Wage Shocks and the Technological Substitution of Low-Wage Jobs*

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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 is economically small, due to concurrent non-routine employment growth, workers previously employed in cognitively routine jobs experience relative wage losses.

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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 McDonalds' experiments with tablet-based ordering systems and mobile payment services and Chili's installation of table-top tablets across its 800 restaurants in the U.S., innovations with the potential to eliminate many low-skill cashier and wait staff jobs.[1] Although technological change has been a source of labor market research for decades, most recently the emphasis has been on technology's role in the relative decline of employment and wages among routine-intensive middle-income occupations.[2] Our paper adds to this important literature by quantifying the potential for technological substitution across the entire low-wage, low-skill labor markets that the McDonald's and Chili'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).[3] However, if low-wage labor costs get 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 literature may mask important heterogeneity, even within an industry, based on whether labor and capital are gross substitutes or

[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 Chili's, see http://www.theatlantic.com/technology/archive/2014/06/chilis-is-installing-tablet-ordering-at-all-its-restaurants/372836/.

[2]On job polarization and technological substitution, see Autor, Levy, and Murnane (2003), Goos and Manning (2007), Acemoglu and Autor (2011), and Jaimovich and Siu (2012), among others. Some prominent studies of low-wage labor markets include Bresnahan, Brynjolfsson, and Hitt (1999), Manning (2004), Autor, Katz, and Kearney (2008), Autor and Dorn (2013), and Lewis (2011).

[3]A sample of recent papers on the employment elasticities of minimum wages include Machin, Manning, and Rahman (2003), Dube, Lester, and Reich (2010), Allegretto, Dube, and Reich (2011), Giuliano (2013), Addison, Blackburn, and Cotti (2013), Neumark, Salas, and Wascher (2013) and Sabia, Burkhauser, and Hansen (2012). Neumark and Wascher (2008) provide an extensive review of the earlier literature.

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. Empirically, we combine the Occupation Information Network (O*NET) database, which allows us to classify 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 then examine whether the employment response to a minimum wage change differs at low-wage occupations that are heavily routine in nature to assess the extent to which changes in the relative price of low-skill labor lead to the technological substitution of these workers.

We find that the short-run impact of a minimum wage increase 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 1.5 percent for every standard deviation increase in the routine cognitive share of an occupation. These findings suggest that at the same time that employers are reducing jobs with a large proportion of routine cognitive tasks, non-routine cognitive employment is expanding, a pattern that can be explained within our theoretical model by assuming capital requires some non-routine labor in order to be productive. Such a situation might arise, for example, when new technologies like self-scanners require employees to assist or monitor customer usage.

Interestingly, 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. Using an occupation-level offshorability index developed by Blinder (2009), we further show that outsourcing tasks overseas 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 the law. There is mixed evidence on higher paying occupations, where the

extent to which a job is offshorable and cognitively routine is highly intertwined.

We also use the Merged Outgoing Rotation Group of the Current Population Survey (CPS) to measure the extent to which technological adjustment affects the employment and wage outcomes of low-wage workers. Broadly consistent with the OES data, we find that a hike in the minimum wage causes low-wage individuals initially employed in high cognitively routine occupations to switch to less routine intensive jobs. Again, we find no such effect among workers in occupations that are expressly manually routine or that are high-paying. Notably, this movement away from highly routinized occupations occurs with little effect on the probability of subsequent employment. However, conditioning the sample on those workers employed in both CPS observations, we find that individuals initially employed at high cognitively routine occupations experience relative wage losses compared to other low-wage workers after a minimum wage hike. Indeed, this wage effect may be large enough to offset much of the gain from the minimum wage hike itself.

In sum, these empirical results are consistent with high labor costs expediting technological substitution in low-wage occupations that are intensive in routine cognitive tasks. This finding differs from past studies, such as Bresnahan, Brynjolfsson, and Hitt (1999), Manning (2004), and Autor, Katz, and Kearney (2008), which have largely argued that technological advancements have had little direct effect on the demand for low-skill workers. Instead, our results are consistent with Lewis (2011)'s study of the manufacturing sector. We also find that the labor market effects of this technological substitution are qualitatively similar to the employment and wage effects of technology on middle skill jobs (Goos and Manning, 2007). However, unlike the findings in the job polarization literature, the loss of low-skill routine cognitive jobs during our period of analysis has been largely offset by employment growth in non-routine low-skill jobs. 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 or in the long-run where there is some evidence of larger negative employment effects (Baker, Benjamin, and Stanger, 1999; Meer and West, 2013; 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 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 technological substitution 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 (the substitution effect) and the elasticity of demand for the output good (the scale effect).[4] 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 effect dominates the scale effect.

It is common in the literature to assume the same elasticity of substitution across all inputs but that obviously need not be the case. Even within low-skill labor, there may be heterogenous 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.[5] However, non-routine low-skill labor may be (at least in part) complementary to technological adoption – making the impact of capital investments on low-skill non-routine employment ambiguous. One reason for this ambiguity is that installing capital to replace low-skill routine labor sometimes requires the customer to perform tasks that were previously executed by employees (e.g. with self-checkout lines).[6] Integrating this type of technology might require a transition period where firms hire additional low-skill non-routine labor to assist customers using the new technology. Indeed, firms might still find it optimal to employ

[4]See Hamermesh (1993) or Aaronson and French (2007) for derivations.

[5]See Autor, Levy, and Murnane (2003), Goos and Manning (2007), Autor, Katz, and Kearney (2008), Dustmann, Ludsteck, and Schönberg (2009), Black and Spitz-Oener (2010), Acemoglu and Autor (2011), and Goos, Manning, and Salomons (2014), among others.

[6]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.

additional non-routine labor to oversee the interaction of customers and capital equipment even after the new technology has been fully adapted, 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-skill service sector is a function of routine tasks 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:

$$Y = N_1^{\alpha}(R + \min(K, N_2 C))^{1-\alpha} \tag{1}$$

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_1) and N used in the production of routine tasks (N_2).

Note that a cost minimizing firm will always set $K = N_2 C$. Therefore, the firm's cost minimization problem simplifies to:

$$\min \mathcal{L} = wN_1 + wR + r'K + \lambda(Y - N_1^{\alpha}(R + K)^{1-\alpha}) \tag{2}$$

where r is the price of capital, w is the minimum wage paid to N and R employees, $\frac{w}{C}$ is the price of the requisite N_2 associated with each unit of K, and $r' = r + \frac{w}{C}$ is the total cost of capital.

The first order conditions $\frac{\partial \mathcal{L}}{\partial R}$ and $\frac{\partial \mathcal{L}}{\partial K}$ imply that $r' = w$ when there is an interior solution to this problem. However, if the nominal price of technology (r) is falling exogenously over time, as is commonly observed, and the nominal minimum wage (w) is both binding and rising over time, there will tend to be a corner solution where firms will either use only R

(i.e. when $r' > w$) or $g(K, N)$ (when $r' < w$) to produce routine tasks.[7] Consequently, we can derive the following conditional factor demands:

$$N_1^* = \begin{cases} Y(\frac{\alpha}{1-\alpha})^{1-\alpha} & \text{if } r' > w \\ Y(\frac{\alpha r'}{(1-\alpha)w})^{1-\alpha} & \text{if } r' < w \end{cases} \qquad R^* = \begin{cases} Y(\frac{1-\alpha}{\alpha})^{\alpha} & \text{if } r' > w \\ 0 & \text{if } r' < w \end{cases} \tag{3}$$

$$K^* = \begin{cases} 0 & \text{if } r' > w \\ Y(\frac{(1-\alpha)w}{\alpha r'})^{\alpha} & \text{if } r' < w \end{cases} \qquad N_2^* = \begin{cases} 0 & \text{if } r' > w \\ \frac{Y}{C}(\frac{(1-\alpha)w}{\alpha r'})^{\alpha} & \text{if } r' < w. \end{cases}$$

Trivially, if the minimum wage increases but w remains below r', routine labor costs remain cheaper than new technology and no input substitution occurs. More interestingly, if the minimum wage increases from being below r' to above r', then N_1^* declines, R^* falls to zero, and both K^* and N_2^* increase from zero. The net effect on non-routine employment $(N_1^* + N_2^*)$ depends on whether the increase in N_2^* is larger or smaller than the fall in N_1^*. This will tend to be the case 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).[8] Regardless, this simple framework highlights the potential for offsetting employment changes in routine-intense and non-routine-intense occupations in response to a shock to the prevailing wage.

We recognize that the conditional factor demands in (3) ignore the scale effect, which would be associated with larger declines among N_1^* jobs and smaller increases among N_2^* jobs. Consequently, if we are to observe an increase in non-routine employment, the substitution effect on non-routine labor used to produce routine tasks (N_2) will have to be sufficiently large to offset the scale effects on N_1 and N_2, in addition to the substitution effect on non-routine labor used in producing non-routine tasks (N_1). This may still hold if the output good is sufficiently inelastic or non-routine labor's share is sufficiently low. Indeed, Aaronson and French (2007) show that total low-wage labor share in the most

[7] Recall that $r' = r + \frac{w}{C}$. So $r' > w$ implies that $r > w - \frac{w}{C}$.

[8] The net effect of this technological substitution on non-routine employment is captured by: $\frac{Y}{C}(\frac{(1-\alpha)w}{\alpha r'})^{\alpha} - Y(\frac{\alpha}{1-\alpha})^{1-\alpha} + Y(\frac{\alpha r'}{(1-\alpha)w})^{1-\alpha}$. 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.

minimum-wage-intensive industry – fast food restaurants – is only 10 percent, implying that the scale effect has only a modest adverse impact on employment (Aaronson, French, and Sorkin, 2015).

We also recognize that this simple static model may ignore some important dynamic considerations. For example, C is presented as a constant value, but it might increase over time as customers require fewer non-routine workers to assist and monitor their interactions with technology. Thus, analogous to the reversal in skilled labor described in Beaudry, Green, and Sand (2013), non-routine labor 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, and Sorkin, 2015). Thus, in our empirical work, we examine employment responses to two years after a minimum wage change.[9]

In sum, this simple theoretical framework implies that technological substitution that stems from a minimum wage hike will be characterized by falling routine employment. However, the short-run employment effects on non-routine labor are ambiguous if such workers complement the new technology. In the empirical analysis that follows, we combine employment data with data on the tasks performed at occupations to understand how minimum wage hikes effect the composition of jobs. We, then, go on to 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 state minimum wage histories from the Department of Labor's website (see Appendix Table A1)[10] and the offshorability of occupational tasks from Blinder (2009).

[9] Our data limits our ability to confidently look beyond two years.

[10] We do not account for city-level differences (e.g. San Francisco, Santa Fe) in the minimum wage.

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 the share of tasks that are cognitively or manually routine to identify those occupations that are most susceptible to technological substitution.

While the O*NET contains hundreds of variables to describe occupation-specific tasks and skills, Acemoglu and Autor (2011) focus on seventeen variables from the Work Activities and Work Context Importance scales to develop six composite task indices for every occupation j, denoted by $T_j = \{T_{j1}, T_{j2}, ..., T_{j6}\}$.[11] These indices are interpreted to 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.[12]

We use Acemoglu and Autor's six composite task measures to calculate the share of tasks in each occupation that are cognitively and manually routine. This calculation requires us to rescale each of their indices, since each is normalized to have a mean of zero and a standard deviation of one, by subtracting off the minimum value across all occupations. For example, the rescaled value of routine cognitive tasks (T_{j1}) for occupation j, is $T^*_{j1} = T_{j1} - min(\{T_{i1}\}_{i=1}^{N})$, where $min(\{T_{i1}\}_{i=1}^{N})$ is the minimum value of T_1 across all N occupations.

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

[12] As described in the data appendix in Acemoglu and Autor (2011), each of these six composite metrics is the normalized sum of the individual O*NET variables included in the grouping. Non-routine cognitive analytical is the sum of 4.A.2.a.4 Analyzing data/information, 4.A.2.b.2 Thinking creatively, and 4.A.4.a.1 Interpreting information for others. Non-routine cognitive interpersonal is the sum of 4.A.4.a.4 Establishing and maintaining personal relationships, 4.A.4.b.4 Guiding, directing and motivating subordinates, and 4.A.4.b.5 Coaching/developing others. Routine cognitive is the sum of 4.C.3.b.7 Importance of repeating the same tasks, 4.C.3.b.4 Importance of being exact or accurate, and 4.C.3.b.8 Structured v. Unstructured work (reverse). Non-routine manual physical is the sum of 4.A.3.a.4 Operating vehicles, mechanized devices, or equipment, 4.C.2.d.1.g Spend time using hands to handle, control or feel objects, tools or controls, 1.A.2.a.2 Manual dexterity, and 1.A.1.f.1 Spatial orientation. Non-routine manual interpersonal is equal to 2.B.1.a Social Perceptiveness. And, lastly, routine manual is the sum of 4.C.3.d.3 Pace determined by speed of equipment, 4.A.3.a.3 Controlling machines and processes, and 4.C.2.d.1.i Spend time making repetitive motions.

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. $Sh_j^{T_1} = \frac{T_{j1}^*}{\sum_{k=1}^{6} T_{jk}^*}$. A higher $Sh_j^{T_1}$ is associated with a greater intensity of routine cognitive tasks in occupation j. The routine manual 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 that provide estimates of occupational employment and hourly wage levels for wage and salary workers.[13] 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 automatatic inflation adjustments) between the federal increase in July 2009 and the end of 2014.[14]

The OES wage data is used to group occupations into four wage bins based on the average 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, 175 to 250 percent, 250 to 300 percent, and 300 to 600 percent 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.[15]

A list of the lowest wage occupations (those with mean wages less than 175 percent of the minimum wage, which we call wage group 1) sorted by their routine cognitive share is presented in Table 1. At least informally, it appears the occupations with high routine

[13] 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.

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

[15] 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.

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 the types of jobs susceptible to technological substitution. On the other hand, occupations with low routine cognitive shares at the bottom of Table 1 – such as bartenders and child care workers – may be less so. Of note, 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. This low association also appears within our higher wage intervals.

Ultimately, we combine the OES employment data with the O*NET routine intensity data and state minimum wage histories to estimate the reduced-form relationship between minimum wages and employment by the level of routinization within an occupation. To begin though, it is illuminating to simply 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 for cashiers (Figure 1a) and food prep workers (Figure 1b).[16] Larger increases in the minimum wage lead to economically and statistically significant employment declines among cashiers – elasticity (standard error) of -0.24 (0.09) – but not among food prep workers (-0.03 (0.26)).

This relationship is not limited to cashiers and food prep 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 routine cognitive share (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 -0.25 (0.08) when all high routine

[16]The four year period covers one year prior to the year of the hike, the year of the hike, and the two years after.

cognitive occupations are included and -0.29 (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 -0.05 (0.07) regardless of the inclusion of food prep workers.[17] No such distinction appears among high and not high manual routine occupations, as illustrated in Figures 3a and 3b.

3.3 Matched 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.[18]

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. The CPS micro data allows us to define wage groupings somewhat more finely than in the occupation-aggregated OES. While we still use four bins to stratify the sample, they are now 80 to 150 percent, 150 to 200 percent, 200 to 400 percent, and 400 to 600 percent of the minimum wage. We group 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. We also present results that group individuals according to the ratio of their first reported CPS wage and

[17] 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 (-0.27 (0.09) when cashiers are included, -0.37 (0.21) when cashiers are excluded) and not high (-0.10 (0.08) when fast food workers are included, -0.11 (0.08) when fast food workers are excluded) cognitive routine occupations is noisier but generally similar.

[18] 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.

the contemporaneous minimum wage.[19]

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.[20]

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 large) increases in the minimum wage.[21]

[19] 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 (2015). 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 one groups 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, but 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 increases are likely to experience faster wage growth.

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

[21] 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.

4.1 Occupation-Level Analysis

Broadly following the empirical specification of Neumark, Schweitzer, and Wascher (2004), we estimate the effect of minimum wages on occupation-level employment using the following statistical model:

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

$\Delta \ln Emp_{jst} = \ln Emp_{jst} - \ln Emp_{js,t-4}$ is the change in the log of the employment level for occupation j in state s and year t from four years prior. We focus on four year employment changes to allow time for the minimum wage to impact labor demand; the base year (i.e. $t-4$) corresponds to employment levels in the year prior to the earliest change in the minimum wage. The $R(W_{js}, MW_s)^k$ variable classifies an occupation-state into one of our four predetermined wage bins. $\Delta \ln MW_{s,t+z} = \ln MW_{s,t+z} - \ln MW_{s,t+z-1}$ represents the one-year change in the log of the minimum wage and its corresponding β_k^z coefficients describe the timing of the employment response to a minimum wage change for a specific wage bin k. For example, β_k^1 measures the leading (pre-treatment) elasticity, and β_k^0, β_k^{-1}, and β_k^{-2} are the employment elasticities associated with the year of the minimum wage change, one year after the change, and two years following the minimum wage change. The regressions also include state, year, and wage bin fixed effects (α_s, α_t, and α_k), an occupation's employment level in its state in the base year ($Emp_{js,t-4}$), and the routine share (manual or cognitive) of an occupation ($RoutineSh_j$). We interact $Emp_{js,t-4}$ and $RoutineSh_j$ with year dummy variables ($Year_t$) and $R(W_{js}, MW_s)^k$ to allow base conditions to vary across time for each of the wage groups, a flexibility that may be particularly germane given that our sample period spans the Great Recession.

Our primary goal is to assess whether the employment response to a minimum wage hike differs by the routineness of an occupation's tasks. Therefore, we augment equation

(4) to include interactions between the change in the minimum wage ($\Delta \ln MW_{s,t+z}$) and the routine share of tasks at an occupation ($RoutineSh_j$) for each wage interval.

$$\begin{aligned}\Delta \ln Emp_{jst} =& \alpha_0 + \alpha_t + \alpha_s + \alpha_k + \sum_{k=1}^{4} \alpha_{1tk} Emp_{js,t-4} * Year_t * R(W_{js}, MW_s)^k \\ &+ \sum_{k=1}^{4} \alpha_{2tk} RoutineSh_j * Year_t * R(W_{js}, MW_s)^k \\ &+ \sum_{z=-2}^{1} \sum_{k=1}^{4} \beta_k^z \Delta \ln MW_{s,t+z} * R(W_{js}, MW_s)^k \\ &+ \sum_{z=-2}^{1} \sum_{k=1}^{4} \beta_{kRS}^z \Delta \ln MW_{s,t+z} * RoutineSh_j * R(W_{js}, MW_s)^k + \epsilon_{jst}.\end{aligned} \tag{5}$$

The β_{kRS}^z coefficients on this interaction term describe how employment responds to changes in the minimum wage for occupations with different levels of routine intensity. Notably, the specification continues to include year-specific effects of an occupation's routine share of tasks. Thus, we remove the overall trend in employment by routine task content, which ensures that the β_{kRS}^z coefficients simply capture the effect of the minimum wage hike. To ease the interpretation of the β_{kRS}^z 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 β_{kRS}^z coefficients should be interpreted as employment elasticities for every standard deviation increase in the routine share of an occupation.

Identification of the β_k^z coefficients in equations (4) and (5) requires that changes in the minimum wage are independent of overall employment growth within each state. This is a common assumption in the minimum wage literature, but some recent evidence suggests that it may not be appropriate (Allegretto, Dube, and Reich, 2011). However, the emphasis in this analysis is on assessing the extent to which employment changes (associated with the minimum wage) differ across occupations according to the routineness of their tasks (i.e. the β_{kRS}^z coefficients). The β_{kRS}^z coefficients are identified so long as changes in the minimum wage are independent of pre-existing state-specific employment trends across occupations according to their routine intensity (since we remove overall trends in employment by routine intensity). This assumption is testable by estimating equation (5) with state-by-year fixed

effects, so long as we exclude the change in the minimum wage (and the associated β_k^z coefficients) from the specification. The results from this altered equation (5) are also presented below.

In the empirical implementation of equations (4) and (5), we weight observations using the occupation-level employment in a given state during the base year. Standard errors are clustered at the state level. In our baseline results, we also exclude observations with four-year employment changes greater than $\pm$ 0.75 log points. Despite this exclusion, results in the appendix show that our findings are robust to the inclusion of observations with these large employment changes.

4.2 Worker-Level Analysis

For CPS regressions, we use a similar specification to equations (4) and (5), tailored to the one-year rotating panels of the CPS and the richness of micro data. That is, we estimate:

$$\begin{aligned} Y_{ijst} =& \alpha_0 + \alpha_t + \alpha_s + \alpha_k + \alpha_x X_{1i} + \sum_{k=1}^{4} \alpha_{1tk} X_{2ijs,t-1} * Year_t * R(W_{ist}, MW_{st})^k \\ &+ \sum_{k=1}^{4} \alpha_{4tk} HighRS_{ijs,t-1} * Year_t * R(W_{ist}, MW_{st})^k \\ &+ \sum_{z=-2}^{1} \sum_{k=1}^{4} \beta_k^z \Delta \ln MW_{s,t+z} * R(W_{ist}, MW_{st})^k \\ &+ \sum_{z=-2}^{1} \sum_{k=1}^{4} \beta_{kRS}^z \Delta \ln MW_{s,t+z} * HighRS_{ijs,t-1} * R(W_{ist}, MW_{st})^k + \epsilon_{jst}. \end{aligned} \tag{6}$$

The main right-hand side difference between equation (6) and equations (4) and (5) is the presence of X_1, which includes basic demographic controls such as age and age squared, and indicators for sex, race, and education level (less than high school, high school only, and some college), and X_2, which includes individual-specific labor market outcomes from the first CPS observation date, such as an individual's ratio of their wage to their state's minimum wage (lagged two years), indicators for industry affiliation (at the 1-digit level), and the routine share of an individual's occupation. Equation (6) also includes an indicator for

being employed at a high routine share occupation ("HighRS") in the first CPS observation, where a high routine share occupation is an occupation with a routine share that is more than one standard deviation above average within the worker's wage bin.[22]

We use this specification to study the effects of minimum wages on a series of dependent variables, captured by Y_{ijst}. One such dependent variable is $HighRS_{ijst}$, an indicator that individual i in state s is employed at a high routine share occupation at the second CPS outgoing rotation survey (month 8). In this case, the β_k^z coefficients measure changes in the probability of being employed at a high routine share occupation when the minimum wage increases and the β_{kRS}^z coefficients capture the additional effect on individuals employed at high routine share occupations. If technological substitution is taking place, we expect that the minimum wage would be associated with movements away from high routine share occupations (negative β^z coefficients), especially for those workers already employed at routine intensive occupations (negative β_{kRS}^z coefficients). Like equation (5), we estimate leading, current, and lagged effects of minimum wage changes (associated with these β_k^z and β_{kRS}^z coefficients). We identify these leading and lagged effects using the timing of minimum wage changes and limiting the sample to occupational switchers between the first and second CPS outgoing rotation survey.

To further examine whether technological substitution is taking place in the CPS, we also estimate equation (6) using the one year change in the routine share of an individual's occupation as the dependent variable. Again, if technological substitution is taking place, the β^z and β_{kRS}^z coefficients will be negative.

Lastly, we use the CPS to assess the outcomes of individual's affected by technological substitution. In this regard, we estimate equation (6) with two alternative dependent variables: (a) an indicator for being employed in year 2 (conditional on being employed in year 1) and (b) the change in the logarithm of wages from year 1 to year 2. Identification of these effects does not require us to limit the sample to occupation switchers. Otherwise, the empirical specifications are identical to those described above.

In the empirical implementation of equation (6), we weight observations using the sample

[22]Recall, the CPS wage bin $R(W_{ist}, MW_{st})^k$ has different intervals than the OES-based wage bins to take advantage of the flexibility of individual CPS data.

weights from the CPS. Again, standard errors are clustered at the state-level. In all but the "Employed in Year 2" regression, where we do not condition the sample on being employed in both year 1 and year 2, we also restrict the sample to individuals that experience year-over-year wage changes less than ± 0.40 log points.[23] However, we also present estimates that do not impose this wage change restriction in the appendix.

5 Results

5.1 Occupation-Level Analysis

Table 2 shows the main OES results. The first four columns, labeled Specification 1, are estimated using equation (4) for each of our four wage groupings. Regardless of the wage group, we find no impact of a minimum wage increase on overall employment in the year of, one year after, and two years after a hike. This finding is robust to a number of adjustments to the regression specification, including the inclusion of occupation*year fixed effects (Appendix Table A2) and large employment changes (Appendix Table A3). That is, there is little evidence of aggregate OES employment changes following a minimum wage hike between 2003 and 2009.

The next eight columns, labeled Specification 2 and Specification 3, add interactions between an occupation's routine cognitive share and lags and leads of the change in the minimum wage (equation 5). The only difference between Specifications 2 and 3 is the inclusion of separate state and year fixed effects (columns 5 to 8) versus state*year fixed effects (columns 9 to 12).

Here, we find strong evidence that minimum wage hikes lead to a decrease in employment among occupations that are more cognitively routine and that this effect gets monotonically stronger as an occupation's average pay nears the minimum wage. Among the lowest-paying occupations, those with a mean wage less than 175 percent of the minimum (wage group 1), we find no immediate impact in the year of the minimum wage change but the estimated employment elasticity grows to -0.10 (0.05) and -0.16 (0.06) one and two years later. In

[23]This exclusion reduces the sample of hourly workers by 19.6 percent

words, the results imply that one and two years after a 10 percent increase in the minimum wage, employment declines about 1.0 and 1.6 percent in occupations one standard deviation above average in their routine cognitive share.[24] 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 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 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 more directly below. Also note there is no employment response prior to the minimum wage hike (in table, "Next Year"). This strongly suggests that we are not picking up some pre-existing trend in employment by routine intensity, but rather the specific effects associated with rising labor costs. Indeed, the slow employment adjustment over multiple years is at least consistent with the idea that capital investments or other sources of substitution tend to take time to implement and could be lumpy (Doms and Dunne, 1998; Aaronson, French, and Sorkin, 2015).

We also find a statistically similar sized employment response, both in the year of the hike and up to two year later, on occupations with an average wage of 175 to 250 percent of the minimum wage (wage group 2). 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.[25] Moreover, we are grouping occupations by their average wage relative to the minimum wage and some individual wages incorporated in these averages may be directly influenced by minimum wage laws.

As expected, the effect of a higher minimum wage dissipates as we move further up the

[24] As mentioned above, standard errors are clustered at the state level. We have experimented with clustering at the occupation level. In this case, the standard errors do rise somewhat but always remain statistically significant at the 10 percent and often at the 5 percent level. Additionally, if we combine wage groups 1 and 2, which are statistically indistinguishable anyway, the coefficients look very similar and the estimates one year after and two years after the minimum wage hike are much more precisely estimated, using either state or occupation-clustered standard errors.

[25] See Lee (1999), Neumark, Schweitzer, and Wascher (2004), Aaronson, Agarwal, and French (2012), Butcher, Dickens, and Manning (2012), and Phelan (2015).

wage distribution. The estimates are mixed for wage group 3 (average wage of 250 to 300 percent of the minimum wage) and, unlike wage groups 1 and 2, sensitive to the specification of the fixed effect (column 11). Moreover, the employment losses for wage group 3 appear statistically and economically similar in the pre-treatment period (-0.08) and two years after the minimum wage (-0.10), suggesting an unobserved trend. For all other occupations – those that pay more than 300 percent of the minimum wage – a boost to the minimum wage has no differential employment impact based on the cognitive routineness of an occupation.

By contrast, 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 (see Table 3, columns 5 to 12).[26] This stands in contrast to the job polarization literature, which has moved away from distinguishing between routine cognitive and routine manual tasks.[27] Rather, the stark differences in our analysis are 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 A2), the expansion of the sample to include very large employment changes (Appendix Table A3), and reasonable adjustments to the list of conditioning variables.

Of course, we do not observe actual technological substitution of labor and our results need not be solely a reflection of this explanation. Another source of substitution could be through alternative sources of low-skill labor unaffected by the minimum wage hike, most prominently labor overseas. To test whether outsourcing is confounding our results, we reestimate equation (5) 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 A4 for wage group 2. The results of this exercise are reported in Table 4.

Controlling for offshorability somewhat lowers the employment elasticities for wage group 1 but has little impact on our inference that the minimum wage lowers employment in highly

[26]The columns of Table 3 match Table 2 except that we control for manual routine share rather than cognitive routine share.

[27]See Goos, Manning, and Salomons (2009) and Autor and Dorn (2013).

cognitive routine jobs. This is not a surprise as only 6.6 percent of employment in wage group 1, are potentially offshorable, according to Blinder (2009).[28] 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 0.55 correlation with the cognitive routine share of its tasks.[29] Consequently, in a horserace (Table 4, 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 stressed in our theoretical framework arises from differences in occupational use across industries that may be correlated with product market elasticities (the scale effect). Unfortunately, we are unable to test this possibility in the OES because we lack industry information. However, we can include industry and industry-by-year fixed effects in the CPS analysis and their inclusion has no substantive effect on any of those results. Thus, we do not believe our results are driven by uncontrolled industry-specific factors.

We reiterate that the overall employment response, even in wage group 1, is indistinguishable from zero. Therefore, minimum wage hikes during the mid-2000s led to a reshuffling of 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 in non-routine cognitive occupations. Among the lowest paid occupations, it is unlikely that this job loss appears as a job gain in another location unaffected by the minimum wage hike.

[28] In Table 1, it appears that only three low-wage occupations, representing 1.8 percent of low-wage employment, is offshorable. The disparity between 1.8 and 6.6 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.

[29] The correlation coefficient between the offshorability of an occupation and its routine manual share is 0.003.

But outsourcing may be part of the explanation for the loss of cognitively routine jobs in slightly higher paying occupations.

5.2 Worker-Level Analysis

5.2.1 Technological Substitution in the CPS

Table 5 shows 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 (columns 1 to 4) as well as the change in the routine cognitive share of an individual's occupation (columns 5 to 8) following a minimum wage hike. Table 6 presents the same results for the routine manual intensity of an occupation.

Like the OES, we again find evidence that the lowest wage workers in high cognitively routine occupations switch away from those jobs after a minimum wage hike. For workers paid 80 to 150 percent of the minimum wage, we estimate that a 10 percent increase in the minimum wage lowers the probability that they will be employed in a high routine cognitive occupation by 4.0 (2.3) and 6.3 (3.0) percentage points one and two years later. Similarly, low-wage workers employed in high routine cognitive occupations respond to a 10 percent increase in the minimum by moving to jobs with 0.12 (0.04) and 0.17 (0.05) standard deviations less routine cognitive tasks one and two years later.

For workers paid 150 to 200 percent of the minimum, there is no statistically significant effect of minimum wages on crossing the discrete threshold of no longer being employed in a "high" routine intensive occupation. However, workers employed in high routine intensive occupations tend to move to occupations with less routine cognitive task intensity. A 10 percent increase in the minimum causes these workers to move to jobs with 0.15 (0.06) and 0.13 (0.05) standard deviations less routine cognitive tasks one and two years later. There is no statistically significant impact on workers paid more than twice the minimum wage. Moreover, similar to the OES estimates, we also find no evidence of movement away from manually routine occupations one and two years after the hike (Table 6).

5.2.2 Employment and Wage Effects

Finally, we ask how this movement away from routine intensive jobs in response to a minimum wage hike impacts worker's employment and wage opportunities. Consistent with the negligible effects on net employment in the OES, we find little to no impact on subsequent employment among wage group 1 workers initially employed at high routine cognitive occupations (see Table 7). The effect on workers in wage group 2 is more mixed. We find a positive employment elasticity of 0.16 (0.07) in the immediate year following a minimum wage increase but a negative elasticity of -0.15 (0.07) two years later. Taken together, we interpret these estimates as suggesting that this movement away from high routine cognitive occupations does not appear to be associated with significant losses in employment for those workers most affected by this reallocation.

This reshuffling of the low-wage labor market does appear to cause some damage to individual wages, however (Table 8). While minimum wage increases lead to overall wage gains for wage group 1 (column 1), those gains are highly muted if the worker was initially employed in a high cognitively routine occupation (column 5). In particular, our estimates imply overall wage elasticities of 0.27 (0.04) and 0.19 (0.02) one and two years after a minimum wage increase for wage group 1 workers not in high cognitive routine occupations compared to 0.10 (0.05) and 0.02 (0.06) for wage group 1 workers in high routine cognitive occupations. Those differences are highly statistically and economically significant. Restricting the sample to job stayers or job movers has no major impact on the results. Thus, the relative wage losses for those employed at high cognitively routine jobs likely stem from both forced transitions to next best alternatives and falling relative wages of routine cognitive work.

These wage results are robust to grouping individuals according to their current minimum wage (see Appendix Table A5) and removing the X_1 and X_2 conditioning variables. However, the wage results are somewhat sensitive to the inclusion of large wage changes (i.e. wage changes greater than $\pm$ 0.40 log points) in the sample.[30] As shown in Appendix

[30]The results from the other three regressions using the CPS – (a) employed in a high routine occupation in year 2, (b) the change in routine share, and (c) employed in year 2 – are largely robust to grouping individuals to their current minimum wage, excluding X_1 and X_2 from the regression specification, and including observations with large wage changes in the sample. These results are also presented in Appendix

Table A6, when all wage change observations are included in the sample, individuals in wage group 1 who were employed at high cognitively routine occupations still experience relative wage losses one year after the minimum wage hike but this effect now disappears two years after the increase. Additionally, the wage losses now appear to be more associated with job stayers, which suggests that much of the relative wage loss in highly cognitively routine jobs arise from falling relative prices of routine cognitive work.

In sum, the CPS results are broadly consistent with the OES estimates. Increases in the minimum wage cause workers to leave routine intensive occupations. These employment adjustments occur without much of a disruption 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 and there is no parallel effect on individuals employed in high routine manual occupations (see Appendix Table A7).

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 substitution. We use the minimum wage as a natural experiment that exogenously increases the cost of low-wage workers and examine the heterogeneous employment and wage responses to this increase based on the routine intensity of an occupation.

We find that increases in the minimum wage 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 hikes – and has no impact on higher paid occupations. Moreover, at the bottom of the pay scale, our results are not confounded by jobs moving to locations unaffected by the new minimum wage levels (i.e. offshoring). While the employment cost of this reshuffling of the low-wage labor market appears to be

Tables A5 and A6.

small in the short-run, those workers previously 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 some studies, such as Bresnahan, Brynjolfsson, and Hitt (1999), Manning (2004), and Autor, Katz, and Kearney (2008), which have largely concluded that technological advancements have little direct effect on the demand for low-skill jobs. Rather, our results are more consistent with Lewis (2011)'s study of the manufacturing sector.

In many respects, the effects we document on the low-wage labor market mirror those found in middle-skill jobs with large proportions of routine cognitive tasks (Goos and Manning, 2007). However, unlike the findings in the job polarization literature, the loss of low-skill routine cognitive jobs during our period of analysis has been largely offset in the short-run by employment growth in non-routine low-skill jobs, a result that our theoretical framework predicts is possible if capital requires non-routine labor to be productive. That said, while the short-run effects on total low-wage/low-skill employment have been economically small, that need not be the case in periods outside of our sample or in the long-run. To the extent that employment at non-routine cognitive occupations does not expand, greater technological substitution among low-wage occupations could ultimately lead to falling employment among low-wage/low-skill workers.

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Table 1: Summary of Occupations in Wage Group 1, by Routine 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 of Occupation
Graders and Sorters, Agricultural Products	1.45	45,546	36.4%	20.9%	0
Gaming and Sports Book Writers and Runners	1.69	12,864	35.1%	15.6%	0
Gaming Dealers	1.41	74,168	34.6%	11.4%	0
Ushers, Lobby Attendants, and Ticket Takers	1.42	100,936	33.6%	8.5%	0
Cashiers	1.44	3,449,321	31.4%	17.0%	0
Pharmacy Aides	1.66	52,491	30.2%	10.6%	0
Motion Picture Projectionists	1.66	9,402	29.9%	22.5%	0
Hotel, Motel, and Resort Desk Clerks	1.57	199,198	28.7%	8.8%	0
Crossing Guards	1.74	62,700	28.2%	8.6%	0
Meat, Poultry, and Fish Cutters and Trimmers	1.70	142,531	28.0%	20.8%	0
Service Station Attendants	1.53	94,625	27.5%	17.1%	0
Sewing Machine Operators	1.62	245,705	27.4%	24.0%	75
Veterinary Assistants and Laboratory Animal Caretakers	1.68	66,165	26.9%	13.1%	0
Cooks, Institution and Cafeteria	1.72	394,841	26.5%	17.1%	0
Food Servers, Nonrestaurant	1.53	189,100	25.9%	13.4%	0
Maids and Housekeeping Cleaners	1.51	906,648	25.3%	21.1%	0
Shampooers	1.35	14,195	25.2%	13.0%	0
Waiters and Waitresses	1.39	2,204,006	25.0%	10.0%	0
Home Health Aides	1.62	690,674	24.8%	8.2%	0
Parking Lot Attendants	1.46	122,110	24.7%	11.1%	0
Lifeguards and Other Recreational Service Workers	1.47	65,422	24.4%	6.6%	0
Transportation Attendants, Except Flight Attendants	1.70	20,834	24.2%	9.6%	0
Packers and Packagers, Hand	1.58	861,186	23.8%	17.7%	0
Cooks, Short Order	1.51	197,902	23.7%	15.9%	0
Sewers, Hand	1.74	12,354	23.1%	14.4%	75
Laundry and Dry-Cleaning Workers	1.54	216,820	22.8%	24.0%	0
Dining Room and Cafeteria Attendants	1.32	402,254	22.8%	17.5%	0
Combined Food Preparation Workers, Including Fast Food	1.31	2,316,221	22.2%	14.8%	0
Pressers, Textile, Garment, and Related Materials	1.53	79,668	22.1%	29.3%	75
Farmworkers and Laborers, Crop and Nursery	1.29	223,452	21.9%	20.8%	0
Counter Attendants, Cafeteria and Food Concession	1.34	483,613	21.8%	13.8%	0
Hosts and Hostesses, Restaurant and Lounge	1.38	320,047	21.7%	6.8%	0
Cooks, Restaurant	1.70	782,388	21.7%	17.0%	0
Cooks, Fast Food	1.31	588,178	21.4%	19.2%	0
Agricultural Equipment Operators	1.69	21,022	20.3%	22.6%	0
Cleaners Of Vehicles and Equipment	1.63	319,070	20.3%	19.0%	0
Food Preparation Workers	1.48	859,402	20.0%	15.4%	0
Personal and Home Care Aides	1.49	519,052	19.8%	4.0%	0
Dishwashers	1.32	502,609	19.4%	22.8%	0
Manicurists and Pedicurists	1.60	35,782	19.0%	11.6%	0
Bicycle Repairers	1.71	5,821	18.3%	6.8%	0
Locker Room, Coatroom, and Dressing Room Attendants	1.56	18,302	17.4%	12.2%	0
Nonfarm Animal Caretakers	1.62	101,092	17.3%	7.4%	0
Farmworkers, Farm and Ranch Animals	1.66	35,710	16.3%	16.6%	0
Bartenders	1.48	463,587	15.8%	11.1%	0
Child Care Workers	1.51	513,328	13.5%	4.0%	0
Amusement and Recreation Attendants	1.41	221,940	13.1%	8.2%	0
Average for Occupations with W<1.75*MW	1.46		23.9%	14.5%	5
Average for Occupations with 1.75*MW<W<2.5*MW	2.14		24.0%	14.3%	29
Average for Occupations with 2.5*MW<W<3*MW	2.74		22.8%	13.6%	28

Notes: The wage and employment data are from the Occupation Employment Statistics. The average wage-to-minimum wage is the 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 Intensity of an Occupation
Routine Intensity = Routine Cognitive Share of Tasks
Occupation Employment Statistics, 2003-2009

	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
ΔMW Next Year	0.01	0.03	0.06	-0.03	0.01	0.03	0.08	-0.02				
	(0.03)	(0.05)	(0.04)	(0.02)	(0.03)	(0.04)	(0.05)	(0.02)				
ΔMW This Year	0.04	-0.04	0.02	0.00	0.05	-0.03	0.05	0.01				
	(0.04)	(0.06)	(0.05)	(0.03)	(0.04)	(0.05)	(0.05)	(0.03)				
ΔMW Last Year	0.02	-0.02	0.06	0.04	0.04	0.00	0.09	0.05				
	(0.05)	(0.05)	(0.06)	(0.04)	(0.06)	(0.05)	(0.05)	(0.04)				
ΔMW 2Yrs Ago	0.10	-0.07	0.07	0.10	0.13	-0.04	0.10	0.11				
	(0.08)	(0.05)	(0.08)	(0.08)	(0.08)	(0.05)	(0.07)	(0.08)				
ΔMW Next Year x RoutineSh					0.02	0.00	-0.08	0.00	0.02	-0.01	-0.05	-0.01
					(0.03)	(0.04)	(0.04)	(0.04)	(0.03)	(0.05)	(0.04)	(0.04)
ΔMW This Year x RoutineSh					-0.05	-0.04	-0.11**	-0.01	-0.04	-0.06	-0.08*	-0.01
					(0.05)	(0.04)	(0.03)	(0.04)	(0.05)	(0.04)	(0.03)	(0.04)
ΔMW Last Year x RoutineSh					-0.10*	-0.09	-0.12	-0.01	-0.10*	-0.11*	-0.09	0.00
					(0.05)	(0.05)	(0.06)	(0.04)	(0.05)	(0.05)	(0.06)	(0.04)
ΔMW 2Yrs Ago x RoutineSh					-0.16**	-0.13*	-0.10	-0.04	-0.15**	-0.17**	-0.07	-0.03
					(0.06)	(0.06)	(0.08)	(0.05)	(0.05)	(0.06)	(0.07)	(0.05)
State FE and Year FE	Yes				Yes				No			
State x Year FE	No				No				Yes			

Notes: Wage Group 1 includes all occupations where the average wage is less than 1.75*MW (within the particular state over the panel). Wage Group 2 includes all occupations where the average wage is between 1.75*MW and 2.5*MW. Wage Group 3 includes all occupations where the average wage is between 2.5*MW and 3*MW. Wage Group 4 includes all occupations where the average wage is between 3*MW and 6*MW. Observations are weighted by state-specific employment levels. Standard errors are clustered at the state level. Occupation-specific employment changes greater than ± 0.75 log points are excluded from the analysis. 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. $N = 118,317$ for all three specifications. * p<0.05 and ** p<0.01.

Table 3: Employment Effect of a Minimum Wage Hike by the Routine Intensity of an Occupation
Routine Intensity = Routine Manual Share of Tasks
Occupation Employment Statistics, 2003-2009

	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
ΔMW Next Year	0.00	0.04	0.04	-0.02	0.01	0.03	0.04	-0.02				
	(0.03)	(0.05)	(0.04)	(0.02)	(0.03)	(0.05)	(0.04)	(0.02)				
ΔMW This Year	0.03	-0.04	0.01	0.00	0.02	-0.04	0.01	0.00				
	(0.04)	(0.06)	(0.05)	(0.03)	(0.04)	(0.05)	(0.05)	(0.03)				
ΔMW Last Year	0.01	-0.02	0.05	0.04	0.02	-0.01	0.06	0.04				
	(0.05)	(0.05)	(0.06)	(0.04)	(0.05)	(0.05)	(0.06)	(0.04)				
ΔMW 2Yrs Ago	0.09	-0.04	0.05	0.09	0.09	-0.06	0.05	0.09				
	(0.08)	(0.05)	(0.09)	(0.06)	(0.07)	(0.05)	(0.10)	(0.06)				
ΔMW Next Year x RoutineSh					-0.06	-0.01	-0.01	-0.05	-0.06	-0.01	-0.01	-0.04
					(0.06)	(0.03)	(0.05)	(0.04)	(0.06)	(0.04)	(0.05)	(0.04)
ΔMW This Year x RoutineSh					0.08	0.00	0.01	-0.04	0.08	0.02	0.00	-0.04
					(0.05)	(0.05)	(0.06)	(0.06)	(0.06)	(0.05)	(0.06)	(0.06)
ΔMW Last Year x RoutineSh					-0.02	0.03	0.01	-0.08	-0.03	0.05	0.00	-0.07
					(0.06)	(0.05)	(0.08)	(0.04)	(0.07)	(0.05)	(0.07)	(0.04)
ΔMW 2Yrs Ago x RoutineSh					0.09	-0.05	-0.01	-0.08	0.09	-0.01	-0.02	-0.07
					(0.05)	(0.12)	(0.11)	(0.05)	(0.05)	(0.10)	(0.10)	(0.05)
State FE and Year FE	Yes				Yes				No			
State x Year FE	No				No				Yes			

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

Table 4: Employment Effect of a Minimum Wage Hike: Technological Substitution vs. Offshoring
Occupation Employment Statistics, 2003-2009

	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
ΔMW Next Year x RoutineSh	0.02	-0.01	-0.05	-0.01					0.02	0.00	0.03	-0.01
	(0.03)	(0.05)	(0.04)	(0.04)					(0.03)	(0.04)	(0.04)	(0.04)
ΔMW This Year x RoutineSh	-0.04	-0.06	-0.08*	-0.01					-0.03	-0.04	-0.09	0.00
	(0.05)	(0.04)	(0.03)	(0.04)					(0.05)	(0.04)	(0.05)	(0.04)
ΔMW Last Year x RoutineSh	-0.10*	-0.11*	-0.09	0.00					-0.09*	-0.09	-0.11	-0.01
	(0.05)	(0.05)	(0.06)	(0.04)					(0.05)	(0.07)	(0.08)	(0.04)
ΔMW 2Yrs Ago x RoutineSh	-0.15**	-0.17**	-0.07	-0.03					-0.11*	-0.05	-0.23	-0.03
	(0.05)	(0.06)	(0.07)	(0.05)					(0.06)	(0.10)	(0.12)	(0.04)
ΔMW Next Year x Offshorability					-0.19**	-0.01	-0.07*	-0.01	-0.19**	-0.01	-0.09**	-0.01
					(0.07)	(0.04)	(0.03)	(0.02)	(0.07)	(0.03)	(0.03)	(0.03)
ΔMW This Year x Offshorability					-0.03	-0.04	-0.03	-0.02	-0.02	-0.02	0.02	-0.02
					(0.06)	(0.03)	(0.03)	(0.04)	(0.05)	(0.02)	(0.05)	(0.04)
ΔMW Last Year x Offshorability					-0.18**	-0.07*	-0.02	0.01	-0.17*	-0.02	0.04	0.01
					(0.07)	(0.02)	(0.05)	(0.04)	(0.07)	(0.03)	(0.07)	(0.04)
ΔMW 2Yrs Ago x Offshorability					-0.16	-0.20**	0.07	-0.03	-0.15	-0.18*	0.21*	-0.02
					(0.09)	(0.05)	(0.04)	(0.05)	(0.08)	(0.08)	(0.09)	(0.05)
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 5: Change in Occupational Routineness Following a Minimum Wage Hike
Routine Cognitive Share of Tasks
Matched CPS, 2004-2009

	Specification 1: Employed in High Routine Cognitive Occupation in Year 2?				Specification 2: Change in Routine Cognitive Task Content			
	Wage Group1	Wage Group2	Wage Group3	Wage Group4	Wage Group1	Wage Group2	Wage Group3	Wage Group4
ΔMW Next Year	0.18**	-0.08	-0.03	0.16	0.45**	-0.09	-0.10	0.41
	(0.09)	(0.07)	(0.05)	(0.12)	(0.21)	(0.22)	(0.09)	(0.24)
ΔMW This Year	0.04	0.03	-0.03	0.06	0.01	0.12	-0.01	0.21
	(0.11)	(0.08)	(0.07)	(0.14)	(0.24)	(0.23)	(0.16)	(0.37)
ΔMW Last Year	0.03	0.04	0.10	0.18	0.00	0.08	0.26	0.44
	(0.09)	(0.09)	(0.07)	(0.14)	(0.25)	(0.31)	(0.17)	(0.29)
ΔMW Two Years Ago	0.17	0.00	0.09	-0.20	0.17	0.21	0.21	-0.01
	(0.12)	(0.07)	(0.06)	(0.15)	(0.37)	(0.26)	(0.17)	(0.44)
ΔMW Next Year x High RoutineSh	-0.37	-0.03	-0.05	0.34	-0.98*	-0.67	-0.12	0.02
	(0.21)	(0.21)	(0.12)	(0.25)	(0.43)	(0.45)	(0.28)	(0.65)
ΔMW This Year x High RoutineSh	-0.39	-0.31	-0.02	-0.74	-0.30	-0.87	0.31	-1.21
	(0.24)	(0.28)	(0.12)	(0.38)	(0.39)	(0.55)	(0.36)	(0.81)
ΔMW Last Year x High RoutineSh	-0.40	-0.42	-0.07	-0.70	-1.18**	-1.54*	-0.21	-0.76
	(0.23)	(0.27)	(0.16)	(0.37)	(0.43)	(0.61)	(0.34)	(0.85)
ΔMW 2Yrs Ago x High RoutineSh	-0.63*	-0.12	0.20	0.26	-1.72**	-1.29*	0.05	0.67
	(0.30)	(0.26)	(0.23)	(0.57)	(0.50)	(0.54)	(0.35)	(1.15)

Notes: Wage Group 1 includes hourly Workers with a first period wage of at least 80 percent but less than 150 percent of the MW. Wage Group 2 includes hourly workers with a first period wage 150 to 200 percent of the MW. Wage Group 3 includes hourly workers with a first period wage 200 to 400 percent of the MW. Wage Group 4 includes hourly workers with a first period wage 400 to 600 percent of the MW. All wage groupings based on minimum wages from two years prior. 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. Standard errors are clustered at the state level. We exclude minimum wage changes less than 0.03 log points. Sample is conditional on being employed as an hourly worker in both years, changing occupations between year 1 and year 2, and a change in log wages less than ± 0.40 log points. $N = 45,854$ for both regression models. * p<0.05 and ** p<0.01.

Table 6: Change in Occupational Routineness Following a Minimum Wage Hike
Routine Manual Share of Tasks
Matched CPS, 2004-2009

	Specification 1: Employed in High Routine Manual Occupation in Year 2?				Specification 2: Change in Routine Manual Task Content			
	Wage Group1	Wage Group2	Wage Group3	Wage Group4	Wage Group1	Wage Group2	Wage Group3	Wage Group4
ΔMW Next Year	-0.11	-0.03	0.03	0.01	-0.07	-0.11	0.09	0.35
	(0.06)	(0.05)	(0.05)	(0.12)	(0.16)	(0.12)	(0.13)	(0.31)
ΔMW This Year	-0.02	0.02	0.06	0.14	0.08	0.05	0.18	0.19
	(0.07)	(0.05)	(0.04)	(0.16)	(0.20)	(0.17)	(0.13)	(0.42)
ΔMW Last Year	0.04	0.08	0.03	0.19	0.20	0.00	0.04	0.55
	(0.11)	(0.08)	(0.06)	(0.19)	(0.26)	(0.28)	(0.15)	(0.37)
ΔMW Two Years Ago	0.15	-0.13	-0.09	0.25	0.32	-0.47*	-0.04	0.48
	(0.09)	(0.10)	(0.06)	(0.20)	(0.28)	(0.20)	(0.15)	(0.42)
ΔMW Next Year x High RoutineSh	-0.34	-0.18	-0.03	-0.09	-0.48	0.07	-0.15	-0.53
	(0.19)	(0.16)	(0.12)	(0.25)	(0.49)	(0.29)	(0.19)	(0.54)
ΔMW This Year x High RoutineSh	-0.21	-0.19	-0.09	0.11	-0.66	0.24	-0.45	0.17
	(0.20)	(0.18)	(0.17)	(0.38)	(0.51)	(0.34)	(0.28)	(0.68)
ΔMW Last Year x High RoutineSh	-0.17	0.21	-0.26	0.13	-0.23	-0.38	-0.39	-0.40
	(0.34)	(0.40)	(0.23)	(0.40)	(0.58)	(0.58)	(0.26)	(0.69)
ΔMW 2Yrs Ago x High RoutineSh	0.21	0.00	0.09	-0.34	-0.69	1.22	0.11	-0.86
	(0.50)	(0.30)	(0.16)	(0.45)	(0.67)	(0.77)	(0.31)	(0.86)

Notes: See notes to Table 5. High routine share occupations are those with a routine manual share that is at least one standard deviation above average for their wage group. $N = 45,854$ for both regression models. * p<0.05 and ** p<0.01.

Table 7: Change in Employment in Response to a Minimum Wage Hike
Conditional on Being Employed in Year 1
Matched CPS, 2004-2009

	Specification 1:				Specification 2:			
	Wage Group1	Wage Group2	Wage Group3	Wage Group4	Wage Group1	Wage Group2	Wage Group3	Wage Group4
ΔMW Next Year	-0.02	-0.02	0.01	0.01	-0.02	-0.02	0.01	0.01
	(0.04)	(0.02)	(0.02)	(0.03)	(0.05)	(0.02)	(0.02)	(0.02)
ΔMW This Year	-0.02	0.04	0.00	0.03	-0.04	0.01	0.00	0.03
	(0.04)	(0.04)	(0.02)	(0.02)	(0.04)	(0.04)	(0.02)	(0.02)
ΔMW Last Year	0.00	-0.02	0.00	0.02	0.01	-0.01	0.01	0.02
	(0.04)	(0.03)	(0.02)	(0.03)	(0.04)	(0.02)	(0.02)	(0.03)
ΔMW Two Years Ago	-0.07	0.02	0.00	0.01	-0.07*	0.04	-0.01	0.02
	(0.04)	(0.03)	(0.04)	(0.03)	(0.04)	(0.05)	(0.03)	(0.04)
ΔMW Next Year x High RoutineSh					0.00	-0.01	0.01	0.00
					(0.07)	(0.07)	(0.03)	(0.05)
ΔMW This Year x High RoutineSh					0.11	0.16*	0.01	0.02
					(0.07)	(0.07)	(0.04)	(0.06)
ΔMW Last Year x High RoutineSh					-0.08	-0.04	-0.04	-0.02
					(0.10)	(0.10)	(0.06)	(0.07)
ΔMW 2Yrs Ago x High RoutineSh					0.04	-0.15*	0.05	-0.04
					(0.14)	(0.07)	(0.07)	(0.09)

Notes: See notes to Table 5. Sample is conditional only on being employed as an hourly worker in first year. $N = 169,714$ for both regression models. * p<0.05 and ** p<0.01.

Table 8: Change in Log Wages in Response to a Minimum Wage Hike

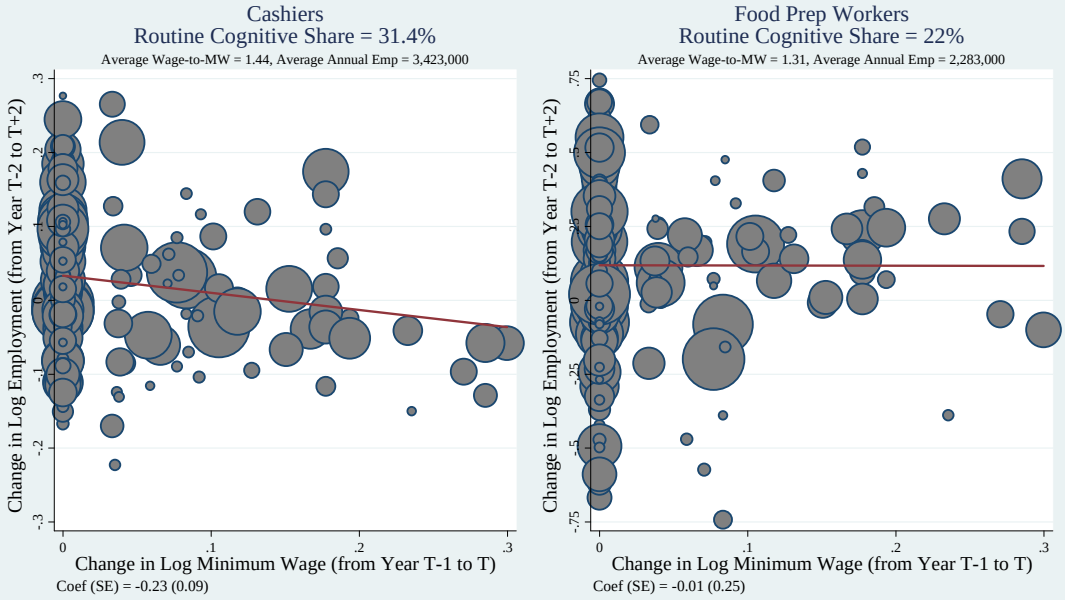
All Employed Workers vs. Those Employed in High Routine Cognitive Job
Matched CPS, 2004-2009

	Specification 1: All Observations				Specification 2: All Observations				Specification 3: Occupation Switchers Only			
	Wage Group1	Wage Group2	Wage Group3	Wage Group4	Wage Group1	Wage Group2	Wage Group3	Wage Group4	Wage Group1	Wage Group2	Wage Group3	Wage Group4
ΔMW Next Year	0.13**	0.03	0.01	-0.06	0.13**	0.03	0.00	-0.06	0.11*	0.04	0.00	-0.06
	(0.03)	(0.02)	(0.02)	(0.04)	(0.04)	(0.02)	(0.02)	(0.04)	(0.05)	(0.03)	(0.03)	(0.05)
ΔMW This Year	0.19**	0.03	0.00	0.01	0.18**	0.03	0.02	-0.02	0.21**	-0.01	0.03	-0.07
	(0.03)	(0.02)	(0.03)	(0.02)	(0.04)	(0.02)	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)	(0.05)
ΔMW Last Year	0.24**	0.04*	0.01	-0.02	0.27**	0.05*	0.00	-0.02	0.27**	0.04	0.00	-0.04
	(0.04)	(0.02)	(0.02)	(0.05)	(0.04)	(0.02)	(0.02)	(0.05)	(0.04)	(0.03)	(0.02)	(0.07)
ΔMW Two Years Ago	0.16**	0.07*	0.02	-0.02	0.19**	0.07	0.01	0.00	0.22**	0.08	0.00	-0.07
					(0.02)	(0.04)	(0.03)	(0.05)	(0.03)	(0.06)	(0.04)	(0.08)
ΔMW Next Year x High RoutineSh					0.00	-0.01	0.03	0.01	-0.05	-0.04	0.04	0.04
					(0.07)	(0.04)	(0.03)	(0.08)	(0.10)	(0.06)	(0.03)	(0.11)
ΔMW This Year x High RoutineSh					0.03	0.02	-0.10**	0.18	0.03	0.09	-0.11*	0.20
					(0.08)	(0.05)	(0.03)	(0.11)	(0.10)	(0.06)	(0.05)	(0.14)
ΔMW Last Year x High RoutineSh					-0.17*	-0.05	0.08*	0.02	-0.24*	-0.02	0.05	-0.03
					(0.06)	(0.05)	(0.03)	(0.09)	(0.09)	(0.09)	(0.04)	(0.14)
ΔMW 2Yrs Ago x High RoutineSh					-0.17**	-0.03	0.09*	-0.11	-0.15	0.07	0.15**	0.09
					(0.05)	(0.08)	(0.04)	(0.12)	(0.08)	(0.09)	(0.05)	(0.15)

Notes: See notes to Table 5. Specification 1 and 2 ($N = 98,467$) include both job stayers and switchers. Specification 3 ($N = 46,713$) is restricted to job switchers. The sample size of job switchers in Specification 3 differs slightly from the sample size in Table 5 because (unlike the expressions in Table 5) these expressions do not require task information in year 2. * p<0.05 and ** p<0.01.

Figure 1: Employment Effect of a Minimum Wage Hike

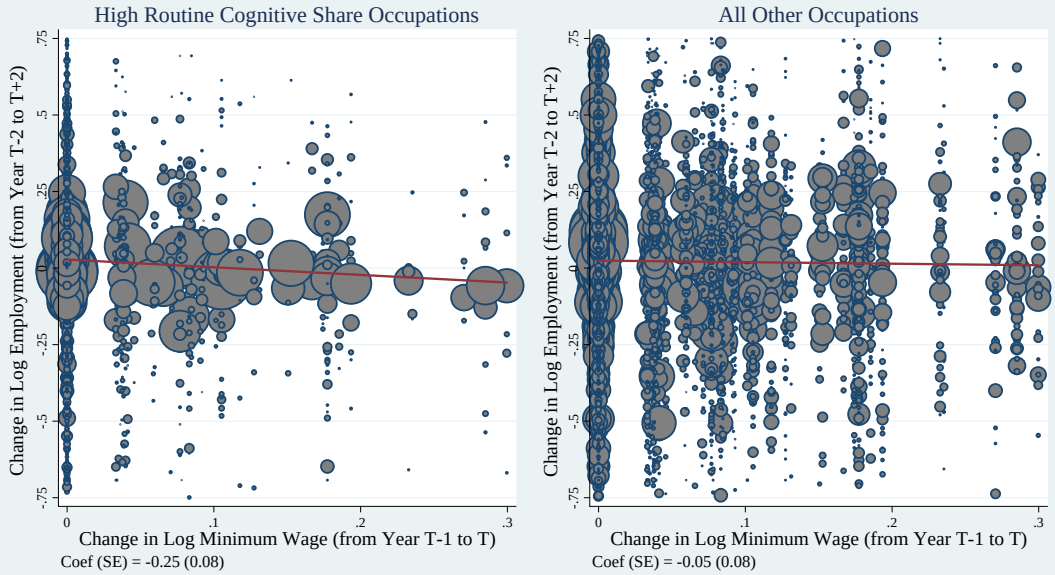
Cashiers versus Food Prep Workers



Note: An observation is a state-year, covering 1999-2009. Food prep workers include fast food workers. Minimum wage hikes less than 0.03 log points are excluded.

Figure 2: Employment Effect of a Minimum Wage Hike

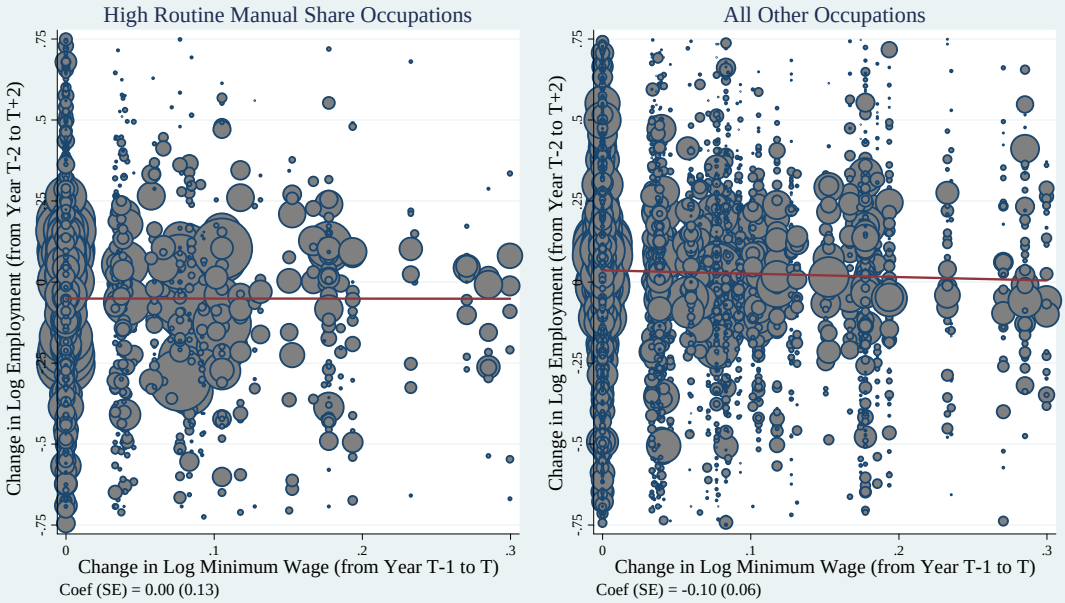
High Routine Cognitive Occupations vs. All Other Occupations in Wage Group 1



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 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.

Table A2: Alternate Employment Estimates by the Routine Intensity of an Occupation

Specification Includes Occupation x Year Fixed Effects
Routine Intensity = Routine Cognitive Share of Tasks
Occupation Employment Statistics, 2003-2009

	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
ΔMW Next Year	0.02	0.06	0.06	-0.02	0.01	0.05	0.08	-0.02				
	(0.04)	(0.04)	(0.05)	(0.03)	(0.05)	(0.04)	(0.06)	(0.03)				
ΔMW This Year	0.04	0.02	0.04	-0.03	0.04	0.03	0.07	-0.03				
	(0.05)	(0.05)	(0.05)	(0.03)	(0.05)	(0.05)	(0.06)	(0.03)				
ΔMW Last Year	0.06	0.04	0.07	-0.01	0.07	0.05	0.11	0.00				
	(0.07)	(0.06)	(0.06)	(0.04)	(0.07)	(0.06)	(0.06)	(0.04)				
ΔMW 2Yrs Ago	0.17*	0.02	0.06	0.01	0.18*	0.04	0.09	0.01				
	(0.08)	(0.07)	(0.08)	(0.07)	(0.08)	(0.07)	(0.06)	(0.07)				
ΔMW Next Year X RoutineSh					0.05	0.01	-0.08	-0.01	0.06	0.02	-0.07	-0.01
					(0.03)	(0.02)	(0.04)	(0.03)	(0.03)	(0.02)	(0.04)	(0.03)
ΔMW This Year X RoutineSh					-0.01	-0.03	-0.08*	0.01	0.00	-0.03	-0.08*	0.00
					(0.05)	(0.02)	(0.03)	(0.03)	(0.05)	(0.02)	(0.03)	(0.03)
ΔMW Last Year X RoutineSh					-0.04	-0.06*	-0.11**	0.01	-0.03	-0.06*	-0.09*	0.01
					(0.04)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)
ΔMW 2Yrs Ago X RoutineSh					-0.06	-0.07*	-0.06	0.00	-0.03	-0.08*	-0.05	0.00
					(0.06)	(0.03)	(0.07)	(0.06)	(0.05)	(0.04)	(0.07)	(0.06)
Combined Effects												
ΔMW Last Year x RoutineSh − ΔMW Next Year x RoutineSh					-0.09*	-0.07**	-0.03	0.02	-0.09*	-0.08**	-0.02	0.02
					(0.05)	(0.02)	(0.06)	(0.03)	(0.04)	(0.02)	(0.05)	(0.03)
ΔMW 2Yrs Ago x RoutineSh − ΔMW Next Year x RoutineSh					-0.11	-0.08*	0.02	0.01	-0.09	-0.10*	0.02	0.01
					(0.06)	(0.04)	(0.10)	(0.07)	(0.06)	(0.04)	(0.09)	(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 A3: Alternative Employment Estimates by the Routine Intensity of an Occupation

No Employment Restrictions
Routine Intensity = Routine Cognitive Share of Tasks
Occupation Employment Statistics, 2003-2009

	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
ΔMW Next Year	0.01	0.04	0.07*	-0.01	0.01	0.04	0.09	0.00				
	(0.04)	(0.04)	(0.04)	(0.02)	(0.04)	(0.04)	(0.05)	(0.02)				
ΔMW This Year	0.01	-0.02	0.06	0.01	0.02	-0.02	0.09	0.02				
	(0.04)	(0.05)	(0.05)	(0.03)	(0.04)	(0.05)	(0.06)	(0.04)				
ΔMW Last Year	0.02	0.00	0.06	0.06	0.03	0.02	0.09	0.06				
	(0.06)	(0.05)	(0.06)	(0.04)	(0.06)	(0.04)	(0.05)	(0.04)				
ΔMW 2Yrs Ago	0.05	-0.02	0.08	0.13	0.08	0.01	0.12	0.14				
	(0.08)	(0.05)	(0.08)	(0.08)	(0.08)	(0.05)	(0.07)	(0.08)				
ΔMW Next Year x RoutineSh					0.02	0.02	-0.08	-0.01	0.02	0.01	-0.05	-0.01
					(0.03)	(0.05)	(0.04)	(0.04)	(0.03)	(0.05)	(0.04)	(0.04)
ΔMW This Year x RoutineSh					-0.03	-0.03	-0.12**	0.00	-0.02	-0.05	-0.09*	-0.01
					(0.05)	(0.05)	(0.04)	(0.04)	(0.05)	(0.05)	(0.04)	(0.04)
ΔMW Last Year x RoutineSh					-0.08	-0.09	-0.12*	-0.01	-0.08	-0.10*	-0.08	0.00
					(0.05)	(0.05)	(0.06)	(0.04)	(0.04)	(0.05)	(0.05)	(0.04)
ΔMW 2Yrs Ago x RoutineSh					-0.17**	-0.15*	-0.12	-0.02	-0.17**	-0.18**	-0.09	-0.02
					(0.06)	(0.06)	(0.06)	(0.05)	(0.06)	(0.06)	(0.05)	(0.04)
State FE and Year FE	Yes				Yes				No			
State x Year FE	No				No				Yes			

Notes: See notes to Table 2. $N = 131,315$ for all three specifications. * p<0.05 and ** p<0.01.

Table A4: Summary of Occupations by Routine Intensity
Wage Group 2: 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 of Occupation
Medical Transcriptionists	2.46	91,195	0.41	0.18	95
Order Clerks	2.26	283,753	0.35	0.11	67
Billing And Posting Clerks And Machine Operators	2.38	498,805	0.35	0.10	90
Medical Secretaries	2.27	368,561	0.34	0.11	0
Coil Winders, Tapers, And Finishers	2.19	28,652	0.33	0.20	68
Gaming Cage Workers	1.98	14,910	0.33	0.14	0
Foundry Mold And Coremakers	2.45	17,395	0.33	0.21	65
Painting, Coating, And Decorating Workers	2.02	29,292	0.33	0.22	68
Cutters And Trimmers, Hand	2.03	27,408	0.33	0.24	69
Counter And Rental Clerks	1.79	441,563	0.32	0.09	0
Security Guards	1.86	1,012,655	0.32	0.05	0
Tellers	1.82	560,091	0.32	0.12	0
Gaming Change Persons And Booth Cashiers	1.78	24,878	0.32	0.11	0
Interviewers, Except Eligibility And Loan	2.12	192,897	0.31	0.11	48
Office Clerks, General	2.03	2,987	0.31	0.09	38
Office Clerks, General	2.03	7,404	0.31	0.09	94
Office Clerks, General	2.03	2,873,783	0.31	0.09	70
Telemarketers	1.95	379,277	0.31	0.11	95
Customer Service Representatives	2.44	5,785	0.30	0.10	38
Customer Service Representatives	2.44	2,027,936	0.30	0.10	94
Customer Service Representatives	2.44	2,600	0.30	0.10	70
Reservation And Transportation Ticket Agents	2.46	146,788	0.30	0.12	94
Switchboard Operators, Including Answering Service	1.92	194,791	0.30	0.12	50
New Accounts Clerks	2.34	90,169	0.30	0.06	0
Pharmacy Technicians	2.09	257,784	0.30	0.11	32
Models	2.29	949	0.30	0.06	0
Shoe And Leather Workers And Repairers	1.76	6,786	0.30	0.19	75
Word Processors And Typists	2.42	169,549	0.30	0.07	94
Shoe Machine Operators And Tenders	1.78	2,785	0.29	0.21	75
Fabric Menders, Except Garment	2.41	1,075	0.29	0.15	0
Weighers, Measurers, And Checkers Recordkeeping	2.28	76,338	0.29	0.09	27
Medical Records And Health Information Technicians	2.36	155,438	0.29	0.10	83
Gaming Surveillance Officers And Gaming Investigators	2.26	7,688	0.29	0.12	0
Parts Salespersons	2.37	233,422	0.29	0.07	0
Parking Enforcement Workers	2.44	8,891	0.29	0.09	0
Forming, Pressing, And Compacting Machine Setters	2.45	77,555	0.28	0.22	68
Semiconductor Processors	2.47	28,129	0.28	0.18	70
Data Entry Keyers	2.05	328,762	0.28	0.12	100
Mail Clerks And Mail Machine Operators	1.97	148,296	0.28	0.20	26
Secretaries, Except Legal, Medical, And Executive	2.30	1,776	0.27	0.11	69
Secretaries, Except Legal, Medical, And Executive	2.30	1,784,789	0.27	0.11	38
Proofreaders And Copy Markers	2.34	18,333	0.27	0.08	95
Bill And Account Collectors	2.46	411,179	0.27	0.10	65
Receptionists And Information Clerks	1.91	1,073,952	0.27	0.09	75
Cutting, Punching, And Press Machine Setters	2.30	267,399	0.27	0.23	68
Cleaning And Metal Pickling Equipment Operators	2.09	16,814	0.27	0.16	68
Truck Drivers, Light Or Delivery Services	2.28	943,020	0.27	0.14	0
Slaughterers And Meat Packers	1.87	106,404	0.27	0.21	0
Bindery Workers	2.18	74,012	0.27	0.25	59
Textile Knitting And Weaving Machine Setters	2.09	42,924	0.27	0.23	75
Team Assemblers	2.19	1,176,191	0.27	0.20	65
Correspondence Clerks	2.42	20,901	0.26	0.14	77
Photographic Process Workers	2.05	22,955	0.26	0.18	34
Rehabilitation Counselors	2.50	109,449	0.26	0.05	0
Electrical And Electronic Equipment Assemblers	2.16	243,014	0.26	0.17	66
Laborers And Freight, Stock, And Material Movers, Hand	1.88	2,264,763	0.26	0.17	0
Ophthalmic Laboratory Technicians	2.13	28,160	0.26	0.21	34
Library Technicians	2.21	106,492	0.26	0.10	33
Veterinary Technologists And Technicians	2.17	63,125	0.26	0.10	0
Cooling And Freezing Equipment Operators	2.09	7,602	0.26	0.17	68
Food, Tobacco Roasting And Drying Machine Operators	2.18	16,890	0.26	0.21	0

Table A4 (Continued): Summary of Occupations by Routine Intensity

Wage Group 2: 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 of Occupation
Farm Labor Contractors	1.84	2,526	0.26	0.08	0
Medical Equipment Preparers	2.11	39,203	0.26	0.19	0
Stock Clerks And Order Fillers	1.82	1,708,535	0.26	0.15	34
Library Assistants, Clerical	1.81	106,978	0.26	0.10	0
Food Batchmakers	2.00	84,032	0.26	0.22	31
Slot Key Persons	2.11	12,436	0.26	0.12	0
Cutting And Slicing Machine Setters	2.37	75,201	0.26	0.20	68
Furniture Finishers	2.15	26,236	0.26	0.24	43
Costume Attendants	2.34	3,349	0.25	0.08	0
Medical Assistants	2.15	397,892	0.25	0.10	0
Upholsterers	2.36	38,809	0.25	0.17	57
Cabinetmakers And Bench Carpenters	2.28	122,850	0.25	0.21	57
Grinding, Lapping, Polishing Machine Tool Setters	2.44	99,344	0.25	0.21	68
Photographic Processing Machine Operators	1.76	48,801	0.25	0.21	48
Rock Splitters, Quarry	2.47	2,360	0.25	0.18	36
Baggage Porters And Bellhops	1.77	49,059	0.25	0.12	0
Couriers And Messengers	1.82	108,970	0.25	0.10	0
Helpers–Painters,Plasterers, And Stucco Masons	1.85	23,823	0.25	0.18	0
Travel Agents	2.44	95,318	0.25	0.07	50
Shipping, Receiving, And Traffic Clerks	2.18	768,290	0.25	0.11	29
Electromechanical Equipment Assemblers	2.27	57,183	0.25	0.18	66
Coating, Painting, And Spraying Machine Setters	2.34	97,651	0.25	0.21	68
Office Machine Operators, Except Computer	2.06	84,972	0.25	0.18	51
Bus Drivers, School	2.02	461,321	0.24	0.12	0
File Clerks	1.87	231,276	0.24	0.11	50
Industrial Truck And Tractor Operators	2.39	609,577	0.24	0.17	0
Butchers And Meat Cutters	2.30	129,775	0.24	0.19	0
Dancers	2.31	11,287	0.24	0.10	0
Conveyor Operators And Tenders	2.28	48,473	0.24	0.17	0
Packaging And Filling Machine Operators And Tenders	2.05	378,422	0.24	0.22	68
Construction Laborers	2.42	901,742	0.24	0.17	0
Refuse And Recyclable Material Collectors	2.38	125,711	0.24	0.21	0
Helpers–Pipelayers, Plumbers,	2.10	78,195	0.24	0.13	0
Food Cooking Machine Operators And Tenders	1.93	36,690	0.24	0.20	27
Machine Feeders And Offbearers	2.02	152,951	0.23	0.23	0
Occupational Therapist Aides	2.20	6,671	0.23	0.09	0
Helpers–Production Workers	1.82	491,202	0.23	0.18	70
Dental Assistants	2.43	274,097	0.23	0.14	0
Molders, Shapers, And Casters	2.22	35,895	0.23	0.19	69
Woodworking Machine Setters, Operators, And Tenders	2.04	90,606	0.23	0.24	57
Dietetic Technicians	2.09	25,646	0.23	0.15	0
Textile Bleaching And Dyeing Machine Operators	1.91	21,492	0.23	0.20	75
Sawing Machine Setters, Operators, And Tenders	2.06	53,840	0.23	0.22	57
Plating And Coating Machine Setters, Operators	2.32	41,487	0.23	0.24	70
Nursing Aides, Orderlies, And Attendants	1.83	1,364,803	0.23	0.13	0
Janitors And Cleaners	1.75	2,089,574	0.22	0.18	0
Extruding And Drawing Machine Setters	2.39	94,246	0.22	0.23	68
Helpers–Carpenters	1.99	94,044	0.22	0.19	0
Textile Winding And Drawing Out Machine Setters	2.06	51,036	0.22	0.22	75
Craft Artists	2.29	2,326	0.22	0.15	0
Retail Salespersons	1.89	4,168,383	0.22	0.07	0
Cementing And Gluing Machine Operators	2.18	23,679	0.22	0.22	68
Tire Repairers And Changers	1.87	91,742	0.22	0.18	0
Helpers–Roofers	1.87	20,462	0.22	0.13	0
Model Makers, Wood	2.45	2,117	0.22	0.13	60
Funeral Attendants	1.77	29,871	0.22	0.05	0
Grinding And Polishing Workers, Hand	2.13	42,528	0.22	0.20	68
Molding, Coremaking, And Casting Machine Setters	2.24	147,855	0.22	0.24	68

Table A4 (Continued): Summary of Occupations by Routine Intensity

Wage Group 2: 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 of Occupation
Psychiatric Technicians	2.30	46,906	0.22	0.03	0
Physical Therapist Aides	1.89	40,193	0.21	0.12	0
Emergency Medical Technicians And Paramedics	2.36	189,648	0.21	0.09	0
Psychiatric Aides	2.03	52,535	0.21	0.03	0
Concierges	2.02	17,143	0.21	0.07	0
Pesticide Handlers, Sprayers, And Applicators	2.33	22,739	0.21	0.17	0
Tailors, Dressmakers, And Custom Sewers	2.05	29,010	0.21	0.17	0
Roustabouts, Oil And Gas	2.39	39,596	0.21	0.15	36
Helpers–Installation And Repair Workers	2.01	150,542	0.21	0.16	0
Animal Control Workers	2.35	12,566	0.20	0.05	0
Textile Cutting Machine Setters	1.87	25,757	0.20	0.22	75
Ambulance Drivers And Attendants, Except EMTs	1.76	17,398	0.20	0.06	0
Helpers–Brickmasons, Blockmasons, Stonemasons	2.30	56,598	0.20	0.20	0
Crushing, Grinding, And Polishing Machine Setters	2.46	42,210	0.20	0.19	68
Coin, Vending, And Amusement Machine Servicers	2.44	37,079	0.20	0.14	0
Helpers–Electricians	2.12	98,684	0.20	0.15	0
Tree Trimmers And Pruners	2.36	32,020	0.20	0.16	0
Timing Device Assemblers, Adjusters, And Calibrators	2.37	2,730	0.20	0.11	62
Fishers And Related Fishing Workers	2.22	134	0.20	0.24	0
Taxi Drivers And Chauffeurs	1.76	143,559	0.20	0.08	0
First-Line Supervisors Of Food Preparation Workers	2.32	723,356	0.19	0.14	0
Merchandise Displayers And Window Trimmers	2.13	57,439	0.19	0.10	0
Fiberglass Laminators And Fabricators	2.22	30,287	0.19	0.18	68
Driver/Sales Workers	2.02	379,902	0.19	0.13	0
Etchers And Engravers	2.20	8,877	0.19	0.22	68
Demonstrators And Product Promoters	2.12	87,584	0.18	0.05	0
Skin Care Specialists	2.26	19,465	0.18	0.12	0
Hairdressers, Hairstylists, And Cosmetologists	1.95	337,629	0.17	0.12	0
Forest And Conservation Workers	1.91	6,942	0.17	0.15	0
Social And Human Service Assistants	2.17	304,757	0.17	0.03	0
Fence Erectors	2.15	19,008	0.17	0.17	0
Animal Breeders	2.48	899	0.16	0.09	0
Bakers	1.89	148,352	0.16	0.14	0
Barbers	1.96	8,771	0.16	0.15	0
Pest Control Workers	2.32	58,172	0.16	0.08	0
Tour Guides And Escorts	1.79	28,231	0.16	0.01	0
Electronic Equipment Installers, Motor Vehicles	2.36	14,636	0.16	0.10	0
Outdoor Power Equipment And Small Engine Mechanics	2.29	25,344	0.15	0.14	0
Logging Equipment Operators	2.46	27,357	0.15	0.26	0
Manufactured Building And Mobile Home Installers	2.18	8,613	0.14	0.16	0
Cooks, Private Household	2.32	162	0.14	0.14	0
Floral Designers	1.84	63,406	0.14	0.12	0
Preschool Teachers, Except Special Education	1.95	364,146	0.14	0.07	0
Landscaping And Groundskeeping Workers	1.84	853,503	0.13	0.23	0
Recreation Workers	1.79	265,064	0.12	0.05	0
Residential Advisors	1.98	47,561	0.12	0.01	0
Animal Trainers	2.27	6,927	0.04	0.11	0
Door-To-Door Sales Workers And Related Workers	2.47	15,706	0.00	0.01	0

Notes: The wage and employment data are from the Occupation Employment Statistics. The average wage-to-minimum wage is the 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 A5: Alternative Employment and Wage Estimates

Use Contemporaneous (Rather than Twice Lagged) Minimum Wage to Compute Wage Group Effects at Occupations with High Routine Cognitive Task Content
Matched CPS, 2004-2009

	Employed in High Routine Cognitive Occ?	Change in Routine Task Content	Employed?	Wage Effect on All Workers
Wage Group 1				
ΔMW Next Year x High RoutineSh	-0.32	-0.84*	0.00	-0.01
	(0.19)	(0.40)	(0.07)	(0.07)
ΔMW This Year x High RoutineSh	-0.46*	-0.62	0.09	0.05
	(0.22)	(0.41)	(0.06)	(0.07)
ΔMW Last Year x High RoutineSh	-0.21	-0.80*	0.02	-0.18**
	(0.17)	(0.32)	(0.08)	(0.05)
ΔMW 2Yrs Ago x High RoutineSh	-0.13	-0.95*	-0.08	-0.10*
	(0.21)	(0.41)	(0.08)	(0.04)
Wage Group 2				
ΔMW Next Year x High RoutineSh	-0.03	-0.62	-0.01	-0.02
	(0.19)	(0.45)	(0.07)	(0.04)
ΔMW This Year x High RoutineSh	0.00	-0.22	0.17**	-0.02
	(0.21)	(0.46)	(0.06)	(0.05)
ΔMW Last Year x High RoutineSh	-0.05	-0.32	-0.13	0.11
	(0.17)	(0.41)	(0.08)	(0.05)
ΔMW 2Yrs Ago x High RoutineSh	0.26	-0.49	0.19*	0.00
	(0.22)	(0.53)	(0.08)	(0.08)
Wage Group 3				
ΔMW Next Year x High RoutineSh	-0.06	-0.16	0.02	0.04
	(0.11)	(0.28)	(0.03)	(0.03)
ΔMW This Year x High RoutineSh	-0.10	0.16	0.00	-0.08**
	(0.11)	(0.35)	(0.04)	(0.03)
ΔMW Last Year x High RoutineSh	-0.07	-0.24	0.00	0.00
	(0.21)	(0.46)	(0.07)	(0.03)
ΔMW 2Yrs Ago x High RoutineSh	0.29	1.00**	-0.02	0.05
	(0.26)	(0.31)	(0.08)	(0.04)
Wage Group 4				
ΔMW Next Year x High RoutineSh	0.34	-0.11	-0.03	-0.06
	(0.31)	(0.68)	(0.07)	(0.08)
ΔMW This Year x High RoutineSh	-0.84	-0.28	0.07	0.09
	(0.46)	(0.94)	(0.08)	(0.11)
ΔMW Last Year x High RoutineSh	-0.69	-1.69	0.08	0.02
	(0.61)	(1.49)	(0.12)	(0.08)
ΔMW 2Yrs Ago x High RoutineSh	-0.60	-1.03	-0.07	-0.03
	(0.54)	(1.09)	(0.21)	(0.14)
N	46,010	46,010	170,703	98,971

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 ** $p<0.01$.

Table A6: Alternative Employment and Wage Estimates
No Wage-based Sample Exclusions
Effects at Occupations with High Routine Cognitive Task Content
Matched CPS, 2004-2009

	Employed in High Routine Cognitive Occ?	Change in Routine Task Content	Wage Effect: All Workers	Wage Effect: Occupation Switchers
Wage Group 1				
ΔMW Next Year x High RoutineSh	-0.27	-0.66	0.08	-0.04
	(0.18)	(0.39)	(0.10)	(0.13)
ΔMW This Year x High RoutineSh	-0.20	-0.17	-0.03	-0.18
	(0.24)	(0.40)	(0.11)	(0.10)
ΔMW Last Year x High RoutineSh	-0.15	-0.53	-0.29*	-0.26
	(0.19)	(0.55)	(0.12)	(0.19)
ΔMW 2Yrs Ago x High RoutineSh	-0.37	-1.59**	-0.04	0.16
	(0.28)	(0.54)	(0.15)	(0.16)
Wage Group 2				
ΔMW Next Year x High RoutineSh	-0.04	-0.44	0.04	0.09
	(0.19)	(0.42)	(0.08)	(0.11)
ΔMW This Year x High RoutineSh	-0.40	-0.85*	0.01	0.10
	(0.22)	(0.39)	(0.11)	(0.12)
ΔMW Last Year x High RoutineSh	-0.35	-1.32*	-0.05	-0.01
	(0.28)	(0.56)	(0.12)	(0.19)
ΔMW 2Yrs Ago x High RoutineSh	0.06	-0.64	-0.14	-0.17
	(0.30)	(0.53)	(0.19)	(0.23)
Wage Group 3				
ΔMW Next Year x High RoutineSh	0.03	0.01	0.04	0.05
	(0.11)	(0.26)	(0.08)	(0.08)
ΔMW This Year x High RoutineSh	0.02	0.42	-0.08	-0.16*
	(0.10)	(0.29)	(0.05)	(0.07)
ΔMW Last Year x High RoutineSh	-0.05	-0.10	-0.07	-0.25*
	(0.16)	(0.37)	(0.06)	(0.10)
ΔMW 2Yrs Ago x High RoutineSh	0.25	0.42	-0.03	-0.03
	(0.18)	(0.34)	(0.10)	(0.12)
Wage Group 4				
ΔMW Next Year x High RoutineSh	0.20	0.11	-0.07	-0.08
	(0.23)	(0.52)	(0.12)	(0.19)
ΔMW This Year x High RoutineSh	-0.50	-0.49	-0.22	0.07
	(0.26)	(0.63)	(0.14)	(0.31)
ΔMW Last Year x High RoutineSh	-0.47	-0.21	-0.03	0.04
	(0.30)	(0.67)	(0.14)	(0.27)
ΔMW 2Yrs Ago x High RoutineSh	0.22	1.12	0.04	0.11
	(0.52)	(1.07)	(0.24)	(0.35)
N	58,519	58,519	121,346	58,519

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.

Table A7: Alternative Employment and Wage Estimates
High Routine Share = High Routine Manual Share
Matched CPS, 2004-2009

	Specification 1: Employed in Year 2?				Specification 2: Wage Effects, All Observations			
	Wage Group1	**Wage Group2**	**Wage Group3**	**Wage Group4**	**Wage Group1**	**Wage Group2**	**Wage Group3**	**Wage Group4**
ΔMW Next Year	-0.03	-0.03	0.00	0.02	0.13**	0.03	0.00	-0.05
	(0.05)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.02)	(0.04)
ΔMW This Year	-0.05	0.05	0.01	0.03	0.19**	0.02	-0.01	-0.01
	(0.04)	(0.05)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)
ΔMW Last Year	-0.01	-0.04	0.00	0.05	0.22**	0.03	0.01	-0.03
	(0.04)	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.05)
ΔMW Two Years Ago	-0.04	0.02	0.00	-0.02	0.15**	0.07*	0.04	-0.03
	(0.05)	(0.05)	(0.03)	(0.04)	(0.02)	(0.03)	(0.03)	(0.04)
ΔMW Next Year x High RoutineSh	0.03	0.07	0.03	-0.04	-0.01	0.02	0.03	0.00
	(0.09)	(0.05)	(0.03)	(0.07)	(0.05)	(0.04)	(0.03)	(0.05)
ΔMW This Year x High RoutineSh	0.27**	-0.09	-0.07	0.02	0.02	0.13*	0.04	0.11*
	(0.08)	(0.10)	(0.04)	(0.07)	(0.07)	(0.05)	(0.04)	(0.05)
ΔMW Last Year x High RoutineSh	0.09	0.16	0.01	-0.14	0.09	0.05	0.00	0.05
	(0.13)	(0.08)	(0.04)	(0.08)	(0.07)	(0.07)	(0.05)	(0.09)
ΔMW 2Yrs Ago x High RoutineSh	-0.20	0.00	0.00	0.15	0.10	0.00	-0.05	0.04
	(0.18)	(0.11)	(0.06)	(0.10)	(0.08)	(0.08)	(0.06)	(0.12)

Notes: See notes to Table 5. The non-interacted change in the minimum wage variables are not shown. $N = 169,714$ for Specification 1 and $N = 98,467$ for Specification 2. * p<0.05 and ** p<0.01.