almost all states and subgroups we have looked at means that any such changes in unobservables are broad based. A reason to doubt that unobservables played a large part in the decline in manufacturing wage premiums is that firms tend to keep their most valuable workers when they lay off workers (Gibbons and Katz, 1991). As manufacturing employment, particularly production employment, has dramatically declined over the 40-year period we examine, it is quite plausible that the unobservable characteristics of manufacturing workers have gotten more valuable over time, as firms selected which workers to keep and which to lay off. In that case, our estimates could understate how much manufacturing wage premiums have declined.

2. **Wages are only part of compensation:** Due to data availability, we have focused on wage premiums. Because manufacturers generally offer better benefits than a comparable worker would receive outside of manufacturing, manufacturing premiums might be greater if they were calculated using total compensation rather than wages. However, it is likely that such total compensation premiums would have trends similar to those of the wage premiums. While benefits are a larger share of total compensation inside manufacturing than outside of manufacturing, the difference between manufacturing and nonmanufacturing has changed little over time. Based on Employer Costs for Employee Compensation data, benefits in 1986 were 30.7 percent of hourly compensation costs in manufacturing and 25.7 percent in the service sector—a difference of 5.0 percentage points. This difference was 5.3 percentage points in 2018.[11]

3. **Cost-of-living differences:** Our estimates of manufacturing wage premiums could be influenced by cost-of-living differences within states.[12] If manufacturing jobs are more likely than nonmanufacturing jobs to be located in regions of a state with low costs of living, then our estimates will understate the size of the manufacturing wage premiums. If this pattern has gotten more prevalent over time, then cost-of-living differences would contribute to the drop in manufacturing wage premiums we observe. However, the fact that we observe large declines in production wage premiums in nearly all states, including those that do not have metropolitan areas with high costs of living, suggests that in-state cost-of-living differences have a limited role in explaining the decline in wage premiums.

These caveats are important, but they are typical of most analyses of wages with cross-sectional microdata. By controlling for the observable characteristics conventionally included in wage regressions and state-fixed effects, our estimates are less subject to these caveats than prior studies of the manufacturing wage premium that did not control for these factors. Therefore, we believe our estimates are valuable, even with these caveats.

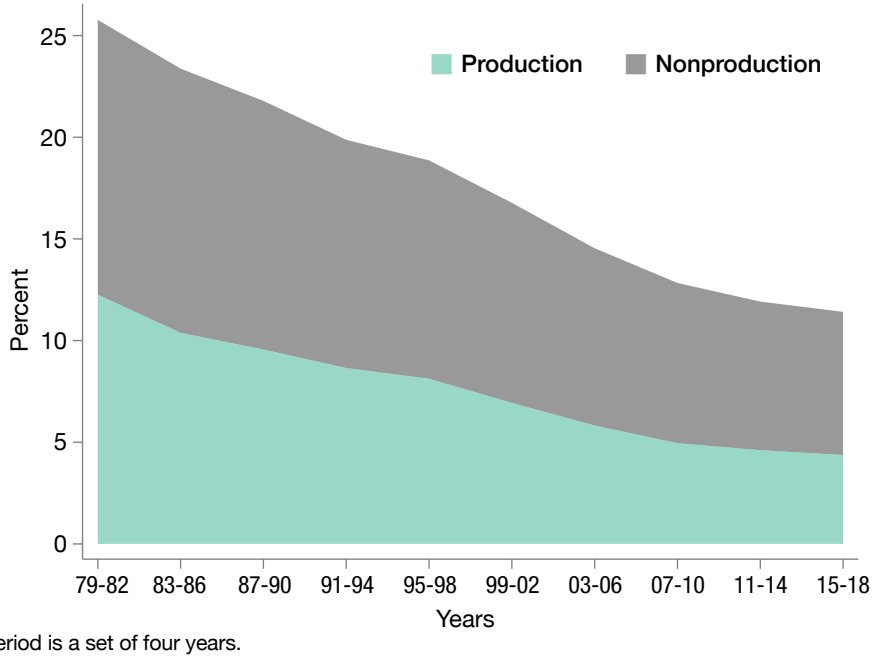
## Factors behind the Decline in the Production Manufacturing Wage Premium

The results above invite the question: Why has the wage premium earned by production workers declined? We believe the decline is largely a story of supply and demand: Manufacturing's demand for production workers has declined, which has put downward pressure on the wages of the remaining production workers. Changes over time in the characteristics of these workers and the characteristics of production manufacturing jobs also contributed to the decline in this premium.

### Reductions in Labor Demand

Manufacturing's share of employment in the United States has fallen throughout the 40-year period we study. Within manufacturing, production occupation employment has fallen faster than nonproduction occupation employment. These trends can be seen in Figure 6. During the 1979 to 1982 period, 26 percent of the nation's employment was in the manufacturing sector, which fell to 11 percent in the 2015 to 2018 period. Production manufacturing workers' share of employment fell to 4 percent in 2015 to 2018, one-third of their 12 percent share in 1979 to 1982. Nonproduction manufacturing workers' share of employment fell to 7 percent in 2015 to 2018, half of their 14 percent share in 1979 to 1982. With these declines, the share of manufacturing employment that is in production occupations fell from 47 percent in 1979 to 1982 to 38 percent in 2015 to 2018.

**Figure 6. Production and Nonproduction Employment in Manufacturing as a Percent of Total Employment**




Notes: Each period is a set of four years.

Source: Authors' calculations from CPS ORG (CEPR 2020).

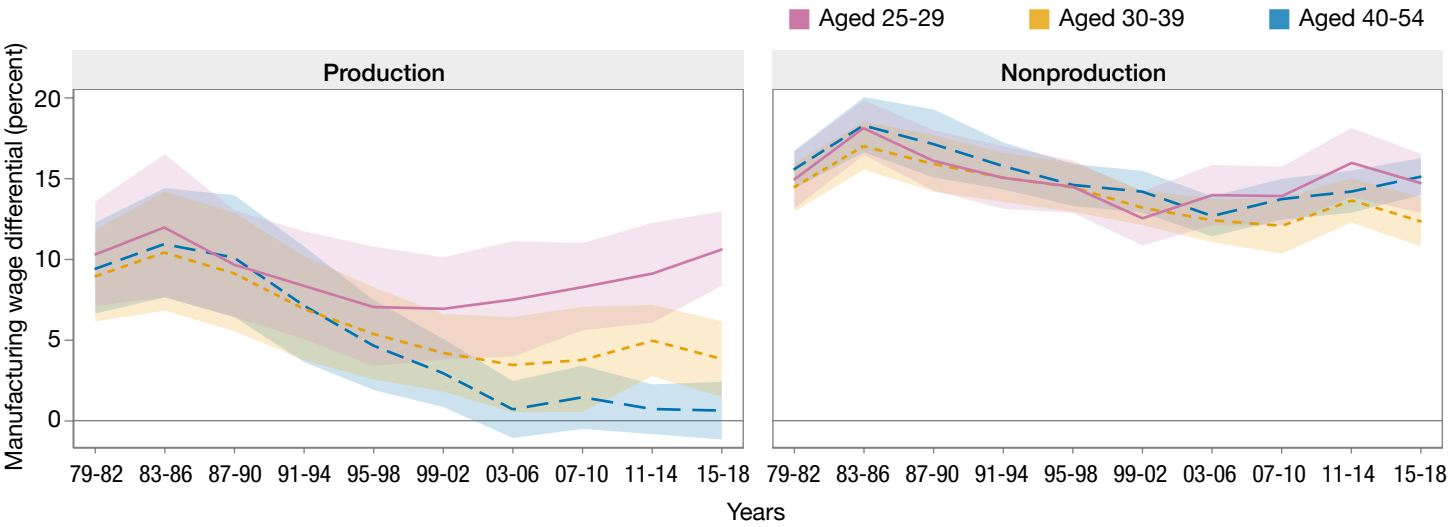
Economists think of these declines in employment shares as downward shifts of the labor demand curves for production and nonproduction workers in manufacturing: As firms close factories or further automate production, the number of workers firms want to hire at a given wage falls. Unless there is a comparably sized drop in the labor supply at the same time, the reduced demand leads to relatively weak wage growth for this category of workers. The skills of nonproduction workers are more readily applicable to work outside of manufacturing than are the skills of production workers; for example, bookkeepers work in many more industries than do milling machine operators. Therefore, when labor demand from the manufacturing sector fell for nonproduction workers, these workers could more readily shift to work in other industries than could production workers. Lacking this flexibility, laid-off production workers look for another production job, so the labor supply of production workers is slow to adjust to a drop in demand, and this puts downward pressure on their wages.

There is substantial evidence that the decline in manufacturing labor demand has slowed wage growth, especially for less-educated workers. Studying the decline in manufacturing employment during the 1980s, Bound and Holzer (2000) find that less-educated workers were less likely than more-educated workers to move out of a metropolitan area when manufacturing declined. They assert that this lack of outmigration contributed to the relatively slow wage growth of less-educated workers in these areas. Charles, Hurst, and Schwartz (2018) find similar effects on wages from the decline in manufacturing employment from 2000 to 2016. Note that the majority of production workers fall into the less-educated group, a group whose labor supply was slow to adjust to its reduced demand.[13]

Both Bound and Holzer (2000) and Charles, Hurst, and Schwartz (2018) studied the impact of the decline in manufacturing employment on all workers, not just those in manufacturing. Autor et al. (2014) focused on the impact that competition with Chinese imports had on earnings for workers who were employed in manufacturing between 1992 and 2007. They found that manufacturing workers in industries that faced more competition from China experienced greater loss of earnings than other manufacturing workers, both because they were employed less often and because they had lower wages when employed. The authors found that these effects are greater for low-wage manufacturing workers. They also found that low-wage manufacturing workers were more likely than high-wage manufacturing workers to stay within the manufacturing sector when they changed jobs; this is an indication that the labor supply of high-wage manufacturing workers is more responsive to changing conditions than the labor supply of low-wage manufacturing workers. Production workers are more likely to be in the low-wage group than are nonproduction workers; therefore, the labor supply of production workers is less responsive to changing conditions than the labor supply of nonproduction workers.

The results from this literature are consistent with the differences between the trends of production and nonproduction wage premiums we identify. Another piece of evidence that the drop in labor demand is a key factor behind the decline in the production wage premium is that the production wage premium trends of older workers have diverged from those of younger workers, as shown in Figure 7. While the production wage premium of workers aged 40 to 54 declined in all but one period after 1983 to 1986, the production wage premium of workers aged 25 to 29 stabilized during the 1990s and has risen steadily since the 2003 to 2006 period. Since 1995, the production wage premium of workers aged 30 to 39 has been between those of the younger and older groups.

**Figure 7. Manufacturing Wage Premiums for Production Occupations and Nonproduction Occupations Relative to Nonmanufacturing Workers, by Age Group**




Notes: The shaded area around each line is the 95 percent confidence interval for the wage premium. Each period is a set of four years. These wage premiums are based on hourly wage regressions that control for a variety of characteristics associated with wages. See Appendix for details.

Source: Authors' calculations from CPS ORG (CEPR 2020).

The drop in demand for production workers can explain the different trends in the wage premiums by age. Once workers have acquired industry- or occupation-specific skills, they have an incentive to stay on the same career path. In the case of production manufacturing workers, it is likely that the falling demand has created a pool of available older workers with relevant experience, putting downward pressure on wages for this group. However, younger workers have not acquired as many of these specific skills. Therefore, the labor supply decisions of younger workers are more responsive to recent market conditions than are the labor supply decisions of older workers. This difference can explain why the production wage premium for younger workers has risen since 2003, while the wage premium for older workers has been stuck at a low level.

**Changes in Worker Characteristics**

If the wage premium associated with a particular subgroup is lower than the overall wage premium, and the share of workers that are in that subgroup increases, that increase in share will cause the overall wage premium to decline. The same applies to states: If the share of manufacturing jobs that are in states with relatively low manufacturing wage premiums rises, then the overall wage premium will decline.

One such change that has occurred is that the share of production workers that are Hispanic rose 15 percentage points between the periods of 1983 to 1986 and 2015 to 2018, while the share of production workers that are non-Hispanic and white fell 19 percentage points. Because Hispanic workers have a smaller production wage premium and this cultural group now makes up a larger share of all production workers, the overall production wage premium has declined.[14] The educational attainment of production workers has also risen over time, a situation that has pushed down the overall production wage premium because the production wage premium is higher for people with less than a high school diploma than it is for people with at least some college.

We can quantify how much the changes in worker characteristics, as a whole, contributed to the decline in the production wage premium (see the Appendix for technical details). Together, the changes in the composition of production workers' educational attainment, cultural group, gender, age group, and state of residence between 1983 to 1986 and 2015 to 2018 explain 2 percentage points of the drop in the production wage premium. This means that the change in the characteristics of production workers can explain about one-quarter of the drop in the production wage premium. Another, perhaps more intuitive, way to think about this is that it suggests that if production workers' characteristics were the same during 2015 to 2018 as they were during 1983 to 1986, then the manufacturing wage premium would have been about 2 percentage points higher during 2015 to 2018.

An equivalent decomposition for nonproduction manufacturing workers shows that the nonproduction wage premium would have been 2 percentage points lower during 2015 to 2018 if the characteristics of nonproduction manufacturing were the same during 2015 to 2018 as they were during 1983 to 1986. This is primarily because the educational attainment of nonproduction manufacturing workers rose between 1983 and 2018, and the nonproduction wage premium is larger for workers with more education. Without the changes in worker characteristics, the decline in the nonproduction wage premium between 1983 to 1986 and 2015 to 2018 would have been 50 percent larger—6 percentage points, rather than 4 percentage points.

The key takeaway from these decompositions is that changes in the observable characteristics of manufacturing workers over time explain only part of the change in the production wage premium and offset some of the change in the nonproduction wage premium.

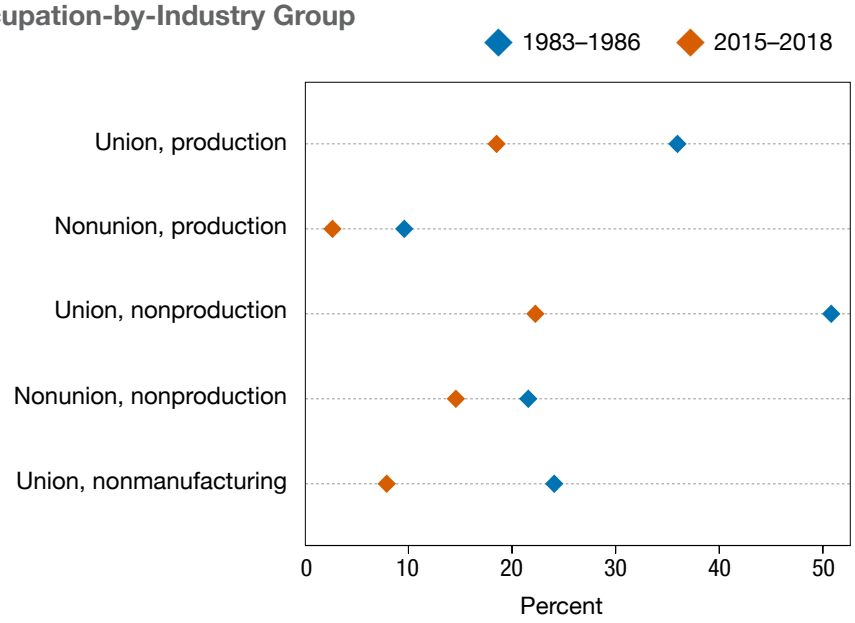
### Changes in Job Characteristics

Just as the characteristics of manufacturing workers have changed over time, the characteristics of manufacturing jobs have also changed. For example, fewer manufacturing workers are covered by union contracts today than in the early 1980s. In addition, production methods have become increasingly advanced and less dangerous. These changes in job characteristics also contribute to the decline in manufacturing wage premiums.

The share of production manufacturing jobs that are covered under union contracts fell from 39 percent during 1983 to 1986 to 13 percent from 2015 to 2018. This contributed to the decline in the overall manufacturing wage premiums because unionized workers have higher manufacturing wage premiums than do nonunionized workers, as shown in Figure 8. Relative to comparable nonunion workers outside of manufacturing, unionized production workers had a wage premium of 36 percent during 1983 to 1986 and 18 percent during 2015 to 2018. The comparable premiums for nonunionized production workers were 10 percent and 3 percent, respectively. Even though the premium for unionized production workers fell substantially over time, the overall production wage premium from 2015 to 2018 would have been approximately 4 percentage points higher if the fraction of production workers that were unionized was the same during 2015 to 2018 as it was during 1983 to 1986.[15] The unionization rate of nonproduction manufacturing workers also fell between 1983 and 2018, but the nonproduction wage premium from 2015 to 2018 would be only 1 percentage point higher if the unionization rate were the same then as it was from 1983 to 1986. This is because, relative to production workers, there is less difference between the wage premiums of unionized and nonunionized nonproduction workers, and there was a smaller drop over time in the share of nonproduction workers that are unionized.

While the focus in this subsection is the change in job characteristics, the declines in the manufacturing wage premiums of workers covered by a union contract are noteworthy. The production wage premium of unionized workers fell from 36 percent during 1983 to 1986 to 18 percent during 2015 to 2018. For the same periods, the nonproduction wage premium of unionized workers fell from 51 percent to 22 percent. While these premiums have fallen by at least half over time, they remain higher than the wage premiums of workers who are not covered by a union contract. During 2015 to 2018, workers not covered by a union contract had a production wage premium of 3 percent and a nonproduction wage premium of 15 percent.

**Figure 8. Wage Premiums Relative to Comparable Nonunion, Nonmanufacturing Workers, by Union Status and Occupation-by-Industry Group**




Notes: These wage premiums are based on hourly wage regressions that control for a variety of characteristics associated with wages. See Appendix for details. These estimates and their confidence intervals are available in an online appendix.

Source: Authors' calculations from CPS ORG (CEPR 2020).

As previously noted, one reason that manufacturing jobs may have a wage premium is that the higher wages compensate for negative job characteristics, such as excessive noise or unfavorable shift work. If production jobs in manufacturing have gotten more pleasant or less dangerous over time, then part of the decline in the wage premium may be because employers no longer need to compensate for undesirable job attributes.

Economists have found it difficult to empirically estimate the size of such compensating wage differentials. However, one job attribute that has been carefully measured and studied is the risk of workplace injury. The risk of nonfatal injuries has fallen in recent decades, and it has fallen more in the manufacturing sector than overall. The number of nonfatal workplace injuries that led to days away from work per 100 fulltime-equivalent workers in the private sector was 3.0 in 1992 and 0.9 in 2018; the comparable figures for manufacturing are 3.5 and 0.9, respectively.[16] By this measure, manufacturing jobs have gotten safer over time and are now as safe as jobs in the private sector overall. Guardado and Ziebrath (2019) find that "Each additional nonfatal accident per 100 [fulltime-equivalent workers] is associated with 1.1 percent higher wages" (p. 146). This implies that the risk of injury increased wages in manufacturing, relative to the private sector overall, by 0.5 percent in 1992 and not at all in 2018. In comparison, the overall manufacturing wage premium fell 2 percentage points: from 12 percent during 1991 to 1994 to 10 percent during 2015 to 2018. Therefore, the safety gains in manufacturing can explain about a quarter of the drop in the manufacturing wage premium over this time frame.

It is plausible that improved job characteristics caused a portion of the decline in the production wage premium. However, the difference in trends in the production wage premiums of younger and older workers suggests that the improved characteristics of production work have not been the dominant reason for the decline in the production wage premium. Because production workers of all ages work together, if improving job characteristics were a major factor in the decline of the production wage premium, then we would expect the trends in the wage premiums to be similar across age groups. As shown earlier, these trends are quite different—the production wage premium of younger workers has been rising since 2003, while the production wage premium of older workers has been stable at a low level.

We noted that one reason for manufacturing wage premiums is that manufacturing is a relatively profitable sector and that, except in perfectly competitive labor markets, workers' bargaining power affects the degree to which the profits translate into higher wages. Both the decline in the unionization rate and the loss of production jobs have eroded workers' bargaining power. The link between bargaining power and unions is clear—collective bargaining is an essential benefit that unions offer their members. The loss of production jobs has also reduced workers' bargaining power. Layoffs create a pool of available workers with similar skills, which reduces the cost of replacing a worker and thereby reduces the strength of a worker's threat to quit. Layoffs also cause workers who remain on the job to worry about future layoffs, so they are less likely to push for raises. It is likely that the loss of bargaining power is part of the reason that manufacturing wage premiums have declined, especially the production wage premium.

It is not possible to identify which of these three factors—reductions in labor demand, changes in worker characteristics, or changes in job attributes—has contributed the most to the drop in manufacturing wage premiums. However, the reduction in manufacturing labor demand stands out from the other two factors because it can explain a broad array of the patterns we observe. We have discussed above how this reduction in labor demand can explain why the decline in the production wage premium is greater than the decline in the nonproduction wage premium and why the decline in the production wage premium is greater for older workers. The reduction in labor demand can also explain why the decline in the production wage premium was especially large in the industrial heartland—manufacturing has been an especially large share of employment in these states, so the reduction in production labor demand impacted a relatively large share of the workforce, leading to a greater disconnect between labor demand and labor supply. The fact that the decline in the production wage premium was especially large for less-educated workers can also be explained by the reduction in labor demand—labor demand for less-educated workers fell in other sectors at the same time demand for production workers was falling in manufacturing, which gave less-educated workers fewer good alternatives to production work than more-educated workers. On their own, neither changes in worker characteristics nor changes in job attributes can explain differences in manufacturing wage premiums as well as the reduction in labor demand can.

## Why Did Manufacturing Employment Decline?

Because declining labor demand in the manufacturing sector can explain many of the changes to the manufacturing wage premiums, it is worth examining why manufacturing employment fell so sharply during the past 40 years. The existing literature attributes the employment decline to two main factors: the increased use of capital and technology in manufacturing and the impact of trade-related policy changes and the propensity of offshoring.

Much of the existing literature posits that the overwhelming driver of the decline in manufacturing employment is an increase in worker productivity, which many economists attribute to the rise of automation. The simplest way to motivate this argument is to point out that while manufacturing employment fell by almost a third between 1983 and 2019, gross output (adjusted for inflation) from the manufacturing sector grew 93.5 percent. Put another way, the average manufacturing worker in 1983 generated annual output equal to $174,598 in 2019 dollars. In 2019, the average manufacturing worker generated annual output equal to $489,115.

Routine tasks that were historically performed by workers have been automated over time, decreasing the demand for labor. Karabarbounis and Neiman (2014) document that falling prices for machinery and other investment goods (generally attributed to improvements in computing technology) contributed to the decline in the labor share of income since the 1980s across countries and industries. Charles, Hurst, and Schwartz (2018) highlighted that the decline has been more pronounced in manufacturing than in other sectors, noting that the "labor share in the manufacturing sector fell by about 20 percent between 2000 and 2015. By comparison, the labor share in the broad non-farm business sector (which includes the manufacturing sector) fell by only about 10 percent over the same period" (p. 16).

However, Houseman (2018) calls attention to the extraordinary role that the pricing of computer and electronic products has played in driving up measured real output in the manufacturing sector. Output per worker is not a direct measure of labor productivity, and steep declines in prices for computers and semiconductors have pulled down the price index for the manufacturing sector as a whole. When this price index is used to adjust manufacturing output for inflation, the mismeasurement leads to artificial growth in real output and, thereby, output per worker. According to her analysis, "From 1979 to 2000, measured real GDP growth in manufacturing was 97 percent of the average for the private sector; when the computer industry is dropped from both series, manufacturing's real GDP growth rate is just 45 percent that of the private sector average" (p. 9). If manufacturing real GDP did not grow as much as the official statistics suggest that it did, then manufacturing workers did not become as productive during that period either. This fact weakens the argument that automation is a key driver of employment decline.

On the other hand, there is compelling evidence that trade and the offshoring of manufacturing work has driven the employment decline in recent years. Autor, Dorn, and Hanson (2013) found that import competition leads to higher unemployment, lower labor force participation, and reduced wages. Building on this work, Acemoglu et al. (2016) attribute 17 percent of the decline in US manufacturing employment between 1999 and 2011 to direct and indirect effects of China's 2001 accession to the World Trade Organization.

Research suggests that both automation and foreign competition have reduced manufacturing employment in the United States. In reality, these two phenomena are related, as some firms have chosen to automate in response to global competition (Charles, Hurst, and Schwartz, 2018). However, if automation were driving the manufacturing employment decline since 2000, then output per worker should have increased substantially. Houseman (2018) shows that has not been the case. Therefore, the evidence suggests that increased global trade explains more of the decline in US manufacturing employment than does automation.

## Policy Implications

So far, this report has detailed that the amount of extra wages afforded to workers just because they work in manufacturing has eroded over time, particularly for workers in production occupations. The primary reason for this erosion is a reduced need for production workers in the US manufacturing sector, which is most likely because of increased global trade. This finding should influence the discourse on public assistance to the manufacturing sector, especially on the goals for workforce training programs. We think these programs will do the most good if they are aimed at getting workers into nonproduction manufacturing jobs, rather than production jobs.

### The Manufacturing Skills Gap

In the past decade, manufacturers have increasingly reported that it is hard to find qualified workers to fill production jobs. CEOs and analysts often attribute the large number of job openings and the difficulty in hiring to an increasing gap between the skills workers have and the skills manufacturers would like them to have, which is commonly referred to as "the manufacturing skills gap."[17] Despite a large number of applicants, they say, few workers are equipped with the necessary skills to work in a modern factory, irrespective of the wages offered. This subject has been at the forefront for many policymakers and economic development practitioners, and much time and many resources have been dedicated to creating job training programs and partnerships between governments, businesses, and community colleges to prepare workers for these jobs.

Academic researchers have found little evidence that a skills gap exists (Cappelli, 2015; Lazear and Spletzer, 2012). The most compelling evidence that manufacturers have increasing difficulty hiring is that the number of unfilled positions relative to total positions (the job openings rate) in manufacturing rose from 24 per 1,000 jobs in 2007 to 33 per 1,000 jobs in 2019, a 39 percent increase.[18] That said, the job openings rate in the economy overall grew at nearly the same rate (38 percent), and the job openings rate in manufacturing is consistently below that of the economy overall. This suggests that it has gotten harder for manufacturers to find qualified workers, but it remains easier for manufacturers to find workers than it is for employers in other sectors.

One of the reasons that researchers doubt that a skills gap exists is that such a labor shortage should lead to an acceleration in wage growth for production workers and, overall, there was no such acceleration.[19] However, we do find that the production wage premium of workers aged 25 to 29 has been growing since 1999. This suggests that manufacturers have been raising wages to attract young workers to the sector. Still, this has been insufficient to raise the production wage premium overall because the premiums of workers aged 30 to 54 have not risen and, since 1994, fewer than one in six production workers is aged 25 to 29.

While the manufacturing skills gap garners a lot of attention, our research points to a different reason that it has become harder for manufacturers to find qualified workers: lower relative wages. When the production manufacturing wage premium was high, more people pursued those jobs. Since 2003, the production wage premium has hovered between 3 percent and 4 percent. This premium may have declined enough that it is unable to compensate workers for the undesirable traits of production jobs, such as a noisy work environment or the perception that there is a greater risk of being laid off.

### Shrinking Profit Margins?

It is likely that manufacturers could increase hiring with increased starting wages, but many report that it has become harder to turn a profit, and they feel that their ability to raise prices is limited. As mentioned, global competition has contributed to the decline in manufacturing labor demand, and demand for production workers in particular, in the United States (Houseman, 2018; Charles, Hurst, and Schwartz, 2018). This competition creates downward price pressure that makes it difficult for manufacturers in the United States to pay higher wages relative to other industries without impacting their profit margins. However, such margin pressure should also reduce the manufacturing wage premium for nonproduction workers, which has changed little since 1995.

In reality, the profits of manufacturing corporations have grown substantially since 1980. Aggregating corporation-level data from Compustat, we find that manufacturing corporations enjoy higher-than-average profits, and that profits for this sector have increased faster than the profits of nonmanufacturing corporations (Compustat North America, 1980–2019). After adjusting for inflation, average gross profits per employee were approximately $114,000 for nonmanufacturing, nonfinancial corporations in 2019, an increase of 53 percent between 1980 and 2019. For corporations in the manufacturing sector, the figure was $156,000, down somewhat from a high of $183,000 in 2007, but 89 percent higher than its level in 1980.[20] While the landscape may be different for smaller, privately held manufacturers, the Compustat data do not support the view that falling profit margins have forced manufacturers to limit wage growth for production workers. In fact, causality may run in the other direction: The decline in the production wage premium has helped contribute to growing profit margins.

**A New Focal Point for Policy**

The combination of a falling production manufacturing wage premium and rising profit margins calls into question whether addressing the perceived manufacturing skills gap is a good use of public resources. The production wage premium for workers aged 25 to 29 is more than 10 percent and has been rising since 2003, which could indicate that production jobs are a good opportunity for those early in their careers. However, if demand for production workers continues to decline in the future (as global competition and process automation continue to evolve), it is likely that those young workers will see their wage premium decline as they age. Overall, the production wage premium is low, so training workers for production jobs within manufacturing is likely to produce only modest long-term income gains.

When a government provides greater subsidies for training for one particular sector, it can distort the labor supply by diverting workers to that sector. If production jobs pay only a small wage premium, why should increasing the supply of labor for production jobs in manufacturing be a public priority? Furthermore, increasing the supply of these workers can further reduce the production wage premium. If policymakers wish to increase people's income by subsidizing training for jobs in manufacturing, the programs will be more effective if they target nonproduction manufacturing jobs, for which there remains a substantial wage premium.

**The Economic Benefits of the Manufacturing Sector**

It is important to remember that manufacturing continues to provide significant economic benefits to the regions where it is located, which may justify policies to support and attract manufacturing. Manufacturing can help drive economic growth in a region by producing goods that can be sold outside the region. Think of it this way: If everyone in your town works in town and only spends on goods and services produced in town, then the opportunities for economic growth are limited. If instead you have a factory that produces goods that people in other towns want to buy, more money will come into the economy from outsiders.

Other arguments for continued policy support for the domestic manufacturing sector are that manufacturing supports jobs in other industries and that the co-location of manufacturers and product designers can help to foster innovation. Houseman (2014) asserts that half of the workers needed to produce manufactured goods in the United States work outside the manufacturing sector, so bolstering manufacturers should add jobs in other sectors. Pisano and Shih (2009) argue that without regular interaction with physical manufacturing, engineers cannot improve processes and products. "In the long term," they say, "an economy that lacks an infrastructure for advanced process engineering and manufacturing will lose its ability to innovate" (p. 119).

Another reason to continue to pursue policies that foster manufacturing is that there continues to be a substantial manufacturing wage premium for nonproduction workers. As noted earlier, the majority of manufacturing workers are in nonproduction occupations, and their share of manufacturing employment has risen steadily over the last 40 years.[21] In this way, manufacturing continues to elevate incomes in the regions where it is located, and this fact may justify continued support for the sector from policymakers.

## Conclusion

Does manufacturing still offer "good wages"? The short answer to this question is yes, but not as broadly as in the past. It depends on a worker's occupation within the sector. Approximately three out of every five manufacturing workers are nonproduction workers, who typically earn an hourly wage that is 14 percent higher than they would receive if they worked in another sector. The wage premium for production workers, on the other hand, is smaller. While this premium was 10 percent or higher throughout the 1980s, it has been no more than 4 percent since 2003. The fact that the manufacturing wage premium is small for production workers, including those with no more than a high school diploma, undermines one of the reasons governments provide special assistance to manufacturers. Perhaps job training programs targeted at manufacturing should focus on nonproduction jobs.

# Appendix

**Details of Log Wage Regressions**

The wage regressions used to estimate the production and nonproduction manufacturing wage premiums have the form

$$W_{it}=\alpha+\beta OccGrp_{it}+\delta X_{it}+\mu_m+\varphi_y+\sigma_s+\varepsilon_{it}, \qquad (1)$$

where $W_{it}$ is the natural log of the real hourly wage of individual $i$ in month $t$, $\mu_m$ is the calendar-month fixed effect (to eliminate seasonality in wages data), $\varphi_y$ is a year fixed effect, and $\sigma_s$ is a state-of-residence fixed effect. $OccGrp_{it}$ is a vector with two indicator variables: one for working in a production occupation in manufacturing and one for working in a nonproduction occupation within manufacturing (the omitted category is working outside of manufacturing, regardless of occupation). This model is estimated separately for each four-year period so that all coefficients can change across periods. Table A1 shows all of the coefficient estimates for the model that produces the estimates of the production and nonproduction wage premiums for the 2015 to 2018 period in Figure 1. Note that one year dummy is omitted from each of the four-year periods in order to have the full set of period dummies.

To make the manufacturing wage premium estimates percentage changes, rather than log approximations of percentage changes, we convert these coefficients to percentage changes using the formula $100(e^{\beta}-1)$. We convert the bounds of the confidence intervals in the same manner.

Aside from the regressions looking at union status, the subgroup regressions have the same specification as the baseline model, but the sample is restricted to individuals from a single subgroup. This allows the coefficients on all variables, including the control variables, to differ across subgroups. The regressions that compare the manufacturing wage premiums of people who are covered by a union contract to those who are not has the following form:

$$W_{it}=\alpha+\beta OccGrp_{it}Union_{it}+\delta X_{it}+\mu_m+\varphi_y+\varepsilon_{it}, \qquad (2)$$

Where $Union_{it}$ is an indicator variable that is 1 if the person is covered by a union contract and 0 if the person is not. The other elements are defined in the same manner as in equation 1. The model is specified this way so that we can compare the manufacturing wage premiums of people covered by a union contract to those of people not covered by a union contract.

**Details of Oaxaca-Blinder Decomposition**

To quantify how much the changes in worker characteristics, as a whole, contributed to the decline in the production wage premium, we decompose the change in the production wage premiums between two periods: 1983 to 1986 and 2015 to 2018. Using a variant on the Oaxaca–Blinder decomposition (Oaxaca, 1973; Blinder, 1973; Neumark, 1988), we decompose only the changes in the manufacturing wage premiums and the characteristics that interact with it. The regression we use to do this is:

$$W_{it}=\alpha+\beta OccGrp_{it}Z_{it}+\delta X_{it}+\mu_m+\varphi_y+\varepsilon_{it}, \qquad (3)$$

where $Z_{it}$ is a vector of the attributes that are interacted with, $OccGrp_{it}$, $X_{it}$ is a vector of the attributes that are not interacted with $OccGrp_{it}$, and the other elements are defined in the same manner as in equation 1. The attributes in $Z_{it}$ are the state fixed effects and the attributes shown in Figure 2. The formula for the decomposition is:

$$\Delta premium = \sum_j \frac{\bar{z}_{j,1}+\bar{z}_{j,0}}{2}(\hat{\beta}_{j,1}-\hat{\beta}_{j,0})+\sum_j \frac{\hat{\beta}_{j,1}+\hat{\beta}_{j,0}}{2}(\bar{z}_{j,1}-\bar{z}_{j,0}), \qquad (4)$$

where $\hat{\beta}_{j,t}$ is the estimated regression coefficient for attribute $j$ at time $t$ and is $\bar{z}_{j,t}$ the mean of attribute j at time t for manufacturing workers in the occupation group that the premium is for. The 1983 to 1986 period is time 0, and the 2015 to 2018 period is time 1. The first summation is the portion of the change in the production wage premium due to changes in regression coefficients—this can be thought of as the part of the change in the manufacturing wage premium that is due to changes in what people are paid. The second summation is the portion due to changes in worker characteristics—this can be thought of as the part of the change in the manufacturing wage premium that is due to changes in who works in manufacturing or where they work.

**Table A1. Full Regression Results of Baseline Model for 2015 to 2018 Period**

| Variable | | Coefficient | Std. Error |
|---|---|---|---|
| Industry-by-occupation indicator variables | Manufacturing – nonproduction | 0.130*** | 0.004 |
| | Manufacturing – production | 0.036*** | 0.009 |
| Educational attainment indicator variables | High school only | 0.216*** | 0.009 |
| | Some college | 0.339*** | 0.011 |
| | Bachelor's degree | 0.636*** | 0.015 |
| | More than bachelor's | 0.797*** | 0.018 |
| Miscellaneous indicator variables | Female | -0.191*** | 0.005 |
| | Married | 0.075*** | 0.004 |
| | Live in a metro area | 0.105*** | 0.006 |
| | Metro-area status is missing | -0.043** | 0.019 |
| | Paid hourly | -0.281*** | 0.006 |
| | Usually work overtime | 0.016*** | 0.005 |
| | Black | -0.130*** | 0.006 |
| | Hispanic | -0.110*** | 0.006 |
| | Other non-white race | -0.040*** | 0.009 |
| Month indicator variables | Feb. | 0.004 | 0.005 |
| | March | -0.002 | 0.005 |
| | April | 0.001 | 0.004 |
| | May | 0.008* | 0.004 |
| | June | 0.008* | 0.004 |
| | July | 0.013** | 0.005 |
| | Aug. | 0.013** | 0.005 |
| | Sept. | 0.013** | 0.005 |
| | Oct. | 0.017*** | 0.004 |
| | Nov. | 0.022*** | 0.005 |
| | Dec. | 0.026*** | 0.004 |
| Year indicator variables | 2015 | (omitted) | |
| | 2016 | 0.020*** | 0.003 |
| | 2017 | 0.027*** | 0.004 |
| | 2018 | 0.060*** | 0.003 |
| Other variables | Experience | 0.044*** | 0.003 |
| | (Experience squared)/10 | -0.014*** | 0.001 |
| | (Experience cubed)/1000 | 0.015*** | 0.002 |
| | Intercept | 2.324*** | 0.022 |
| Model summary statistics | Within $R^2$ | 0.345 | |
| | Between $R^2$ | 0.735 | |
| | Overall $R^2$ | 0.351 | |
| | Observations | 422,583 | |

Note: Regression includes state fixed effects. * = p-value < 0.10 ** = p-value < 0.05 *** = p-value < 0.01

## Endnotes

1. The Fourth Federal Reserve District encompasses all of Ohio, western Pennsylvania, eastern Kentucky, and the northern panhandle of West Virginia.
2. For more information on efficiency wages and differences in wages across industries, see Krueger and Summers (1988).
3. Katz and Summers (1989) provide a good summary of the early literature.
4. More info at http://ceprdata.org/cps-uniform-data-extracts/cps-outgoing-rotation-group/.
5. Metropolitan-area status is suppressed for some observations in the ORG, with suppression more common prior to 1985. To keep our sample comparable over time, we keep observations with suppressed metro-area status in the sample and include an indicator that records whether an observation's metro-area status is missing or not and use the indicator as an explanatory variable.
6. Specifically, 1990 census codes for occupation and industry, which we get from IPUMS CPS and merge into the CEPR ORG data (Flood et al., 2020).
7. The figures in this paragraph are approximations based on the CPS ORG data and assume that people worked their usual weekly hours for 48 weeks. We assume 48 weeks to account for workers who do not work a full year.
8. The "Other" cultural group includes Asians, Pacific Islanders, Native Americans, and people who report multiple races.
9. These clusters were determined visually, not through spatial statistics.
10. The figures in this paragraph are approximations based on the CPS ORG data and assume that people worked their usual weekly hours for 48 weeks. We assume 48 weeks to account for workers who do not work a full year.
11. The Employer Costs for Employee Compensation figures in this paragraph are based on December data. The definitions of sectors are not exactly the same in 1986 and 2018 because the earlier data are based on SIC industry codes and later data are based on NAICS industry codes. The gap between manufacturing and services fell between 2004 and 2019, suggesting that the change in industry coding may be understating the extent to which manufacturing and services benefits have converged over time.
12. The state-fixed effects in the regressions account for constant cost-of-living differences across states.
13. The percent of production manufacturing workers that had at most a high school diploma was 83 percent during 1979 to 1982. This percent has consistently fallen over time and was 62 percent during 2015 to 2018.
14. One possible reason for a lower production wage premium for Hispanic workers is that some Hispanic workers have low English proficiency and therefore are confined to relatively low-wage job opportunities. Another possible reason is that some Hispanic workers are undocumented immigrants, a situation that limits both their job opportunities and their bargaining power in wage negotiations.
15. $0.39*18 + (1 - 0.39)*39$ vs. $0.13*18 + (1 - 0.13)*35$.
16. These figures are from the 1992 and 2018 Industry Injury and Illness Data from the Bureau of Labor Statistics.
17. See, for example, Deloitte Insights and The Manufacturing Institute (2018), "2018 Deloitte and The Manufacturing Institute skills gap and future of work study."
18. Based on average monthly job openings rates from the Bureau of Labor Statistics' Job Openings and Labor Turnover Survey.
19. This disconnect between firms' perceptions of labor shortages and the lack of acceleration in wage growth is not unique to manufacturing. Cappelli (2012) analyzes how changes in human resources practices cause this disconnect and explains how these practices hurt firms and the economy. Gross (2017) argues that firms and workers have gotten used to slow wage growth for an extended period after the Great Recession, so wages no longer accelerate in the face of a labor shortage.
20. In order to address the potential upward bias on the growth rate of profits introduced by selection effects (more profitable companies are more likely to survive), we construct a historical series by calculating the growth rate in profits per worker between each pair of years for only those corporations that are in the sample in both years and then compounding that growth over time.
21. This is one of the reasons that Fee, Wardrip, and Nelson (2019) find that manufacturing has a relatively high number of "opportunity occupations"—jobs that require less than a bachelor's degree and pay higher-than-median wages.

## References


Acemoglu, Daron, David Autor, David Dorn, Gordon H. Hanson, and Brendan Price. 2016. "Import Competition and the Great US Employment Sag of the 2000s." *Journal of Labor Economics* 34 (S1): S141–98. https://doi.org/10.1086/682384.

Autor, David H., David Dorn, and Gordon H. Hanson. 2013. "The China Syndrome: Local Labor Market Effects of Import Competition in the United States." *American Economic Review* 103 (6): 2121–68. https://doi.org/10.1257/aer.103.6.2121.

Autor, David H., David Dorn, Gordon H. Hanson, and Jae Song. 2014. "Trade Adjustment: Worker-Level Evidence." *The Quarterly Journal of Economics* 129 (4): 1799–1860. https://doi.org/10.1093/qje/qju026.

Blinder, Alan S. 1973. "Wage Discrimination: Reduced Form and Structural Estimates." *The Journal of Human Resources* 8 (4): 436–55. https://doi.org/10.2307/144855.

Bound, John, and Harry J. Holzer. 2000. "Demand Shifts, Population Adjustments, and Labor Market Outcomes during the 1980s." *Journal of Labor Economics* 18 (1): 20–54. https://doi.org/10.1086/209949.

Cappelli, Peter H. 2012. *Why Good People Can't Get Jobs: The Skills Gap and What Companies Can Do About It*. Wharton Digital Press.

Cappelli, Peter H. 2015. "Skill Gaps, Skill Shortages, and Skill Mismatches: Evidence and Arguments for the United States." *ILR Review* 68 (2): 251–90. https://doi.org/10.1177/0019793914564961.

Center for Economic and Policy Research. 2020. *CPS Outgoing Rotation Group (ORG) Uniform Extracts* (version 2.5). Washington, DC. https://ceprdata.org/cps-uniform-data-extracts/cps-outgoing-rotation-group/.

Charles, Kerwin Kofi, Erik Hurst, and Mariel Schwartz. 2019. "The Transformation of Manufacturing and the Decline in US Employment." *NBER Macroeconomics Annual* 33 (January): 307–72. https://doi.org/10.1086/700896.

Compustat North America [2019]. 1980 to 2019. Available: Standard & Poor's/Compustat [March 31, 2021]. Retrieved from Wharton Research Data Service.

Dupuy, Max, and Mark E. Schweitzer. 1994. "Are Service-Sector Jobs Inferior?" *Economic Commentary (Federal Reserve Bank of Cleveland)*, (February 1). https://doi.org/10.26509/frbc-ec-19940201.

Fee, Kyle, Keith Wardrip, and Lisa Nelson. 2019. "Opportunity Occupations Revisited: Exploring Employment for Sub-Baccalaureate Workers Across Metro Areas and Over Time." Federal Reserve Banks of Cleveland and Philadelphia. https://www.clevelandfed.org/-/media/content/newsroom%20and%20events/publications/a%20look%20behind%20the%20numbers/albtn%20opportunity%20occupations/opportunity%20occupations%20revisited.pdf?la=en.

Flood, Sarah, Miriam King, Renae Rodgers, Steven Ruggles and J. Robert Warren. 2020. Integrated Public Use Microdata Series, Current Population Survey: Version 8.0 [dataset]. Minneapolis, MN: IPUMS. https://doi.org/10.18128/D030.V8.0.

Gibbons, Robert, and Lawrence F. Katz. 1991. "Layoffs and Lemons." *Journal of Labor Economics* 9 (4): 351–80. https://doi.org/10.1086/298273.

Gross, Daniel. 2017. "Why Can't Americans Get a Raise?" Slate.com. July 13, 2017. https://slate.com/business/2017/07/why-cant-americans-get-a-raise.html.

Guardado, José R., and Nicolas R. Ziebarth. 2019. "Worker Investments in Safety, Workplace Accidents, and Compensating Wage Differentials." *International Economic Review* 60 (1): 133–55. https://doi.org/10.1111/iere.12347.

Houseman, Susan N. 2014. "The Role of Manufacturing in a Jobs Recovery." Washington, DC: Center on Budget and Policy Priorities. http://www.pathtofullemployment.org/wp-content/uploads/2014/04/houseman.pdf.

Houseman, Susan N. 2018. "Understanding the Decline of U.S. Manufacturing Employment." Working paper 18–287. Kalamazooo, MI: Upjohn Institute. https://doi.org/10.17848/wp18-287.

Karabarbounis, Loukas, and Brent Neiman. 2014. "The Global Decline of the Labor Share*." *The Quarterly Journal of Economics* 129 (1): 61–103. https://doi.org/10.1093/qje/qjt032.

Katz, Lawrence F., and Lawrence H. Summers. 1989. "Industry Rents: Evidence and Implications." *Brookings Papers on Economic Activity. Microeconomics* 1989: 209–90. https://doi.org/10.2307/2534722.

Krueger, Alan B., and Lawrence H. Summers. 1988. "Efficiency Wages and the Inter-Industry Wage Structure." *Econometrica* 56 (2): 259–93. https://doi.org/10.2307/1911072.

Lazear, Edward P., and James R. Spletzer. 2012. "The US Labor Market: Status Quo or a New Normal?" In *Annual Proceedings of the Jackson Hole Federal Reserve Conference*. Jackson Hole, WY.

Lombardi, Britton, and William A. Testa. 2011. "Why Are Manufacturers Struggling to Hire High-Skilled Workers?" *Chicago Fed Letter*, no. July. https://ideas.repec.org/a/fip/fedhle/y2011ijulyn289.html.

Neumark, David. 1988. "Employers' Discriminatory Behavior and the Estimation of Wage Discrimination." *The Journal of Human Resources* 23 (3): 279. https://doi.org/10.2307/145830.

Oaxaca, Ronald. 1973. "Male-Female Wage Differentials in Urban Labor Markets." *International Economic Review* 14 (3): 693. https://doi.org/10.2307/2525981.

Pisano, Gary P., and Willy C. Shih. 2009. "Restoring American Competitiveness." *Harvard Business Review* 2009 (07): 114–25. https://hbr.org/2009/07/restoring-american-competitiveness.

Schweitzer, Mark E. 2017. "Manufacturing Employment Losses and the Economic Performance of the Industrial Heartland." Working paper 17–12. Federal Reserve Bank of Cleveland. https://doi.org/10.26509/frbc-wp-201712.