Product Market Evidence on the Employment Effects of the Minimum Wage

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Abstract

We calibrate a model of labor demand to infer the employment response to a change in the minimum wage in the food away from home industry. Assuming a perfectly competitive labor market, the model predicts a 2.5 to 3.5 percent fall in employment in response to a 10 percent minimum wage change. We then introduce monopsony power in local labor markets. We identify the extent of monopsony power using information on the degree to which minimum wage cost shocks are passed on to consumers in the form of higher prices. Whereas the competitive model implies that employment falls and prices rise in response to an increase in the minimum wage, the monopsony model potentially implies that employment can rise and prices fall in response to an increase in the minimum wage. Previous research shows that prices rise in response to an increase in the minimum wage. We show that this price response is consistent with the prediction of the competitive model. Calibrating the full model, we can place fairly tight bounds on the elasticity of demand for labor with the most plausible parameter values suggesting a 2 to 3 percent loss in employment in reaction to a 10 percent increase in the minimum wage.

1 Introduction

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Until the early 1990s, the consensus was that an increase in the minimum wage causes a small but statistically and economically significant loss in jobs (e.g. Brown, Gilroy, and Kohen (1982)). While it was known that this need not be the case (Lester (1946)), particularly if firms have wage-setting power (Stigler (1946)), the empirical results confirmed the qualitative predictions of standard models of perfect competition, which most researchers suspected were relevant for industries which primarily employed minimum wage workers.

However, Card and Krueger's work in the early 1990s spawned a contentious debate over the magnitude, and perhaps even the sign, of this fundamental parameter. In a series of papers, they find no employment reaction or, in some cases, a small positive employment response to an increase in the minimum wage.[1] Moreover, they discuss a number of other facts that they argue are inconsistent with competitive markets but consistent with monopsony power, including a spike in the distribution of wages at the minimum and the prevalence of posted vacancies. Models that introduce labor market search with frictions[2], efficiency wages[3], or monopsonistic competition with free entry[4] generate monopsony-like behavior that could potentially explain these findings.

This line of research has not gone unchallenged, as exemplified by the discussions in Card and Krueger (2000) and Neumark and Wascher (2000). The latter authors, again in a series of papers (e.g. Neumark and Wascher (1996) for a review), consistently find an effect more in line with the Brown et al. literature review; a 10 percent increase in the minimum wage leads to roughly a 2 percent decrease in teen employment.[5] Others, including Deere et al. (1995), Kim and Taylor (1995), and Burkhauser et al. (2000), find even larger negative effects, on the order of 2 to 6 percent. This confusion is particularly acute since the majority of these papers use the same sources of variation to identify the employment elasticity (albeit often from different time periods or geographic areas): either the cross-sectional or time series co-movement of teenage employment and the minimum wage.

[1] See Card and Krueger (1995) for a review. A sampling of other papers that corroborate these findings include Wellington (1991), Machin and Manning (1996, 1997), and Dickens et al (1999). See Neumark and Wascher (2003) for an exhaustive list of international studies, many of which find no employment response.

[2] Burdett and Mortenson (1998).

[3] Rebitzer and Taylor (1995) and Manning (1995).

[4] Bhaskar and To (1999).

[5] These results are consistent with views reported in a survey of leading labor economists (Fuchs, Krueger, and Poterba 1998). However, even though the survey occurred shortly after the release of much of Card and Krueger's work, a full quarter of respondents believe there is no teenage disemployment effect from a 10 percent increase in the minimum wage. Another quarter judge the response to be 3 percent or higher.

These papers claim to be testing the market structure of low wage labor markets without explicitly showing what the competitive and monopsonistic models imply. In this paper, we show the employment and price responses implied by the two models. In particular, we calibrate a computational model of labor demand to infer the employment response to a change in the minimum wage in the restaurant industry.

We initially compute this elasticity assuming all firms are price-takers in both the input and output markets.[6] The model uses several pieces of information, including factor costs, the intensity of usage of low-wage workers, the elasticity of substitution between labor, materials, and capital, and the elasticity of demand. Our model predicts employment elasticities well within the bounds set by most empirical work, with the disemployment impact of a 10 percent increase in the minimum wage ranging from 2.5 to 3.5 percent. We also show that a second implication of perfect competition is that higher labor costs are pushed onto consumers in the form of higher prices.

Next, we augment the model so employers potentially have monopsony power in the labor market. Under monopsony, employment potentially rises in response to an increase in the minimum wage. An implication is that when employment rises, output also rises and thus output prices fall. Therefore, the employment and output price responses to changes in the minimum wage differ between the competitive and monopsony models.

We use the models' output price implications to test for the potential importance of monopsony behavior in the labor market. This test relies on research that shows that most of the higher labor costs incurred by employers are pushed onto consumers in the form of higher prices, a finding that is in sharp contrast to the prediction of monopsony models.[7] Consequently, we infer that few restaurants will increase employment in response to a minimum wage increase. Using the most plausible range of estimates for the model's key parameters, we find that the employment response to a 10 percent change in the minimum wage is likely between 2 and 3 percent, encapsulating many of the estimates in the literature. All of these predictions are robust to allowing for imperfect competition in the product market.

It is important to emphasize that our estimates are for the restaurant industry only. Nevertheless, this industry is a major employer of low-wage labor and therefore a particularly

[6] We assume that the minimum wage affects wages and the price of the output good but does not affect the price of other inputs.

[7] Section 4 describes this research, which includes Card and Krueger (1995), Lee and O'Roarke (1999), Aaronson (2001), and Aaronson, French, and MacDonald (2003).

relevant one to study.[8] However, as a result of different intensity of use of minimum wage labor, substitution possibilities, market structure, or demand for their products, other industries might face distinct employment responses. For example, empirical evidence suggests that demand for food at home is significantly more inelastic than food away from home.[9] Consequently, our results are consistent with a smaller employment response for at home consumption (i.e. retail grocery stores, the second largest employer of minimum wage workers) than for food away from home consumption.

The next section describes the basic framework of our study. The details of the computational techniques used to calibrate the model and an analytical solution for the more common two input case are reserved for the appendices. In this section, we also introduce monopsonistic behavior to the model and show how to use price pass-through to estimate the extent of monopsony power. Section 3 provides details on the main parameters used in the model. Finally, in sections 4 and 5, the results of the calibrated model are described and some concluding comments are offered.

2 The Model

This section outlines the structure of the model and the assumptions used to identify the employment response to a minimum wage change. We begin with the perfect competition case and then introduce monopsony power, offering some intuition for the ambiguous impact it has on employment. Finally, we provide a framework for bounding the importance of monopsony power in the labor market, using primarily the output price response to minimum wage changes.

[8] Prominent examples of studies that concentrate on the restaurant industry include Katz and Krueger (1992), Card and Krueger (1995, 2000) and Neumark and Wascher (2000). Eating and drinking places (SIC 641) is the largest employer of workers at or near the minimum, accounting for roughly a fifth of such employees in 1994 and 1995. The next largest employer, retail grocery stores, employs less than 7 percent of minimum or near minimum wage workers. Moreover, the intensity of use of minimum wage workers in the eating and drinking industry is amongst the highest of all sectors, with approximately 23 of all workers, encompassing 11 percent of the industry wage bill, within 10 percent of the minimum wage. All calculations are based on the Current Population Survey's outgoing rotation groups.

[9] See, for example, Huang and Lin (2000), and Piggott (2003).

2.1 Model Set Up

Throughout this paper, we assume that a large number[10], N, of firms with identical production technologies are perfectly competitive in the output market, sell their products at a price p, and choose their inputs to maximize profits π :

$$\pi(K, L, M) = pQ - rK - wL - p_M M \tag{1}$$

where $Q = F(K, L, M)$. We assume that the production function depends upon a constant elasticity of substitution aggregator of labor L, capital K, and materials M, purchased at prices r, w, and p_M, respectively:

$$Q = ((1-\alpha)M^{\rho} + \alpha G^{\rho})^{\frac{1}{\rho}}, \tag{2}$$

where

$$G = ((1-\alpha_G)K^{\rho_G} + \alpha_G L^{\rho_G})^{\frac{1}{\rho_G}}, \tag{3}$$

$\sigma \equiv \frac{1}{1-\rho}$ is the partial elasticity of substitution between G and M in the production of Q, and $\sigma_G \equiv \frac{1}{1-\rho_G}$. Equations (2) and (3) are a special case of Sato's (1967) two level CES production function, which restricts the Allen partial elasticity of substitution between labor and materials to be equal to the elasticity of substitution between capital and materials, an assumption that appears to be consistent with the empirical literature described in Hamermesh (1993).[11] The market price is:

$$p = Z(\sum_{n=1}^{N} Q_n)^{-\frac{1}{\eta}} \tag{4}$$

where $\sum_{n=1}^{N} Q_n$ is market output and η is the elasticity of demand for the output good. For the case where output Q_n is differentiated, see Appendix D. We must solve for profit

[10] We do not allow for exit or entry, although we allow the size of businesses to change in response to wage changes.

[11] The partial elasticity of substitution between labor and materials is equal to the partial elasticity of substitution between capital and materials only when labor's share is equal to capital's share. Based on 10-K reports of restaurant companies, this appears to be the case for the restaurant industry.

maximizing quantities of K, L, M and the equilibrium price p for the output good computationally, as there is no simple analytic expressions for the equilibrium.[12] The model solution techniques are demonstrated in appendix A. Moreover, since we do not have good information on several key parameters, α, ρ, α_G, and ρ_G, we use labor's share and material's share to recover α and α_G and show how to use the elasticity of substitution between labor and both capital and materials to recover ρ and ρ_G. Again, appendix A describes the details.

Our interest in this paper is solving for the employment response to a minimum wage change. Equilibrium quantities of inputs and the output price depend on, among other factors, the wage. Therefore, we can obtain the object $\frac{d \ln L}{d \ln w}$ by changing the wage one percent and re-solving the model while holding $\{\alpha, \alpha_G, \rho, \rho_G\}$ at their previous values.

Finally, in the short-run, firms cannot adjust their capital stock due to adjustment costs and the irreversibility of investments.[13] To capture this detail, we fix K at its initial level (i.e., the solution to all equations of the model), increase the wage one percent, and re-solve the model, letting L, M, and p adjust.[14] We define

$$\lambda_{comp} \equiv -\frac{d \ln L}{d \ln w_{min}}\bigg|_K \tag{5}$$

to be the elasticity of employment with respect to a change in the minimum wage, holding K constant. We also provide values of λ that introduce the elasticity of substitution between labor and capital, thus allowing capital to adjust to the minimum wage shock.

Two related special cases, derived in appendix C, have simple and familiar analytical solutions that are noteworthy. First, assume that capital can adjust and that $\alpha = 1$ (i.e.,

[12]The size of each firm is indeterminate under constant returns production functions. However, assuming infinitesimally decreasing returns to scale and an infinitesimally small fixed cost of running the firm preserves all the results, yet implicitly defines a firm's size. Therefore, we consider the firm size problem unimportant.

[13]This creates a conceptual problem because empirical work on the disemployment effect of the minimum wage typically focuses on annual changes to employment, comparing levels pre- and post- the new minimum wage. However, this short-run response likely abstracts from many adjustments to the capital-labor ratio that may arise over time in response to higher wage bills. For example, in the fast food industry over the last decade or so, cash registers have been modified so that the cashier need not know the price of a product, only its appearance. These machines also save time by directly transferring orders from the cash register to the cooks. It is these long-run responses that are likely of greater interest to policymakers. Baker et al (1999) illustrate the potentially distinct employment effects that arise at different time horizons.

[14]This approach can be justified by the following three period model. In period 1, firms choose K, and believe they know period 2 prices with probability 1. In period 2, all prices are revealed, and the wage potentially changes. The firm can then pick L and M. Although K is set for period 2, the firm can pick period 3 values of K. In period 3, all prices were as anticipated. In this case, period 2 represents the short run equilibrium, and period 3 represents the long run equilibrium.

output does not depend on materials). The elasticity of demand for labor (in absolute value) is then:

$$\lambda = (1 - s_L)\sigma_G + s_L\eta \tag{6}$$

where $s_L \equiv \frac{wL}{pQ}$ is labor's share. Likewise, if capital can adjust and $\alpha_G = 1$, the elasticity of demand for labor is:

$$\lambda = (1 - s_L)\sigma + s_L\eta. \tag{7}$$

In both cases, the elasticity of demand is rising in the elasticity of substitution between labor and the other factor of production (the "substitution effect") and the elasticity of demand for the output good (the "scale effect"). The substitution effect measures the change in inputs given a wage change, holding output fixed. The scale effect measures the change in output given a wage change, holding inputs fixed. These equations are restatements of equation (2.7a') in Hamermesh (1993) and (11.6) in Card and Krueger (1995).

Lastly, we note that if firms are perfectly competitive and have a constant returns production function, then economic profits must be zero both before and after the wage change. Therefore, all changes in labor costs are passed on to the consumer, i.e.

$$\frac{d\ln p}{d\ln w} = s_L. \tag{8}$$

2.2 The Short Run Labor Demand Response of Monopsonistic Firms

This section derives the employment effects of minimum wage changes when firms are monopsonists in the labor market. The basic framework is the same as the previous section. However, we show that monopsony power implies that the wage is not necessarily equal to the marginal revenue product of labor. It is this result that makes the employment response to an increase in the minimum wage ambiguous. In this case, we demonstrate how to use measures of price pass-through to infer the importance of monopsonistic behavior.

Many researchers have argued that fast food restaurants are highly competitive and therefore monopsony power is likely negligible.[15] However, models where employee search is costly

[15] See, for example, Brown et al (1982). Although Stigler (1946) was the first to observe the potential

often imply that employers have some degree of monopsony power.[16] Furthermore, Card and Krueger (1995) document several facts that may be inconsistent with competitive models but are consistent with monopsony models. For example, they argue that a well-documented spike in the wage distribution at the minimum implies that, unless there is a similarly sized and placed spike in the distribution of ability, some workers are not paid their marginal revenue product of labor. However, as we show below, the presence of a spike in the minimum wages is not ex ante evidence of monopsony power. Our model generates a spike in the minimum wage even if there is no monopsony power. Nevertheless, other facts are not consistent with our model unless monopsony power is important. Many firms have posted vacancies, suggesting that they cannot attract an infinite amount of labor at their offered wage. Therefore it seems plausible that restaurants have some amount of monopsony power.

In this model, all workers are identical in their productivity, but because of differences in local labor market conditions, some firms pay above the minimum wage and others at the minimum wage. Firms face the inverse labor supply curve:

$$w(L) = \theta L^{\gamma} \tag{9}$$

and their offered wage is

$$w = \max\{w(L), w_{min}\} \tag{10}$$

where $\frac{1}{\gamma}$ is the (Marshallian) labor supply elasticity and θ is a shift parameter. We assume that θ potentially varies by labor market, although we do not give θ a subscript for notational convenience. We assume that labor markets are the same size as product markets. Therefore, within each local labor market, all firms face the same output price. However, the output price varies across labor markets.

Figure 1 shows the competitive and monopsony solutions to the firm's problem. The

importance of monopsonies when analyzing minimum wage policy, he was clearly suspicious that this was a relevant scenario. However, it is important to emphasize that monopsony power need not imply a sole buyer of labor. See Boal and Ransom (1997), Sullivan () and Bhaskar, Manning, and To (2002) for a theoretical and empirical discussion of monopsony power in labor markets.

[16] See Burdett and Mortenson (1998). Other models that introduce monopsony power include Card and Krueger (1995), Manning (1995), Rebitzer and Taylor (1995), and Bhaskar and To (1999). Card and Krueger write down a simple dynamic model where increases in the wage increase the hire rate and reduce the quit rate. The comparative statics of their model generate an inverse labor supply curve that is identical to ours.

competitive solution (if the firm is a price taker in the labor market) is for the firm to hire L^{**} workers at a wage w^{**}. However, if the firm has monopsony power, the firm will pay only w^* and will hire L^* workers.

Whether employment rises, falls or remains constant in response to an increase in the minimum wage is determined by the level of the minimum wage. Perhaps the simplest case occurs when the minimum wage is not binding ($w_{min} < w(L^*)$). In this case, a small change in the minimum wage has no effect on employment. Equilibrium employment and wages are L^* and w^*, respectively.

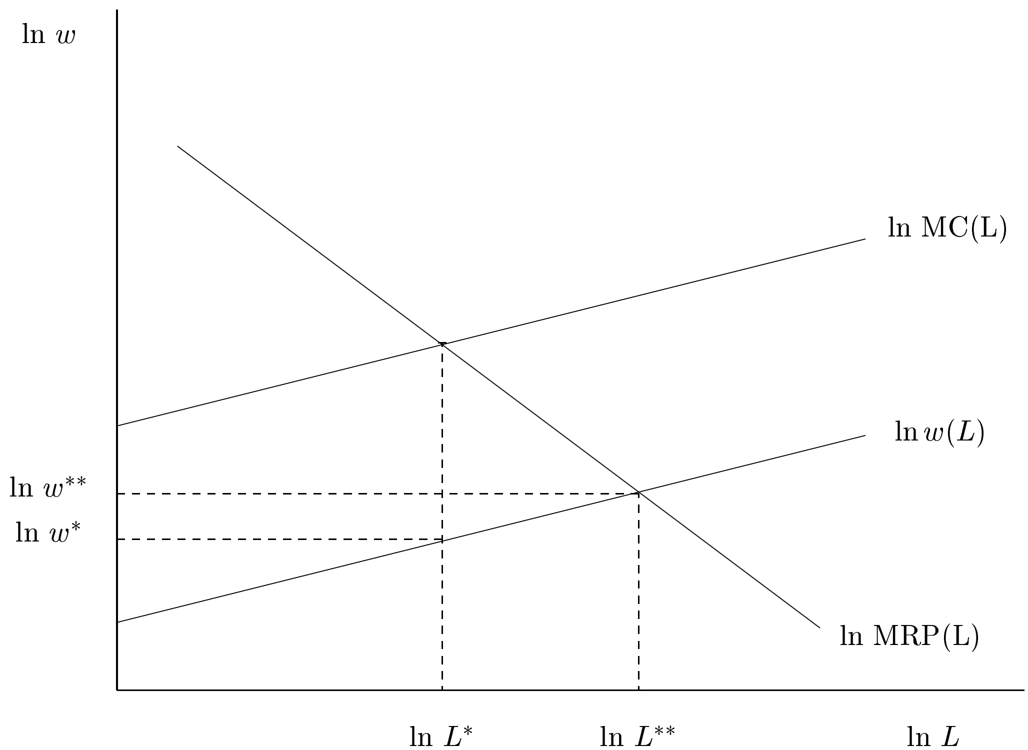

Figure 1: Illustration of monopsony equilibrium

Now, suppose the minimum wage is set between w^* and w^{**}. In this case, employment in a labor market with a minimum wage (e.g. L_{min} in figure 2) is greater than employment in the absence of the minimum wage (L^*). The intuition for this result is that although the minimum wage increases the average cost of labor for the firm, it reduces the marginal cost of labor from $(1+\gamma)w$ to w_{min}. Below L_{min}, the marginal cost of labor is the minimum wage. Whether the firm hires L_{min} or $L_{min}-1$ workers, all workers are paid w_{min}. However, for employment levels above L_{min}, the marginal cost of labor is above the minimum wage; no additional workers will work for w_{min}. The employer must increase the pay of all workers in order to obtain an additional one. Consequently, employment is determined by the intersection of the minimum wage and the inverse labor supply function $w(L)$. Therefore, increases in the minimum wage lead to increases in employment for $w_{min} \in [w^*, w^{**})$.

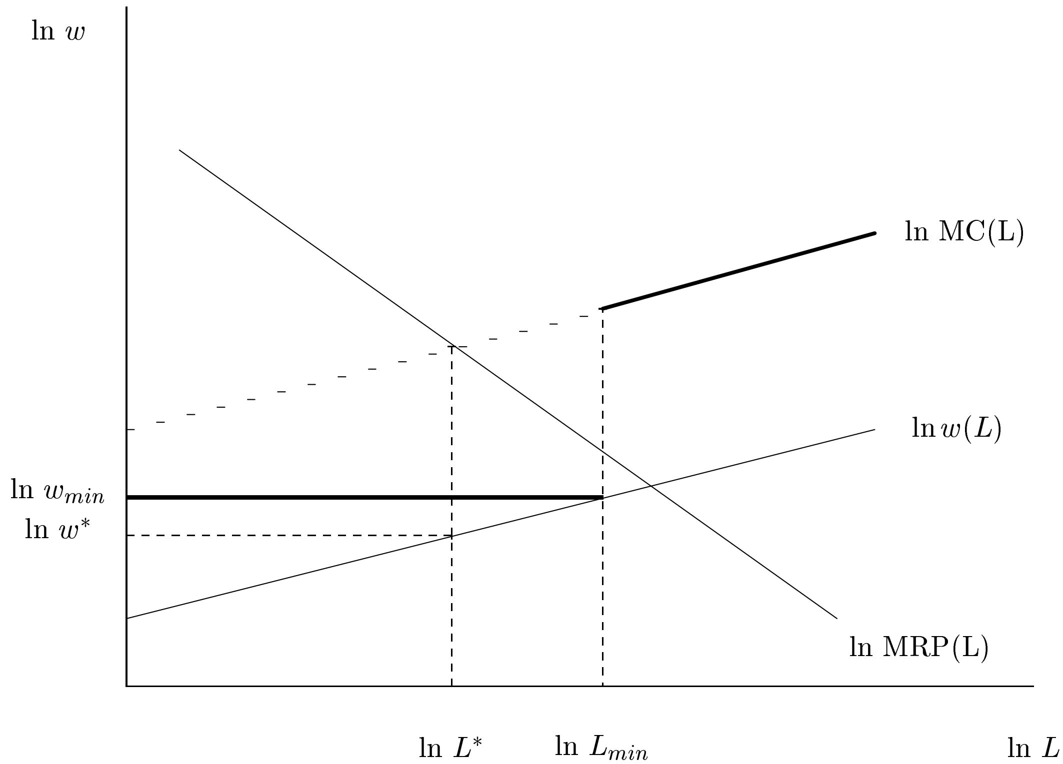

Figure 2: Illustration of monopsony equilibrium with minimum wage (Bold line denotes $\ln MC(L)$ curve)

Finally, if the minimum wage lies above the point of intersection of the inverse labor supply function and the marginal revenue product of labor function MRP(L), i.e., $w_{min} > w(L^{**},$

employment falls as the minimum wage rises. The marginal cost of labor function, MC(L), is always equal to the minimum wage. The firm then sets the minimum wage equal to MRP(L). The MRP(L) function slopes down. Therefore, in this case, increases in the minimum wage unambiguously lead to a reduction in employment.

Consequently, since all three of these cases are plausible, whether employment rises, falls, or does neither in response to an increase in the minimum wage appears to be ultimately an empirical question.

Within this model, we can directly solve out for λ:

$$\lambda(\theta) = \begin{cases} \lambda_{comp} & \text{if } \; w_{min} \geq w(L^{**}) \\ -\frac{1}{\gamma} & \text{if } \; w(L^{*}) \leq w_{min} < w(L^{**}) \\ 0 & \text{if } \; w_{min} < w(L^{*}). \end{cases} \tag{11}$$

where λ_{comp} is defined in equation (5). We write out $\lambda = \lambda(\theta)$ to point out that the employment elasticity varies as θ varies. Equation (11) is derived by noting that if $w_{min} \geq w(L^{**})$, as in line 1, then the wage is equal to the marginal revenue product of labor and the employment outcome is the competitive one. Increases in the minimum wage trace out the labor supply curve if $w(L^{*}) < w_{min} < w(L^{**})$, as shown in line 2. Finally, if the minimum wage is not binding, as in line 3, there is no employment response.

Following the reasoning in equation (11), the price response to a minimum wage change is:

$$\frac{d\ln p}{d\ln w_{min}}(\theta) = \begin{cases} \frac{d\ln p}{d\ln w}_{comp} & \text{if } \; w_{min} \geq w(L^{**}) \\ \frac{d\ln p}{d\ln w}_{monop}(\theta) & \text{if } \; w(L^{*}) \leq w_{min} < w(L^{**}) \\ 0 & \text{if } \; w_{min} < w(L^{*}). \end{cases} \tag{12}$$

The top line merely states that the equilibrium output price, like the equilibrium employment level, will be competitive if $w_{min} > w(L^{**})$. The middle line is derived by noting that $\frac{d\ln L}{d\ln w_{min}} = \frac{1}{\gamma}$ if $w(L^{*}) \leq w_{min} < w(L^{**})$,[17] then solving for the new price level, letting M

[17]Note that along this range, the factor mix varies with θ, and thus $\frac{d\ln p}{d\ln w}_{monop}(\theta)$ varies with θ. In practice, this is a minor concern.

adjust. This is described in greater detail in appendix B.[18]

Finally, we note that it is possible to solve out for $\frac{d\ln p(\theta)}{d\ln w_{monop}}$, assuming that capital can adjust and that $\alpha = 1$. Appendix C shows that in this case,

$$\frac{d\ln p}{d\ln w_{monop}} = -\frac{s_L(1+\gamma(L))}{\gamma\left(\sigma_G(1-s_L)+s_L\eta\right)} \tag{13}$$

Note that this term is unambiguously negative. Therefore, in response to a minimum wage hike, employment falls and prices rise under perfect competition, and employment rises and prices fall under monopsony. Therefore, price data allows us to infer the importance of monopsony power in the labor market.

3 Using Price Pass-Through to Infer the Extent of Monopsony Power

This section proposes a method to infer the extent to which monopsonistic behavior is important using values of price pass-through, $\frac{d\ln p}{d\ln w}$.

Define $V = prob(w_{min} \geq w^{**} | w_{min} > w^*)$ as the share of firms facing a binding minimum wage such that the minimum wage is equal to the MRP(L). Assuming that we know V, we can use equation (11) to compute the average employment response:

$$E_\theta[\lambda(\theta)] = \int_\theta \lambda(\theta)dF(\theta) = prob(w_{min} > w^*) \times \left(V\lambda_{comp} - \big(1-V\big)\big(\frac{1}{\gamma}\big)\right). \tag{14}$$

As equation (14) makes clear, we can infer the employment response to a minimum wage change while allowing for monopsonistic labor markets if we know values for λ_{comp}, $prob(w_{min} > w^*)$, V, and γ. We calibrate λ_{comp} and γ and estimate $prob(w_{min} > w^*)$.

Using price pass-through, we can calculate V. Analogous to equation (14), the average

[18] Note that $\frac{d\ln p\theta}{d\ln w}_{monop}$ varies depending on where w_{min} lies on the interval between $w(L^*)$ and $w(L^{**})$. See appendix B for how we account for this issue.

price response is

$$E_\theta[\frac{d\ln p}{d\ln w}(\theta)] = \int_\theta \frac{d\ln p}{d\ln w}(\theta)dF(\theta) = prob(w_{min} > w^*) \times \left(\left[\frac{d\ln p}{d\ln w}_{comp} \times V\right] + \left[\frac{d\ln p}{d\ln w}_{monop} \times (1-V)\right]\right). \tag{15}$$

Rearranging, we can solve explicitly for V:

$$V = \frac{E_\theta[\frac{d\ln p}{d\ln w}(\theta)]\frac{1}{prob(w_{min}>w^*)} - \frac{d\ln p}{d\ln w}_{monop}}{\frac{d\ln p}{d\ln w}_{comp} - \frac{d\ln p}{d\ln w}_{monop}(\theta)}. \tag{16}$$

We solve $\frac{d\ln p}{d\ln w}_{monop}(\theta)$ and $\frac{d\ln p}{d\ln w}_{comp}$ numerically. A detailed discussion of our estimates of $E_\theta[\frac{d\ln p}{d\ln w}(\theta)]$ and $prob(w_{min} > w^*)$, as well as the parameters we use to calibrate $\frac{d\ln p}{d\ln w}_{monop}(\theta)$ and $\frac{d\ln p}{d\ln w}_{comp}$ are provided in the next section.

We make two final observations about the model. First, all of the competitive and monopsony predictions described in this section are robust to allowing for imperfect competition in the product market, so long as there is a constant elasticity of demand. This result is established in appendix D.

Second, this model generates a spike in the distribution of wages at the minimum, even if monopsony power is nonexistent. This is the case so long as σ_G and σ are finite (i.e., labor is not a perfect substitute for materials or capital) and $\eta > 0$. Under these reasonable assumptions, labor will still be used as a factor of production even when the price of labor rises and increases in output prices will lead to a reduction but not cessation in output. Therefore, higher labor costs caused by an increase in the minimum wage can be (partially) pushed onto consumers.

4 Parameters

This section documents the source of the parameters that are used in the model's simulation exercises. We estimate values for $prob(w_{min} \geq w(L^*))$, s_L, and s_M using existing data and take estimates of $E[\frac{d\ln p}{d\ln w_{min}}]$, η, γ, $\sigma_{L,K}$, and $\sigma_{L,M}$ from the literature.

4.1 Price Pass-Through, $E[\frac{d \ln p}{d \ln w_{min}}]$

Aaronson, French, and MacDonald (2003) use store-level data from the food away from home component of the Consumer Price Index (CPI) during 1995 to 1997 to identify the extent of price pass-through.[19] They find that, in the aggregate, a 10 percent increase in the minimum wage increases prices by roughly 0.7 percent during a four month period around the minimum wage enactment date. These results are comparable to Aaronson (2001), who uses panels of U.S. city and Canadian province CPI data from 1978 to 1995, and Lee and O'Roarke's (1999) input-output analysis. Card and Krueger (1995) also use CPI indexes for Food Away from Home in 27 large metropolitan areas, finding larger price increases in those cities with higher proportions of low-wage workers. Although their estimates are consistent with full pass-through, their standard errors are extremely large. They cannot reject zero price pass-through in many of their specifications. Moreover, additional evidence from specific state increases in Texas and New Jersey suggests close to no price response. As a result, they conclude that their estimates are "too imprecise to reach a more confident assessment about the effects of the minimum wage on restaurant prices." However, Aaronson (2001) and Aaronson, French, and MacDonald (2003) use substantially more data and document large and significant increases in food away from home prices immediately surrounding an increase in the minimum wage. These latter results are consistent with studies of price pass-through resulting from other costs shocks, such as sales taxes levies (e.g. Besley and Rosen 1999) and exchange rate movements (e.g. Yang 1997).

In the calibration exercise, which aggregates all markets and types of restaurants, we use a value for $E[\frac{d \ln p}{d \ln w}]$ of 0.07 but test the robustness of the results to values between 0.05 and 0.09. We also discuss what happens as $E[\frac{d \ln p}{d \ln w}]$ approaches zero.

4.2 Labor's Share, s_L

There are a number of sources for labor share, all of which tend to report similar numbers for the food away from home industry. First, 10-K company reports contain payroll to total

[19] While the time frame is somewhat short, this three-year period contains an unusual amount of minimum wage activity. A bill signed on August 20, 1996 raised the federal minimum from \$4.25 to \$5.15 per hour, with the increase phased in gradually. An initial increase to \$4.75 (11.8 percent) occurred on October 1, and the final installment (8.4 percent) took effect on September 1, 1997. Moreover, additional variation can be exploited by taking advantage of cross-state differences in market wages, state-imposed minimum wages that exceed federal levels, and differences in establishment type.

expense ratios. Of the 17 restaurant companies that appear in a search of 1995 reports using the SEC's Edgar database, the unconditional mean and median of this measure of labor share is 30 percent and it ranges from 21 to 41 percent.[20] Generally, limited service establishments, like McDonalds and Burger King, are at or below the mean, and full service restaurant companies, like Bob Evans and California Pizza Kitchen, lie above. This difference between limited and full service establishments can also be seen in a second source of data, the 1997 Economic Census for accommodations and foodservices. This industry census reports payroll as 31 and 25 percent of sales at full and limited service restaurants, respectively. Several 10-K reports show that wages account for 85 percent of compensation. Therefore, labor's share based on compensation is roughly 36 and 29 percent at full and limited service restaurants. Finally, these numbers appear to be in-line with a sampling of 1995 corporate income tax forms from the Internal Revenue Service's Statistics on Income Bulletin. Because operating costs are broken down by category, it is possible to estimate labor's share. However, the IRS claims that labor cost is notoriously difficult to decompose for corporations and therefore we restrict our analysis to partnerships, where there is less concern about reporting. Despite the quite different sampling of firms relative to the Edgar Database, labor cost as a share of operating costs for eating place partnerships is of a similar magnitude to the other estimates, roughly 33 percent. We set s_L to 30 percent but test the robustness of the results to values between 25 and 35 percent.

4.3 Materials Share, s_M

Based on the same sample of company financial reports used to compute s_L, we assume that materials share is 40 percent. Again, we test the robustness of the results to values between 35 and 45 percent.

4.4 The Share of Minimum Wage Workers, $prob(w_{min} \geq w(L^*))$

The minimum wage should affect prices and employment only if it affects wages. Therefore, we need the share of workers' wages impacted by minimum wage policy. Since this is not available in company reports, we estimate the share of employees that are paid at or very near the minimum wage from the outgoing rotation files of the CPS for the two years

[20] The search uses five keywords: restaurant, steak, seafood, hamburger, and chicken.

prior to the 1996 legislation.[21] During this time period, 23 percent of restaurant industry workers were within 10 percent of the minimum wage, and therefore clearly impacted by a characteristically-sized 10 percent increase in the minimum wage.

However, this estimate is insufficient for understanding the fraction of workers affected by the minimum wage change. Workers paid slightly above the minimum wage also tend to receive pay increases in response to minimum wage increases, presumably to continue to provide work incentives for these groups.[22] To approximate this phenomena, we use the outgoing rotation file wage distributions combined with a survey reported in Card and Krueger (1995, p. 162). Their survey results suggest roughly one-third of workers who are within 20 percent of the old minimum but above the new minimum receive wage increases. For workers beyond 20 percent of the old minimum, the evidence is less clear and seems to be quite dependent on the firm's typical starting wage. For example, if we assume that one-third of workers above 20 percent but within 50 percent of the old minimum wage receive a pay boost that is comparable to the minimum wage increase, then 35 percent of workers would be affected. In the simulations, we set $prob(w_{min} \geq w(L^*)) = 0.30$ but test the robustness of the results to values between 0.25 and 0.40.

It is worth noting that taking the product of s_L and the share of wages due to workers impacted by the minimum wage gives a rough indication of the extent to which the competitive model's prediction of full price pass-through is upheld. Based on the range of s_L observed in firm and tax publications and assumptions about the share of the wage hierarchy impacted by minimum wage law, the predicted price responses is likely bounded by 0.05 and 0.12, with our best assessment falling around 0.075 to 0.09. Clearly, full pass-through cannot be rejected given the size of the standard errors on $\frac{d \ln p}{d \ln w_{min}}$. Even if the predicted price response is as high as 12 percent, our estimate of price pass-through of 7 percent implies that at least 60 percent of labor cost increases are passed on to consumers in the form of higher prices.

[21] There are no federal changes and only two state changes during these two years. We exclude the two states, Vermont and Washington, with such activity, as well as all data from June to August of 1995, for which there are no geographic identifiers.

[22] See Grossman (1983) and Card and Krueger (1995) for evidence.

4.5 The Elasticity of Demand for Food Away From Home, η

Piggott (2003) provides estimates of η using a generalized model of food demand that nests the main demand systems currently in use. Using annual time-series data on expenditures and prices between 1968 and 1999, he finds the own price elasticity of demand for food away from home ranges from 1.16 to 2.03, depending on the model specification used. However, limiting it to models with parameter restrictions that are not rejected, the range narrows substantially to 1.37 to 1.50.[23] This is virtually identical to the 1.4 point estimate derived from an older time-series in Houthakker and Taylor (1970), although a bit more elastic than Brown (1990), who uses 1977 and 1982 cross-sectional Census data to calculate an η of 0.2 and 1 for food away from home and fast food, respectively. To capture these different estimates, we allow η to stretch from 1.0 to 2.0, with the middle of this range, around 1.5, being our best interpretation of the value for this industry.

4.6 The Elasticity of Substitution Between Labor and Capital and Labor and Materials, $\sigma_{L,K}$ and $\sigma_{L,M}$

We could not find estimates of $\sigma_{L,K}$ and $\sigma_{L,M}$ for restaurants. On the one hand, this is unfortunate since there is little reason to expect that factor substitution is equal across industries. In fact, Hamermesh's (1993) review of industry- and product-specific $\sigma_{L,K}$ reveals a fairly broad range of estimates. However, as Hamermesh stresses, micro-orientied estimates generally do not alter conclusions reached from studies using aggregated data. $\sigma_{L,K}$ is generally between 0.5 and 1.0 for the vast majority of industries, with a mean estimate of 0.75 from Hamermesh's review of aggregate studies and 0.50 from his review of micro studies. Given that the overwhelming majority of these studies are based on manufacturing sectors, the closest parallel to the eating and drinking industry that we could find was Goodwin and Brester (1995), who analyze the food manufacturing industry and find that $\sigma_{L,K}$ is roughly 0.9 in the 1970s and 0.5 thereafter.

[23] Although Piggott covers multiple functional forms, his approach is limited in other dimensions. For example, he does not distinguish between income and substitution effects, and he does not consider the importance of aggregation across goods. To take one example, MacDonald and Aaronson (2002) show that firms do not raise all prices by amounts that reflect the cost of minimum wages but rather raise prices on a subset of items by amounts that exceed the cost impact of the minimum wage increase. This response is consistent with item-specific costs to changing prices or demand elasticities that vary across items. Nevertheless, Piggott's estimates for all food are similar to Attanasio and Weber's (1995) uncompensated elasticities, which account for these problems.

Likewise, Hamermesh's review of the substitutability of labor and materials suggests that $\sigma_{L,M}$ is likely the same size or a bit smaller than $\sigma_{L,K}$. Again, this is consistent with the findings in Goodwin and Brester (1995). Therefore, we allow both of these elasticities to vary between 0.5 and 1.0.

4.7 The Marshallian labor supply elasticity, $\frac{1}{\gamma}$

We set $\gamma = 0.2$ but examined the robustness of the results to values between 0.1 and 0.5. This range is based on Card and Krueger's (1995, p. 376) interpretation of γ calibrated from estimates of wage elasticities of the hiring and quit functions. They conclude that while γ could vary between 0.1 and 0.5, the lower range is more theoretically and empirically plausible.

On the other hand, Bhaskar and To (1999) point out that if the labor market is characterized by monopsonistic competition rather than pure monopsony, then a value of γ calibrated using hire and quit rates will lead to erroneous inference. Under monopsonistic competition, increases in a firm's wage reduce the quantity of labor supplied at all other firms. Because an increase in a binding minimum wage increases the wage of all firms, it will have a smaller effect on a firm's labor supply than just increasing that firm's wage.

5 Results

Table 1 reports our estimates of the employment response to a 1 percent minimum wage hike. The table includes three panels, which are differentiated by their assumption on the substitutability of the three inputs, and three rows within each panel, which allow the demand elasticity, η, to vary to its lower bound (1), likely value (1.5), and upper bound (2). Throughout the table, the remaining parameters are set to our best assessment, as reviewed in the previous section: $s_L = 0.30$, $s_M = 0.4$, $E[\frac{d \ln p}{d \ln w_{min}}] = 0.07$, $prob(w_{min} > w^*) = 0.30$, and $\gamma = 0.2$. Robustness checks of the sensitivity of the results to these selections are reported in table 2 below.

The first column of each panel displays $\lambda_{comp} * prob(w_{min} > w^*)$, the employment response to a 1 percent minimum wage increase under the condition that all firms are price-takers in the labor market. First, consider the case (top panel, middle line) where $\eta = 1.5$, $\sigma_{L,K} = 1.0$, and $\sigma_{L,M} = 1.0$. Under these conditions, a 10 percent increase in the minimum wage cuts the food away from home workforce by 3.5 percent. Reducing the extent of substitutability between labor, materials, and capital eases the disemployment effect because firms have less opportunity to substitute labor for other inputs. For example, if $\sigma_{L,K}$ and $\sigma_{L,M}$ are reduced from 1 to 0.5, λ_{comp} falls from 0.35 to 0.24. While this difference is noteworthy, given that the experiment covers the range of plausible values for the two σ parameters, it appears to us that the employment elasticity is not especially sensitive to the choice of σ. The results are equally robust to varying η to the lower and upper bounds reported in the literature. The difference between λ_{comp} when $\eta = 1$ and $\eta = 2$ is, again, about 0.1. Therefore, we can place very tight bounds on the employment response under fairly strict assumptions about market structure.

Parameter Assumptions	$\lambda_{comp} * prob(w_{min} > w^*)$	V	$E[\lambda]$
$\sigma_{L,K} = \sigma_{L,M} = 1.0$			
$\eta = 1.0$	0.29	0.94	0.19
$\eta = 1.5$	0.35	0.97	0.29
$\eta = 2.0$	0.39	1.00	0.39
$\sigma_{L,K} = \sigma_{L,M} = 0.75$			
$\eta = 1.0$	0.25	0.96	0.19
$\eta = 1.5$	0.29	1.00	0.29
$\eta = 2.0$	0.34	1.04	0.40
$\sigma_{L,K} = \sigma_{L,M} = 0.5$			
$\eta = 1.0$	0.20	1.00	0.19
$\eta = 1.5$	0.24	1.03	0.29
$\eta = 2.0$	0.30	1.06	0.40

See text for detail. Column (1) is the employment elasticity assuming all firms are price-takers in the labor market.
Column (2) reports the extent to which monopsony power in the labor markets is important. See equation (16).
Column (3) is the employment elasticity when the extent of monopsony power is taken into account.
The following parameters are fixed throughout:
$s_L = 0.3$, $s_M = 0.4$, $E[\frac{d \ln p}{d \ln w_{min}}] = 0.07$,
$prob(w_{min} > w^*) = 0.30$ and $\gamma = 0.2$.

Table 1: Estimates of λ Under Different Assumptions About Labor Market Structure and η, $\sigma_{L,K}$, and $\sigma_{L,M}$

Next, we introduce monopsony power in the labor market. Recall that increases in the minimum wage trace out the labor supply curve for monopsonists and therefore the employment response is $\frac{1}{\gamma}$. Consequently, if all firms are monopsonists, $\lambda_{monop} * prob(w_{min} > w^*)$ is, under reasonable assumptions about γ, large and positive.[24] Since firms are adding workers in response to a minimum wage change, output increases and prices fall. The model predicts that $\frac{d\ln p}{d\ln w}_{monop} = -0.37$. By comparison, $\frac{d\ln p}{d\ln w}_{comp}$ tends to be around 0.08.

Column (2) reports the value of V, which is, as described in equation (16), identified by the degree of actual pass-through relative to the pure monopsony and perfect competition cases. A number substantially below 1 would imply that monopsony power is important.[25] For example, if $\eta = 1.5$ and substitution possibilities are moderate (0.75), $V = 0.999$, suggesting that there is little monopsony power in the industry. However, as inputs become more substitutable and product markets become less elastic, the extent of monopsony power increases. If η remains at 1.5 but $\sigma_{L,K} = 1$ and $\sigma_{L,M} = 1$, then $V = 0.95$.

Finally, column (3) reports our estimate of $E[\lambda]$, the employment response to a 1 percent minimum wage change when the extent of monopsony power is accounted for explicitly. Like our estimates based on the pure perfect competition setting, these employment elasticities tend to bunch in the 0.2 to 0.4 range, with the former appearing when η is low and the latter when η is high.[26] In the likeliest case, when $\eta = 1.5$, the employment elasticity is 0.29. Using the σ values stressed in Hamermesh (1993) ($\sigma_{L,K} = 1$ and $\sigma_{L,M} = 0.5$), $V = 0.96$ and $E[\lambda] = 0.23$.

Table 2 reports the sensitivity of these findings to varying the five parameters held fixed in table 1. For these tests, we set $\eta = 1.5$, $\sigma_{L,K} = 1.0$, $\sigma_{L,M} = 1.0$, and all other values, but the one being modified, to those used in table 1. Column (1) clarifies which parameter is being adjusted and column (2) is its new value. The values chosen are the likely lower and upper bounds described in the previous section. Relative to the base case reported in row (1), these alterations have a small impact on the results.[27] In all cases, $\lambda_{comp} * prob(w_{min} > w^*)$

[24] For example, when $\gamma = 0.2$, $\lambda_{monop} * prob(w_{min} > w^*) = 1.25$.

[25] V can exceed one if firms pass on more of a price increase than would be expected given perfect competition. Empirically, overshifting of ad valorem taxes has been found by, among others, Besley and Rosen (1999) in the retail apparel industry and Karp and Perloff (1989) in the Japanese television market.

[26] Note also that, unlike the perfect competition case, as inputs become less substitutable, the employment response increases. This result arises because the slope of the supply curve changes as σ changes, which directly influences our estimate of V.

[27] Note that there is a negative relationship between γ and V. For example, if γ is very small, firms that set wages between w^* and w^{**} (i.e., those firms whose employment is determined by the intersection of the minimum wage and the inverse labor supply curve) will experience large employment increases in response to an increase in the minimum wage. If all firms had these employment responses, on average, output prices would fall. Because, prices do not fall after a minimum wage increase, it must be the case that, on average, relatively few firms have their employment determined by the intersection of the minimum wage curve and the inverse labor supply curve. That is, the extent of monopsony power in the restaurant industry is limited.

and $E[\lambda]$ remain within 0.1 and usually within 0.03 of the base case.[28] Again, we conclude that the model's predictions appear to be quite robust to reasonable perturbations of the underlying parameters, with the employment elasticity likely falling between 0.2 and 0.3.

Parameter Changed	Value	$\lambda_{comp} * prob(w_{min} > w^*)$	V	$E[\lambda]$
baseline		0.35	0.97	0.29
γ	0.1	0.35	0.99	0.31
	0.5	0.35	0.90	0.26
s_L	0.22	0.33	1.02	0.38
	0.35	0.35	0.93	0.24
s_M	0.35	0.35	0.97	0.29
	0.45	0.35	0.96	0.28
$prob(w_{min} > w^*)$	0.25	0.29	1.00	0.29
	0.40	0.46	0.93	0.29
$E[\frac{d \ln p}{d \ln w_{min}}]$	0.05	0.35	0.92	0.21
	0.09	0.35	1.01	0.37
See text for detail. The following parameters are fixed throughout: $\eta = 1.5$, $\sigma_{L,K} = 1.0$, and $\sigma_{L,M} = 1.0$				

Table 2: Robustness of the Results to Other Parameter Assumptions

Are our findings consistent with studies that directly estimate the employment response to a minimum wage change? Again, we want to emphasize that our estimates are for the restaurant industry only. As a result of different intensity of use of minimum wage labor, substitution possibilities, market structure, and demand for products, other industries might face distinct employment responses. Consequently, it is difficult to compare our results to those that identify $E[\lambda]$ off the co-movement of teenage employment and the minimum wage, without knowing the full range of these parameters for the major industry employers of teens. However, among those studies that explicitly look at the restaurant industry, our results are reasonably consistent with Neumark and Wascher (2000), who find a λ of just over 0.2. A λ of zero, while clearly theoretically plausible, does not seem consistent with the level of monopsony power inferred from the price responses observed in the food away from home

[28]In an extreme example, if we assume the least amount of pass-through that seems plausible based on the literature (i.e. $s_L = 0.35$ and $E[\frac{d \ln p}{d \ln w_{min}}] = 0.05$), $E[\lambda] * prob(w_{min} > w^*) = 0.17$. To get $E[\lambda]$ as low as 0.10 requires pass-through to be 0.03. No pass-through ($E[\frac{d \ln p}{d \ln w_{min}}] = 0$) results in no employment response.

sector.

6 Conclusion

We use a computational model of labor demand to calibrate the employment response to a change in the minimum wage for the food away from home industry. If all firms are price-takers in the labor market, the model predicts a 2.5 to 3.5 percent fall in employment in response to a 10 percent increase in the minimum wage. A second implication of the competitive model is that higher labor costs are pushed onto consumers in the form of higher prices. This price response stands in sharp contrast to the monopsony model, offering a way to identify the extent of monopsony power in the labor market for the restaurant industry. Relying on previous research that shows that most of the higher labor costs incurred by employers are pushed onto consumers in the form of higher prices, we infer that few restaurants will have positive employment responses in reaction to a minimum wage increase. Consequently, using the most plausible range of estimates for the key parameters in the model, we find that the employment response to a 10 percent change in the minimum wage is likely between 2 and 3 percent, just slightly below the perfect competition prediction and encapsulating many of the moderate empirical estimates in the literature.

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Appendix A: Solution to the Model Under Perfect Competition

This appendix shows how to solve for the equilibrium quantities and prices $\{K, L, M, p\}$ as well as the unknown parameters $\{\alpha, \rho, \alpha_G, \rho_G\}$ under perfect competition. We have good information, described in section 4, on the following objects: $\sigma_{L,K}$, the elasticity of substitution between capital and labor, $\sigma_{L,M}$, the elasticity of substitution between materials and labor, the shares s_M and s_L of material and labor costs, and the elasticity of demand for the output good η. We set r, w, p_M and Z equal to one. Under constant returns production (in our case, when K can adjust) it is straightforward to show that none of these parameters will affect any of the elasticities. However, when K cannot adjust or when firms have monopsony power (as in appendix B), it is not clear if this is true. Nevertheless, we experimented with different values of these parameters, and none of these robustness checks substantially impacted the elasticities of interest.

Sato (1967) shows how to use equations (17) and (18) to map $\sigma_{L,M}$ and $\sigma_{L,K}$ into σ and σ_G :

$$\sigma_{L,K} = \sigma_G, \tag{17}$$

$$\sigma_{L,M} = \frac{\frac{1}{s_L} + \frac{1}{s_M}}{(\frac{1}{\sigma_G})(\frac{1}{s_L} - \frac{1}{s_L+s_K}) + (\frac{1}{\sigma})(\frac{1}{s_L+s_K} + \frac{1}{s_M})}. \tag{18}$$

These two equations identify σ and σ_G.

The first order conditions for maximization of the profit function in equation (1) are:

$$\frac{\partial Q}{\partial K} = \frac{r}{p}, \tag{19}$$

$$\frac{\partial Q}{\partial L} = \frac{w}{p}, \tag{20}$$

$$\frac{\partial Q}{\partial M} = \frac{p_M}{p}. \tag{21}$$

The marginal products of capital, labor, and materials (obtained by differentiating equation (2) with respect to K, L and M) are equal to their relative prices

$$\frac{r}{p} = \alpha(1-\alpha_G)\big(\frac{Q}{G}\big)^{1-\rho}\big(\frac{G}{K}\big)^{1-\rho_G}, \tag{22}$$

$$\frac{w}{p} = \alpha\alpha_G\big(\frac{Q}{G}\big)^{1-\rho}\big(\frac{G}{L}\big)^{1-\rho_G}, \tag{23}$$

$$\frac{p_M}{p} = (1-\alpha)\big(\frac{Q}{M}\big)^{1-\rho} \tag{24}$$

which allow us to identify K, L, and M. Rewriting equations (23) and (24) allow us to pin down α and α_G :

$$\alpha_G = \frac{s_L}{\alpha}\left(\frac{Q}{G}\right)^{\rho}\left(\frac{G}{L}\right)^{\rho_G} \tag{25}$$

$$(1-\alpha) = s_M\left(\frac{Q}{M}\right)^{\rho}. \tag{26}$$

Finally, the demand function defined in equation (4) identifies the price. Consequently, we have eight equations and eight unknowns, giving us an exactly identified model.

Appendix B: Solution to the Model Under Monopsony

This appendix shows how to solve for the equilibrium quantities and prices $\{K, L, M, p\}$ when firms have monopsony power.

As pointed out in the text, we assume that dispersion in θ causes dispersion in the distribution of wages. Therefore, the endogenous variables will all depend on $\theta \in \Theta$. This means that we must solve for $\{K(\theta), L(\theta), M(\theta), p(\theta)\}$. We can then compute the aggregate employment level L by integrating over the distribution of θ.

To solve the monopsony model, we note that equations (17), (18), (22), and (24) still hold. However, equation (23) must be replaced by equation (27) where the marginal product of labor is:

$$F_L(K,L,M) = \alpha\alpha_G\big(\frac{Q}{G}\big)^{1-\rho}\big(\frac{G}{L}\big)^{1-\rho_G} = \begin{cases} w_{min} & \text{if } \ w_{min} \geq w(L^{**}) \\ (1+\gamma(L))w_{min} & \text{if } \ w(L^{*}) \leq w_{min} < w(L^{**}) \\ (1+\gamma)w(L) & \text{if } \ w_{min} < w(L^{*}). \end{cases} \quad (27)$$

$\gamma(L) = (1+\gamma)^{(\frac{\ln L^{**} - \ln L}{\ln L^{**} - \ln L*})} - 1$ measures the difference between the wage and the marginal revenue product of labor, the vertical distance between $\ln w(L)$ and $\ln MRP(L)$ in figure 1, and always lies between 0 and γ when L is between L^{*} and L^{**}. Note that equation (27) has three segments; θ determines which of these segments is equal to the marginal product of labor. This point, made in the text, is described more precisely below.

Define θ^{*} as the value of θ such that $w^{*} = w_{min}$ and θ^{**} as the value of θ such that $w^{**} = w_{min}$. Note that $\theta^{*} > \theta^{**}$. Also note that $\gamma(L)$ equals 0 if $\theta = \theta^{**}$ and $\gamma(L) = \gamma$ if $\theta = \theta^{*}$. We assume that θ has a uniform distribution over $[\theta^{*}, \theta^{**}]$. Equations (9) and (10) show that $L = \left(\frac{w_{min}}{\theta}\right)^{\frac{1}{\gamma}}$ over this range of θ. Note that along this range $\frac{d\ln L}{d\ln w_{min}} = \frac{1}{\gamma}$, so this is the range of θ for which increases in the minimum wage lead to increases in employment.

We also note that for $\theta < \theta^{**}$, the top line of equation (27) holds. In other words, $w = w_{min}$ and $L = L^{**}$ for all values of $\theta < \theta^{**}$. Equilibrium prices and quantities are identical for all values of θ where $\theta < \theta^{**}$. For this range of θ, increases in the minimum wage lead to employment reductions.

Lastly, we note that for $\theta > \theta^*$, the minimum wage does not bind and changes in the minimum wage will not affect employment. As pointed out below, however, our assumed distribution for $\theta > \theta^*$ will affect our value of α and α_G. Therefore we pick the distribution of $\theta > \theta^*$ to match the empirical distribution of wages for food away from home workers in the CPS outgoing rotation files.

We evaluate the model at the following values of θ. With probability $V \times prob(w_{min} > w(L^*))$, $\theta = \theta^{**}$. With probability $(1 - V) \times prob(w_{min} > w(L^*))$, θ is distributed uniformly over the interval $[\theta^{**}, \theta^*]$. With probability $1 - prob(w_{min} > w(L^*))$ the distribution of θ matches the empirical distribution of wages for $w > w_{min}$.

We must also re-calibrate the parameters α and α_G. Although equations (25) and (26) still hold for every value of θ, the variables Q, M, L and p vary with θ. Therefore, the equations need not hold in the aggregate. Nevertheless, we can still use the aggregate input shares:

$$s_L = \frac{\int w(\theta)L(\theta)dF(\theta)}{\int p(\theta)Q(\theta)dF(\theta)}, \tag{28}$$

$$s_M = \frac{\int p_M M(\theta)dF(\theta)}{\int p(\theta)Q(\theta)dF(\theta)}. \tag{29}$$

Note that the function $M(\theta)$ and $L(\theta)$ are also functions of α and α_G. This implies that equations (28) and (29) pin down α and α_G. In order to obtain the employment and price responses, we solve for equations (17), (18), (22), (24), (27), (28), and (29) to determine the price and employment level. Note that we must integrate over the distribution θ, which we do by discretizing θ over the range $[\theta^*, \theta^{**}]$. We then change the wage one percent, and re-compute the equilibrium price. In practice, we solve the model at three points for θ. Because moving from two to three points had a negligible effect on our results, we did not experiment with more points for θ.

Appendix C: Labor Demand when Capital Can Adjust

In this appendix, we solve for the case where $\alpha = 1$ and $\alpha_G \in (0, 1)$. All differences between this case and that where $\alpha_G = 1$ and $\alpha \in (0, 1)$ are purely notational. If $\alpha = 1$, then the production function reduces to

$$Q = ((1 - \alpha_G)K^{\rho_G} + \alpha_G L^{\rho_G})^{\frac{1}{\rho_G}}, Q = G. \tag{30}$$

Taking logs of equations (22) and (23) then yields:

$$\sigma_G(\ln r - \ln p) = \sigma_G \ln(1-\alpha_G) + \big(\ln Q - \ln K\big) \tag{31}$$

and

$$\sigma_G(\ln w - \ln p) = \sigma_G \ln \alpha_G + \big(\ln Q - \ln L\big) \tag{32}$$

respectively.

In this appendix, we make use of the following definitions:

$$\frac{d\ln K}{d\ln w_{min}} \equiv \mu \tag{33}$$

$$\frac{d\ln Q}{d\ln w_{min}} \equiv -\tau \tag{34}$$

in addition to $\frac{d\ln L}{d\ln w_{min}} \equiv -\lambda$. Differentiating equations (31) and (32) with respect to $\ln w_{min}$ and assuming $\frac{d\ln r}{d\ln w_{min}} = 0$[29] yields

$$\sigma_G\big(\frac{\tau}{\eta}\big) = \tau + \mu \tag{35}$$

and

$$\lambda = \sigma_G\big(1 - \frac{\tau}{\eta}\big) + \tau \tag{36}$$

respectively.[30]

[29] Since a small share of workers (and an even smaller share of the wage bill) is affected by the minimum wage, aggregate income and demand are probably impervious to changes in the minimum wage. Therefore, the interest rate is unlikely to be impacted as well.

[30] The only difficult part of deriving equations (35) and (36) is recognizing the fact that $\frac{d\ln p}{d\ln w_{min}} = \frac{\frac{d\ln Q}{d\ln w_{min}}}{\frac{d\ln Q}{d\ln p}} = \frac{-\tau}{-\eta}$. Note that τ represents the equilibrium output response to a minimum wage change. To see that the equilibrium output response to a price change caused by the minimum wage is merely the elasticity of demand, η, note that the production function is constant returns to scale. In other words, the supply curve for Q is horizontal. Because the supply curve is horizontal, shifts in the supply curve merely trace out the demand curve, which has elasticity η.

In order to obtain the output response to a minimum wage change, differentiate output with respect to the minimum wage:

$$\frac{dQ}{dw_{min}} = \frac{\partial Q}{\partial K}\frac{dK}{dw_{min}} + \frac{\partial Q}{\partial L}\frac{dL}{dw_{min}}. \tag{37}$$

Multiplying both sides by $\frac{w_{min}}{Q}$ and inserting equations (19) and (20), equation (37) can be rewritten as:

$$\frac{d\ln Q}{d\ln w_{min}} = (1-s_L)\frac{d\ln K}{d\ln w_{min}} + s_L\frac{d\ln L}{d\ln w_{min}}. \tag{38}$$

Combining equations (35), (36) and (38) and solving for the unknowns $\{\mu, \lambda, \tau\}$ yields:

$$\lambda = (1-s_L)\sigma_G + s_L\eta \tag{39}$$

which is equation (6) of the text, and

$$\tau = s_L\eta. \tag{40}$$

Recall that $\frac{d\ln p}{d\ln w_{min}} = \frac{\tau}{\eta}$ for reasons discussed in footnote 30. Consequently, equation (40) can be rewritten as

$$\frac{d\ln p}{d\ln w_{min}} = s_L \tag{41}$$

which is equation (8) of the text.

Equation (32) need not hold under monopsony. When the minimum wage is set between w^* and w^{**}, equation (36) must be replaced by

$$\lambda = -\frac{1}{\gamma}, \tag{42}$$

and equation (20) must be replaced by equation (27). Using equation (27) in place of (20), equations (19) and (37) can be rewritten as:

$$\frac{d\ln Q}{d\ln w_{min}} = (1-s_L)\frac{d\ln K}{d\ln w_{min}} + s_L(1+\gamma(L))\frac{d\ln L}{d\ln w_{min}}. \tag{43}$$

Combining equations (35), (42), and (43) gives us

$$\tau = -\frac{(1+\gamma(L))s_L\eta}{\gamma\Bigg(\sigma(1-s_L)+\eta s_L\Bigg)}. \tag{44}$$

Using $\frac{d\ln p}{d\ln w_{min}} = \frac{(}{\tau})\eta$, the price response is

$$\frac{d\ln p}{d\ln w_{min}} = -\frac{(1+\gamma(L))s_L}{\gamma\Bigg(\sigma(1-s_L)+\eta s_L\Bigg)}. \tag{45}$$

Appendix D: Labor Demand Under Monopolistic Competition when Capital Can Adjust

In this appendix we augment the model to allow for monopolistic competition in the output market, although we note that the results in this section hold if firms are monopolists in the output market as well. The critical assumption is that there is a constant elasticity of demand. If this is the case, there is a constant mark-up over marginal cost. Consequently, increases in labor cost are pushed onto the consumer, as is the case under perfect competition. For simplicity, assume the production function is the same as in Appendix B. In this appendix, we show that equilibrium elasticities are the same as in Appendix B as well.

We assume that consumers have the utility function

$$U = U\Bigg(Q_0, \tilde{Q}\Bigg) \tag{46}$$

where $\tilde{Q} \equiv \Bigg(\sum_{n=1}^{N} Q_n^{1-\eta_Z}\Bigg)^{\frac{1}{1-\eta_Z}}$ and Q_n denotes output at the nth restaurant. Furthermore, we assume that the aggregator $U(.,.)$ is such that

$$\frac{d\ln\tilde{Q}}{d\ln\tilde{p}} = -\eta \tag{47}$$

where $\tilde{p}$ is the price index associated with $\tilde{Q}$: $\tilde{p} \equiv \Bigg(\sum_{n=1}^{N} p_n^{\frac{\eta_Z-1}{\eta_Z}}\Bigg)^{\frac{\eta_Z}{1-\eta_Z}}$. Equation (47) is satisfied if $U(.,.)$ is a CES aggregator and the share of income spent on $\tilde{Q}$ is close to 0. Dixit and Stiglitz (1977) point out that two-stage budgeting techniques can be used to analyze this consumer demand problem. In the second stage the consumer solves:

$$\max_{\{Q\}_{n=1}^{N}} \left(\sum_{n=1}^{N} Q_n^{1-\eta_Z}\right)^{\frac{1}{1-\eta_Z}} \tag{48}$$

subject to

$$\sum_{n=1}^{N} p_n Q_n = X, \tag{49}$$

where X is total expenditure on $\tilde{Q}$. The consumer's first order condition for utility maximization yields

$$p_n = \lambda^{-1}\left(\frac{Q_n}{\tilde{Q}}\right)^{-\eta_Z} \tag{50}$$

where λ is the Lagrange multiplier on the budget constraint. If N is sufficiently large, then Q_n is small relative to $\tilde{Q}$ and thus the firm does not take into account the effect of Q_n on $\tilde{Q}$ when assessing the effect of Q_n on p_n.

Therefore, the nth firm's problem is to maximize

$$\pi(K_n, L_n) = \Omega Q_n^{1-\eta_Z} - rK_n - wL_n \tag{51}$$

where $\Omega = \lambda^{-1}\tilde{Q}^{\eta_Z}$. The first order conditions for profit maximization are:

$$w = \Omega(1-\eta_Z)Q_n^{-\eta_Z}\alpha_G\left(\frac{Q_n}{L_n}\right)^{1-\rho_G} \tag{52}$$

$$r = \Omega(1-\eta_Z)Q^{-\eta_Z}(1-\alpha_G)\left(\frac{Q_n}{K_n}\right)^{1-\rho_G}. \tag{53}$$

Taking logs of both sides of equations (52) and (53) and differentiating with respect to $\ln w_{min}$ yields

$$1 = -\frac{d\ln\lambda}{d\ln w_{min}} + \eta_Z\frac{d\ln\tilde{Q}}{d\ln w_{min}} - \eta_Z\frac{d\ln Q_n}{d\ln w_{min}} + \frac{1}{\sigma_G}\left(\frac{d\ln Q_n}{d\ln w_{min}} - \frac{d\ln L_n}{d\ln w_{min}}\right) \tag{54}$$

$$0 = -\frac{d\ln\lambda}{d\ln w_{min}} + \eta_Z \frac{d\ln\tilde{Q}}{d\ln w_{min}} - \eta_Z \frac{d\ln Q_n}{d\ln w_{min}} + \frac{1}{\sigma_G}\left(\frac{d\ln Q_n}{d\ln w_{min}} - \frac{d\ln K_n}{d\ln w_{min}}\right). \tag{55}$$

Note that in equilibrium all firms produce the same amount and thus prices p_n are equal. Using the definition of the aggregate quantity index $\tilde{Q}$ and price index $\tilde{p}$ we obtain

$$\tilde{Q} = N^{\frac{1}{1-\eta_Z}} Q_n \tag{56}$$

$$\tilde{p} = N^{\frac{\eta_Z}{\eta_Z - 1}} p_n. \tag{57}$$

Inspection of equation (56) shows that

$$\frac{d\ln\tilde{Q}}{d\ln w_{min}} = \frac{d\ln Q_n}{d\ln w_{min}}. \tag{58}$$

Moreover, equations (50), (56), and (57) show that

$$\frac{d\ln\lambda}{d\ln w_{min}} = -\frac{d\ln\tilde{p}}{d\ln w_{min}}. \tag{59}$$

Inserting equations (58) and (59) into equations (54) and (55) gives equations (31) and (32).

In order to get the output response to a change in the minimum wage, differentiate output with respect to the minimum wage, as in equation (37). Note, however, that the marginal products of capital and labor are:

$$\frac{\partial Q_n}{\partial K_n} = \frac{r}{p_n(1 - \frac{1}{\eta_Z})} \tag{60}$$

$$\frac{\partial Q_n}{\partial L_n} = \frac{w}{p_n(1 - \frac{1}{\eta_Z})}. \tag{61}$$

Using equation (37), multiplying both sides by $\frac{w_{min}}{Q}$ and using equations (60) and (61) yields

$$\frac{d\ln Q_n}{d\ln w_{min}} = \frac{1}{(1 - \frac{1}{\eta_Z})}\left[\frac{wL_n}{p_n Q_n}\frac{d\ln L_n}{d\ln w_{min}} + \frac{rK_n}{p_n Q_n}\frac{d\ln L_n}{d\ln w_{min}}\right]. \tag{62}$$

Note that $p_n Q_n(1 - \frac{1}{\eta_Z}) = wL_n + rK_n$. Inserting this into equation (62) gives equation (38), where $s_L = \frac{wL}{wL+rK}$. Because all firms are identical, $\frac{d\ln Q_n}{d\ln w_{min}} = \frac{d\ln Q}{d\ln w_{min}}$, where Q is aggregate output of all restaurants. Given that the equations and unknowns are the same as in Appendix B, the resulting elasticities are the same as in Appendix B.

Although all elasticities are the same as before, special care must be made in interpreting labor's share, s_L. Labor's share is labor's share of the firm's expenses, not labor's share of the firm's income. If the firm makes an economic profit, then the two will not be the same.

Lastly, we note that if firms are monopsonists in the labor market, the employment response to minimum wage change is as in equation (42). Therefore, the output response is determined by equations (31), (38) and (42), and thus the price response is the same as in equation (45).