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The Employment Effects of a $15 Minimum Wage in the U.S. and in Mississippi: A Simulation Approach

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PREFACE

Minimum wages can have both positive and negative effects on employment. HR 582, the Raise the Wage Act of 2019, would phase in minimum wage increases over six years, to $15 by 2024 throughout the U. S. In 2017, we conducted, but did not release, a comprehensive analysis of the effects of a similar bill-- The Raise the Wage Act of 2017. That bill also proposed to increase the federal minimum to $15 in 2024, but over eight years.

Our 2017 report found a very small positive effect-- of about 0.1 percent of employment, for the U.S. as a whole and for Mississippi, our lowest-wage state. These findings are highly pertinent to assessing the effects of the 2019 bill. We present this earlier work here to inform current policy discussion.

Developments since 2017 indicate that our report overstates the pay and employment effects of the 2019 bill. Two states— Illinois and New Jersey, as well as the District of Columbia-- subsequently enacted their own paths to a $15 minimum wage. Two additional states—Arkansas and Missouri--voted in 2018 to increase their state minimum wages. And a number of large businesses, notably Amazon in 2018, implemented $15 minimum wages for their workforces. Moreover, annual wage growth has accelerated since we conducted our analysis, from about 2.5 percent then to about 3 percent in 2018. These public and business policy developments and the higher rate of recent wage increases imply that HR 582 would increase pay and affect employment by somewhat smaller amounts than we analyze here.

How much smaller? Cooper (2017) estimated that the 2017 bill would raise pay for about 41.5 million workers. In his 2019 update, Cooper estimates that the 2019 bill would raise pay for about 39.7 million workers, or about 96 percent of his earlier estimate. Using this benchmark, one can obtain the 2019 adjusted estimates by multiplying the pay and employment estimates in our 2017 report by 96 percent.

For a related and more recent discussion, including an expanded analysis suggesting that the minimum wage increase will have more positive effects in Mississippi and other low-wage states than in more affluent states, see Michael Reich (2019), "What are the Likely Effects of a $15 Federal Minimum Wage by 2024?" http://irle.berkeley.edu/likely-effects-of-a-15-federal-minimum-wage-by-2024/

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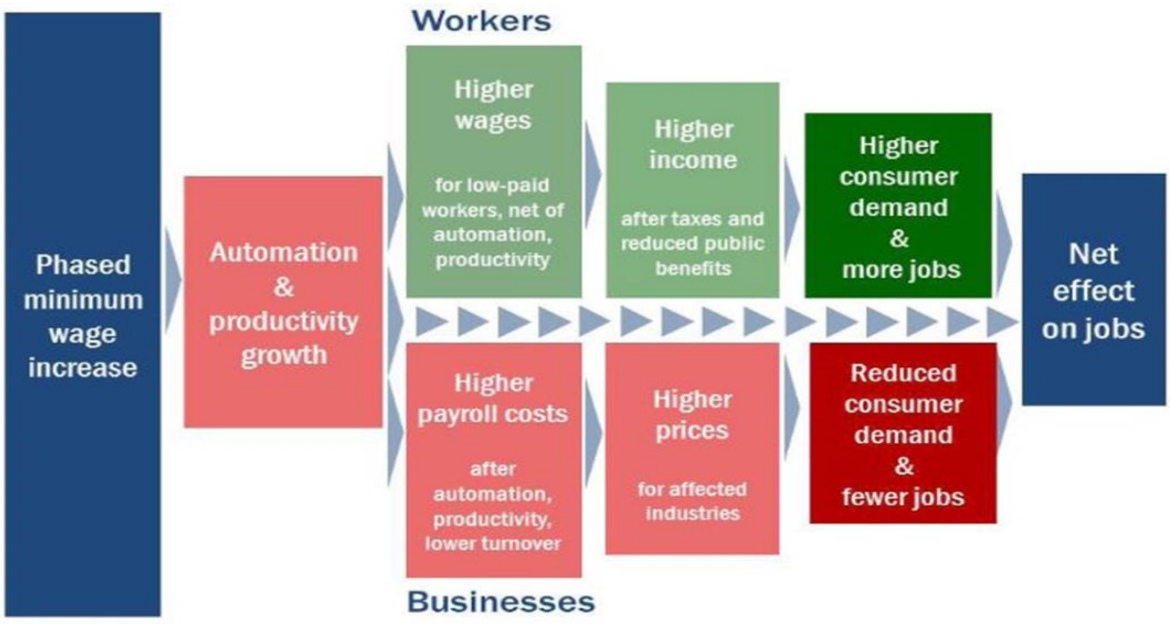
Methods

We estimate a calibrated labor market model that we created specifically to analyze the effects of a $15 minimum wage. We take into account how workers, businesses, and consumers are affected and respond to such a policy and we integrate their responses in a unified manner. In doing so, we draw upon modern economic analyses of labor and product markets. As we explain in the report, the main effects of minimum wages are made up of substitution, scale, and income effects. The figure below provides a guide to the structure of our model.

Figure 1. Berkeley CWED minimum wage model



Our estimates compare employment numbers if policy were adopted to employment numbers if the policy had not been adopted. Other factors that may affect employment by 2024 are therefore outside the scope of our analysis.

Our analysis incorporates recent laws that raised state minimum wages, such as in New York State and California. However, we ignore laws that raise minimum wages at the city level. We do so to simplify the presentation. We pay special attention to Mississippi because it is one of the lowest-wage states in the U.S.

Key Findings

The policy's effects on workers by 2024

- Increasing the minimum wage to $15 would increase earnings for 41.5 million workers, or 29.2 percent of the U.S. workforce.

- Among those getting raises, annual pay would increase 17.3 percent, or about $3,470 (in 2016 dollars) on average.

Effects on businesses and consumers by 2024

- Three industries account for more than 40 percent of the U.S. private sector workers who would get increases: retail trade (18.2 percent), restaurants (15.6 percent), and health services (10.5 percent). The remaining low-wage workers are scattered among a broad variety of industries. Total wage costs would increase 1.9 percent across all employers.

- Restaurants comprise the most affected sector: 67.8 percent of workers in the restaurant industry would receive a wage increase. Total wage costs in restaurants would increase 11.3 percent.

- Automation, increases in worker productivity and reduced employee recruitment and retention costs would offset some of these payroll cost increases.

- Businesses could absorb the remaining payroll cost increases by increasing prices by 0.6 percent through 2024. This price increase is well below the annual inflation rate of 1.7 percent over the past five years. Prices in restaurants would increase 4.3 percent by 2024.

- The consumers who would pay these increased prices range across the entire income distribution.

Net effect on employment in the U.S. and in Mississippi by 2024

- We estimate a very small increase in employment growth, relative to what would occur without the minimum wage increase: 90,000 more jobs by 2024, which corresponds to 0.1 percent of projected 2024 employment. By comparison, census benchmark revisions of annual employment have averaged 0.3 percent over the past decade and the Congressional Budget Office projects that employment in the U.S. will grow 3.15 percent in the same time period.

- Our estimates for Mississippi project a similar positive (0.1 percent) effect on employment.

Summary of key findings

- A $15 nationwide minimum wage by 2024 would generate a significant increase in living standards for about 41.5 million workers and their families in the U.S. while creating a minimal effect on employment and a small price increase borne by all consumers. The effects in Mississippi would be roughly similar.

- How can such a major improvement in living standards occur without adverse employment effects? While a higher minimum wage induces some automation, as well as increased worker productivity and slightly higher prices, it simultaneously reduces worker turnover and increases worker purchasing power.

- Our results leave open the possibility that minimum wages much higher than $15 might generate negative employment effects. At $15, however, the negative and positive effects on employment largely offset each other. A phased-in $15 minimum wage will be absorbed partly by employee turnover reductions and productivity increases, and mainly by modest price increases in restaurants and by increases in consumer spending.

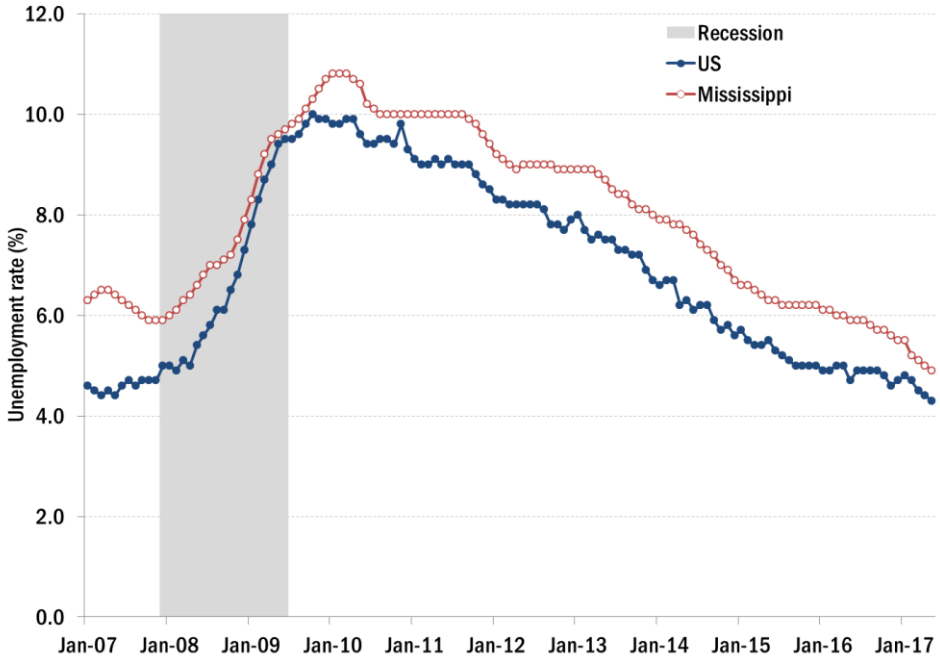
PART 1. THE POLICY CONTEXT

1. LABOR MARKET CONTEXT

We review here recent labor market conditions in the U.S. and in Mississippi. We focus on how five indicators changed during the Great Recession and the subsequent recovery: unemployment, employment changes, employment rates, worker pay, and pay inequality. Each indicator provides a somewhat different perspective on the nature of the current recovery.

The Great Recession began at the end of 2007; the recovery began in June 2009. As Figure 2 shows, U.S. unemployment rate continued to increase into 2010, later than the beginning of the economic recovery. Mississippi was especially affected by the recession, with the state unemployment rate reaching to about 11 percent. The Mississippi unemployment rate has been one of the highest in the nation. However, since 2010 the U.S. and Mississippi unemployment rates have fallen at about the same rate. By May 2017, the unemployment rate in Mississippi was 4.9 percent, lower than its 2007 pre-recession rate, and very close to the U.S. rate.

Figure 2. Monthly unemployment rates, 2007-2017

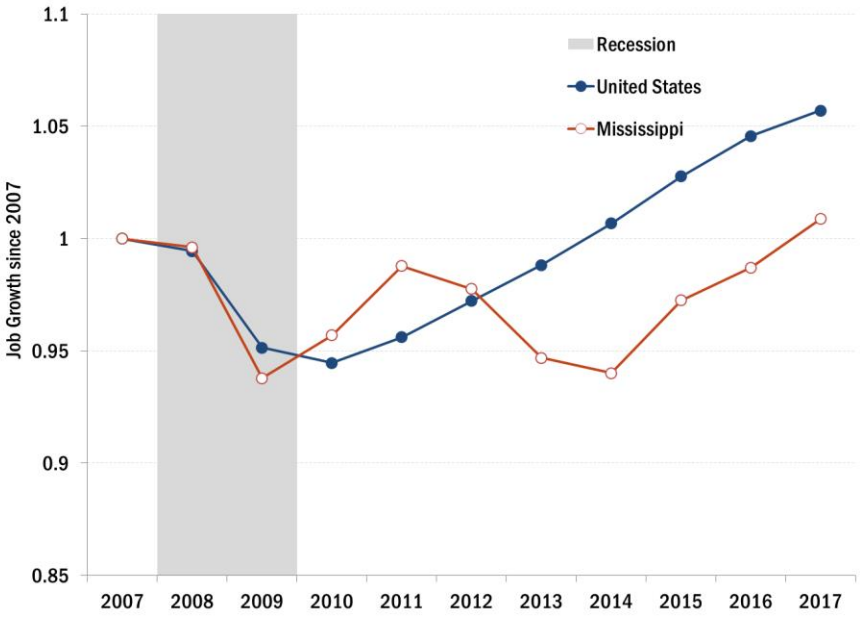


Sources: Monthly unemployment rates. Labor Force Statistics from the CPS for the U.S. Local Area Unemployment statistics for MS. These series are seasonally adjusted.

Figure 3 shows that the U.S. and Mississippi each experienced sizable job losses during the Great Recession, in about equal proportions for the nation and the state. Net job losses lasted longer in

Mississippi until 2014. Mississippi employment then recovered, growing at the same pace as in the U.S., and reaching its 2007 level in 2016.

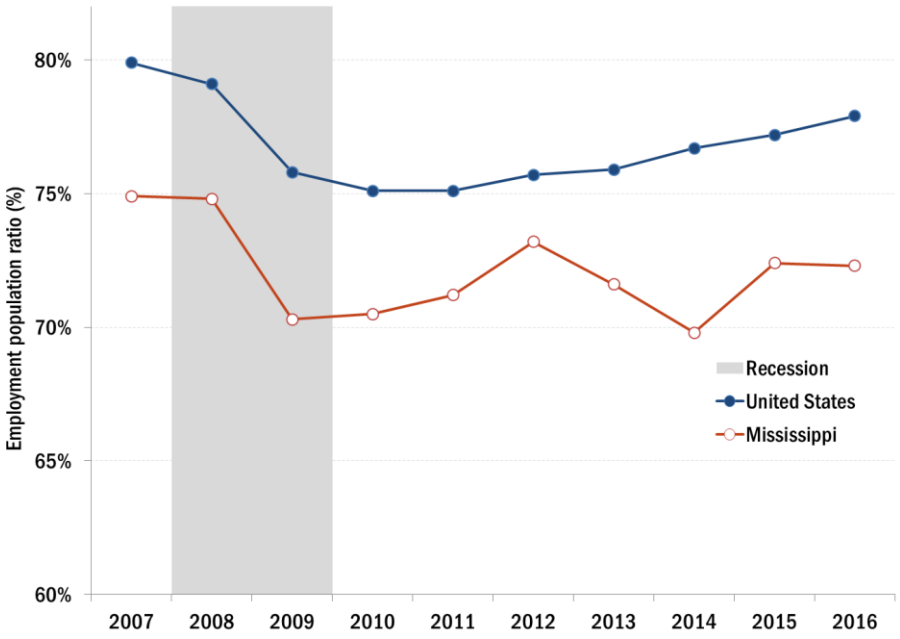
Figure 3. Employment changes, 2007-2016



Note: National and state employment levels are indexed to equal 1 in 2007.

Source: Authors' calculations of growth in total nonfarm payrolls (annual averages) since 2007 from Current Employment Statistics.

Figure 4. Employment to population ratio, 2007-2016, 25-54 year olds



Sources: Labor Force Statistics from the CPS for the U.S. Local Area Unemployment statistics for MS. These series are seasonally adjusted.

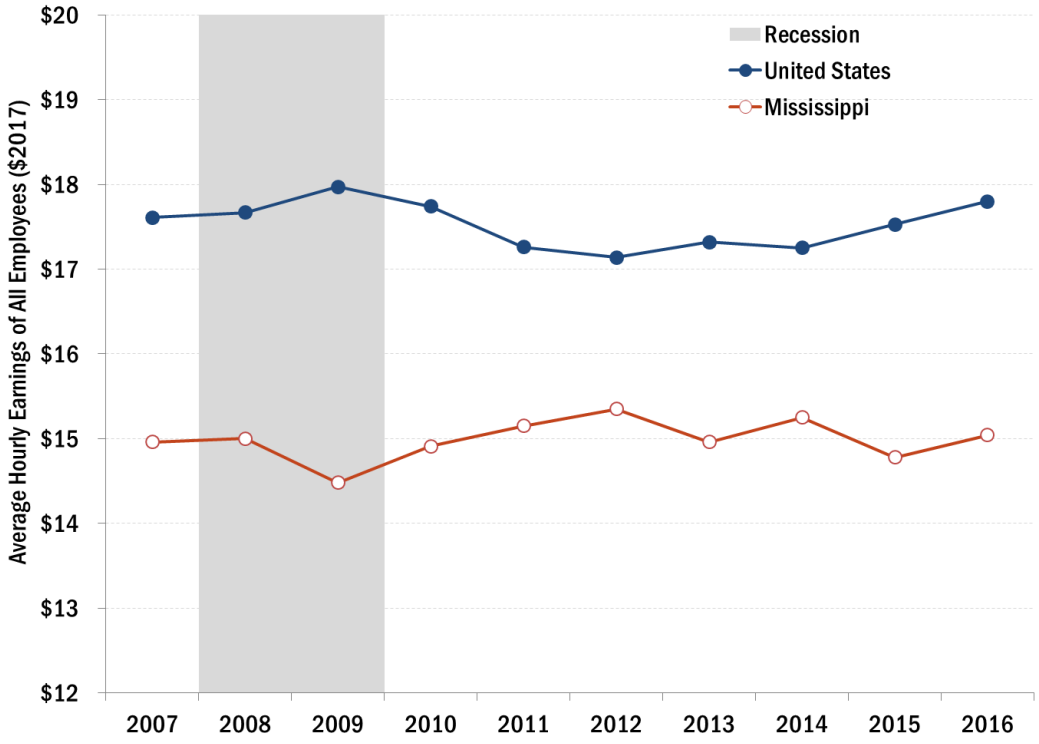
Figure 4 depicts trends in the employment rate -- the share of the prime working age population that is employed-- for both the U.S. and Mississippi. This indicator provides a companion to the unemployment rate, as it counts workers who stopped looking for work for whatever reason. After the employment rate in the U.S. fell rapidly during the Great Recession, it has been growing slowly since 2010. Nonetheless, the employment rate remains well below its pre-recession level. Economic analyses indicate that slow economic growth during the recovery is mainly responsible for the weak improvement of the prime working age employment rate.

The prime-age employment rate in Mississippi has long been below the U.S. rate. This pattern is present during the Great Recession-- and it has continued since. Indeed, despite the sustained decline in Mississippi's unemployment rate, the state's employment rate remains one of the lowest in the U.S.

We turn next to recent pay level and pay inequality patterns. Figure 5 displays recent trends in average hourly earnings, adjusted for inflation, in the U.S. and the Mississippi. Median hourly pay in Mississippi is the lowest of any state in the U.S. and considerably lower than the U.S. average. Hourly pay at first fell during the recession and then increased. Real average earnings continued

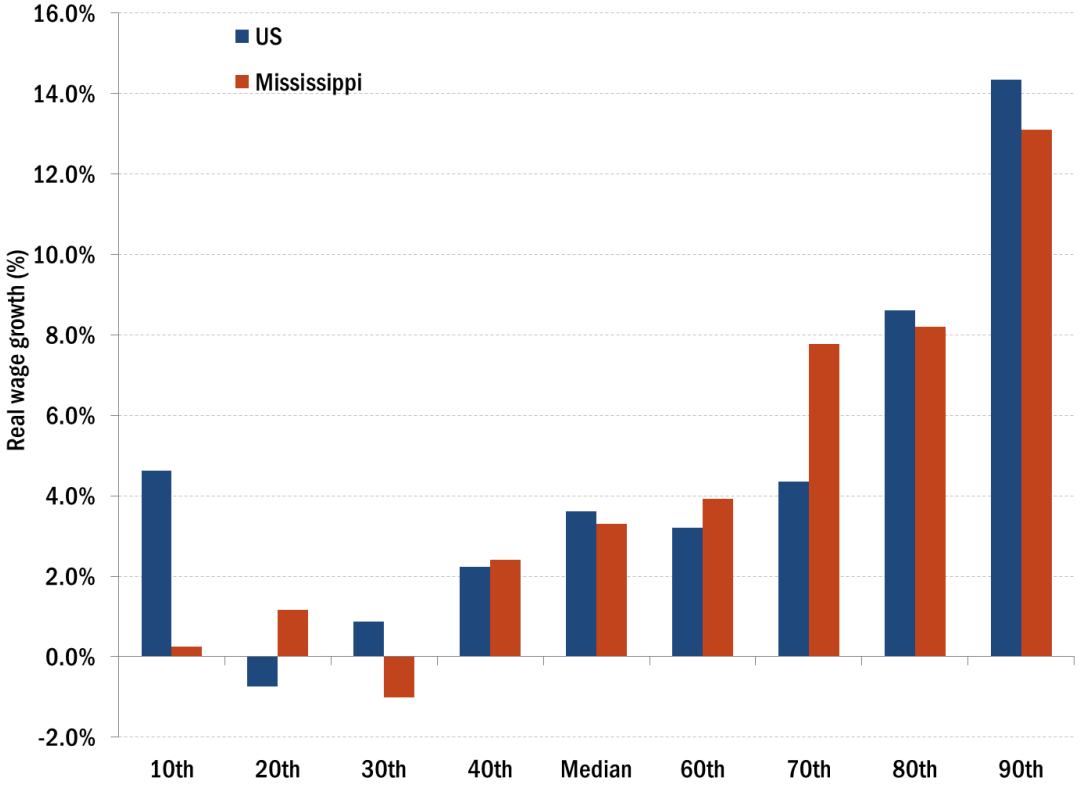
to decline during the first half of the economic recovery. Although real earnings have ticked up slightly since 2013, their level remains no higher than it was before the onset of the recession.

Figure 5. Median hourly pay, adjusted for inflation (in 2016 dollars)



Source: Current Population Survey data provided by the Economic Policy Institute. CPI-U-RS is used to translate nominal wage into 2016 dollars.

Figure 6. Real wage growth in the U.S. and Mississippi by wage percentiles, 2000-2016



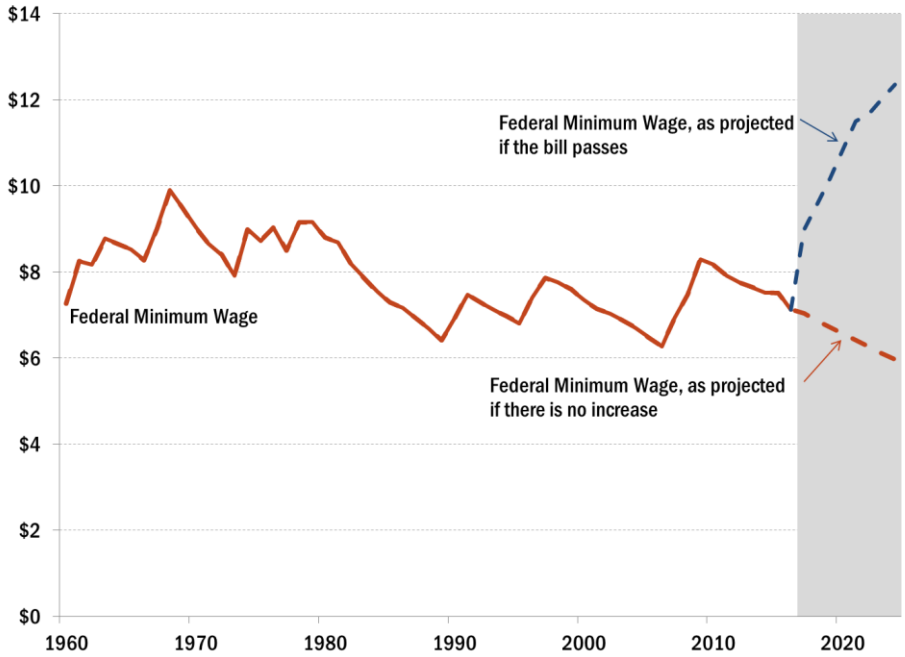
Source: Authors' analysis of Current Population Survey data provided by the Economic Policy Institute. CPI-U-RS is used to translate nominal wage into 2016 dollars.

Figure 6 shows that recent wage trends have been remarkably uneven. Despite six years of official economic recovery in the U.S., workers' real wages (adjusted for inflation) only increased for the bottom 10 percent of the nation's workforce in the U.S. and for those at the 80th percentile and above. In Mississippi, only workers between the median and the 70th percentile of the real wage distribution had increases.

In summary, unemployment and employment trends have improved substantially in recent years. However, the earnings of typical workers have not increased, despite the economic recovery.

2. MINIMUM WAGE INCREASE SCHEDULE

Figure 7. Federal minimum wage history with projections to 2024 (in 2017 dollars)



Source: All data are in 2017 dollars, adjusted using CPI-U-RS, as published by the Bureau of Labor Statistics. Projections assume an annual inflation of 2.3% in 2017-2018, 2.4% in 2019-2020, and 2.4% in 2021-2027, according to CBO projections for the consumer price index, see p.40: http://www.cbo.gov/sites/default/files/115th-congress-2017-2018/reports/52370-outlook.pdf.

Figure 7 displays the recent history of the federal minimum wage rate, adjusted for inflation and projected forward to 2024. Since 1980, Congress has passed bills raising the federal minimum wage on only three occasions. Since the federal minimum wage is not indexed to inflation, its value as declined over several long periods.

The red dashed line represents the future evolution of the federal minimum wage in the absence of any legislated increase. The blue dashed line represents the evolution of the federal minimum wage in 2017 dollars if the Raise the Minimum Wage Bill of 2017 is enacted.

Table 1 reports the U.S. minimum wage schedule proposed in the Raise the Wage Act of 2017. The minimum wage increases would be phased in over eight years, starting with $9.25 an hour on July 1, 2017 and reaching $15 an hour in 2024.

In this report, we use a slightly different and simplified schedule. We take into account enacted state minimum wage increases, but ignore interim increases that are implemented earlier by some cities and counties.

Table 1. Proposed federal minimum wage schedule

Date	New minimum wage (nominal)	New minimum wage ($2016)	New tipped minimum wage (nominal)	New tipped minimum wage ($2016)
July 1, 2017	$9.25	$9.04	$4.15	$2.76
July 1, 2018	$10.10	$9.65	$5.30	$3.45
July 1, 2019	$11.00	$10.27	$6.45	$4.10
July 1, 2020	$12.00	$10.95	$7.60	$4.72
July 1, 2021	$13.00	$11.58	$8.75	$5.31
July 1, 2022	$13.50	$11.75	$9.90	$5.86
July 1, 2023	$14.25	$12.12	$11.05	$6.39
July 1, 2024	$15.00	$12.46	$12.20	$6.90

Source: Raise the Wage Act of 2017

PART 2. EMPLOYMENT ANALYSIS FOR THE U.S.

1. THE BERKELEY CWED MINIMUM WAGE MODEL

Reich et al. (2015) developed a calibrated model to study the prospective impacts of a $15 minimum wage in Los Angeles.[1] This model was further enhanced to study the effects of a $15 minimum wage in New York State (Reich et al. 2016a), in San Jose and Santa Clara County (Reich et al. 2016b) and in California and Fresno (Reich et al. 2017). Those reports all focus on city and state policies. In this report, we build upon our previous model by incorporating macroeconomic considerations that become important in assessing a national policy. We also adapt the model to apply to Mississippi in particular.

Our estimates draw on standard government data sources, the large body of economic research on the minimum wage, other research studies, and a standard input-output economic model (IMPLAN). These data sources and models are fully documented in the text, accompanying endnotes, and in the appendix.

Our economic impact model recognizes that higher minimum wages will affect labor supply and labor demand. Adjustments to labor supply include lower employee turnover and reduced recruitment costs for employers. Standard labor supply studies of low-wage labor markets find elasticities of about 0.3, low enough to ignore as a first approximation. Our own as yet unpublished estimates of minimum wage labor supply elasticities are somewhat higher for some groups, notably low-educated parents of children under six. Since these estimates are preliminary, we do not incorporate them here. As a result, we may underestimate the positive effects of the policy on the earnings of these groups. Recent research reviews (Leigh, Leigh and Du 2019) indicate that minimum wages improve health outcomes and reduce absenteeism from work. We do not attempt to quantify these effects in our model, but note that they imply productivity improvements that will be larger in lower-wage states.

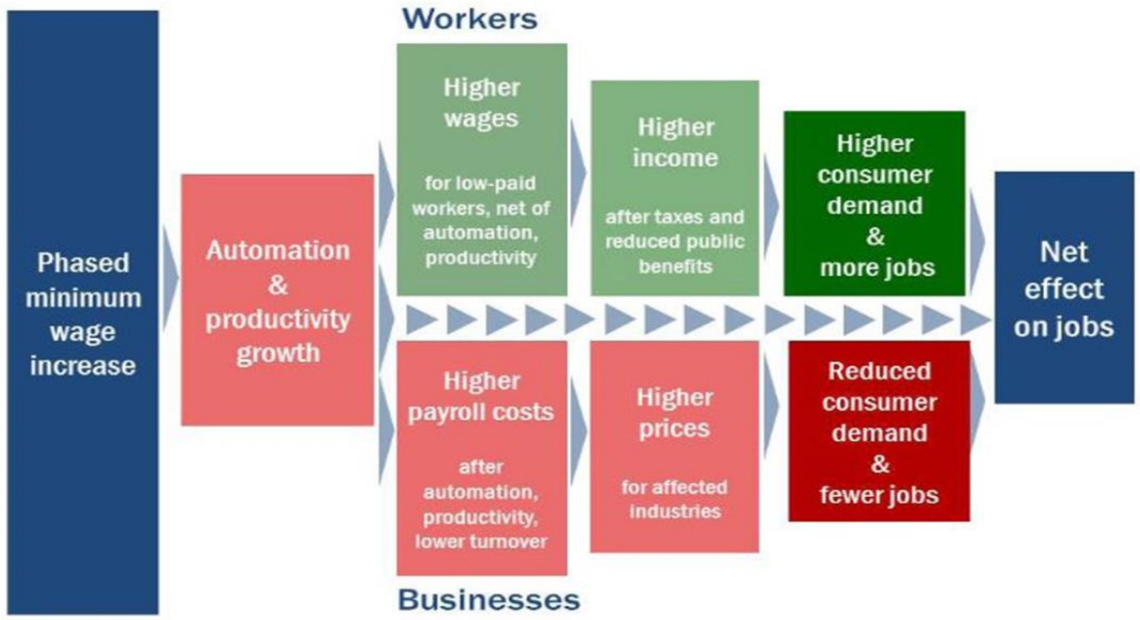
Adjustments to labor demand include possible substitution of capital or materials for labor and of skilled labor for unskilled labor, greater worker productivity when wages rise, reductions in employment because higher prices reduce sales, and increases in employment because workers' spending out of their higher income will increase sales and employment. The net effect depends upon the magnitudes of the individual adjustments, again taking into account interactions among them.

The labor demand model draws from standard labor economic textbook analyses. For industry labor demand, these analyses incorporate "substitution" and "scale" effects in labor, capital, and goods markets. (For a formal version of this labor demand model, see Cahuc, Carcillo and Zylberberg 2014). Since our concern here is on the effects of an economy-wide minimum wage, we add an "income effect." The income effect accounts for changes in the level of economic output when wage increases lead to increased consumer demand.

Model Structure

Figure 8 summarizes our model qualitatively in a flow diagram. The green boxes refer to the effects on workers and the red boxes refer to the effects on businesses. The automation and productivity box is placed first to highlight how businesses will respond to a minimum wage. Automation here refers only to capital-labor substitution that is induced by the minimum wage, not to the much larger degree of automation that has taken place for decades. Productivity growth can come from automation, from workers working harder or smarter when pay is high, and from workers having more experience, as when minimum wages reduce employee turnover.

Figure 8. UC Berkeley CWED minimum wage model



Examine next the effects on workers, shown in the green boxes and move from left to right. The first green box refers to the higher wages received by lower-paid workers. The next green box accounts for the net effect of taxes and reduced receipt of public benefit programs on workers' income. Workers will pay more in taxes as their wages increase and eligibility for public benefits will decline. The third box refers to how workers' increased spending power out of their higher net income translates into higher consumer demand and more jobs. We will refer to this mechanism as the *income effect* of minimum wages.

Examine now the effects on businesses and again move from left to right. The higher minimum wage will increase businesses' payroll costs, but some of these higher costs will be offset because employee turnover will fall, generating savings in recruitment and retention costs. Firms may also find that higher-paid and more experienced workers will be more productive, which

could also offset payroll cost increases. In other words, one effect of a higher minimum wage is to induce more efficient management practices.

Higher payroll costs (net of turnover and productivity savings) will lead firms to increase prices, leading to reduced consumer demand. We will refer to this adjustment mechanism as the *scale effect*, as it identifies reductions in the scale of output that will reduce the demand for workers.

As we have already mentioned, businesses may also respond to higher minimum wages by increasing their investment in equipment. This *substitution effect* (think automation) also reduces their demand for workers.

The income effect has a positive effect on employment, while the scale and substitution effects each have negative effects on employment. The sum of the income, scale, and substitution effects determines the net employment effect of the minimum wage, as shown in the blue box on the right side of Figure 8.

Figure 8 is useful for understanding the basic structure of our model. But it leaves out some important details. First, the effects on businesses and workers in the red and green boxes of the model occur simultaneously, not sequentially. The effects in reality are therefore captured only by examining the net effects on the economy and employment. These net effects are symbolized by the blue box at the right of the diagram. Second, Figure 8 omits some lesser feedback loops that would make the figure unwieldy, but which are included in our calculations.

Model calibration and dynamics

The net effect of minimum wages on employment equals the sum of the income, scale, and substitution effects. The income effect will always be positive, while the scale and substitution effects will always be negative. Whether the net effect is positive, zero, or negative therefore depends upon the relative magnitudes of its three components.

These relative magnitudes in turn depend upon the quantitative responses of workers and businesses to a minimum wage increase. We refer to the model's parameters as the inputs that determine these multiple quantitative responses. Some of these parameters, such as the propensity to substitute capital for labor, may not vary with the magnitude of the minimum wage increase. Other parameters, such as turnover cost savings, are likely to vary with the size of the increase. As with any economic model, we calibrate our model using the best data and research findings available. The details are presented in Section 5 below and in the Appendix.

Note that the substitution, turnover and productivity effects operate entirely on low-wage workers, while the scale and income effects operate on the entire wage distribution of workers. It is thus possible that minimum wage policies that do not reduce employment overall can still reduce the number of low-wage jobs and increase the number of middle and high wage jobs. Since the wage

distribution of jobs is thickest in its middle ranges, we would expect most of the new jobs to be located near the middle of the wage distribution.

The model's parameters and dynamics must be consistent with two conditions. First, the model must be consistent with the very small effects that researchers find for the smaller pre-2015 increases in federal and state minimum wages. Second, the model must be consistent with growing negative effects if minimum wages were to reach extremely high levels, such as at $30 or $40 per hour.

Reich et al. (2017) show that our calibrated model predicts extremely small employment effects for minimum wage increases of up to 25 percent, to a minimum wage of $10. At this minimum wage, the income, scale, and substitution effects are each very small. At minimum wages well above the mean, the (positive) income effect weakens because the increase in the proportion of workers getting pay increases slows down, and because the propensity to consume of higher-paid workers is lower than that of lower paid workers. At the same time, the (negative) scale effect strengthens because turnover cost savings diminish and the price elasticity of consumer demand becomes higher for higher-priced goods.[2] Our model is thus consistent with growing negative employment effects at higher minimum wage levels.

The big question, of course, is: At what level do the negative effects become important? How quickly do they become still more negative?

We have tested our model's calibration by undertaking a series of robustness tests. The tests show that this net effect changes by small amounts when we vary the model's parameters. In the next sections, we discuss how we quantify the effects in each of the boxes in Figure 8.

Macroeconomic considerations

Our state and local prospective studies of possible employment effects at $15 accounted for capital-labor substitution possibilities in low-wage industries, efficiency-wage like productivity increases, reduction in employee turnover costs, price increases that would reduce consumer demand and therefore employment, and increased consumer demand resulting from higher consumption propensities among low-wage workers—calculated from the net income increase after increased tax payments and reduced receipt of public transfer programs. When relevant, we also considered spending leakages because of in-commuters who lived outside the city or state.

We consider here three issues for modeling a prospective study of a $15 federal minimum wage policy that were not salient for our modeling of prospective state and local increases: price increases and pass-throughs of intermediate goods; changes in interest rates if inflation increases; and potential output constraints that could generate inflation and constrain the income effect.

1. Price changes of intermediate inputs

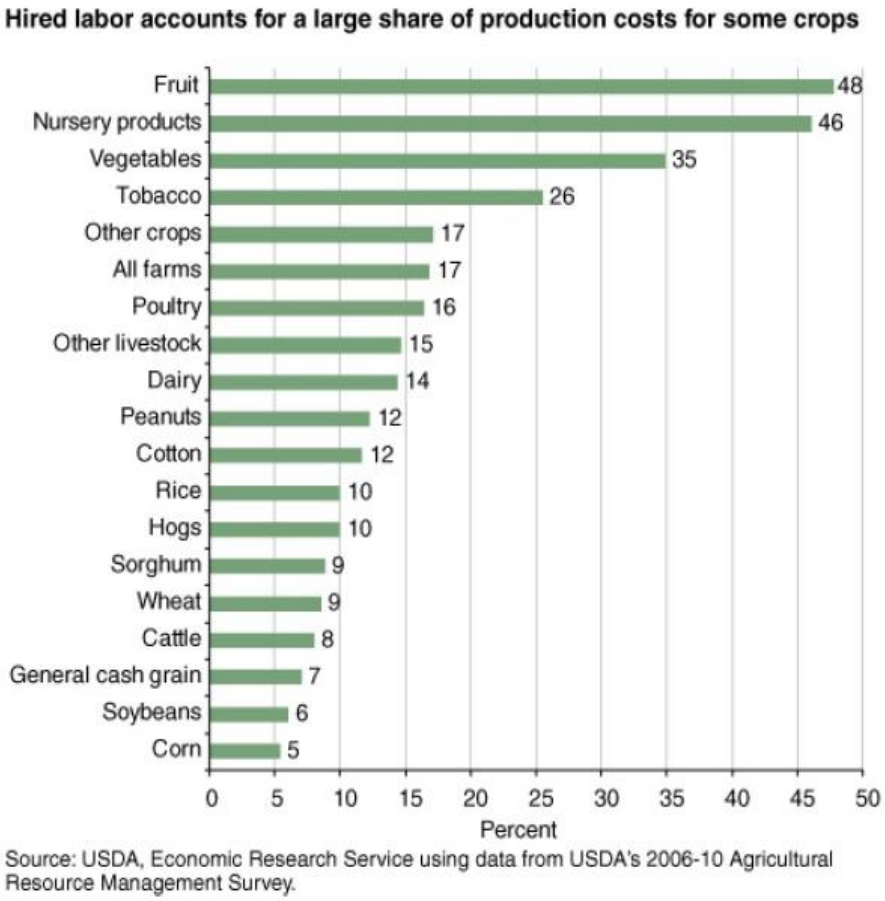
In our state and local prospective studies, we estimated price effects by focusing solely on changes in payroll costs after taking into account minimum wage effects on capital-labor substitution, on increasing productivity growth and on reducing employee turnover costs. Here we examine adjustments in the quantities and prices of intermediate inputs that might be passed on to final demand industries. Concerning quantities of inputs, previous work (cited in Harastozi and Lindner 2015) shows that labor-materials substitution elasticities are close to zero. Changes in quantities of materials will not offset payroll increases.

Concerning input prices, we assumed that effects of higher state and local minimum wages on materials prices would be constrained, to the extent that these prices are determined at the national level. This constraint does not apply in the case of a federal minimum wage increase.

Materials prices will increase in proportion to the share of low-wage labor costs in their operating costs. In practice, only a few intermediate inputs embody a large enough share of low-wage work to generate detectible price effects from a $15 federal minimum wage. In practice, the most affected intermediate input industries are the agricultural sectors that are low-wage and labor-intensive, much of food manufacturing and much of apparel manufacturing. Agriculture and food manufacturing prices are partly limited by prices of agricultural imports. Import competition will almost completely limit price increases in apparel manufacturing.

The materials most affected by changes in input prices are thus food and food products used or sold in restaurants and retail. (We ignore direct farm sales to consumers, such as at farmers' markets, because they constitute a small percentage of total farm sales.) Material inputs in other industries that are highly affected by minimum wage increases, such as childcare, care for the disabled and elderly, and janitorial and protective services, do not use materials in sufficient quantities to be affected substantially by changes in materials prices.

Regarding agriculture, labor accounts for 17 percent of operating costs in agriculture overall. But this average masks substantial heterogeneity by sector, as the chart below shows:



In general, the more labor-intensive sectors are those that have proven difficult to mechanize and pay lower wages to their workers. These are concentrated among fruits, vegetables and horticultural nursery products. (Wages in poultry are also low.) Within fruits, vegetables and horticultural products, we can further distinguish between crops whose planting and harvesting are nearly fully mechanized (tomatoes, almonds) from those that are hardly mechanized (strawberries, oranges). Fruit, vegetables and nursery products together account for about-one fourth of U.S. agricultural product.

Method Our method is iterative. In the first round we estimate price increase for individual two-digit industries using only the changes in labor-related costs, just as in our previous studies. In the second round, we enter these price increases into the material costs expression of the price equation. Since only a few inputs and outputs are likely to be significantly nonzero, we expect that the second round effects will be significant but much smaller than for the first round. We then test this intuition by computing a third round, using round 2 price increases for inputs into the price equations. If round 3 generates additional detectible effects, we continue through further rounds, until the results have significantly converged.

2. Effects on growth and employment through the interest rate channel

If our state-level price effects estimates are a guide to the federal effect, overall prices nationally would increase cumulatively by about 0.4 percent over the eight years to 2025. The CBO model forecasts 2 percent inflation between now and then. It also predicts that real interest rates will be above the zero lower bound that has applied in recent years.

If inflation is higher because of the $15 minimum wage policy, the Federal Reserve Board might increase the federal funds rate, which in turn could have a negative effect on inflation and on real economic growth and employment. (The federal funds rate is the price the Fed charges for overnight borrowing by banks; changes in this rate are usually fully passed along to short-term rates for consumers and businesses.)

Modern macroeconomic theory posits that the Federal Reserve Board will use a formula known as the Taylor Rule to set the federal funds rate:

$$r = p + .5y + .5(p - 2) + 2$$

where r = the federal funds rate, p = the inflation rate and y = the gap between potential and actual output. The Taylor Rule implies that the real federal funds rate would adjust by 0.5 time the amount that inflation exceeds 2. A minimum wage-generated increase in the inflation rate from 2.0 to 2.4 thus implies that the federal funds rate would increase, by 2025, by 0.20 points more than it would, absent the minimum wage policy.

The quantitative effects of this small increase on the longer-term interest rates that are relevant to much consumer and business borrowing are highly uncertain, as they depend upon expectations of the future. Some economists forecast that we have entered an era of secular stagnation for interest rates and economic growth. If they are correct, a 0.20 increase by 2025 would not have any measurable effects on longer-term interest rates. If they are wrong, the effects might be detectable, but it remains unlikely that the effects on economic growth and employment would be of more than modest importance. We conclude that the effects of $15 federal minimum wages on interest rates are too small and uncertain to warrant including in our federal model.

3. Capacity constraints that could generate inflation rather than output growth

CBO projections assume that economic growth through 2024 will continue to close the gap between potential and actual output, while maintaining inflation at the Federal Reserve Board's target rate of 2 percent. Of course, the economy's future growth path, absent a federal minimum wage increase, might differ from these projections. Nonetheless, these projections constitute our baseline.

3. EFFECTS ON WORKERS

We begin with the effects on workers, shown in the green boxes in Figure 8. To quantify these effects we draw upon the estimates in Cooper (2017). Cooper applies the federal $15 minimum wage proposal to the U.S. wage distribution to estimate the number of workers who will receive a wage increase, as well as the size of those wage increases. To do so, Cooper's model simulates changes in the U.S. wage distribution in future years, under two scenarios. In the first scenario, the proposed minimum wage policy is not adopted, but wages increase in line with recent trends; in the second scenario, the policy is adopted.

Cooper estimates, for each scenario and each yearly phase-in step, the number of workers who would be affected by the law and the additional wages they would receive as a result. In constructing these estimates, Cooper's model adjusts for expected growth in employment, real wages, and inflation over time. His estimates also take into account what is often referred to as an "indirect" or "compression" effect: workers who make slightly more than the new proposed minimum wage level are also likely to receive wage increases.

3.1 Workforce Impacts

Table 2 shows the estimated number and percentage of eligible workers who will receive pay increases by 2024. Cooper (2017) estimates that 41.5 million U.S. workers will receive a pay raise by 2024, or about 29.2 percent of the eligible workforce. Of these, 22.5 million would receive increases because their pay would otherwise be below $15 per hour when the increases would be fully implemented in 2024 (the group directly affected by the law). Another 19.0 million would receive pay increases because their pay would be only slightly more than $15 when the increases would be fully implemented (this the group indirectly affected by the law).

Table 2. Cumulative pay increases for workers by 2024

Percent of the workforce receiving pay increases	29.2
Total number of workers receiving increases (millions)	41.47
Number of workers affected directly (millions)	22.48
Number of workers affected indirectly (millions)	18.98
Average hourly wage increase ($2016)	$2.08
Annual earnings increase, for workers receiving increases ($2016)	$3,470
Percent earnings increase for workers receiving increases ($2016)	17.3
Total aggregate increase in wages (billions, $2016)	$144

Source: Cooper (2017) analysis of CPS data.

Note: Eligible workers are those that work in the city/county where the new minimum wage policy is implemented. Directly affected workers earned between 50 percent of the old minimum wage and 100 percent of the new minimum wage. Indirectly affected workers earned between 100 percent and 115 percent of the new minimum wage. Average annual earnings per worker, not per job.

Table 2 also displays the additional earnings that affected workers would receive: the estimated cumulative increase in affected workers' hourly wages, annual earnings, and percentage increase in annual earnings, as well as the cumulative total earnings increase for all affected workers. Cooper (2017) estimate that the hourly wages of workers who will receive pay increases will rise by about $2.08 by 2024. That amounts to an estimated additional $3,470 in earnings per year. In total, workers will receive an additional $144 billion in aggregate pay by 2024.

3.2 Impact on Benefits Eligibility

Some policymakers have expressed concern that affected workers and their families could ultimately be worse off after minimum wage increases if they are no longer eligible for means-tested social assistance programs. However, research suggests that most workers will come out well ahead financially, because the benefits from most social assistance programs phase out gradually as recipients' income rises. As the pay of affected workers increases, the benefits they receive will gradually decline—they are not eliminated all at once. The Congressional Budget Office (Congressional Budget Office 2012) estimates that the average marginal tax rate for low- and moderate-income workers is 34.8 percent, meaning that affected workers will keep 65.2 cents of each additional dollar they earn. So while taxes and reductions in social assistance benefits will offset some of the additional earnings for affected workers, most families will still obtain significant net gains in income from the minimum wage increases.

3.5 Downstream effects

The increases in earnings shown in Table 2 would be substantial and would have an immediate impact on the lives of low-wage workers and their families. But it is important to recognize that there are longer-term effects of minimum wage increases as well.

Low wages have been shown to affect workers negatively in a variety of ways, but the health impacts are most pronounced. All else being equal, low wages (and in turn poverty) result in increased rates of high blood pressure and high levels of stress, as well as shorter life expectancy (Leigh and Du 2012). A recent study from the United Kingdom found that by reducing the financial strain on low-wage workers, an increase in the minimum wage improves mental health at a level comparable to the effect of antidepressants on depression (Reeves et al. 2016). In another study, additional income led to fewer arrests for parents and increases in parental supervision of their children (Akee et al. 2010). Similarly, increases in Earned Income Tax Credit (EITC) program payments led to improvements in the mental health of mothers (Evans and Garthwaite 2010; Congressional Budget Office 2012), as well as reduction in the incidence of low birth weights (Hoynes, Miller, Simon 2015).

Multiple studies also establish a causal negative effect of low incomes on outcomes for children. A recent review of peer-reviewed articles found that 29 of 34 studies established a negative effect of poverty on children's outcomes (Cooper and Stewart 2013). Using data from a randomized control trial of the Minnesota Family Investment Program, researchers found positive, significant effects on children's social behavior and school engagement due to increases in income (Morris and Gennetian 2003). Other researchers analyzed data from ten such studies and found significant effects of increased income on school achievement (Rodgers 2004). Similarly, increases in the Earned Income Tax Credit are found to lead to large benefits on math and reading test scores in elementary and middle schools (Dahl, and Lochner 2012; Chetty, Friedman, Rockoff 2011; Maxfield 2014). The EITC also leads to higher rates of high school completion (or GED) and higher college attendance rates (Maxfield 2014; Manoli and Turner 2014). This in turn translates into better employment outcomes and higher earnings (Bastian, Michelmore 2015).

Generally, these studies show that additional income has a positive effect on the outcomes of children in households of all income levels. However, multiple studies also suggest that additional income has a larger effect in very-low-income households compared to middle-income households (Dahl and Lochner 2012; Akee et al. 2010; Costello et al. 2003). Some evidence indicates that additional income early in life is important to cognitive outcomes, whereas additional income in later childhood may be more important in terms of behavioral outcomes (Cooper and Stewart 2013).

4. EFFECTS ON BUSINESSES

How a higher minimum wage affects a firm depends on how much the firm's operating costs change and on how the firm responds to those changes. In this section, we first identify the industries that will be highly affected by the two minimum wage increase scenarios. We then estimate the impact of the minimum wage increases on firms' operating costs across the entire economy and for highly affected industries, taking into account savings from reduced turnover.

Minimum wage increases do not affect all industries equally. Table 3 shows the estimated distribution of affected workers across U.S. industries by 2024. In the first column, we show the percentage of the overall eligible workforce in each industry. The second column displays our estimate of *the distribution across industries* of workers getting a raise. The third column presents our estimate of the percentage of workers getting a raise *within each industry*.

About 40 percent of affected workers are employed in just three service sector industries: food services (15.6 percent), retail (18.2 percent), and health services (10.5 percent), which is comprised mainly of building services contractors and employment agencies. The service sector also dominates the list of industries that have high rates of low-wage work—that is, industries in which a high share of workers will get a raise (for example, 67.8 percent in food services and 47.0 percent in retail).

Table 3 also displays the sectoral distribution of affected workers who will get pay increases.

Table 3. Cumulative impacts for workers by major industries in the U.S. by 2024

	Percent of all workers getting raises	Percent of industry workers getting raises	Percent change in industry's payroll costs
Agriculture, Forestry, Fishing, Hunting	1.5	42.6	4.8
Mining	0.2	10.7	0.5
Construction	4.2	20.7	1.3
Manufacturing	8.5	22.8	1.3
Wholesale Trade	1.7	20.5	1.2
Retail Trade	18.2	47.0	4.2
Transportation, Warehousing, and Utilities	3.9	21.0	1.3
Information	1.1	17.1	0.7
Finance, Insurance, Real Estate, and Rental and Leasing	3.7	16.1	0.6
Professional, Scientific, and Management	2.2	9.5	0.3
Administrative and Waste Management Services	5.8	40.2	3.7
Educational Services	6.8	20.5	1.2
Health Services	10.5	25.5	1.5
Social Assistance	2.8	38.9	3.8
Arts, Entertainment, Recreation, and Accommodation	4.9	46.2	4.6
Food Services	15.6	67.8	11.3
Other Services	5.9	38.9	3.8
Public Administration	2.5	14.3	0.7
Total	100	29.2	1.9

Source: Cooper (2017) analysis of CPS data.

Note: The percent change in payroll costs includes payroll taxes and workers' compensation as well as employee turnover savings. The percent change in payroll costs presented here does not take into account the reduction in the total wage bill due to substitution and productivity-based job losses. We do integrate these effects into the model calculations.

We determine changes in a firm's operating costs due to a minimum wage increase from the following factors: the share of workers receiving wage increases, the average size of the wage increases, and the labor share of operating costs within the firm. As we saw in Table 3, in most industries only a minority of workers will receive a wage increase. Furthermore, among workers that do receive an increase, not everyone will receive the full increase (because many of the affected workers already earn more than the current minimum). Specifically, we estimate that the total wages of all affected workers will increase by 17.3 percent. However, affected workers' wages represent only 13.0 percent of all workers' wages in the U.S. As a result, total wages will increase by only 1.9 percent.

Economic research suggests that some of the increased labor costs that businesses face as a result of a higher minimum wage can be offset through lower turnover. In our calculations below, we take the midpoint of those estimates and assume that 17.5 percent of increased labor costs are absorbed via turnover savings in the first year.[3] These savings are likely to accrue at smaller rates as wage levels go higher; we therefore assume that by 2024 the marginal increase in earnings relative to 2017 no longer yields any additional turnover savings. As a result, we estimate that the total savings from turnover at a $15 minimum wage in 2024 would be 7.5 percent of increased labor costs.[4]

Operating Costs and Prices

Table 4 shows our estimates of the increase in business operating costs (net of savings from reduced turnover) in all sectors. By 2024, we estimate that businesses in the restaurant industry would see their payroll costs rise by 11.3 percent and businesses in the retail industry would see their payroll costs rise by 4.2 percent; these cost estimates include payroll taxes and workers' compensation insurance expenses.[5] Across the entire U.S. economy, we estimate that payroll costs would rise by 1.9 percent by 2024.

However, operating costs will rise by a much smaller amount, because labor costs only make up a portion of the total costs that businesses face. We estimate that labor costs excluding health benefits will account for 38.3 percent of restaurant operating costs, 12.0 percent of retail operating costs, and 29.1 percent for the overall economy by 2024. We therefore estimate that total operating costs would rise by 2024, by 4.3 percent for restaurants, 0.5 percent for retail, and 0.6 percent for the overall economy. (See Appendix A2.2 for more detail on how we estimate the labor share of operating costs by industry.)

Table 4. Cumulative cost impacts for U.S. industries by 2024

	Percent change in payroll costs	Labor costs as percent of operating costs	Percent change in operating costs and prices
All Sectors	1.9	29.1	0.6
Agriculture, Forestry, Fishing, Hunting	4.8	16.8	0.8
Mining	0.5	16.8	0.1
Construction	1.3	33.7	0.5
Manufacturing	1.3	17.4	0.2
Wholesale Trade	1.2	8.8	0.1
Retail Trade	4.2	12.0	0.5
Transportation, Warehousing, and Utilities	1.3	28.3	0.4
Information	0.7	21.2	0.2
Finance, Insurance, Real Estate, and Rental and Leasing	0.6	16.1	0.1
Professional, Scientific, and Management	0.3	47.6	0.2
Administrative and Waste Management Services	3.7	44.6	1.7
Educational Services	1.2	56.2	0.7
Health Services	1.5	49.8	0.8
Social Assistance	3.8	49.8	1.9
Arts, Entertainment, Recreation, and Accommodation	4.6	34.3	1.6
Food Services	11.3	38.3	4.3
Other Services	3.8	44.5	1.7
Public Administration	0.7	52.4	0.4

Source: U.S. Census, *Annual Wholesale Trade Report* and Cooper (2017) analysis of CPS data. See Appendix for details.

Note: The percent change in payroll costs includes payroll taxes and workers' compensation as well as employee turnover savings. In this table, the percent change in payroll costs does not take into account the reduction in total wage bill due to substitution and productivity gains job losses. Those effects are, however, integrated later, in the calculations we perform in our model.

5. EFFECTS ON EMPLOYMENT

In previous sections, we have assessed the benefits to low-wage workers as well as the impact on businesses' operating costs in particular industries. In this section we consider whether the proposed policy would generate net gains or losses to the U.S. economy.

In Section 5.1, the key issues concern how much employers will substitute equipment or skilled labor for unskilled labor and how much of their cost increases employers will pass on in the form of higher prices. In Section 5.2, we discuss who might pay the costs of the higher minimum wage. Higher prices reduce consumption demand, which translates into reductions in employment and economic activity.

Section 5.3 examines the increased spending that derives from the higher income of low-wage workers. We take into account the effects of taxes and reduction in public benefits on the affected workers' take-home pay and the rate at which their households spend income compared to others. Greater spending from consumers increases economic demand, which translates into increases in employment and economic activity.

The net effects on the economy will then depend upon the sum of the effects estimated in each of these three sections. Section 5.4 estimates these net impacts on economic activity and employment.

Reductions in paid hours relative to working hours

Some commentators assert that a higher minimum wage will lead employers to cheat workers of a portion of their wages. However, such practices already exist; the question at hand is how much the minimum wage increase will increase their prevalence and intensity. Although it is difficult to measure changes in wage theft, we know that employee-reported increases in pay (to a census surveyor) after a minimum wage increase match up well to employer-reported increases in pay on administrative reports that determine payroll taxes (Dube, Lester, and Reich 2010). These results suggest that most employers comply about as much after the increase as before.

Employee turnover and employer recruitment and retention costs

The correlation between low wages and high employee turnover is well known (Cotton and Tuttle 1986).[6] Over the last decade, annual employee turnover in accommodation and food service averaged 70 percent a year, compared to 41.4 percent in other services, 30.5 percent in health care and social assistance, and 32 percent in non-durable manufacturing (Statistics 2014).[7] Quits are higher in low-wage occupations because workers leave to find higher-wage jobs or because they are unable to stay in their jobs due to problems such as difficulties with transportation, child care, or health.

Recent labor market research has gone beyond establishing a correlation between pay and turnover. We now know minimum wage increases have well-identified caU.S.al impacts that

reduce worker turnover. Dube, Naidu and Reich (2007) found that worker tenure increased substantially in San Francisco restaurants after the 2003 minimum wage law, especially in limited service restaurants. Dube, Lester and Reich (2016) found that a 10 percent increase in the minimum wage results in a 2.1 percent reduction in turnover for restaurant workers and for teens. Jacobs and Graham-Squire (2010) reviewed studies of the impact of living wage laws on employment separations and found that a 1 percent increase in wages is associated with a decline in separations of 1.45 percent.

Turnover creates financial costs for employers (Blake 2000; Dube, Freeman, and Reich 2010; Hinkin and Tracey 2000). These costs include both direct costs for administrative activities associated with departure, recruitment, selection, orientation, and training of workers, and the indirect costs associated with lost sales and lower productivity as new workers learn on the job. Hinkin and Tracey (2000) estimate the average turnover cost for hotel front desk employees at $5,864. A study of the cost of supermarket turnover by the Coca Cola Research Council estimates the replacement cost for an $8 an hour non-union worker at $4,199 (Blake 2000). Boushey and Glynn (2012) estimate that the median replacement cost for jobs paying $30,000 or less equals 16 percent of an employee's annual salary.

Pollin and Wicks-Lim (2015) estimate that 20 percent of the increased costs from a minimum wage increase are offset by reductions in turnover. Similar estimates can be found in Fairris (2005) and Jacobs and Graham-Squire (2010). In a small case study of quick service restaurants in Georgia and Alabama (Hirsch, Kaufman, and Zelenska 2011), managers reported they offset 23 percent of the labor cost increases through operational efficiencies.

For our calculations below, we assume that 17.5 percent of the increase in payroll costs is absorbed through lower turnover in the early years of the proposed minimum wage increase.[8] However, these turnover savings do not continue to grow at higher wage levels. Dube, Lester and Reich (2016) find that most of the reduction in turnover occurs among workers with less than three months of job tenure. Zipperer (in progress) also finds that employee turnover rates begin to level off at wages that are twice the minimum wage.

These results suggest that the effect of higher wages on increasing tenure dissipates as wage levels increase. We therefore assume that the increases in wages after 2020 no longer result in turnover reductions, yielding an overall lower rate of savings from turnover of 7.5 percent in 2024.

Impact of higher wages on worker performance

Paying workers more can also affect worker performance, morale, absenteeism, the number of grievances, customer service, and work effort, among other metrics (Hirsch, Kaufman, and Zelenska 2011; Reich, Jacobs, and Dietz 2014; Ton 2012; Wolfers and Zilinsky 2015).

Efficiency wage models of the labor market argue that wage increases elicit higher worker productivity. The possible mechanisms include: When employers pay workers more, workers are

more willing to be more productive and require less supervision; workers remain with the firm longer and thereby gain valuable experience; and higher pay tends to reduce idleness on the job. This theoretical result holds whether one company raises its wage above the market-clearing level, or whether all do (Akerlof and Yellen 1986).

Reduced employee turnover means that workers will have more tenure with the same employer, which creates incentives for both employers and workers to increase training and therefore worker productivity. A large scholarly literature makes this point, and it has been emphasized recently by firms such as Walmart, TJ Maxx, and The Gap as principal reasons underlying their announced policies to increase their minimum wages nationally to $10. However, because of the lack individual- or firm-level productivity data, the earlier efficiency wage literature does not provide a reliable quantitative assessment of the importance of the effect on worker productivity among low-wage workers.

A recent paper by Burda, Gedanek and Hamermesh (2016) does just that. Using microdata for 2003- 2012 from the American Time Use Study, Burda et al. find that working time while on the job increases when wages are higher. Their results imply that an increase in hourly pay from $10 to $15 increases the level of productivity by 0.05 percent.

Burda et al.'s estimate may be too high, given the difficulty of disentangling cause from effect in their idleness data. On the other hand, they do not have measures of worker engagement while working, which could make the actual worker productivity improvement potentially twice as large. To capture this range of productivity effects in our model, we use the low Burda et al. estimate of 0.05 percent.[9]

A recent study by John Abowd et al. (2012) demonstrates the substantial room for productivity and wage growth in low-wage industries in the U.S. Using longitudinally linked employer-employee data, Abowd et al. disentangle wage differentials among industries that are attributable to individual heterogeneity (such as the demographic, educational, and work experience characteristics of workers in the industry), which they label person effects, from the characteristics of the product market and bargaining power of firms in the industry, which they label industry effects.

Abowd et al. can observe wage changes when individual workers move from one employer to another. They find very strong industry average firm effects, particularly for industries that have high average pay and low average pay. Among restaurants, for example, they find that 70 percent of the relatively low wages in the industry are attributable to firm effects, and only 30 percent to person effects. These findings suggest that a change in an industry's environment can have large effects on worker pay.

Effects on prices

As we have seen, previous prospective studies have made different assumptions on how much costs will affect prices—and therefore also profits. Card and Krueger (1995) provide an extensive

discussion of this issue. As they point out, from the point of view of an individual employer in a perfectly competitive industry, profits would be unaffected only in the extreme case in which firms can costlessly replace low-wage labor with high-skill labor and/or capital, and without cutting output. Since such substitutions are in fact costly, from this perspective a minimum wage increase would have to reduce profits. Firms do not envision a price increase as a solution, as it fears losing sales to its competitors.

A different result emerges when Card and Krueger consider the point of view of an industry as a whole. This perspective is necessary since the minimum wage increase applies to all the firms in an industry. Now, when individual firms respond to the prospect of reduced profits by raising their prices, they find that other firms are doing the same. Some of the price increases will stick and the industry will recapture some of the reduced profits. However, since demand for the industry's product is not fixed, this increase in price entails some reduction in product demand, implying that industry output (and therefore employment) will fall. In other words, the price increase will permit employers to recover only a portion of their reduced profits. Card and Krueger do not, however, take into account the income effect that will increase sales when a minimum wage applies to an entire economy, not just a single industry.

The evidence on whether profits do fall is extremely scant. The most important study remains the one in Card and Krueger (1995). These authors obtained mixed results when examining the effects of minimum wage changes on shareholder returns for fast-food restaurant chains. Using British data, Draca et al. (2011) find a small negative effect on profits. However, one segment of this study uses data for firms in the British residential care industry. Firms in this industry were not permitted to increase prices, making the results not very useful for other sectors. Harasztosi and Lindner (2015) examine a large (60 percent) and persistent increase in the Hungarian minimum wage, which affected much of manufacturing. These authors find that cost increases were entirely passed through, but employment did not change and profits did not fall. Of course, the relevance of the British and Hungarian studies for the U.S. is highly uncertain.

In our model, employers pass all of the increase in operating costs stemming from a minimum wage increase onto prices, after accounting for the above-mentioned turnover savings, automation, and productivity growth. Studies of price effects of minimum wages are consistent with this model. These studies generally examine data on restaurants. Aaronson (2001) and Aaronson, French and MacDonald (2008) both find complete pass through of costs. However, their data come from a period of much higher inflation, are based on a handful of observations per metro area, and they do not correct their standard errors for clustering. In contrast, Allegretto and Reich (2018) collected a large sample of restaurant price data in and near San Jose, before and after a 25 percent minimum wage increase in 2013 (from $8.00 to $10.00). Their results indicate that most of the costs are passed through to consumers in higher prices. Using scanner data from supermarkets, Renkin et al. (2019) find a similar effect for grocery prices.

Effects on profits and rent

Some economists have argued that many firms have captured above-normal profits in recent decades. An increase in the minimum wage could therefore reduce such economic rents. We attempted to include such an effect in our model, but were stymied by limited data on the proportion of reduced profits that would be borne within the study area.

Our simulations did confirm that insofar as payroll cost increases are partly absorbed by profits, then the scale effect is smaller. The reduced profits have much less effect on the income effect because propensities to spend are low among shareholders and managers, and because much of the profit decline affects capital owners outside of the study area. As a consequence, including a fall in profits in our model would have led to more positive effects on employment.

Minimum wage increases will likely affect the composition of businesses within and among industries. Aaronson, French and Sorkin (2015) find that minimum wage increases raise both exit and entry rates among restaurants, suggesting that entering firms arrive with a business model that is more oriented to the higher wage minimums. These higher-wage firms could be instituting business methods that improve productivity or improve product quality, or both. It is not possible for U.S. to quantify these secondary effects, as they require more data on such adjustment mechanisms than are available.

Franchisee-franchiser relationships and commercial rental leases could also be altered by minimum wage increases. Franchises are particularly important among restaurants. In principle, franchisees could pass their increased costs to franchisers, either through a relaxation of fees or land rent. However, data on such changes are not available, to our knowledge. Effects on commercial rents are also difficult to detect, in part because of the lack of data and in part because such leases are typically of longer duration.

5.2 Scale effects of increased prices on reduced sales of consumer goods

Economists use the term price elasticity of consumer demand to refer to the effect of an increase in prices on reducing consumer demand. Taylor and Houthakker (2010) report price elasticities for six categories of goods and services that together cover all of consumption. We adjU.S.t their health care elasticity to -0.20, to take into account changes in the structure of health care provision since the 1990s, and then compute a weighted average elasticity across the six categories Using personal consumption expenditure shares from the U.S. Consumer Expenditure Survey (McCully 2011). The result is a price elasticity of consumer demand of -0.72.[10]

This estimate is compatible with, but somewhat larger than, price elasticities estimated from aggregate panel data. Hall (2009), for example, obtains a consumer price elasticity of -0.50. On the other hand, our estimate is very close to that of Blundell et al. (1993).

5.3 Income effects

We consider here the increased spending that derives from the higher income of low-wage workers. Our model takes into account the effects of taxes and reduction in public benefits on the affected workers' take-home pay and the rate at which their households spend (as opposed to save) income compared to others. Greater spending by consumers increases economic demand, which translates into increases in employment and economic activity.

We do not expect all of the increases in household incomes to translate into increased consumption demand. A substantial portion of minimum wage earners come from households in the middle of the household wage distribution. These households will save some of their increased income. The amount of such savings will depend on their current savings rates and on the extent to which they view the increase in income as permanent, rather than a short-term windfall.

Economic research has found that changes in permanent income generate much higher consumption effects than changes that are, or are perceived as, transitory. Low wage-earners who are young and have more education may regard their low-wage status as transitory. These earners may regard a minimum wage increase as transitory.

Recent research has found that an increasing proportion of minimum wage workers are stuck in minimum wage careers (Boushey 2005; Casselman 2015). These results suggest that the proportion of workers who regard a minimum wage increase as constituting a one-time increase will be small. Moreover, economic theory and evidence suggests strongly that the distinction between permanent and transitory income does not apply to workers who are credit-constrained and whose households' assets are very limited (Achdou et al. 2014). The majority of minimum wage workers fit this description.

The IMPLAN model does not account for savings that come from transitory income. The considerations above indicate that any such effects are likely to be small. This is nonetheless a topic for future research.

5.4 Model calculations: net effects on employment

Table 5 displays the results of our model for 2024. Note that the estimates in this table represent *cumulative totals*. They are estimated relative to the federal minimum wage in each year, and therefore capture the full effect of increases in the suggested federal minimum wage in previous years.

Table 5. Cumulative employment changes, U.S., by 2024

A. Substitution effects: Reduction in wage bill due to automation and productivity gains	
Change in number of jobs from substitution effects and productivity gains (thousands)	-490
Percent reduction in number of jobs from substitution effects and productivity gains	-0.28%
B. Scale effect: reduction in consumer spending	
Change in number of jobs due to scale effect (thousands)	-940
Percent reduction in number of jobs due to scale effect	-0.7%
C. Income effect: increase in consumer demand	
Change in number of jobs due to income effect (thousands)	1,520
Percent increase in number of jobs due to income effect	1.1%
D. Cumulative net change in employment	
Net change in employment (thousands)	90
Net change in employment, as a percent of total employment	0.1%

Source: Authors' calculations using the IMPLAN economic impact model.

Panel A: Reduction in employment due to capital-labor substitution and productivity gains

Panel A in Table 5 shows our estimates for the reduction in the number of jobs due to both capital-labor substitution effects and productivity gains. With an assumed capital-labor substitution elasticity of 0.2 and a productivity effect of 0.005, we find a negative employment effect from these sources of about 490,000 jobs, or about 0.28 percent.

Panel B: Scale effects due to reduced consumer spending

Panel B in Table 5 presents our estimates of the reductions in jobs because of reduced consumer spending resulting from the higher prices generated by higher payroll costs.[11] We estimate that the scale effect reduces jobs by about 940,000, or about 0.7 percent

Panel C: Income effect-- cumulative increases in wages from proposed minimum wage increase

Panel C presents the estimated increase in jobs because of the income effect: increases in consumer demand deriving from increased incomes of low-paid workers. Our estimated income effect indicates an increase of about 1.7 million jobs, or 1.18 percent of the initial workforce.

Panel D: Net effect

As we have previously emphasized, the substitution, productivity, scale and income effects in Parts A to C occur simultaneously, not sequentially. It is thus not correct to infer that the employment changes in Parts A to C actually occur. Net employment changes occur only to the extent that we register in Part D, after we add Parts A to C together to obtain the net effects.

As Part D indicates, we estimate a net cumulative increase of about 90,000 jobs by 2024, equivalent to 0.1 percent of the workforce. To put this estimate in context, the Congressional Budget Office projects that the U.S. workforce will grow 0.45 percent *each year*, from 2017 to 2024. (For more details see Appendix A2.)

The models that underpin Panels A to C indicate that the effects in each panel will likely differ by job wage rates. In particular, the automation and productivity effects in Part A will occur entirely among low-wage jobs. The scale and income effects of Parts B and C, however, will affect jobs throughout the state's consumer demand industries and among a much broader wage distribution. We have not been able to quantify these differences, as they depend on the relative concentration of scale and income effects in low-wage industries.

The key finding in Table 5 is thus that a $15 minimum wage will have a negligible effect on net employment in the U.S.

PART 3. EMPLOYMENT ANALYSIS FOR MISSISSIPPI

1. Effects on Workers

Table 6 shows the estimated number and percentage of eligible workers who will receive pay increases by 2024. We estimate that about 504,000 Mississippi workers will receive a pay raise by 2024, or about 44.4 percent of the eligible workforce. Of these, about 342,000 will receive increases because their pay would otherwise be less than $15 in 2024 (the group directly affected by the law). Another 162,000 will receive pay increases because their pay will be slightly more than $15 by 2024 (the group indirectly affected by the law).

Table 6. Estimated cumulative impacts on Mississippi workers by 2024

Cumulative workforce benefits	
Percent of all workforce receiving pay increases	44.4
Total number of workers receiving increases (thousands)	504
Number of workers affected directly (thousands)	342
Number of workers affected indirectly (thousands)	162
Average hourly wage increase ($2016)	$2.74
Annual increase for workers receiving increases ($2016)	$4,950
Percent earnings increase for workers receiving increases ($2016)	24.6
Total aggregate increase in wages, billions ($2016)	$2.49

Source: Cooper (2017) analysis of CPS data.

Note: Directly affected workers earned between 80 percent of the old minimum wage and 100 percent of the new minimum wage. Indirectly affected workers earned between 100 percent and 115 percent of the new minimum wage. Average annual earnings per worker, not per job.

Table 6 also displays the additional earnings that affected Mississippi workers would receive: the estimated cumulative increase in affected workers' hourly wages, annual earnings, and percentage increase in annual earnings, as well as the cumulative total earnings increase for all affected workers. We estimate that the hourly wages of workers who will receive pay increases will rise by $2.74 by 2024. That amounts to an estimated additional $4,950 in earnings per year for these workers. In total, Mississippi workers will receive an additional $2,490 million in aggregate pay by 2024.

2. Pay increases by industry

Table 7 shows the estimated distribution of affected workers across Mississippi's industries by 2024. In the first column, we show the percentage of the overall eligible workforce in each industry. The second column displays our estimate of *the distribution across industries* of workers getting a raise. The third column presents our estimate of the percentage of workers getting a raise *within each industry*.

About half of the workers getting increases are employed in just three industries: retail trade (19.6 percent), manufacturing (14.3 percent) and food services (13.3 percent). The two

industries with the highest proportions of workers getting increases are: food services (82.8 percent) and retail trade (66.0 percent).

	Percent of all workers getting raises	Percent of industry workers getting raises	Percent change in payroll costs
Agriculture, Forestry, Fishing, Hunting	2.1	64.8	13.5
Mining	0.1	7.6	0.3
Construction	4.3	35.4	3.6
Manufacturing	14.3	39.5	3.8
Wholesale Trade	1.8	39.9	3.0
Retail Trade	19.6	66.0	12.0
Transportation, Warehousing, and Utilities	2.9	21.8	1.8
Information	1.0	36.3	2.1
Finance, Insurance, Real Estate, Rental and Leasing	2.7	29.5	2.2
Professional, Scientific, and Management	1.5	26.9	1.2
Administrative and Waste Management Services	4.3	61.8	10.5
Educational Services	7.2	29.6	3.4
Health Services	10.2	36.4	3.5
Social Assistance	2.6	62.2	10.8
Arts, Entertainment, Recreation, and Accommodation	3.6	63.7	13.3
Food Services	13.3	82.8	21.5
Other Services	4.6	49.1	5.0
Public Administration	3.9	31.6	3.0
Total	100	44.4	5.2

Source: Cooper (2017) analysis of CPS data.

Note: Percent change in payroll costs includes payroll taxes and workers' compensation as well as turnover offsets. The percent change in payroll costs presented here does not take into account the reduction in total wage bill due to substitution and productivity-based job losses. We do integrate those into our model calculations.

Table 8 shows our estimates of the increase in business operating costs (net of savings from reduced turnover). Across the entire Mississippi economy, we estimate that payroll costs would rise by 5.2 percent by 2024. Payroll costs in the restaurant industry would rise by 21.5 percent in the restaurant industry, 12.0 percent in retail, 13.5 percent in agriculture, and 3.8 percent in manufacturing.

Operating cost increases will be much smaller: 1.5 percent of the entire Mississippi economy, 8.2 percent in restaurants, 1.4 percent in retail, 2.3 percent in agriculture and 0.7 percent in manufacturing.

Table 8. Cost impacts for businesses in Mississippi by 2024

	Percent change in payroll costs	Labor costs as percent of operating costs	Percent change in operating costs and prices
All Sectors	5.2	29.1	1.5
Agriculture, Forestry, Fishing, Hunting	13.5	16.8	2.3
Mining	0.3	16.8	0.1
Construction	3.6	33.7	1.2
Manufacturing	3.8	17.4	0.7
Wholesale Trade	3.0	8.8	0.3
Retail Trade	12.0	12.0	1.4
Transportation, Warehousing, and Utilities	1.8	28.3	0.5
Information	2.1	21.2	0.4
Finance, Insurance, Real Estate, and Rental and Leasing	2.2	16.1	0.4
Professional, Scientific, and Management	1.2	47.6	0.6
Administrative and Waste Management Services	10.5	44.6	4.7
Educational Services	3.4	56.2	1.9
Health Services	3.5	49.8	1.8
Social Assistance	10.8	49.8	5.4
Arts, Entertainment, Recreation, and Accommodation	13.3	34.3	4.6
Food Services	21.5	38.3	8.2
Other Services	5.0	44.5	2.2
Public Administration	3.0	52.4	1.6

Source: U.S. Census. *Annual Wholesale Trade Report* and authors' analysis of ACS, OES, and QCEW data. See Appendix A2 Part B for details.
Note: The percent change in payroll costs includes payroll taxes and workers' compensation as well as turnover offsets. The percent change in payroll costs presented here does not take into account the reduction in total wage bill due to substitution and productivity-based job losses. Those effects are, however, integrated later into the calculations we perform in our model.

3. Effects on Mississippi employment

We turn next to our estimates of the effects of a $15 minimum wage by 2024 on Mississippi employment, using the same method we described above for the U.S. Table 9 displays the results of our model.

Table 9. Cumulative employment change in Mississippi by 2024

A. Substitution effects: Reduction in wage bill due to automation and productivity gains	
Change in number of jobs from substitution effects and productivity gains	-6,000
Percent reduction in number of jobs from substitution effects and productivity gains	-0.7%
B. Scale effect: reduction in consumer spending	
Reduction in number of jobs due to the scale effect	-9,000
Percent reduction in number of jobs due to the scale effect	-0.8%
C. Income effect: increase in consumer demand	
Increase in number of jobs due to the income effect	17,000
Percent increase in number of jobs due to the income effect	1.3%
D. Cumulative net change in employment	
Net change in employment	2,000
Net change in employment, as a percent of total employment	0.1%

Source: Authors' calculations using the IMPLAN economic impact model

Panel A: Reduction in employment due to capital-labor substitution and productivity gains

Panel A in Table 9 shows our estimates for the reduction in the number of jobs due to both capital-labor substitution effects and productivity gains. With an assumed capital-labor substitution elasticity of 0.29 and a productivity effect of 0.005, we find a negative employment effect of about 6,000 jobs from these channels.

Panel B: Scale effects due to reduced consumer spending

Panel B in Table 9 presents our estimates of the reductions in jobs associated with reduced consumer spending because of price increases. Our estimate of the reduction in consumer spending from price increases departs in one detail from our estimate for the U.S. as a whole. For Mississippi, we estimate that each 1 percent increase in consumer prices results in a -0.92

percent decline in consumer spending. We use this higher demand elasticity because incomes in Mississippi are lower than in the U.S. as a whole. The result is an estimated negative effect of 9,000 jobs from this channel.

Panel C: Income effect-- cumulative increases in wages from proposed minimum wage increase

Panel C of Table 9 presents the estimated job increases because of the income effect: increases in consumer demand deriving from increased incomes of low-paid workers. We estimate that the income effect will generate 17,000 jobs in Mississippi.

Panel D: Net effect

As we have previously mentioned, the substitution productivity, scale, and income effects in Parts A to C occur simultaneously, not sequentially. It is thus not correct to infer that the employment changes in Parts A to C actually occur. Net employment changes occur only to the extent that is registered after we add Parts A to C together to obtain the net effects.

Panels A to C tell U.S. that the net effects will likely differ by job wage rates. In particular, the automation and productivity effects in Part A will occur entirely among low-wage jobs. The scale and income effects of Parts B and C, however, will affect jobs throughout the state's consumer demand industries and among a much broader wage distribution. We have not been able to quantify these differences, as they depend on the relative concentration of the scale and income effects in low-wage industries.

Panel D of Table 9 presents our estimate of the net change in employment. We estimate a small cumulative net gain in employment, due to the policy, of 2,000 jobs by 2024, equivalent to 0.1 percent of total employment. To put this estimate in context, we project that Mississippi will grow annually by 0.27 percent from 2016 to 2024.

The key finding in Table 9 is that a $15 minimum wage will have a very small positive net effect on employment in Mississippi.

CONCLUSION

Like all forecasts, our estimates of the benefits and costs are subject to some uncertainty. First, economic conditions, such as employment and wage growth in the absence of the policy, may differ in future years from the standard forecasts that we rely upon in this report. For example, in recessions employment falls and wages do not grow as quickly. Our cost estimates might then be somewhat larger, but then so would our benefit estimates. Our estimates of the net effects are therefore likely to change, but not by a large amount. Second, our estimates rely on parameters that are themselves estimated with some uncertainty.

The proposed policy would result in substantial benefits to low-wage workers and their families, raising wages for 41.5 million workers by 2024. Annual pay for these workers will increase by 17.3 percent or $3,470 by 2024.

These pay increases in pay will raise overall wages in for-profit businesses by only 0.6 percent in the U.S. This amount is surprisingly small because many of the workers who are now paid below $15 are already paid above the current minimum wage, and because the pay of low-wage workers makes up a small share of total payroll costs.

Businesses will absorb the additional payroll costs partly through savings on employee turnover costs, higher worker productivity gains, and some automation. Most of the increase in costs will likely be passed on to consumers via increased prices. Since labor costs make up only about one-fourth of operating costs, consumer prices will increase only slightly—about 0.6 percent over the entire phase-in period. Prices will be most affected in the restaurant industry, where they will increase by 4.3 percent over the entire phase-in period.

These higher prices by themselves would somewhat reduce consumer sales and reduce the demand for labor. But simultaneous positive effects on increased consumer spending from workers receiving wage increases will offset these negative effects.

After taking into account all of these factors, we estimate that the proposed minimum wage policy would increase overall U.S. employment (as a percent of total employment) by 0.1 percent by 2024, over the baseline. This estimate is cumulative (and so will be spread over the phase-in period). In comparison, employment in the U.S. is projected to grow 0.45 percent annually in the same time period. We also find a similar employment effect for Mississippi.

In sum, a $15 minimum wage by 2024 would substantially improve living standards for nearly 30 percent of the U.S. workforce (and 44 percent of Mississippi's) without generating a significant net adverse employment effect. The minimum wage increase will be paid for primarily by induced efficiencies (more automation, productivity gains, and turnover savings) and slight price increases borne by all consumers. Based on our analysis, we conclude that the proposed minimum wage will have its intended effects in improving incomes for low-wage workers. Any effects on employment and overall economic growth are likely to be small. The net impact of the policy will therefore be positive.

APPENDIX: DATA AND METHODS

A1 THE DETAILED STRUCTURE OF THE BERKELEY CWED MINIMUM WAGE MODEL

Table A1 presents the 27 steps that we use to calibrate our employment estimates. These steps are aggregated into five main parts, labeled Parts A-E in Table A1. Part A describes the number of workers in the state who will receive pay increases by 2024. Part B describes the effects of automation and worker productivity gains. Part C describes how much consumer prices will increase and how much those increases will reduce consumer demand and employment. Part D describes how we calculate the income effect: how much pay increases will increase consumer spending and employment. Part E describes how we add up the estimates in Parts B, C and D to calculate the net effect on employment. We document here the data and methods that we use in each part of Table A1. In section A2, we document the source of the key parameters we use to calibrate our model.

Part A: Workers affected and wage increase

Lines [1] to [3] in Table A1 use our estimates (described in detail in the first section of the appendix) on how the labor force will grow and how the proposed minimum wage increase would affect the wage distribution of workers in the U.S. The wage estimates include the number of workers directly and indirectly affected in the two scenarios, and their nominal wages with and without the policy. We also use here our estimates of the total wage bill by 2024: $7.55 trillion in the U.S. in $2016 with the minimum wage increases and $7.41 trillion without the policy. We provide the details for these estimates in Section A2.

Part B: Impact of capital-labor substitution and productivity gains

Part B displays our estimated impact of capital-labor substitution and productivity gains on employment and on the total wage bill. Both calculations estimate the reduction in employment when output is held constant, everything else equal.

We estimate the reduction in the number of jobs from substitution effects (line [5] in Table A1) by multiplying four components: (i) the capital-labor substitution elasticity; (ii) the average wage increase of workers getting increases, which we estimate to be 25 percent, (iii) the profit share of revenues, and (iv) the total number of workers getting pay increases.

We calculate the reduction in the number of jobs from productivity gains ([6]) by multiplying two components: (i) the productivity gains and (ii) the total number of affected workers (estimated as 5.26 million in our wage simulation model).

We calculate the reduction in the wage bill due to substitution effects and productivity gains ([7]) by multiplying the reduction in number of jobs due to capital-labor substitution and productivity gains ([8]) by the nominal average annual earnings of workers who would otherwise remain employed ([9]).

Table A1. Detailed structure of the Berkeley CWED minimum wage model

A. Workers affected and wage increases	
Total employment	[1]
Total number of affected (directly and indirectly) workers in 2024	[2]
Working age population growth from 2014 to 2024	[3]
B. Impact of K-L substitution and productivity gains on number of jobs and wage bill	
Reduction in employment from substitution effects and productivity gains	[4]=[5]+[6]
Reduction in employment from substitution effects in 2024	[5]
Reduction in employment from productivity gains in 2024	[6]
Reduction in wage bill due to substitution effects and productivity gains-based job loss	[7]=[8]*[9]/1e6
Reduction in employment from substitution effects and productivity gains	[8]=[4]
Nominal average annual earnings of directly and indirectly affected workers without the policy	[9]
C. Scale effects: increase in consumer prices and reduction in consumer demand	
Percentage increase in consumer prices	[10]=[11]
Percentage increase in operating costs	[11]=[12]*[13]
Payroll share of operating costs	[12]
Net percentage payroll increase, accounting for savings from reduced turnover and productivity gains	[13]
Annual reduction in consumer demand from price increase	[14]=[15]*[16]
Percentage reduction in demand from price increase	[15]
Annual aggregate consumer spending	[16]
Reduction in employment from consumer spending reduction	[17]
Reduction in employment, as a percentage of total employment	[18]
D. Income effects: effects of pay increases on consumer spending and employment	
Net change in compensation for workers (millions)	[19]=[20]-[21]
Total wage increase for workers from proposed minimum wage increase (millions)	[20]
SNAP and ACA benefit reduction	[21]
Increase in employment from wage increase	[22]
Increase in employment, as a percentage of total employment	[23]
E. Net effects	
Cumulative net change in employment	[24]
Cumulative net change in employment, as a percent of total employment	[25]=[24]/[1]
Annual net change in employment	[26]=[24]/5
Annual net change in employment, as a percent of total employment	[27]=[25]/5

Source: UC Berkeley CWED minimum wage model

Part C: Scale effects: increase in consumer prices and reduction in consumer demand

Part C of Table A1 estimates the percentage increase in consumer prices due to an increase in operating costs for firms and the annual reduction in consumer demand from these price increases. We then use the 2015 IMPLAN model to calculate the impact of this reduction in consumer spending on employment. Our estimates are calculated as follows:

- We assume that the percentage increase in consumer prices [10] is equal to the percentage increase in operating costs [11], following the widely-used Dixit-Stiglitz model of monopolistic competition (Dixit and Stiglitz 1977).
- We obtain the percentage increase in operating costs [11] by multiplying the net percentage payroll increase [13] by the labor share of operating costs [12].
- The net percentage payroll increase [13] includes savings from reduced turnover and the reduction in wage bill due to substitution effects and productivity gains. We estimate the total wage bill increase to be $144bn in the U.S. by 2024. We subtract the reduction in the total wage bill due to substitution effects and productivity gains [1]. We also account for the increase in payroll costs that corresponds to Medicare, Social Security, and Workers' Compensation costs. This share equals 10.36 percent in 2024.To compute the net percentage increase in payroll costs, we apply a partial offset for turnover cost savings.
- We obtain the reduction in consumer demand from the price increase [14] by multiplying the percentage reduction in consumer demand from price increase [15] by annual aggregate consumer spending [16]. The estimated reduction in consumer demand due to higher prices equals $67bn in the U.S. The key components of this calculation are:
    - The percentage reduction in consumer demand from price increase [14] depends on two parameters: (i) the percentage increase in consumer prices as calculated in line [10], and (ii) the price elasticity of consumer demand.
    - We obtain annual aggregate consumer spending [16])by multiplying projected annual GDP for the U.S. by our overall estimated share of household consumer spending in GDP. We estimate the U.S. GDP so that it is consistent with the underlying value of the GDP in IMPLAN in 2024. We estimate that annual aggregate household consumer spending is $13.79 trillion in 2024.
- We translate the annual reduction in consumer spending resulting from price increases into employment effects using the multipliers in the 2015 IMPLAN model. Day (2013) provides documentation of the IMPLAN model. We adjust those estimates by projected working age population growth from 2017 to 2024.

Part D: Income effects

Part D of Table A1 estimates the income effects resulting from pay increases for low-wage workers, the resultant increase in consumer demand, and its impact on employment. Our estimates are calculated as follows:

- We compute the net change in compensation for affected workers [19] as the total wage bill increase for affected workers [20] minus the wage bill reduction from a reduction in the Supplemental Nutrition Assistance Program (SNAP) and in premium tax credits under the Affordable Care Act benefit reduction [21].

- We estimate the offset from SNAP and premium tax credits [21] under the ACA to be 14.35 percent of the total wage increase (see Appendix A2). We apply this amount to the total wage bill increase for all households, as there is no easy way to disaggregate this effect by income brackets.

- We estimate the annual increase in jobs resulting from higher consumer demand using the 2015 IMPLAN model. We adjust those estimates by estimated working age population growth from 2014 to 2024-- 4. 2 percent for the overall period in the U.S. (see section A2.2 for the source). Our estimated effects on increased consumption are supported by two related empirical studies (Alonso 2016) and Cooper, Luengo-Prada and Parker (2017).

Part E: Net effects

Part E of Table A1 presents our estimated cumulative net effect on employment [24]. We subtract the reductions in employment due to substitution effects, productivity gains [4] and scale effects [17] from the employment gains due to income effects [22]. We compute the annual estimates by dividing the cumulative effects on employment by seven, to account for the number of years over which the policy will phase in fully.

A2. KEY MODEL PARAMETERS

We summarize in Table A2 the values of our model's key parameters, for both the U.S. and Mississippi. We explain and document below the values of our parameters and the sources we used to obtain them.

Table A2. Key parameters of the model for the U.S. and Mississippi

A. Workers affected and wage increases	US 2017	US 2021	US 2024	Mississippi
Working age population, percentage growth, 2015 to 2024 (percent)	0.01	0.02	0.04	0.03
B. Impact of K-L substitution and productivity gains on number of jobs and wage bill				
Capital-Labor substitution elasticity	0.20	0.25	0.29	0.29
Capital share in gross output (excluding depreciation)	0.14	0.14	0.14	0.14
Productivity gains - in levels	0.005	0.005	0.005	0.005
C. Scale effects: increase in consumer prices and reduction in consumer demand				
Labor share of gross output	0.29	0.30	0.30	0.33
Materials share of gross output in the restaurant industry	0.51	0.51	0.51	0.51
Materials share of gross output in retail trade	0.78	0.78	0.78	0.78
Percent of wage costs for Medicare, Social Security, and worker compensation (employee side)	0.10	0.10	0.10	0.10
Turnover reduction (as share of payroll increase)	0.18	0.13	0.07	0.07
Price elasticity of demand	-0.72	-0.72	-0.72	-0.72
Projected annual GDP in 2024 (in billions)	$19,286	$22,248	$24,918	$149
Share of consumer spending in GDP	0.588	0.588	0.588	0.588
D. Income effects: effects of pay increases on consumer spending and employment and employment				
Percentage offset from reduced SNAP benefits and lower premium tax credits	0.14	0.14	0.14	0.14
Offset from reduced EITC	0.20	0.20	0.20	0.20
Offset from reduced SNAP benefits	4.20	4.20	4.20	4.20
Offset from lower premium tax credits under the ACA	2.30	2.30	2.30	2.30
Offset from reduced payroll taxes	7.65	7.65	7.65	7.65
E. Net effects				
No key parameters used in this section				

Source: UC Berkeley CWED minimum wage model

Future Employment Growth

See Cooper (2017).

Capital-labor substitution

It is often argued that a higher minimum wage will lead firms to reduce their use of workers. This reduction in labor demand can occur through two different channels: one involves substituting capital for labor, *i.e.*, automation or mechanization of jobs while keeping sales at the same level; the other involves lower demand for workers when prices increase and sales fall. We discuss here the automation channel and consider the effect on sales in the following section.

Automation: economic theory and measurement

Mechanization does not necessarily lead to a net loss of jobs. As David Autor (2014a; 2014b) points out, machines (including smart robots) do not just substitute for labor; they are also complements to existing jobs and they can lead to the creation of new jobs and industries. Indeed, previous rounds of automation and computerization have created more jobs than they destroyed. Moreover, automation does not involve only the replacement of labor by machines. It also involves the replacement of old machines (think manual cash registers) with newer ones (think electronic cash registers and electronic screens like iPads).

In general, the effect of automation on employment depends upon the elasticity of substitution of capital for labor —the change in the relative prices of capital and labor—and the share of profits in revenue. The lower this elasticity is, the more difficult it is to substitute capital for labor. Robert Chirinko, the leading economist specializing in estimates of capital-labor substitution, finds an economy-wide elasticity of about 0.4 (Chirinko and Mallick 2016). While the estimates in this study are identified across all economic sectors, most of the variation occurs among manufacturing industries. Lawrence (Lawrence 2015) also finds that the economy-wide sigma is less than 1 and that it is lower still in low-wage manufacturing industries than in high-wage manufacturing industries.

Alvarez-Cuadrado, Van Long and Poschke (2015) estimate substitution elasticities separately for manufacturing and services using data on 16 countries. They find that service sector elasticities are considerably lower than in manufacturing. However, their study does not examine low-wage services separately. The results in these papers nonetheless suggest, as Autor et al. conjectured, that automation possibilities are lower in low-service jobs.

Aaronson and Phelan (2015) have carefully studied the short-run impact of minimum wages on the automation of different kinds of low-wage jobs. Their study is the first to examine automation within low-wage industry contexts. Aaronson and Phelan find that minimum wage increases do reduce routinized low-wage jobs (such as cashiers) and increase the number of less-routinized low-wage jobs (such as food preparation). As it turns out, the changes offset each other almost equally, resulting in no net change in employment. Thus, Aaronson and Phelan find that the capital-labor substitution elasticity is essentially zero in low-wage occupations.

We use an elasticity of 0.2 in our calculations, half-way between Chirinko and Mallick and Aaronson and Phelan. This conservative assumption may therefore result in an over-estimate of the magnitude of the automation effect.

Aaronson and Phelan's findings also suggest very little substitution of highly skilled workers for lower skilled workers. Dube, Lester and Reich (2016) and Cengiz, Dube, Lindner and Zipperer (2019) obtain similar results. Consequently, we do not include any substitution of skilled labor for unskilled labor in our model.

Automation in practice

Machines that process automated transactions—at airports and in airplanes, banks, self-checkout stations in retail stores, parking garages, and gasoline stations—have become particularly widespread over the past 30 years. During this period, the price of computer-related machines has rapidly declined. Labor-saving automation will occur even when wages do not rise, insofar as the technological change continues to push down the price of equipment, making investments in new equipment and software profitable.

The effects of a rising minimum wage on actual automation depend in part upon whether new labor-saving technology that has not yet been adopted continues to become available. We suggest that much of existing labor-saving technological change has already been embodied in low-wage industries, in equipment and software such as smart electronic cash registers, remote reservations, and ordering systems. An increase in the minimum wage is likely only to generate small increases in the adoption of more automated systems.

Equally important, the rate of adoption of technical change depends on changes in the relative prices of capital and labor, not just on the price of low-wage labor. Although the prices of computer-related equipment and software have fallen dramatically, by approximately a factor of ten in the past several decades, the decline in the past five years is much smaller. Meanwhile, median wages have stagnated and real minimum wages remain lower than they were in the early 1970s.

The declining cost of capital is also reflected in declines in long-term interest rates in recent decades. Five-year and ten-year inflation-protected interest rates have also fallen dramatically. These changes in relative prices have been the main impetus to increased automation. Even a doubling of the minimum wage policy, which would imply (according to (Allegretto et al. 2015) an average wage increase of about 22 percent, would have very little impact in comparison. However, interest rates are unlikely to fall further. It is therefore likely that actual automation in low-wage industries is slowing.

To summarize, empirical estimates of the elasticity of substitution of capital for labor that include low-wage industries in their sample range between 0 and 0.4. We use 0.2, the midpoint of this range. Since Aaronson and Phelan find a much smaller elasticity, our use of 0.2 is conservative.

Profit share of revenues

We estimate that the profit share of revenues is 14 percent. To calculate this number, we use Annual Trade reports for wholesale trade and retail trade and BEA tables for all other sectors.

Productivity gains

For a discussion of productivity gains and the sources we used, see section 5.1 in the main report.

Labor share of operating costs

Net payroll cost increases for businesses are a function of three factors: (1) the total wage bill increase, after reduction due to substitution effects and productivity gains; (2) Medicare, Social Security, and Workers' Compensation increases, and (3) turnover costs savings. The payroll costs increase as total compensation increases and decrease with turnover costs savings.

- The total wage bill increase from 2016 to 2024 is estimated using Cooper (2017) wage simulation model based on micro data. For each year, Cooper (2017) calculate the reduction in wage bill due to job losses from substitution effects and productivity gains, assuming that capital-labor substitution and productivity gains are constant over the years. We assume in our calculations that capital-labor substitution is equal to 20 percent every year, and that productivity gains are equal to 5 percent every year.

- Employers' costs for Medicare, Social Security, and Workers' Compensation will equal 10.36 percent of wages from 2017 to 2024. We estimate the three components—Medicare (1.45 percent), Social Security (6.2 percent), and Workers' Compensation costs—separately. Since we are estimating only the effects of a minimum wage increase, we assume the Medicare and Social Security rates will not change between 2017 and 2024. For Workers' Compensation costs, we draw from a report of the National Academy of Social Insurance (2013). Table 14 (p. 37) of this report indicates that Workers' Compensation employer costs in 2013 amounted to $1.50 per $100 of eligible wages. These costs increased $0.11 cent increase a year over 2011–2013, slightly more than the 2009–2011 change. To account for these cost increases, we adjU.S.t the 2013 cost by $0.34. Consequently, we estimate that Workers' Compensation costs will equal 1.84 percent of wages in the U.S. and in MS from 2017 to 2024.

- Turnover costs savings are based on the estimates of Pollin and Wicks-Lim (2015), Fairris (2005), Dube, Freeman and Reich (2010), Dube, Lester and Reich (2016), Boushey and Glynn (2012), and Jacobs and Graham-Squire (2010). See section 5.1 in the main report.

The labor share of operating costs by industry

For retail trade and wholesale trade, we estimate labor costs as the sum of the annual wage costs, payroll taxes and employer paid insurance premiums (except health insurance), and other benefits (other than contributions to pension plans). The labor share is estimated using 2012 Census Bureau surveys—the most recent year available. We document here our sources and methods for these two individual industries:

- Retail trade (including grocery stores): The 2012 U.S. Census Annual Retail Trade Reports provides data on retail sales, payroll costs, merchandise purchased for resale, and detailed

operating expenses. We add operating expenses and purchases together to determine total operating costs. We add the costs of payroll taxes, employer paid insurance premiums, and employer benefits (excluding health insurance and retirement benefits) to annual payroll to estimate total labor costs. Health and retirement benefits are excluded since, unlike payroll taxes and Workers' Compensation insurance, the costs of the benefits will not change if wages are increased. Dividing labor costs by operating costs gives U.S. the labor share in retail trade.

- Wholesale trade: Data are from the U.S. Census. Annual Wholesale Trade Report. We follow the same methods as with retail trade.

For all other sectors, we use the 2015 BEA accounts to compute the labor share of operating costs. The numerator is composed of total compensation. The denominator is composed of the gross output (sum of value added and intermediate inputs) net of taxes on production and imports less subsidies.

The overall labor share of the economy is computed as a weighted average of the labor shares obtained for each sectors. The share of each sector in gross output is used as the weight variable. We estimate that overall, the labor share of operating costs for the U.S. is 29.1 percent in 2015. We use the same assumption for Mississippi. By 2024, we estimate that the overall labor share will increase to 30.3 percent in scenario 1 for the U.S. (i.e. with a capital-labor substitution elasticity of 0.2 and productivity gains at 0.05 percent) and 32.7 percent in scenario 1 for Mississippi.

Share of payroll costs for Medicare, Social Security and Workers' compensation

We estimate the Medicare, Social Security, and Workers' Compensation costs separately. Employers are liable for 6.2 percent Social Security taxes and 1.45 percent Medicare taxes. We estimate that the Workers' Compensation employer cost is 2.71 percent of wages in the U.S. as a whole and in Mississippi. The share of Medicare, Social Security, and Workers' Compensation is 10.36 percent from 2017. We assume that this same share applies throughout the phase-in period.

Turnover reduction

For a discussion of savings generated by turnover reduction and the sources we used, see section 5.1 in the main report.

Price elasticity of demand

The price elasticity of demand measures the effect of a price increase on reducing consumer demand. We use a price elasticity of 0.72 for the U.S. and 0.92 for MS. The 0.72 estimate is based on Taylor and Houthakker (2010), who report price elasticities for six categories of goods and services. We adjust their estimates to account for changes in the elasticity of health care spending attributable to the Affordable Care Act and other changes in the health care system.

GDP in 2024 for the U.S. and in Mississippi

We forecast 2024 GDP using the following method:

- We start with the 2015 GDP reported in IMPLAN, i.e. $23,454 billion in the U.S. and $140 billion in Mississippi.

- We then forecast the GDP for the U.S. by applying the employment growth forecast of 4.2 percent from 2015 to 2024 (2.51 percent for Mississippi), projected wage growth using CBO projections of the Employment Cost index of 3.0 percent, and the GDP deflator in IMPLAN for 2024 (1.058 for both the U.S. and Mississippi).

Share of consumer spending in GDP

Our estimate of the share of consumer spending in GDP includes only consumer spending that flows through households. We therefore reduce the BEA's estimate of the consumption share by 14.1 percent.

Offsets from benefit reductions and payroll tax increases

We estimate that the total offset from reduced EITC payments to be 0.2 percent, the offset from reduced SNAP benefits to be 4.20 percent, the offset from lower premium tax credits under the ACA to be 2.3 percent, and the offset from reduced payroll taxes to be 7.65 percent (the remaining personal income taxes are automatically subtracted by IMPLAN). We used Congressional Budget Office (2012) to calculate these offsets. These offsets refer to 2012; we assume they will remain constant until 2024.

ENDNOTES

[1] Reich, Jacobs, Bernhardt and Perry (2015).

[2] The capital-labor substitution elasticity is not likely to be higher or lower at higher minimum wage rates.

[3] Hirsch, Kaufman, and Zelenska (2011) and Reich, Hall, and Jacobs (2003) found improvements in worker productivity following higher wage mandates.

[4] The turnover savings are considered constant in 2018, 2019 and 2020, at 17.5 percent of increased labor costs, a midpoint estimate in the literature (Hirsch, Kaufman, and Zelenska 2011; Reich, Hall, and Jacobs 2003). These savings are likely to accrue at smaller rates as wage levels go higher; we therefore assume that by 2024 the marginal increase in earnings relative to 2018 no longer yields any additional turnover savings. As a result, we estimate that the total savings from turnover at a $15 minimum wage in 2024 would be 7.4 percent of increased labor costs.

[5] We use a payroll tax rate of 7.65 percent (6.2 percent for Social Security and 1.45 percent for Medicare). Workers' compensation insurance rates vary by industry (see Table 6: http://www.wcirb.com/sites/default/files/documents/state_of_the_wc_system_report_140815.pdf.

[6] Since workers often increase their wages by moving from one employer to another, we cannot assume that the correlation between wages and turnover indicates that low wages are causing higher turnover. As we discuss below, however, policy experiments with living wages and minimum wages have provided the evidence needed to determine that wages do, in fact, affect turnover.

[7] These averages include the low-turnover period of the Great Recession, and can be expected to increase towards higher pre-recession levels as the labor market tightens.

[8] The estimate of 17.5 percent represents the midpoint between the 20 percent estimate of Pollin and Wicks-Lim (2015) and a 15 percent (unpublished) estimate that draws upon Dube, Freeman and Reich (2010) and Dube, Lester and Reich (2016).

[9] Burda et al. 2016, Table 6 (cols. 3 and 5) reports that a $1 increase in weekly pay reduces the incidence of shirking by -.027 (.0054), on a base of .032 (from Table 1). For a full-time worker, going from $10 to $15 per hour raises weekly pay by $200, so the effect on productivity would be about .2x.027 = .005, or 0.5 percent. This estimate measures just the effect of reducing

idleness. Positive effects on absenteeism and worker engagement would add to the productivity improvement.

[10] Taylor and Houthakker's industry elasticities are based on regressions of U.S. panel data across over 300 cities and pooled over 1996-99. As we discuss below in Section 5.5, we do not expect that a substantial component of consumer sales will move outside the state's borders. Liu and Chollet (2006)'s review essay suggests that the price elasticity of demand for out-of-pocket individual healthcare expenses is -0.2. Our health care elasticity recognizes that employers shift their cost of health care on to employees. We also recognize that for those with subsidized coverage, increases in premium costs for lower-income families—who are more price-sensitive—are borne by the federal government.

[11] IMPLAN household spending model (proportional to city consumer spending patterns by household income level), using reduced consumer spending in Row 3 and forcing IMPLAN to apply 100 percent of the reduction in the city. See the appendix for details on IMPLAN modeling.

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