

Chicago Fed Letter

Does automation always lead to a decline in low-wage jobs?

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To what extent are low-wage jobs in the United States being replaced by technology? Our research¹ suggests that low-wage jobs that are intensive in routine cognitive tasks, such as cashier, were supplanted by automation during the 2000s. Moreover, since the Great Recession, jobs intensive in both routine manual and routine cognitive tasks have been negatively impacted by automation. Nevertheless, the overall effect on individual low-wage workers has been surprisingly small.

One reason is that we also find that automation, while changing the composition of jobs, has not led to a net decline in the total number of jobs. Moreover, since low-wage jobs have few skill requirements and the minimum wage acts as a wage floor, individual low-wage workers displaced from low-wage employment have been able to transition into newly created jobs without much of a wage

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penalty. This stands in sharp contrast to the impact of automation on higher-wage jobs, including former manufacturing jobs. For those workers, other research has shown that the newly created jobs associated with automation tend to pay much lower wages.²

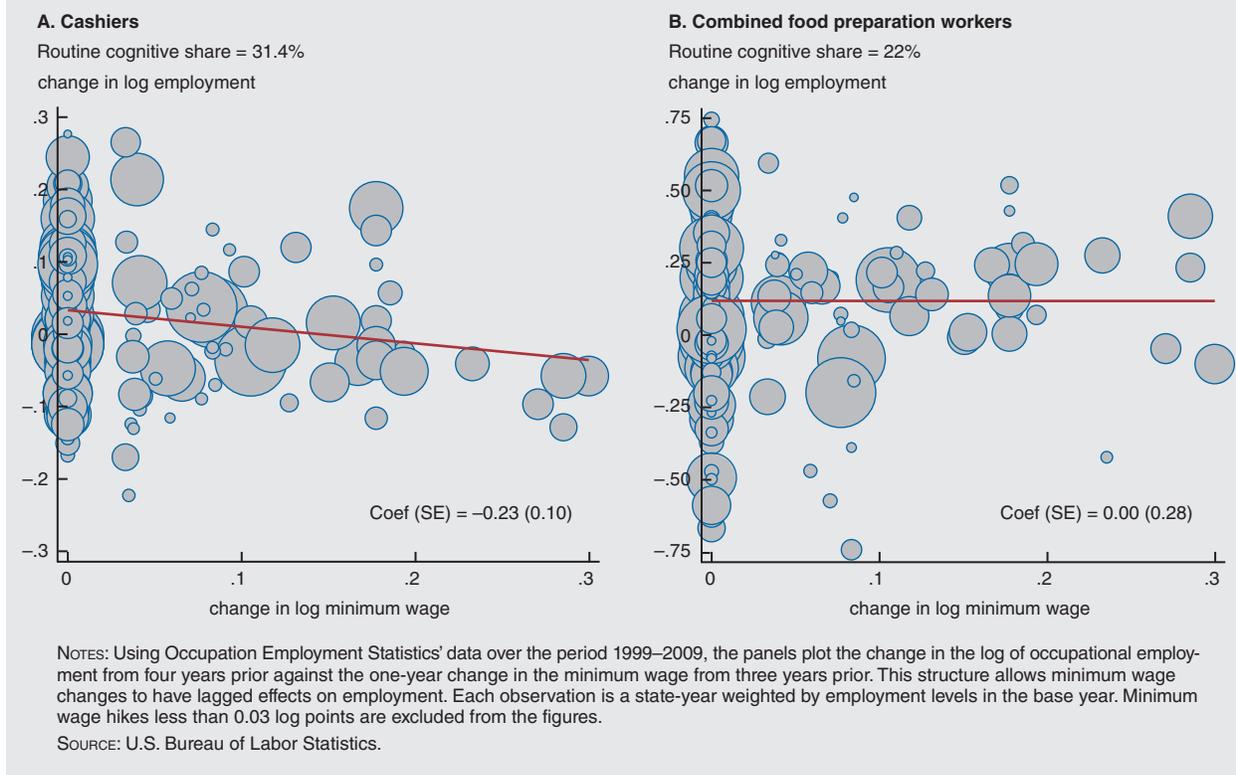
In this *Chicago Fed Letter* we discuss our research and the mechanisms that might be driving these results.

Evidence from occupations

In our empirical work, we examine how an unexpected increase to the cost of low-wage labor, through a minimum wage hike, affects employment growth differently, depending on how likely it is that jobs within an occupation could be automated. We infer the likelihood of automation by using the tasks required to do a job. Specifically, we follow an earlier academic literature and assume that automation technology is more likely to replace jobs with a larger share of tasks that are routine in nature. We take this indirect approach to studying the impact of automation on employment because, as far as we know, there are no comprehensive data available on the use of automation technologies.

Our main analysis relies on two large occupation-specific data sets: the U.S. Department of Labor's Occupation Information Network (O*NET) and the U.S. Bureau of Labor Statistics' Occupation Employment Statistics (OES). O*Net provides data on the tasks and activities, as well as skills, abilities, and knowledge necessary to perform those tasks and activities, for every U.S. occupation. We assign to each occupation the share of time required to do six broad categories of tasks: those

1. Employment effect of a minimum wage hike



that are routine cognitive, nonroutine cognitive analytical, nonroutine cognitive interpersonal, routine manual, nonroutine manual physical, and nonroutine manual interpersonal.³ Occupational employment levels and average occupational wage data come from the OES.

Figure 1 provides an illustration of our main results using data from 1999 to 2009. These plots show one-year changes to the log minimum wage (horizontal axis) against four-year changes to log employment (vertical axis) for two large low-wage occupations that tend to be offered at similar establishments and receive comparable pay. A dot represents a state-year (e.g., California in 2007) and the size of the dot is proportional to that state's employment level. The left panel features the occupation cashier, which has an especially high proportion of time spent on routine cognitive tasks. As the minimum wage hike gets larger, so does the decline in employment among cashiers. On average, a 10% increase in the minimum wage is associated with a 2.3% decline in cashier employment. By contrast, there is no discernible effect of a minimum wage hike on the employment of food preparation workers (right panel), a job that tends to involve an average proportion of time on routine cognitive tasks.

In our statistical model, we use all low-wage occupations, and we find very similar results to those shown in figure 1. Minimum wage hikes decrease employment in occupations that typically require a larger proportion of time spent on routine cognitive tasks. The results imply that a 10% increase in the minimum wage lowers employment by an average of 0.9% one year after the hike and 1.3% two years after the hike among low-wage occupations that have a high share (i.e., one standard deviation above average) of routine cognitive tasks. Such occupations would include hotel desk clerk, motion picture projectionist, and pharmacy aide. Occupations with routine cognitive tasks that are two standard deviations above average, which the estimates imply would experience employment declines twice as large after a minimum wage hike, include usher/ticket-taker, gaming dealer, and grader and sorter of agricultural products. The employment decline takes place slowly over multiple years, consistent with capital investment or other sources of labor substitution taking time to implement. Moreover, we find that the effect of a minimum wage hike dissipates to zero among higher wage occupations.

Our initial analysis, which used data from 1999 to 2009, found no evidence of job loss based on the extent to which an occupation is manually routine. However, in ongoing work using data over the period 2010–17, we find that minimum wage hikes are associated with relative declines in employment both at occupations that are intensive in routine cognitive tasks and at occupations that are intensive in routine manual tasks. That is, new labor-saving technology appears to be spreading to a broader set of low-wage jobs.

Although we find that minimum wage hikes cause job loss in routine-oriented occupations, we also find that the overall impact of a minimum wage hike on aggregate low-wage employment is indistinguishable from zero. This striking result has to imply that as some routine jobs disappear after wages rise, other nonroutine, low-wage jobs appear. In both the 1999–2009 and 2010–17 periods, this offsetting positive employment growth is especially notable in occupations intensive in nonroutine interpersonal tasks.

Mechanisms driving the lack of an overall employment response

How could the use of technology intended to replace certain low-wage jobs lead to offsetting employment growth in other types of jobs? In our research paper, we offer one possible explanation based on the nature of low-wage automation. Often the introduction of new technologies involves moving some tasks that were previously performed by an employee onto the customer, such as scanning items with self-scanners. As firms introduce these new labor-saving technologies, they simultaneously create new jobs to guide and oversee customer interactions with the technology. In the short run, this employment growth could help offset the decline in jobs from automation. However, this offsetting employment growth is unlikely to persist over long periods. These positions could become redundant once customers adapt to the new technology.

However, two other potential explanations that are consistent with offsetting nonroutine employment growth could persist over longer time horizons. Automation technology could ease what economists call a *fixed input in production* problem. For example, the area behind the counter at one's favorite café is a fixed amount of space that is often crowded with workers both taking orders and making drinks. The end result can be long queues. During busy times, some people may choose to avoid the café altogether. However, the introduction of ordering kiosks or a smartphone-based ordering app could eliminate the need for cashiers, freeing up precious space behind the counter, which the café could repurpose to increase its capacity to make drinks. As wait times fall, fewer people skip their coffee purchase and the café can profitably hire more baristas. Thus, the new barista positions would offset the decline in cashiers.

Alternatively, long-lasting and offsetting nonroutine employment growth could arise from changes to the composition of firms. Some evidence suggests that minimum wage hikes cause labor-intensive firms disproportionately to fail because the cost of the hike falls more heavily on these types of firms.⁴ As production shifts to more capital-intensive incumbent and entrant firms, the tasks associated with their newly expanded employment would reflect their higher-tech production. Moreover, if these new capital-intensive firms are more productive, their expansion could offset nearly all of the employment declines at labor-intensive firms.

It is important to reemphasize that we do not observe actual technological substitution of labor and our results need not be solely due to automation. For example, a reasonable alternative source of substitution could be low-skilled labor unaffected by the minimum wage hike, most prominently overseas outsourcing. However, using one common measure of occupational outsourcing, we can show that this cannot explain our set of results. In hindsight, this is unsurprising since a very small share of the lowest wage occupations can be moved offshore. Most of these jobs are in the service sector and require workers to be physically present.

The cost to workers

Lastly, we corroborate and extend our results using individual worker data. This exercise offers additional insight into how occupational realignment impacts the wage and employment prospects of individual low-wage workers. Our analysis uses the 2003 to 2009 U.S. Bureau of Labor Statistics' *Current Population Survey* (CPS), a monthly mini-census of roughly 60,000 households. The CPS allows us to account for basic demographics of individuals, such as age, gender, and education, as well as the state of their local labor market.

Consistent with the OES results, we find that minimum wage hikes cause individuals to move to occupations with fewer routine cognitive tasks, and in particular transition away from especially high-routine occupations. Most importantly, we find that this reallocation is only associated with a modest decline in the short-run probability of employment for workers previously employed at jobs that are intensive in routine cognitive tasks. That is, very few workers are unable to find employment, even among those who switch occupations because their previous job was likely automated.

We also find that those initially employed in high-cognitively routine jobs appear to miss out on a portion of the wage gains associated with the minimum wage hike and, thus, experience relative wage losses compared with other workers in their state. Nevertheless, the overall cost on individual low-wage workers of reallocating jobs after minimum wage hikes appears to be relatively modest. These workers experience only slightly lower probabilities of subsequent employment and mildly lower wages, compared with otherwise similar low-wage workers.

Conclusion

To sum up, our analysis suggests that certain types of low-wage jobs are disappearing due to automation. However, the typical high cost of job loss may be attenuated because automation of low-wage jobs has also led to the creation of new, similar-paying jobs that many displaced workers have been able to fill. Still, the source of this offsetting employment growth remains unclear and, therefore, we cannot be certain it will persist over longer time horizons. This means that the cost of low-wage automation on individual workers could increase over time.

¹ Daniel Aaronson and Brian J. Phelan, 2019, "Wage shocks and the technological substitution of low-wage jobs," *Economic Journal*, Vol. 129, No. 617, January, pp. 1–34. Crossref, <https://doi.org/10.1111/eoj.12529>

² See, for example, Maarten Goos and Alan Manning, 2007, "Lousy and lovely jobs: The rising polarization of work in Britain," *Review of Economics and Statistics*, Vol. 89, No. 1, February, pp. 118–133. Crossref, <https://doi.org/10.1162/rest.89.1.118>

³ Low-wage occupations, i.e., occupations with average wages below 175% of the minimum wage that are intensive in routine cognitive tasks, include gaming dealer, cashier, and service station attendant. Low-wage occupations intensive in routine manual tasks include garment and textile presser, laundry worker, and dishwasher. See Daron Acemoglu and David Autor, 2011, "Skills, tasks and technologies: Implications for employment and earnings," in *Handbook of Labor Economics*, David Card and Orley Ashenfelter (eds.), Vol. 4, Part B, Amsterdam: Elsevier / North-Holland, pp. 1043–1171. Crossref, [https://doi.org/10.1016/S0169-7218\(11\)02410-5](https://doi.org/10.1016/S0169-7218(11)02410-5)

⁴ On exit, entry, and reallocation, see Daniel Aaronson, Eric French, Isaac Sorkin, and Ted To, 2018, "Industry dynamics and the minimum wage: A putty-clay approach," *International Economic Review*, Vol. 59, No. 1, February, pp. 51–84. Crossref, <https://doi.org/10.1111/iere.12262> ; on profits, see Brian Bell and Stephen Machin, 2018, "Minimum wages and firm value," *Journal of Labor Economics*, Vol. 36, No. 1, January, pp. 159–195. Crossref, <https://doi.org/10.1086/693870>

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ISSN 0895-0164