Labor Market Power*

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Abstract

What are the welfare implications of labor market power? We provide an answer to this question in two steps: (1) develop a tractable quantitative, general equilibrium, oligopsony model of the labor market, (2) estimate key parameters using within-firm-states, across-market differences in wage and employment responses to state corporate tax changes in U.S. Census data. We validate the model against recent evidence on productivity-wage pass-through, and new measurements of the distribution of market concentration. The model implies welfare losses from labor market power range from 2.9 to 8.0 percent of lifetime consumption. However, despite large contemporaneous losses, labor market power has not contributed to the declining labor share. Finally, we show that minimum wages can deliver moderate welfare gains by reallocating workers from smaller to larger, more productive firms.

JEL codes: E2, J2, J42

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1 Introduction

How competitive are U.S. labor markets? How has labor market competition changed over time? What are the implications of labor market power for welfare, labor's share of income, and minimum wage policy? We answer these questions by developing and estimating a quantitative, general equilibrium model of oligopsony.

We depart from standard models of monopsony (Burdett and Mortensen (1998), Manning (2003), and Card, Cardoso, Heining, and Kline (2018)) by incorporating Cournot competition into a framework with a finite set of employers (e.g. Atkeson and Burstein (2008)). In our model, firms face upward sloping labor supply curves that depend on their relative size in a labor market. In our benchmark oligopsony model, there are two sources of market power: (i) firms internalize their upward sloping labor supply curve and (ii) firms are non-atomistic and engage in Cournot competition. As a result, a firm's equilibrium wage is a size-dependent markdown on it's workers' marginal revenue product of labor.

We measure labor market power by estimating market-share-dependent labor supply curves in U.S. Census data, combining insights from trade (e.g Amiti, Itskhoki, and Konings (2016)) and public finance (e.g. Giroud and Rauh (2019)). Our identification approach works by comparing the way a firm's establishments respond to state-level corporate taxes in labor markets where the firm accounts for a relatively large share of total payrolls versus labor markets within the same state where the firm's share is smaller. The firm's differential wage and employment response across these markets lets us recover market-share-dependent labor supply elasticities. Our estimate range between 0.76 for a firm that employs the entire local labor market, to 3.74 for an atomistic firm. These elasticities map directly to key parameters governing labor market power in our model.

When we implement our identification approach, and throughout the remainder of the paper, we define a labor market to be a 3-digit industry within a Commuting Zone (CZ). Furthermore, we restrict attention to tradeable goods industries to mitigate the role of product market power. Despite this, we show that none of our results are specific to the tradeable sector.

After estimating our model to match 2014 U.S. labor market conditions, we measure the welfare losses of labor market power by computing the consumption equivalent welfare gain associated with a counterfactual competitive equilibrium in which firms do not internalize their market power. Under an aggregate Frisch elasticity of labor supply of 0.5, households would be willing to give up 5.4 percent of lifetime consumption to attain the competitive equilibrium, supplying 19.6 percent more labor at higher wages.[1] Roughly 25 percent of the increase in

[1] Under an aggregate Frisch elasticity of labor supply of 0.2 (0.8), households would be willing to give up 2.9 (8.0) percent of lifetime consumption in order to attain the competitive equilibrium.

output result from a reallocation of workers from smaller, less productive firms to larger, more productive firms. In the oligopsonistic economy, large firms have a lot of labor market power, so are inefficiently small. A by-product of this efficient reallocation is a sharp rise in concentration, despite significant welfare, consumption, and output gains.

Despite large welfare losses from labor market power, we find that declining labor market concentration *increased* labor's share of income by 2.89 percentage points between 1976 and 2014. Letting our model guide measurement, we show that the distribution of market-level wage-bill Herfindahls (the sum of squared firm payroll shares in a market) is a sufficient statistic for labor's share of income. Moreover, when aggregating, our model implies that the market-level wage-bill Herfindahls should be weighted by each market's total share of U.S. payroll. Using the Longitudinal Business Dynamics (LBD) database, we show that our model relevant measure of concentration, the payroll weighted wage-bill Herfindahl, declined from 0.20 to 0.14 between 1976 and 2014. These estimates imply that the effective number of firms in a typical labor market was equivalent to 5.0 equally sized firms per market in 1976, and 7.1 equally sized firms per market in 2014. Our theory implies that this declining labor market concentration increased labor's share of income by 2.89 percentage points between 1976 and 2014, suggesting that labor market concentration is not the reason for a declining labor share.

Given the large degree of labor market power in the U.S., is there a role for minimum wages? We first theoretically characterize how minimum wages affect firm-level and worker-level behavior in our environment, which features both decreasing returns to scale and strategic complementarities. We then show that our model's prediction that workers reallocate to larger firms as the minimum wage increases is consistent with recent work by Dustmann, Lindner, Schoenberg, Umkehrer, and vom Berge (2019), who use German data. We compute that the optimal minimum wage binds for roughly 5 percent of workers (measured in the pre-minimum wage equilibrium), and that this policy delivers a welfare gain worth 0.07 percent of lifetime consumption. What limits the efficacy of minimum wages is that small, low-wage firms, for whom the minimum wage binds, reduce employment the most. This has two effects. First, concentration rises, delivering market power to larger, unconstrained, firms who increase wages. Second, households face lower *perceived* wages—our terminology for wages that are adjusted for demand constraints—causing aggregate employment to decline if the minimum wage is raised too much.

Lastly, we validate the model against two sets of non-targeted moments that often enter the discussion of labor market power: (1) the distribution of weighted and unweighted wage-bill Herfindahls, and (2) wage-pass through. First, in both the model and data, the payroll weighted wage-bill Herfindahl, which is targeted in the calibration, is significantly lower than the *un-*

weighted wage-bill Herfindahl, which is untargeted in the calibration. The ratio of weighted to unweighted wage-bill Herfindahls is approximately 3.2 in the data and 2.5 in the model. Why is the payroll weighted wage-bill Herfindahl so much lower than the unweighted wage-bill Herfindahl? In both the model and data, concentrated markets are small markets. In the U.S. data, roughly 15 percent of markets have one firm, with a wage-bill Herfindahl equal to one. However, these markets comprise only 0.4 percent of aggregate employment and are therefore uninformative of labor market conditions faced by most U.S. households. In the model, employment in these regions is small as monopsonists pay low wages and hire few workers.

Second, we replicate the quasi-experiment that identifies reduced-form pass-through estimates in Kline, Petkova, Williams, and Zidar (2018). In the benchmark oligopsony model we find a pass-through rate from value added per worker to wages of 42.3 percent. For every one dollar increase in value added per worker, the wage-bill per worker increases by 42.3 cents. Kline, Petkova, Williams, and Zidar (2018) report a pass-through rate of 31.7 percent, which, by construction, is directly comparable to our point estimate.

This paper proceeds as follows. Section 2 reviews the relevant literature. Section 3 provides new summary statistics on labor market concentration in the U.S. in 1976 and 2014. Section 4 lays out our model. Section 5 characterizes the equilibrium. In Section 6 we establish our empirical results regarding market-share dependent labor supply elasticities and use these along with concentration data to parameterize the model. Section 7 provides our key validation exercises testing the model against non-targeted moments. Section 8 presents our main quantitative welfare results. Section 9 studies the implications of declining labor market concentration for labor's share of income. Section 10 applies the model to study minimum wage policy, and Section 11 concludes.

2 Literature

Recent studies have focused on the role of market power in the product market. A number of papers have focused on empirical measures of national sales concentration (e.g. Gutiérrez and Philippon (2016), Autor, Dorn, Katz, Patterson, and Van Reenen (2017)). While other studies have measured markups directly (De Loecker and Eeckhout, 2017). Notably, concurrent and innovative work by Rossi-Hansberg, Sarte, and Trachter (2018) document declining regional sales and employment concentration, despite rising national concentration, which is consistent with the findings in our paper. Contemporaneous work by Brooks, Kaboski, Li, and Qian (2019) combines theory and data to study the macroeconomic consequences of monopsony, either by a single producer or group of producers, in China and India. They find falling labor market concentration in China and India and find a significant adverse impact of monopsony power on labor's share of income.

Our main empirical contributions are to (1) measure size-dependent labor supply elasticities using state corporate tax shocks in the LBD (2) provide better measures of labor market concentration for the U.S. by computing regional wage-bill shares (as opposed to employment shares) in the U.S.

Our measurement of size-dependent labor supply elasticities combines the corporate tax identification approach of Giroud and Rauh (2019) with recent advances in measuring pass-through rates from the trade literature (e.g Amiti, Itskhoki, and Konings (2014) and Amiti, Itskhoki, and Konings (2016)). By measuring the size-dependent pass-through rates of corporate tax shocks to wages and employment, we are able to provide the first estimates of size-dependent labor supply elasticities. By doing so, we contribute to a large literature which has, to date, measured labor supply elasticities of individual firms in specific contexts. This literature finds widely varying labor supply elasticities, which, when viewed alone, seem to be implausible measures of aggregate labor supply elasticities.[2] Showing that firm-specific labor supply elasticities vary systematically with the firm's share of wage payments in a labor market reconciles the range of low and high labor supply elasticities found in the literature.

Recently, several studies have documented cross-sectional and time-series patterns of U.S. Herfindahls in employment (e.g. Benmelech, Bergman, and Kim (2018), Rinz (2018), and Hershbein et al. (2018)) and vacancies (e.g. Azar, Marinescu, Steinbaum, and Taska (2018) and Azar, Marinescu, and Steinbaum (2017)). Notably, concurrent work by Rinz (2018) documents declining regional employment Herfindahls, despite rising national employment concentration. Our contributions to this literature are (i) to measure and discuss the discrepancies between our model relevant wage-bill Herfindahls and employment Herfindahls in the cross-section and over time, (ii) map these measures of concentration to labor market power through a structural model, and (iii) measure the welfare losses associated with labor market power. Moreover, we document and explain significant differences between weighted and unweighted wage-bill Herfindahl distributions which indicate that much of the concentration observed in U.S. data comes from very small rural regions.

Our main quantitative contribution is to build a general equilibrium model of oligopsony and measure the welfare costs of current levels of U.S. labor market power. We depart from benchmark models of monopsony described in Burdett and Mortensen (1998), Manning (2003),

[2] As Manning (2011) writes when discussing the widely cited natural experiment estimates of Staiger, Spetz, and Phibbs (2010a) and others: "Looking at these studies, one clearly comes away with the impression not that it is hard to find evidence of monopsony power but that the estimates are so enormous to be an embarrassment even for those who believe this is the right approach to labour markets."

and Card, Cardoso, Heining, and Kline (2018) by modeling a finite set of employers who engage in Cournot competition. Our framework adapts the general tools developed in Atkeson and Burstein (2008) to the labor market, extended to general equilibrium. We further depart from Atkeson and Burstein (2008) by integrating decreasing returns and capital. We show that these additional ingredients are crucial to simultaneously match the distribution of labor market concentration and labor's share of income.

By modeling a finite set of employers, our model may be used to understand the wage and welfare effects of mergers, firm exit, and other shocks to local labor market competition. Moreover, our model has important implications for measurement. We show that the wage-bill Herfindahl, as opposed to the employment Herfindahl, is a sufficient statistic—when intermediated through other estimated parameters of the model—for labor market competition and the labor share. Moreover, the employment Herfindahl overstates labor market competition by ignoring the positive covariance between wages and employer size.

Our model features strategic complementarity between oligopsonists. Strategic complementarity is not new to the monopsony literature. The earliest models used to motivate monopsony power are based on the spatial economies of Hotelling (1990) and Salop (1979). Boal and Ransom (1997) and Bhaskar, Manning, and To (2002) provide excellent summaries of strategic complementarity in spatial models of the labor market. Relative to earlier stylized models, we develop a quantitative general equilibrium model. Our framework incorporates firm heterogeneity, decreasing returns to scale, and general equilibrium across multiple markets, making it rich enough to be estimated on U.S. Census data and with a structure that allows us to provide estimates of counterfactual welfare losses from monopsony power.

3 Labor market concentration: 1976 and 2014

In this section, we provide new statistics summarizing labor market concentration in 1976 and 2014 using the Census Longitudinal Business Database (LBD).[3]

In order to compute concentration, we must define a market. In our model, a market will have two features: (i) a worker drawn at random from the economy will have a greater attachment to one market than others on the basis of idiosyncratic preferences, but will be able to move across markets nonetheless, and (ii) firms within a market will compete strategically.

With these assumptions in mind and given what we can observe in the LBD, we define a *local labor market* as a 3-digit NAICS industry within a Commuting Zone (CZ).[4] Examples of

[3]Years 1976 and 2014 are the first and last years of data availability in the LBD 'snapshot' for which our project had access. For additional information regarding the data sources in this paper see Appendix C.

[4]Using data from the BLS Occupational Employment Statistics micro data, Handwerker and Dey (2018) show

adjacent 3-digit NAICS codes are subsectors 323-325: *'Printing and Related Support Activities,'*, *'Petroleum and Coal Products Manufacturing,'* and *'Chemical Manufacturing,'* which we regard as suitably different. Examples of commuting zones include the collection of counties surrounding downtown Minneapolis and Chicago.[5]

Our aim is to cleanly study labor market power. A key step in our analysis is therefore to restrict our attention to tradeable goods industries. For these industries we conceive of the spot market for goods as outside the local labor market, an assumption made explicit in our model. We restrict our sample to the industries specialized in tradeable goods identified by Delgado, Bryden, and Zyontz (2014).[6] In Appendix D, we show that all trends we report for the tradeable sector are also true for the economy as a whole.

Finally, we define a firm in a local labor market as the collection of establishments operated by that firm. Since the LBD provides establishment-level employment and pay annually, we aggregate establishments owned by the same firm within a market.[7] For each resulting firm-market-year observation we compute total employment, total pay, and herein define the *wage* as total pay per worker. Appendix C provides more details on the sample restrictions and data definitions.

Table 1 summarizes our sample from the LBD. Panel A describes characteristics of the firm-market-year observations. Average nominal payroll was \$470,900 in 1976 and \$1,839,000 in 2014. Within a market, the average firm employment was 37 workers in and 28 workers in 2014. The average nominal wage was \$12,696 in 1976 and \$65,773 in 2014.

Panel B describes alternative measures of market concentration. First, we consider two common measures: (1) the wage-bill Herfindahl, and (2) the employment Herfindahl. Let i denote a firm and j denote a market. Let w_{ij} denote the firm-market wage, and let n_{ij} denote the firm's employment in market j. Equation (1) defines the wage-bill Herfindahl, which is the sum of the squared wage-bill shares. As we will discuss in the model section, this is the relevant measure of market concentration according to our theory.

$$HHI_j^{wn} := \sum_{i\in j}(s_{ij}^{wn})^2, \quad s_{ij}^{wn} = \frac{w_{ij}n_{ij}}{\sum_{i\in j} w_{ij}n_{ij}} \tag{1}$$

that there is little practical difference in defining a market at the industry-city rather than occupation-city level as these two measures are highly correlated in their sample. In particular, if one computes Herfindahl-Hirschman Indices at the CBSA-occupation or CBSA-industry level, the two different measures of employer concentration have a correlation of 0.97.

[5] We provide many more examples in Tables C1 and C2 in Appendix C.

[6] These include the following 2-digit NAICS industries: 11, 21, 31, 32, 33, and 55. When identifying industries throughout the paper, we use the time consistent 2007 NAICS codes provided by Fort and Klimek (2016).

[7] Firm is identified by the LBD variable *firmid*.

A. Firm-market-level averages	1976	2014
Total firm pay (000s)	470.90	1839.00
Total firm employment	37.09	27.96
Pay per employee	$ 12,696	$ 65,773
Firm-market level observations	660,000	810,000

B. Market-level averages	1976	2014
Wage-bill HHI (Unweighted)	0.45	0.45
Employment HHI (Unweighted)	0.43	0.42
Wage-bill HHI (Weighted by market's share of total payroll)	0.20	0.14
Employment HHI (Weighted by market's share of total payroll)	0.17	0.11
Wage-bill HHI (Weighted by market's share of total employment)	0.19	0.14
Employment HHI (Weighted by market's share of total employment)	0.18	0.12
Firms per market	42.6	51.6
Percent of markets with 1 firm	14.6%	14.7%
National employment share of markets with one firm	0.63%	0.36%
Market-level observations	15,000	16,000

C. Across market correlations with wage-bill HHI	1976	2014
Number of firms	-0.22	-0.21
Market employment	-0.20	-0.21
Employment Herfindahl	0.98	0.98
Standard deviation of relative wages	-0.49	-0.51
Market level observations	15,000	16,000

Table 1: Summary Statistics, Longitudinal Employer Database 1976 and 2014

Notes: Tradeable NAICS2 codes (11,21,31,32,33,55). Market defined to be NAICS3 within Commuting Zone. Observations rounded to nearest thousand and numbers rounded to 4 significant digits according to Census disclosure rules. Firm-market-level refers to a 'firmid by Commuting Zone by 3-digit NAICs by Year' observation. Market-level refers to a 'Commuting Zone by 3-digit NAICs by Year' aggregation of observations.

Equation (2) defines the employment Herfindahl. As we discuss in the model section, this measure ignores the covariance of wages and employment and so is biased downward relative to the wage-bill Herfindahl:

$$HHI_j^n := \sum_{i \in j} (s_{ij}^n)^2, \quad s_{ij}^n = \frac{n_{ij}}{\sum_{i \in j} n_{ij}} \tag{2}$$

We provide across-market means of these statistics, unweighted and weighted by market payroll. The unweighted average wage-bill Herfindahl is 0.45 and remains unchanged between 1976 and 2014. Likewise for the employment Herfindahl, falling slightly from 0.43 to 0.42. When weighted by market-level payroll, however, the *level* of average Herfindahls drop. This is a distinct statistical property of labor market concentration that our model will reproduce.

In the time-series, *changes* are also more pronounced when the Herfindahls are weighted. We weight the market-level Herfindahls by market-level payroll—which will be the model relevant weighting scheme—and market-level employment. The payroll weighted wage-bill Herfindahl declines from 0.20 to 0.14. The payroll weighted employment Herfindahl declines from 0.17 to 0.11. If we weight by total employment instead, we also see a similar result.[8] In Appendix D, we show that these patterns are consistent in non-tradeable industries. In the broad economy, labor market concentration begins at a similar level and falls by a similar magnitude.

Why is there a large discrepancy between the weighted and unweighted Herfindahls? Approximately 14 percent of markets in both periods have only one employer, and so have Herfindahls equal to one. But these markets account for less than one percent of national employment. When weighted by payroll or employment, sparsely populated markets are ignored and Herfindahls decline three-fold.

Finally, Panel C shows that, as expected, the number of firms and total market employment are negatively correlated with the Herfindahl. This negative correlation is important for understanding why the weighted and unweighted Herfindahls are so different (Panel B). Despite this, employment and wage-bill Herfindahls are highly correlated. More interestingly, we find that across markets the correlation of (a) the market Herfindahl and (b) within market dispersion of relative wages, is also strongly negative.[9] More concentrated markets have less dispersed wages. Our model will target a single concentration measure and use these other moments as over-identifying tests of the quantitative relevance of our theory.

Figure 1 illustrates the changes in concentration graphically. Panel A describes the changes in the weighted Herfindahl indexes. To interpret these Herfindahls, Panel B plots the *inverse* wage-bill Herfindahl ($\frac{1}{HHI_j^{wn}}$) and the *inverse* employment Herfindahl ($\frac{1}{HHI_j^{n}}$). The Inverse Herfindahl (IHI) can be interpreted as the effective number of equally sized firms competing in the market.[10] Using the inverse payroll weighted wage-bill Herfindahl, the effective number of firms in tradeable U.S. labor markets increased from 5.01 in 1976 to 7.09 in 2014. Labor market concentration has fallen according to both measures, and the effective number of firms per market has risen. In the raw data, we also observe a 20 percent increase in the average number of firms per market.

[8]The employment weighted wage-bill Herfindahl declines from 0.19 to 0.14, and the employment weighted employment Herfindahl falls from 0.18 to 0.12.

[9]A firm's relative wage is defined by $w_{ij}^{rel} := \frac{w_{ij}M_j}{\sum_i w_{ij}}$, where M_j is the number of firms in market j. We then compute the standard deviation of this term within each market j.

[10]If three firms operate in a market and have equal shares, then the Herfindahl is $1/3 = \sum_{i\in j}(1/3)^2$. So a market with M_j firms of different sizes and a Herfindahl of $1/x$ has the same level of concentration as a market with x firms of equal size.

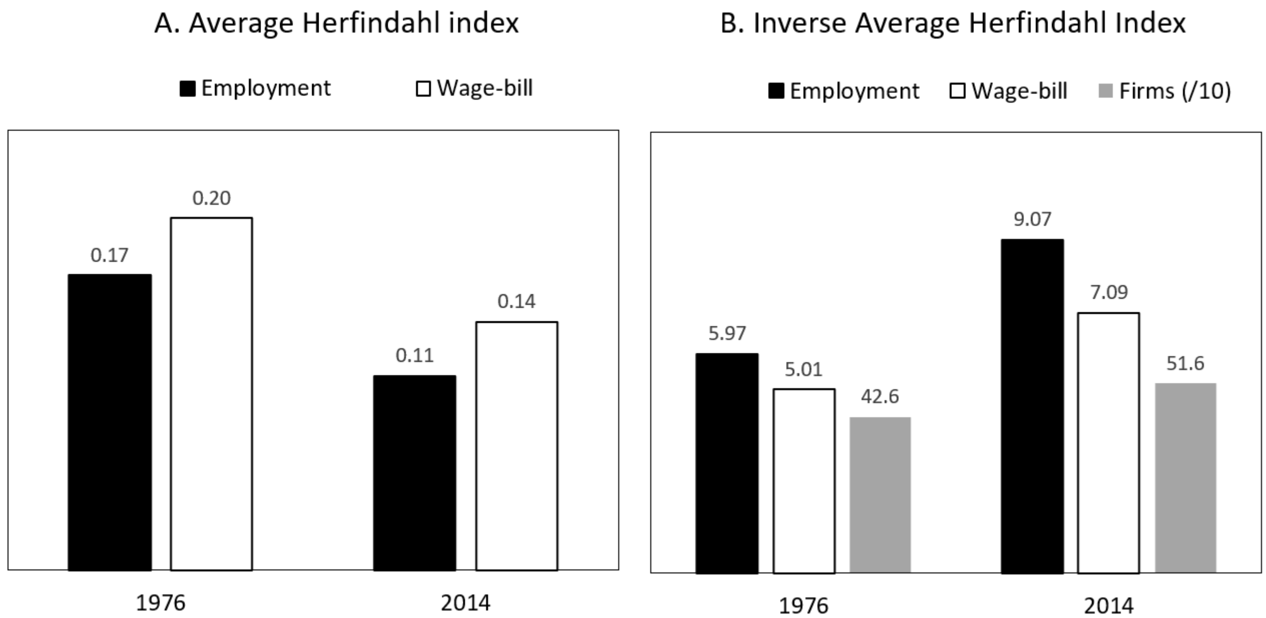


Figure 1: Labor Market Concentration, 1976 and 2014

To map these measures of labor market concentration to welfare, we require a model. Our theoretical framework is specifically designed to accommodate these commonly used statistics. In fact, within our framework wage-bill Herfindahls and knowledge of key structural parameters are a sufficient set of ingredients to compute the share of aggregate income paid to workers. From the point of view of measurement, we can also quantify how other measures of concentration that are not welfare relevant are biased with respect to our statistics.

4 Model

4.1 Environment

Agents. The economy consists of a representative household and a continuum of firms. Firms are heterogeneous in two dimensions. First, firms inhabit a continuum of different local labor markets indexed by $j \in [0,1]$. In each labor market there are an exogenously given finite number of firms indexed $i \in \{1, 2, ...M_j\}$. Second, firms are heterogeneous in their productivity $z_{ijt} \in (0, \infty)$. Productivities are drawn from a distribution $F(z)$ which is location invariant. The only *ex-ante* difference between markets is M_j.

Goods and technology. The household finds the goods that the continuum of firms produce to be perfect substitutes, and hence trade in a perfectly competitive economy-wide market at a price P_t that we normalize to one. These indistinguishable goods can be used for consumption or investment. The technology for production uses inputs of capital k_{ijt} and labor n_{ijt}. Let $\overline{Z}$ be a common component of productivity across firms.[11] A firm then produces y_{ijt} according to the production function:

$$y_{ijt} = \overline{Z} z_{ijt} \left(k_{ijt}^{1-\gamma} n_{ijt}^{\gamma} \right)^{\alpha} \quad , \quad \gamma \in (0,1) \quad , \quad \alpha > 0.$$

We remain agnostic as to the degree of returns to scale α and estimate this along with other model parameters. The capital stock is owned by the representative household, and rented to firms in a competitive market at price R_t. To model imperfect labor market competition, we draw on tools developed in the trade literature (e.g. Atkeson and Burstein (2008)), which we describe in detail.

4.2 Household

Preferences and problem. A representative household chooses the amount of labor to supply to each firm, n_{ijt}, how much capital to carry into next period, K_{t+1}, and how much of each good, c_{ijt} to consume in order to maximize their net present value of utility. Given an initial capital stock K_0, the household solves the following problem:

$$U_0 = \max_{\{n_{ijt}, c_{ijt}, K_{t+1}\}} \sum_{t=0}^{\infty} \beta^t u \left(\mathbf{C}_t - \frac{1}{\bar{\varphi}^{\frac{1}{\varphi}}} \frac{\mathbf{N}_t^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}} \right) \quad , \quad \beta \in (0,1) \quad , \quad \varphi > 0 \tag{3}$$

where the aggregate disutility of labor supply is given by,

$$\mathbf{N}_t := \left[\int_0^1 \mathbf{N}_{jt}^{\frac{\theta+1}{\theta}} \, dj \right]^{\frac{\theta}{\theta+1}} \quad , \quad \theta > 0$$

$$\mathbf{N}_{jt} := \left[n_{1jt}^{\frac{\eta+1}{\eta}} + \cdots + n_{M_j jt}^{\frac{\eta+1}{\eta}} \right]^{\frac{\eta}{\eta+1}} \quad , \quad \eta > \theta$$

and maximization is subject to the household's budget constraint:

$$\mathbf{C}_t + \left[K_{t+1} - (1-\delta) K_t \right] = \int_0^1 \left[w_{1jt} n_{1jt} + \cdots + w_{M_j jt} n_{M_j jt} \right] dj + R_t K_t + \Pi_t, \tag{4}$$

$$\mathbf{C}_t = \int_0^1 \left[c_{1jt} + \cdots + c_{M_j jt} \right] dj. \tag{5}$$

[11] In our calibration we will use $\overline{Z}$ to scale the economy such that it replicates the average wage in Table 1.

The return on capital, net of depreciation, is R_t. Firm profits, Π_t, are rebated lump sum to the household. The function u is twice continuously differentiable with $u' > 0$, $u'' < 0$ and satisfies the Inada conditions. The final equation captures the fact that consumption goods produced by firms are perfect substitutes, such that our assumption of a single price $P_t = 1$ is valid.[12]

Notation. Our convention is to use a bold font to denote indexes. Indexes are not directly observable in the raw data but can be constructed from observables. For example, the disutility of labor supply is given by $\mathbf{N}_t$, and does not correspond to any aggregates reported by the Bureau of Labor Statistics. However, given parameters, $\mathbf{N}_t$ can be constructed from data on observed firm-level employment, $\{n_{ijt}\}$ from the universe of firms. If we compute an aggregate such as labor N_t, this is computed by adding up bodies: $N_t = \sum_{ij} n_{ijt}$.

Elasticities. The elasticities of substitution at the firm and market levels, $\eta > 0$ and $\theta > 0$, jointly play a role in the labor market power of firms. Both across and within markets, the lower the degree of substitutability, the greater the market power of firms. Below we discuss a micro-foundation of the representative agent problem—presented in full in Appendix B—that exactly maps these parameters into the relative net costs to individuals of relocating within versus across markets.[13]

Across-market substitutability θ stands in for mobility costs across markets, which are often estimated to be significant (e.g. Kennan and Walker (2011)). As such costs increase ($\theta \to 0$), the representative household minimizes labor disutility $\mathbf{N}_t$ by choosing an equal division of workers across markets: $\mathbf{N}_{jt} = \mathbf{N}_{j't}$, $\forall j, j' \in [0,1]$. This limiting case results in the largest degree of local labor market power for firms. The total allocation of employment to a market is completely inelastic market by market, and does not respond to market wages. As substitutability approaches infinity, the representative household chooses to send all workers to the market with the highest wages, eroding the market power of firms outside of that market.

Within-market substitutability η stands in for within-market, across-firm mobility costs such as the job search process (e.g. Burdett and Mortensen (1998)), some degree of non-generality of accumulated human capital (e.g. Becker (1962)), or heterogeneity in worker-firm specific

[12]Observe that since we are solving the model with decreasing returns to scale in production, we are arbitrarily able to introduce monopolistic competition in the market-wide spot market for goods. Let $\mathbf{C}_t = \left[\int \sum_{i \in j} c_{ijt}^{(\sigma-1)/\sigma} dj\right]^{\sigma/(\sigma-1)}$, then under the household's optimal demand schedules, the only difference will be that the firm optimizes a *revenue* function for the firm that is isomorphic to a decreasing returns to scale production function. Firms would all charge a fixed markup, and additional profits from product market power would be rebated to the household. To keep our analysis clean, we ignore this case.

[13]By *net* costs we have in mind total mean non-pecuinary benefits—such as firm-worker specific amenities—minus total non-pecuinary costs—such as firm-worker specific commuting costs.

amenities or commuting costs. As substitutability within a market declines ($\eta \to 0$), the representative household minimizes within-market disutility of labor supply $\mathbf{N}_{jt}$ by choosing an equal division of workers across firms: $n_{ijt} = n_{i'jt}, \ \forall i, i' \in \{1, 2, ...M_j\}$. This generates the largest degree of monopsony power for firms. Regardless of its wage, firm ij will employ the same number of workers, allowing it to push down wages while maintaining its workforce. As substitutability increases, the representative household sends all workers it allocated to the market to the firm with the highest wage. The local labor market becomes perfectly competitive and firms set equal wages.

Labor supply. Given the distribution of wages $\{w_{ijt}\}$, the necessary conditions for household optimality consist of first order conditions for labor at each firm $\{n_{ijt}\}$. Combining these yields the following system of firm specific, upward sloping, labor supply curves:

$$n_{ijt} = \bar{\varphi} \left(\frac{w_{ijt}}{\mathbf{W}_{jt}} \right)^{\eta} \left(\frac{\mathbf{W}_{jt}}{\mathbf{W}_t} \right)^{\theta} \mathbf{W}_t^{\varphi} \quad , \quad \text{for all} \quad ij \tag{6}$$

This expression includes our definitions of the market wage index $\mathbf{W}_{jt}$ and the aggregate wage index $\mathbf{W}_t$. $\mathbf{W}_t$ and $\mathbf{W}_{jt}$ are defined as the numbers that satisfy

$$\mathbf{W}_{jt}\mathbf{N}_{jt} := \sum_{i \in j} w_{ijt} n_{ijt} \qquad , \qquad \mathbf{W}_t \mathbf{N}_t := \int_0^1 \mathbf{W}_{jt}\mathbf{N}_{jt} \, dj.$$

Together with (6) these definitions imply the following indexes:

$$\mathbf{W}_{jt} = \left[\sum_{i \in j} w_{ijt}^{1+\eta} \right]^{\frac{1}{1+\eta}} \qquad , \qquad \mathbf{W}_t = \left[\int_0^1 \mathbf{W}_{jt}^{1+\theta} dj \right]^{\frac{1}{1+\theta}} . \tag{7}$$

Equation (6) immediately implies that labor supplied to a firm increases when that firm offers a higher wage. Since we focus on Cournot competition, it is convenient to work with the inverse labor supply function:

$$w_{ijt} = \bar{\varphi}^{-\frac{1}{\varphi}} \left(\frac{n_{ijt}}{\mathbf{N}_{jt}} \right)^{\frac{1}{\eta}} \left(\frac{\mathbf{N}_{jt}}{\mathbf{N}_t} \right)^{\frac{1}{\theta}} \mathbf{N}_t^{\frac{1}{\varphi}} \tag{8}$$

We state the remaining optimality conditions for consumption and capital in Appendix E.

Micro-foundation. What is our representative household representative of? In Appendix B we micro-found our preference specification. In the model presented, labor supply curves to firms are determined by a representative agent with nested-CES preferences. We show that the exact same supply system described by equations (6) and (7) can be obtained in an environment with heterogeneous workers making independent decisions.

The environment is as follows. Each worker decides which firm to work for and how many units of labor to supply. In making this decision, each worker minimizes the total disutility of attaining some random level of income. Total disutility is the sum of the logarithm of hours supplied and a worker specific disutility of supplying labor to each firm, ξ_{ij}. The worker specific disutility of supplying labor to each firm is *iid* across individuals and time, and drawn from a correlated Gumbel in which θ governs the overall variance of ξ_{ij}, and η governs the within-market conditional correlation of ξ_{ij}.

Similar, non-nested, formulations of individual decisions have been used to model the total supply of labor to a firm in competitive markets by Card, Cardoso, Heining, and Kline (2018) and Borovickova and Shimer (2017). Our contribution is to adapt existing results in the discrete choice literature to demonstrate a supply-system equivalence with our 'nested-CES' representative household specification, and to set the problem in oligopsonistic markets.[14]

Additionally, under constant returns to scale, we can establish that the same supply system obtains in the steady-state of a *dynamic* discrete-choice setting in which workers are paid constant individual-firm specific, constant wages. Workers then separate from their firm with probability δ and when separating draw a new firm, and firms compete in a dynamic oligopsony for these workers.

Beyond unifying alternative approaches, this micro-foundation is useful for delivering an intuitive interpretation of our key parameters θ and η.[15] In the discrete choice setting, increasing θ decreases workers' overall variance of net disutility ξ_{ij}. If θ is high, a worker has a high likelihood that their lowest draws of non-wage utility ξ_{ij} are close together, increasing overall competition on wages between firms. Increasing η increases the covariance of ξ_{ij} within markets. If $\eta > \theta$, then the smallest realizations of a worker's disutilities are more likely to be *bunched* within a particular j, so facing similar non-pecuniary utility the worker closely compares wages within j. If $\eta \approx \theta$, then the smallest realizations of a worker's disutilities are more likely to be *spread* across sectors, so the worker compares wages across j's. In the former case, a

[14]We adapt arguments from the product market case due to Verboven (1996). In that paper the author establishes the equivalence of nested-logit and nested-CES, extending the results of Anderson, De Palma, and Thisse (1987) who established an equivalence between single sector CES and single sector logit.

[15]This framework also clarifies the economics of the wage indexes $\mathbf{W}_t$ ($\mathbf{W}_{jt}$). These relate the *ex-ante expected* utility of one unit of labor supply in the economy (sector j)

productive firm in sector j is shielded from competing with the continuum of firms outside of its market. This provides a direct mapping of the model back to the originally proposed sources of monopsony power by Robinson (1933).[16]

An important feature of the model is that workers are not confined to particular markets. The micro-foundation makes clear that workers are able to move across markets. The limitation that markets impose is on the boundary of the strategic behavior of firms. Within markets firms are strategic, but with respect to firms in other markets, firms are price takers. We now describe the behavior of the firm.

4.3 Firms

Firms draw idiosyncratic productivities z_{ijt} from a distribution $F(z)$. Within a market, we assume that M_j firms engage in either Cournot or Bertrand competition. Firms take the aggregate wage index $\mathbf{W}_t$ and aggregate labor supply $\mathbf{N}_t$ as given. In order to maximize profits, firms choose how much capital to rent, k_{ijt}, and either the number of workers to hire n_{ijt} (i.e. Cournot competition) or wages w_{ijt} (i.e. Bertrand competition). Our baseline calibration assumes Cournot competition and Appendix E explores Bertrand competition.

The firm maximizes profits:

$$\pi_{ijt} = \max_{n_{ijt}, k_{ijt}} \overline{Z} z_{ijt} \left(k_{ijt}^{1-\gamma} n_{ijt}^{\gamma} \right)^{\alpha} - R_t k_{ijt} - w_{ijt} n_{ijt} \quad , \quad \text{subject to (8).}$$

Given capital demand, we can rewrite firm profits. To facilitate derivations, we define three hyper-parameters:

$$\tilde{\alpha} := \frac{\gamma\alpha}{1-(1-\gamma)\,\alpha} \quad , \quad \widetilde{z}_{ijt} := \left[1-(1-\gamma)\,\alpha\right] \left(\frac{(1-\gamma)\,\alpha}{R_t} \right)^{\frac{(1-\gamma)\alpha}{1-(1-\gamma)\alpha}} z_{ijt}^{\frac{1}{1-(1-\gamma)\alpha}} \quad , \quad \widetilde{\overline{Z}} := \overline{Z}^{\frac{1}{1-(1-\alpha)\gamma}}$$

[16] To quote in full: *"We have seen in what circumstances the supply of a factor to an industry may be less than perfectly elastic. The supply of labor to an individual firm might be limited ... there may be a certain number of workers in the immediate neighborhood and to attract workers from further afield it may be necessary to pay a way equal to what hey can earn at home plus their fares to and fro; or there may be workers attached to the firm by preference or custom... Or ignorance may prevent workers from moving from one firm to another."* In our micro-foundation of the CES supply structure the heterogeneous ξ_{ij} realizations across workers could reasonably be interpreted in any of these ways. A firm's marginal cost of labor curve lies above its supply curve because to hire more labor it must (i) pay more to hire a new worker away from another firm that that workers has a lower disutility of working for, (ii) must then pay this wage to all workers.

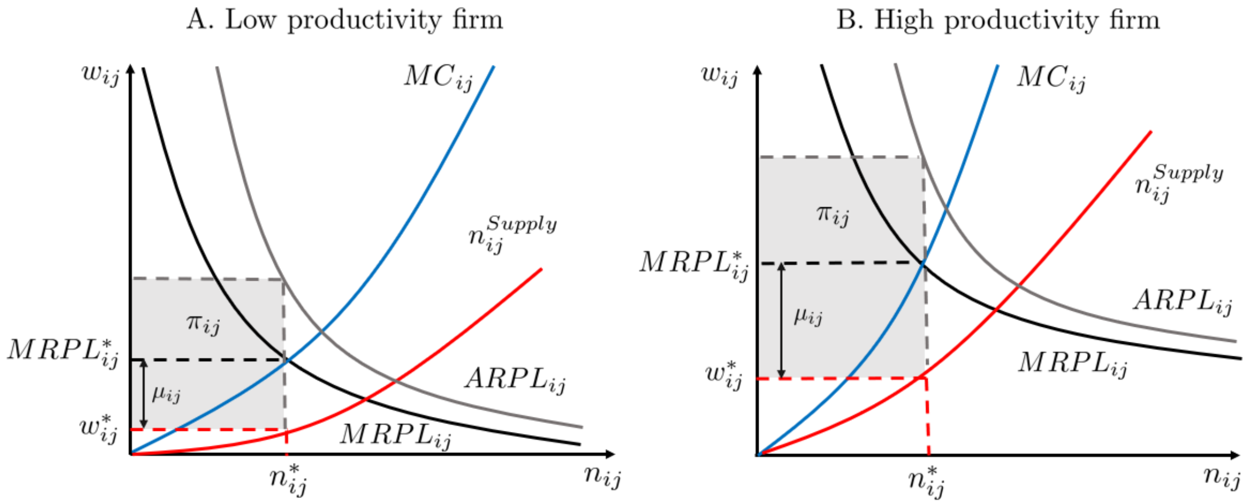


Figure 2: Firm level optimality

With this notation, the firm's labor demand problem can be expressed as follows:

$$\pi_{ijt} = \max_{n_{ijt}} \widetilde{Z}\widetilde{z}_{ijt} n_{ijt}^{\tilde{\alpha}} - w_{ijt} n_{ijt} \quad , \quad \text{subject to (8).} \tag{9}$$

Define the marginal revenue product of labor: $MRPL_{ijt} = \tilde{\alpha}\widetilde{Z}\widetilde{z}_{ijt} n_{ijt}^{\tilde{\alpha}-1}$. Then the first order conditions of this problem yield the solution that the wage is a *markdown* (μ_{ijt}) below the marginal revenue product of labor:

$$w_{ijt} = \mu_{ijt} MRPL_{ijt} \qquad , \qquad \mu_{ijt} \in (0,1).$$

Figure 2 describes firm level optimality. Decreasing returns to scale in production yields a downward sloping marginal revenue product of labor strictly below the average revenue product. An internalized sloping labor supply curve yields an upward sloping marginal cost of labor that lies strictly above labor supply (which is equivalent to average cost of labor). Adding an additional unit of labor costs more than just the higher wage to the marginal worker, since the firm must increase wages paid to all workers. As such, choosing n_{ijt} such that labor's marginal revenue product equals its marginal cost necessarily yields a *markdown* of the wage w^*_{ij} relative to marginal revenue product.

In the Nash equilibrium, this markdown is determined by the equilibrium elasticity of the firms' inverse labor supply curve $(1/\varepsilon_{ijt})$. From the inverse labor supply curve (8), this is straight-forward to compute. Given their competitors' labor demands,

$$\frac{1}{\varepsilon_{ijt}} := \frac{d\log w_{ijt}}{d\log n_{ijt}} = \frac{1}{\eta} + \left(\frac{1}{\theta} - \frac{1}{\eta}\right) \underbrace{\frac{d\log \mathbf{N}_{jt}}{d\log n_{ijt}}}_{s_{ijt}^{wn}} \quad , \quad s_{ijt}^{wn} := \frac{w_{ijt}n_{ijt}}{\sum_{k\in j} w_{kjt}n_{kjt}}.$$

In the nested-CES case the Nash equilibrium inverse labor supply elasticity is therefore linear in the sectoral payroll share of the firm, s_{ijt}^{wn}. Markdowns are therefore given by

$$\mu_{ijt} = \frac{\varepsilon_{ijt}}{\varepsilon_{ijt}+1} \quad , \quad \varepsilon_{ijt} = \left[\frac{1}{\eta}\left(1 - s_{ijt}^{wn}\right) + \frac{1}{\theta} s_{ijt}^{wn}\right]^{-1}. \tag{10}$$

Appendix E includes the derivations of these expressions.

Returning to Figure 2, panel A describes the equilibrium outcomes for a low productivity firm. Relative to the high productivity firm in panel B, the low productivity firm has a lower $MRPL_{ij}$ for any n_{ij}. In equilibrium it has both lower wages, w_{ij}^*, and lower employment, n_{ij}^*, so its equilibrium share of wage payments, s_{ij}^{wn*}, is smaller. With a smaller share of the labor market wage payments, its inverse elasticity of labor supply is larger, and its supply curve flatter. A flatter inverse supply curve yields a narrower markdown at its optimal labor demand, n_{ij}^*. The larger firm faces an endogenously steeper labor supply curve and hires workers at a wider markdown.

4.4 Equilibrium

We will focus on a steady state equilibrium and drop time subscripts from this point forward. The economy-wide vector of wage-bill shares, $\mathbf{s}^{wn} = \{\mathbf{s}_j^{wn}\}$ where $\mathbf{s}_j^{wn} = (s_{1j}^{wn}, \ldots, s_{M_j j}^{wn})$, is the only object that needs to be determined in a steady state equilibrium. This is key to our empirical strategy, since in Census data we will be able to measure exactly these shares.

A steady state equilibrium is a vector of wage-bill shares that yields wages and employment consistent with the vector of wage-bill shares. The steady state equilibrium interest rate is determined by the discount factor.

Definition *A steady state equilibrium is a vector of wage-bill shares $\mathbf{s}^{wn}$ and an interest rate r, that are consistent with firm optimization, and that clear the labor market, capital market, and final good market.*

5 Characterization

We discuss the properties of the equilibrium in two steps. First, we describe the role of labor market power in determining employment and wages at the market level. Second, we describe the role of labor market power in determining employment and wages at the aggregate level.

5.1 Market equilibrium

In this section, we explore several properties of the model. Lemma 5.1 summarizes the relationship between wage-bill shares, labor supply elasticities, and markdowns. If $\mu_1 < \mu_2$ our convention will be to describe μ_1 as having a greater, or wider, mark-down.

Lemma 5.1. *Firms with larger market shares face smaller labor supply elasticities, and pay wages that represent larger mark-downs:*

$$\frac{\partial \varepsilon_{ij}}{\partial s_{ij}^{wn}} < 0 \quad , \quad \frac{\partial \mu_{ij}}{\partial s_{ij}^{wn}} < 0.$$

Share dependence of labor supply elasticities. Under the maintained assumption that $\eta > \theta$, large firms within a market face lower labor supply elasticities (if $s_{ij} > s_{kj}$, then $\varepsilon_{ij} < \varepsilon_{kj}$). Single firm monopsonists face a labor supply elasticity of θ, whereas infinitesimally small firms face a labor supply elasticity of η. In Section 6 we will use quasi-natural experiments that shift $MRPL_{ij}$ to estimate how ε_{ij} varies by s_{ij} in the data and use this to infer η and θ.

To further explore Lemma 5.1, Figure 3 plots examples of the equilibrium shares, markdowns, wages, and employment in three markets. The first market has a single low productivity firm (red), the second adds a firm with median productivity (blue), the third an additional high productivity firm (green).[17]

Consider the market with a single firm. Panel (A) shows that the wage bill share is one. Panel (B) shows that the markdown on the marginal product of labor is approximately 73 percent which is equal to $\theta/(\theta+1)$ since they face the lower bound on labor supply elasticities, θ (see Lemma E.2). Panel (C) shows that wages are low due to low productivity *and* a wide markdown, while panel (D) shows that these contribute to low employment.

Consider the addition of a firm with higher productivity, a duopsony. The low-productivity firm's wage bill share drops to around 25 percent and the firm with higher productivity hires most of the market. The low-productivity firm's markdown narrows to around 60 percent, as with increased competition they face a labor supply elasticity closer to η than θ. Panels (C) show that with no change to its productivity, but with narrower markdowns, the less productive

[17]Figure 3 is constructed from our benchmark calibration of the model (Section 6).

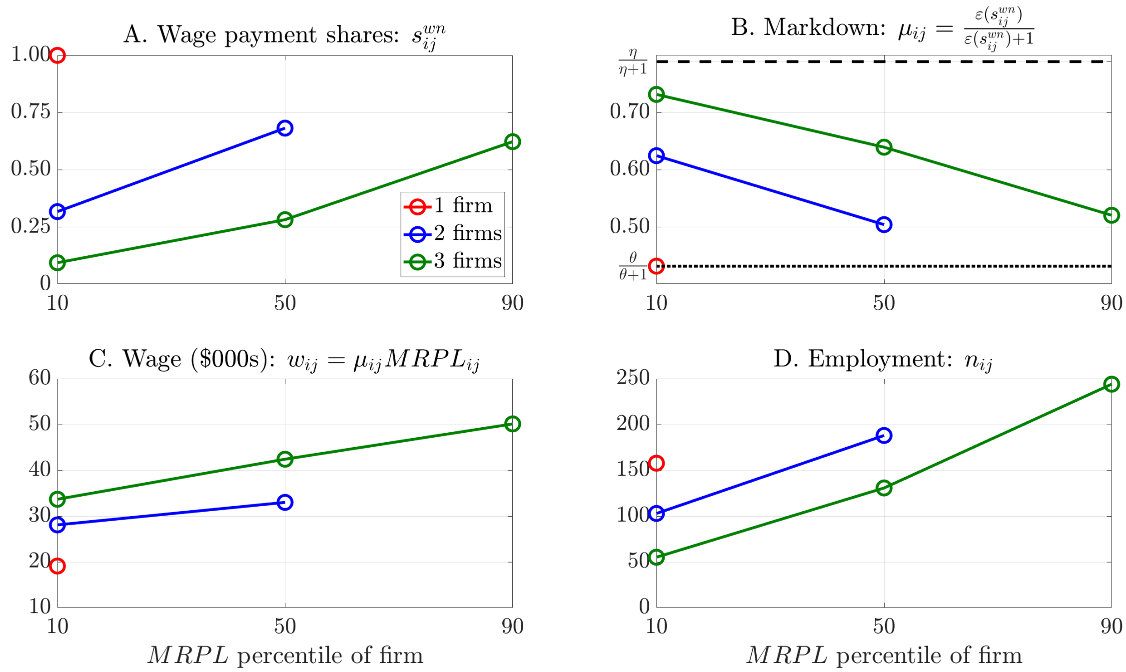


Figure 3: Oligopsonistic equilibrium in three labor markets

firm's wage increases. Panel (D) shows that despite this wage increase, the higher wage at its new competitor causes the low productivity firm's employment to fall. Adding another firm, the markdown at the low- and mid-productivity firms declines. The largest firm has the greatest markdown (panel (B)), but pays more (panel (C)) and employs more workers (panel (D)).

In equilibrium, strategic interaction naturally occurs when there is local labor market power $(\eta > \theta)$ and finitely many firms. This leads to a negative covariance between markdowns and productivity—visible along the green line in Panel (C)—which will show up as a wedge in the aggregate conditions that we now turn to. These consequences of labor market power would be ignored in a model of monopsonistic competition.

5.2 General equilibrium

A key object of interest in macroeconomic studies of the labor market is the share of total output being paid to labor. In this section, we aggregate across markets to characterize the general equilibrium labor share.

We show that labor's share of income is a function of market-level wage-bill Herfindahl indexes which we define as follows:

$$HHI_{jt}^{wn} \equiv \sum_{i \in j} (s_{ijt}^{wn})^2 \tag{11}$$

The model relevant aggregate measure of the extent of local labor market concentration is the inverse of the payroll weighted wage-bill Herfindahl:

$$\widetilde{IHI}_t^{wn} = \left[\int_0^1 s_{jt}^{wn} HHI_{jt}^{wn} dj \right]^{-1} \quad , \quad s_{jt}^{wn} = \frac{\sum_{i \in j} w_{ijt} n_{ijt}}{\int \sum_{i \in j} w_{ijt} n_{ijt} \, dj} \quad ,$$

where s_{jt}^{wn} is market j's share of aggregate income.

Under Cournot competition, we can show that the labor share is determined by this statistic, intermediated by the key parameters of our model, η and θ:

$$LS_t = \frac{\tilde{\alpha} \widetilde{IHI}_t^{wn}}{\left(\frac{\eta+1}{\eta}\right) \widetilde{IHI}_t^{wn} + \left(\frac{\theta+1}{\theta} - \frac{\eta+1}{\eta}\right)} \tag{12}$$

The intuition for this expression is as follows. A single firm's labor share is proportional to its markdown. The market-level labor share LS_{jt} will put highest weight on firms that pay the largest share of wages in each market, which, in our model, are also firms with the widest markdowns and so lowest labor shares. Comparing two markets, a market with a higher HHI_{jt}^{wn} has more dispersed shares so its largest firms have both a lower markdown and a greater share of wage payments, leading to a lower market-level labor share. This delivers a closed-form relationship between LS_{jt} and HHI_{jt}^{wn}. That local labor shares LS_{jt} are then aggregated to the economy-wide labor share using payroll weights s_{jt}^{wn}, is accounting.

Under the assumption of stable preferences—and once η and θ are known—equation (12) implies that the dynamics of the distribution of local wage-bill Herfindahls is sufficient to forecast labor share dynamics. A contribution of this paper is to both identify η and θ, and measure this statistic in the same Census data.

Lemma 5.2.

(i) Under oligopsonistic competition ($\eta > \theta$) the labor share is an increasing function of the wage-bill weighted inverse Herfindahl index, $\frac{\partial LS}{\partial \widetilde{IHI}^{wn}} > 0$. Under monopsonistic competition ($\eta = \theta$), the labor share is independent of the wage-bill weighted inverse Herfindahl index.

(ii) Suppose $cov(w_{ij}, n_{ij}) > 0$, then the wage-bill Herfindahl is strictly larger than the employment Herfindahl, $HHI_j^{wn} \equiv \sum_{i \in j} (s_{ij}^{wn})^2 > HHI_j^{n} \equiv \sum_{i \in j} (s_{ij}^{n})^2$.

Lemma 5.2 has important implications for measurement. Part (i) implies that labor's share of income is determined by the *wage-bill Herfindahl*, as defined in equation (11). Our theory rationalizes why the wage-bill Herfindahl can be used as a proxy for both local and national labor shares.

The model-implied measure of labor market concentration differs from most existing studies. For example, recent work by Benmelech, Bergman, and Kim (2018) and Rinz (2018) use employment Herfindahls. Independent of our model framework, employment Herfindahls understate concentration since they ignore the positive relationship between wages and employment, i.e. the positive size-wage premium. Part (ii) states this formally. So long as there is a size-wage premium—a robust feature of the data (e.g. Brown and Medoff (1989), Lallemand, Plasman, and Rycx (2007), Bloom, Guvenen, Smith, Song, and von Wachter (2018))—Lemma 5.2 shows that the employment Herfindahl understates concentration relative to the wage-bill Herfindahl.

6 Calibration

We calibrate the model in two steps. First, we estimate share-dependent labor supply elasticities. We show that these estimates allow us to directly infer the degree of within-market (η) and cross-market (θ) labor substitutability. Second, we calibrate the remaining parameters to target relevant moments included in Table 1.

As discussed in Section 5, the model predicts that the labor supply elasticity faced by firms varies by their market share (equation 10). If this relationship were known in the data, it would precisely pin down the elasticities of substitution of labor within and across sectors. Existing work estimating labor supply elasticities to firms has focused either on specific markets with their own idiosyncrasies (e.g. Webber (2016), Staiger, Spetz, and Phibbs (2010b)), or in well identified responses to small experimental variations in wages (Arindrajit Dube, 2019; Dube, Cengiz, Lindner, and Zipperer, 2019). A contribution of this paper is to estimate a share-elasticity relationship through a novel quasi-natural experiment using a large cross-section of firms.

We exploit state level corporate tax shocks (Giroud and Rauh, 2019).[18] Corporate tax shocks affect a subset of firms' demand for workers through their effect on accounting profits, which differ from the economic profits. We show that the mapping of our model to the data will not require us to take a stance on the transmission mechanism from corporate taxes to productivity.

[18]Giroud and Rauh (2019) establish the plausible exogeneity of state-corporate tax changes. From a public finance perspective they study the effects of these tax changes on employment and wages. Their focus is *within firm*, *across state* responses, and the reallocation of firm employment across states following tax changes. For an exhaustive description of these tax changes we point the interested reader to their paper.

Nevertheless, Appendix G shows how corporate tax rates map to shocks to the marginal revenue productivity of labor in our framework. As in Section 3, we define a market to be a 3-digit NAICS industry within a commuting zone.[19]

As we rely on state-level corporate tax variation to isolate changes in labor demand, restrict our analysis to C-Corporation firms (C-Corps) in the LBD from 2002 to 2012.[20] As discussed in Section 3, in order to remove product market power from the analysis, we restrict our sample to tradeable industries identified by Delgado, Bryden, and Zyontz (2014) and listed in Appendix C. We aggregate plants owned by the same firm (the same *firmid*) within a market, such that an observation in our analysis is a firm-market-year. For each observation, we compute wages as total pay per worker.

Our identification strategy is to compare how plants owned by the same firm within the same state, but in different markets and with different market shares s_{ij}^{wn} respond differently to the labor demand shock induced by the change in state corporate taxes. To isolate this variation, we use firm-by-state fixed effects and further restrict our sample to firms operating in at least two markets. Let i denote the firm identifier (firmid), let j denote industry (3-digit NAICS), let k denote commuting zone, and let t denote year. Let y_{ijkt} denote the outcome of interest at the firm-i, market-jk, year-t level, such as employment or the wage. The term $\alpha_{is(k)}$ denotes firm-state fixed effects.[21] Let δ_j, ψ_k, and μ_t denote industry, commuting zone, and year fixed effects, respectively. Let $\tau_{s(k)t}$ denote state-level corporate taxes and s_{ijkt}^{wn} denote the wage-bill share of firm i in industry j and commuting zone k in year t.[22]

We estimate specifications of the following form:

$$\log n_{ijkt} = \alpha_{is(k)} + \delta_j + \phi_k + \mu_t + \psi s_{ijkt}^{wn} + \beta \tau_{s(k)t} + \gamma \left(\tau_{s(k)t} \times s_{ijkt}^{wn} \right) + \epsilon_{ijkt}. \tag{13}$$

We are interested in estimating the parameters β and γ. Note that *only* within-firm, across-tax-regime differences identify these parameters. If either (i) $\tau_{s(k)t}$ is constant over the sample period, or (ii) s_{ijkt}^{wn} is constant across markets within a firm, then β and γ are absorbed into firm-state fixed effects $\alpha_{is(k)}$.

[19] See Appendix C for more details.

[20] The tax series ends in 2012. In the 'Year t+1' specifications, we use employment and wage information from the 2013 LBD.

[21] In this exercise only, we exclude commuting zones that straddle multiple states since defining a market gives rise to conceptual issues.

[22] State-level corporate taxes are proportional flat-taxes on firms' accounting profits. Our data for state-level corporate taxes comes from the data made publicly available by Giroud and Rauh (2019): (https://web.stanford.edu/ rauh/).

Variable		Mean	Std. Dev.
Corporate tax rate (percent)	$\tau_{s(k)t}$	7.14	3.19
Change in corporate tax rate	$\Delta\tau_{s(k)t}$	0.05	0.78
Total Pay At Firm (Thousands)	$w_{ijt}n_{ijt}$	2,148	19,010
Employment	n_{ijt}	37.99	215.2
Wage bill Herfindahl	HHI^{wn}_{jt}	0.10	0.16
Employment Herfindahl	HHI^{n}_{jt}	0.09	0.15
Wage bill share	s^{wn}_{ijkt}	0.03	0.12
Employment share	s^{n}_{ijt}	0.03	0.11
Number of firms per market	M_j	1,345	2,813
Log number of firms per market	$\log M_j$	5.56	2.01
Log employment	$\log n_{ijkt}$	2.39	1.32
Log wage	$\log w_{ijkt}$	3.58	0.71
Observations			4,425,000

Table 2: Summary Statistics

Notes: Tradeable C-Corps from 2002 to 2012.

6.1 Summary statistics: C-Corps

Table 2 includes summary statistics for our sample at the firm-market-year level. There are 4.5 million observations. The average corporate tax rate in our dataset is 7.14 percent. The average worker earns \$56,541 (=\$2,148,000/37.99). The average firm has 38 employees and a market wage-bill share of 3 percent. The standard deviation of wage-bill shares is equal to 0.12, indicating that most firms have wage bill shares well below 20 percent and that the distribution of shares is left-skewed. In a typical market, the wage-bill Herfindahl indicates concentration that would be equivalent to roughly 10 equally sized firms ($= 1/0.10$).[23] As the theory predicts, the employment Herfindahl understates concentration and is equivalent to roughly 11.1 equal sized firms ($= 1/0.09$). The number of firms in a market is highly skewed; while the average is $1,345$, the average of the log of the number of firms per market implies only 260 ($= \exp(5.56)$) firms per market.

[23]Note that concentration measures are lower here than in Table 1. In restricting our sample of *firms* to those with establishments in at least two markets within the same state, we reduce the number of small, highly concentrated markets. A hypothetical market with one single-establishment firm, for example, will have been dropped.

6.2 Empirical analysis: Size-dependent labor supply elasticities

Table 3 estimates equation (13), progressively adding covariates and fixed effects. We start with employment as a dependent variable. Column (1) projects firm-market-year employment on corporate taxes $\tau_{s(k)t}$ including year and commuting zone fixed effects. Since $\tau_{s(k)t}$ is in percent, the coefficient on $\tau_{s(k)t}$ is an elasticity: A one percent increase in corporate taxes results in a 0.18 percent reduction in employment at the firm-market-year level. Column (2) adds our full set of industry and firm-state fixed effects, followed by column (3) which adds the interaction term, and column (4) which includes both the full set of fixed effects and the interaction term.

In column (4), the coefficient on the wage-bill share is positive and significant. Larger firms have greater employment responses. The positive and significant interaction between the tax rate and share indicate that the pass-through rate of taxes to employment is weaker for firms with larger market shares. To interpret the interaction terms, it is useful to consider some examples. The mean wage-bill share is 0.03 and one standard deviation is 0.11. Therefore roughly 68 percent of our observations have market wage-bill shares less than 0.14. The elasticity of employment with respect to the corporate tax rate is -0.32% for a firm with a wage bill share of 0.03 and -0.15% for a firm with a wage bill share of 0.14. A one standard deviation larger wage bill share yields a roughly *half* as large employment response.

Columns (5) through (8) of Table 3 repeat the above with the firm-market-year wage as the dependent variable. We focus our attention on column (8) which includes firm-state and industry fixed effects. In this column, the elasticity of wages with respect to the corporate tax rate is -0.18% for a firm with a wage bill share of 0.03 and -0.14% for a firm with a wage bill share of 0.14, roughly *three-fourths* as large. Relative to the wage response—the employment response is smaller at larger firms, indicating a lower labor supply elasticity.

Table 4 repeats the analysis using employment and wages measured one year after the corporate tax rate change. We estimate equation (13) using year $t+1$ employment, $\log n_{ijkt+1}$, as the dependent variable. In column (1), the coefficient on $\tau_{s(k)t}$ indicates that a 1 percent increase in corporate taxes in year t results in a 0.16 percent reduction in employment in year $t+1$ measured at the firm-market-year level. Column (4) is our benchmark employment specification. The elasticity of employment with respect to the corporate tax rate is -0.27% for a firm with a wage bill share of 0.03 and -0.08% for a firm with a wage bill share of 0.14, now around one-quarter as large.

In contrast to employment responses, the wage responses in year t and year $t+1$ are about the same. Column (8) implies that the elasticity of wages with respect to the corporate tax rate is -0.08% for a firm with a wage bill share of 0.03 and -0.04% for a firm with a wage bill share of 0.14, again around half as large. With larger employment responses but similar wage

Dependent variable	$\log n_{ijkt}$ (1)	$\log n_{ijkt}$ (2)	$\log n_{ijkt}$ (3)	$\log n_{ijkt}$ (4)	$\log w_{ijkt}$ (5)	$\log w_{ijkt}$ (6)	$\log w_{ijkt}$ (7)	$\log w_{ijkt}$ (8)
$\tau_{s(k)t}$	-0.00180***	-0.00357***	-0.00367***	-0.00368***	-0.00263***	-0.00181***	-0.00305***	-0.00187***
	(0.000618)	(0.000644)	(0.000859)	(0.000757)	(0.000644)	(0.000584)	(0.000782)	(0.000588)
s^{wn}_{ijkt}			3.263***	2.085***			0.537***	0.214***
			(0.0801)	(0.0467)			(0.0322)	(0.00724)
$\tau_{s(k)t} \times s^{wn}_{ijkt}$			0.0810***	0.0158***			0.0168***	0.00310***
			(0.0112)	(0.00495)			(0.00496)	(0.000749)
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Commuting zone FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry FE	N	Y	N	Y	N	Y	N	Y
(Firm×State) FE	N	Y	N	Y	N	Y	N	Y
R-squared	0.036	0.872	0.132	0.879	0.112	0.819	0.122	0.82
Round obs.	4,425,000	4,425,000	4,425,000	4,425,000	4,425,000	4,425,000	4,425,000	4,425,000

Table 3: Regression of contemporaneous market level employment and wages on state-level corporate taxes and market payroll share.

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors clustered at State × Year level. Tradeable C-Corps from 2002 to 2012.

responses, we infer larger labor supply elasticities after one year. Larger responses in year $t+1$ are consistent with the presence of adjustment frictions not modeled here, either through labor market search and matching or technological costs of adjustment.

We combine the employment and wage responses to corporate tax shocks to estimate market-share-dependent labor supply elasticities. Let β^w and γ^w denote the coefficients on taxes and the interaction term from column (4) in Table 4. Let β^n and γ^n denote the coefficients on taxes and the interaction term from column (8) in Table 4. Differentiate our main specification (13) with respect to corporate taxes to obtain share-dependent wage and employment elasticities:

$$\frac{\mathrm{d}\log w_{ijkt}}{\mathrm{d}\tau_{s(k)t}} = \beta^w + \gamma^w s^{wn}_{ijkt} \quad , \quad \frac{\mathrm{d}\log n_{ijkt}}{\mathrm{d}\tau_{s(k)t}} = \beta^n + \gamma^n s^{wn}_{ijkt}. \tag{14}$$

Taking the ratio of the expressions in (14) yields the labor supply elasticity as a function of a firm's market share. Let the market-share-dependent labor supply elasticity be denoted $\varepsilon(s_{ijkt})$:

$$\varepsilon(s^{wn}_{ijkt}) := \frac{\mathrm{d}\log n_{ijkt}}{\mathrm{d}\log w_{ijkt}} = \frac{\mathrm{d}\log n_{ijkt}/\mathrm{d}\tau_{s(k)t}}{\mathrm{d}\log w_{ijkt}/\mathrm{d}\tau_{s(k)t}} = \frac{\beta^n + \gamma^n s^{wn}_{ijkt}}{\beta^w + \gamma^w s^{wn}_{ijkt}}. \tag{15}$$

Note that nothing in our empirical exercise restricts this to produce a negative relationship.

Figure 4 plots the labor supply elasticity $\varepsilon(s^{wn}_{ijkt})$ using our estimated coefficients. As motivated above, we will focus on the year $t+1$ estimates. The smallest firms face a labor supply

Dependent variable	$\log n_{ijkt+1}$ (1)	$\log n_{ijkt+1}$ (2)	$\log n_{ijkt+1}$ (3)	$\log n_{ijkt+1}$ (4)	$\log w_{ijkt+1}$ (5)	$\log w_{ijkt+1}$ (6)	$\log w_{ijkt+1}$ (7)	$\log w_{ijkt+1}$ (8)
$\tau_{s(k)t}$	-0.00164***	-0.00302***	-0.00352***	-0.00321***	-0.00203***	-0.000819	-0.00244***	-0.000913
	(0.000627)	(0.000642)	(0.000875)	(0.000740)	(0.000647)	(0.000908)	(0.000779)	(0.000902)
s^{wn}_{ijkt}			3.220***	1.931***			0.541***	0.147***
			(0.0793)	(0.0460)			(0.0311)	(0.00835)
$\tau_{s(k)t} \times s^{wn}_{ijkt}$			0.0810***	0.0172***			0.0166***	0.00373***
			(0.0111)	(0.00490)			(0.00474)	(0.000982)
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Commuting zone FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry FE	N	Y	N	Y	N	Y	N	Y
(Firm×State) FE	N	Y	N	Y	N	Y	N	Y
R-squared	0.034	0.871	0.127	0.877	0.096	0.797	0.105	0.797
Round obs.	4,425,000	4,425,000	4,425,000	4,425,000	4,425,000	4,425,000	4,425,000	4,425,000

Table 4: Regression of year $t+1$ market level employment and wages on state-level corporate taxes and market payroll share.

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors clustered at State $\times$ Year level. Tradeable C-Corps from 2002 to 2012.

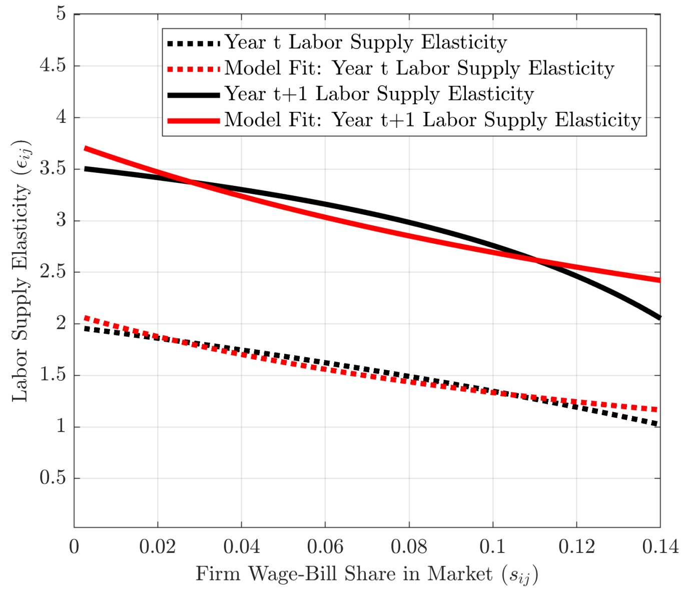
elasticity of 3.5, whereas extremely large firms with a market share of 14 percent or more face a labor supply elasticity of 2. Most of the variation in our data lies between wage bill shares of approximately zero and 0.14 (one standard deviation above the mean). These labor supply elasticities imply markdowns on marginal revenue products of labor of roughly 23 percent at small firms and roughly 33 percent at large firms. Our year $t+1$ estimates imply higher elasticities of labor supply as labor adjusts more over time.

The year $t+1$ estimates yield higher labor supply elasticities than the year t estimates. As discussed in Boal and Ransom (1997), there is reason to believe that short-run elasticities are smaller than long-run elasticities due to various forms of path-dependence. Boal and Ransom (1997) consider a reduced form case were the wage is a function of labor today and labor yesterday. They argue that many researchers use short-run elasticities which, being lower, may overstate the degree of monopsony power. Therefore our benchmark specifications are column (4) and column (8) of Table 4, which we will refer to as the 'Year $t+1$' elasticities.

6.3 Calibration of labor market substitutability

We estimate the within-market substitutability η and the across-market substitutability θ to match the relationship between labor supply elasticity and firm size. Through the lens of our

Figure 4: Labor supply elasticity by firm market wage share



Notes: Figure plots the empirical implied size-dependent labor supply elasticity according to (15)

theory, the labor supply elasticity is given by:

$$\varepsilon_{ij} = \left[s_{ij}^{wn} \frac{1}{\theta} + (1 - s_{ij}^{wn}) \frac{1}{\eta} \right]^{-1} \tag{16}$$

For any s_{ijkt}^{wn}, our regression model (equation (15)) delivers data $\{\varepsilon(s_{ijkt}^{wn}), s_{ijkt}^{wn}\}$. This empirical relationship between wage-bill shares and labor supply elasticities (equation (15)) in conjunction with the model-implied relationship between wage-bill shares and labor supply elasticities (equation (16)) allow us to identify the within-market and across-market degrees of substitution.[24]

In Table 5 we provide our preferred point estimates. Being over-identified, we use non-linear least squares to estimate η and θ using the predicted pairs of $\{\varepsilon(s_{ijkt}^{wn}), s_{ijkt}^{wn}\}$. Figure 4 plots the model-fitted values of labor supply elasticities versus the data. The model closely matches the declining labor supply elasticity by firm market share. The only caveat being that the model implies a convex labor supply elasticity schedule, whereas the data is concave.

[24] In fact, only two labor supply elasticity and wage-bill share pairs are necessary for identification. For instance, the implied labor elasticity at the mean market share observed in the data, $\{\varepsilon(\bar{s}_{ijkt}^{wn}), \bar{s}_{ijkt}^{wn}\}$, and the implied labor elasticity one standard deviation above the mean, $\{\varepsilon(\bar{s}_{ijkt}^{wn} + \sigma(s_{ijkt}^{wn})), \bar{s}_{ijkt}^{wn} + \sigma(s_{ijkt}^{wn})\}$, provide two equations in two unknowns $\{\eta, \theta\}$.

	Year t (1)	Year t+1 (2)
Within market substitutability, η	2.09	3.74
Across market substitutability, θ	0.31	0.76

Table 5: Non-linear regression estimates of substitutability based on equation (16)

Notes: We use an evenly spaced grid of labor shares on $[\underline{s}^{wn}, \bar{s}^{wn}] = [0.0025, 0.14]$ (within 1 standard deviation of the mean wage-bill share), in conjunction with equation (15) to generate 56 tuples of labor supply elasticities and wage-bill shares, $\{\varepsilon(s^{wn}_{ijkt}), s^{wn}_{ijkt}\}$ (one for every grid point). We then use these predicted values as data for $\{\varepsilon_{ij}, s^{wn}_{ij}\}$ to provide non-linear regression estimates of η and θ using equation (16). Column (1) uses estimates from Columns (4) and (8) in Table 3 and Column (2) uses estimates from Columns (4) and (8) in Table 4.

Distribution of number of firms M_j	**Mean** (1)	**Std.Dev.** (2)	**Skewness** (3)
Data (LBD, 2014)	51.6	264.9	29.9
Model	51.6	264.9	28.7

Table 6: Distribution of firms across markets, $M_j \sim G(M_j)$

6.4 Calibration of other parameters

We assume a log-normal distribution of productivity $\tilde{z}_{ijt}$ with mean one and standard deviation $\sigma_{\tilde{z}}$. We then scale the distribution by $\widetilde{Z}$ in order to match mean firm employment. To match the 2014 distribution of firms across markets, $M_j \sim G(M_j)$, we employ a mixture of Pareto distributions. We fit this mixture to the first three moments of the distribution, given in Table 6. Appendix H provides additional details, including parameter estimates. By construction we generate the correct fraction of markets with one firm. Throughout we simulate 5,000 markets and verify that our results are not sensitive to this choice.

We set $\theta = 0.76$ and $\eta = 3.74$ based on our long-run estimates in Table 5. The 'Year $t+1$' values for θ and η generate less labor market power than the short-run 'Year t' estimates. Our baseline aggregate Frisch elasticity of labor supply is $\varphi = 0.50$, which lies in the range of estimates obtained in micro-data analyses (e.g. Keane and Rogerson (2012)).[25] The discount rate is 4 percent per annum, $\beta = 0.9615$. The depreciation rate is 10 percent per annum, $\delta = 0.10$. The remaining parameters $\{\widetilde{Z}, \bar{\varphi}, \tilde{\alpha}, \sigma_{\tilde{z}}\}$ are calibrated to match the following moments: (1) average firm employment, (2) average earnings per worker, (3) the labor share, and (4) the employment-weighted wage-bill Herfindahl.

[25]The CBO uses estimates between 0.27 and 0.53. See Reichling and Whalen (2012) for more discussion.

Parameter	Description	Value
Assigned		
η	Within market substitutability	3.74
θ	Across market substitutability	0.76
φ	Aggregate Frisch Elasticity	0.5
J	Number of markets	5,000
r	Risk free rate	0.04
δ	Depreciation	0.1
γ	Cobb-Douglas Exponent	0.818
$G(M_j)$	Firms per mkt, mixtures of Paretos w/ mass pt at 1	{15% mkts have 1 firm, Sh1=.67, Sc1=5.7, Loc1=2, Sh2=.67, Sc2=35.625, Loc2=2}
Estimated		
$\tilde{\alpha}$	DRS parameter	0.984
$\sigma_{\tilde{z}}$	Log Normal Standard Deviation	0.391
$\widetilde{Z}$	Productivity shifter	23,570
$\bar{\varphi}$	Aggregate labor disutility shifter	6.904

Table 7: Summary of Parameters

To determine the scale of the economy, we exploit the closed-form mapping of our model's parameters, $\{\widetilde{Z}, \bar{\varphi}\}$, to average earnings per worker and average firm size.[26] Setting $\widetilde{Z} = 23,570$ and $\bar{\varphi} = 6.904$ generates the 2014 average earnings per worker of $\$65,773$ and 2014 average firm size of 27.96 employees (Table 1).

We calibrate $\tilde{\alpha} = 0.984$ to deliver the 2014 labor share of 57 percent (Giandrea and Sprague, 2017). In order to recover aggregates as well as the labor share, we choose $\gamma = 0.818$ to deliver a capital share of 18 percent in 2014 (Barkai, 2016).[27] Given $\tilde{\alpha}$ and γ we can solve for the structural decreasing returns parameter $\alpha = 0.987$.[28] We calibrate $\sigma_{\tilde{z}} = 0.391$ to deliver a payroll weighted wage-bill Herfindahl of 0.14 (see Table 1). Conditional on other parameters, a higher dispersion in productivity naturally increases concentration as large firms face less competition.

Table 7 summarizes the parameters, and Table 8 compares the model targets to the data.

[26]We provide the closed-form mapping in Appendix F.1.

[27]We must also take a stance on the capital share in our economy in order to go from the 'hatted' equilibrium described in Appendix F to the equilibrium with capital.

[28] Let K^s be capital's share of income, which we treat as data: $K^s = 0.18$. Then given this moment and our estimate of $\tilde{\alpha}$, the structural decreasing returns to scale parameter $\alpha = \tilde{\alpha}/\left(\frac{K^s}{1-K^S} + \tilde{\alpha}\right)$. We then determine the capital share parameter: $\gamma = K^s/(1-\alpha)$.

Par.	Description	Value	Targeted Moment	Model	Data
$\tilde{\alpha}$	DRS parameter	0.984	Labor share	0.57	0.57
$\sigma_{\tilde{z}}$	Log Normal Standard Deviation	0.391	$E(HHI_j^{wn})$ Payroll wtd.	0.14	0.14
$\widetilde{Z}$	Productivity shifter	23,570	Avg. wage per worker	$ 65,773	$ 65,773
$\bar{\varphi}$	Aggregate labor disutility shifter	6.904	Avg firm size	27.96	27.96

Table 8: Estimated parameters

7 Validation

Before conducting our welfare experiments we complete a number of over-identifying tests of the model. These confirm that the model is well suited to studying issues of labor market power.

First, we verify that the model produces rates of pass-through from productivity to wages, including recent estimates by Kline, Petkova, Williams, and Zidar (2018) and Card, Cardoso, Heining, and Kline (2018). Second, despite calibrating the model to payroll weighted measures of concentration across markets, we verify that the model matches the very different *unweighted* distribution of these measures.

7.1 Pass-through

We compare model and data estimates of the rate of pass-through from productivity to worker wages. Since productivity is often not observed, most empirical studies focus on the pass-through of sales- or value added-per-worker. Wages are then measured either as labor compensation per worker or as an hourly wage. While there many papers conduct such pass-through regressions, Kline, Petkova, Williams, and Zidar (2018) is one of the few papers that provides sufficient summary statistics to replicate their natural experiment in our model. Their sample contains relatively large firms—median size of 25 employees—that successfully obtain a high-value patent. Their estimates imply that the receipt of a high-value patent increases various measures of productivity, such as value added per worker, by approximately 20 percent. They then evaluate the effect on wages.

In order to compare our estimates to Kline, Petkova, Williams, and Zidar (2018), we first construct a random sample of firms consisting of one firm per market, and such that the median of the sample is similarly 25 employees.[29] We then multiply the productivity ($\tilde{z}_{ij}$) of firms in our

[29]To obtain a sample of firms with the same median size as in the Kline, Petkova, Williams, and Zidar (2018) sample, we simply drop all firms with employment below a cut-off $\underline{n}$. We then choose $\underline{n}$ to deliver a median firm size of 25 workers.

	Benchmark Model (1)	Kline et al (2018) (2)	Cardoso et al (2018) (3)	Competitive Model (4)
Pass-through coefficient	0.423	0.317	0.327	0.984
Dependent Variable	w_{ij}	Labor compensation per worker	Hourly wage	w_{ij}
Independent Variable	y_{ij}/n_{ij}	Labor compensation plus earnings (EBITDA) per worker	Value added per worker (IV with avg. sales per worker)	y_{ij}/n_{ij}

Table 9: Wage pass-through, model versus data

Notes: Model point estimate generated by randomly sampling 1% of firms in the benchmark oligopsonistic economy with size greater than 10 employees (corresponding to median size of 25.4 in the sample vs 25.2 in Kline et al (2018)), increasing productivity by 30% (corresponding to a 25% increase in y_{ij}/n_{ij} versus $\approx 20\%$ in Kline et al (2018)), and repeating this exercise 100 times. Average We report the average point estimate for 100 repetitions.

sample by $\Delta > 1$, choosing Δ to match an average increase in output per worker (y_{ij}/n_{ij}) of 20 percent. Let primes denote the new steady state variables among the firms in our sample. We regress the level change in wages ($\Delta w_{ij} = w'_{ij} - w_{ij}$) on the level change in output per worker ($\Delta \frac{y_{ij}}{n_{ij}} = \frac{y'_{ij}}{n'_{ij}} - \frac{y_{ij}}{n_{ij}}$) and a constant.

Table 9 reports our estimates of wage pass-through in the model. We find a pass-through rate of 42.3 percent, meaning that for every one dollar increase in output per worker, wages increase by 42.3 cents. Kline, Petkova, Williams, and Zidar (2018) find a pass-through rate of 31.7 percent using U.S. data, which, by design, is directly comparable to our model estimate. Using Portuguese data, other recent work by Card, Cardoso, Heining, and Kline (2018) uses lagged sales per worker as an instrument for value added per worker. While we cannot replicate their regressions directly, they find a pass-through rate of 32.7 percent. Since we did not target pass-through in our estimation, we view the model's ability to generate a pass-through rate quite close to recent empirical estimates as a success of our theory.

Lastly, when we consider the competitive version of our model (defined later in Section 8), we find that the pass-through rate is equal to 0.984. This coincides with the value of $\tilde{\alpha}$, which governs decreasing returns to scale. In order for the competitive model to match observed pass-through rates, the decreasing returns parameter would have to be around 0.3, which we view as implausible and at odds with existing estimates of returns to scale.

7.2 Non-targeted concentration statistics

Figure 5 compares the weighted and unweighted distributions of wage-bill Herfindahl indexes in model and data.[30] Panel A plots the payroll weighted distribution of the wage-bill Herfind-

[30] Table A1 in Appendix C provides point estimates referenced in this section and additional statistics.

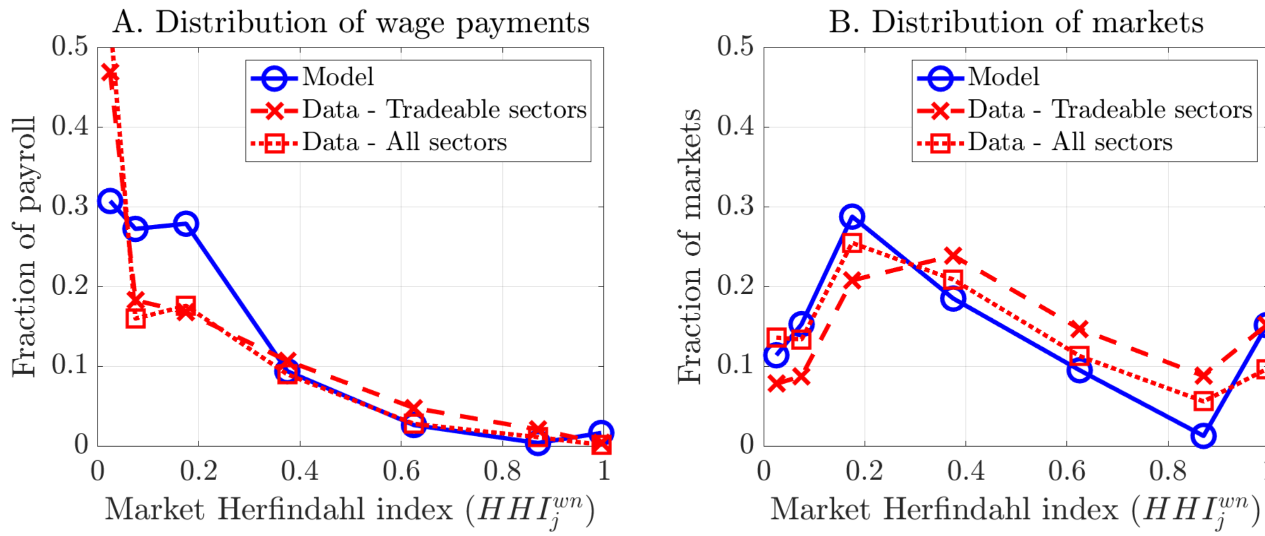


Figure 5: Cross-market distribution of concentration: Model and Data, 2014.

Notes: Figure plots the across market distribution of the payroll Herindahl index (HHI_j^{wn}). Bins are determined by the following bounds: $\{0, 0.05, 0.10, 0.25, 0.50, 0.75, 0.99, 1\}$. The horizontal axis gives the center of each bin. Panel A plots the fraction of total payroll in each bin. Panel B plots the fraction of markets in each bin. The former informs the *payroll weighted* index, the latter informs the *unweighted* index referenced in the text. Data is Census LBD. See Appendix C for additional details.

ahl. Very little mass is to the right of 0.25, and the mean of the distribution is 0.14. Panel B plots the unweighted distribution of the wage-bill Herfindahl. Around half of the mass is to the right of 0.25, and the mean is 0.45, three times larger than the weighted mean.

This wide difference is due to the strongly negative correlation between concentration and total payroll, and employment. While 15 percent of markets have one firm, those markets comprise less than half of one percentage point of total employment. Figure 5 also includes the economy-wide distribution of Herfindahls. The large difference between the weighted and unweighted Herfindahl distributions is not specific to the tradeable sector.

Figure 5 shows that the model does well fitting both distributions. The model exactly reproduces the mean payroll weighted wage-bill Herfindahl, since it is a calibration target. However, none of the other moments of the distribution were used as targets. The model also generates an unweighted average payroll Herfindahl of 0.31, which is not targeted in our calibration. Similar to the data, the unweighted mean wage-bill Herfindahl is roughly two times larger than the weighted mean.

The reason that the model is able to produce the large empirical discrepancy between the weighted and unweighted measures is because the model generates a strong negative correlation between market concentration and market size. The model correlation between market size and market concentration is -0.75, whereas in the data the correlation is -0.21. Because smaller markets are highly concentrated, their firms pay wider markdowns on the marginal product of labor as discussed in Section 5. Without competition, these firms act as monopsonists, restricting quantity (lower employment) and widening markdowns (lowering wages).

The model is also able to replicate the negative correlation of the wage-bill Herfindahl and the number of firms per market, as well as the negative correlation between the wage-bill Herfindahl and the variance of relative wages within a market (Table A1). Lastly, the wage-bill and employment Herfindahls are perfectly correlated in both the model and the data, despite their significant level differences.

8 Welfare consequences of labor market power

We use our calibrated model to measure the welfare consequences of labor market power. We discuss the sources of labor market power in our economy, define a competitive equilibrium, and then compute the consumption equivalent welfare gain associated with a competitive equilibrium.

Labor market power. Our estimated preferences imply upward sloping labor supply curves. In our benchmark oligopsonistic model, there are two sources of market power: (i) firms internalize this feature of their environment, understanding that hiring an additional worker requires not only a higher wage to the marginal worker, but also all previous workers hired, and (ii) firms are non-atomistic and so compete strategically for workers. Existing models such as Burdett and Mortensen (1998) feature the first source of market power, but since firms are atomistic, lack the second.

Competitive equilibrium. To measure the welfare losses from both sources of market power, we compare our benchmark oligopsonistic equilibrium to a competitive equilibrium. We keep preferences, technology and the distribution of firms-per-market (M_j) fixed, changing only the equilibrium concept. The competitive equilibrium still features upward sloping labor supply curves, but firms do not internalize this. The competitive equilibrium still features finitely many firms in each market, but firms behave as atomistic price takers.[31] Thus, there are no strategic complementarities.

We formally define the competitive equilibrium as follows:

[31] Keeping the number of firms in each market constant purges our exercise of changes in welfare due to 'love of variety' effects.

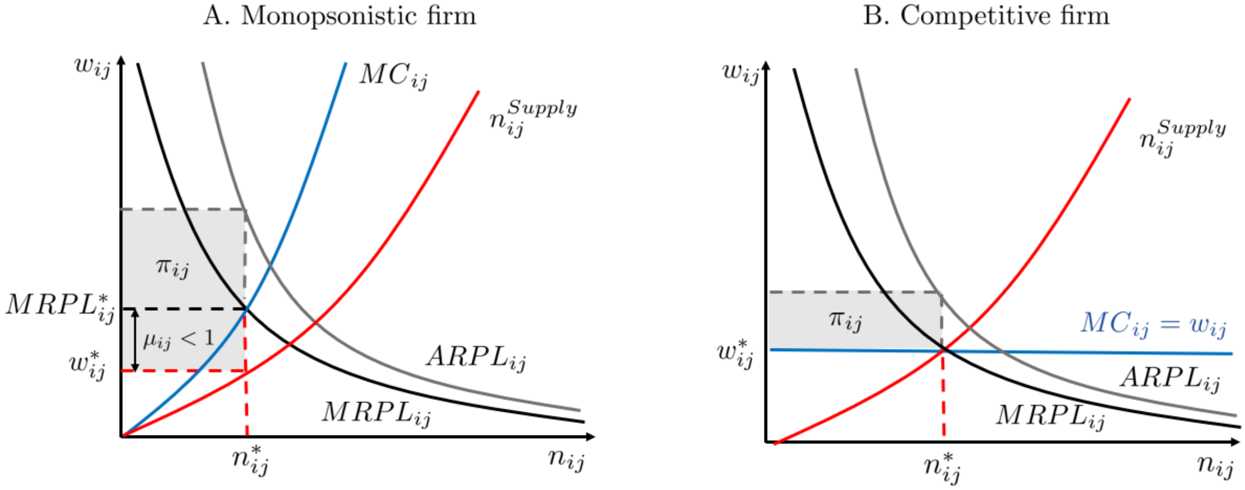


Figure 6: Oligopsonistic vs. Competitive equilibrium

Notes: In a *oligopsonistic equilibrium* (Panel A) the firm understands that its marginal cost MC_{ij} is increasing in its employment. In a *competitive equilibrium* (Panel B) the firm perceives that its marginal cost MC_{ij} is simply equal to its wage, which it takes as given.

Definition *A* ***Competitive (Walrasian) equilibrium*** *is an allocation of employment n_{ij}, and wages w_{ij} such that:*

1. *Taking w_{ij} as given, n_{ij} solves each firm's optimization problem*

$$n_{ij} = \arg\max_{n_{ij}} \widetilde{Z}\tilde{z}_{ij} n_{ij}^{\tilde{\alpha}} - w_{ij} n_{ij}$$

2. *Taking w_{ij} as given, n_{ij} solves the household's labor supply problem:*

$$n_{ijt} = \bar{\varphi} \left(\frac{w_{ijt}}{\mathbf{W}_{jt}} \right)^{\eta} \left(\frac{\mathbf{W}_{jt}}{\mathbf{W}_t} \right)^{\theta} \mathbf{W}_t^{\varphi}$$

Figure 6 describes the difference between a firm behaving monopsonistically (Panel A) and the same firm behaving competitively (Panel B). Firms' wages are unambiguously higher in the competitive equilibrium. The net effect on employment, however, varies across firms. Since large firms have the widest markdowns in the oligopsonistic equilibrium, their wages increase the most. This reallocates employment away from small firms toward large firms, undoing the direct effect of small firms' higher wages, and can lead employment to *decline* at small firms in the competitive equilibrium.

Frisch Elasticity (1)	Consumption Equivalent Welfare Gain (Percent) (2)	Relative Employment Index **N** (Competitive/Monopsony) (3)
0.2	2.9	1.075
0.5	5.4	1.196
0.8	8.0	1.330

Table 10: Welfare gains from competition

Notes: Consumption equivalent welfare gain corresponds to $100 * (\lambda - 1)$ where λ is given by (17). Consumption equivalent welfare gain corresponds to moving from benchmark oligopsony to competitive equilibrium.

Welfare. To compute the welfare losses from oligopsony, we introduce some additional notation. Let $\{\mathbf{C}_o, \mathbf{N}_o\}$ denote consumption and disutility of labor in the benchmark oligopsonistic equilibrium. Let $\{\mathbf{C}_c, \mathbf{N}_c\}$ denote consumption and disutility of labor in the competitive equilibrium.

We express the welfare losses as a consumption equivalent. Households are willing to give up $100 \times (\lambda - 1)$ percent of their consumption in the benchmark oligopsonistic economy in order to move to the competitive economy. That is, λ equates the following:

$$\lambda \mathbf{C}_o - \frac{1}{\bar{\varphi}^{\frac{1}{\varphi}}} \frac{\mathbf{N}_o^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}} = \mathbf{C}_c - \frac{1}{\bar{\varphi}^{\frac{1}{\varphi}}} \frac{\mathbf{N}_c^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}} \tag{17}$$

Table 10 reports the welfare gain in our benchmark calibration, which assumes a Frisch elasticity of $\varphi = 0.5$. We also compute the welfare gain under alternate values of $\varphi \in \{0.2, 0.8\}$. At our benchmark calibration, individuals would be willing to give up 5.4 percent of lifetime consumption in order to face a labor market with competitive firms. With higher wages, time spent working increases 19.6 percent, producing higher consumption. For lower values of φ, the utility cost of additional time spent working is higher, so the welfare gains are lower. Therefore, larger Frisch elasticities ($\varphi = 0.8$) generate larger welfare gains.

Decomposing effects. To understand the sources of the welfare gains, we decompose *output* gains into two components: (1) scale-effects resulting from overall higher wages and labor supply, (2) reallocation from less productive to more productive firms. Figure 7 plots the percent change in employment across the oligopsonistic and competitive equilibrium, conditional on productivity.

In the lowest deciles of productivity, firms *decrease* employment. High-productivity, high wage-bill share firms had disproportionately larger markdowns in the oligopsonistic equilib-

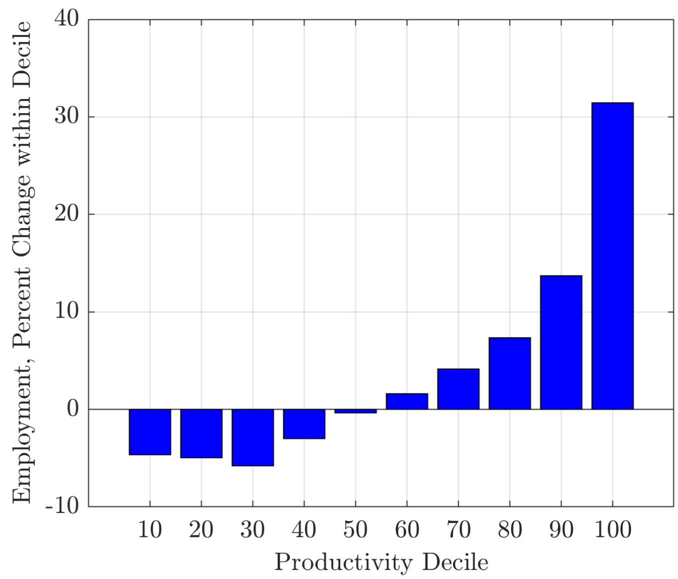


Figure 7: Employment gains due to perfect competition.

Notes: Percent change in total employment within productivity decile bin. Change measured between benchmark oligopsony equilibrium and competitive equilibrium.

rium. In the competitive equilibrium, they pay disproportionately higher wages and expand, attracting a greater share of employment. The result is a reallocation from less productive firms to more productive firms.

Figure 7 also includes the aggregate scale effect resulting from higher overall pay. To isolate the role of scale-effects versus reallocation, we compute the welfare gains conditional on maintaining the original proportion of workers across firms. Let n_{ij}^{o} (N^{o}) denote firm-level (aggregate) employment in the oligopsonistic equilibrium, and n_{ij}^{c} (N^{c}) denote firm-level (aggregate) employment in the competitive equilibrium. We can compute counterfactual employment (n_{ij}^{s}) and output (y_{ij}^{s}) under no reallocation by keeping firms' share of aggregate employment constant:

$$n_{ij}^{s} = \frac{n_{ij}^{o}}{N^{o}} \times N^{c} \quad , \quad y_{ij}^{s} = \widetilde{Z}\tilde{z}_{ij}(n_{ij}^{s})^{\tilde{\alpha}} \quad , \quad Y^{s} = \int \sum_{i \in j} y_{ij}^{s}\, dj\,.$$

Let Y^{c} denote aggregate output in the competitive equilibrium, let Y^{o} denote aggregate output in the oligopsonistic equilibrium. The share of output gains due to the reallocation effect from low-productivity to high-productivity firms is then

$$\textit{Share of gains due to reallocation} = \frac{Y^{c} - Y^{s}}{Y^{c} - Y^{o}}.$$

	Benchmark Model	Competitive Model
Payroll weighted wage-bill Herfindahl	0.14	0.27
Payroll weighted employment Herfindahl	0.11	0.20
Unweighted wage-bill Herfindahl	0.35	0.42
Unweighted employment Herfindahl	0.32	0.38

Table 11: Concentration and competition

Notes: Reports the average HHI_j^{wn} weighted by employment across markets. Computed for the baseline calibration with Frisch elasticity of φ.

Output increases by 20.9 percent between the oligopsonistic and competitive equilibrium. We find that reallocation increases output by 5.5 percent. This implies that roughly 25 percent of the overall increase in output is driven by reallocation, whereas 75 percent is driven by scale effects. The importance of scale effects highlights why the choice of the aggregate Frisch elasticity has a significant effect on welfare counterfactuals. For a larger φ, workers are more sensitive to wages changes and thus work significantly more in the competitive equilibrium. These scale effects drive the majority of output gains observed in the counterfactual competitive environment.

Increasing concentration. A consequence of the reallocation in Figure 7 is *rising* concentration. Table 11 illustrates that in the competitive equilibrium, the weighted wage-bill Herfindahl *increases*. This result also holds for weighted and unweighted employment-based measures of concentration. As large firms become larger, concentration rises even though the labor market is more competitive. Competition, output, wages and welfare all increase at the same time as markets become more concentrated.

To illustrate, Figure 8 extends our example Figure 3, adding the competitive outcomes for the three labor markets studied. In the sector with three firms, the payroll share of the most productive firm increases, while that of the two least productive firms fall. As a consequence, concentration increases. Meanwhile, the employment at the most productive firm also increases, while their competitors' fall, improving the allocation of employment in the economy and increasing output.

9 Labor market power and the labor share: 1976 and 2014

In this section, we use the aggregation results of Section 5 to compute the impact of falling labor market concentration on labor's share of income. In particular, we use the closed-form

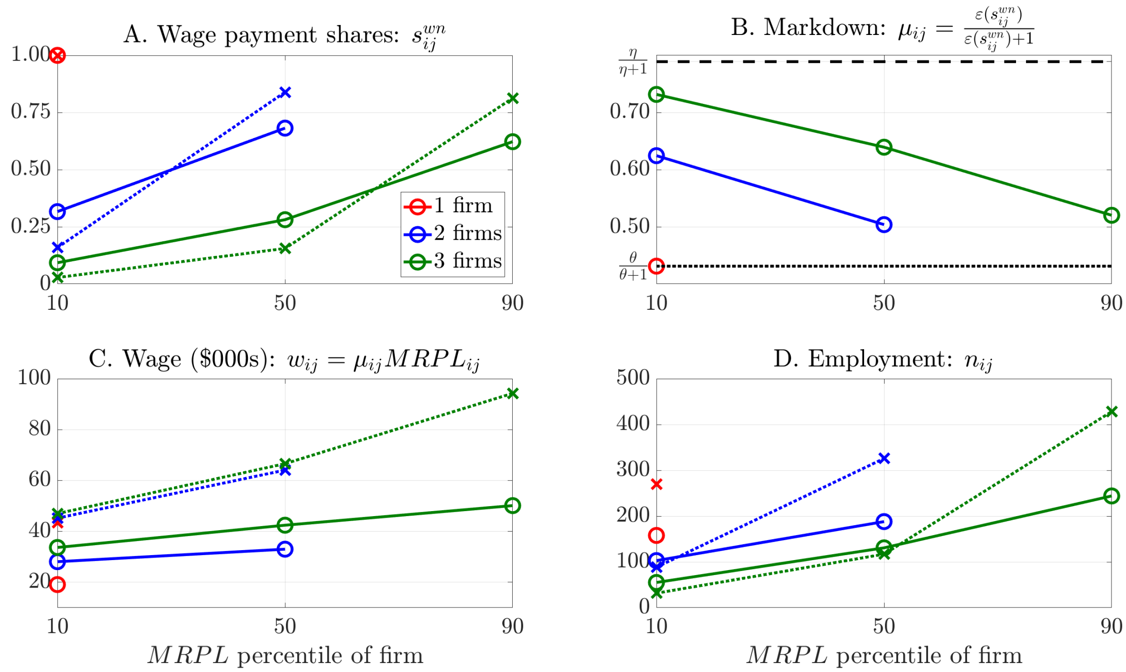


Figure 8: Oligopsonistic [solid] and competitive [dashed] equilibrium in three labor markets

expression for labor's share of income given by equation (12) to link the dynamics of labor's share of income to our measures of wage-bill Herfindahls in Table 1.

The weighted wage-bill Herfindahl fell from 0.20 in 1976 to 0.14 in 2014, which implies that the inverse weighted wage-bill Herfindahl increased from 5.01 to 7.09. Under the assumption of stable preference parameters ($\theta = 0.76$, $\eta = 3.74$) and technology ($\tilde{\alpha} = 0.984$) as calibrated in Table 7, equation (12) implies that declining wage-bill Herfindahls between 1976 and 2014 have contributed to an increase in the labor share of 2.89 percentage points.

We conclude that changes in labor market concentration are unlikely to have contributed to the declining labor share in the United States (e.g. Karabarbounis and Neiman (2013)).

10 Minimum wages

As an application of the model, we study minimum wages. The effect of a minimum wage on wages and employment has been a significant motivation for developing monopsonistic models (e.g. Boal and Ransom (1997), Manning (2003)). The central prediction in a monopsonistic model is that if some firms are paying below their marginal revenue products, a higher minimum wage may lead these firms to compress their markdowns, increasing wages, and at the same time increasing employment as they move along their labor supply curves. Our model shares this prediction, but due to decreasing returns to scale this is not universally true.

The presence of decreasing returns to scale and strategic complementarities in wages yields rich implications for the theory of minimum wages, so we describe the effects in some detail. We then compare the effects of a minimum wage to those found in Germany in a recent paper by Dustmann, Lindner, Schoenberg, Umkehrer, and vom Berge (2019). We finish by computing the optimal minimum wage in our framework.

10.1 Theory

To formalize our analysis, we must rewrite the household problem subject to the constraint that labor supply lies below labor demand, which the household takes as given. The representative households maximizes utility (equation (3)) subject to the budget constraint (equation (4)) and the new constraint that labor supply is less than labor demand:

$$n_{ijt} \leq \underline{n}_{ijt} \tag{18}$$

To facilitate interpretation, we define $\lambda_t \nu_{ijt}$ be the multiplier associated with constraint (18), where λ_t is the multiplier on the budget constraint. We refer to ν_{ijt} as the scaled multiplier and we refer to $\tilde{w}_{ijt} = w_{ijt} - \nu_{ijt}$ as the *perceived wage*. From the perspective of the household, ν_{ijt} is the value of sending an additional worker to a firm with a binding minimum wage in which labor supply exceeds labor demand (these are firms in *Region III* or *Region IV* in the notation that follows). In the instances where ν_{ijt} is greater than zero, the household is not on their labor supply curve. Although they are not on their labor supply curve, they perceive the wage to be $\tilde{w}_{ijt}$ and therefore supply $\underline{n}_{ijt}$ workers to firm i in market j.

As before, firms maximize profits π_{ijt} subject to the constraint that the wage implied by their choice of n_{ijt} must lie above the minimum wage.

$$w_{ijt} = \begin{cases} \bar{\varphi}^{-\frac{1}{\varphi}} \mathbf{N}_t^{\frac{1}{\varphi}} \left(\frac{\mathbf{N}_{jt}}{\mathbf{N}_t} \right)^{\frac{1}{\theta}} \left(\frac{n_{ijt}}{\mathbf{N}_{jt}} \right)^{\frac{1}{\eta}} & , \quad \text{if} \quad n_{ijt} > \underline{n}_{ijt} \\ \underline{w} & , \quad \textit{otherwise} \end{cases} \tag{19}$$

In Appendix I we detail the solution algorithm. We show that the equilibrium of the sectoral oligopsony can be solved in terms of wage payment shares of *perceived* wages, $\tilde{s}^{wn}_{ijt}$, as well as the the *perceived* aggregate wage index, $\widetilde{\mathbf{W}}_t$.[32] Firms now operate with markdowns $\mu(\tilde{s}^{wn}_{ijt})$.

[32]The perceived wage payment share is $\tilde{s}^{wn}_{ijt} = \tilde{w}_{ijt} n_{ijt} / \sum_{k \in j} \tilde{w}_{ijt} n_{ijt}$, where $\tilde{w}_{ijt} = w_{ijt} - \nu_{ijt}$.

As we will show below, this can lead to cases where productive firms that are not directly affected by the minimum wage may *lower* their wages as the minimum wage increases. Although their small competitors' wages increase, their perceived wages and perceived wage shares fall, increasing the market power of large firms.

10.2 Characterization

Figure 9 illustrates the impact of the minimum wage on a firm. We keep the firm the same, and vary the minimum wage. Four cases obtain as we increase the minimum wage:

$$\text{Range for } \underline{w}: \quad 0 \underset{\textit{Region I}}{\xrightarrow{\hspace{2cm}}} w^*_{ij} \underset{\textit{Region II}}{\xrightarrow{\hspace{2cm}}} w^{Comp.}_{ij} \underset{\textit{Region III}}{\xrightarrow{\hspace{2cm}}} MC^*_{ij} \underset{\textit{Region IV}}{\xrightarrow{\hspace{2cm}}} \infty$$

Panel A illustrates a low minimum wage. The firm is in *Region I* where the minimum wage has no effect on equilibrium labor supply ($\underline{w} < w^*_{ij}$). In Panel B we increase the minimum wage. In *Region II* the minimum wage binds, which the firm absorbs into its markdown. Employment increases relative to *Region I* and the marginal revenue product of labor falls, while the household remains on its labor supply curve.

The marginal cost curve is now quite different from the benchmark economy without a minimum wage. With a minimum wage of $\underline{w}$, the new marginal cost curve (solid blue) is horizontal and equal to the minimum wage until it reaches the labor supply curve where the firm employs $\underline{n}_{ij}$ workers. Up to this point, all workers must be paid $\underline{w}$. Marginal cost then discontinuously increases as hiring further requires raising pay for all existing workers. Since marginal cost jumps above the marginal revenue product, profit maximizing employment is $\underline{n}_{ij}$. In *Region II*, firms still generate profits from both a non-zero markdown μ_{ij} and a positive wedge between average and marginal revenue products due to decreasing returns to scale.

By increasing the minimum wage further, the firm enters *Region III* (Panel C). The same rationale for marginal cost applies as in *Region II*, however now the minimum wage is above the competitive wage, and so households are off of their labor supply curve. Like *Region II*, employment is still higher than under a zero minimum wage, but there is now *excess labor supply*. As such, employment is determined by the firm's labor demand at $\underline{w}$ and $\underline{n}_{ij} < n^{Supply}_{ij}$ workers are hired. Since $w_{ij} = \underline{w} = MRPL_{ij}$, the wage markdown is zero but profits π_{ij} are positive due to decreasing returns to scale.[33] Below we formalize this problem and model excess supply as a constraint on household labor supply. Households associate a scaled multiplier ν_{ij} with the

[33]Note that *Region III* does not exist with constant returns to scale. With constant returns to scale the competitive wage is equal to $MRPL_{ij}$ which is a constant. Therefore as $\underline{w}$ increases past the competitive wage, the firm exits.

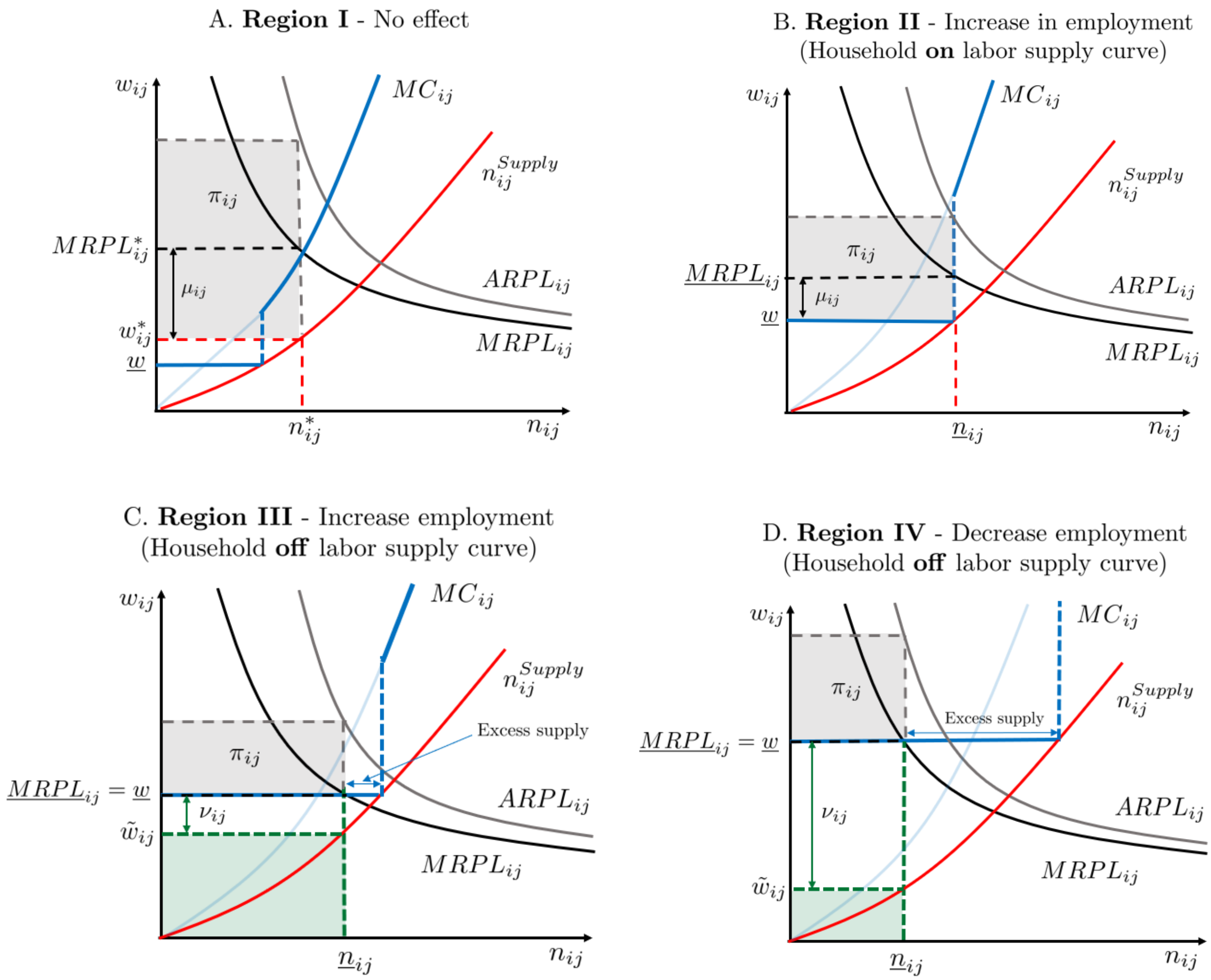


Figure 9: Theory of minimum wage

constraint $n_{ij} \leq \underline{n}_{ij}$. Labor supply is then *as if* the wage is $\tilde{w}_{ij} = w_{ij} - \nu_{ij}$, such that when $\nu_{ij} > 0$ households perceive a wage lower than the equilibrium wage.

Increasing the minimum wage beyond the equilibrium marginal cost in the unconstrained case causes the firm to enter *Region IV* (Panel D). The same economics apply as in *Region III*, but here equilibrium employment is *less* than would occur absent a minimum wage.

Our *perceived wage* formulation allows for a sharp characterization of the effect of a minimum wage on the policies of firms for which the minimum wage does not bind (*Region I*). The perceived wages $\tilde{w}_{ij}$ of their smaller competitors are lower than their actual wages, and falling as the minimum wage increases. As an unconstrained firm responds to the perceived sectoral wage $\tilde{\mathbf{W}}_j$, which is falling, they best-respond by cutting their own wages.[34] Despite widening

[34] Alternatively, the *perceived* wage bills of constrained firms—given by the green squares in Figure 9—are smaller

Moment	Model	Data
Post experiment min-median ratio (percent): w_{min}/w_{p50}	61	48
Δ log Ave firm size	0.01	0.12
Δ log Number of firms with $n_{ij} \leq 2$	-0.28	-0.15
Δ log Number of firms with $n_{ij} \geq 50$	0.000	0.120
Δ Share Emp at firms with $n_{ij} \leq 2$	-0.04	-0.03
Δ Share Emp at firms with $n_{ij} \geq 50$	0.00	0.01
Inequality	**Pre**	**Post**
$p50$-$p10$ (log difference)	0.50	0.49
$p90$-$p50$ (log difference)	0.43	0.43

Table 12: Effects of a minimum wage

Notes: Minimum wage introduced at the 10.4 percentile of the individual wage distribution in the benchmark oligopsony model.

their markdowns, employment at large firms grow as employment is reallocated from small to large firms.

10.3 An example of a minimum wage policy

Recent empirical work has described the effect of a minimum wage on the allocation of employment across firms. Dustmann, Lindner, Schoenberg, Umkehrer, and vom Berge (2019) find that in response to a national minimum wage increase in Germany, (i) employment in small firms shrinks, (ii) the largest employment affects are among medium sized firms, (iii) employment also reallocates to larger firms.

Table 12 presents results from a simulation of the same minimum wage increase studied by Dustmann, Lindner, Schoenberg, Umkehrer, and vom Berge (2019). The federal minimum wage introduced in Germany was such that 10.4 percent of workers earned less than the minimum wage before the policy was introduced. To map this natural experiment to our framework, we first identify the a minimum wage $\underline{w}$ such that 10.4 percent of workers earn less than $\underline{w}$ in the benchmark equilibrium. In the new equilibrium, the minimum wage is 61 percent of the median wage, which is a little higher than the case of the German experiment (48 percent).

Table 12 describes the effects of the minimum wage.[35] Average firm size increases by 1 percent in the model versus 12 percent in the data. The source of the size gain is a reallocation

than actual wage bills. This leads to a larger perceived wage bill share of the unconstrained firms. A higher perceived wage bill share yields a wider markdown, reducing wages.

[35]The 'data' column was taken from preliminary slides available to us at the time of writing. In some instances these statistics are inferred from graphs, and are thus subject to change.

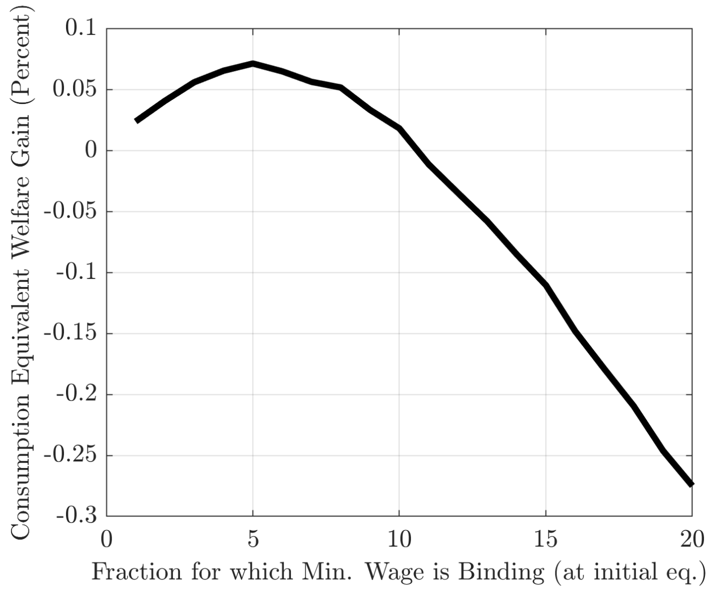


Figure 10: Optimal minimum wage

Notes: Plots the consumption equivalent welfare gains (percent) for various different minimum wages $\underline{w}$. The horizontal axis indexes these minimum wages by the fraction of workers in the benchmark equilibrium (without a minimum wage) with a wage less than $\underline{w}$.

of workers from smaller firms to larger firms that attain a greater share of the market. We find a 28 percent reduction in the number of small firms with less than two employees, and a marginal rise in the number of firms with greater than 50 employees. Employment at small firms falls by 4 percent in the model and 3 percent in the data.

The minimum wage has small effects on income inequality. The $p50$-$p10$ wage ratio is largely unaffected, declining only one log point from 0.50 to 0.49. The minimum wage does not have significant effects at the top of the wage distribution. As our theory predicts, the minimum wage increases total employment N $(= \int_j \sum_i n_{ij} dj)$ by 1.07 percent, and increases aggregate consumption by 0.37 percent. Lastly, we find that households would be willing to give up 0.064 percent of lifetime consumption in order to have this particular minimum wage imposed.

10.4 Optimal minimum wage

Recall from Section 8, that the welfare gains associated with a counterfactual competitive equilibrium were 5.4 percent. One way to regard the competitive equilibrium allocation is as being equivalent to that obtained by setting a *firm-specific* minimum wage equal to the competitive wage. From this perspective, an economy-wide minimum wage is a relatively blunt tool at undoing firm labor market power, but quantitatively how far can a minimum wage go toward

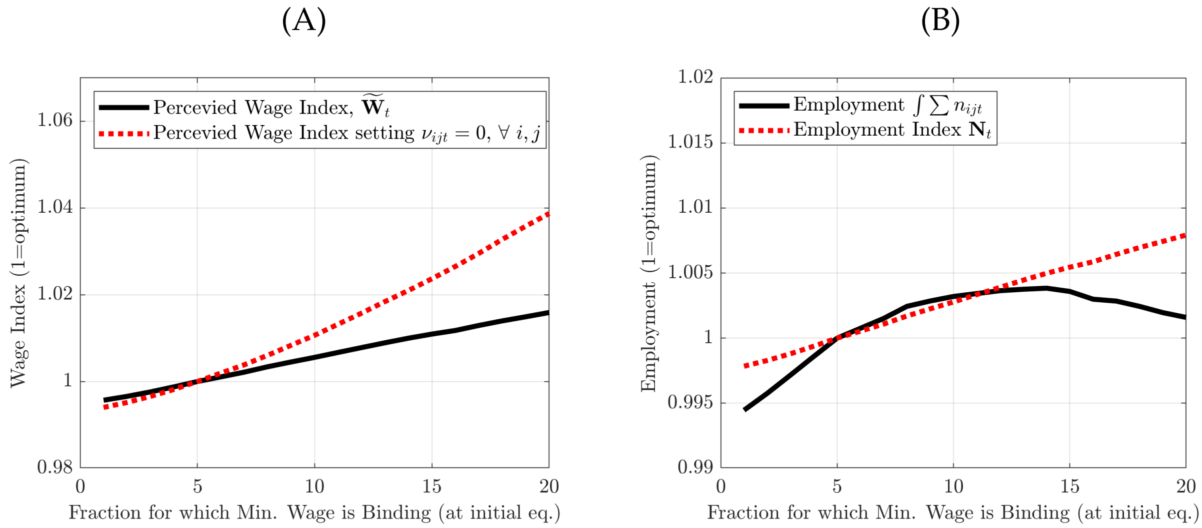


Figure 11: Perceived wage index and employment

Notes: Panel (A) plots (1) the perceived aggregate wage index $\widetilde{\mathbf{W}}_t := \left[\int \widetilde{\mathbf{W}}_{jt}^{1+\theta} dj\right]^{\frac{1}{1+\theta}}$ where the perceived sectoral wage index is given by $\widetilde{\mathbf{W}}_{jt} := \left[\sum_{i\in j}\left(w_{ijt} - \nu_{ijt}\right)^{1+\eta}\right]^{\frac{1}{1+\eta}}$; (2) the perceived wage index setting ν_{ijt}=0. See appendix I for more. Panel (B) plots the employment index and total employment. Both panels are normalized so that the optimum is 1.

achieving the first-best?

Figure 10 plots the welfare gains associated with alternative values of the minimum wage. The optimal minimum wage would exceed the wages of the lowest paid 5 percent of workers in the initial equilibrium, and delivers a welfare gain of 0.072 percent, and an increase in employment (output) of .74 (0.25) percent.[36]

What limits the welfare gains from minimum wages? As we learned from Figure 7, the welfare gains associated with the competitive equilibrium were driven by the reduction in markdowns and increase in employment at large firms. This would require the minimum wage to be such that large firms are in *Region II*. As we increase the minimum wage, however, small firms are primarily in *Region II*. They then quickly move into *Region III* and *Region IV* and shrink further as the minimum wage increases. This has the effect of *increasing* the market power of large firms, generating welfare losses that limit gains from the minimum wage.

Figure 11 illustrates these mechanisms by plotting the perceived wage index and employment. Panel (A) plots (1) the perceived wage index $\widetilde{\mathbf{W}}_t$ including the as-if wage multipliers $\nu_{ijt} > 0$, and (2) the perceived wage index setting the as-if wage multipliers to zero, $\nu_{ijt} = 0\ \forall i, j$. Positive values of the multiplier, $\nu_{ijt} > 0$, imply lower effective wages faced by the household.

[36]In dollar terms, the minimum wage corresponds to annual earnings of $\$32,084$.

As the minimum wage expands, the gap between the two indexes grows exponentially, meaning that the multipliers $\nu_{ijt} > 0$ are growing exponentially. The larger multipliers imply that households perceive wages to be falling among a large set of firms. The positive and growing multipliers also imply that firms are moving deeper into *Region III* and *Region IV*, eventually leading to a decline in employment. Panel (B) illustrates the employment index as well as total employment. As firms move further into *Region IV*, total employment declines. The low perceived wages and falling employment limit the possible welfare gains that a minimum wage can deliver.

11 Conclusion

In this paper, we develop a model of labor market oligopsony. We use the framework to (1) inform measurement of labor market concentration and map labor market concentration to labor market power, (2) link labor market power to labor's share of income, (3) measure the welfare losses of labor market power, and (4) study the efficacy of minimum wage policy.

In our framework, we show that the relevant measure of labor market concentration is the wage-bill Herfindahl and the distribution of wage-bill Herfindahls is a sufficient statistic for the labor share. We apply our measures of labor market concentration to tradeable sector firms in the Longitudinal Business Database (LBD). We show that the payroll weighted wage-bill Herfindahl fell from 0.20 to 0.14 between 1976 and 2014, indicating a significant decrease in labor market concentration. Using our theory's closed-form mapping between labor's share of income and wage-bill Herfindahls, we show that declining labor market concentration has *increased* labor's share of income by 2.89 percent between 1976 and 2014.

To assess the normative implications of our measures of labor market concentration, we estimate our model and conduct several counterfactuals. We use within-state-firm, across-market differences in the response of employment and wages to state corporate tax changes (e.g. Giroud and Rauh (2019)) to estimate the size-dependent labor supply elasticities. The size-dependent labor supply elasticities allow us to discipline the degree of labor market power in our model. To test how sensible our estimates are, we show that the model successfully replicates two key non-targeted moments: the large discrepancy between weighted and unweighted wage-bill Herfindahls, and the pass-through rate of value added per worker to wages.

We then use our model to measure the consumption equivalent welfare gain of leaving the benchmark oligopsonistic equilibrium and entering the competitive equilibrium. We find that households would be willing to give up 5.4 percent of lifetime consumption in order to leave the oligopsonistic equilibrium and enter the competitive equilibrium. We show that roughly one-fourth of the output gains generated by moving to the competitive equilibrium come from a reallocation of workers from smaller, less productive firms to larger, more productive firms.

Finally, as an application of the model, we compute optimal minimum wage policy. We find that a minimum wage which binds for 5% of workers in the pre-minimum wage equilibrium is welfare maximizing. The welfare gains from implementing this policy are worth .07% of lifetime consumption. What limits the efficacy of the minimum wage is that since the minimum wage binds mostly for smaller low-wage firms, concentration rises as the minimum wage rises. In many markets, households face lower perceived wages, and eventually, employment begins to fall if the minimum wage rises too much.

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Appendix For Online Publication

This Appendix is organized as follows. Section A provides additional tables and figures references in the text. Section B provides our micro-foundation for nested-CES preferences used in the main text and references in Section 4. Section C contains details about the data and sample selection criteria. Section E contains derivations of the household labor supply curves, optimal firm markdowns, and other formulas referenced in the main text. Section F contains additional details regarding the computation of the baseline model. Section G provides a model of the effect of corporate taxes on the marginal revenue product of labor. Section H provides additional details regarding the calibration. Section I provides our solution algorithm for the model with a minimum wage.

A Additional tables and figures

Moment	Model	Data
A. Unweighted		
Wage-bill Herfindahl (unweighted)	0.35	0.45
Std. Dev. of Wage-bill Herfindahl (unweighted)	0.33	0.33
Skewness of Wage-bill Herfindahl (unweighted)	1.07	0.48
B. Weighted		
Wage-bill Herfindahl (weighted by market's share of total payroll)	0.14	0.14
Std. Dev. of Wage-bill Herfindahl (weighted by market's share of total payroll)	0.03	0.20
Skewness of Wage-bill Herfindahl (weighted by market's share of total payroll)	3.01	2.20
C. Correlations of Wage-bill Herfindahl		
Number of firms	-0.52	-0.21
Std. Dev. Of Relative Wages	-0.31	-0.51
Employment Herfindahl	1.00	0.98
Market Employment	-0.75	-0.21

Table A1: Labor market concentration and cross-market correlations, model versus data

Notes: Benchmark oligopsonistic equilibrium. See data notes in Section 3.

B Microfounding the nested CES labor supply system

In this section we provide a micro-foundation for the nested CES preferences used in the main text. The arguments used here adapt those in Verboven (1996). We begin with the case of monopsonistic competition to develop ideas and then move to the case of oligopsonistic labor markets studied in the text. We then show that the same supply system occurs in a setting where workers solve a dynamic discrete choice problem and firms compete in a dynamic oligopoly.

B.1 Static discrete choice framework

Agents. There is a unit measure of ex-ante identical individuals indexed by $l \in [0,1]$. There is a large but finite set of J sectors in the economy, with finitely many firms $i \in \{1,\ldots,M_j\}$ in each sector.

Preferences. Each individual has random preferences for working at each firm ij. Their disutility of labor supply is *convex* in hours worked h_l. Worker l's disutility of working h_{lij} hours at firm ij are:

$$\nu_{lij} = e^{-\mu\varepsilon_{lij}} h_{lij} \qquad , \qquad \log \nu_{lij} = \log h_{ij} - \mu\varepsilon_{ij},$$

where the random utility term ε_{lij} from a multi-variate Gumbel distribution:

$$F(\varepsilon_{i1}, ..., \varepsilon_{NJ}) = \exp\left[-\sum_{ij} e^{-(1+\eta)\varepsilon_{ij}}\right].$$

The term ε_{lij} is a worker-firm specific term which reduces labor disutility and hence could capture (i) an inverse measure of commuting costs, or (ii) a positive amenity.

Decisions. Each individual must earn $y_l \sim F(y)$, where earnings $y_l = w_{ij} h_{lij}$. After drawing their vector $\{\varepsilon_{lij}\}$, each worker solves

$$\min_{ij} \{\log h_{ij} - \varepsilon_{lij}\} \equiv \max_{ij} \{\log w_{ij} - \log y_l + \varepsilon_{lij}\}.$$

This problem delivers the following probability that worker l chooses to work at firm ij, which is independent of y_l:

$$Prob_l\left(w_{ij}, w_{-ij}\right) = \frac{w_{ij}^{1+\eta}}{\sum_{ij} w_{ij}^{1+\eta}}. \tag{B1}$$

Aggregation. Total labor supply to firm ij, is then found by integrating these probabilities, multiplied by the hours supplied by each worker l:

$$n_{ij} = \int_0^1 Prob_l\left(w_{ij}, w_{-ij}\right) h_{lij} dF\left(y_l\right) \qquad , \qquad h_{lij} = y_l / w_{ij}$$

$$n_{ij} = \frac{w_{ij}^{\eta}}{\sum_{ij} w_{ij}^{1+\eta}} \underbrace{\int_0^1 y_l dF\left(y_l\right)}_{:=Y} \tag{B2}$$

Aggregating this expression we obtain the obvious result that $\sum_{ij} w_{ij} n_{ij} = Y$. Now define the following indexes:

$$\mathbf{W} := \left[\sum_{ij} w_{ij}^{1+\eta}\right]^{\frac{1}{1+\eta}} \quad , \quad \mathbf{N} := \left[\sum_{ij} n_{ij}^{\frac{\eta+1}{\eta}}\right]^{\frac{\eta}{\eta+1}} .$$

Along with (B2), these indexes imply that $\mathbf{WN} = Y$. Using these definitions along with $\mathbf{WN} = Y$ in (B2) yields the CES supply curve:

$$n_{ij} = \left(\frac{w_{ij}}{\mathbf{W}}\right)^{\eta} \mathbf{N}.$$

We therefore have the result that the supply curves that face firms in this model of individual discrete choice are equivalent to those that face the firms when a representative household solves the following income maximization problem:

$$\max_{\{n_{ij}\}} \sum_{ij} w_{ij} n_{ij} \quad s.t. \quad \left[\sum_{ij} n_{ij}^{\frac{\eta+1}{\eta}}\right]^{\frac{\eta}{\eta+1}} = \mathbf{N}.$$

Since at the solution, the objective function is equal to $\mathbf{WN}$, then the envelope condition delivers a natural interpretation of $\mathbf{W}$ as the equilibrium payment to total labor input in the economy for one additional unit of aggregate labor disutility. That is, the following equalities hold:

$$\frac{\partial}{\partial \mathbf{N}} \sum_{ij} w_{ij} n_{ij}^{*}(w_{ij}, w_{-ij}) = \lambda = \mathbf{W} = \frac{\partial}{\partial \mathbf{N}} \mathbf{WN}.$$

Nested logit and nested CES. Consider changing the distribution of preference shocks as follows:

$$F(\varepsilon_{i1}, ..., \varepsilon_{NJ}) = \exp\left[-\sum_{j=1}^{J}\left(\sum_{i=1}^{M_j} e^{-(1+\eta)\varepsilon_{ij}}\right)^{\frac{1+\theta}{1+\eta}}\right].$$

We recover the distribution (B1) above if $\eta = \theta$. Otherwise, if $\eta > \theta$ the problem is convex and the conditional covariance of within sector preference draws differ from the economy wide variance of preference draws. We discuss this more below.

In this setting, choice probabilities can be expressed as the product of the conditional choice probability of supplying labor to firm i conditional on supplying labor to market j, and the probability of supplying labor to market j:

$$Prob_l\left(w_{ij}, w_{-ij}\right) = \underbrace{\frac{w_{ij}^{1+\eta}}{\sum_{i=1}^{M_j} w_{ij}^{1+\eta}}}_{Prob_l(\text{Choose firm } i \mid \text{Choose market } j)} \times \underbrace{\frac{\left[\sum_{i=1}^{M_j} w_{ij}^{1+\eta}\right]^{\frac{1+\theta}{1+\eta}}}{\sum_{l=1}^{J}\left[\sum_{k=1}^{M_l} w_{kl}^{1+\eta}\right]^{\frac{1+\theta}{1+\eta}}}}_{Prob_l(\text{Choose market } j)}.$$

Following the same steps as above, we can aggregate these choice probabilities and hours decisions to obtain firm level labor supply:

$$n_{ij} = \frac{w_{ij}^{\eta}}{\sum_{i=1}^{M_j} w_{ij}^{1+\eta}} \frac{\left[\sum_{i=1}^{M_j} w_{ij}^{1+\eta}\right]^{\frac{1+\theta}{1+\eta}}}{\sum_{l=1}^{J}\left[\sum_{k=1}^{M_l} w_{kl}^{1+\eta}\right]^{\frac{1+\theta}{1+\eta}}} Y. \tag{B3}$$

We can now define the following indexes:

$$\mathbf{w}_j = \left[\sum_{i=1}^{M_j} w_{ij}^{1+\eta}\right]^{\frac{1}{1+\eta}} \quad , \quad \mathbf{n}_j = \left[\sum_{i=1}^{M_j} n_{ij}^{\frac{1+\eta}{\eta}}\right]^{\frac{\eta}{1+\eta}},$$

$$\mathbf{W} = \left[\sum_{j=1}^{J} \mathbf{w}_j^{1+\theta}\right]^{\frac{1}{1+\theta}} \quad , \quad \mathbf{N} = \left[\sum_{i=1}^{M_j} \mathbf{n}_j^{\frac{1+\theta}{\theta}}\right]^{\frac{\theta}{1+\theta}}.$$

Using these definitions and similar results to the above we can show that $\mathbf{w}_j\mathbf{n}_j = \sum_{i=1}^{M_j} w_{ij}n_{ij}$, and $Y = \mathbf{W}\mathbf{N} = \sum_{j=1}^{J} \mathbf{w}_j\mathbf{n}_j$.

Consider the thought experiment of adding more markets J (which is necessary to identically map these formulas to our model). While the min of an infinite number of draws from a Gumbel distribution is not defined (it asymptotes to $-\infty$), the distribution of choices across markets is defined at each point in the limit as we add more markets J (Malmberg (2013)). As a result, the distribution of choices will have a well defined limit, and with the correct scaling as we add more markets (we can scale the disutilities at each step and not affect the market choice), as described in (Malmberg (2013)), the limiting wage indexes will be defined as above.

We can then express (B3) as:

$$n_{ij} = \left(\frac{w_{ij}}{\mathbf{w}_j}\right)^{\eta} \left(\frac{\mathbf{w}_j}{\mathbf{W}}\right)^{\theta} \mathbf{N},$$

which completes the CES supply system defined in the text.

Comment. The above has established that it is straightforward to derive the supply system in the model through a discrete choice framework. This is particularly appealing given recent modeling of labor supply using familiar discrete choice frameworks first in models of economic geography and more recently in labor (Borovickova and Shimer (2017), Card, Cardoso, Heining, and Kline (2018), Lamadon, Mogstad, and Setzler (2018)). Since firms take this supply system as given, we can then work with the nested CES supply functions as if they were derived from the preferences and decisions of a representative household. This vastly simplifies welfare computations and allows for the integration of the model into more familiar macroeconomic environments.

A second advantage of this micro-foundation is that it provides a natural interpretation of the somewhat nebulous elasticities of substitution in the CES specification: η and θ. Returning to the Gumbel distribution we observe the following

$$F(\varepsilon_{i1}, ..., \varepsilon_{NJ}) = \exp\left[-\sum_{j=1}^{J}\left(\sum_{i=1}^{M_j} e^{-(1+\eta)\varepsilon_{ij}}\right)^{\frac{1+\theta}{1+\eta}}\right]$$

A higher value of η *increases* the correlation of draws within a market (McFadden, 1978). Within a market if η is high, then an individual's preference draws are likely to be clustered. With little difference in non-pecuniary idiosyncratic preferences for working at different firms, wages dominate in an individual's labor supply decision and wage posting in the market is closer to the competitive outcome. A higher value of θ *decreases* the overall variance of draws across all firms (i.e. it *increases* the correlation across any two randomly chosen sub-vectors of an individual's draws). An individual is therefore more likely to find that their lowest levels of idiosyncratic disutility are in two different markets, increasing across market wage competition.

In the case that $\eta = \theta$, the model collapses to the standard logit model. In this case the following obtains. Take an individual's ε_{lij} for some firm. The conditional probability distribution of some other draw $\varepsilon_{li'j'}$ is the same whether firm i' is in the same market ($j' = j$) or some other market ($j' \neq j$). Individuals are as likely to find somewhere local that incurs the same level of labor disability as finding somewhere in another market. In this setting economy-wide monopsonistic competition obtains. When an individual is more likely to find their other low disutility draws in the *same* market, then firms within that market have local market power. This is precisely the case that obtains when $\eta > \theta$.

B.2 Dynamic discrete choice framework

We show that the above discrete choice framework can be adapted to an environment where some individuals draw new vectors ε_l each period and reoptimize their labor supply. Firms therefore compete in a dynamic oligopoly. Restricting attention to the stationary solution to the model where firms keep employment and wages constant—as in the tradition of Burdett and Mortensen (1998)—we show that the allocation of employment and wages once again coincide with the solution to the problem in the main text. To simplify notation we consider the problem for a market with M firms $i \in \{1, \ldots, M\}$ which may be generalized to the model in the text.

Environment. Every period a random fraction λ of workers each draw a new vector ε_l. Let n_i be employment at firm i. Let $\bar{w}_i$ be the *average wage* of workers at firm i, such that the total wage bill in the firm is $\bar{w}_i n_i$. Let the equilibrium labor supply function $h(w_i, w_{-i})$ determine the amount of hires a firm makes if it posts a wage w_i when its competitors wages in the market are given by the vector w_{-i}.

Value function. Let $V(n_i, \bar{w}_i)$ be the firm's present discounted value of profits, where the firm has discount rate $\beta = 1$. Then $V(n_i, \bar{w}_i)$ satisfies:

$$V\left(n_i, \bar{w}_i\right) = \left(Pz_i - \bar{w}_i\right)\left(1-\lambda\right) n_i + \max_{w_i'} \left\{\left(Pz_i - w_i'\right) h\left(w_i', w_{-i}'\right) + V\left(n_i', \bar{w}_i'\right)\right\} \tag{B4}$$

$$n'\left(n_i, w_i', w_{-i}'\right) = \left(1-\lambda\right) n_i + h\left(w_i', w_{-i}'\right) \quad , \tag{B5}$$

$$\bar{w}'\left(n_i, \bar{w}_i, w_i', w_{-i}'\right) = \frac{\left(1-\lambda\right)\bar{w}_i n_i + h\left(w_i', w_{-i}'\right) w_i'}{\left(1-\lambda\right) n_i + h\left(w_i', w_{-i}'\right)}. \tag{B6}$$

The firm operates a constant returns to scale production function. Of the firm's n_i workers, a fraction $(1-\lambda)$ do not draw new preferences. The total profit associated with these workers is then average revenue (Pz_i) minus average cost $(\bar{w}_i)$. The firm chooses a new wage w_i' to post in the market. In equilibrium, given its competitor's wages w_{-i}', it hires $h(w_i, w_{-i})$ workers. The total profit associated with these workers is again average revenue (Pz_i) minus average cost (w_i'). The second and third equations account for the evolution of the firm's state variables.

Optimality. Given its competitor's prices, the first order condition with respect to w_i' is:

$$\left(Pz_i - w_i'\right) h_1\left(w_i', w_{-i}'\right) - h\left(w_i', w_{-i}'\right) + V_n\left(n_i', \bar{w}_i'\right) n_w'\left(n_i, w_i', w_{-i}'\right) + V_{\bar{w}}\left(n_i', \bar{w}_i'\right) \bar{w}_w\left(n_i, \bar{w}_i, w_i', w_{-i}'\right) = 0$$

The relevant envelope conditions are

$$\begin{aligned} V_n\left(n_i, \bar{w}_i\right) &= \left(Pz_i - \bar{w}_i\right)(1-\lambda) + V_n\left(n_i', \bar{w}_i'\right) n_n'\left(n_i, w_i', \mathbf{w}_{-i}'\right) + V_{\bar{w}}\left(n_i', \bar{w}_i'\right) \bar{w}_n'\left(n_i, \bar{w}_i, w_i', \mathbf{w}_{-i}'\right) \\ V_{\bar{w}}\left(n_i, \bar{w}_i\right) &= -(1-\lambda) n_i + V_{\bar{w}}\left(n_i', \bar{w}_i'\right) \bar{w}_{\bar{w}}'\left(n_i, \bar{w}_i, w_i', \mathbf{w}_{-i}'\right) \end{aligned}$$

In a stationary equilibrium $\bar{w}_i = w_i'$, and $n_i' = n_i$. One can compute the partial derivatives involved in these expressions, and evaluate the conditions under stationarity to obtain

$$\left(Pz_i - w_i\right) h_1\left(w_i, w_{-i}\right) = h\left(w_i, w_{-i}\right).$$

Rearranging this expression:

$$w_i = \frac{\varepsilon_i(w_i, w_{-i})}{\varepsilon_i(w_i, w_{-i}) + 1} Pz_i \qquad , \qquad \varepsilon_i(w_i, w_{-i}) \; := \; \frac{h_1(w_i, w_{-i}) w_i}{h(w_i, w_{-i})}$$

The solution to the dynamic oligopsony problem for a *given* supply system is identical to the solution of the static problem. In this setting, the supply system is obviously that which is obtained from the individual discrete choice problem in the previous section.

Comments. This setting establishes that the model considered in the main text can also be conceived as a setting where individuals periodically receive some preference shock that causes them to relocate, and firms engage in a dynamic oligopoly given these worker decisions. When $\eta > \theta$ the shock causes a worker to consider all firms in one market very carefully to the exclusion of other markets when they are making their relocation decision. When $\eta = \theta$ the individual considers all firms in all markets equally.

C Data

This section provides additional details regarding the data sources used in the paper, sample restrictions, and construction of a number of variables.

C.1 Census Longitudinal Business Database (LBD)

The LBD is built on the Business Register (BR), Economic Census and surveys. The BR began in 1972 and is a database of all U.S. business establishments. The business register is also called the Standard Statistical Establishment List (SSEL). The SSEL contains records for all industries except private households and illegal or underground activities. Most government owner entities are not in the SSEL. The SSEL includes single and multi unit establishments. The longitudinal links are constructed using the SSEL. The database is annual.

C.2 Sample restrictions

For both the summary statistics and corporate tax analysis, we isolate all plants (lbdnums) with non missing firmids, with strictly positive pay, strictly positive employment, non-missing county codes for the continental US (we exclude Alaska, Hawaii, and Puerto Rico). We then isolate all lbdnums with non-missing 2 digit NAICS codes equal to 11,21,31,32,33, or 55. We use the consistent 2007 NAICS codes provided by Fort and Klimek (2016) throughout the paper. These are the top tradeable 2-digit NAICS codes as defined by Delgado, Bryden, and Zyontz (2014). We winsorize the relative wage at the 1% level to remove outliers. Each plant has a unique firmid which corresponds to the owner of the plant.[37] Throughout the paper, we define a firm to be the sum of all establishments in a commuting zone with a common firmid and NAICS3 classification.

Summary Statistics Sample: Our summary statistics include all observations that satisfy the above criteria in 1976 and 2014.

Corporate Tax Sample: The corporate tax analysis includes all observations that satisfy the above criteria between 2002 and 2012 (note the tax series ends in 2012, but the 'Year t+1' estimates use 2013 observations). We further restrict the sample to firmid-market-year observations which have a 'Corporation' legal form of organization. The legal form of organization changes discontinuously in 2001 and earlier years, and thus we restrict our analysis to post-2002 observations. We must further restrict our attention to corporations that operate in at least two markets, since we use variation across markets, within a state, in order to isolate the impact of the corporate tax shocks on employment and wages.

Sample NAICS Codes and Commuting Zones: Table C1 describes the NAICS 3 codes in our sample. Table C2 provides examples of commuting zones and the counties that are associated with those commuting zones.

[37] Each firm only has one firmid. The firmid is different from the EIN. The firmid aggregates EINS to build a consistent firm identifier in the cross-section and over time.

Table C1: Examples of NAICS3 Codes.

NAICS3	Description	NAICS3	Description
111	Crop Production	322	Paper Manufacturing
112	Animal Production and Aquaculture	323	Printing and Related Support Activities
113	Forestry and Logging	324	Petroleum and Coal Products Manufacturing
114	Fishing, Hunting and Trapping	325	Chemical Manufacturing
115	Support Activities for Agriculture and Forestry	326	Plastics and Rubber Products Manufacturing
211	Oil and Gas Extraction	327	Nonmetallic Mineral Product Manufacturing
212	Mining (except Oil and Gas)	331	Primary Metal Manufacturing
213	Support Activities for Mining	332	Fabricated Metal Product Manufacturing
311	Food Manufacturing	333	Machinery Manufacturing
312	Beverage and Tobacco Product Manufacturing	334	Computer and Electronic Product Manufacturing
313	Textile Mills	335	Electrical Equipment, Appliance, and Component Manufacturing
314	Textile Product Mills	336	Transportation Equipment Manufacturing
315	Apparel Manufacturing	337	Furniture and Related Product Manufacturing
316	Leather and Allied Product Manufacturing	339	Miscellaneous Manufacturing
321	Wood Product Manufacturing	551	Management of Companies and Enterprises

Table C2: Commuting Zone Examples

Commuting Zone ID, 2000	County Name	Metropolitan Area, 2003	County Population 2000	Commuting Zone Population 2000
58	Cook County	Chicago-Naperville-Joliet, IL Metropolitan Division	5,376,741	8,704,935
58	DeKalb County	Chicago-Naperville-Joliet, IL Metropolitan Division	88,969	8,704,935
58	DuPage County	Chicago-Naperville-Joliet, IL Metropolitan Division	904,161	8,704,935
58	Grundy County	Chicago-Naperville-Joliet, IL Metropolitan Division	37,535	8,704,935
58	Kane County	Chicago-Naperville-Joliet, IL Metropolitan Division	404,119	8,704,935
58	Kendall County	Chicago-Naperville-Joliet, IL Metropolitan Division	54,544	8,704,935
58	Lake County	Lake County-Kenosha County, IL-WI Metropolitan Division	644,356	8,704,935
58	McHenry County	Chicago-Naperville-Joliet, IL Metropolitan Division	260,077	8,704,935
58	Will County	Chicago-Naperville-Joliet, IL Metropolitan Division	502,266	8,704,935
58	Kenosha County	Lake County-Kenosha County, IL-WI Metropolitan Division	149,577	8,704,935
58	Racine County	Racine, WI Metropolitan Statistical Area	188,831	8,704,935
58	Walworth County	Whitewater, WI Micropolitan Statistical Area	93,759	8,704,935
47	Anoka County	Minneapolis-St. Paul-Bloomington, MN-WI Metropolitan Statistical Area	298,084	2,904,389
47	Carver County	Minneapolis-St. Paul-Bloomington, MN-WI Metropolitan Statistical Area	70,205	2,904,389
47	Chisago County	Minneapolis-St. Paul-Bloomington, MN-WI Metropolitan Statistical Area	41,101	2,904,389
47	Dakota County	Minneapolis-St. Paul-Bloomington, MN-WI Metropolitan Statistical Area	355,904	2,904,389
47	Hennepin County	Minneapolis-St. Paul-Bloomington, MN-WI Metropolitan Statistical Area	1,116,200	2,904,389
47	Isanti County	Minneapolis-St. Paul-Bloomington, MN-WI Metropolitan Statistical Area	31,287	2,904,389
47	Ramsey County	Minneapolis-St. Paul-Bloomington, MN-WI Metropolitan Statistical Area	511,035	2,904,389
47	Scott County	Minneapolis-St. Paul-Bloomington, MN-WI Metropolitan Statistical Area	89,498	2,904,389
47	Washington County	Minneapolis-St. Paul-Bloomington, MN-WI Metropolitan Statistical Area	201,130	2,904,389
47	Wright County	Minneapolis-St. Paul-Bloomington, MN-WI Metropolitan Statistical Area	89,986	2,904,389
47	Pierce County	Minneapolis-St. Paul-Bloomington, MN-WI Metropolitan Statistical Area	36,804	2,904,389
47	St. Croix County	Minneapolis-St. Paul-Bloomington, MN-WI Metropolitan Statistical Area	63,155	2,904,389

D Labor market concentration in all industries

Table D1 includes summary statistics of labor market concentration across all industries. Similar to tradeable industries, the market-level unweighted and weighted Herfindahls decline. The unweighted wage-bill Herfindahl declines from 0.36 to 0.34. The payroll weighted wage-bill Herfindahl declines from 0.17 to 0.11. The payroll weighted employment Herfindahl declines from 0.15 to 0.09. Similar to tradeable industries, Herfindahls are negatively correlated with the number of firms as well as total employment in the market.

	(A) Firm-market-level averages	
	1976	**2014**
Total firm pay (000s)	209.40	1102.00
Total firm employment	19.43	23.21
Pay per employee	$ 10,777	$ 47,480
Firm-Market level observations	3,746,000	5,854,000

	(B) Market-level averages	
	1976	**2014**
Wage-bill Herfindahl (Unweighted)	0.36	0.34
Employment Herfindahl (Unweighted)	0.33	0.32
Wage-bill Herfindahl (Weighted by market's share of total wage-bill)	0.17	0.11
Employment Herfindahl (Weighted by market's share of total wage-bill)	0.15	0.09
Firms per market	75.70	113.20
Percent of markets with 1 firm	10.4%	9.4%
Market level observations	49,000	52,000

	(C) Market-level correlations	
	1976	**2014**
Correlation of Wage-bill Herfindahl and number of firms	-0.20	-0.17
Correlation of Wage-bill Herfindahl and Employment Herfindahl	0.97	0.97
Correlation of Wage-bill Herfindahl and Market Employment	-0.15	-0.16
Market-level observations	49,000	52,000

Table D1: Summary Statistics, Longitudinal Employer Database 1976 and 2014

Notes: All NAICS. Market defined to be NAICS3 within Commuting Zone. Observations rounded to nearest thousand and numbers rounded to 4 significant digits according to Census disclosure rules. Firm-market-level refers to a 'firmid by Commuting Zone by 3-digit NAICs by Year' observation. Market-level refers to a 'Commuting Zone by 3-digit NAICs by Year' aggregation of observations.

E Mathematical derivations

This section details derivation of mathematical formulae appearing in the main text. It covers: (i) the household problem, (ii) sectoral equilibria of the firm problem, (iii) the labor share, (iv) wage pass-through results.

E.1 Household problem derivations

We solve for demand of the final good by taking the first order condition of the household problem with respect to C_t

$$u'\left(\mathbf{C}_t - \frac{1}{\bar{\varphi}^{\frac{1}{\varphi}}}\frac{\mathbf{N}_t^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}}\right) = \Lambda_t$$

The Euler equation for households yields:

$$R_t = \frac{\Lambda_{t-1}}{\Lambda_t}\left[r_t + \delta\right]$$

Where the discount rate is given by r_t:

$$r_t = \frac{1}{\beta} - 1$$

To determine labor supply, we proceed with a three-step budgeting problem. Consider the first stage. Suppose the household must earn S_t by choosing labor supply across markets:

$$\mathbf{N}_t = \min_{\{\mathbf{n}_{jt}\}} \left[\int_0^1 \mathbf{n}_{jt}^{\frac{\eta+1}{\eta}} dj\right]^{\frac{\eta}{\eta+1}} \quad \text{s.t} \int_0^1 \mathbf{w}_{jt}\mathbf{n}_{jt} dj \geq S_t$$

The *FOC* $\left(\mathbf{n}_{jt}\right)$ is[38]

$$
\begin{aligned}
\mathbf{N}_t^{-\frac{1}{\eta}}\mathbf{n}_{jt}^{\frac{1}{\eta}} &= \lambda \mathbf{w}_{jt} \\
\mathbf{N}_t^{-\frac{1}{\eta}}\left[\int_0^1 \mathbf{n}_{jt}^{\frac{\eta+1}{\eta}} dj\right] &= \lambda \int_0^1 \mathbf{w}_{jt}\mathbf{n}_{jt} dj \\
\mathbf{N}_t &= \lambda \int_0^1 \mathbf{w}_{jt}\mathbf{n}_{jt} dj
\end{aligned}
$$

then define $\mathbf{W}_t$ by the number that satisfies $\mathbf{W}_t\mathbf{N}_t = \int_0^1 \mathbf{w}_{jt}\mathbf{n}_{jt}dj$, which implies that $\lambda = \mathbf{W}_t^{-1}$. Using the wage index in the first-order condition, we obtain:

$$
\begin{aligned}
\mathbf{N}_t^{-\frac{1}{\eta}}\mathbf{n}_{jt}^{\frac{1}{\eta}} &= \lambda \mathbf{w}_{jt} \\
\mathbf{n}_{jt} &= \left(\frac{\mathbf{w}_{jt}}{\mathbf{W}_t}\right)^{\eta} \mathbf{N}_t \qquad \text{(E1)}
\end{aligned}
$$

We then recover the wage index by multiplying (E1) by w_{ijt} and integrating across markets:

$$
\begin{aligned}
\mathbf{w}_{jt}\mathbf{n}_{jt} &= \mathbf{w}_{jt}^{1+\eta}\mathbf{W}_t^{-\eta}\mathbf{N}_t \\
\int_0^1 \mathbf{w}_{jt}\mathbf{n}_{jt} dj &= \int_0^1 \mathbf{w}_{jt}^{1+\eta} dj \mathbf{W}_t^{-\eta}\mathbf{N}_t \\
\mathbf{W}_t\mathbf{N}_t &= \int_0^1 \mathbf{w}_{jt}^{1+\eta} dj \mathbf{W}_t^{-\eta}\mathbf{N}_t \\
\mathbf{W}_t &= \left[\int_0^1 \mathbf{w}_{jt}^{1+\eta} dj\right]^{\frac{1}{1+\eta}}
\end{aligned}
$$

Moving to the second stage, suppose that a household must raise resources S_t within a market and chooses labor supply to each firm within that market:

$$
\mathbf{n}_{jt} = \min_{\{n_{ijt}\}} \left(\sum_{i=1}^{M} n_{ijt}^{\frac{\eta+1}{\eta}}\right)^{\frac{\eta}{\eta+1}} \qquad s.t. \quad \sum_{i=1}^{M} w_{ijt}n_{ijt} \geq S_t
$$

Let $\mathbf{w}_{jt}$ be the number such that $\mathbf{w}_{jt}\mathbf{n}_{jt} = \sum_i w_{ijt}n_{ijt}$. Taking first order conditions and pro-

[38]Where we have used $\left[\int_0^1 \mathbf{n}_{jt}^{\frac{\eta+1}{\eta}} dj\right]^{\frac{\eta}{\eta+1}-1} = \left[\int_0^1 \mathbf{n}_{jt}^{\frac{\eta+1}{\eta}} dj\right]^{-\frac{1}{\eta+1}} = \mathbf{N}_t^{-\frac{1}{\eta}}$

ceeding similarly to the first stage we obtain the following:

$$n_{ijt} = \left(\frac{w_{ijt}}{\mathbf{w}_{jt}}\right)^{\theta} \mathbf{n}_{jt} \tag{E2}$$

$$\mathbf{w}_{jt} = \left[\int_0^1 w_{ijt}^{1+\eta} dj\right]^{\frac{1}{1+\eta}}$$

Moving to the third stage, we recast the original problem and take first order conditions for $\mathbf{N}_t$:

$$U = \max_{\{\mathbf{N}_t, C_t, K_t\}} \sum_{t=0}^{\infty} \beta^t u \left(C_t - \frac{1}{\bar{\varphi}^{\frac{1}{\varphi}}} \frac{\mathbf{N}_t^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}} \right)$$

subject to the household's budget constraint which is given by,

$$C_t + \Big[K_{t+1} - (1-\delta)K_t\Big] = \mathbf{N}_t \mathbf{W}_t + R_t K_t + \Pi_t.$$

This yields the following expression for the aggregate labor supply index:

$$\mathbf{N}_t = \bar{\varphi} \mathbf{W}_t^{\varphi} \tag{E3}$$

Substituting (E1) and (E3) into equation (E2), we derive the labor supply curve in the main text:

$$n_{ijt} = \left(\frac{w_{ijt}}{\mathbf{w}_{jt}}\right)^{\eta} \left(\frac{\mathbf{w}_{jt}}{\mathbf{W}_t}\right)^{\theta} (\mathbf{W}_t)^{\varphi}$$

$$\mathbf{w}_{jt} = \left[\int_0^1 w_{ijt}^{1+\eta} dj\right]^{\frac{1}{1+\eta}}$$

$$\mathbf{W}_t = \left[\int_0^1 \mathbf{w}_{jt}^{1+\theta} dj\right]^{\frac{1}{1+\theta}}$$

To obtain the inverse labor supply curve, we use the first order conditions for labor supply within the market:

$$n_{ijt} = \left(\frac{w_{ijt}}{\mathbf{w}_{jt}}\right)^{\eta} \mathbf{n}_{jt}$$

Inverting this equation yields,

$$\mathbf{w}_{ijt} = \left(\frac{\mathbf{n}_{ijt}}{\mathbf{n}_{jt}}\right)^{1/\eta} \mathbf{w}_{jt} \tag{E4}$$

Labor supply across markets is given by the following expression:

$$\mathbf{n}_{jt} = \left(\frac{\mathbf{w}_{jt}}{\mathbf{W}_t}\right)^{\theta} \mathbf{N}_t$$

Inverting this equation yields,

$$\mathbf{w}_{jt} = \left(\frac{\mathbf{n}_{jt}}{\mathbf{N}_t}\right)^{1/\theta} \mathbf{W_t} \tag{E5}$$

Combining (E5), (E4) and (E3) yields the expression in the text.

E.2 Derivation of firm problem under Cournot competition

Let $y_{ijt} = \overline{Z} z_{ijt} \left(k_{ijt}^{1-\gamma} n_{ijt}^{\gamma}\right)^{\alpha}$. The firm problem with capital and decreasing returns to scale is given by,

$$\max_{k_{ijt}, n_{ijt}} \overline{Z} z_{ijt} \left(k_{ijt}^{1-\gamma} n_{ijt}^{\gamma}\right)^{\alpha} - R_t k_{ijt} - w_{ijt} n_{ijt}$$

Taking first order conditions for k_{ijt} yields $\frac{R_t k_{ijt}}{y_{ijt}} = (1-\gamma)\,\alpha$. We substitute this expression into the profit function

$$\max_{k} \left[1 - (1-\gamma)\,\alpha\right] y_{ijt} - w_{ijt} n_{ijt}$$

We solve for capital using the first order condition for capital (again):

$$k_{ijt} = \left(\frac{(1-\gamma)\,\alpha z_{ijt} \overline{Z}}{R_t}\right)^{\frac{1}{1-(1-\gamma)\alpha}} n_{ijt}^{\frac{\gamma\alpha}{1-(1-\gamma)\alpha}}$$

We substitute this into the expression for y_{ijt} to obtain firm-level output as a function of n_{ijt}:

$$y_{ijt} = \left(\frac{(1-\gamma)\,\alpha}{R_t}\right)^{\frac{(1-\gamma)\alpha}{1-(1-\gamma)\alpha}} \left(z_{ijt}\overline{Z}\right)^{\frac{1}{1-(1-\gamma)\alpha}} n_{ijt}^{\frac{\gamma\alpha}{1-(1-\gamma)\alpha}}$$

The firm optimization problem becomes:

$$\pi_{ijt} = [1-(1-\gamma)\alpha]\left(\frac{(1-\gamma)\alpha}{R_t}\right)^{\frac{(1-\gamma)\alpha}{1-(1-\gamma)\alpha}} (z_{ijt}\overline{Z})^{\frac{1}{1-(1-\gamma)\alpha}} n_{ijt}^{\frac{\gamma\alpha}{1-(1-\gamma)\alpha}} - w_{ijt}n_{ijt}$$

Defining $\tilde{\alpha} := \frac{\gamma\alpha}{1-(1-\gamma)\alpha}$, $\widetilde{z}_{ijt} := [1-(1-\gamma)\alpha]\left(\frac{(1-\gamma)\alpha}{R_t}\right)^{\frac{(1-\gamma)\alpha}{1-(1-\gamma)\alpha}} z_{ijt}^{\frac{1}{1-(1-\gamma)\alpha}}$, and $\widetilde{Z} := \overline{Z}^{\frac{1}{1-(1-\gamma)\alpha}}$ yields the firm profit maximization problem, expression (9), in the text.

Define $MRPL_{ijt} = \tilde{\alpha}\widetilde{Z}\tilde{z}_{ijt}n_{ijt}^{\tilde{\alpha}-1}$. Define $X_t = \frac{1}{\bar{\varphi}^{\frac{1}{\varphi}}}\mathbf{N}_t^{\frac{1}{\varphi}-1/\theta}$ and substitute this into the inverse labor supply function to derive the following expression:

$$w_{ijt} = n_{ijt}^{1/\eta}\mathbf{n}_{jt}^{1/\theta-1/\eta}X_t \tag{E6}$$

We substitute this expression into the profit function to obtain,

$$\pi_{ijt} = \max_{n_{ijt}} \widetilde{Z}\widetilde{z}_{ijt}n_{ijt}^{\tilde{\alpha}} - n_{ijt}^{\frac{1}{\eta}+1}n_{jt}^{\frac{1}{\theta}-\frac{1}{\eta}}X_t$$

Before taking first order conditions, we derive a useful result, $\frac{\partial\mathbf{n}_{jt}}{\partial n_{ijt}}\frac{n_{ijt}}{\mathbf{n}_{jt}} = s_{ijt}^{wn}$.

Lemma E.1. $\frac{\partial n_{jt}}{\partial n_{ijt}}\frac{n_{ijt}}{n_{jt}} = s_{ijt}^{wn}$

Proof: Using the definition of $\mathbf{n}_{jt} = \left[\sum_i n_{ijt}^{\frac{\eta+1}{\eta}}\right]^{\frac{\eta}{\eta+1}}$ and taking first order conditions yields:

$$\begin{aligned}\frac{\partial\mathbf{n}_{jt}}{\partial n_{ijt}} &= \left[\sum_i n_{ijt}^{\frac{\eta+1}{\eta}}\right]^{\frac{\eta}{\eta+1}-1} n_{ijt}^{\frac{\eta+1}{\eta}-1}\\ &= \mathbf{n}_{jt}^{-\frac{1}{\eta}}n_{ijt}^{\frac{1}{\eta}}\end{aligned}$$

This yields the elasticity of market level labor supply:

$$\frac{\partial\mathbf{n}_{jt}}{\partial n_{ijt}}\frac{n_{ijt}}{\mathbf{n}_{jt}} = \left(\frac{n_{ijt}}{\mathbf{n}_{jt}}\right)^{\frac{\eta+1}{\eta}} \tag{E7}$$

Substituting (E7) into the definition of the wage-bill share:

$$s_{ijt}^{wn} = \frac{w_{ijt}n_{ijt}}{\sum_i w_{ijt}n_{ijt}} = \frac{n_{ijt}^{\frac{1}{\eta}+1}\mathbf{n}_{jt}^{\frac{1}{\theta}-\frac{1}{\eta}}X}{\sum_i n_{ijt}^{\frac{1}{\eta}+1}\mathbf{n}_{jt}^{\frac{1}{\theta}-\frac{1}{\eta}}X} = \frac{n_{ijt}^{\frac{1}{\eta}+1}}{\sum_i n_{ijt}^{\frac{1}{\eta}+1}} = \frac{n_{ijt}^{\frac{\eta+1}{\eta}}}{\left[\sum_i n_{ijt}^{\frac{\eta+1}{\eta}}\right]^{\frac{\eta}{\eta+1}\frac{\eta+1}{\eta}}} = \frac{n_{ijt}^{\frac{\eta+1}{\eta}}}{\mathbf{n}_{jt}^{\frac{\eta+1}{\eta}}} \implies s_{ijt}^{wn} = \frac{\partial \mathbf{n}_{jt}}{\partial n_{ijt}}\frac{n_{ijt}}{\mathbf{n}_{jt}}$$

□

Lemma E.2. *The equilibrium markdown μ_{ijt} is a wage bill share weighted harmonic mean of the monopsonistically competitive markup under η or θ.*

$$\begin{aligned} w_{ijt} &= \mu_{ijt} MRPL_{ijt} \\ \mu_{ijt} &= \frac{\varepsilon_{ijt}}{\varepsilon_{ijt}+1} \\ \varepsilon_{ijt} &= \left[\left(1-s_{ijt}^{wn}\right)\frac{1}{\eta} + s_{ijt}^{wn}\frac{1}{\theta}\right]^{-1} \end{aligned} \tag{E8}$$

Proof: Using Lemma E.1, we take first-order conditions to derive the optimal employment decision:

$$\begin{aligned} 0 &= MRPL_{ijt} - \left(\frac{1}{\eta}+1\right)\left[n_{ijt}^{\frac{1}{\eta}}\mathbf{n}_{jt}^{\frac{1}{\theta}-\frac{1}{\eta}}X\right] - \left(\frac{1}{\theta}-\frac{1}{\eta}\right)\left[n_{ijt}^{\frac{1}{\eta}+1}\mathbf{n}_{jt}^{\frac{1}{\theta}-\frac{1}{\eta}}X\right]\frac{1}{\mathbf{n}_{jt}}\frac{\partial \mathbf{n}_{jt}}{\partial n_{ijt}} \\ MRPL_{ijt} &= \left[\frac{\eta+1}{\eta} + \left(\frac{\theta+1}{\theta} - \frac{\eta+1}{\eta}\right)s_{ijt}^{wn}\right] w_{ijt} \\ w_{ijt} &= \left[1 + \left(1-s_{ijt}^{wn}\right)\frac{1}{\eta} + s_{ijt}^{wn}\frac{1}{\theta}\right]^{-1} MRPL_{ijt} \end{aligned}$$

□

E.3 Equilibrium properties - Labor Share

Using Lemma E.2, an individual firm's labor share, ls_{ij}, can be written in terms of the equilibrium markup:

$$\begin{aligned} ls_{ij} &= \frac{w_{ij}n_{ij}}{\tilde{Z}\tilde{z}_{ij}n_{ij}^{\tilde{\alpha}}} \\ ls_{ij} &= \tilde{\alpha}\frac{w_{ij}}{MRPL_{ij}} \\ ls_{ij} &= \tilde{\alpha}\mu_{ij} \end{aligned}$$

Let $y_{ij} = \widetilde{Z}\tilde{z}_{ij}n_{ij}^{\tilde{\alpha}}$. At the market level, the inverse labor share in market j, LS_j^{-1}, is given by the following expression:

$$LS_j^{-1} = \frac{\sum_i y_{ij}}{\sum_i w_{ij}n_{ij}} = \sum_i \left(\frac{w_{ij}n_{ij}}{\sum_i w_{ij}n_{ij}}\right)\frac{y_{ij}}{w_{ij}n_{ij}}$$

Using the definition of the wage-bill share,

$$\begin{aligned}
LS_j^{-1} &= \sum_i s_{ij}^{wn}\tilde{\alpha}^{-1}\mu_{ij}^{-1} \\
LS_j^{-1} &= \tilde{\alpha}^{-1}\sum_i s_{ij}^{wn}\left[\frac{\eta+1}{\eta} + s_{ij}^{wn}\left(\frac{\theta+1}{\theta} - \frac{\eta+1}{\eta}\right)\right] \\
LS_j^{-1} &= \tilde{\alpha}^{-1}\frac{\eta+1}{\eta} + \tilde{\alpha}^{-1}\left(\frac{\theta+1}{\theta} - \frac{\eta+1}{\eta}\right)HHI_j^{wn}
\end{aligned}$$

Aggregating across markets yields the economy-wide labor share:

$$LS^{-1} = \frac{\int \sum y_{ij}}{\int \sum w_{ij}n_{ij}} = \int \frac{\sum w_{ij}n_{ij}}{\int \sum w_{ij}n_{ij}}\frac{\sum y_{ij}}{\sum w_{ij}n_{ij}} = \int s_j^{wn}LS_j^{-1}$$

This yields the expression in the text:

$$LS^{-1} = \frac{1}{\tilde{\alpha}}\left(\frac{\eta+1}{\eta} + \left(\frac{\theta+1}{\theta} - \frac{\eta+1}{\eta}\right)\int s_j^{wn}HHI_j^{wn}dj\right)$$

F Non-Constant Returns to Scale Computation $\gamma \neq 1$

We solve the model by (i) guessing a vector of wage-bill shares, $\mathbf{s}_j^{wn} = (s_{1j}^{wn}, \ldots, s_{M_jj}^{wn})$, (ii) solving for firm-level markdowns, firm-level wages, and the sectoral wage index, and (iii) updating the wage-bill share using firm-level wages and the sectoral wage index.

From the main text, we define the marginal revenue product of labor as follows:

$$MRPL_{ij} = \widetilde{Z}\tilde{z}_{ijt}\tilde{\alpha}n_{ijt}^{\tilde{\alpha}-1}$$

Substituting for n_{ijt} using the labor supply equation (6), and defining $\hat{z}_{ij} = \tilde{\alpha}\tilde{z}_{ij}$ and $\omega = \frac{\widetilde{Z}}{\bar{\varphi}^{1-\tilde{\alpha}}}$, then the marginal revenue product of labor can be written as:

$$MRPL_{ij} = \omega \mathbf{W}^{(1-\tilde{\alpha})(\theta-\varphi)} \hat{z}_{ij} \left\{ w_{ij}^{-\eta} \mathbf{w}_j^{\eta-\theta} \right\}^{1-\tilde{\alpha}}$$

Use Lemma E.2 to write the wage in terms of the marginal revenue product of labor:

$$\begin{aligned} w_{ij} &= \mu_{ij} MRPL_{ij} \\ &= \mu_{ij} \omega \mathbf{W}^{(1-\tilde{\alpha})(\theta-\varphi)} \hat{z}_{ij} \left\{ w_{ij}^{-\eta} \mathbf{w}_j^{\eta-\theta} \right\}^{1-\tilde{\alpha}} \end{aligned}$$

Use Lemma **??** (which implies $\mathbf{w}_j = w_{ij} s_{ij}^{-\frac{1}{\eta+1}}$) to write this expression in terms of wage-bill shares, and then solve for w_{ij}. The resulting expression is given below:

$$w_{ij} = \omega^{\frac{1}{1+(1-\tilde{\alpha})\theta}} \mathbf{W}^{\frac{(1-\tilde{\alpha})(\theta-\varphi)}{1+(1-\tilde{\alpha})\theta}} \mu_{ij}^{\frac{1}{1+(1-\tilde{\alpha})\theta}} \hat{z}_{ij}^{\frac{1}{1+(1-\tilde{\alpha})\theta}} s_{ij}^{-\frac{(1-\tilde{\alpha})(\eta-\theta)}{\eta+1} \frac{1}{1+(1-\tilde{\alpha})\theta}}$$

We will solve for an equilibrium in 'hatted' variables, and then rescale the 'hatted' variables to recover the equilibrium values of n_{ij} and w_{ij}. Define the following 'hatted' variables:

$$\begin{aligned} \hat{w}_{ij} &:= \mu_{ij}^{\frac{1}{1+(1-\tilde{\alpha})\theta}} \hat{z}_{ij}^{\frac{1}{1+(1-\tilde{\alpha})\theta}} s_{ij}^{-\frac{(1-\tilde{\alpha})(\eta-\theta)}{\eta+1} \frac{1}{1+(1-\tilde{\alpha})\theta}} \\ \hat{\mathbf{w}}_j &:= \left[\sum_{i \in j} \hat{w}_{ij}^{\eta+1} \right]^{\frac{1}{\eta+1}} \\ \hat{\mathbf{W}} &:= \left[\int \hat{\mathbf{w}}_j^{\theta+1} dj \right]^{\frac{1}{\theta+1}} \\ \hat{n}_{ij} &:= \left(\frac{\hat{w}_{ij}}{\hat{\mathbf{w}}_j} \right)^{\eta} \left(\frac{\hat{\mathbf{w}}_j}{\hat{\mathbf{W}}} \right)^{\theta} \left(\frac{\hat{\mathbf{W}}}{1} \right)^{\varphi} \end{aligned}$$

These definitions imply that

$$\begin{aligned} w_{ij} &= \omega^{\frac{1}{1+(1-\tilde{\alpha})\theta}} \mathbf{W}^{\frac{(1-\tilde{\alpha})(\theta-\varphi)}{1+(1-\tilde{\alpha})\theta}} \hat{w}_{ij} \\ \mathbf{w}_j &= \omega^{\frac{1}{1+(1-\tilde{\alpha})\theta}} \mathbf{W}^{\frac{(1-\tilde{\alpha})(\theta-\varphi)}{1+(1-\tilde{\alpha})\theta}} \hat{\mathbf{w}}_j \\ \mathbf{W} &= \omega^{\frac{1}{1+(1-\tilde{\alpha})\theta}} \mathbf{W}^{\frac{(1-\tilde{\alpha})(\theta-\varphi)}{1+(1-\tilde{\alpha})\theta}} \hat{\mathbf{W}} \end{aligned}$$

These definitions allow us to compute the equilibrium market shares in terms of 'hatted' variables:

$$s_j^{wn} = \left(\frac{w_{ij}}{\mathbf{w}_j}\right)^{\eta+1} = \left(\frac{\hat{w}_{ij}}{\hat{\mathbf{w}}_j}\right)^{\eta+1} \tag{F1}$$

For a given set of values for parameters $\{\widetilde{Z}, \bar{\varphi}, \tilde{\alpha}, \beta, \delta\}$, we can solve for the non-constant returns to scale equilibrium as follows:

1. Guess $\mathbf{s}_j^{wn} = (s_{1j}^{wn}, \ldots, s_{M_j j}^{wn})$
2. Compute $\{\varepsilon_{ij}\}$ and $\{\mu_{ij}\}$ using the expressions in Lemma E.2.
3. Construct the 'hatted' equilibrium values as follows:

$$\begin{aligned}
\hat{w}_{ij} &= \mu_{ij}^{\frac{1}{1+(1-\tilde{\alpha})\theta}} \hat{z}_{ij}^{\frac{1}{1+(1-\tilde{\alpha})\theta}} s_{ij}^{-\frac{(1-\tilde{\alpha})(\eta-\theta)}{\eta+1}\frac{1}{1+(1-\tilde{\alpha})\theta}} \\
\hat{\mathbf{w}}_j &= \left[\sum_{i\in j} \hat{w}_{ij}^{\eta+1}\right]^{\frac{1}{\eta+1}} \\
\hat{\mathbf{W}} &= \left[\int \hat{\mathbf{w}}_j^{\theta+1} dj\right]^{\frac{1}{\theta+1}} \\
\hat{n}_{ij} &= \left(\frac{\hat{w}_{ij}}{\hat{\mathbf{w}}_j}\right)^{\eta} \left(\frac{\hat{\mathbf{w}}_j}{\hat{\mathbf{W}}}\right)^{\theta} \left(\frac{\hat{\mathbf{W}}}{1}\right)^{\varphi}
\end{aligned}$$

4. Update the wage-bill share vector using equation (F1).
5. Iterate until convergence of wage-bill shares.

Recovering true equilibrium values from 'hatted' equilibrium: Once the 'hatted' equilibrium is solved, we can construct the true equilibrium values by rescaling as follows:

$$\omega = \frac{\widetilde{Z}}{\bar{\varphi}^{1-\tilde{\alpha}}} \tag{F2a}$$

$$\mathbf{W} = \omega^{\frac{1}{1+(1-\tilde{\alpha})\varphi}} \hat{\mathbf{W}}^{\frac{1+(1-\tilde{\alpha})\theta}{1+(1-\tilde{\alpha})\varphi}} \tag{F2b}$$

$$w_{ij} = \omega^{\frac{1}{1+(1-\tilde{\alpha})\theta}} \mathbf{W}^{\frac{(1-\tilde{\alpha})(\theta-\varphi)}{1+(1-\tilde{\alpha})\theta}} \hat{w}_{ij} \tag{F2c}$$

$$\mathbf{w}_j = \omega^{\frac{1}{1+(1-\tilde{\alpha})\theta}} \mathbf{W}^{\frac{(1-\tilde{\alpha})(\theta-\varphi)}{1+(1-\tilde{\alpha})\theta}} \hat{\mathbf{w}}_j \tag{F2d}$$

$$n_{ij} = \bar{\varphi} \left(\frac{w_{ij}}{\mathbf{w}_j}\right)^{\eta} \left(\frac{\mathbf{w}_j}{\mathbf{W}}\right)^{\theta} \left(\frac{\mathbf{W}}{1}\right)^{\varphi} \tag{F2e}$$

F.1 Scaling the economy

We set the scale parameters $\bar{\varphi}$ and $\widetilde{Z}$ in order to match average firm size observed in the data ($AveFirmSize^{Data} = 27.96$ from Table 8), and average earnings per worker in the data ($AveEarnings^{Data} = \$65,773$ from Table 8):

$$\widehat{AveFirmSize}^{Data} = \frac{\int \left\{ \sum_{i \in j} n_{ij} \right\} dj}{\int \left\{ M_j \right\} dj} \tag{F3a}$$

$$\widehat{AveEarnings}^{Data} = \frac{\int \left\{ \sum_{i \in j} w_{ij} n_{ij} \right\} dj}{\int \left\{ \sum_{i \in j} n_{ij} \right\} dj} \tag{F3b}$$

To compute the values of $\bar{\varphi}$ and $\widetilde{Z}$ that allow us to match $AveFirmSize^{Data}$ and $AveEarnings^{Data}$, we substitute the model's values for n_{ij}, w_{ij}, and M_j into $AveFirmSize^{Data}$ and $AveEarnings^{Data}$. We repetitively substitute equations (F2a) through (F2e) into (F3a) and (F3b). We then solve for $\bar{\varphi}$ and $\widetilde{Z}$ in terms of 'hatted' variables as follows:

$$\bar{\varphi} = \frac{\dfrac{AveFirmSize^{Data}}{\widehat{AveFirmSize}^{Model}}}{\left(\dfrac{AveEarnings^{Data}}{\widehat{AveEarnings}^{Model}} \right)^{\varphi}} \tag{F4}$$

$$\widetilde{Z} = \bar{\varphi}^{1-\tilde{\alpha}} \left(\frac{AveEarnings^{Data}}{\widehat{AveEarnings}^{Model}} \right)^{1+(1-\tilde{\alpha})\varphi} \times \hat{\boldsymbol{W}}^{-(1-\tilde{\alpha})(\theta-\varphi)} \tag{F5}$$

where

$$\widehat{AveFirmSize}^{Model} = \frac{\int \left\{ \sum_{i \in j} \hat{n}_{ij} \right\} dj}{\int \left\{ M_j \right\} dj}$$

$$\widehat{AveEarnings}^{Model} = \frac{\int \left\{ \sum_{i \in j} \hat{w}_{ij} \hat{n}_{ij} \right\} dj}{\int \left\{ \sum_{i \in j} \hat{n}_{ij} \right\} dj}$$

The scaled model equilibrium values (defined by (F2a) through (F2e) evaluated at (F4) and (F5)) will now match $AveFirmSize^{Data}$ and $AveEarnings^{Data}$.

G Corporate Taxes and Labor Demand

Consider a single firm i. Assume constant returns to scale. Let the corporate tax rate be given by τ_c, and let the fraction of capital financed by debt be λ. Accounting profits of a firm (on which taxes are based) are given by

$$\pi^A = Pz_i k_i^{1-\alpha} n_i^{\alpha} - w_i n_i - \underbrace{\lambda r k_i}_{\text{interest expense}} - \delta k_i$$

The pre-tax economic profits of a firm are given by

$$\pi^E = Pz_i k_i^{1-\alpha} n_i^{\alpha} - w_i n_i - r k_i - \delta k_i$$

The after-tax economic profits of a firm are given by

$$\pi = \pi^E - \tau_c \pi^A$$

Define $\tilde{z}_i = (1-\tau_c) z_i$, $\tilde{w}_i = (1+\tau_c) w_i$, and $\tilde{r} = (1+\lambda\tau_c) r + (1+\tau_c)\delta$. After substituting and solving, the profit maximization problem of the firm becomes:

$$\max_{k_i, n_i} \tilde{z}_i P k_i^{1-\alpha} n_i^{\alpha} - \tilde{w}_i n_i - \tilde{r} k_i$$

Substituting for capital, the profit maximization problem becomes

$$\pi = \max_{n_i} \left[\left[(1-\alpha)^{\frac{1-\alpha}{\alpha}} - (1-\alpha)^{\frac{1}{\alpha}} \right] \tilde{z}_i^{\frac{1}{\alpha}} \tilde{r}^{-\frac{1-\alpha}{\alpha}} - \tilde{w}_i \right] n_i$$

We can scale the profits by $\frac{1}{1+\tau_c}$ and then use the definition of $\tilde{w}_i$ to write profits as follows:

$$\hat{\pi} = \frac{\pi}{1+\tau_c} = \max_{n_i} \left[\widehat{MRPL}_i - w_i \right] n_i$$

Where the marginal product is given by,

$$\widehat{MRPL}_i = \frac{\left[(1-\alpha)^{\frac{1-\alpha}{\alpha}} - (1-\alpha)^{\frac{1}{\alpha}} \right] \tilde{z}_i^{\frac{1}{\alpha}} \tilde{r}^{-\frac{1-\alpha}{\alpha}}}{1+\tau_c}$$

In the estimation, we do not need to take a stance on the value of λ (the share of capital financed by debt), but this expression shows how corporate tax rates map to labor demand.

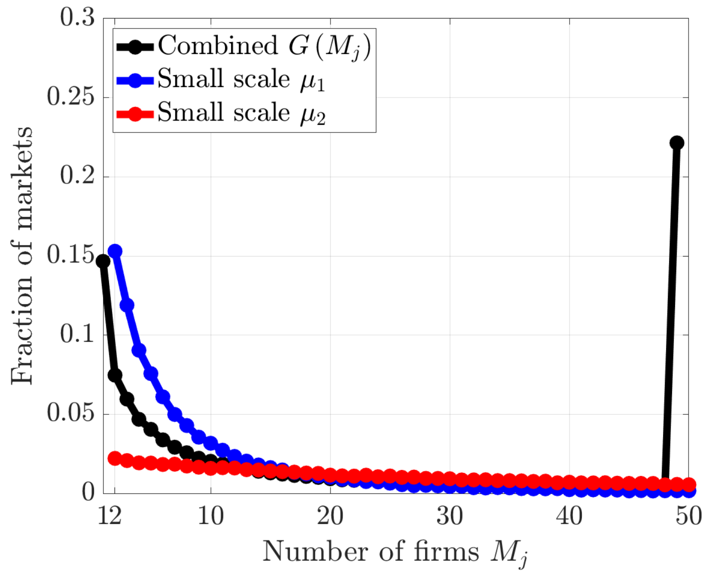

Figure H1: Distribution of the number of firms across sectors

Notes: This is a mixture of Pareto distributions. Thin Tailed: Shape=0.67, Scale=5.7, Location=2.0. Fat Tailed: Shape=0.67, Scale=6.25×5.7, Location=2.0.

H Calibration details

We assume there are 5,000 markets. For computational reasons, we must cap the number of firms per market since the Pareto distribution has a fat tail. We set the cap equal to 200 firms per market. Our results are not sensitive to the number of markets or the cap on firms per market. Figure H1 plots the mixture of Pareto distributions from which we draw the number of firms per market, M_j. The distribution of the number of firms per market, $G(M_j)$, is a mixture of Pareto distributions. The thin tailed Pareto has the following parameters: Shape=0.67, Scale=5.7, Location=2.0. The fat tailed Pareto has the following parameters: Shape=0.67, Scale=6.25×5.7, Location=2.0.

I Minimum wage

In order to solve the firm's problem, we will have to take account of the households multipliers, ν_{ijt} on equation (18). Define the *perceived* wage-bill share:

$$\tilde{s}_{ijt} = \frac{(w_{ijt} - \nu_{ijt})n_{ijt}}{\sum_{i\in j}(w_{ijt} - \nu_{ijt})n_{ijt}}$$

Define the *perceived* sectoral and aggregate wage indexes:

$$\widetilde{\mathbf{W}}_{jt} := \left[\sum_{i\in j}\left(w_{ijt}-\nu_{ijt}\right)^{1+\eta}\right]^{\frac{1}{1+\eta}} \quad , \quad \widetilde{\mathbf{W}}_{t} := \left[\int \widetilde{\mathbf{W}}_{jt}^{1+\theta}dj\right]^{\frac{1}{1+\theta}}.$$

I.1 Minimum wage solution algorithm

We implement the following solution algorithm. Initialize the algorithm by (i) guessing a value for $\widetilde{\mathbf{W}}_t^{(0)}$, (ii) assuming all firms are in *Region I*, which implies guessing $\nu_{ijt}^{(0)} = 0$. These will all be updated in the algorithm.

1. Solve the sectoral equilibrium:
   (a) Guess perceived shares $\tilde{s}_{ijt}^{(0)}$.
   (b) In *Region I*, where minimum wage does not bind, solve for the firm's wage as before, except with the perceived aggregate wage index $\widetilde{\mathbf{W}}_t$ instead of $\mathbf{W}_t$:

$$w_{ijt} = \left[\omega\mu\left(\tilde{s}_{ijt}\right)\widetilde{\mathbf{W}}_t^{(1-\tilde{\alpha})(\theta-\varphi)}\tilde{z}_{ijt}\tilde{s}_{ijt}^{(l)-\frac{(1-\tilde{\alpha})(\eta-\theta)}{\eta+1}}\right]^{\frac{1}{1+(1-\tilde{\alpha})\theta}}$$

   (c) In all other regions *Region II, III, IV*, set $w_{ijt} = \underline{w}$.
   (d) Compute perceived wages using the guess $\nu_{ijt}^{(k)}$: $\tilde{w}_{ijt} = w_{ijt} - \nu_{ijt}^{(k)}$
   (e) Update shares using $\tilde{w}_{ijt}$:

$$\tilde{s}_{ijt}^{(l+1)} = \frac{\tilde{w}_{ijt}^{1+\eta}}{\sum_{i\in j}\tilde{w}_{ijt}^{1+\eta}} \qquad \left(:= \frac{\tilde{w}_{ijt}n_{ijt}}{\sum_{i\in j}\tilde{w}_{ijt}n_{ijt}} = \frac{\tilde{w}_{ijt}\bar{\varphi}\left(\frac{\tilde{w}_{ijt}}{\widetilde{\mathbf{W}}_{jt}}\right)^{\eta}\left(\frac{\widetilde{\mathbf{W}}_{jt}}{\widetilde{\mathbf{W}}_{t}}\right)^{\theta}\widetilde{\mathbf{W}}_t^{\varphi}}{\sum_{i\in j}\tilde{w}_{ijt}\bar{\varphi}\left(\frac{\tilde{w}_{ijt}}{\widetilde{\mathbf{W}}_{jt}}\right)^{\eta}\left(\frac{\widetilde{\mathbf{W}}_{jt}}{\widetilde{\mathbf{W}}_{t}}\right)^{\theta}\widetilde{\mathbf{W}}_t^{\varphi}}\right)$$

   (f) Iterate over (b)-(e) until $\tilde{s}_{ijt}^{(l+1)} = \tilde{s}_{ijt}^{(l)}$.

2. Recover employment n_{ijt} according to the current guess of firm region. First use $\tilde{w}_{ijt}$ to compute $\widetilde{\mathbf{W}}_{jt}$, $\widetilde{\mathbf{W}}_t$. Then by region:
   (I) Firm is unconstrained:

$$n_{ijt} = \bar{\varphi}\left(\frac{w_{ijt}}{\widetilde{\mathbf{W}}_{jt}}\right)^{\eta}\left(\frac{\widetilde{\mathbf{W}}_{jt}}{\widetilde{\mathbf{W}}_{t}}\right)^{\theta}\widetilde{\mathbf{W}}_t^{\varphi}$$

(II) Firm is constrained and employment is determined by the household labor supply curve at $\underline{w}$:

$$n_{ijt} = \bar{\varphi}\left(\frac{\underline{w}}{\widetilde{\mathbf{W}}_{jt}}\right)^{\eta}\left(\frac{\widetilde{\mathbf{W}}_{jt}}{\widetilde{\mathbf{W}}_{t}}\right)^{\theta}\widetilde{\mathbf{W}}_{t}^{\varphi}$$

(III),(IV) Firm is constrained and employment is determined by firm $MRPL_{ij}$ curve at $\underline{w}$:

$$n_{ijt} = \left(\frac{\tilde{\alpha}\widetilde{Z}\tilde{z}_{ijt}}{\underline{w}}\right)^{\frac{1}{1-\tilde{\alpha}}}$$

3. Update $\nu_{ijt}^{(k)}$:
   (a) Use n_{ijt} to compute $\mathbf{N}_{jt}$, $\mathbf{N}_t$.
   (b) Update ν_{ijt} from the *household's* first order conditions:

$$\nu_{ijt}^{(k+1)} = w_{ijt} - \bar{\varphi}^{-\frac{1}{\varphi}}\left(\frac{n_{ijt}}{\mathbf{N}_{jt}}\right)^{\frac{1}{\eta}}\left(\frac{\mathbf{N}_{jt}}{\mathbf{N}_{t}}\right)^{\frac{1}{\theta}}\mathbf{N}_{t}^{\frac{1}{\varphi}}$$

4. Update $\widetilde{\mathbf{W}}_{t}^{(k)}$:
   (a) Compute $\tilde{w}_{ijt} = w_{ijt} - \nu_{ijt}^{(k+1)}$
   (b) Use $\tilde{w}_{ijt}$ to update the aggregate wage index to $\widetilde{\mathbf{W}}_{t}^{(k+1)}$.
5. Update firm regions:
   (a) Compute profits for all firms: $\pi_{ijt} = \widetilde{Z}\tilde{z}_{ijt}n_{ijt}^{\tilde{\alpha}} - \underline{w}n_{ijt}$.
   (b) If in sector j there exists a firm with $w_{ijt} < \bar{w}$, then move the firm with the lowest wage into *Region II*.
   (c) If in sector j there exists a firm that was initially in *Region II* and has negative profits $\pi_{ijt} < 0$, move that firm into *Region III*.[39]
6. Iterate over (1) to (5) until $\nu_{ijt}^{(k+1)} = \nu_{ijt}^{(k)}$ and $\widetilde{\mathbf{W}}_{t}^{(k+1)} = \widetilde{\mathbf{W}}_{t}^{(k)}$.

[39] We do not need to distinguish *Region III* from *Region IV* in the algorithm, since it the determination of equilibrium wages and employment are the same in each region.