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ABSTRACT

Elasticity of Supply to the Firm and the Business Cycle*

A body of recent empirical work has found strong evidence that the labor elasticity of supply to the firm is finite, implying that firms may have wage setting power. However, these studies capture only snapshots of the parameter. We study this parameter over a period that provides substantial variation in the business cycle. Using a rich employee level dataset from the inter-war period, we are able to estimate the elasticity of supply to the firm during several recessions and expansions. Our analysis suggests that the elasticity is indeed lower during recessions, consistent with the comparative statics from the Burdett-Mortensen search model. This differential wage setting power over the business cycle provides an alternative explanation of the pro-cyclicality of wages.

JEL Classification: J42, J31, J64

Keywords: monopsony, labor market frictions, business cycles

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1 Introduction

One of the most important, yet understudied, parameters of the labor market is the elasticity of labor supply to the firm. A finite elasticity of supply may contradict the classic assumption that firms have no wage setting power. If firms face no other constraints in setting wages, the finite elasticity will drive a wedge between a worker's wage and her marginal revenue product. Manning (2003) posits that labor market frictions imply that a model with upward sloping supply curves to the firm, as first described by Robinson (1933), best represents the labor market.[1] Ultimately, the value of the elasticity of supply to the firm is an empirical question. A small but quickly growing literature has attempted to estimate this parameter.[2]

All previous work has captured only snapshots of this elasticity. Our primary contribution is to study how this elasticity varies over the business cycle. We show that the Burdett-Mortensen search model predicts pro-cyclicality in the elasticity of supply to the firm. This implies that firms may have more wage setting power during recessions than during expansions. This is consistent with empirical evidence of the pro-cyclicality of wages, but provides a different theoretical basis than has been offered in the past: differential wage setting ability over the business cycle.

To test for the cyclicality of this parameter, we employ a rich dataset of employee records from the Ford Motor Company for the inter-war years of 1919 through 1940 (Whatley and Wright 1995). From this data, Whatley and Sedo (1998) and Foote, Whatley and Wright (2003) suggest that Ford may have enjoyed monopsony power during this period, but do not estimate the supply elasticity directly. This data covers five NBER defined contractions and six NBER defined expansions (Committee 2011). The highly volatile labor market during this period provides us with the variation needed in the business cycle to identify the cyclicality of the elasticity of supply to the firm. No other twenty year period provides us with the same frequency and degree of business cycle variation. Our primary finding is that the elasticity of supply to the firm, never more than six in

[1] For a more detailed summary of monopsonistic labor markets see Ransom (1993) and Boal and Ransom (1997)

[2] See Boal (1995), Ransom and Oaxaca (2005), Ransom and Oaxaca (2010), Hirsch, Shank and Schnabel (2006), Hirsch (2007), Hotchkiss and Quispe-Agnoli (2009), Ransom and Sims (2009), Ransom and Lambson (2011), Hirsch, Shank and Schnabel (2010), Falch (2010), and Falch (2011). Many of these estimates are in the range of 1 to 3. Dube, Lester and Reich (2011) estimate structural parameters of the Burdett-Mortensen search model using reduced form supply elasticities resulting from exogenous variation in minimum wages and find estimates in the 4 to 10 range. Staiger, Spetz and Phibbs (2010) use an exogenous wage change and find a short-run elasticity of supply of 0.1.

any period, drops by around half in a recession. Lack of an instrumental variable likely biases our point estimates of the elasticity downward. However, we show that we are likely *underestimating* the cyclicality of the elasticity as estimates are more biased during periods of economic growth than during periods of contraction, thus strengthening our results regarding the cyclicality of the parameter.

Our work also contributes to the literature on the identification of the labor elasticity of supply to the firm. First, our identification strategy extends the standard methodology by relaxing the assumption that the firm replaces all separations with recruits. This strategy is necessary because our study involves a long period of time involving large fluctuations in employment. It will also prove useful as a more robust estimation strategy for future researchers. Second, our rich-firm level data allows our empirical analysis to more closely follow the theoretical model than prior studies. Specifically, we document that a downward bias occurs when separation elasticities are calculated using both voluntary and involuntary separations, as has been done in the past.

2 Model and Empirical Strategy

We extend the standard model used to estimate labor supply elasticities to the firm to take into account fluctuations in the business cycle. Our extension is applicable for firms that are expanding or contracting employment. This allows us to credibly estimate how ϵ_{Lw} changes over the business cycle. We also present a simplified Burdett and Mortensen (1998) search model that provides the theoretical foundation for the dynamic monopsony setting. We derive predictions of how macroeconomic shocks cause changes in ϵ_{Lw} through changes in the structural parameters of the model.

2.1 Estimating Labor Elasticity of Supply to the Firm

Manning's (2003) dynamic model of monopsony provides the foundation for the estimation approach used in this paper. The model makes use of an assumption of a steady state in employment and an insight from Card and Krueger (1995) which provides a method for obtaining the long-run supply elasticities to the firm. From Card and Krueger (1995) the elasticity of supply to the firm is

$$\epsilon_{Lw} = \epsilon_R - \epsilon_s, \tag{1}$$

where ϵ_R is the recruitment elasticity and ϵ_s is the separation elasticity. When a firm is neither expanding nor contracting in employment, i.e. employment is in a steady state, Manning (2003) shows that $\epsilon_s = -\epsilon_R$. This identity is derived from the fact that workers in the same labor market face a similar job offer arrival rate, λ, and wage offer distribution, $F(\cdot)$. One can then simply apply the identity from Card and Krueger (1995) to show that $\epsilon_{Lw} = -2\epsilon_s$. This identity has been used in most previous work measuring ϵ_{Lw}, because separations are much easier to observe in data than are recruits. Thus, other studies implement a strategy estimating ϵ_s and then calculating ϵ_{Lw} as -2 times ϵ_s.

As the goal of this paper is to understand how the labor elasticity of supply to the firm, ϵ_{Lw}, varies over the business cycle, we must consider how to calculate ϵ_{Lw} when the firm's employment levels are not constant. To the best of our knowledge, prior work has not developed an estimation strategy robust to growth or contraction in employment at the firm.

We find that the generalized relationship between ϵ_{Lw} and ϵ_s is

$$\epsilon_{Lw} = -(1+\gamma)\epsilon_s \frac{s(w)}{1-[1-s(w)]\gamma}, \tag{2}$$

where γ is the inverse employment growth rate during the period and $s(w)$ is the separation rate. Note that when $\gamma = 1$, the elasticity of labor supply to the firm, ϵ_{Lw}, is simply equal to the result given above: $\epsilon_{Lw} = -2\epsilon_{sw}$. The derivation of equation 2 is found in the appendix.

It is easy to see that if $\gamma \neq 1$, an incorrect assumption of constant employment between time periods will generate a biased result. If the firm is expanding ($\gamma < 1$), ϵ_{Lw} will be overestimated, and if the firm is contracting ($\gamma > 1$), ϵ_{Lw} will be underestimated. This is important as we study how ϵ_{Lw} changes over the business cycle so that we do not over estimate the elasticity during expansion and under estimate it during contraction.

2.2 Pro-cyclicality in the Labor Elasticity of Supply to the Firm

Here we show how changes in two key structural parameters of the Burdett-Mortensen search model (the job offer arrival rate and the job destruction rate) affect the elasticity of supply to the firm. As would be expected, a higher rate of job arrivals and a lower rate of job destruction decrease frictions in the labor market and decrease attachment to a particular firm. In sum, the Burdett-Mortensen search model tells us that ϵ_s will be counter-cyclical and thus ϵ_{Lw} will be pro-cyclical.

In the Burdett-Mortensen model, the separation rate of employees at a firm, $s(w)$, is defined by

$$s(w) = \delta + \lambda[1 - F(w)], \tag{3}$$

where δ is the job destruction rate, or the rate at which employed workers exit the firm for non-employment, λ is the job offer arrival rate, and $F(w)$ is the probability that a wage offer dominates the current wage. The separation elasticity is therefore defined as

$$\epsilon_s = -\frac{ws'(w)}{s(w)} = \frac{-\lambda f(w)w}{\delta + \lambda[1-F(w)]}. \tag{4}$$

During an economic downturn, we would expect δ to increase[3] and λ to decrease. The reverse should hold during an expansion. The effects of changes in these two parameters on the elasticity of separation is

$$\begin{aligned}\frac{\partial \epsilon_s}{\partial \delta} &= \frac{f(w)\lambda w}{(\delta+\lambda[1-F(w)])^2} \geq 0 \\ \frac{\partial \epsilon_s}{\partial \lambda} &= -\frac{\delta f(w) w}{(\delta+\lambda[1-F(w)])^2} \leq 0. \end{aligned} \tag{5}$$

Thus, in an economic expansion as δ decreases and λ increases, the elasticity of separation (ϵ_s) decreases towards negative infinity, and the elasticity of labor supply to the firm (ϵ_{Lw}) increases towards positive infinity as the two elasticities are negatively related. In an economic downturn, as δ increases and λ decreases, the elasticity of separation and supply both approach zero. These two predictions are consistent with the literature that real wages are pro-cyclical, as a standard profit maximization model shows that firms set wages at $w = \frac{MRP_L}{1+\frac{1}{\epsilon_{Lw}}}$.

[3] The data documents this as δ is at its largest during the years 1930-1933 as the economy sank into the depths of the Great Depression. Also, Figure 4 shows how δ increases during contractions at Ford Motors.

3 Data

The data for this paper is extracted from a larger dataset covering a sample of employee records at Ford Motors from 1918 to 1947. The data's principal investigators, Warren Whatley and Gavin Wright, obtained employee work history through random sampling of archived records (Whatley and Wright 1995). Maloney and Whatley (1995) begin to convey the idea that Ford Motors may have had potential monopsony power over its workers. Later work by Whatley and Sedo (1998) studies the quit behavior of workers at Ford Motors. Although the labor supply parameters that are the focus of our paper are not estimated, their work did recognize potential monopsony power. They state that, "the additional monopsony power that employers have over black workers results in poorer job matches for black workers and lower reservation utilities. A lower reservation utility reduces job search and the propensity to quit." Foote et al. (2003) extends the work of Whatley and Sedo (1998) and also suggests the existence of monopsony power.

The data was obtained in such a way that only workers who had separated from Ford Motors by 1947 were intended to be included in the sample. Therefore, observations of workers with hire dates closer to 1947 are fundamentally different from those in earlier time periods. Observations for these workers had shorter tenure spans by construction of the sample. We limit our sample to pre-1941 data not only because of this sample selection bias, but also because Ford Motors became unionized in 1941 and the industrial landscape began to change due to the war. Observations from 1918 may have also been affected by policies related to World War I and are thus also omitted.

Each worker in the original sample is identified by a unique ID. When a job characteristic such as wage or job position changes, a new job record was recorded. Included in the job record is a variable that indicates when the job ended and whether the person moved internally in the firm, such as to a new position or even a new wage, or whether the move was external through quitting, being fired, being laid-off, military leave, etc.

In order to estimate the labor elasticity of supply to the firm, we needed the data to be structured into equal length periods. We follow an estimation approach similar to Ransom and Oaxaca (2010), who used year-end payroll data of a firm. We use the original Ford Motor employee data to create semi-annual observations of employment status, wages, and tenure. We chose semi-annual observations rather than annual observations because the average time between a wage change for an employee was typically between five to six months, as reported in Table 2.[4] Having finer time periods also allows us to more precisely estimate the cyclicality of the labor elasticity of supply to the firm.

The employee records provided the specific job title of each employee. However, these job titles were not systematically organized. To capture the causal effect of wages on separation, one needs to control for jobs or tasks that may be correlated with wages and that also affect an employee's decision to separate from the firm, for example, compensating wage differentials for working in undesirable jobs. We use the job titles from the data to create job-specific indicator variables. We found the most commonly used words to describe a job position and matched it with a corresponding indicator variable.[5]

Summary statistics for the Ford data are given in Table 1. Each observation in the table is a semi-annual worker observation as used in the analysis section. Table 2 provides detailed information on separations and nominal wage changes at Ford. Involuntary separations were not a trivial share of total separations in any time period. The number of nominal wage changes was dominated by upward changes. However, there were downward changes in wages in each period. From the second of 1929 through the first half of 1933, 35% of wage changes were downward.

We also obtained average and peak employment data from Ford's archive to calculate year to year growth rates during this period(Archives 1903-1972). Data on growth rates is needed to correctly adjust the elasticities when a firm's employment levels are not constant over time. Figure 1 shows both average and peak employment over the period of study.

[4]There is no consensus in the literature on the frequency of data to be used. Ransom and Oaxaca (2010) use yearly observations while Hotchkiss and Quispe-Agnoli (2009) use monthly observations. Intuitively, the length of time used should coincide with the employees' decisions to separate. Since we are interested in how wages affect separation decisions it seems appropriate to equate the length of the time period to the average time between wage changes. Also, as we are interested in changes in the parameter over the business cycle, our final results should be invariant to specification choices uniformly affecting the level of the parameter in different time periods, as a different choice of time frame may do.

[5]We chose to aggregate to the following ten job titles: assembly, operator, laborer, maker, gdr, trade, hand, upper, missing, and other. The "trade" job title refers to jobs such as welding and electrician. The title "hand" refers to jobs such as machine hand or press hand. "Upper" workers are in reference to clerks, inspectors, and foreman. The abbreviation "gdr" is unknown but commonly used.

4 Estimation Strategy and Identification

As shown previously, the elasticity of labor supply to a firm can be identified through the elasticity of separation. Between the years 1919-1940, Ford Motors was often expanding or contracting in employment. Manning's (2003) assumption that the firm's employment level is in a steady state can be relaxed if one knows the growth rates of the firm over the time period and applies the methods in Section 2. Here we explain how we will estimate the separation elasticities and then solve for the labor elasticity of supply to Ford Motors.

4.1 Estimation Strategy

We use a linear probability model (LPM) to estimate the elasticity of separation with respect to wage,[6]

$$s_i = \beta_0 + \beta_1 \ln(w_i) + X_i B + \mu_i, \tag{6}$$

where s_i is the binary variable indicating that individual i separated from their job at Ford Motors by voluntarily quitting. w_i is the wage of individual i and the vector X_i represents other observable variables for each individual that affect the separation decision. Included in X_i are age, job tenure, age and job tenure squared, race, marital status, job, plant, and year fixed effects. μ_i is a vector of unobserved variables.

We estimate four specifications of the LPM. The first specification excludes all controls except for year fixed effects which control for the price level. The second specification adds the individual level control covariates into the model. Controlling for actual experience at Ford is important, as we are trying to isolate the effect of wages on the decision to separate. Without controlling for this the true effect of wages on separation is confounded by more tenured workers receiving higher wages and being more attached to the firm because of other reasons. The third and fourth specifications add plant and job title fixed effects, respectively. Plant fixed effects control for working conditions, which varied across plants (Foote et al. 2003). The job titles are used to control for unobserved

[6] We also estimated the elasticities with a Probit model and found similar results. The choice to use the LPM over the Probit model mainly resulted from the ease in bootstrapping the standard errors. The Probit specification is much more sensitive than the LPM specification when bootstrapping over smaller samples. However, point estimates and statistical significance were similar between the two models when there was a relatively large sample.

tasks that were required of workers. Controlling for job titles and race is important in light of the evidence in Foote et al. (2003) showing that black workers were often placed into more dangerous and less desirable jobs than white workers.

The separation elasticity for each individual i is calculated from the linear regression model in the following way,

$$\hat{\epsilon}_{s,i} = \frac{\partial \hat{s}_i}{\partial w_i} \frac{w_i}{\hat{s}_i} = \frac{\hat{\beta}_1}{\hat{\beta}_0 + \hat{\beta}_1 \ln(w_i) + X_i \hat{B}}. \tag{7}$$

A point estimate of ϵ_{Lw} was calculated by first solving for the average separation elasticity, $\bar{\epsilon}_s = \frac{1}{N} \sum_i \hat{\epsilon}_{s,i}$, then applying equation 2 from Section 2.

Figure 1 shows the trends in average and peak employment at Ford Motors over our period of study.[7] Period specific γ's were obtained from the year level data seen in the figure. From 1919 through 1929 employment, for the most part, steadily increased; this is consistent with the general growth of the U.S. economy. Ford Motors experienced a large-scale contraction along with the U.S. economy between 1929 and 1933. Growth once again picked up in 1933.

Given these different economic conditions over the time period of study, we begin our analysis of the variation in ϵ_{Lw} by estimating the value of the parameter for each of the following three major sub-periods: 1) 1919 through the first half of 1929 ("The Roaring Twenties"), 2) the end of 1929 through the first half of 1933 ("The Great Contraction"), and 3) the period from the second half of 1933 through 1940 ("The New Deal").

We next turn our attention to the NBER defined expansions and contractions during our period of study. No other 22-year period in the United States during the 20th century observed such large and frequent fluctuations in the business cycle. We partition the data into 11 sub-periods for each expansion (6) and contraction (5) in the period of study. We then estimate the elasticity of supply to the firm for each sub-period.

4.2 Identification

Causal identification of the elasticity of separation is the first step in the identification of ϵ_{Lw}. To consistently identify the elasticity of separation, we must have variation in wages which is

[7] The data was obtained from the Ford Motor archives through personal request (Archives 1903-1972).

independent from other unobserved factors that affect the probability of separating. Our wage variation comes from different workers being paid different wages after conditioning on job title, plant location, year, tenure, and other demographic information. Even with this rich set of controls, we acknowledge the potential for omitted variable bias. Below we discuss the instrumental variable approaches that have been undertaken by a small number of papers in this literature, then we attempt to sign the bias that may affect our estimates.

Ransom and Sims (2009) is able to identify the elasticity of separation by instrumenting actual salaries with pre-negotiated salaries for school teachers. Similarly, Falch (2011) was able to exploit an exogenous wage change for a subset of school teachers. Ransom and Sims (2009) finds that without instrumental variables, the elasticity of separation is biased upward and as a result the labor elasticity of supply to the firm is biased downward. Other recent papers in this literature that have analyzed private sector data, like ours, have not been able to find a valid instrument to overcome endogeneity issues.[8]

Following the linear specification described above, suppose μ_i can be decomposed as $\tau y_i + \xi_i$. Therefore, the equation of interest is,

$$s_i = \beta_0 + \beta_1 \ln(w_i) + X_i\beta_2 + \tau y_i + \xi_i, \tag{8}$$

where y_i represents an unobserved variable that is correlated with $\ln(w_i)$ and ξ_i represents a vector of unobserved characteristics such that $E[\xi_i|ln(w_i), X_i, y_i] = 0$. As long as $\tau \neq 0$, the parameter of interest, β_1 cannot be estimated consistently:

$$\text{plim } \hat{\beta}_1 = \beta_1 + \tau\theta, \tag{9}$$

where θ is the coefficient on $\ln(w)$ in the population regression of the omitted variable, y, on $\ln(w)$

[8]To properly instrument for wages we need an instrument that is correlated with wages, does not directly affect separation decisions, and varies across individual employees. An ideal instrument would be a mechanism that randomly assigns wages to individual employees. Uncovering such an instrument in this context is difficult to imagine. Dube et al. (2011) is able to account for interactions among firms and workers in their estimation. Such equilibrium effects are important as identification comes through changes in the minimum wage which in turn affects the wage distribution of all firms. Our identification comes through variation in wages at Ford alone. However, outside firm-employee interactions are still a concern as we describe later in the section.

and X.

The potential endogeneity issue that arises in our study is the concern that outside labor demand shocks, y_i, faced by individual i are positively correlated with wages after controlling for individual characteristics as well as year, plant and job title fixed effects.[9] Therefore, θ is positive. Likewise, τ is believed to be positive as outside positive demand shocks for labor increase the job offer arrival rate, λ, and the probability of separating from the firm. With $\tau\theta > 0$, the estimated coefficient on $\ln(w)$, $\hat{\beta}_1$, is biased in a positive direction. Therefore, ϵ_s would also be biased in a positive direction, which would cause ϵ_{Lw} to be biased in a negative direction.

However, we expect that θ is not constant over the business cycle. Specifically, wages are typically more sticky downward than upward. Table 2 shows wage changes at Ford Motors over time. Although, we see variation in both directions, wages move upward more easily in periods with high outside labor demand than they move downward during periods of low outside labor demand. These movements suggest that the magnitude of the bias, $\tau\theta$, is not constant because θ is greater during times of economic expansion than during times of economic contraction. The greater downward bias during expansions implies that our estimate of the difference in the elasticity between expansions and contractions will also be biased downwards. Thus we will *underestimate* the pro-cyclicality of the elasticity of labor supply to the firm.

4.3 Estimation Bias from Involuntary Separations

The underlying idea in the search framework is that individuals voluntarily separate because they accept a higher wage elsewhere (Manning 2003). Therefore, identification of ϵ_{Lw} should come from seeing how wages and *voluntary* separations covary. The data used in previous empirical work has not specified the reason for separation, which creates measurement error problems. The Ford employee data specifies whether the separation was a voluntary quit or a forced lay-off or

[9] We also experimented with including peer variables that may be correlated with log wages and plausibly correlated with unobserved labor demand shocks. The three peer variables included in the estimation equation are the average wage of workers with the same tenure, workers in the same job title, and workers in the same plant. It is possible that individuals make wage comparisons between themselves and their peers when determining quitting decisions. However, the key idea behind the peer variables is to proxy for labor demand shocks at the individual level in order to minimize the endogeneity of wages. However, the estimated results were robust to the inclusion of these peer variables.

firing. Therefore, we are in the position to eliminate and assess the potential bias due to the misclassification of reasons for separating.

The bias is not straightforwardly signed when both voluntary and involuntary separations are used to estimate population parameter on $\ln(w)$, β. In the extreme case, suppose that involuntary separations, s_i', are orthogonal to log wages. Therefore, the estimate of β, using both voluntary and involuntary separations, is biased towards zero as it is a weighted average of zero and β. However, it is not clear that log wages are orthogonal to involuntary separations. One possibility is that log wages and involuntary separations are negatively correlated even after controlling for X_i. We address the direction of this bias empirically in the next section by comparing point estimates of the elasticity of supply to the firm under inclusion and exclusion of involuntary quits. Furthermore, we separately analyze the correlation between wages and fires and layoffs.

5 Results and Discussion

5.1 Main Results

Results from a set of linear probability model estimations using all years of data are presented in Table 3. In each estimation, we find a negative and statistically significant coefficient on log wage. The relatively small magnitudes of these coefficients suggest that a finite elasticity of labor supply to the firm is expected. The first specification includes only year fixed effects. In the second specification, we control for individual covariates. The linear tenure term is always negative and significant, while age is positively correlated with separations. Marital status has a marginally significant and positive effect on separations. The coefficient on an indicator variable for African-American workers is negative and always significant (consistent with Foote et al. (2003)). The third and fourth specifications include additional fixed effects for the plant at which the worker was employed and the worker's job title, respectively. The results are similar to the second specification and suggest robustness in our results after conditioning on key demographic variables.

In Table 4, we report the labor elasticity of supply to the firm (ϵ_{Lw}) from the estimation strategy outlined in Section 2 and 4, which incorporates γ. The standard errors on the elasticity estimates are obtained by bootstrapping with 500 replications.[10] Estimates of the elasticity obtained from pooling all years range from 3.03 to 3.88. The estimates from three major sub-periods are also reported in Table 4.[11] Across all four specifications we note a similar pattern. First, the estimate of the labor elasticity of supply to the firm in *The Roaring Twenties* is similar in magnitude to the estimate in the pooled sample (because a large fraction of observations come from those years). Second, the estimate of the labor supply elasticity falls sharply during the *Great Contraction*. This result is consistent with the finding of Bresnahan and Raff (1991), that show from the peak of 1929 to the trough of 1933, half of the U.S. auto plants shut down while only one third of U.S.

[10]To obtain the bootstrapped standard errors, we used the bootstrapping package provided by Stata. This package called a program from which an LMP was run and the supply elasticity was calculated post-estimation. We then found the standard deviation of the distribution of all 500 estimates of the elasticity provided, including from estimates in which not all parameters or their standard could be estimated. We presume that some parameters could not be estimated in every bootstrapped sub-sample on account of the high number of fixed effects in the full model combined with the relatively small sample size in some of the sub-periods.

[11]In the appendix we report the estimates of the linear probability model run for the preferred fourth specification for each of the three major sub-periods. The full set of results is available upon request from the authors.

manufacturing establishments were closed. Therefore, job specific capital that Ford workers had would have been relatively less demanded. Thus, the decrease in the elasticity of supply is due to this decrease in the job offer arrival rate (λ). None of our point estimates from *The Great Contraction* are significantly different from 0, thus we cannot reject a null hypothesis of perfectly inelastic labor supply to the firm during this period.[12] Finally, during the recovery period beginning after 1933, the labor supply elasticity increases to levels comparable to those of the *Roaring Twenties*. Elasticities during the *New Deal* were slightly higher than during the *Roaring Twenties*, suggestive of the effects of various changes to the labor market enacted during the *New Deal*.[13]

The results in Table 4 are prima facia evidence of the pro-cyclicality of the elasticity of labor supply to the firm: the elasticity plummeted as the country sank into the Great Depression, and then increased in value as the economy began to recover. We now further examine this relationship using finer sub-periods in time from our data. First, in Figure 2 we present estimates of the elasticity obtained from pooling data into three period windows.[14] The figure also plots the national unemployment rate.[15] We see more evidence consistent with pro-cyclicality of the elasticity: the large increase in unemployment beginning after 1929 is consistent with the plummeting elasticities during this period. While the persistently high unemployment of the mid 1930s is not consistent with the increasing elasticity during the same time, we do see the unemployment rate start to decrease in 1934, around the time the elasticity of supply starts to increase.

[12]While we would expect that the economic conditions during this period would create very inelastic labor supply, we also believe that our estimates tend to be biased downwards for reasons as noted previously. Ransom and Sims (2009) find that estimates of the elasticity of supply to the firm are biased downward prior to implementing instrumental variables. This is consistent with Falch (2010) who finds downward bias through omitted variables.

[13]The Wagner Act of 1935 expanded employee collective bargaining rights and resultantly union membership rose. While Ford did not unionize until 1941, General Motors and Chrysler unionized during the mid 1930s. As union contracts increased wages significantly (we see this in our data from Ford when comparing 1940 and 1941), this likely shifted the wage offer distribution to the right for Ford workers (as GM and Chrysler's wages increased more quickly than Ford's.) The Fair Labor Standards Act of 1938 set a national minimum wage and overtime requirements. The Federal Emergency Relief Administration, the Civil Works Administration, and the Works Progress Administration, all created in the New Deal era, offered government sponsored work relief on a large scale. These would have the effect of increasing the job arrival rate during this period. Social insurance programs were created through the Social Security Act of 1935. Such reform likely impacted the reservation wage of workers. See Fishback (2008) for a more detailed summary of New Deal policies.

[14]To make the scale of the figure more concise, we bound the elasticity at its theoretical lower bound of 0. The approximate values of the parameter not shown above are as follows for each window centered around the given year: 1931(I) is -3.7, 1931(II) is -6.7, 1932(I) is -4.9, 1932(II) is -6.0, 1933(I) is -1.2.

[15]Source of unemployment data is drawn from Romer (1986) and Coen (1973) as compiled by at http://en.wikipedia.org/wiki/User_talk:Peace01234 .

A cleaner test for the pro-cyclicality of the elasticity requires a sharper definition of the state of the economy. Therefore, we turn to NBER business cycle data that defines peak and trough dates of the business cycles throughout the 1920s and 1930s in order to directly test whether recessions decrease the labor elasticity of supply to the firm. Figure 3 presents the 11 NBER defined sub-periods and the estimates of the labor elasticity of supply to the firm in each sub-period.[16] Six blue dots represent estimates obtained during periods of expansion, while five red dots represent estimates obtained during recessions. The size of each dot is proportional to the number of years represented. With the exception of the first recessionary sub-periods, we see that whenever the economy fell into recession, our estimate of the elasticity was lower than in the expansions that preceded and followed the recession.[17] This data is also presented in Table 5. Arrows indicate the direction of the economy in the period. Note that with the lower elasticities in recessionary periods also come higher markdown rates.[18]

Finally, in Table 6 we present the results of tests for the pro-cyclicality of the elasticity of labor supply to the firm using the data presented in Table 5 and Figure 3. We regress both the level of the elasticity and changes in the elasticity on an indicator variable for a recessionary sub-period. Additionally, we perform non-parametric tests of a null hypothesis that the estimated elasticities during expansions and contractions resulted from the same data generating process.

We run three parametric regressions on each dependent variable; these differ according to regression weights used. Regardless of the weights, all 6 regressions yield negative coefficients varying between -1.12 and -5.09, indicating the economic significance of a recession on the elasticity of labor supply to the firm. Our first weighting strategy is to weight by the inverse of the standard error on the point estimate of the elasticity in the sub-period. Thus, when using this weight, we put more weight on periods for which we have a more precise estimate. Our second weighting strategy is to weight proportionately to the number of years covered in each sub-period. This weight allows the model to put more weight on longer expansions or contractions. This may be appropriate for

[16] We define a semi-annual period as being part of an expansion/recession if more than half of the period was in an NBER defined expansion/recession.

[17] We present this same figure with the supply elasticities calculated by multiplying the separation elasticity by negative two in Appendix Figure 1. This evidence points more strongly towards pro-cyclicality of the parameter.

[18] The potential markdown is defined as $\frac{MRP_L - w}{MRP_L}$ and was equated through the identity that the rate of potential employee exploitation is equal to the inverse of ϵ_{Lw}.

two reasons. If we consider an observation to be a recession or an expansion, this weighting is not necessary. But if we consider an observation to be a time period in a given economy, we should put more weight on longer expansions and contractions than on shorter ones. Second, a recession may require some persistence in order to affect the elasticity of supply to the firm. This weighting strategy would capture the effects of persistence. Finally, we weight by the product of both of the weights described above, addressing both of the issues discussed here simultaneously.

We find negative but insignificant results when weighting by the inverse of the standard errors for both of the dependent variables. However, when we weight by period length, we find negative results that are significant at the 5% level for the elasticity level and 10% level for changes in the elasticity. Finally, when weighting by the product of the two earlier weights, we find negative and marginally significant results. Our non-parametric test is a Mann-Whitney "ranksum" test. The null hypothesis is that elasticity estimates for both the recession and expansion periods were generated by the same data generating process. We are able to reject the null at the 0.0001 level. This rejection implies that the data generating process for recessionary periods produced lower elasticities of supply.

Together, these results confirm the comparative statics derived from the Burrdett-Mortensen model and presented in Section 3, namely that the labor elasticity of supply to the firm is procyclical. Potential downward estimation bias of the elasticity is larger during periods of economic growth. Therefore, endogeneity issues bias us against finding a result.

5.2 Additional Estimation Issues

5.2.1 Employment Adjustment and Voluntary Quits

Here we address the importance of adjusting for changes in the employment level over time and using only voluntary quits to estimate ϵ_{Lw}. To examine the potential bias we 1) re-estimated the model without adjusting for changes in the employment level and using only voluntary quits, and 2) re-estimated the model where we adjust for employment changes but include both voluntary and involuntary separations in the analysis. The results in Table 8 are estimated from specification four, which included individual controls as well as year, plant, and job title fixed effects. Both types of specification error impact the estimates of ϵ_{Lw}.

If the firm is expanding employment and we use the traditional approach of setting $\epsilon_{Lw} = -2\epsilon_s$ then the ϵ_{Lw} is over-estimated. Similarly, if the firm's employment level is decreasing and we follow the traditional approach, ϵ_{Lw} will be under-estimated. This is confirmed with the results in Table 8, which show that the Unadjusted estimate of ϵ_{Lw} is above the Preferred estimate when employment expanded. During the employment expansion of the Roaring 20s period the Unadjusted estimate is 3.93, which is approximately 17% larger than the Preferred estimate of 3.36. Similarly, the New Deal period shows an Unadjusted estimate of 5.53, which is approximately 18% larger than the Preferred estimate of 4.70. Things are more complicated during the Great Depression period as the estimates are negative (although not statistically different from zero) and therefore the adjustment procedure is not valid.[19]

Table 2 shows the number of observed separations that are not voluntary. During the whole period of study, involuntary separations accounted for around 20% of total separations. Notably, layoffs and firings were an even larger share of total separations during the two periods in the Great Depression. Figure 4 shows voluntary and involuntary separation rates over the period of study. Voluntary separations appear to be pro-cyclical and involuntary separations appear to be counter-cyclical. To further analyze the heterogeneity in separation behavior we present the results from three regressions in Table 7. The specification is identical to the preferred specification described above. However, the sample includes separations through fires and lay-offs instead of quits. The first column shows there is a negative relationship between log wages and involuntary separations, but the magnitude is several times smaller than the main results from the preferred specification in Table 3. The second and third column separately show the correlation between log wages and fires and quits, respectively. Log wages are negatively related with fires at a statistically significant level, but not for lay-offs.

The potential bias from including involuntary quits in the analysis can be found by comparing the estimates from the column labeled "Invol Quits" in Table 8 to our preferred estimates. Adding involuntary separations to voluntary quits leads to lower estimates of the labor elasticity of supply

[19]See Appendix Figure 1 for the effect of using the traditional approach over the NBER established business cycles.

in all periods. Therefore, previous work that has identified ϵ_{Lw} through all separations is likely to have underestimated ϵ_{Lw} if involuntary separations occurred with high frequency.

5.2.2 Efficiency Wages at Ford Motors and Separation

Ford Motors is commonly cited as paying an efficiency wage. Is an efficiency wage during the time period simply causing a lack of separations, thus driving the finite elasticities at the firm? Raff (1986) and Raff and Summers (1987) establish that Ford did pay higher than market wages around 1914. However, when one considers the entire labor market during our period of study, all auto manufacturing firms were paying high wages. Rae (1965) finds that in the mid to late 1920s auto companies were paying wages that were nearly 40% greater than firms in other manufacturing industries. Using the 1940 U.S. Census (Ruggles, Alexander, Genadek, Goeken, Schroeder and Sobek 2010) and the Ford employee data from 1939 and 1940, we find that Ford's wages were 17.6% higher than other durable good manufacturing wages in Michigan after controlling for age and race. Work by Bresnahan and Raff (1991) also documents heterogeneity in firms that existed during this period. If we believe that Ford competes primarily with other auto plants for employees, we should then consider the entire labor market of auto workers.

Table 2 shows that in the time periods studied the semi-annual ratio of voluntary quits to non-separations ranged from .13 during the *Great Contraction* to .35 during the *Roaring 20s*. Therefore, although Ford may have been paying an efficiency wage, the size of the efficiency wage was not large enough to stop high voluntary turnover. Importantly, the identification strategy relies on estimating voluntary separations on log wages. Therefore, as long as there is sufficient variation in log wages and observed voluntary separations, one can estimate ϵ_{Lw}. Furthermore, our focus is on how this parameter changed over this period of time. So our results about the changes in the elasticity over time should be informative, even if our point estimates from Ford are not representative of the typical firm.

5.3 Potential Wage Mark Downs and Pro-cyclical Real Wages

A firm facing a finite elasticity of supply is able to pay a wage less than the marginal revenue product of labor. Therefore, given the pro-cyclicality of the labor elasticity of supply, the negative effects of a recession can mitigated through lower labor costs. Table 8 reports the potential wage markdown and its 95% confidence interval for the entire time period as well as the three major sub-periods. We provide no evidence that Ford exploited the finite elastic labor supply and actually paid workers less than their MRP_L. The results suggest that during the Roaring 20s the potential markdown on wages was 23% (wages potentially equated only 77% of MRP_L). A perfectly inelastic supply of labor to the firm during the *Great Contraction* suggests a potential 100% markdown of wages. However, the upper-bound of the imprecise estimate suggests a potential markdown of only 27%. The expected New Deal period potential markdown was 18%.

The relationship between real wages and the business cycle has been studied in a number of settings, including noncompetitive *output* markets and with price markups (Abraham and Haltiwanger 1995). However, to our knowledge, the relationship has not been studied in a setting with noncompetitive *input* markets, where firms can pay below the perfectly competitive wage through finite ϵ_{Lw}. A pro-cyclical ϵ_{Lw} allows for firms to mark down wages during economic downturns and forces firms to pay more competitive wages during economic growth. Our results provide an additional explanation for pro-cyclical real wages. Bils (1985) shows convincing evidence that real wages are pro-cyclical by using disaggregated panel data. Beaudry and DiNardo (1991) develops a contract model to understand how labor market conditions affect real wages. Under the condition that mobility between firms is costly (labor market frictions), the model predicts the unemployment rate at the time of hire and the individual's entered into contract wage to be negatively correlated. This is consistent with the monopsonistic outcome that labor market frictions can grant firms the ability to pay workers less than their marginal revenue product of labor.

Solon, Whately and Stevens (1997) uses the Ford Motor Employee data set to try to explain that empirical evidence suggests that real wages are pro-cyclical. While we focus on ϵ_{Lw} as a potential cause, they show that intra-firm mobility can also explain the pro-cyclicality of real wages for individuals who do not separate from the firm.

6 Conclusion

Our study has for the first time addressed both theoretical and empirical evidence that the labor elasticity of supply to the firm is pro-cylical. Comparative statics on the Burdett-Mortensen search model predict that the labor elasticity of supply to the firm should increase during economic expansion and decrease during economic contraction. Examining data that allows us to identify the relationship between the elasticity and the business cycle, we find evidence that the elasticity is lower during recessions than it is during expansions. Regressions that weight by the length of the business cycles examined in our data allow us to reject the null hypothesis at the 5% level that the mean elasticity is the same during expansionary and contractionary periods. Non-parametric tests unequivocally allow us to reject a null that elasticities in these two states of the economy come from the same data generating process.

We also present two identification related contributions. First, we derive a generalized estimation strategy that can be applied to data sets where the firm's employment level is not constant. Second, we find that the inclusion of involuntary separations in the estimation of the elasticity of supply to the fir can create significant attenuation bias if there is a high frequency of involuntary quits.

The elasticity of supply to the firm potentially plays a large role in how wages and employment levels are determined within labor markets. A pro-cyclical labor elasticity of supply to the firm allows firms to mark down wages during economic contractions and forces firms to pay more competitive wages during economic expansions. This is consistent with recent work establishing that wages are pro-cyclical, but under the scope of a new mechanism. It also provides insight into how reduced labor costs for a firm can mitigate potential economic losses during a recession. Our research adds to a small but growing literature on the elasticity and furthers future work with its methodological contributions.

Table 1: Summary Statistics

	Mean	SD	Min	Max	N
1919(I)-1940(II)					
Separations	0.222	0.416	0.000	1.000	6979
Wage	0.799	0.143	0.130	2.030	6979
Age	31.201	7.413	15.000	57.500	6967
Tenure	2.413	2.935	0.000	21.000	6967
Married	0.535	0.499	0.000	1.000	6967
Black	0.077	0.266	0.000	1.000	6967
1919(I)-1929(I)					
Separations	0.257	0.437	0.000	1.000	5255
Wage	0.788	0.139	0.300	2.030	5255
Age	30.567	6.644	16.500	57.500	5243
Tenure	1.802	2.043	0.000	14.000	5243
Married	0.527	0.499	0.000	1.000	5243
Black	0.072	0.258	0.000	1.000	5243
1929(II)-1933(I)					
Separations	0.113	0.317	0.000	1.000	820
Wage	0.878	0.169	0.130	1.630	820
Age	34.659	7.955	18.000	51.000	820
Tenure	4.273	3.438	0.000	14.500	820
Married	0.632	0.483	0.000	1.000	820
Black	0.066	0.248	0.000	1.000	820
1933(II)-1940(II)					
Separations	0.123	0.328	0.000	1.000	904
Wage	0.797	0.119	0.250	1.150	904
Age	31.744	9.838	15.000	57.500	904
Tenure	4.268	4.769	0.000	21.000	904
Married	0.494	0.500	0.000	1.000	904
Black	0.115	0.319	0.000	1.000	904

Table 2: Separations and Wage Changes at Ford

	1919(I)-1940(II)	1919(I)-1929(I)	1929(II)-1933(I)	1933(II)-1940(II)
# Stays	5422	3902	727	793
# Quits	1545	1341	93	111
# Fires	193	163	20	10
# Layoffs	260	32	148	80
Wage Δ Per Worker	1.34	1.13	1.28	1.87
Δ Up	0.89	0.92	0.65	0.93
Δ Down	0.11	0.08	0.35	0.07
Avg Days between Δ	152.41	150.65	169.89	174.97

Table 3: LPM Estimates for Years 1919(I) through 1940(II)

	Year FEs	**Year FEs**	**Year and Plant FEs**	**Year Plant and Job FEs**
Log Wage	-0.47	-0.37	-0.39	-0.39
	(0.039)	(0.040)	(0.041)	(0.042)
Black		-0.07	-0.07	-0.08
		(0.016)	(0.016)	(0.017)
Age		0.01	0.01	0.01
		(0.005)	(0.005)	(0.005)
Age-Squared		-0.00	-0.00	-0.00
		(0.000)	(0.000)	(0.000)
Tenure		-0.04	-0.04	-0.03
		(0.004)	(0.004)	(0.004)
Tenure-Squared		0.00	0.00	0.00
		(0.000)	(0.000)	(0.000)
Married		0.01	0.01	0.02
		(0.011)	(0.011)	(0.011)
R-squared	0.099	0.114	0.117	0.123
N	6979	6967	6967	6967

[1] Robust Standard Errors in parentheses.

Table 4: Elasticity Estimates Over Major Sub-Periods

	Spec 1	Spec 2	Spec 3	Spec 4
1919(I)-1940(II)	3.88	3.03	3.23	3.19
	(0.31)	(0.34)	(0.33)	(0.35)
1919(I)-1929(I)	4.15	3.20	3.41	3.36
	(0.30)	(0.32)	(0.32)	(0.34)
1929(II)-1933(I)	1.04	-1.29	-0.61	-0.90
	(1.43)	(1.65)	(1.73)	(1.84)
1933(II)-1940(II)	4.54	4.30	4.63	4.70
	(1.37)	(1.39)	(1.69)	(1.70)

[1] Bootstrap standard errors presented in parentheses from 500 replications.

Table 5: Business Cycle (NBER) Estimates

Start Year	End Year	BS Direction	Elasticity of Supply	Markdown	Obs
1919(I)	1919(II)	↗	1.59	0.39	228
			(2.05)		
1920(I)	1921(I)	↘	5.00	0.17	410
			(1.18)		
1921(II)	1923(I)	↗	3.82	0.21	977
			(0.68)		
1923(II)	1924(I)	↘	2.98	0.25	711
			(0.89)		
1924(II)	1926(II)	↗	3.90	0.20	1692
			(0.81)		
1927(I)	1927(II)	↘	0.72	0.58	363
			(2.69)		
1928(I)	1929(I)	↗	3.28	0.23	862
			(0.82)		
1929(II)	1933(I)	↘	-0.90	1.00	820
			(1.85)		
1933(II)	1937(I)	↗	5.49	0.15	504
			(2.10)		
1937(II)	1938(I)	↘	3.49	0.22	118
			(8.86)		
1938(II)	1940(II)	↗	4.61	0.18	282
			(2.95)		

[a] Bootstrap standard errors displayed in parentheses from 500 replications.

Table 6: Parametric and Non-Parametric Test

		$\frac{1}{SE}$	# of Periods	$\frac{\text{\# of Periods}}{SE}$	Non-Parametric
	β	-1.120	-3.474	-2.816	
Level	p-value	0.340	0.043	0.126	.0001
	Obs	11	11	11	44
	β	-1.831	-5.090	-3.473	
Difference	p-value	0.351	0.055	0.190	.0001
	obs	10	10	10	42

Table 7: LPM Estimates on Involuntary Quits

	Fires and Layoffs	**Fires**	**Layoffs**
Log Wage	-0.09	-0.08	-0.02
	(0.024)	(0.018)	(0.019)
Black	-0.00	0.00	-0.00
	(0.013)	(0.009)	(0.010)
Age	-0.00	-0.00	-0.00
	(0.004)	(0.003)	(0.003)
Age-Squared	0.00	-0.00	0.00
	(0.000)	(0.000)	(0.000)
Tenure	-0.01	-0.01	-0.00
	(0.003)	(0.002)	(0.002)
Tenure-Squared	0.00	0.00	-0.00
	(0.000)	(0.000)	(0.000)
Married	-0.01	0.00	-0.01
	(0.008)	(0.005)	(0.006)
R-squared	0.112	0.040	0.181
N	5875	5615	5682

[1] Robust Standard Errors in parentheses.

Table 8: Bias Reduction and Potential Wage Markdown[a]

	Invol Quits	Unadjusted	Preferred	CI Low	CI High	Markdown	Markdown High	Markdown Low
1919(I)-1940(II)	2.61	3.50	3.19	2.50	3.83	0.24	0.29	0.20
	(0.30)	(0.39)	(0.35)					
1919(I)-1929(I)	3.16	3.93	3.36	2.69	4.03	0.23	0.27	0.20
	(0.31)	(0.40)	(0.34)					
1929(II)-1933(I)	-1.72	-0.59	-0.90	-4.51	2.72	1.00	1.00	0.27
	(0.90)	(1.22)	(1.84)					
1933(II)-1940(II)	3.65	5.53	4.70	1.37	8.03	0.18	0.42	0.11
	(0.95)	(2.00)	(1.70)					

[a] "Markdown" represents the potential proportion of MRP_L that wages are marked down ($(MRP_L - w)/MRP_L$) through the firm exploiting a finite labor elasticity of supply.

Figure 1: Employment at Ford Motors

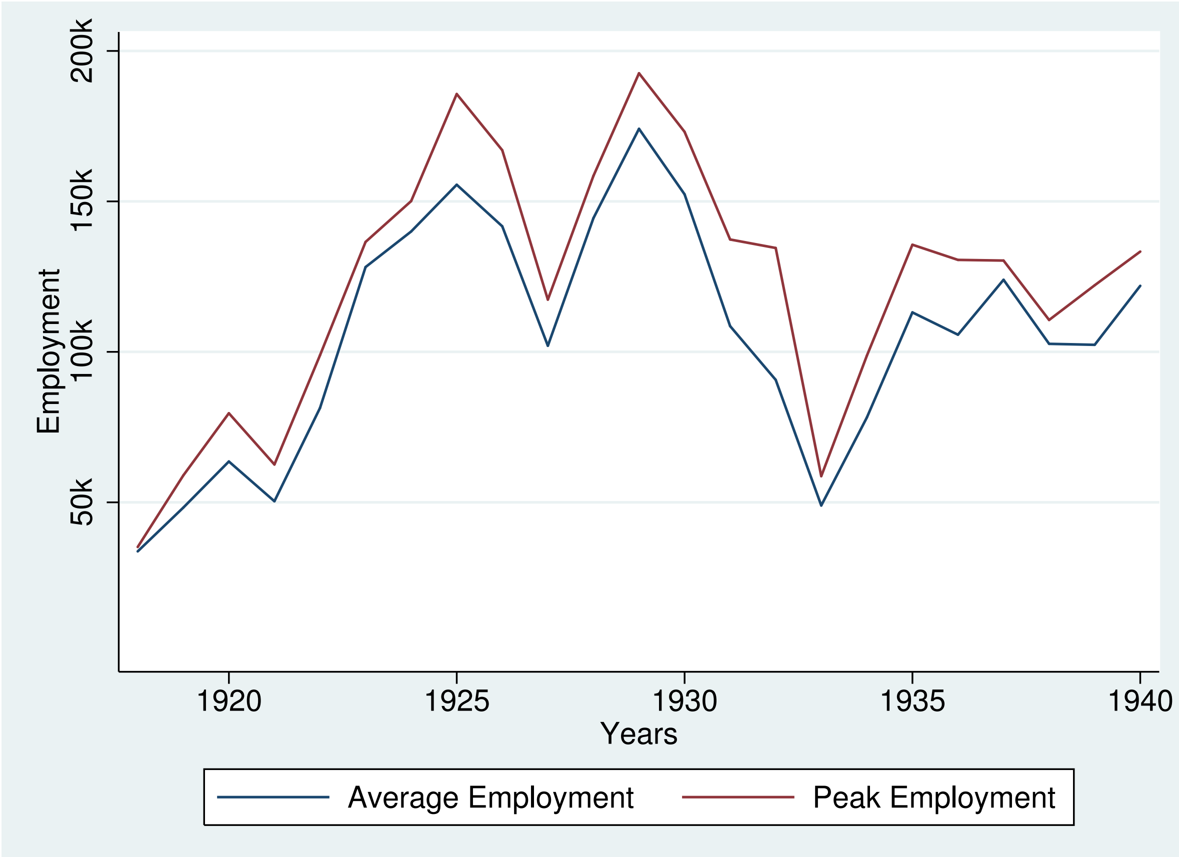


Figure 2: Elasticities over Time at Ford (1.5 Year Avg)

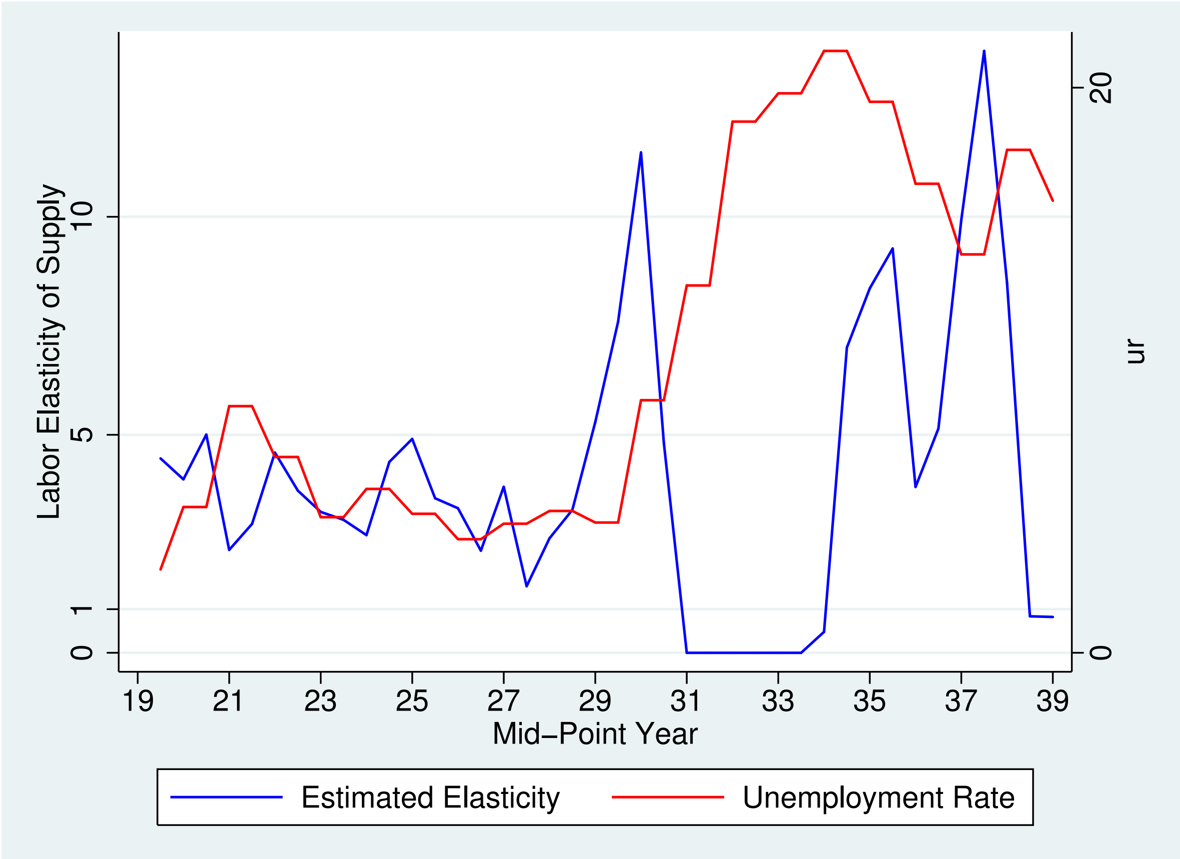


Figure 3: Elasticity of Supply to the Firm and the Business Cycle (NBER)

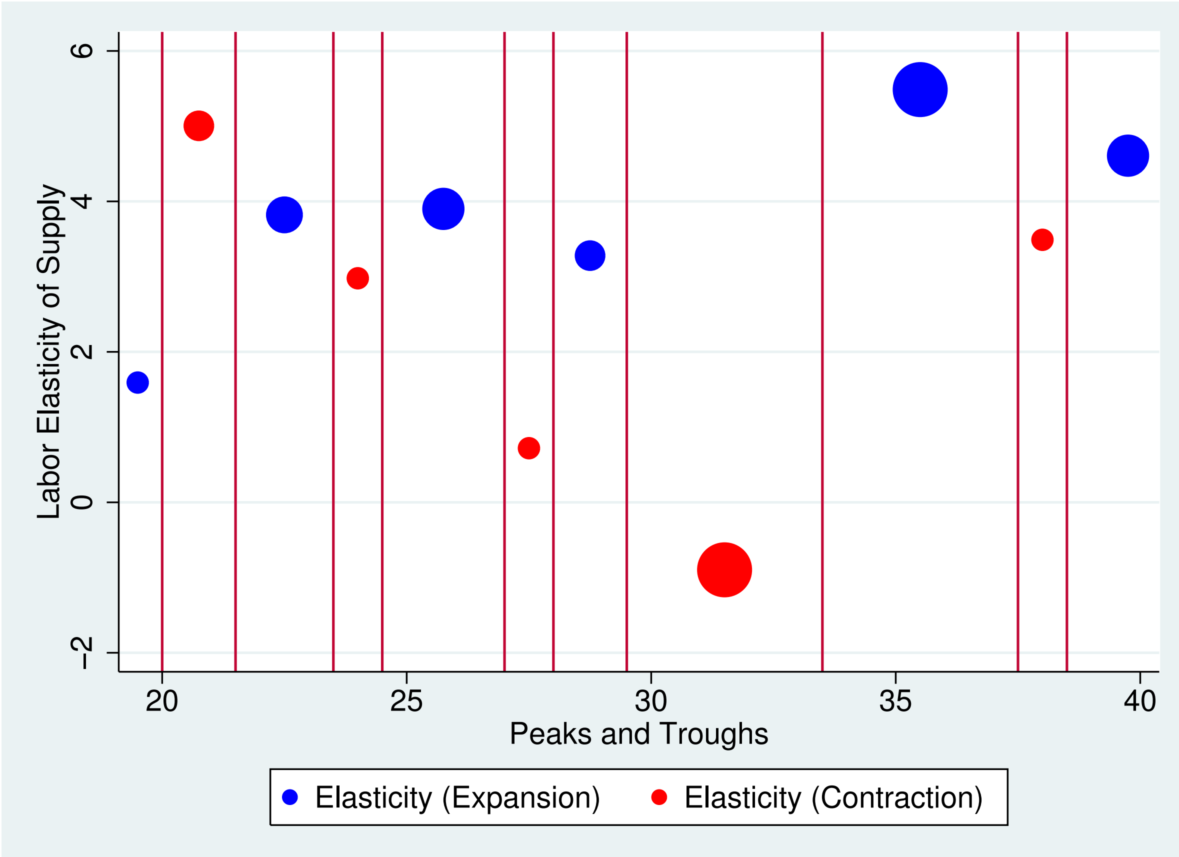
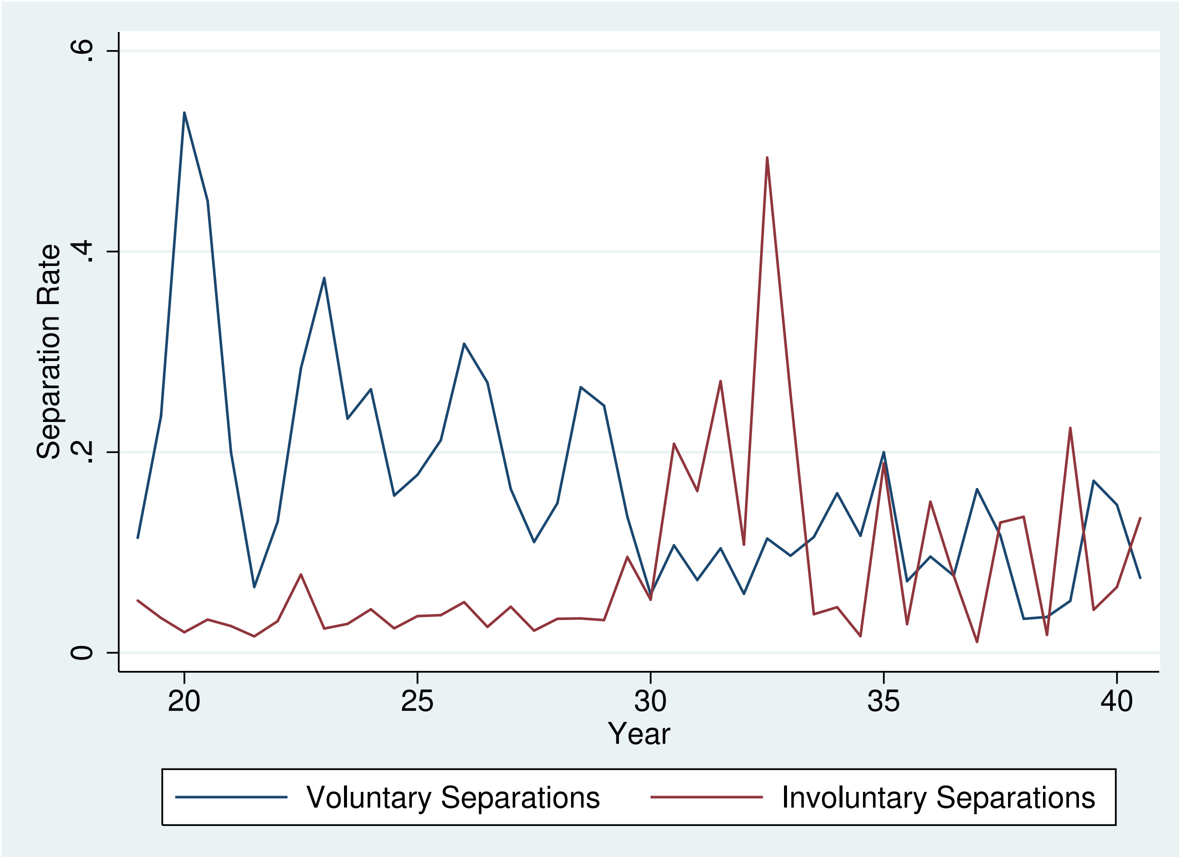


Figure 4: Separation Rates by Type



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A Appendix

A.1 Elasticity of Supply to the Firm with Changes in Employment

In this section we derive the relationship between the elasticity of supply to the firm, ϵ_{Lw}, and the elasticity of separation to the firm, ϵ_s, while relaxing the assumption that the firm is neither expanding or contracting. By knowing the employment growth rate and separation rate at the firm, we show a straightforward relationship between ϵ_{Lw} and ϵ_s. We begin by showing the relationship derived by Manning (2003) which is only applicable when separations in the firm are replaced by recruits. We then show our extension to the model which is more applicable when studying ϵ_{Lw} while employment at the firm is not constant.

Let $s(w)$ represent the rate at which workers separate from the firm and $R(w)$ represent the number of new recruits (workers) that are employed at the firm in a given time period. Therefore, if a firm has L_{t-1} workers last period and pays w_t this period, the firm's labor supply this period is

$$L_t = [1 - s(w_t)]L_{t-1} + R(w_t). \tag{10}$$

If the firm's employment is constant, $L_t = L_{t-1}$, replacing L_{t-1} for L_t in equation 10 and solving for L_t results with,

$$L(w) = \frac{R(w)}{s(w)}.$$

By taking the log of each side and differentiating with respect to w, the following equality holds:

$$\epsilon_{Lw} = \epsilon_R - \epsilon_s,$$

where ϵ_R is the recruitment elasticity and ϵ_s is the separation elasticity. Manning (2003) shows that through the Burdett and Mortensen (1998) search model, $\epsilon_s = -\epsilon_R$. This relationship results from separations and recruits having common job offer arrival rates and facing the same wage offer distribution in the labor market. As separations are much easier to observe in data than recruits, this result is extremely important in allowing researchers to estimate the ϵ_{Lw} under the assumption that the firm's employment is constant.

To study the ϵ_{Lw} over a period of time it is more difficult to satisfy the assumption that a firm's employment levels are constant. Therefore, multiplying the separation elasticity by negative two does not correctly calculate the ϵ_{Lw}. Let γ represent a parameter that measures the inverse growth rate of the particular firm. If $\gamma < 1$ the firm is expanding, if $\gamma > 1$ the firm is contracting, and if $\gamma = 1$ the firm's employment is constant. As shown, relaxing the assumption that $\gamma = 1$ allows us to derive a generalized relationship between labor elasticity of supply to the firm, the elasticity of recruits to the firm, and the elasticity of separations from the firm.[20]

Consider the dynamic equation relating employment this year to employment last year. We substitute for L_{t-1}, however we relax the assumption of employment being constant between periods by introducing our γ term,

$$L_t = [1 - s(w_t)]L_{t-1} + R(w_t) = [1 - s(w_t)]\gamma L_t + R(w_t).$$

[20] In practice, γ could be computed using either the change between $t-1$ and t or the change between t and $t+1$. Because the choice of using next or previous period is arbitrary, we choose to use an average of both. Specifically, we find the ratio of employment between the pervious and succeeding calendar year and take the quartic root of this to obtain the semi-annual change over the period.

Therefore,

$$L_t = \frac{R(w_t)}{1 - [1 - s(w_t)]\gamma}. \tag{11}$$

Taking logs and simplifying, we have

$$ln(L_t) = ln(R(w_t)) - ln(1 + s(w_t)\gamma - \gamma).$$

Differentiating the above equation and multiplying by w we have

$$\begin{aligned} \epsilon_{Lw} &= \epsilon_R - \frac{\gamma s'(w_t)w_t}{1 + \gamma s(w_t) - \gamma} \\ \epsilon_{Lw} &= \epsilon_R - \epsilon_s s(w_t)\frac{\gamma}{1 + \gamma s(w_t) - \gamma} \end{aligned} \tag{12}$$

We can see above that there is now a more complex relationship between changes in wages and changes in labor supply to the firm. We have found the effect through separations.

Our challenge now is to find ϵ_R in terms of ϵ_s. To do this, we turn to the definition of the recruitment elasticity and then to the search model. The elasticity of recruitment with respect to the wage can be expressed by

$$\epsilon_R = \frac{w \times R'(w)}{R(w)}. \tag{13}$$

Under the Burdett and Mortensen (1998) model, the recruitment function is given by

$$R(w) = R^u + \lambda \int_0^w f(x)L(x)\mathrm{d}x,$$

where R^u is the amount of recruits that are hired from unemployment, λ is the job offer arrival rate, $f(w)$ is the density wage offers. Thus,

$$R'(w) = \lambda f(w)L(w). \tag{14}$$

Therefore, using equation (14) and (13), we have

$$\epsilon_R = \frac{w\lambda f(w)L(w)}{R(w)}. \tag{15}$$

By combining equation (11) and (15) the elasticity or recruitment with respect to wage is,

$$\epsilon_R = \frac{w\lambda f(w)}{1 + s(w)\gamma - \gamma} \tag{16}$$

Last, we must consider the separations side of the Burdett and Mortensen model in order to find the relationship between ϵ_R and ϵ_s. Separations in this model are given by

$$s(w) = \delta + \lambda[1 - F(w)],$$

where δ is the exogenous job destruction rate, λ is the job offer arrival rate and $F(w)$ the distribution of wage offers. The derivative of the separation function with respect to the wage is then

$$s'(w) = -\lambda f(w). \tag{17}$$

Therefore by combining equation (16) and (17) the elasticity of recruitment is

$$\begin{aligned}\epsilon_R &= \frac{-ws'(w)}{1-(1-s(w))\gamma}, \\ \epsilon_R &= -\epsilon_s \frac{s(w)}{1-(1-s(w))\gamma}. \end{aligned} \tag{18}$$

Finally, by substituting equation (18) into equation (12), the elasticity of labor supply with respect to wage can be identified through the separation elasticity of wage, ϵ_s, the separation rate, $s(w)$, and rate of expansion or contraction of the firm, γ. We find that

$$\epsilon_{Lw} = -(1+\gamma)\epsilon_s \frac{s(w)}{1-(1-s(w))\gamma}.$$

This derived adjustment is consistent with Manning (2003) as the equation collapses to $\epsilon_{Lw} = -2\epsilon_s$ when employment is constant over time ($\gamma = 1$). Note that the lower bound on $s(w)$ is determined by γ. As $R(w) \geq 0$, then $s(w) \geq 1 - \frac{1}{\gamma}$.

A.2 Appendix Tables and Figures

Table 1: LPM Estimates for Major Sub-Periods

	1919(I)-1940(II)	**1919(I)-1929(I)**	**1929(II)-1933(I)**	**1933(II)-1940(II)**
Log Wage	-0.39	-0.50	0.03	-0.34
	(0.042)	(0.050)	(0.066)	(0.116)
Black	-0.08	-0.07	0.05	-0.11
	(0.017)	(0.021)	(0.062)	(0.031)
Age	0.01	0.02	-0.02	0.02
	(0.005)	(0.008)	(0.013)	(0.010)
Age-Squared	-0.00	-0.00	0.00	-0.00
	(0.000)	(0.000)	(0.000)	(0.000)
Tenure	-0.03	-0.05	-0.00	-0.01
	(0.004)	(0.007)	(0.011)	(0.008)
Tenure-Squared	0.00	0.00	-0.00	0.00
	(0.000)	(0.001)	(0.001)	(0.000)
Married	0.02	0.02	0.00	0.03
	(0.011)	(0.013)	(0.028)	(0.034)
R-squared				
N	7070	5346	820	904

[1] Robust Standard Errors in parentheses.

Figure 1: Standard Elasticity Calculations and the Business Cycle (NBER)