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Abstract

We extend the task-based empirical framework used in the job polarization literature to analyze the susceptibility of low-wage employment to technological substitution. We find that increases in the cost of low-wage labor, via minimum wage hikes, lead to relative employment declines at cognitively routine occupations but not manually-routine or non-routine low-wage occupations. This suggests that low-wage routine cognitive tasks are susceptible to technological substitution. While the short-run employment consequence of this reshuffling on individual workers is economically small, due to concurrent employment growth in other low-wage jobs, workers previously employed in cognitively routine jobs experience relative wage losses.

JEL CLASSIFICATION: J24, J38

Keywords: technological substitution, routine tasks, minimum wage

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1 Introduction

The extent to which firms can substitute labor with capital is a longstanding research question that, if anything, has grown in policy importance as automation technology continues to spread to a broad range of jobs. Some recent, highly-publicized examples include McDonald's experiments with tablet-based ordering systems and mobile payment services and Wendy's plan to install self-ordering kiosks across its 6,000-plus restaurants, innovations with the potential to eliminate many low-skill cashier jobs.[1] Although technological change has been a source of labor market research for decades, the recent emphasis has been on technology's role in the relative decline of employment and wages among routine-intensive middle-income occupations (Autor, Levy, and Murnane, 2003; Goos and Manning, 2007; Autor, Katz, and Kearney, 2008; Jaimovich and Siu, 2012; Autor and Dorn, 2013; Autor, Dorn, and Hanson, 2015). Our paper contributes to this important literature by quantifying the potential for technological substitution across the low-wage labor market, including the low-wage service sector jobs that the McDonald's and Wendy's examples highlight.

To study the role of technological substitution in low-wage labor markets, we take advantage of plausibly exogenous variation in the cost of low-wage labor caused by minimum wage hikes. We interpret the extensive minimum wage literature as indicating that the short-run employment elasticity is likely to be economically modest, at least compared to the benchmark range of estimates laid out many years ago by Brown, Gilroy, and Kohen (1982).[2] However, if low-wage labor costs rise high enough, and the price of technology continues to fall as it has for decades, businesses may increasingly look to automate certain tasks currently performed by minimum wage workers. One implication is that the average short-run disemployment effect estimated in the minimum wage literature may mask impor-

[1] For McDonald's, see http://www.business2community.com/us-news/mcdonalds-offers-customized-burgers-utilizing-tablet-based-ordering-system-01093942 and http://news.mcdonalds.com/Corporate/news-stories/McDonald%E2%80%99s-Announces-New-Collaboration-with-Apple. For Wendy's, see http://www.investors.com/politics/policy-analysis/wendys-serves-up-kiosks-as-wages-rise-hits-fast-food-group/.

[2] A sample of recent papers that estimate the employment response to minimum wage hikes include Machin, Manning, and Rahman (2003), Dube, Lester, and Reich (2010), Allegretto, Dube, and Reich (2011), Giuliano (2013), Addison, Blackburn, and Cotti (2013), Sabia, Burkhauser, and Hansen (2012) and Neumark, Salas, and Wascher (2014). Neumark and Wascher (2008) provide an extensive review of the earlier literature.

tant heterogeneity, even within an industry, based on whether labor and capital are gross substitutes or complements.

Our paper addresses these questions by extending the theoretical framework in Autor, Levy, and Murnane (2003) and the task-based empirical framework used in Acemoglu and Autor (2011) to capture the susceptibility of occupational employment in the low-wage labor market to technological substitution. Our main empirical exercise combines the Occupation Information Network (O*NET) database, which classifies occupations by the extent to which they are associated with routine cognitive and routine manual tasks, with state-level occupational employment data from the 1999-2009 Occupation Employment Statistics (OES). We use this data to examine whether the employment response to a minimum wage change differs at low-wage occupations that are heavily routine. Whereas past studies have relied upon variation in the degree of routineness to study the implications of automation, we believe our research design better identifies this effect by using plausibly exogenous variation in the cost of low-wage labor caused by minimum wage hikes to study changes in employment among routine jobs.

We find that the short-run impact of a minimum wage hike on overall employment is indistinguishable from zero but the employment effects vary based on the extent to which an occupation entails routine cognitive tasks. In particular, a 10 percent increase in the minimum wage causes low-wage employment to fall by about 1.5 percent for every standard deviation increase in the routine cognitive share of an occupation. These findings suggest that at the same time employers are reducing jobs with a large proportion of routine cognitive tasks, other low-wage employment is expanding. The negligible effect on net employment is consistent with other studies of automation (Autor, Dorn, and Hanson, 2015). Moreover, the empirical results are explained within our theoretical model, which assumes that capital requires some non-routine labor in order to be productive. Such a situation might arise when new technologies, like self-scanners, require employees to assist or monitor customer usage.

By contrast, there is no evidence of a differential employment response based on the extent to which an occupation is manually routine or, assuredly, in higher-paying occupations relatively untouched by minimum wage laws. Thus, the potential for technological substitution of low-skill labor that we uncover appears to be limited to low-wage, cognitively-routine tasks. We further show – using an occupation-level offshorability index developed by Blinder (2009) – that overseas outsourcing cannot explain the loss of cognitively routine jobs after a minimum wage increase, at least among the lowest-wage occupations that are most impacted by minimum wage laws. There is mixed evidence on somewhat higher paying occupations, where the extent to which a job is offshorable and cognitively routine is highly intertwined.

We also examine the extent to which technological substitution affects the employment and wage outcomes of individual low-wage workers in the Current Population Survey (CPS). Broadly consistent with the OES data, we find that minimum wage hikes cause low-wage individuals to move to occupations with fewer routine cognitive tasks. This employment realignment is especially evident among individuals initially employed in high cognitively routine occupations. Again, we find no such effect among workers in occupations that are expressly manually routine or that are high-paying. This movement away from highly routinized occupations occurs with little effect on the probability of subsequent employment. However, conditioning the CPS sample on workers employed in consecutive years, we find that individuals employed at high cognitively routine occupations experience relative wage losses following a minimum wage hike compared to otherwise similar low-wage workers.

In sum, the empirical results are consistent with high labor costs expediting technological substitution in low-wage occupations that are intensive in routine cognitive tasks. These findings contrast with previous studies, such as Bresnahan, Brynjolfsson, and Hitt (2002), Manning (2004), and Autor, Katz, and Kearney (2008), which have found little direct effect of technological advancements on the demand for the lowest wage workers. Instead, our results are consistent with Lewis (2011)'s study of the manufacturing sector. In many respects, our findings suggest that the effects of technological substitution on the low-wage labor market are qualitatively similar to the employment and wage effects of technology on middle-wage jobs (Goos and Manning, 2007). However, unlike the findings in the job polarization literature, the loss of low-wage routine cognitive jobs during our period of analysis has been largely offset by employment growth in other similarly-paid jobs – primarily low-wage occupations intensive in non-routine interpersonal tasks. Thus, the short-run impact on total low-wage/low-skill employment has been economically small. Of course, that need not be the case in periods outside of our sample (Clemens and Wither, 2014) or in the long-run where there is evidence that minimum wages have larger negative employment effects (Baker, Benjamin, and Stanger, 1999; Meer and West, 2016; Sorkin, 2015).

This paper is organized as follows. In the next section, we consider a simple theoretical framework that highlights potential heterogeneous effects of capital on different types of work. Sections 3 through 5 describe the data, empirical specification, and results. Within each of these sections, we first examine our results at the occupation-level, followed by a worker-level analysis. Section 6 concludes.

2 Theoretical Framework

The textbook model of the minimum wage considers a large number of perfectly competitive firms making the same product with the same technology. In such a setting, it is well-known that higher costs arising from a minimum wage hike unambiguously lead to less local low-skill employment through both the elasticity of substitution between labor and other factors of production, i.e. the substitution effect, and the elasticity of demand for the output good, i.e. the scale effect (Hamermesh, 1996; Aaronson and French, 2007). Other inputs, such as capital, low-wage labor untouched by the minimum wage hike (e.g. overseas), high-wage labor, or materials, may go up (gross substitute) or down (gross complement) depending on whether the substitution or scale effect dominates.

It is common in the minimum wage literature to assume the same elasticity of substitution across all inputs but that obviously need not be the case. Even within low-wage labor markets, there may be heterogeneous effects of higher labor costs on employment. For example, it is well-recognized that technology is particularly suitable to displacing labor that performs routine tasks (Autor, Levy, and Murnane, 2003; Goos and Manning, 2007; Dustmann, Ludsteck, and Schönberg, 2009; Black and Spitz-Oener, 2010; Acemoglu and Autor, 2011; Goos, Manning, and Salomons, 2014). Thus, low-wage routine labor may experience disproportionate employment declines via the substitution effect. On the other hand, non-routine low-wage labor may be, at least in part, complementary to technological adoption – making the impact of capital investments on low-wage non-routine employment ambiguous. One reason for this ambiguity is that installing capital to replace low-wage routine labor sometimes requires the customer to perform tasks that were previously executed by employees (e.g. following our earlier example, self-checkout lines).[3] Integrating this type of technology might require a transition period where firms hire additional low-wage, non-routine labor to assist customers or other employees using the new technology. In fact, firms might find it optimal to continue to employ some additional non-routine labor even after the new technology has been fully adapted to oversee interactions with capital equipment, especially if the new process creates ways for transactions to go awry (e.g. customers not scanning items in a self-checkout line).

To draw out the implications of a minimum wage hike in such a setting, we extend the theoretical framework of Autor, Levy, and Murnane (2003) by requiring capital to use some fixed proportion of non-routine labor in order to be productive. In particular, suppose production in the low-wage sector is a function of routine and non-routine tasks, where non-routine tasks can only be produced by non-routine labor (N) but routine tasks can be produced by either routine labor (R) or some combination of capital (K) and non-routine labor, $g(K, N)$. If R and $g(K, N)$ are perfect substitutes and K and N in $g(K, N)$ are perfect complements, output Y is produced by:

$$Y = N_N^{\alpha}(R + \min(K, N_R C))^{1-\alpha} \tag{1}$$

where C is a scale variable describing the relative unimportance of non-routine labor in the production of routine tasks. We assume $C > 1$ or else capital adoption would never occur. Additionally, for ease of exposition, we distinguish between N used for non-routine tasks (N_N) and routine tasks (N_R).

A cost minimizing firm will always set $K = N_R C$. Therefore, the firm's cost minimization problem simplifies to:

$$\min \mathcal{L}(N_N, R, K, \lambda) = w_N N_N + w_R R + r' K + \lambda(\bar{Y} - N_N^{\alpha}(R + K)^{1-\alpha}) \tag{2}$$

[3] Basker, Foster, and Klimek (2015) study the introduction of self-service gas stations, another example where technology allowed routine tasks to move from employees to customers.

where w_N is the wage paid to N, w_R is the wage paid to R, and $r' = r + \frac{w_N}{C}$ is the total cost associated with each unit of capital – i.e. the direct cost of capital (r) and the requisite N_R needed for each unit of K.

The first order conditions $\frac{\partial \mathcal{L}}{\partial R}$ and $\frac{\partial \mathcal{L}}{\partial K}$ imply that $r' = w_R$ when there is an interior solution. However, if the nominal price of technology (r) is falling exogenously over time, as is commonly observed, and w_R is a function of the nominal minimum wage (w_{mw}), which is both binding and rising over time, there will be a corner solution where firms will either use only R (i.e. when $r' > w_R$) or only $g(K, N)$ (when $r' < w_R$) to produce routine tasks. Consequently, we can derive the following conditional factor demands:

$$N_N^* = \begin{cases} \bar{Y}(\frac{\alpha}{(1-\alpha)}\frac{w_R}{w_N})^{1-\alpha} & \text{if } r' > w_R \\ \bar{Y}(\frac{\alpha}{(1-\alpha)}\frac{r'}{w_N})^{1-\alpha} & \text{if } r' < w_R \end{cases} \qquad R^* = \begin{cases} \bar{Y}(\frac{(1-\alpha)}{\alpha}\frac{w_N}{w_R})^{\alpha} & \text{if } r' > w_R \\ 0 & \text{if } r' < w_R \end{cases} \tag{3}$$

$$K^* = \begin{cases} 0 & \text{if } r' > w_R \\ \bar{Y}(\frac{(1-\alpha)}{\alpha}\frac{w_N}{r'})^{\alpha} & \text{if } r' < w_R \end{cases} \qquad N_R^* = \begin{cases} 0 & \text{if } r' > w_R \\ \frac{\bar{Y}}{C}(\frac{(1-\alpha)}{\alpha}\frac{w_N}{r'})^{\alpha} & \text{if } r' < w_R. \end{cases}$$

The effect of minimum wage hikes on demand for R and N depend on, among other factors, the relationship between w_R, w_N, and the minimum wage (w_{mw}). We consider two scenarios: (1) all low-wage workers are paid the minimum wage ($w_R = w_N = w_{mw}$), and (2) R is paid the minimum wage ($w_R = w_{mw}$) but N is paid above the minimum wage ($w_N > w_{mw}$) . In both scenarios, we treat w_R and w_N as parameters that are affected by changes in w_{mw}. We further assume that productivity at N and R is capped for a specific occupation – i.e. a PhD physicist will be no more productive as a cashier than many high school graduates. Consequently, firms hire workers with productivity levels greater than or equal to the required/capped level but pay only the maximum productivity of that job. This assumption eliminates the possibility of wage heterogeneity within N and R. When wages at N and R differ, individuals at the higher paying job will be more productive on average.

2.1 All Low-Wage Jobs Pay the Minimum Wage

First, we sketch how employment responds to a minimum wage hike when routine and non-routine labor are both paid the minimum wage, i.e. $w_R = w_N = w_{mw}$. We find that a shock to the prevailing wage may cause firms to invest in routine labor-replacing capital (automation). However, we also find that there is potential for a partially offsetting increase in non-routine employment.

There are two relevant cases. When the minimum wage increases but w_{mw} remains below r', routine labor costs remain cheaper than new technology so no input substitution occurs. Far more interestingly, if the minimum wage increases from below r' to above r', non-routine labor performing non-routine tasks (N_N^*) declines and routine labor (R^*) falls to zero; these inputs are replaced by capital (K^*) and non-routine labor performing routine tasks (N_R^*). The net effect of these employment changes is that routine labor will experience disproportionate employment declines relative to non-routine labor. However, the overall effect on N employment is ambiguous, depending on whether the increase in N_R^* is larger or smaller than the fall in N_N^*. Following a minimum wage hike, employment at N is more likely to increase as the importance of routine tasks in overall production rises (i.e. the smaller is α) and the importance of non-routine labor in the production of routine tasks rises (i.e. the smaller is C).[4] To the extent that growth in N offsets the fall in R, the model implies that individuals moving out of R may be able to find employment at newly created N jobs since productivity requirements are similar across R and N jobs in this scenario.

2.2 Routine Jobs Pay Minimum Wage, Nonroutine Jobs Pay More

Next, we consider a second plausible scenario where R is paid the minimum wage and N is paid above the minimum wage. The model again predicts that minimum wage hikes lead to larger employment declines at routine jobs, but the cause of the relative employment decline is less clear. When w_{mw} increases but remains below r', routine job loss arises from labor-

[4] The net effect of this technological substitution on non-routine employment is captured by: $\frac{\bar{Y}}{C}(\frac{(1-\alpha)w}{\alpha r'})^{\alpha} - \bar{Y}(\frac{\alpha}{1-\alpha})^{1-\alpha} + \bar{Y}(\frac{\alpha r'}{(1-\alpha)w})^{1-\alpha}$. Rearranging, this expression reduces to $\frac{1-\alpha}{\alpha} + Cr' - Cr'^{\alpha}w^{1-\alpha}$. Since $w > r'$, we can subtract off the larger $Cw^{\alpha}w^{1-\alpha} = Cw$, reducing the expression to $\frac{1-\alpha}{\alpha} + Cr' - Cw$. Consequently, the net effect of a minimum wage increase on non-routine employment when $w > r'$ is more likely to be positive when α and C are smaller.

labor substitution (from R to N) rather than automation.[5] However, when w_{mw} increases from below r' to above r', technological substitution emerges. R^* still falls to zero as firms replace R^* with a combination of K^* and N_R^*. But unlike the case when all low wage workers are paid the same rate (Section 2.1), the employment effect of a minimum wage hike on N_N^* is ambiguous. N_N^* may increase because of labor-labor substitution but may decrease because the spillover effect in wages on w_N could make N relatively more expensive than the newly automated routine tasks. With the expected growth in N_R^* combined with an ambiguous effect on N_N^*, the probability of N job growth offsetting R job losses rises relative to Section 2.1.

Under this wage scenario, the overall effect of the minimum wage hike is a realignment of jobs away from routine labor and towards non-routine labor. This employment realignment can be caused by either labor-labor or capital substitution. Additionally, the employment realignment of individual workers from R to N will be complicated by the different productivity requirements at R and N jobs. Consequently, not all individuals employed at R jobs will be able to move into new N jobs.[6]

2.3 Further Extensions to the Model

We recognize that the conditional factor demands in equation (3) ignore the scale effect, which would be associated with larger declines among N_N^* jobs and smaller increases among N_R^* jobs when w_{mw} increases above r'. Therefore, if we are to observe an increase in non-routine employment, the substitution effect on non-routine labor used to produce routine tasks (N_R) will have to be sufficiently large to offset the scale effects on N_N and N_R, in addition to the substitution effect on N_N. This will occur if the output good is sufficiently inelastic or non-routine labor's share is sufficiently low. Indeed, there is evidence to suggest that this is the case. Aaronson and French (2007) show that the total low-wage labor share

[5] When w_{mw} remains below r', R^* will decline and N_N^* will increase simply because the relative price of R increases relative to N, so long as $\frac{\partial w_N}{\partial w_{mw}} < 1$.

[6] A third scenario, which we do not think is likely, is that routine jobs pay more than non-routine minimum wage jobs. This set-up also leads to both labor-labor substitution (when w_{mw} increases but remains below r') and technological substitution (when w_{mw} increases above r'). However, labor-labor substitution with w_N greater than w_R would be associated with declining N and growing R. We find no empirical evidence to support this prediction.

in the most minimum-wage-intensive industry – fast food restaurants – is only 10 percent, implying that the scale effect has only a modest adverse impact on employment.

We also recognize that this simple static model ignores dynamic considerations. For example, the parameter C in equation (3), which represents the relative unimportance of non-routine labor in the production of routine tasks, is assumed to be constant. It is reasonable to conjecture that C might change over time as, for example, customers require fewer non-routine workers to assist and monitor their interactions with technology. Thus, analogous to the reversal in skilled labor demand described in Beaudry, Green, and Sand (2016), non-routine labor demand may increase in the short-run but ultimately fall in the longer-run. Additionally, employment dynamics resulting from minimum wage hikes may take time, especially when the firm makes large investments in equipment, technology, or processes (Aaronson, French, Sorkin, and To, 2017). In our empirical work, data limitations only allow us to examine employment responses up to two years after a minimum wage change but we acknowledge it would be ideal to study beyond that (Sorkin, 2015).

2.4 Empirical Implications

This simple theoretical framework implies that technological substitution stemming from a minimum wage hike will be characterized by falling routine employment among low-wage jobs. However, the short-run employment effects on non-routine labor are ambiguous and depend on whether workers complement the new technology. As such, the overall employment effects of minimum wage hikes may be negligible even if technological substitution is taking place. The model also implies that this employment realignment (from R to N) can be caused by either labor-labor or technological substitution. Thus, the empirical analysis will need to compare employment at similarly paid occupations to distinguish between the two. It will also be instructive to examine whether it is the same individual workers moving from R into N as this will also help distinguish between whether we are observing technological or labor-labor substitution.

In the empirical analysis that follows, we combine data on employment and occupational tasks to understand how minimum wage hikes effect the composition of jobs within the low-wage sector. We then assess the impact of this change on individual low-wage workers.

3 Data

Our empirical analysis relies on several datasets. The Department of Labor's Occupation Information Network (O*NET) database, the Bureau of Labor Statistics' Occupation Employment Statistics (OES), and the U.S. Census Bureau's Merged Outgoing Rotation Group of the Current Population Survey (CPS) are described below. Additionally, we collect data on state minimum wage histories from the Department of Labor's website (see Appendix Table A1)[7] and the offshorability of occupations from Blinder (2009).

3.1 O*NET

The O*NET is the primary U.S. source of tasks and activities, as well as skills, abilities, and knowledge necessary to perform those tasks and activities, for every Standard Occupational Classification (SOC) occupation. The O*NET was first released in December 1998 to replace the now-defunct Dictionary of Occupational Titles (DOT). Since the DOT was last updated in 1991, we use the O*NET-based composite task variables developed in Acemoglu and Autor (2011) to compute an occupation's share of tasks that are cognitively or manually routine.

While the O*NET contains hundreds of variables to describe occupation-specific tasks and skills, Acemoglu and Autor (2011) focus on seventeen measures from the Work Activities and Work Context Importance scales to develop six composite task indices for every occupation j, denoted by $T_j = \{T_{j1}, T_{j2}, ..., T_{j6}\}$.[8] These indices represent the extent to which an occupation is routine cognitive, non-routine cognitive analytical, non-routine cognitive interpersonal, routine manual, non-routine manual physical, and non-routine manual interpersonal.[9]

[7] We do not account for city-level differences (e.g. San Francisco, Santa Fe) in the minimum wage, which were still unusual during our period of study.

[8] The indices are available on David Autor's website. We thank David Autor and Daron Acemoglu for making the data available.

[9] See the data appendix in Acemoglu and Autor (2011) for a description of how they construct each of these six composite task metrics from the O*NET variables.

We use Acemoglu and Autor's six composite indices to calculate the share of tasks in each occupation that are cognitively and manually routine. Our emphasis on task shares (as opposed to levels) follows Autor, Levy, and Murnane (2003), who also categorize occupations by the share of tasks that are routine.[10] To calculate the task shares, we first rescale Acemoglu and Autor's six composite indices by subtracting off the minimum value across all occupations. This rescaling is necessary since each of Acemoglu and Autor's composite indices is normalized to have a mean of zero and a standard deviation of one. As such, the rescaled value of routine cognitive tasks (T_{j1}) for occupation j, is $T^*_{j1} = T_{j1} - min(\{T_{i1}\}_{i=1}^{M})$, where $min(\{T_{i1}\}_{i=1}^{M})$ is the minimum value of T_1 across all M occupations. The routine cognitive share of tasks for each occupation is then the ratio of the rescaled routine cognitive task value to the sum of all six rescaled values, i.e. $Sh_j^{T_1} = \frac{T^*_{j1}}{\sum\limits_{q=1}^{6} T^*_{jq}}$. A higher $Sh_j^{T_1}$ is associated with a greater intensity of routine cognitive tasks in occupation j. The routine manual share (or any task share) is defined analogously.

3.2 Occupation Employment Statistics (OES)

Our primary employment data are from the OES, a semi-annual survey of about 200,000 nonfarm establishments. The OES provides estimates of occupational employment and hourly wage levels for wage and salary workers.[11] We begin the sample in 1999, when state-level data matched to the O*NET occupation classification system became available. We end in 2009 because of a scarcity of state-wide changes in the nominal minimum wage, other than automatic inflation-based adjustments, between the federal increase in July 2009 and the end of 2014.[12]

The OES wage data is used to group occupations into four wage bins based on the average

[10]The "task intensities" used in Autor and Dorn (2013) and Autor, Dorn, and Hanson (2015), which are measured as the logarithm of the routine task level minus the logarithm of each of the other task levels, more closely approximate task shares than task levels as well. That said, we perform robustness tests using task levels to categorize occupations.

[11]Each release is a weighted average of the previous six surveys, covering the last three years, where the weights are computed to reflect changes in the occupational distribution over time. Over the most recent three years, the 1.2 million participating establishments cover over 60 percent of U.S. employment. The self-employed are excluded. While the data is released in May and November, we focus on the May release. Prior to 2003, the survey was conducted annually.

[12]Alaska and Washington, D.C. increased their minimum wage in 2010. There were no changes in 2011 or 2012, other than inflation-based adjustments. Rhode Island increased its minimum wage in 2013.

ratio over the panel of an occupation's state-level mean wage to the state-level minimum wage. The four bins are occupations with average wages less than 175 percent ("wage group 1"), 175 to 250 percent ("wage group 2"), 250 to 300 percent ("wage group 3"), and 300 to 600 percent ("wage group 4") of the minimum wage. Note that our definition requires that an occupation-state's wage bin is fixed over the panel, although the same occupation in different states can appear in separate wage bins, reflecting variation in mean wages and minimum wage levels across states.[13] Additionally, the relatively wide wage bin for the lowest paying occupations is necessary because essentially no occupations have average wages, say, less than 130 percent of the minimum wage (see Table 1).

Table 1 lists the wage group 1 occupations sorted by their routine cognitive share.[14] At least informally, the occupations with high routine cognitive shares listed at the top of Table 1 – such as graders and sorters of agricultural products, cashiers, and motion picture projectionists – seem to be susceptible to technological substitution. By contrast, occupations with low routine cognitive shares at the bottom of Table 1 – such as bartenders and child care workers – appear to be less so. Table 1 also presents each occupation's routine manual share of tasks. While low-wage occupations have less routine manual tasks than routine cognitive tasks on average, the relative importance of routine cognitive and routine manual tasks are not highly correlated (the correlation coefficient is 0.21 in wage group 1 and 0.23 among all four wage groups). Moreover, the correlation between an occupation's average wage and its routine cognitive and routine manual share is a modest 0.09 and 0.01, respectively. The general lack of a correlation between these characteristics will help us pin down the effects of a minimum wage hike on employment associated with different types of tasks.[15] It should also assuage some concerns that an employment realignment from routine

[13]We also explored fixing an occupation's wage bin across states. This makes little qualitative difference to our empirical results. However, grouping occupations by a national average wage ratio changes the composition of occupations in our wage bins, in particular reducing the number of occupations that fall in the lowest wage interval.

[14]A list of the occupations included in wage group 2 is included in Appendix Table A2.

[15]While some of the original studies using task-based data to capture the susceptibility of employment to technological substitution treated routine manual tasks separately from routine manual tasks (Autor, Levy, and Murnane, 2003), most recent studies have combined the two and merely analyze occupations according to the overall importance of all routine tasks (Autor and Dorn, 2013; Goos, Manning, and Salomons, 2014; Autor, Dorn, and Hanson, 2015). Nonetheless, we maintain that distinguishing between types of routine tasks may be important in the context of this study.

to non-routine jobs following a minimum wage hike may be due to labor-labor substitution as opposed to technological substitution.

Ultimately, we combine the OES with state minimum wage histories to estimate the reduced-form relationship between minimum wages and employment by the level of routinization within an occupation, as measured by the O*NET. To begin though, it is illuminating to compare the employment response to a minimum wage hike at occupations that draw from a similar labor pool, are susceptible to similar demand shocks, are of comparable size, but differ on the extent of routinization. An example of this contrast is cashiers and combined food preparation workers. The former is about 1.5 standard deviations above average in terms of routine cognitive intensity (within wage group 1) while the latter is about a half of a standard deviation below average. If technology is replacing routine cognitive tasks, we should see a larger employment response to a minimum wage hike among cashiers. Indeed, we illustrate such a pattern by plotting the state-year variation in the log minimum wage against the change in state-year log employment over a four year period – from one year prior to the year of the hike to two years after – for cashiers (Figure 1a) and combined food preparation workers (Figure 1b). Larger increases in the minimum wage lead to economically and statistically significant employment declines among cashiers – elasticity (standard error) of -0.23 (0.09) – but not among combined food preparation workers (-0.01 (0.25)).

This relationship is not limited to cashiers and combined food preparation workers. Figure 2 plots all state-year occupations in wage group 1, stratified by whether the occupation is either one standard deviation above the average in its routine cognitive share of tasks (Figure 2a) or not (Figure 2b). We again find that employment declines at the high routine cognitive occupations when the minimum wage increases; the elasticity is estimated to be -0.24 (0.08) when all high routine cognitive occupations are included and -0.26 (0.19) when cashiers are excluded. By contrast, minimum wage hikes have no effect at occupations that are not highly cognitive routine, with an estimated elasticity of -0.04 (0.07) regardless of the inclusion of combined food preparation workers.[16] Furthermore, we find no such distinction

[16] These estimates exclude observations where the change in log employment is greater than $\pm$ 0.75 log points. Including these outliers, the distinction between high (-0.24 (0.08) when cashiers are included, -0.22 (0.19) when cashiers are excluded) and not high (-0.10 (0.08) when combined food preparation workers are

among high and not high manual routine occupations, as illustrated in Figures 3a and 3b.

3.3 Current Population Survey (CPS)

Individual worker employment and wage data come from the CPS, a monthly, nationally representative survey of approximately 60,000 households conducted by the U.S. Census Bureau. Participating households are surveyed for four consecutive months, ignored for the next eight months, and then surveyed again for four more months. Wage information is collected in the outgoing rotation months – the fourth and eighth month of the survey, spaced a year apart. We picked a time period, 2003 to 2009, which roughly mimics the OES sample while also avoiding problems arising from multiple generations of occupation codes.[17]

Our sample includes workers age 17 to 65, paid by the hour, who report pay between 80 and 600 percent of their state's effective minimum wage. We assign individuals to wage bins using the ratio of an individual's first reported CPS wage (outgoing rotation month four) to the minimum wage in their state two years prior.[18] The specific wage bins we use in the CPS analysis match the wage bins we use in the OES (80 to 175 percent, 175 to 250 percent, 250 to 300 percent, and 300 to 600 percent of the minimum wage). However, in the results presented below, we combine the three highest wage intervals into one interval (175 to 600 percent) because we find minimal differences among individuals earning more than

included, -0.10 (0.08) when combined food preparation workers are excluded) cognitive routine occupations is noisier but similar.

[17]The short panel structure of the matched CPS restricts us to one year changes in wage and employment. Hence, we stick to the same 2003-2009 period in the CPS, although fully acknowledging that it is not a direct time match as we use it to examine one-year changes from 2004-2009. Going back further in time in the CPS comes at a cost. Prior to 2003, the CPS used the 1990 Census Occupation Codes and while crosswalks exist between the 1990 Census Occupation Codes and the 2000 Census Occupation Codes, Autor, Levy, and Murnane (2003) and Goos and Manning (2007) have warned against matching them up due to large changes in classification over time.

[18]Using the lagged minimum wage is meant to avoid problems with using the contemporaneous minimum wage discussed in Neumark, Schweitzer, and Wascher (2004) and Phelan (2016). In particular, as the minimum wage increases, an individual's ratio of their wage to the minimum wage falls – even when one accounts for the spillover effect in wages. Thus, if we group individuals according to the current minimum wage, individuals in the treatment state who had been high wage individuals (before the minimum wage went up) will be compared with lower wage individuals in control states (where the minimum wage did not change). Grouping individuals by their lagged minimum wage in their state addresses this problem. However, it may create a separate problem since we do not observe an individual's wage two years prior and individuals in states where the minimum wage is increased are likely to experience faster wage growth.

175 percent of the minimum wage. We also present robustness results that group individuals according to the ratio of their first reported CPS wage and the contemporaneous minimum wage.

Finally, we merge the O*NET task data into the CPS using the occupational crosswalk provided by David Autor to match the SOC occupations used in the O*NET with the Census Occupation Codes used in the CPS.[19]

4 Empirical Specification

Our empirical strategy is straightforward. We first examine the relationship between changes in the minimum wage and changes in occupation-level employment in the OES, with an emphasis on understanding how this relationship differs depending on the routine intensity of the work required in an occupation. Next, using the CPS, we examine how the minimum wage impacts an individual worker's occupational task content and ultimately their employment and wage growth. In both the OES and CPS analyses, we exclude state-year observations where the minimum wage increased by less than 0.03 log points. These very small changes in the minimum wage are frequently due to inflation-based adjustments, which are unlikely to have the same effect as unanticipated and larger increases in the minimum wage.[20] This is especially true in the context of investment decisions that tend to be lumpy.

4.1 Occupation-Level Analysis

The OES analysis follows the empirical strategy in Baker, Benjamin, and Stanger (1999). In a difference-in-difference framework, short and long differences represent alternative filters of the data. Short (long) differences amplify high (low) variation and therefore capture short-run (longer-run) effects of minimum wage hikes. If minimum wages have only an

[19] When two or more SOC occupations merge into a single Census Occupation Code, we use OES-based employment weights to determine the task composition of the new occupation.

[20] This exclusion impacts Arizona in 2008, Colorado in 2008, Connecticut in 2003 and 2004, Florida in 2008, Maine in 2005 and 2006, Michigan in 2008, Missouri in 2008, Montana in 2008, Nevada in 2008, Ohio in 2008, Oregon in 2004, 2005, and 2008, Vermont in 2008, Washington in 2003, 2004, 2005, and 2008, and Wisconsin in 2009. State-year observations associated with leading and lagged years of these small changes were also excluded from the analysis. In all, these exclusions decrease the state-year observations over the period 2003-2009 by 17 percent.

immediate impact on employment, short- and long-differences will produce similar results. However, if the impact of a minimum wage increase occurs over several years, the two empirical estimates will diverge.[21] Indeed, recent studies applying long differencing have found larger disemployment effects over longer periods of time (Sorkin, 2015; Meer and West, 2016). This strategy may be especially germane to our analysis if capital investment, and the ensuing substitution of labor, takes time to implement.

Therefore, we follow the long difference stategy advised in Baker, Benjamin, and Stanger (1999) and estimate specifications of the form:

$$\Delta_\tau \ln Emp_{jst} = \alpha_t + \alpha_s + \alpha_k + \sum_{k=1}^{4} \beta_\tau^k (\Delta_\tau \ln MW_{st} * R(W_{js}, MW_s)^k) + \epsilon_{jst}. \quad (4)$$

where $\Delta_\tau \ln Emp_{jst} = \ln Emp_{jst} - \ln Emp_{js,t-\tau}$ is the change in the log of the employment level for occupation j in state s and year t from τ years prior. Similarly, minimum wages are differenced over τ years, with $\Delta_\tau \ln MW_{st} = \ln MW_{st} - \ln MW_{s,t-\tau}$. $R(W_{js}, MW_s)^k$ represents the grouping of occupations into $k = 4$ predetermined wage bins based upon the ratio of the average wage to the minimum wage in state s. Thus, the β_τ^k coefficients represent the average cumulative effect of minimum wages on employment for wage interval k over τ years. Equation (4) also includes state, year, and wage bin fixed effects (α_s, α_t, and α_k).

We alter this baseline specification in two key ways. Since our primary goal is to assess whether the employment response to a minimum wage hike differs by the routineness of an occupation's tasks, we include the interaction between the change in the minimum wage and the routine share of tasks at an occupation ($RoutineSh_j$). Second, since trends in occupational employment may be a function of the employment level and the routineness of a job, we add the base year employment level $Emp_{js,t-\tau}$ and $RoutineSh_j$ to the specification, which we interact with year dummy variables ($Year_t$) and $R(W_{js}, MW_s)^k$. The interactions on these additional covariates allow the base conditions to affect occupational

[21] Including lagged changes in the minimum wage in a first-difference framework will amplify low-frequency variation in the data like a long-difference framework. However, Baker, Benjamin, and Stanger (1999) point out that serially uncorrelated measurement error could add noise to the first differences and complicate identification compared to specifications using long differences.

employment in a way that varies across time for each of the wage groups, a flexibility that may be particularly suitable to our sample period that spans the Great Recession. Thus, the estimating equation takes the form:

$$\begin{aligned}\Delta_\tau \ln Emp_{jst} =& \alpha_t + \alpha_s + \alpha_k + \sum_{k=1}^{4} \alpha_{1t}^k (Emp_{js,t-\tau} * Year_t * R(W_{js}, MW_s)^k) \\ &+ \sum_{k=1}^{4} \alpha_{2t}^k (RoutineSh_j * Year_t * R(W_{js}, MW_s)^k) \\ &+ \sum_{k=1}^{4} \beta_{\tau RS}^k (\Delta_\tau \ln MW_{st} * RoutineSh_j * R(W_{js}, MW_s)^k) \\ &+ \sum_{k=1}^{4} \beta_{\tau}^k (\Delta_\tau \ln MW_{st} * R(W_{js}, MW_s)^k) + \epsilon_{jst}.\end{aligned} \tag{5}$$

The $\beta_{\tau RS}^k$ coefficients describe how employment responds to changes in the minimum wage for occupations with different routine intensities. To ease the interpretation of the $\beta_{\tau RS}^k$ coefficients, we normalize the distribution of routine shares across occupations within each wage grouping to be mean zero with a standard deviation of one. This means that the $\beta_{\tau RS}^k$ coefficients should be interpreted as employment elasticities for every standard deviation increase in the routine share of an occupation.

While we remove overall occupational trends in employment by routine task intensity, identification of the $\beta_{\tau RS}^k$ coefficients requires that changes in the minimum wage are independent of pre-existing state-specific employment trends across occupations according to their routine intensity. This assumption is testable by estimating equation (5) using state-by-year fixed effects rather than state and year fixed effects separately and excluding the non-interacted change in the minimum wage. The results from this altered equation (5) are also presented below. Likewise, identification of the β_τ^k coefficients requires that changes in the minimum wage are independent of overall employment growth within each state.[22]

We present estimates of (4) and (5) over a range of values for τ (i.e. durations of differences) to capture the short- and long-run effects of minimum wages on overall employment and employment at highly routinized occupations. For example, the β_2^k coefficient is the

[22]This assumption is common in the minimum wage literature although some recent evidence suggests that it may not be appropriate (Allegretto, Dube, and Reich, 2011).

weighted average of the cumulative employment effect over one year and the cumulative employment effect over two years, where the weights will depend upon how much of $\Delta_2 \ln MW_{st}$ is due to changes in the minimum wage over the past year versus changes over the prior year. As τ increases, β_τ^k should converge to the long-run effect of minimum wages, with the caveat that the long-run effect of minimum wages will be confounded by both inflation, which diminishes the bite of the minimum wage, and time-varying treatments, which make it difficult to locate a suitable control group over long periods of time (Sorkin, 2015).

Therefore, we propose an alternative specification that marries the benefits of long-differencing with a distributed lag framework. That is, we estimate a variant of equation (5) that breaks up $\Delta_\tau \ln MW_{st}$ into one year changes in the minimum wage. The benefit of this hybrid specification is that the estimated coefficients on the one year minimum wage changes reflect the cumulative employment effect of minimum wages up until that point in time – and not the average cumulative effect. This hybrid specification takes the form:

$$\begin{aligned}\Delta_4 \ln Emp_{jst} =& \alpha_0 + \alpha_t + \alpha_s + \alpha_k + \sum_{k=1}^{4} \alpha_{1t}^k (Emp_{js,t-4} * Year_t * R(W_{js}, MW_s)^k) \\ &+ \sum_{k=1}^{4} \alpha_{2t}^k (RoutineSh_j * Year_t * R(W_{js}, MW_s)^k) \\ &+ \sum_{k=1}^{4} \sum_{z=-2}^{1} \beta_z^k (\Delta \ln MW_{s,t+z} * R(W_{js}, MW_s)^k) \\ &+ \sum_{k=1}^{4} \sum_{z=-2}^{1} \beta_{zRS}^k (\Delta \ln MW_{s,t+z} * RoutineSh_j * R(W_{js}, MW_s)^k) + \epsilon_{jst}.\end{aligned} \tag{6}$$

where $\Delta_4 \ln Emp_{jst} = \ln Emp_{jst} - \ln Emp_{js,t-4}$ is the change in the log of the employment level for occupation j in state s and year t from four years prior and $\Delta \ln MW_{s,t+z}$ represents the following one-year changes in the log of the minimum wage in state s: the leading one-year change ($\ln MW_{s,t+1} - \ln MW_{st}$), the current one-year change ($\ln MW_{st} - \ln MW_{s,t-1}$), and two lagged one-year changes ($\ln MW_{s,t-1} - \ln MW_{s,t-2}$ and $\ln MW_{s,t-2} - \ln MW_{s,t-3}$). The corresponding β_z^k coefficients describe the timing of the employment response to a minimum wage change for a specific wage bin k – from the leading, pre-treatment, elasticity (β_1^k) to the cumulative employment elasticities associated with the year of the minimum wage change (β_0^k), one year after the change (β_{-1}^k), and two years following the minimum wage change (β_{-2}^k). This specification differs only slightly from the standard distributed lag specification but it is potentially a better way to estimate the longer run effects of minimum wages because it focuses on low-frequency variation in the data, it lessens concerns associated with serially uncorrelated measurement error in employment, and it identifies the cumulative employment effect as opposed to the partial effects over the one-year increment. In robustness tests, we also present estimates of equation (6) using one-year, two-year, and three-year (rather than four-year) occupational employment changes as our dependent variable.

The regressions are weighted by the occupation-level employment in a given state during the base year. Standard errors are clustered at the state level. In our baseline results where we examine four-year changes in employment, we exclude observations with four-year employment changes greater than ± 0.75 log points.[23] However, the appendix shows that our findings are robust to the inclusion of these outliers. Lastly, we report results separately for routine cognitive and routine manual tasks. Again, this distinction differs from much of the literature on task-based technological change, which has tended to lump them together. But as we show, this modification appears to matter in low-wage labor markets.

4.2 Worker-Level Analysis

We use the CPS to corroborate our OES findings and assess how technological substitution, to the extent it takes place, impacts individual workers. We estimate a specification similar

[23] We limit the sample to ± 0.75 log points in the specifications that use three-year and four-year changes in employment as the dependent variable. However, we limit the sample to ± 0.5 log points in the specifications that use one-year and two-year changes in employment as the dependent variable.

to equation (6):

$$
\begin{aligned}
\Delta Y_{ijst} =& \alpha_t + \alpha_s + \alpha_k + X_{1i}\alpha_x + \sum_{k=1}^{2}(X_{2ijs,t-1} * Year_t * R(W_{ist}, MW_{st})^k)\alpha_{1t}^k \\
&+ \sum_{k=1}^{2} \alpha_{2t}^k (RoutineSh_{ijs,t-1} * Year_t * R(W_{ist}, MW_{st})^k) \\
&+ \sum_{k=1}^{2}\sum_{z=-2}^{1} \beta_z^k (\Delta \ln MW_{s,t+z} * R(W_{ist}, MW_{st})^k) \\
&+ \sum_{k=1}^{2}\sum_{z=-2}^{1} \beta_{zRS}^k (\Delta \ln MW_{s,t+z} * RoutineSh_{ijs,t-1} * R(W_{ist}, MW_{st})^k) + \epsilon_{jst}.
\end{aligned}
\tag{7}
$$

The individual-level regression in equation (7) differs from equation (6) in two ways. First, it takes advantage of the detailed covariates available in the CPS. In particular, X_1 includes basic demographic controls – age and age squared, sex, race, and education – and X_2 includes individual-specific labor market outcomes from the first CPS observation date – an individual's ratio of their wage to their state's minimum wage (lagged two years) and indicators for industry affiliation. Second, due to the one-year rotating panels of the CPS, our worker-level analysis uses a first-differenced distributed lag specification. Thus, the β_k^z and β_{kRS}^z coefficients capture marginal effect of a minimum wage change on the outcome – as opposed to the cumulative effect in equation (6).

We use two dependent variables to broadly corroborate the basic OES findings: an indicator that individual i is employed at an occupation with a high-level of routine tasks (one standard deviation above average) during the second CPS outgoing rotation survey and the one-year change in the routine share of individual i's occupation.[24] In addition, we look at two key measures of the potential impact of technological substitution on individual workers: an indicator for being employed in year 2 conditional on being employed in year 1, and the change in the logarithm of wages from year 1 to year 2. Throughout, the β_z^k coefficients measure the overall effect of minimum wage hikes and the β_{zRS}^k coefficients capture

[24]In the specification that regresses an indicator for being employed in a high routine share occupation in year 2 on changes in the minimum wage, we also control for being employed in a high routine share occupation in year 1, interacted with wage interval and year dummy variables.

the additional impact associated with the routine intensity of an individual's occupation. If technological substitution is taking place, minimum wage hikes would be associated with movements away from high routine share occupations (negative β^z coefficients), especially among those employed at routine intensive occupations prior to the minimum wage hike (negative β^z_{kRS} coefficients). Consistent with the previous statistical models, we include leading, current, and lagged minimum wage changes.

With the exception of the "Employed in year 2" outcome, the sample is limited to individuals employed in both outgoing rotation survey months (survey months 4 and 8, spaced one year apart) who experience year-over-year wage changes less than $\pm$ 0.35 log points.[25] This wage growth restriction encompasses the largest year-over-year minimum wage increase in our sample period – the 0.35 log point hike in Iowa between January 2007 and January 2008. We do not expect wage changes larger than 0.35 log points are driven by minimum wage hikes. However, we present robustness estimates in the appendix that do not impose this wage change restriction. All regressions are weighted using the CPS sample weights, and standard errors are clustered at the state-level.

5 Results

5.1 Occupation-Level Analysis

Table 2 presents the long difference OES results. The first four columns, labeled Specification 1, are estimated using equation (5), which excludes interaction terms between the change in the minimum wage and the routine cognitive share of tasks. Each row differs only by the length of the data differencing – from first to fourth differences. Regardless of the wage group or the duration of the differencing, we find no impact of a minimum wage increase on overall employment. This finding is robust to a number of adjustments such as our preferred long-difference/distributed lag specification (Table 3), including occupation-by-year fixed effects (Appendix Table A3), and including large employment changes (Appendix Table A4). That is, there is little evidence of aggregate OES employment changes following a

[25] This exclusion reduces the sample of hourly workers by 27 percent.

minimum wage hike over the period 1999-2009.

Columns (5) through (12), labeled Specifications 2 and 3, include the interactions between an occupation's routine cognitive share and the change in the minimum wage, again at different durations of differencing. Specification 2 includes separate state and year fixed effects and Specification 3 includes state-by-year fixed effects. We find that minimum wage hikes lead to a decrease in employment among occupations that are more cognitively routine, and this effect gets stronger as an occupation's average pay nears the minimum wage. Among the lowest-paying wage group 1 occupations, those with a mean wage less than 175 percent of the minimum, we find no immediate impact associated with first differences of the data. However, the estimated employment effect grows to -0.04 (0.02) in second differences and -0.09 (0.03) in third and fourth differences of the data. In words, the results imply that a 10 percent increase in the minimum wage has no immediate effect on employment but employment declines by an average of 0.4 percent over the first two years and an average of 0.9 percent over three and four years in occupations one standard deviation above average in their routine cognitive share of tasks. For context, occupations one standard deviation above average in routine cognitive intensity include hotel desk clerk, motion picture projector, and pharmacy aid. Occupations two standard deviations above average, those that the estimates suggest would experience particularly large employment declines after a minimum wage hike, include usher/ticket-taker, gaming dealer, gaming and sports book writer and runner, and grader and sorter of agricultural products. Note that all of these occupations tend to require physical presence and therefore cannot be easily substituted with identical workers that work overseas or in another state. We'll return to this issue below.

We also find a statistically similar sized response on wage group 2 occupations. Like wage group 1, the effect at high routine cognitive wage group 2 occupations shows up in the second differences and becomes especially pronounced in the third and fourth difference specifications (i.e. -0.07 (0.03) and -0.10 (0.04), respectively, in Specification 3). That there is some spillover into wage group 2 is not entirely surprising. It is well established that increases in the minimum wage lead to wage gains for workers earning above the new minimum (Lee, 1999; Neumark, Schweitzer, and Wascher, 2004; Aaronson, Agarwal, and French, 2012; Butcher, Dickens, and Manning, 2012; Phelan, 2016). Moreover, we are grouping occupations by their average wage relative to the minimum wage and therefore some workers included in higher wage groups may still be directly influenced by minimum wage laws. That said, the effect of a higher minimum wage unsurprisingly dissipates to zero as we move further up the wage distribution.

Table 3 presents estimates of equation (6) that incorporates our preferred hybrid long-difference/distributed lag specification. These results confirm that minimum wage hikes had minimal impact on overall employment but led to employment declines at occupations with high levels of routine cognitive tasks. Moreover, we find that there is no employment response prior to the minimum wage hike ("ΔMW Next Year" in the tables), suggesting no pre-existing employment trend. We also find that the minimum wage effect on routine cognitive employment takes place slowly over multiple years, which is consistent with capital investment or other sources of substitution that take time to implement (Doms and Dunne, 1998; Aaronson, French, Sorkin, and To, 2017). For wage group 1, employment in high cognitively routine occupations does not change in the year of (or prior to) a 10 percent minimum wage hike but decreased by 0.9 (0.4) percent and 1.3 (0.5) percent one and two years after the increase. A similar pattern arises at high routine cognitive occupations in wage group 2. We again find little evidence of an impact among wage groups 3 and 4.[26]

That the longer-run coefficients from this specification are slightly larger than the long-difference estimates in Table 2 is to be expected when the response is not immediate. Table 3's coefficients capture the cumulative effect of the minimum wage hike up until that point in time, while the long-difference estimates in Table 2 capture the average cumulative effect over each of the years associated with the long-difference.[27] We prefer the long-difference/distributed lag specification because the estimates better captures the dynamics and ultimately will be closer to the long-run employment effect at the end of our estimation horizon.

[26]While wage group 3's point estimate of -0.08 (0.07) is economically, albeit not statistically significant two years after the minimum wage hike, the pre-treatment period effect of -0.05 (0.04) is of a similar size. Consequently, if there is an "effect" in wage group 3, it appears to be arising from an unobserved pre-trend.

[27]For example, the results in column (9) of Table 3 imply that the cumulative employment effect three years after a minimum wage hike for high routine cognitive occupations in wage group 1 is -0.13. However, the average cumulative effect over the three years after a hike is approximately -0.09 ($\frac{1}{3} * (-0.032 - 0.092 - 0.132) = -0.086$). This is precisely what we find in the long-difference estimates reported in Table 2.

Strikingly, we find no evidence, even among the lowest paid occupations in wage group 1, that higher minimum wage laws cause employment losses in occupations requiring more manual routine tasks. This is evident in the long-difference estimates in Table 4 and the long-difference/distributed lag estimates in Table A5 (see columns 5 to 12 in both tables).[28] This finding stands in contrast to the job polarization literature, which has moved away from distinguishing between routine cognitive and routine manual tasks (Goos, Manning, and Salomons, 2009; Autor and Dorn, 2013). Rather, the stark difference we find by task type is at least suggestive that technological substitution of low-wage labor occurs primarily in jobs where other inputs can replace cognitively routine tasks.

The cognitively and manually routine results are robust to a number of specification checks, including the inclusion of occupation-by-year fixed effects (Appendix Table A3), the expansion of the sample to include very large employment changes (Appendix Table A4), the use of task levels as opposed to task shares to measure the routine intensity of an occupation (Appendix Table A6), and reasonable adjustments to the list of conditioning variables. Moreover, the results in Table 3 are largely robust to different durations of employment changes in the dependent variable of the long-difference/distributed lag empirical specification (Appendix Table A7).

Finally, because the overall employment response, even in wage group 1, is indistinguishable from zero, it must be the case that minimum wage hikes during the mid-2000s led to a reshuffling of employment across occupations in the low-wage labor market. Consistent with our theoretical framework of technological substitution of low-wage jobs, employment declined in occupations that are particularly cognitively routine in nature but was roughly offset by employment growth elsewhere in the low-wage labor market. Indeed, using the other task shares, it appears that much of the offsetting employment growth was in occupations intensive in non-routine cognitive interpersonal tasks (see Table 5). This finding is consistent with our theoretical model – where the elimination of cognitively routine jobs requires a short-run increase in non-routine labor to, e.g., help with customer or employee interactions with the new technology.[29]

[28] The columns of Table 4 match Table 2 except that we control for the manual routine share of tasks in the associated specification rather than cognitive routine share of tasks.

[29] While there also appears to be some offsetting employment gains among wage group 2 occupations

5.1.1 Alternative Explanations

We do not observe actual technological substitution of labor and our results need not be solely a reflection of this explanation. An alternative source of substitution could be low-skill labor unaffected by the minimum wage hike, most prominently labor overseas. To test whether outsourcing is confounding our results, we re-estimate equation (6) with additional interaction terms between the change in the minimum wage and the offshorability of an occupation, as measured by Blinder (2009). The offshorability index is reported in Table 1 for wage group 1 and Appendix Table A2 for wage group 2. The results of this exercise are reported in Table 6, where for convenience the first four columns repeat columns 9 to 12 from Table 3.

Controlling for offshorability somewhat lowers the employment elasticities for wage group 1 but has little impact on the estimated employment response in highly cognitive routine occupations. The lack of an impact is not a surprise as only 6.7 percent of employment in wage group 1 is potentially offshorable according to the Blinder index.[30] The great majority of wage group 1 occupations are instead low-skill service sector occupations that are physically immobile.

However, the results for wage group 2 are more mixed. The offshorability of an occupation has a 0.56 correlation with the cognitive routine share of its tasks. Consequently, in a horserace (Table 6, column 10), offshorability confounds some of the variation in employment that is otherwise (column 2) attributed to cognitive routine share two years after the minimum wage hike. Therefore, we cannot rule out that the employment loss that we observe for cognitively routine work in wage group 2 occupations may actually be due to the ability to offshore this type of work.

Another possible confounding factor arises from differences in occupational use across

intensive in non-routine manual physical tasks and employment losses among wage group 1 occupations intensive in non-routine manual interactive tasks, neither of these effects is statistically different from the leading/pre-treatment effect. Thus, these effects appear to reflect pre-treatment trends in outcomes and not the effects of minimum wage changes.

[30]In Table 1, it appears that only three low-wage occupations, representing 1.6 percent of low-wage employment, is offshorable. The disparity between 1.6 and 6.7 percent stem from Table 1 reporting occupations where the average wage to the minimum wage is below 175 percent of the minimum wage when averaged across all states and years, whereas in our data analysis an occupation in a particular state will be classified in wage group 1 if its average wage to the minimum wage in a state is below 175 percent.

industries that may be correlated with product market elasticities (the scale effect). Unfortunately, we are unable to test this possibility in the occupation-level analysis since the OES does not provide data on occupational employment within industries. However, we can include industry and industry-by-year fixed effects in the CPS analysis. There, we find that the inclusion of industry-by-year fixed effects has no substantive effect on outcomes related to employment at high cognitive routine occupations. Therefore, we suspect that uncontrolled industry-specific factors, such as differences in the the scale effect, are unlikely to be the source of our OES results.

5.2 Worker-Level Analysis

5.2.1 Technological Substitution in the CPS

Table 7 presents estimates of the effect of a minimum wage change on the probability of being employed at a "high" – one standard deviation above average – routine cognitive occupation and the change in the routine cognitive share of an individual's occupation following a minimum wage hike. A similar table presenting the employment response at high routine manual occupations is included in the appendix (Table A8). As a reminder, the dependent variable is a first-difference in this analysis; therefore, the coefficients represent marginal effects rather than the cumulative effects reported in the long-difference/distributed-lag OES specifications.

Like the OES, we find evidence that minimum wage hikes decrease employment at occupations with high routine cognitive task content. For workers paid 80 to 175 percent of the minimum wage (wage group 1), we estimate that a 10 percent increase in the minimum wage lowers the probability that these workers will be employed in a high routine cognitive occupation by 1.1 (0.5) and 1.5 (0.9) percentage points one and two years later.[31] Employment declines are especially large, 1.7 (0.6) and 2.3 (1.2) percentage points one and two years after a 10 percent hike, for those workers employed at occupations with routine cognitive tasks that are one standard deviation above average prior to the hike (column 3). The economic

[31] To be clear, the estimated effect two years after the increase, in this case of 1.5 (0.9) percentage points, comes from summing the "ΔMW Last Year" and "ΔMW Two Years Ago" coefficients and calculating the appropriate standard error.

magnitude of these point estimates are consistent with, though somewhat larger than, the OES estimates reported in Table 3.[32] Similar to the OES results, the coefficients also imply that minimum wage hikes do not cause employment declines at higher wage occupations (wage group 2) that have high levels of routine cognitive tasks (columns 2 and 4) or among occupations with high levels of routine manual work (Appendix Table A8).

Related, the final six columns of Table 7 highlight that minimum wage hikes also cause individuals in high routine cognitive occupations to move to new jobs with less routine cognitive tasks. One and two years after a 10 percent increase in the minimum wage, individuals previously employed at occupations with routine cognitive tasks that are one standard deviation above average tend to move to occupations with 0.025 (0.012) and 0.034 (0.021) standard deviations less routine cognitive tasks. While these estimates may seem economically small, that is a consequence of the relative rarity of changing jobs. Indeed, when we limit the sample to job changers (see columns 11 and 12), the magnitudes are almost three times as large. Again, these effects are unique to the lowest wage workers and we find no evidence that minimum wages cause individuals previously employed at high routine manual occupations to move to occupations with less routine manual tasks (see Appendix Table A8).

These results are robust to the exclusion of industry-by-year fixed effects (see Appendix Table A10), the use of more detailed industry (two and three digit) controls, and the inclusion of year-over-year wage change outliers greater than $\pm$ 0.35 log points (Appendix Table A11).[33] As previously mentioned, the robustness of these results to the inclusion/exclusion

[32] To compare the OES and CPS results, we a) convert the CPS results from percentage point changes to percent changes and b) alter the OES results so that they reflect employment changes at "high" routine cognitive occupations relative to all other occupations. These adjustments imply that, following a 10 percent increase in the minimum wage, employment declines at high routine cognitive occupations by 4.3 (1.9) and 5.6 (3.2) percent one and two years later in the CPS and 1.8 (0.8) and 2.5 (0.9) percent one and two years later in the OES.

[33] We also tested the robustness of our results to grouping individuals by the ratio of their first CPS period wage to the current minimum wage, as opposed to the twice lagged minimum wage. These results suggest less movement away from occupations intensive in routine cognitive tasks. However, this result is not surprising. Grouping occupations according to the current minimum alters the composition of the treatment and control samples in states that previously increased the minimum wage. Higher wage individuals in states that increased their minimum wage in the lagged year are compared with lower wage individuals in states that did not. This comparison biases estimates towards zero if higher wage workers in the states that increased the minimum wage are not affected by the minimum wage hike – see the discussion of this issue in footnote 18. Nonetheless, we do find a similar reemployment alignment when we group individuals according

of industry-by-year fixed effects suggests that the OES results are unlikely to be driven by uncontrolled industry-specific factors.

5.2.2 Employment and Wage Effects

Lastly, Table 8 describes how the movement away from routine intensive jobs in response to a minimum wage hike impacts workers' employment and wage opportunities. Consistent with the OES, we find little to no overall impact of minimum wage changes on subsequent employment (columns 1 and 2), including among workers initially employed at high routine cognitive occupations (columns 3 and 4).[34] Thus, movement away from occupations intensive in routine cognitive tasks does not appear to be associated with significant losses in employment for those workers most affected by this reallocation. This finding also implies that the reallocation of employment from cognitively routine to non-routine occupations is unlikely to be due to labor-labor substitution since the same individuals are shifting between tasks.

The reshuffling of individuals across the low-wage labor market causes some damage to individual wages, however. While minimum wage increases lead to overall wage gains for individuals in the lowest wage group, those gains are muted if the worker was initially employed at an occupation with a high-level of routine cognitive tasks (column 7). Our estimates imply that a 10 percent increase in the minimum wage leads to relative wage gains of 1.2 (0.2) percent in the year just following the hike, 2.7 (0.5) percent one year after the hike, and 4.1 (0.5) percent two years after the hike for individuals in the lowest wage interval who were employed at an occupation with an average level of routine cognitive tasks.[35] However, these estimates would be 0.4 (0.2), and 1.1 (0.2) percent lower one year

to the first year minimum wage but use a dummy variable for being employed at a high routine cognitive occupation in the first CPS year, as opposed to the continuous routine cognitive share of an individual's occupation that we use in our main analysis.

[34]In the latter case, the inclusion of industry controls matter. Without them, the employment probability for individuals at a high cognitive routine occupation is somewhat lower after a minimum wage hike. See Appendix Table A10.

[35]These cumulative values are estimated by summing the marginal coefficients from column 7 in Table 7 – beginning with the year of the minimum wage change if it is statistically significant. All coefficients have a similar level of statistical significance if I include the leading effect. The fact that ripple effects increase over time is consistent with Phelan (2016) and may be due to labor-labor substitution or labor supply substitution stemming from changes in hedonic compensation, both of which appear to take place

and two years after the hike for every standard deviation increase in the routine cognitive share of tasks. For an occupation like a cashier, which typically involves 1.5 standard deviations more routine cognitive tasks than average, the wage gain would be about 2.4 (0.7) percent two years after the hike, a little more than half of the gain of the typical wage group 1 occupation. The timing of these relative wage losses are consistent with the timing of the employment realignment that we observe. Moreover, we do not observe a wage penalty on higher wage workers or workers employed at high routine manual occupations (Appendix Table A9).

The relative wage losses for individuals employed at high routine cognitive jobs persist if we limit the sample to either occupation stayers or occupation movers, although the effect is larger among stayers, suggesting the wage losses likely stem from both forced transitions to next best alternatives and falling relative wages for routine cognitive work. The wage results are also robust to removing industry-by-year fixed effects (Appendix Table A10) and X_1 and X_2 conditioning variables, including individuals with wage changes greater than $\pm$ 0.35 log points in the sample (see Appendix Table A11), and grouping individuals according to their current minimum wage (see Appendix Table A12).

In sum, the CPS results are broadly consistent with the OES estimates. Increases in the minimum wage cause workers to leave occupations intensive in routine cognitive tasks. These employment adjustments occur without much change in the short-run probability of employment. However, cognitively routine jobholders appear to miss out on a good portion of the wage gains associated with increases in the minimum wage and thus experience relative wage losses compared to other workers in their state. This result is unique to individuals employed in high routine cognitive occupations; there is no parallel effect on individuals employed in high routine manual occupations.

6 Conclusion

This paper extends the task-based theoretical and empirical framework used in the job polarization literature to analyze the susceptibility of low-wage jobs to technological sub-

with a lag.

stitution. We find that increases in the cost of labor arising from minimum wage hikes lead to relative employment declines at occupations that are intensive in routine cognitive tasks but not at occupations that are intensive in routine manual tasks. The employment effect is largest among the lowest wage occupations – those most affected by minimum wage laws – and has no impact on higher paid occupations. Moreover, these results are not confounded by jobs moving overseas, at least among the lowest paid occupations most impacted by the minimum wage. While the employment implications of this reshuffling of the low-wage labor market appear to be small in the short-run, those workers initially employed in cognitively routine jobs may miss out on a good portion of the wage gains associated with a minimum wage hike. These results suggest that the low-wage labor market is susceptible to technological substitution, in contrast with Bresnahan, Brynjolfsson, and Hitt (2002), Manning (2004), and Autor, Katz, and Kearney (2008), which have largely concluded that technological advancements have had little direct effect on the demand for low-wage jobs.

In many respects, the wage and employment effects we document mirror the effects of automation on routine-intensive middle-wage jobs (Goos and Manning, 2007). However, our results differ in several important dimensions. While much of the job polarization literature has moved on from distinguishing between routine cognitive and routine manual tasks (Goos, Manning, and Salomons, 2014), we find this distinction mattered among low-wage jobs during the 2000s. We also find that the loss of low-wage routine cognitive jobs has been largely offset in the short-run by job growth among other types of similar paying, albeit low-wage, jobs. This pattern differs from the job polarization literature which emphasizes that some middle-wage, routine work has been replaced by lower-paying jobs (Autor and Dorn, 2013). Our theoretical framework shows that the empirical patterns we document are possible if capital requires low-wage, non-routine labor to be productive. However, the model also suggests that the employment consequences of technological substitution on the low-wage sector can become more negative over the longer run if non-routine labor is primarily needed during a transitional period when new equipment is introduced. Thus, while we find that the short-run effects on overall low-wage employment are economically small, our empirical results have little to say about what will transpire in the long-run.

References

Aaronson, D., S. Agarwal, and E. French (2012): "The spending and debt response to minimum wage hikes," *American Economic Review*, 102(7), 3111–3139.

Aaronson, D., and E. French (2007): "Product Market Evidence on the Employment Effects of the Minimum Wage," *Journal of Labor Economics*, 25(1), 167–200.

Aaronson, D., E. French, I. Sorkin, and T. To (2017): "Industry Dynamics and the Minimum Wage: A Putty-Clay Approach," *International Economics Review*, Forthcoming.

Acemoglu, D., and D. Autor (2011): "Skills, Tasks and Technologies: Implications for Employment and Earnings," *Handbook of Labor Economics*, 4, 1043–1171.

Addison, J. T., M. L. Blackburn, and C. D. Cotti (2013): "Minimum Wage Increases in a Recessionary Environment," *Labour Economics*, 23(0), 30–39.

Allegretto, S. A., A. Dube, and M. Reich (2011): "Do Minimum Wages Really Reduce Teen Employment? Accounting for Heterogeneity and Selectivity in State Panel Data," *Industrial Relations: A Journal of Economy and Society*, 50(2), 205–240.

Autor, D. H., and D. Dorn (2013): "The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market," *American Economic Review*, 103(5), 1553–1597.

Autor, D. H., D. Dorn, and G. H. Hanson (2015): "Untangling Trade and Technology: Evidence from Local Labour Markets," *The Economic Journal*, 125(584), 621–646.

Autor, D. H., L. F. Katz, and M. S. Kearney (2008): "Trends in US wage inequality: Revising the revisionists," *Review of Economics and Statistics*, 90(2), 300–323.

Autor, D. H., F. Levy, and R. J. Murnane (2003): "The Skill Content of Recent Technological Change: An Empirical Exploration," *Quarterly Journal of Economics*, 118(4), 1279–1333.

Baker, M., D. Benjamin, and S. Stanger (1999): "The Highs and Lows of the Minimum Wage Effect: A Time-Series Cross-Section Study of the Canadian law," *Journal of Labor Economics*, 17(2), 318–350.

Basker, E., L. Foster, and S. Klimek (2015): "Customer-Labor Substitution: Evidence from Gasoline Stations," Discussion paper, University of Missouri.

Beaudry, P., D. A. Green, and B. M. Sand (2016): "The Great Reversal in the Demand for Skill and Cognitive Tasks," *Journal of Labor Economics*, 34(S1), S199–S247.

Black, S. E., and A. Spitz-Oener (2010): "Explaining Women's Success: Technological Change and the Skill Content of Women's Work," *Review of Economics and Statistics*, 92(1), 187–194.

Blinder, A. S. (2009): "How Many US Jobs Might be Offshorable?," *World Economics*, 10(2), 41–78.

Bresnahan, T. F., E. Brynjolfsson, and L. M. Hitt (2002): "Information Technology, Workplace Organization and the Demand for Skilled Labor: Firm-Level Evidence," *Quarterly Journal of Economics*, 117(1), 339–376.

Brown, C., C. Gilroy, and A. Kohen (1982): "The Effect of the Minimum Wage on Employment and Unemployment," *Journal of Economic Literature*, 20(2), 487–528.

Butcher, T., R. Dickens, and A. Manning (2012): "Minimum wages and wage inequality: some theory and an application to the UK," Discussion paper, Centre for Economic Performance, London School of Economics and Political Science.

Clemens, J., and M. Wither (2014): "The Minimum Wage and the Great Recession: Evidence of Effects on the Employment and Income Trajectories of Low-Skilled Workers," Discussion paper, National Bureau of Economic Research.

Doms, M., and T. Dunne (1998): "Capital Adjustment Patterns in Manufacturing Plants," *Review of Economic Dynamics*, 1(2), 409–429.

Dube, A., T. W. Lester, and M. Reich (2010): "Minimum Wage Effects Across State Borders: Estimates using Contiguous Counties," *Review of Economics and Statistics*, 92(4), 945–964.

Dustmann, C., J. Ludsteck, and U. Schönberg (2009): "Revisiting the German Wage Structure," *Quarterly Journal of Economics*, 124(2), 843–881.

Giuliano, L. (2013): "Minimum Wage Effects on Employment, Substitution, and the Teenage Labor Supply: Evidence from Personnel Data," *Journal of Labor Economics*, 31(1), 155–194.

Goos, M., and A. Manning (2007): "Lousy and Lovely Jobs: The Rising Polarization of Work in Britain," *Review of Economics and Statistics*, 89(1), 118–133.

Goos, M., A. Manning, and A. Salomons (2009): "Job Polarization in Europe," *American Economic Review*, 99(2), 58–63.

——— (2014): "Explaining Job Polarization: Routine-Biased Technological Change and Offshoring," *American Economic Review*, 104(8), 2509–2526.

Hamermesh, D. S. (1996): *Labor Demand*. Princeton University Press.

Jaimovich, N., and H. E. Siu (2012): "The Trend is the Cycle: Job Polarization and Jobless Recoveries," Discussion paper, National Bureau of Economic Research.

Lee, D. (1999): "Wage Inequality in the United States During the 1980s: Rising Dispersion or Falling Minimum Wage?," *Quarterly Journal of Economics*, 114(3), 977–1023.

Lewis, E. (2011): "Immigration, skill mix, and capital skill complementarity," *Quarterly Journal of Economics*, 126(2), 1029–1069.

Machin, S., A. Manning, and L. Rahman (2003): "Where the Minimum Wage Bites Hard: Introduction of Minimum Wages to a Low Wage Sector," *Journal of the European Economic Association*, 1(1), 154–180.

Manning, A. (2004): "We Can Work It Out: The Impact of Technological Change on the Demand for Low-Skill Workers," *Scottish Journal of Political Economy*, 51(5), 581–608.

Meer, J., and J. West (2016): "Effects of the Minimum Wage on Employment Dynamics," *Journal of Human Resources*, 51(2), 500–522.

Neumark, D., J. I. Salas, and W. Wascher (2014): "Revisiting the Minimum WageEmployment Debate: Throwing Out the Baby with the Bathwater?," *Industrial & Labor Relations Review*, 67(3S), 608–648.

Neumark, D., M. Schweitzer, and W. Wascher (2004): "Minimum Wage Effects throughout the Wage Distribution," *Journal of Human Resources*, 39(2), 425.

Neumark, D., and W. L. Wascher (2008): *Minimum Wages*. MIT Press.

Phelan, B. J. (2016): "Hedonic-Based Labor Supply Substitution and the Ripple Effect of Minimum Wages," Discussion paper, DePaul University.

Sabia, J. J., R. V. Burkhauser, and B. Hansen (2012): "Are the Effects of Minimum Wage Increases Always Small-New Evidence from a Case Study of New York State," *Industrial & Labor Relations Review*, 65(2), 350–376.

Sorkin, I. (2015): "Are There Long-Run Effects of the Minimum Wage?," *Review of Economic Dynamics*, 18(2), 306–333.

Table 1: Occupations Sorted by Routine Cognitive Intensity

Average Wage less than 175 Percent of Minimum Wage

Occupation	Average Wage-to-MW	Average Annual Employment	Share of Tasks Routine Cognitive	Share of Tasks Routine Manual	Offshorability Index
Graders and Sorters, Agricultural Products	1.44	46,735	36.4%	20.9%	0
Gaming and Sports Book Writers and Runners	1.68	12,170	35.1%	15.6%	0
Gaming Dealers	1.40	72,509	34.6%	11.4%	0
Ushers, Lobby Attendants, and Ticket Takers	1.41	99,214	33.6%	8.5%	0
Cashiers	1.44	3,423,209	31.4%	17.0%	0
Pharmacy Aides	1.66	52,071	30.2%	10.6%	0
Motion Picture Projectionists	1.67	9,188	29.9%	22.5%	0
Shoe And Leather Workers And Repairers	1.74	7,072	29.8%	19.0%	75
Hotel, Motel, and Resort Desk Clerks	1.56	194,910	28.7%	8.8%	0
Crossing Guards	1.73	63,034	28.2%	8.6%	0
Meat, Poultry, and Fish Cutters and Trimmers	1.70	140,562	28.0%	20.8%	0
Service Station Attendants	1.52	95,411	27.5%	17.1%	0
Sewing Machine Operators	1.61	260,009	27.4%	24.0%	75
Veterinary Assistants and Laboratory Animal Caretakers	1.67	64,807	26.9%	13.1%	0
Cooks, Institution and Cafeteria	1.71	398,825	26.5%	17.1%	0
Food Servers, Nonrestaurant	1.53	189,373	25.9%	13.4%	0
Maids and Housekeeping Cleaners	1.50	907,266	25.3%	21.1%	0
Shampooers	1.35	13,792	25.2%	13.0%	0
Baggage Porters And Bellhops	1.75	49,614	25.1%	12.0%	0
Waiters and Waitresses	1.38	2,188,726	25.0%	10.0%	0
Home Health Aides	1.62	680,325	24.8%	8.2%	0
Parking Lot Attendants	1.45	120,265	24.7%	11.1%	0
Lifeguards and Other Recreational Service Workers	1.47	59,475	24.4%	6.6%	0
Transportation Attendants, Except Flight Attendants	1.69	20,432	24.2%	9.6%	0
Packers and Packagers, Hand	1.57	884,109	23.8%	17.7%	0
Cooks, Short Order	1.51	193,991	23.7%	15.9%	0
Laundry and Dry-Cleaning Workers	1.53	216,498	22.8%	24.0%	0
Dining Room and Cafeteria Attendants	1.31	404,375	22.8%	17.5%	0
Janitors and Cleaners, Except Maids	1.74	2,089,665	22.5%	17.7%	0
Combined Food Preparation Workers, Including Fast Food	1.31	2,282,241	22.2%	14.8%	0
Pressers, Textile, Garment, and Related Materials	1.52	80,722	22.1%	29.3%	75
Farmworkers and Laborers, Crop and Nursery	1.29	222,026	21.9%	20.8%	0
Counter Attendants, Cafeteria and Food Concession	1.34	476,737	21.8%	13.8%	0
Hosts and Hostesses, Restaurant and Lounge	1.38	325,578	21.7%	6.8%	0
Cooks, Restaurant	1.69	770,806	21.7%	17.0%	0
Cooks, Fast Food	1.30	569,517	21.4%	19.2%	0
Agricultural Equipment Operators	1.69	20,464	20.3%	22.6%	0
Cleaners Of Vehicles and Equipment	1.62	317,549	20.3%	19.0%	0
Food Preparation Workers	1.48	861,151	20.0%	15.4%	0
Personal and Home Care Aides	1.48	498,922	19.8%	4.0%	0
Dishwashers	1.32	505,858	19.4%	22.8%	0
Manicurists and Pedicurists	1.59	34,161	19.0%	11.6%	0
Bicycle Repairers	1.69	5,803	18.3%	6.8%	0
Locker Room, Coatroom, and Dressing Room Attendants	1.57	18,714	17.4%	12.2%	0
Nonfarm Animal Caretakers	1.61	99,373	17.3%	7.4%	0
Farmworkers, Farm and Ranch Animals	1.65	35,302	16.3%	16.6%	0
Bartenders	1.47	453,883	15.8%	11.1%	0
Child Care Workers	1.51	499,441	13.5%	4.0%	0
Amusement and Recreation Attendants	1.40	218,711	13.1%	8.2%	0
Average for Occupations with W<1.75*MW	1.48		24.1%	15.1%	1.2
Average for Occupations with 1.75*MW<W<2.5*MW	2.09		25.9%	12.4%	31.9
Average for Occupations with 2.5*MW<W<3*MW	2.77		22.8%	14.3%	23.8

Notes: The wage and employment data are from the Occupation Employment Statistics. The average wage-to-minimum wage is the employment weighted average (for a given occupation) across all states and years. The routine share values are calculated by the authors using O*NET task data reported in Acemoglu and Autor (2011). The offshorability measure is from Blinder (2009).

Table 2: Employment Effect of a Minimum Wage Hike, by the Routine Cognitive Share of Tasks
Long-Difference Estimates using the Occupation Employment Statistics

	Specification 1: No Interaction Terms				Specification 2: Routine Share Interacted with Change in Minimum Wage				Specification 3: Routine Share Interacted with Change in Minimum Wage			
	Wage Group1	Wage Group2	Wage Group3	Wage Group4	Wage Group1	Wage Group2	Wage Group3	Wage Group4	Wage Group1	Wage Group2	Wage Group3	Wage Group4
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ΔMW Over Past Year	0.01	-0.01	-0.03	-0.01	0.01	-0.01	-0.03	-0.01				
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)				
ΔMW Over Past 2 Yrs	0.03	0.00	0.02	0.03	0.03	0.01	0.03	0.03				
	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)				
ΔMW Over Past 3 Yrs	0.05	-0.01	0.03	0.05	0.06	0.00	0.05	0.06				
	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)	(0.03)				
ΔMW Over Past 4 Yrs	0.04	-0.04	0.04	0.04	0.05	-0.02	0.06	0.05				
	(0.05)	(0.04)	(0.05)	(0.03)	(0.05)	(0.04)	(0.04)	(0.04)				
ΔMW Over Past Year X RoutineSh					-0.01	0.01	0.00	0.00	-0.01	0.00	0.00	0.00
					(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
ΔMW Over Past 2 Yrs X RoutineSh					-0.04*	-0.02	-0.04	-0.01	-0.04*	-0.03	-0.02	-0.01
					(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
ΔMW Over Past 3 Yrs X RoutineSh					-0.09**	-0.05	-0.06	-0.01	-0.09**	-0.07*	-0.04	-0.01
					(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
ΔMW Over Past 4 Yrs X RoutineSh					-0.09**	-0.08	-0.09*	-0.02	-0.09**	-0.10*	-0.06	-0.02
					(0.03)	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)
State & Year FE	**Yes**				**Yes**				**No**			
State-by-Year FE	**No**				**No**				**Yes**			

Wage Group 1 includes all occupations where the average wage is less than 175 percent of the minimum wage (within the particular state over the panel). Wage Group 2 includes all occupations where the average wage is between 175 percent and 250 percent of the minimum wage. Wage Group 3 includes all occupations where the average wage is between 250 percent and 300 percent of the minimum wage. Wage Group 4 includes all occupations where the average wage is between 300 percent and 600 percent of the minimum wage. Observations are weighted by state-specific employment levels. Standard errors are clustered at the state level. Occupation-specific employment changes greater than ± 0.5 log points are excluded from the 1-year and 2-year change estimates. Occupation-specific employment changes greater than ± 0.75 log points are excluded from the 3-year and 4-year change estimates. All specifications use the OES data from 1999-2009, but the sample for 1-year changes (2000-2009) is 192,293; the sample for 2-year changes (2001-2009) is 157,838; the sample for 3-year changes (2002-2009) is 143,445; and the sample for 4-year changes (2003-2009) is 118,059. Increases in the minimum wage less than 0.03 log points are also excluded from the analysis. The routine share of an occupation is standardized to have a mean of zero and a standard deviation of one. *p<0.05 and **p<0.01.

Table 3: Employment Effect of a Minimum Wage Hike, by Routine Cognitive Share of Tasks
Four Year Long-Difference/Distributed Lag Estimates using the Occupation Employment Statistics

	Specification 1: No Interaction Terms				Specification 2: Routine Share Interacted with Change in Minimum Wage				Specification 3: Routine Share Interacted with Change in Minimum Wage			
	Wage Group1	Wage Group2	Wage Group3	Wage Group4	Wage Group1	Wage Group2	Wage Group3	Wage Group4	Wage Group1	Wage Group2	Wage Group3	Wage Group4
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ΔMW Next Year	0.01	0.03	0.05	-0.02	0.01	0.04	0.06	-0.02				
	(0.03)	(0.05)	(0.04)	(0.02)	(0.03)	(0.04)	(0.05)	(0.02)				
ΔMW This Year	0.04	-0.05	0.03	0.01	0.05	-0.04	0.06	0.01				
	(0.04)	(0.06)	(0.05)	(0.03)	(0.04)	(0.05)	(0.05)	(0.03)				
ΔMW Last Year	0.01	-0.01	0.04	0.04	0.03	0.01	0.07	0.05				
	(0.05)	(0.06)	(0.06)	(0.04)	(0.06)	(0.05)	(0.05)	(0.04)				
ΔMW 2Yrs Ago	0.11	-0.06	0.05	0.09	0.13	-0.03	0.09	0.10				
	(0.08)	(0.05)	(0.09)	(0.07)	(0.08)	(0.05)	(0.07)	(0.08)				
ΔMW Next Year X RoutineSh					0.03	-0.01	-0.07	-0.01	0.03	-0.01	-0.05	-0.01
					(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)
ΔMW This Year X RoutineSh					-0.04	-0.04	-0.11**	-0.01	-0.03	-0.06	-0.08**	-0.01
					(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)
ΔMW Last Year X RoutineSh					-0.09*	-0.09	-0.13*	-0.01	-0.09*	-0.11*	-0.09	0.00
					(0.04)	(0.05)	(0.06)	(0.04)	(0.04)	(0.05)	(0.05)	(0.04)
ΔMW 2Yrs Ago X RoutineSh					-0.14**	-0.12*	-0.11	-0.04	-0.13**	-0.16**	-0.08	-0.03
					(0.05)	(0.06)	(0.07)	(0.06)	(0.05)	(0.06)	(0.07)	(0.05)
State FE and Year FE	**Yes**				**Yes**				**No**			
State x Year FE	**No**				**No**				**Yes**			

Notes: See the notes to Table 2. Occupation-specific employment changes greater than ± 0.75 log points are excluded from the analysis. $N = 118,896$ for all three specifications. *p<0.05 and **p<0.01.

Table 4: Employment Effect of a Minimum Wage Hike by the Routine Manual Share of Tasks
Long-Difference Estimates using the Occupation Employment Statistics

	Specification 1: No Interaction Terms				**Specification 2: Routine Share Interacted with Change in Minimum Wage**				**Specification 3: Routine Share Interacted with Change in Minimum Wage**			
	Wage Group1	**Wage Group2**	**Wage Group3**	**Wage Group4**	**Wage Group1**	**Wage Group2**	**Wage Group3**	**Wage Group4**	**Wage Group1**	**Wage Group2**	**Wage Group3**	**Wage Group4**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ΔMW Over Past Year	0.01	-0.01	-0.02	-0.01	0.01	-0.02	-0.03	-0.01				
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)				
ΔMW Over Past 2 Years	0.03	0.00	0.02	0.03	0.03	0.00	0.02	0.03				
	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)				
ΔMW Over Past 3 Years	0.04	0.00	0.03	0.05	0.04	-0.01	0.03	0.05				
	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)				
ΔMW Over Past 4 Years	0.03	-0.03	0.03	0.04	0.03	-0.03	0.03	0.04				
	(0.04)	(0.04)	(0.05)	(0.03)	(0.04)	(0.03)	(0.05)	(0.03)				
ΔMW Over Past Year X RoutineSh					-0.01	-0.02	-0.02	-0.01	-0.01	-0.02	-0.02	-0.01
					(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)
ΔMW Over Past 2 Years X RoutineSh					0.01	0.00	0.01	-0.03	0.00	0.00	0.00	-0.02
					(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)
ΔMW Over Past 3 Years X RoutineSh					0.01	0.00	0.02	-0.04	0.01	0.01	0.01	-0.03
					(0.03)	(0.05)	(0.05)	(0.02)	(0.04)	(0.04)	(0.05)	(0.03)
ΔMW Over Past 4 Years X RoutineSh					0.06	0.01	0.01	-0.04	0.06	0.03	0.01	-0.04
					(0.03)	(0.06)	(0.06)	(0.04)	(0.03)	(0.05)	(0.06)	(0.04)
State & Year FE	**Yes**				**Yes**				**No**			
State-by-Year FE	**No**				**No**				**Yes**			

See notes for Table 2. *p<0.05 and **p<0.01.

Table 5: Employment Effect of Minimum Wages
by Alternative Task Intensities

	Wage Group 1	**Wage Group 2**	**Wage Group 3**	**Wage Group 4**
	(1)	(2)	(3)	(4)
Non-Routine Manual Physical Task Share				
ΔMW Next Year X TaskSh	0.08	0.04	0.08	0.01
	(0.09)	(0.03)	(0.04)	(0.04)
ΔMW This Year X TaskSh	0.08	0.07*	0.01	0.03
	(0.05)	(0.03)	(0.04)	(0.06)
ΔMW Last Year X TaskSh	-0.02	0.09**	0.05	-0.01
	(0.07)	(0.03)	(0.06)	(0.05)
ΔMW 2Yrs Ago X TaskSh	0.13	0.09	-0.04	0.00
	(0.09)	(0.05)	(0.03)	(0.05)
Non-Routine Manual Interactive Task Share				
ΔMW Next Year X TaskSh	-0.09	0.04	-0.01	0.07
	(0.07)	(0.05)	(0.05)	(0.04)
ΔMW This Year X TaskSh	-0.18**	0.00	0.02	0.06
	(0.04)	(0.05)	(0.07)	(0.05)
ΔMW Last Year X TaskSh	0.03	-0.01	-0.02	0.06
	(0.09)	(0.04)	(0.07)	(0.04)
ΔMW 2Yrs Ago X TaskSh	-0.10	0.09	0.08	0.07
	(0.10)	(0.10)	(0.08)	(0.03)
Non-Routine Cognitive Analytical Task Share				
ΔMW Next Year X TaskSh	0.07	-0.04	-0.08	0.03
	(0.05)	(0.03)	(0.05)	(0.04)
ΔMW This Year X TaskSh	0.08	0.00	0.02	0.05
	(0.06)	(0.04)	(0.07)	(0.05)
ΔMW Last Year X TaskSh	0.07	-0.01	0.06	0.10
	(0.05)	(0.03)	(0.08)	(0.05)
ΔMW 2Yrs Ago X TaskSh	0.06	-0.03	0.19*	0.08
	(0.06)	(0.04)	(0.09)	(0.07)
Non-Routine Cognitive Interpersonal Task Share				
ΔMW Next Year X TaskSh	0.01	-0.03	0.01	-0.04
	(0.04)	(0.03)	(0.04)	(0.05)
ΔMW This Year X TaskSh	0.08	-0.04	0.10	-0.08
	(0.07)	(0.04)	(0.05)	(0.05)
ΔMW Last Year X TaskSh	0.14*	-0.06*	0.06	-0.06
	(0.07)	(0.03)	(0.08)	(0.04)
ΔMW 2Yrs Ago X TaskSh	0.06	-0.01	0.06	-0.05
	(0.08)	(0.07)	(0.11)	(0.05)

Notes: See the notes to Table 2. Results from separate specifications that include state-by-year FE. Occupation-specific employment changes greater than ± 0.75 log points are excluded from the analysis. All task shares standardized to be mean zero with a standard deviation of one. $N = 118,896$ for all specifications. *p<0.05 and **p<0.01.

Table 6: Employment Effect of a Minimum Wage Hike: Robustness to Offshoring

Occupation Employment Statistics

	Specification 1: Routine Share Interaction Terms				Specification 2: Offshorability Interaction Terms				Specification 3: Routine Share and Offshorability Interaction Terms			
	Wage Group1	**Wage Group2**	**Wage Group3**	**Wage Group4**	**Wage Group1**	**Wage Group2**	**Wage Group3**	**Wage Group4**	**Wage Group1**	**Wage Group2**	**Wage Group3**	**Wage Group4**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ΔMW Next Year X RoutineSh	0.03	-0.01	-0.05	-0.01					0.03	-0.01	0.03	-0.01
	(0.04)	(0.05)	(0.04)	(0.04)					(0.03)	(0.04)	(0.04)	(0.05)
ΔMW This Year X RoutineSh	-0.03	-0.06	-0.08**	-0.01					-0.03	-0.05	-0.07	-0.01
	(0.04)	(0.04)	(0.03)	(0.04)					(0.05)	(0.04)	(0.05)	(0.04)
ΔMW Last Year X RoutineSh	-0.09*	-0.11*	-0.09	0.00					-0.09*	-0.10	-0.09	-0.02
	(0.04)	(0.05)	(0.05)	(0.04)					(0.04)	(0.07)	(0.08)	(0.04)
ΔMW 2Yrs Ago X RoutineSh	-0.13**	-0.16**	-0.08	-0.03					-0.10*	-0.06	-0.19	-0.04
	(0.05)	(0.06)	(0.07)	(0.05)					(0.05)	(0.10)	(0.12)	(0.05)
ΔMW Next Year X Offshorability					-0.17**	-0.01	-0.07*	0.00	-0.17**	0.00	-0.09*	0.00
					(0.05)	(0.04)	(0.03)	(0.02)	(0.05)	(0.03)	(0.03)	(0.03)
ΔMW This Year X Offshorability					-0.05	-0.03	-0.04	-0.01	-0.05	-0.01	0.00	0.00
					(0.05)	(0.03)	(0.03)	(0.04)	(0.05)	(0.02)	(0.05)	(0.04)
ΔMW Last Year X Offshorability					-0.22**	-0.05	-0.04	0.03	-0.21**	0.00	0.01	0.04
					(0.07)	(0.03)	(0.05)	(0.04)	(0.07)	(0.03)	(0.07)	(0.04)
ΔMW 2Yrs Ago X Offshorability					-0.16	-0.18**	0.01	0.01	-0.16	-0.16	0.13	0.02
					(0.09)	(0.06)	(0.05)	(0.06)	(0.08)	(0.09)	(0.11)	(0.06)
State x Year FE	**Yes**				**Yes**				**Yes**			

Notes: See notes to Table 2. The offshorability of an occupation (like the routine cognitive share) is standardized to have a mean of zero and a standard deviation of one. $N = 118,317$ for all three specifications. * p<0.05 and ** p<0.01.

Table 7: Effect of Minimum Wage Hikes on Employment at High Routine Cognitive Occupations

Matched CPS

	Probability of Employment at High Routine Cognitive Occupation in Second Matched CPS Observation						One-Year Change in Routine Cognitive Task Share at Occupation					
	Specification 1:		Specification 2:				Specification 1:		Specification 2:			
	Wage Group1	**Wage Group2**	**Wage Group1**	**Wage Group2**	**Wage Group1**	**Wage Group2**	**Wage Group1**	**Wage Group2**	**Wage Group1**	**Wage Group2**	**Wage Group1**	**Wage Group2**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ΔMW Next Year	0.00	0.00	0.03	-0.01	0.01	-0.03	0.02	-0.01	0.12	-0.02	0.10	-0.03
	(0.04)	(0.02)	(0.04)	(0.02)	(0.07)	(0.05)	(0.08)	(0.05)	(0.11)	(0.06)	(0.16)	(0.11)
ΔMW This Year	0.01	0.02	0.01	0.00	0.03	0.01	-0.07	0.06	-0.11	0.03	0.07	0.07
	(0.04)	(0.02)	(0.04)	(0.02)	(0.08)	(0.05)	(0.10)	(0.06)	(0.11)	(0.09)	(0.19)	(0.14)
ΔMW Last Year	-0.11*	-0.02	-0.07	-0.02	-0.17	0.01	-0.14	0.04	-0.05	-0.01	-0.33	0.14
	(0.05)	(0.03)	(0.05)	(0.03)	(0.09)	(0.05)	(0.10)	(0.07)	(0.11)	(0.07)	(0.20)	(0.12)
ΔMW Two Years Ago	-0.03	0.01	-0.02	-0.01	-0.11	0.00	0.05	0.10	0.14	0.05	0.03	0.24
	(0.05)	(0.04)	(0.04)	(0.03)	(0.08)	(0.06)	(0.13)	(0.07)	(0.17)	(0.10)	(0.25)	(0.13)
ΔMW Next Year X RoutineSh			-0.07	0.02	-0.08	0.02			-0.25	0.03	-0.25	0.05
			(0.05)	(0.02)	(0.06)	(0.05)			(0.13)	(0.05)	(0.13)	(0.09)
ΔMW This Year X RoutineSh			0.00	0.03	-0.05	0.01			0.10	0.06	-0.11	0.08
			(0.04)	(0.03)	(0.06)	(0.05)			(0.11)	(0.08)	(0.10)	(0.12)
ΔMW Last Year X RoutineSh			-0.10*	0.01	-0.21**	0.01			-0.20	0.10	-0.36*	0.11
			(0.05)	(0.04)	(0.06)	(0.07)			(0.11)	(0.08)	(0.17)	(0.12)
ΔMW 2Yrs Ago X RoutineSh			-0.04	0.04	-0.12	0.06			-0.23	0.10	-0.45*	0.03
			(0.06)	(0.05)	(0.09)	(0.08)			(0.18)	(0.15)	(0.22)	(0.19)
Occupation Changers Only	No		No		Yes		No		No		Yes	
N	108,189		108,189		51,021		108,189		108,189		51,021	

Notes: Wage Group 1 includes hourly workers with a first period wage of at least 80 percent but less than 175 percent of the MW. Wage Group 2 includes hourly workers with a first period wage 175 to 600 percent of the minimum wage. The wage groups are computed relative to the minimum wages from two years prior. Specification 1 does not include interaction terms between changes in the minimum wage and being employed at a high routine cognitive occupation in the first matched CPS observation. Specification 2 includes those interaction terms. High routine share occupations are those with a routine cognitive share that is at least one standard deviation above average for their wage group. Observations are weighted using sample weights. Routine cognitive share of tasks standardized to be mean zero with a standard deviation of one. Standard errors are clustered at the state level. We exclude minimum wage changes less than 0.03 log points. The sample is conditional on a) hourly employment in the first CPS observation and b) the log wage change between outgoing rotation months being within ± 0.35 log points. *p<0.05 and **p<0.01.

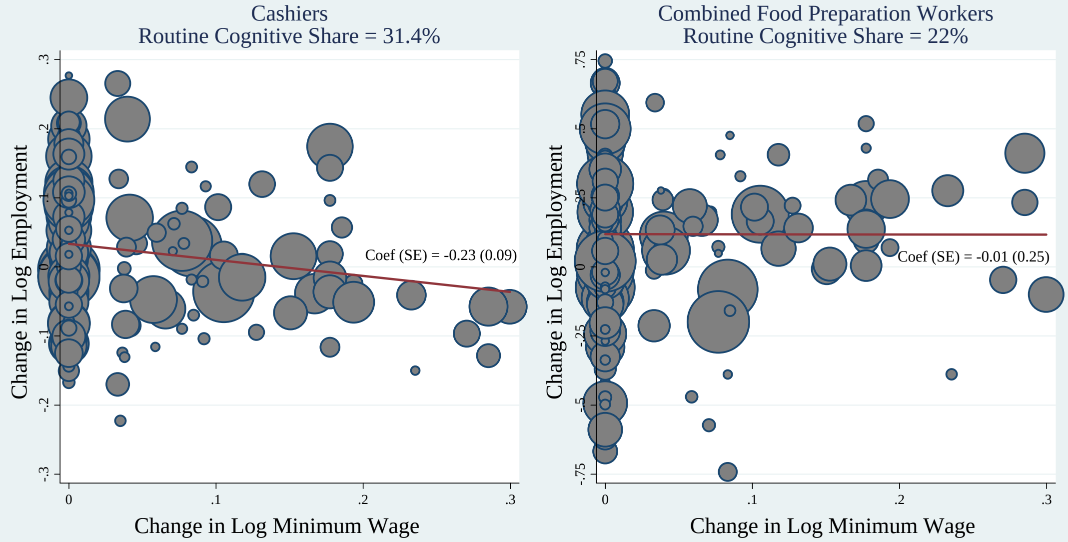
Table 8: Employment and Wage Effect of Minimum Wage Hikes on Individuals Employed at Routine Cognitive Jobs
Matched CPS

	Employment Effect				Wage Effect			
	Specification 1:		Specification 2:		Specification 1:		Specification 2:	
	Wage Group1	Wage Group2	Wage Group1	Wage Group2	Wage Group1	Wage Group2	Wage Group1	Wage Group2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔMW Next Year	-0.03	0.01	-0.03	0.01	0.10**	0.00	0.11**	0.00
	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.01)	(0.03)	(0.01)
ΔMW This Year	0.01	0.01	-0.01	0.01	0.11**	0.00	0.12**	0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)
ΔMW Last Year	0.00	0.00	0.01	0.00	0.14**	0.01	0.15**	0.00
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
ΔMW Two Years Ago	0.00	-0.01	0.01	-0.01	0.11**	0.02	0.14**	0.02
	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
ΔMW Next Year X RoutineSh			0.01	-0.01			-0.01	0.00
			(0.02)	(0.01)			(0.02)	(0.01)
ΔMW This Year X RoutineSh			0.04	0.00			-0.02	-0.01
			(0.03)	(0.01)			(0.02)	(0.01)
ΔMW Last Year X RoutineSh			-0.03	-0.01			-0.04*	0.02*
			(0.02)	(0.02)			(0.02)	(0.01)
ΔMW 2Yrs Ago X RoutineSh			-0.02	0.01			-0.06**	-0.01
			(0.02)	(0.02)			(0.02)	(0.01)
N	169,733		169,733		108,189		108,189	

Notes: See notes from Table 7. The employment analysis sample is conditional on being employed as an hourly-paid worker in the first CPS observation. The wage analysis sample also conditions on being employed in the second CPS observation with log employment changes not exceeding ± 0.35 log points. *p<0.05 and **p<0.01.

Figure 1: Employment Effect of a Minimum Wage Hike

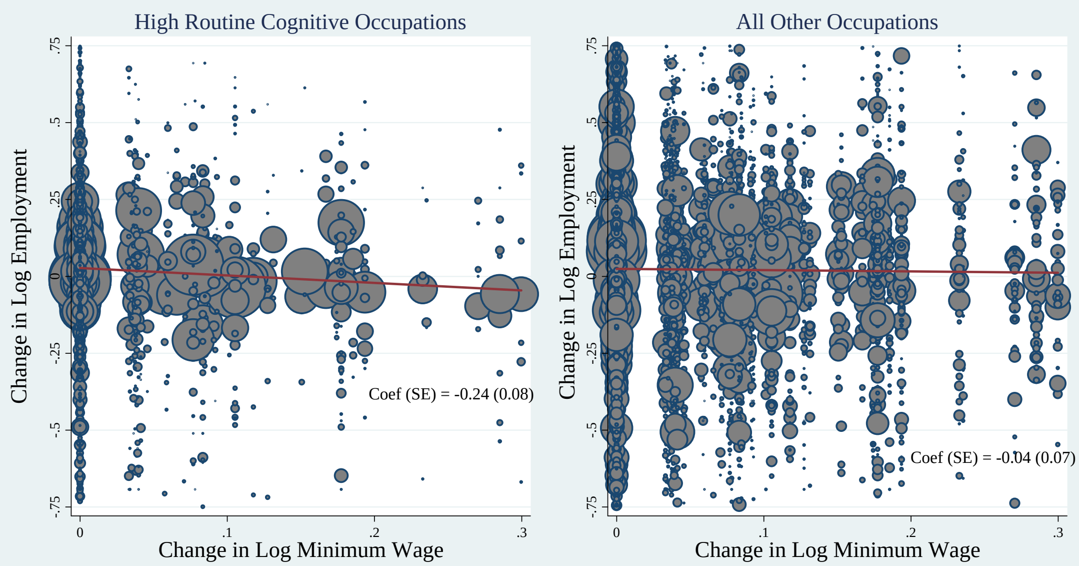
Cashiers versus Combined Food Preparation Workers



Note: Using OES data from 1999-2009, the figures plot total changes in occupational employment from four years prior against the one-year change in the state-level minimum wage from three years prior. This structure allows minimum wage changes to have lagged effects on employment. Each observation is a state-year weighted by employment levels in the base year. Minimum wage hikes less than 0.03 log points are excluded from the figures.

Figure 2: Employment Effect of a Minimum Wage Hike

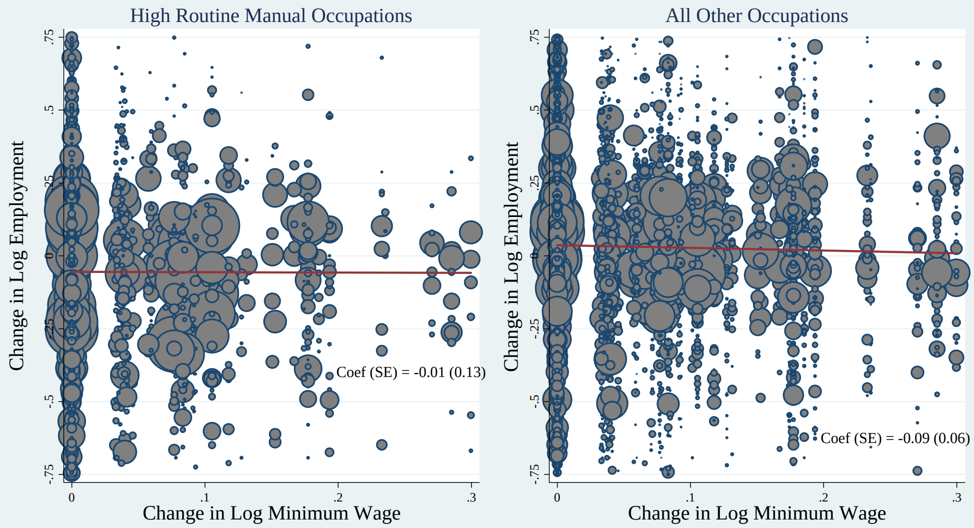
High Routine Cognitive Occupations vs. All Other Occupations in Wage Group 1



Note: See notes to Figure 1. Wage Group 1 includes all occupations where the average wage to the minimum wage within a state is less than 1.75. A high routine cognitive occupation has a routine cognitive share that is more than one standard deviation above average.

Figure 3: Employment Effect of a Minimum Wage Hike

High Routine Manual Occupations vs. All Other Occupations in Wage Group 1



Note: See notes to Figure 1 and Figure 2. A high routine manual occupation has a routine manual share that is more than one standard deviation above average.

A Appendix

Table A1: Federal & State Minimum Wage Increases

1999-2009

	U.S.	**AK**	**AR**	**AZ**	**CA**	**CO**	**CT**	**DC**	**DE**	**FL**	**HI**	**IA**	**IL**	**MA**	**ME**	**MD**	**MI**
1999	5.15	5.65	5.15	5.15	5.75	5.15	5.65	6.15	5.65	5.15	5.25	5.15	5.15	5.25	5.15	5.15	5.15
2000							6.15							6.00			
2001					6.25		6.40		6.15					6.75			
2002		7.15			6.75		6.70				5.75				5.25		
2003							6.90				6.25				6.25		
2004							7.10						5.50				
2005								6.60		6.15			6.50		6.35		
2006							7.40	7.00		6.40	6.75				6.50	6.15	
2007			6.25	6.75	7.50	6.85	7.65		6.65	6.67	7.25	6.20		7.50	6.75		6.95
2008	5.85			6.9	8.00	7.02			7.15	6.79		7.25	7.50	8.00	7.00		7.15
2009	6.55		6.55	7.25		7.28	8.00	7.55		7.21			7.75		7.25	6.55	7.40

	MN	**MO**	**MT**	**NC**	**NH**	**NJ**	**NM**	**NV**	**NY**	**OH**	**OR**	**PA**	**RI**	**VT**	**WA**	**WV**	**WI**
1999	5.15	5.15	5.15	5.15	5.15	5.15	5.15	5.15	5.15	5.15	6.50	5.15	5.65	5.75	5.70	5.15	5.15
2000															6.50		
2001													6.15	6.25	6.72		
2002															6.90		
2003											6.90				7.01		
2004											7.05		6.75	6.75	7.16		
2005									6.00		7.25			7.00	7.35		
2006	6.15					6.15			6.75		7.50			7.25	7.63		5.70
2007		6.50	6.15	6.15		7.15		6.15	7.15	6.85	7.80	6.25	7.40	7.53	7.93	5.85	6.50
2008		6.65	6.25		6.50		6.50	6.33		7.00	7.95	7.15		7.68	8.07	6.55	
2009	6.55	7.05	6.55	6.55	7.25		7.50	6.55		7.30	8.40			8.06	8.55	7.25	6.55

Note: The first row presents the minimum wage in 1999 for all states that changed their minimum wage (separate from the federal minimum wage) during the period 1999-2009. All values are as of January. Empty cells reflect no change in the minimum wage. Missing states followed the federal minimum wage throughout the sample period.

Table A2: Occupations Sorted by Routine Cognitive Intensity
Average Wage Between 175 and 250 Percent of Minimum Wage

Occupation	Average Wage-to-MW	Average Annual Employment	Share of Tasks Routine Cognitive	Share of Tasks Routine Manual	Offshorability Index
Medical Transcriptionists	2.44	91,685	0.41	0.18	95
Order Clerks	2.25	291,355	0.35	0.11	67
Billing And Posting Clerks And Machine Operators	2.36	503,584	0.35	0.10	90
Medical Secretaries	2.26	357,574	0.34	0.11	0
Coil Winders, Tapers, And Finishers	2.17	30,149	0.33	0.20	68
Gaming Cage Workers	1.97	14,597	0.33	0.14	0
Foundry Mold And Coremakers	2.42	18,200	0.33	0.21	65
Painting, Coating, And Decorating Workers	2.02	29,647	0.33	0.22	68
Cutters And Trimmers, Hand	2.04	27,745	0.33	0.24	69
Counter And Rental Clerks	1.77	437,109	0.32	0.09	0
Bookkeeping, Accounting, And Auditing Clerks	2.49	1,761,393	0.32	0.08	84
Security Guards	1.85	1,019,062	0.32	0.05	0
Tellers	1.81	550,335	0.32	0.12	0
Gaming Change Persons And Booth Cashiers	1.77	25,373	0.32	0.11	0
Interviewers, Except Eligibility And Loan	2.11	189,938	0.31	0.11	48
Office Clerks, General	2.02	2,854,823	0.31	0.09	67.3
Telemarketers	1.94	388,868	0.31	0.11	95
Customer Service Representatives	2.43	2,009,411	0.30	0.10	67.3
Transportation Ticket Agents And Travel Clerks	2.45	149,871	0.30	0.12	94
Switchboard Operators, Including Answering Service	1.91	199,683	0.30	0.12	50
New Accounts Clerks	2.32	87,955	0.30	0.06	0
Pharmacy Technicians	2.07	252,209	0.30	0.11	32
Models	2.23	1,047	0.30	0.06	0
Word Processors And Typists	2.39	178,769	0.30	0.07	94
Shoe Machine Operators And Tenders	1.77	2,940	0.29	0.21	75
Fabric Menders, Except Garment	2.33	1,153	0.29	0.15	0
Extruding And Forming Machine Operators, Glass Fibers	2.49	20,365	0.29	0.24	68
Weighers, Measurers, And Samplers, Recordkeeping	2.28	76,819	0.29	0.09	27
Medical Records And Health Information Technicians	2.34	154,066	0.29	0.10	83
Gaming Surveillance Officers And Gaming Investigators	2.22	7,897	0.29	0.12	0
Parts Salespersons	2.36	236,324	0.29	0.07	0
Parking Enforcement Workers	2.43	8,680	0.29	0.09	0
Forming, Pressing, And Compacting Machine Operators	2.44	76,835	0.28	0.22	68
Semiconductor Processors	2.47	26,726	0.28	0.18	70
Data Entry Keyers	2.03	346,024	0.28	0.12	100
Mail Machine Operators, Except Postal Service	1.94	152,854	0.28	0.20	26
Secretaries, Except Legal, Medical, And Executive	2.29	1,767,974	0.27	0.11	53.5
Proofreaders And Copy Markers	2.30	18,974	0.27	0.08	95
Bill And Account Collectors	2.45	408,046	0.27	0.10	65
Receptionists And Information Clerks	1.90	1,066,109	0.27	0.09	75
Cutting And Press Machine Operators, Metal And Plastic	2.28	275,174	0.27	0.23	68
Washing And Metal Pickling Equipment Operators	2.08	16,814	0.27	0.16	68
Truck Drivers, Light Or Delivery Services	2.26	955,932	0.27	0.14	0
Slaughterers And Meat Packers	1.86	104,953	0.27	0.21	0
Bindery Workers	2.17	76,775	0.27	0.25	59
Textile Knitting And Weaving Machine Operators	2.07	46,039	0.27	0.23	75
Team Assemblers	2.18	1,187,650	0.27	0.20	65
Correspondence Clerks	2.37	23,109	0.26	0.14	77
Photographic Process Workers	2.05	22,500	0.26	0.18	34
Rehabilitation Counselors	2.49	107,335	0.26	0.05	0
Electrical And Electronic Equipment Assemblers	2.14	254,795	0.26	0.17	66
Laborers And Freight, Stock, And Material Movers, Hand	1.87	2,243,929	0.26	0.17	0
Ophthalmic Laboratory Technicians	2.12	28,185	0.26	0.21	34
Library Technicians	2.20	105,336	0.26	0.10	33
Veterinary Technologists And Technicians	2.15	61,521	0.26	0.10	0
Cooling And Freezing Equipment Operators And Tenders	2.08	7,292	0.26	0.17	68
Food And Tobacco Roasting And Drying Machine Operators	2.17	16,334	0.26	0.21	0
Farm Labor Contractors	1.78	2,942	0.26	0.08	0
Medical Equipment Preparers	2.10	38,260	0.26	0.19	0
Stock Clerks And Order Fillers	1.82	1,716,924	0.26	0.15	34

Notes: See notes to Table 1.

Table A2 (Continued): Occupations Sorted by Routine Cognitive Intensity
Average Wage Between 175 and 250 Percent of Minimum Wage

Occupation	Average Wage-to-MW	Average Annual Employment	Share of Tasks Routine Cognitive	Share of Tasks Routine Manual	Offshorability Index
Library Assistants, Clerical	1.81	105,272	0.26	0.10	0
Food Batchmakers	2.00	81,821	0.26	0.22	31
Slot Key Persons	2.11	12,151	0.26	0.12	0
Cutting And Slicing Machine Operators	2.35	75,520	0.26	0.20	68
Furniture Finishers	2.13	26,965	0.26	0.24	43
Costume Attendants	2.31	3,286	0.25	0.08	0
Medical Assistants	2.14	387,186	0.25	0.10	0
Upholsterers	2.35	38,897	0.25	0.17	57
Cabinetmakers And Bench Carpenters	2.26	123,901	0.25	0.21	57
Grinding And Buffing Machine Tool Operators	2.43	101,692	0.25	0.21	68
Photographic Processing Machine Operators	1.76	48,382	0.25	0.21	48
Rock Splitters, Quarry	2.46	2,236	0.25	0.18	36
Couriers And Messengers	1.81	110,803	0.25	0.10	0
Painters And Plasterers, Helpers	1.84	23,843	0.25	0.18	0
Travel Agents	2.42	96,686	0.25	0.07	50
Shipping, Receiving, And Traffic Clerks	2.16	779,011	0.25	0.11	29
Electromechanical Equipment Assemblers	2.26	56,888	0.25	0.18	66
Coating, Painting, And Spraying Machine Operators	2.33	97,765	0.25	0.21	68
Office Machine Operators, Except Computer	2.05	86,252	0.25	0.18	51
Bus Drivers, School	2.01	461,065	0.24	0.12	0
File Clerks	1.85	234,515	0.24	0.11	50
Industrial Truck And Tractor Operators	2.39	607,846	0.24	0.17	0
Butchers And Meat Cutters	2.30	130,585	0.24	0.19	0
Dancers	2.35	10,846	0.24	0.10	0
Conveyor Operators And Tenders	2.28	48,732	0.24	0.17	0
Packaging And Filling Machine Operators And Tenders	2.03	378,526	0.24	0.22	68
Construction Laborers	2.42	887,727	0.24	0.17	0
Refuse And Recyclable Material Collectors	2.37	125,322	0.24	0.21	0
Plumbers, Pipefitters, And Steamfitters, Helpers	2.09	78,410	0.24	0.13	0
Food Cooking Machine Operators And Tenders	1.94	36,293	0.24	0.20	27
Machine Feeders And Offbearers	2.01	154,959	0.23	0.23	0
Occupational Therapist Aides	2.19	6,825	0.23	0.09	0
Helpers–Production Workers	1.81	498,714	0.23	0.18	70
Dental Assistants	2.42	264,579	0.23	0.14	0
Molders, Shapers, And Casters, Except Metal And Plastic	2.22	35,462	0.23	0.19	69
Woodworking Machine Operators And Tenders	2.02	91,735	0.23	0.24	57
Sewers, Hand	1.75	13,134	0.23	0.14	75
Dietetic Technicians	2.07	25,725	0.23	0.15	0
Farm Equipment Mechanics	2.48	31,638	0.23	0.11	0
Textile Bleaching And Dyeing Machine Operators	1.89	22,774	0.23	0.20	75
Sawing Machine Setters, Operators, And Tenders, Wood	2.05	53,866	0.23	0.22	57
Plating And Coating MachineTenders, Metal And Plastic	2.30	42,540	0.23	0.24	70
Nursing Aides, Orderlies, And Attendants	1.81	1,359,709	0.23	0.13	0
Drawing Machine Operators And Tenders, Metal And Plastic	2.37	95,412	0.22	0.23	68
Helpers–Carpenters	1.98	94,612	0.22	0.19	0
Textile Winding Machine Setters And Operators	2.05	53,657	0.22	0.22	75
Craft Artists	2.29	2,115	0.22	0.15	0
Retail Salespersons	1.88	4,128,443	0.22	0.07	0
Cementing And Gluing Machine Operators And Tenders	2.16	24,258	0.22	0.22	68
Tire Repairers And Changers	1.85	91,724	0.22	0.18	0
Helpers–Roofers	1.85	20,792	0.22	0.13	0
Model Makers, Wood	2.47	2,184	0.22	0.13	60
Funeral Attendants	1.76	29,262	0.22	0.05	0
Grinding And Polishing Workers, Hand	2.12	42,925	0.22	0.20	68
Molding And Casting Machine Setters And Operators	2.22	150,109	0.22	0.24	68
Psychiatric Technicians	2.29	46,489	0.22	0.03	0
Physical Therapist Aides	1.89	40,541	0.21	0.12	0
Emergency Medical Technicians And Paramedics	2.34	187,925	0.21	0.09	0
Psychiatric Aides	2.03	50,603	0.21	0.03	0
Concierges	2.02	16,971	0.21	0.07	0

Notes: See notes to Table 1.

Table A2 (Continued): Occupations Sorted by Routine Cognitive Intensity
Average Wage Between 175 and 250 Percent of Minimum Wage

Occupation	Average Wage-to-MW	Average Annual Employment	Share of Tasks Routine Cognitive	Share of Tasks Routine Manual	Offshorability Index
Pesticide Handlers, Sprayers, And Applicators, Vegetation	2.32	22,380	0.21	0.17	0
Tailors, Dressmakers, And Custom Sewers	2.04	29,045	0.21	0.17	0
Roustabouts, Oil And Gas	2.37	38,088	0.21	0.15	36
Helpers–Installation, Maintenance, And Repair Workers	2.00	150,034	0.21	0.16	0
Animal Control Workers	2.34	12,135	0.20	0.05	0
Textile Cutting Machine Setters, Operators, And Tenders	1.86	26,791	0.20	0.22	75
Ambulance Drivers And Attendants, Except EMTs	1.77	16,815	0.20	0.06	0
Brickmasons, Stonemasons, And Tile Helpers	2.30	56,275	0.20	0.20	0
Grinding And Polishing Machine Operators And Tenders	2.45	42,770	0.20	0.19	68
Coin And Vending Machine Servicers And Repairers	2.44	36,761	0.20	0.14	0
Helpers–Electricians	2.11	98,454	0.20	0.15	0
Tree Trimmers And Pruners	2.34	32,570	0.20	0.16	0
Timing Device Assemblers, Adjusters, And Calibrators	2.32	2,818	0.20	0.11	62
Fishers And Related Fishing Workers	2.22	122	0.20	0.24	0
Taxi Drivers And Chauffeurs	1.76	141,205	0.20	0.08	0
Supervisors/Managers Of Food Preparation Workers	2.31	707,205	0.19	0.14	0
Merchandise Displayers And Window Trimmers	2.11	56,391	0.19	0.10	0
Fiberglass Laminators And Fabricators	2.21	30,997	0.19	0.18	68
Driver/Sales Workers	2.03	378,985	0.19	0.13	0
Etchers And Engravers	2.19	8,801	0.19	0.22	68
Helpers–Extraction Workers	2.47	25,484	0.18	0.19	36
Demonstrators And Product Promoters	2.10	86,777	0.18	0.05	0
Skin Care Specialists	2.24	18,638	0.18	0.12	0
Hairdressers, Hairstylists, And Cosmetologists	1.94	335,463	0.17	0.12	0
Forest And Conservation Workers	1.92	6,683	0.17	0.15	0
Social And Human Service Assistants	2.16	299,097	0.17	0.03	0
Fence Erectors	2.14	17,926	0.17	0.17	0
Animal Breeders	2.47	824	0.16	0.09	0
Bakers	1.88	150,872	0.16	0.14	0
Barbers	1.95	8,744	0.16	0.15	0
Pest Control Workers	2.31	55,732	0.16	0.08	0
Tour Guides And Escorts	1.79	28,235	0.16	0.01	0
Auto Electronic Equipment Installers And Repairers	2.37	13,915	0.16	0.10	0
Small Engine Mechanics	2.27	25,426	0.15	0.14	0
Logging Equipment Operators	2.44	27,562	0.15	0.26	0
Manufactured Building And Mobile Home Installers	2.17	8,739	0.14	0.16	0
Cooks, Private Household	2.32	147	0.14	0.14	0
Floral Designers	1.83	62,929	0.14	0.12	0
Preschool Teachers, Except Special Education	1.93	361,378	0.14	0.07	0
Landscaping And Groundskeeping Workers	1.84	843,131	0.13	0.23	0
Recreation Workers	1.78	263,086	0.12	0.05	0
Residential Advisors	1.97	46,828	0.12	0.01	0
Animal Trainers	2.27	6,629	0.04	0.11	0

Notes: See notes to Table 1.

Table A3: Alternate Employment Estimates of a Minimum Wage Hike, by Routine Cognitive Share of Tasks

Robustness to Inclusion of Occupation-by-Year Fixed Effects

Four Year Long-Difference/Distributed Lag Estimates using the OES

	Specification 1: No Interaction Terms				**Specification 2: Routine Share Interacted with Change in Minimum Wage**				**Specification 3: Routine Share Interacted with Change in Minimum Wage**			
	Wage Group1	**Wage Group2**	**Wage Group3**	**Wage Group4**	**Wage Group1**	**Wage Group2**	**Wage Group3**	**Wage Group4**	**Wage Group1**	**Wage Group2**	**Wage Group3**	**Wage Group4**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ΔMW Next Year	0.02	0.06	0.04	-0.02	0.02	0.06	0.06	-0.02				
	(0.04)	(0.04)	(0.05)	(0.02)	(0.04)	(0.04)	(0.05)	(0.03)				
ΔMW This Year	0.04	0.03	0.05	-0.04	0.04	0.03	0.08	-0.04				
	(0.05)	(0.05)	(0.05)	(0.02)	(0.05)	(0.05)	(0.05)	(0.03)				
ΔMW Last Year	0.05	0.06	0.06	-0.01	0.06	0.07	0.09	-0.01				
	(0.07)	(0.06)	(0.06)	(0.04)	(0.07)	(0.06)	(0.06)	(0.04)				
ΔMW 2Yrs Ago	0.18*	0.03	0.06	0.00	0.18*	0.05	0.09	0.01				
	(0.08)	(0.07)	(0.08)	(0.06)	(0.08)	(0.07)	(0.06)	(0.07)				
ΔMW Next Year X RoutineSh					0.06	0.00	-0.06	-0.02	0.07	0.01	-0.06	-0.02
					(0.03)	(0.02)	(0.04)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)
ΔMW This Year X RoutineSh					-0.01	-0.03	-0.08*	-0.01	0.00	-0.03	-0.07	-0.01
					(0.05)	(0.02)	(0.04)	(0.03)	(0.05)	(0.02)	(0.03)	(0.04)
ΔMW Last Year X RoutineSh					-0.04	-0.06*	-0.10*	0.01	-0.03	-0.06*	-0.08	0.01
					(0.04)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)	(0.04)	(0.04)
ΔMW 2Yrs Ago X RoutineSh					-0.04	-0.07	-0.06	-0.01	-0.02	-0.08	-0.04	-0.01
					(0.06)	(0.03)	(0.06)	(0.06)	(0.05)	(0.04)	(0.06)	(0.06)
Combined Effects												
ΔMW This Year X RoutineSh - ΔMW Next Year X RoutineSh					-0.07	-0.03	-0.02	0.02	-0.07	-0.04	-0.01	0.01
					(0.06)	(0.02)	(0.05)	(0.03)	(0.06)	(0.02)	(0.04)	(0.03)
ΔMW Last Year X RoutineSh - ΔMW Next Year X RoutineSh					-0.10*	-0.07**	-0.04	0.03	-0.10*	-0.07**	-0.02	0.03
					(0.04)	(0.02)	(0.06)	(0.03)	(0.04)	(0.02)	(0.05)	(0.03)
ΔMW 2Yrs Ago X RoutineSh - ΔMW Next Year X RoutineSh					-0.10	-0.07	0.01	0.01	-0.09	-0.09*	0.01	0.01
					(0.06)	(0.04)	(0.09)	(0.07)	(0.06)	(0.04)	(0.08)	(0.07)
State FE and Year FE	**Yes**				**Yes**				**No**			
State x Year FE	**No**				**No**				**Yes**			
Occupation x Year FE	**Yes**				**Yes**				**Yes**			

Notes: See notes to Table 2. $N = 118,317$ for all three specifications. * p<0.05 and ** p<0.01.

Table A4: Alternate Employment Estimates of a Minimum Wage Hike, by Routine Cognitive Share of Tasks

Robustness to Inclusion of Large Employment Changes

Four Year Long-Difference/Distributed Lag Estimates using the OES

	Specification 1: No Interaction Terms				**Specification 2: Routine Share Interacted with Change in Minimum Wage**				**Specification 3: Routine Share Interacted with Change in Minimum Wage**			
	Wage Group1	**Wage Group2**	**Wage Group3**	**Wage Group4**	**Wage Group1**	**Wage Group2**	**Wage Group3**	**Wage Group4**	**Wage Group1**	**Wage Group2**	**Wage Group3**	**Wage Group4**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ΔMW Next Year	0.02	0.05	0.06	0.00	0.02	0.05	0.06	0.00				
	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)	(0.03)				
ΔMW This Year	0.03	-0.02	0.06	0.02	0.04	-0.02	0.08	0.02				
	(0.04)	(0.05)	(0.05)	(0.04)	(0.04)	(0.05)	(0.05)	(0.04)				
ΔMW Last Year	0.02	0.01	0.04	0.06	0.03	0.03	0.07	0.07				
	(0.06)	(0.05)	(0.06)	(0.05)	(0.06)	(0.05)	(0.06)	(0.05)				
ΔMW 2Yrs Ago	0.06	-0.02	0.07	0.13	0.08	0.02	0.11	0.14				
	(0.08)	(0.05)	(0.09)	(0.08)	(0.08)	(0.05)	(0.08)	(0.08)				
ΔMW Next Year X RoutineSh					0.04	0.00	-0.03	-0.02	0.04	-0.01	-0.01	-0.03
					(0.03)	(0.04)	(0.04)	(0.04)	(0.03)	(0.05)	(0.04)	(0.04)
ΔMW This Year X RoutineSh					-0.02	-0.04	-0.08	-0.02	-0.02	-0.06	-0.05	-0.02
					(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)	(0.05)
ΔMW Last Year X RoutineSh					-0.06	-0.09	-0.10*	-0.02	-0.07	-0.10	-0.07	-0.01
					(0.04)	(0.05)	(0.05)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)
ΔMW 2Yrs Ago X RoutineSh					-0.13*	-0.16*	-0.11	-0.04	-0.13*	-0.19**	-0.08	-0.03
					(0.05)	(0.06)	(0.06)	(0.05)	(0.05)	(0.06)	(0.05)	(0.05)
State FE and Year FE	**Yes**				**Yes**				**No**			
State x Year FE	**No**				**No**				**Yes**			

Notes: See notes to Table 2. $N = 132,050$ for all three specifications. *p<0.05 and **p<0.01.

Table A5: Employment Estimates of a Minimum Wage Hike, by Routine Manual Share of Tasks
Four Year Long-Difference/Distributed Lag Estimates using the OES

	Specification 1: No Interaction Terms				Specification 2: Includes Routine Share Interacted with Change in Minimum Wage				Specification 3: Routine Share Interacted with Change in Minimum Wage			
	Wage Group1	Wage Group2	Wage Group3	Wage Group4	Wage Group1	Wage Group2	Wage Group3	Wage Group4	Wage Group1	Wage Group2	Wage Group3	Wage Group4
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ΔMW Next Year	0.00	0.04	0.02	-0.02	0.01	0.04	0.02	-0.01				
	(0.03)	(0.05)	(0.04)	(0.02)	(0.03)	(0.04)	(0.04)	(0.02)				
ΔMW This Year	0.03	-0.04	0.02	0.01	0.03	-0.04	0.02	0.01				
	(0.04)	(0.06)	(0.05)	(0.03)	(0.04)	(0.05)	(0.05)	(0.03)				
ΔMW Last Year	0.01	-0.01	0.03	0.05	0.01	0.01	0.03	0.05				
	(0.05)	(0.05)	(0.06)	(0.04)	(0.05)	(0.05)	(0.06)	(0.04)				
ΔMW 2Yrs Ago	0.09	-0.04	0.03	0.08	0.09	-0.05	0.03	0.08				
	(0.07)	(0.05)	(0.09)	(0.06)	(0.07)	(0.05)	(0.10)	(0.06)				
ΔMW Next Year X RoutineSh					-0.04	-0.02	0.00	-0.06	-0.05	-0.02	0.01	-0.05
					(0.06)	(0.03)	(0.04)	(0.04)	(0.06)	(0.04)	(0.04)	(0.04)
ΔMW This Year X RoutineSh					0.07	0.00	0.00	-0.06	0.07	0.02	-0.01	-0.05
					(0.05)	(0.04)	(0.06)	(0.05)	(0.05)	(0.04)	(0.06)	(0.05)
ΔMW Last Year X RoutineSh					-0.03	0.04	0.01	-0.09*	-0.04	0.06	0.01	-0.08
					(0.06)	(0.05)	(0.07)	(0.04)	(0.07)	(0.05)	(0.07)	(0.04)
ΔMW 2Yrs Ago X RoutineSh					0.07	-0.04	-0.02	-0.09	0.07	-0.01	-0.03	-0.08
					(0.05)	(0.11)	(0.09)	(0.05)	(0.05)	(0.10)	(0.08)	(0.05)
State FE and Year FE	Yes				Yes				No			
State x Year FE	No				No				Yes			

Notes: See notes to Table 2. $N = 118,986$ for all three specifications. * p<0.05 and ** p<0.01.

Table A6: Alternate Employment Estimates of a Minimum Wage Hike
Robustness to Using Routine Task Levels
Four Year Long-Difference/Distributed Lag Estimates using the OES

	Wage Group 1	Wage Group 2	Wage Group 3	Wage Group 4
	(1)	(2)	(3)	(4)
Routine Cognitive Task Level				
ΔMW Next Year X RoutineLev	0.04	-0.03	-0.06	-0.07*
	(0.03)	(0.04)	(0.04)	(0.03)
ΔMW This Year X RoutineLev	0.01	-0.04	-0.07**	-0.08*
	(0.04)	(0.03)	(0.02)	(0.03)
ΔMW Last Year X RoutineLev	-0.10	-0.07*	-0.08	-0.06*
	(0.05)	(0.04)	(0.05)	(0.03)
ΔMW 2Yrs Ago X RoutineLev	-0.12*	-0.13*	-0.12*	-0.09*
	(0.06)	(0.06)	(0.06)	(0.04)
Routine Manual Task Level				
ΔMW Next Year X RoutineLev	-0.04	-0.02	0.00	-0.07
	(0.06)	(0.05)	(0.04)	(0.04)
ΔMW This Year X RoutineLev	0.09*	0.03	0.00	-0.07
	(0.04)	(0.05)	(0.05)	(0.05)
ΔMW Last Year X RoutineLev	-0.08	0.06	0.01	-0.09*
	(0.07)	(0.06)	(0.07)	(0.04)
ΔMW 2Yrs Ago X RoutineLev	0.03	-0.01	-0.03	-0.10
	(0.06)	(0.11)	(0.08)	(0.05)

Notes: RoutineSh=Routine Share. RoutineLev=Level of Routine Tasks. Routine share and routine level are standardized to be mean zero and standard deviation one within each wage group. Results from separate specifications that include state-by-year FE. See notes to Table 2 for all other info. N=118,896. *p<0.05 and **p<0.01.

Table A7: Alternate Employment Estimates of a Minimum Wage Hike
Robustness to Different Duration of Employment Changes
Long-Difference/Distributed Lag Estimates using the OES

	Duration of Employment Change in Dependent Variable			
	1 Year	**2 Years**	**3 Years**	**4 Years**
	(1)	(2)	(3)	(4)
Wage Group 1				
ΔMW Next Year X RoutineSh	-0.01	-0.03	0.00	0.03
	(0.02)	(0.02)	(0.03)	(0.04)
ΔMW This Year X RoutineSh	-0.01	-0.05	-0.07*	-0.03
	(0.02)	(0.02)	(0.03)	(0.04)
ΔMW Last Year X RoutineSh	-0.03	-0.04*	-0.09**	-0.09*
	(0.02)	(0.02)	(0.03)	(0.04)
ΔMW 2Yrs Ago X RoutineSh	-0.02	-0.05*	-0.12**	-0.13**
	(0.02)	(0.02)	(0.03)	(0.05)
Wage Group 2				
ΔMW Next Year X RoutineSh	0.00	0.01	0.01	-0.01
	(0.01)	(0.02)	(0.03)	(0.05)
ΔMW This Year X RoutineSh	0.02	-0.03	-0.06	-0.06
	(0.02)	(0.02)	(0.03)	(0.04)
ΔMW Last Year X RoutineSh	-0.05**	-0.03	-0.07	-0.11*
	(0.02)	(0.03)	(0.04)	(0.05)
ΔMW 2Yrs Ago X RoutineSh	0.00	-0.08	-0.09*	-0.16**
	(0.02)	(0.04)	(0.04)	(0.06)
Wage Group 3				
ΔMW Next Year X RoutineSh	-0.03	-0.03	-0.06	-0.04
	(0.02)	(0.02)	(0.03)	(0.04)
ΔMW This Year X RoutineSh	0.00	-0.03	-0.04	-0.08**
	(0.01)	(0.02)	(0.03)	(0.03)
ΔMW Last Year X RoutineSh	-0.04	-0.02	-0.08	-0.09
	(0.02)	(0.04)	(0.04)	(0.05)
ΔMW 2Yrs Ago X RoutineSh	0.00	0.01	-0.01	-0.08
	(0.02)	(0.04)	(0.06)	(0.07)
Wage Group 4				
ΔMW Next Year X RoutineSh	0.02	0.01	-0.02	-0.01
	(0.01)	(0.02)	(0.03)	(0.04)
ΔMW This Year X RoutineSh	0.00	0.00	-0.01	-0.01
	(0.01)	(0.02)	(0.03)	(0.04)
ΔMW Last Year X RoutineSh	0.00	-0.02	0.01	0.00
	(0.01)	(0.02)	(0.03)	(0.04)
ΔMW 2Yrs Ago X RoutineSh	-0.02	-0.04	-0.06	-0.03
	(0.02)	(0.03)	(0.05)	(0.05)
N	192,293	157,838	143,445	118,896

Notes: Results from separate specifications that include state-by-year FE. See notes for Table 2. *p<0.05 and **p<0.01.

Table A8: Effect of Minimum Wage Hikes on Employment at High Routine Manual Occupations Matched CPS

	Probability of Employment at High Routine Cognitive Occupation in Second Matched CPS Observation						One-Year Change in Routine Cognitive Task Share at Occupation					
	Specification 1:		Specification 2:		Specification 3:		Specification 1:		Specification 2:		Specification 3:	
	Wage Group1	Wage Group2	Wage Group1	Wage Group2	Wage Group1	Wage Group2	Wage Group1	Wage Group2	Wage Group1	Wage Group2	Wage Group1	Wage Group2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ΔMW Next Year	-0.01	0.01	-0.01	0.01	-0.05	0.00	0.01	-0.01	-0.01	-0.01	-0.05	0.03
	(0.02)	(0.02)	(0.02)	(0.02)	(0.05)	(0.03)	(0.05)	(0.04)	(0.06)	(0.04)	(0.09)	(0.08)
ΔMW This Year	0.05	0.05*	0.06	0.05*	-0.02	0.05	0.09	0.06	0.10	0.06	0.04	0.13
	(0.03)	(0.02)	(0.03)	(0.02)	(0.04)	(0.03)	(0.08)	(0.04)	(0.08)	(0.04)	(0.13)	(0.08)
ΔMW Last Year	0.09**	0.04	0.10**	0.04*	0.15**	0.05	0.13	0.02	0.12	0.02	0.09	0.08
	(0.03)	(0.02)	(0.04)	(0.02)	(0.05)	(0.03)	(0.09)	(0.04)	(0.09)	(0.04)	(0.16)	(0.08)
ΔMW Two Years Ago	0.01	-0.01	0.00	-0.01	0.03	-0.01	0.09	0.03	0.07	0.02	0.04	0.15
	(0.05)	(0.03)	(0.06)	(0.03)	(0.08)	(0.05)	(0.10)	(0.06)	(0.09)	(0.06)	(0.19)	(0.11)
ΔMW Next Year X RoutineSh			-0.02	-0.01	-0.07	0.00			-0.13	-0.02	-0.13	0.01
			(0.02)	(0.02)	(0.04)	(0.04)			(0.09)	(0.04)	(0.12)	(0.05)
ΔMW This Year X RoutineSh			0.05	0.02	-0.05	0.01			0.12	-0.02	0.11	-0.04
			(0.04)	(0.02)	(0.04)	(0.04)			(0.09)	(0.06)	(0.13)	(0.10)
ΔMW Last Year X RoutineSh			0.04	0.00	0.03	-0.05			-0.16	-0.01	-0.28	-0.15
			(0.04)	(0.02)	(0.04)	(0.05)			(0.12)	(0.06)	(0.17)	(0.10)
ΔMW 2Yrs Ago X RoutineSh			-0.05	0.02	-0.02	0.05			-0.11	0.11	0.01	0.18
			(0.06)	(0.03)	(0.07)	(0.03)			(0.22)	(0.11)	(0.31)	(0.11)
N	108,189		108,189		51,021		108,189		108,189		51,021	

Notes: See notes from Table 7. *p<0.05 and **p<0.01.

Table A9: Employment and Wage Effect of Minimum Wage Hikes at Routine Manual Jobs Matched CPS

	Employment Effects				Wage Effects			
	Specification 1:		Specification 2:		Specification 1:		Specification 2:	
	Wage Group1	Wage Group2	Wage Group1	Wage Group2	Wage Group1	Wage Group2	Wage Group1	Wage Group2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔMW Next Year	-0.03	0.01	-0.03	0.01	0.10**	0.00	0.10**	0.00
	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.01)	(0.03)	(0.01)
ΔMW This Year	0.01	0.01	0.01	0.01	0.11**	0.00	0.11**	0.00
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
ΔMW Last Year	0.00	0.00	0.00	0.00	0.14**	0.01	0.14**	0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
ΔMW Two Years Ago	0.00	-0.01	-0.02	-0.01	0.11**	0.02	0.11**	0.02
	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)	(0.03)	(0.02)
ΔMW Next Year X RoutineSh			-0.01	0.00			0.02	0.00
			(0.03)	(0.01)			(0.01)	(0.01)
ΔMW This Year X RoutineSh			0.05	-0.02			0.02	0.01
			(0.04)	(0.01)			(0.02)	(0.01)
ΔMW Last Year X RoutineSh			0.00	-0.01			0.02	0.01
			(0.04)	(0.02)			(0.02)	(0.01)
ΔMW 2Yrs Ago X RoutineSh			-0.14*	0.01			0.00	0.00
			(0.06)	(0.02)			(0.04)	(0.01)
N	169,733		169,733		108,189		108,189	

Notes: See notes from Table 7. The employment analysis sample is conditional on being employed as an hourly-paid worker in the first CPS observation. The wage analysis sample also conditions on being employed in the second CPS observation with log employment changes not exceeding ± 0.35 log points. *p<0.05 and **p<0.01.

Table A10: Alternate Employment and Wage Effect of Minimum Wage Hikes on Individuals Employed at Routine Cognitive Jobs Robustness to Exclusion of Industry-X-Year Dummy Variables, Matched CPS

	Employed in High Routine Cognitive Occ?	Change in Routine Task Content	Employed?	Wage Effect on All Workers
	(1)	(2)	(3)	(4)
Wage Group 1				
ΔMW Next Year X RoutineSh	-0.07	-0.27*	0.03	-0.01
	(0.04)	(0.12)	(0.03)	(0.02)
ΔMW This Year X RoutineSh	0.01	0.11	0.05	-0.02
	(0.04)	(0.11)	(0.03)	(0.02)
ΔMW Last Year X RoutineSh	-0.10*	-0.20	-0.04	-0.04*
	(0.04)	(0.11)	(0.04)	(0.02)
ΔMW 2Yrs Ago X RoutineSh	-0.05	-0.27	-0.07*	-0.06**
	(0.06)	(0.18)	(0.03)	(0.02)
Wage Group 2				
ΔMW Next Year X RoutineSh	0.02	0.02	-0.02	0.00
	(0.02)	(0.06)	(0.02)	(0.01)
ΔMW This Year X RoutineSh	0.03	0.06	0.01	-0.01
	(0.03)	(0.08)	(0.01)	(0.01)
ΔMW Last Year X RoutineSh	0.00	0.08	-0.02	0.02*
	(0.04)	(0.08)	(0.02)	(0.01)
ΔMW 2Yrs Ago X RoutineSh	0.04	0.09	0.01	-0.01
	(0.05)	(0.16)	(0.03)	(0.01)
N	108,189	108,189	169,733	108,189

Notes: See notes to Table 7 and Table 8. The non-interacted change in the minimum wage coefficients are not shown. * p<0.05 and ** p<0.01.

Table A11: Alternate Employment and Wage Effect of Minimum Wage Hikes on Individuals Employed at Routine Cognitive Jobs Robustness to Inclusion of Large Wage Changes, Matched CPS

	Employed in High Routine Cognitive Occ?	Change in Routine Task Content	Employed?	Wage Effect on All Workers
	(1)	(2)	(3)	(4)
Wage Group 1				
ΔMW Next Year X RoutineSh	-0.04	-0.16	0.01	0.04
	(0.03)	(0.08)	(0.02)	(0.04)
ΔMW This Year X RoutineSh	0.02	0.05	0.04	-0.07*
	(0.03)	(0.09)	(0.03)	(0.04)
ΔMW Last Year X RoutineSh	-0.05	-0.17*	-0.03	-0.07
	(0.03)	(0.08)	(0.02)	(0.04)
ΔMW 2Yrs Ago X RoutineSh	0.01	-0.13	-0.02	-0.15**
	(0.05)	(0.13)	(0.02)	(0.05)
Wage Group 2				
ΔMW Next Year X RoutineSh	0.01	0.02	-0.01	-0.01
	(0.02)	(0.04)	(0.01)	(0.03)
ΔMW This Year X RoutineSh	0.03	0.09	0.00	0.02
	(0.02)	(0.09)	(0.01)	(0.03)
ΔMW Last Year X RoutineSh	0.00	0.09	-0.01	0.02
	(0.03)	(0.05)	(0.02)	(0.03)
ΔMW 2Yrs Ago X RoutineSh	0.05	0.18	0.01	0.00
	(0.04)	(0.12)	(0.02)	(0.05)
N	168,195	161,240	169,733	148,255

Notes: See notes to Table 7 and Table 8. The non-interacted change in the minimum wage coefficients are not shown. * p<0.05 and ** p<0.01.

Table A12: Alternate Employment and Wage Effect of Minimum Wage Hikes on Individuals Employed at Routine Cognitive Jobs Robustness to Grouping Individuals by Contemporaneous Minimum Wage, Matched CPS

	Employed in High Routine Cognitive Occ?	Change in Routine Task Content	Employed?	Wage Effect on All Workers
	(1)	(2)	(3)	(4)
Wage Group 1				
ΔMW Next Year X RoutineSh	-0.07	-0.26*	0.01	0.00
	(0.04)	(0.12)	(0.02)	(0.02)
ΔMW This Year X RoutineSh	-0.02	-0.05	0.05*	0.00
	(0.04)	(0.09)	(0.02)	(0.02)
ΔMW Last Year X RoutineSh	-0.03	-0.05	-0.02	-0.02
	(0.04)	(0.10)	(0.02)	(0.01)
ΔMW 2Yrs Ago X RoutineSh	0.01	-0.11	-0.03	-0.05**
	(0.06)	(0.17)	(0.03)	(0.02)
Wage Group 2				
ΔMW Next Year X RoutineSh	0.03	0.05	-0.01	-0.01
	(0.02)	(0.05)	(0.01)	(0.01)
ΔMW This Year X RoutineSh	0.04	0.14	-0.01	-0.01
	(0.03)	(0.09)	(0.01)	(0.01)
ΔMW Last Year X RoutineSh	0.03	0.15	-0.01	0.02
	(0.04)	(0.09)	(0.02)	(0.01)
ΔMW 2Yrs Ago X RoutineSh	0.03	0.13	0.03	-0.01
	(0.05)	(0.13)	(0.03)	(0.01)
N	108,875	108,875	170,731	108,875

Notes: See notes to Table 5, Table 7, and Table 8. The non-interacted change in the minimum wage coefficients are not shown. * p<0.05 and ** p<0.01.

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