# Imperfect Competition and Rents in Labor and Product Markets: The Case of the Construction Industry

Kory Kroft, Yao Luo, Magne Mogstad, Bradley Setzler Carnegie Mellon & U of Pittsburgh – September 2023

*Disclaimer:* The opinions expressed here are those of the authors alone and do not reflect the views of the Internal Revenue Service or the U.S. Treasury Department.

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**Empirical context:** We link the universe of U.S. **firm** and **worker** tax returns with records we collected from **procurement auctions**.

Framework for jointly analyzing labor and product market power.

- Distinguish supply and demand factors in both markets.
- Closed-form identification of all model parameters.
- Measures of rents and incidence of procurement.
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- Challenge: Unobserved firm-specific labor supply shocks.
- **Approach:** Leverage institutional features of the **auction** to isolate an observable firm-specific labor demand shock.
- **Preview:** Labor supply elasticity  $\approx$  4, wage markdown 20%.

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### Identify returns to labor and product demand elasticities:

- Challenge: Unobserved firm-specific productivity shocks.
- Approach: Invert the bidding strategy in the auction.
- **Preview:** technology  $\approx$  CRS, 16% price markup.

#### Model estimates:

- Labor market power: Wage markdown 20% below MRPL.
- **Double markdown:** MRPL depends on price **markup**. Accounting for **markup**, **double markdown** on wages is 31%
- Double markup: MC depends on wage markdown. Double markup on price is 44%, versus 16% ignoring markdown.

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- Intuition: Cut employment to exploit labor ⇒ less output means higher prices ⇒ mitigates incentive to cut.
- Quantitative finding: Reducing labor supply elasticity in half,
  - if the firm were a price-taker: 27% less employment
  - with product market power: 15% less employment

Wage inequality, imperfect competition, compensating differentials

Rosen 1986; Murphy and Topel 1990; Gibbons and Katz 1992; Abowd Lemieux 1993; Abowd et al 1999; Hamermesh 1999; Pierce 2001; Bhaskar et al 2002; Manning 2003, 2011; Mas and Pallais 2017; Wiswall and Zafar 2017; Card et al 2013, 2016, 2018; Maestas et al 2018; Caldwell Oehlsen 2018; Berger et al 2019; Jarosch et al 2019; Chan et al 2020; Bassier et al 2020; Hershbein et al 2020; Azar Berry Marinescu 2020; many more

Inferring monopsony from pass-through of firm-specific shocks

• van Reenen 1996; Kline et al 2019; Howell Brown 2020; Lamadon Mogstad Setzler 2022; Garin Silvério 2023

Empirical designs for auctions

• Ferraz et al 2015; Lee 2017; Cho 2018; Hvide Meling 2019; Gugler et al 2020

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## Model

We develop a model with imperfect competition in both labor and **product** markets.

The model serves several purposes:

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Key equations provided by the model in **blue**, they will be:

- Labor supply curve
- Product demand curve
- Optimal intermediate inputs
- Optimal auction bid
- Rents expression

**Preferences** If employed by firm j at wage  $W_{jt}$ , worker i utility is

$$\mathcal{U}_{it}(j, W_{jt}) = \log W_{jt} + \log G_{jt} + \eta_{ijt}$$
(1)

- G<sub>jt</sub> is common, gives rise to vertical differentiation
- $\eta_{ijt}$  is idiosyncratic to worker *i*, gives *horizontal* differentiation

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#### Firm-specific labor supply curve:

$$W_{jt} = L_{jt}^{\theta} U_{jt} \implies w_{jt} = \theta \ell_{jt} + u_{jt}$$
(2)

where  $1/\theta$  is the LS elasticity and  $U_{it}$  is the firm-specific amenity

• Strategically small: no firm can shift aggregate labor supply

## Technology

**Production Function** Firms produce using labor L, capital K, and intermediate inputs M in the Ackerberg et al (2015) technology,

$$Q_{jt} = \min\{\Omega_{jt} L_{jt}^{\beta_L} K_{jt}^{\beta_K}, \beta_M M_{jt}\} \exp(e_{jt})$$
(3)

where  $\Omega_{jt}$  is TFP and  $e_{jt}$  is measurement error in output

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Composite Production If capital market is perfect, simplifies to

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**Optimal intermediate inputs** Defining  $X_{jt} \equiv p_M M_{jt}$ , the Leontief FOC and competitive market for intermediate inputs gives,

$$X_{jt} = \frac{\rho_M}{\beta_M} L_{jt}^{\rho} \Phi_{jt} \implies x_{jt} = \kappa_X + \rho \ell_{jt} + \phi_{jt}$$
(5)

## **Firm's Problem**

**Output** Let G denote govt market and H denote private market. Denote output in G by  $Q_{it}^G$  and in H by  $Q_{it}^H$ 

- First-stage: Firms bid to produce  $\bar{Q}^{G}$ ,  $D_{it} = 1$  if winner
- Second-stage: Choose total output  $Q_{jt} = \bar{Q}^G D_{jt} + Q_{it}^H$

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Private Market Firms face downward-sloping demand,

$$P_{jt}^{H} = p_{H} \left( Q_{jt}^{H} \right)^{-\epsilon} \implies R_{jt}^{H} = p_{H} \left( Q_{jt}^{H} \right)^{1-\epsilon} \implies r_{jt}^{H} = \kappa_{R} + (1-\epsilon)q_{jt}^{H}$$
  
where  $1/\epsilon$  is the price elasticity of demand (6)

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**Firm's Problem** Given  $Q_j \ge \overline{Q}^G d$  and auction outcome  $D_j = d$ ,

$$\max_{L_{djt},K_{djt},M_{djt}} \quad \pi_{djt}^{H} = R_{djt}^{H} - W_{djt}L_{djt} - p_{M}M_{djt} - p_{K}K_{djt}$$
(7)

subject to the labor supply curve, the product demand curve, and the production function.

### **Government Market for Procurements**

**Opportunity Cost** Given private market profits  $\pi_{dit}^{H}$  if  $D_{jt} = d$ ,

$$\sigma_{u}(\phi_{jt}) = \pi_{0jt}^{H} - \pi_{1jt}^{H} > 0, \qquad (8)$$

Auction problem Firm j chooses optimal bid  $Z_{jt}$  that solves,

$$\max_{Z_{jt}} \underbrace{\left(Z_{jt} - \sigma_u\left(\phi_{jt}\right)\right)}_{\text{payoff}} \times \underbrace{\Pr\left(D_{jt} = 1 | Z_{jt}\right)}_{\text{probability of winning}}$$
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Optimal bid Unique symmetric equilibrium is defined by,

$$s_{u}(\phi_{jt}) = \sigma_{u}(\phi_{jt}) \,\delta_{u}(\phi_{jt}), \ \delta_{u}(\phi_{jt}) \equiv 1 + \frac{\int_{\sigma_{u}(\phi_{jt})}^{\bar{\sigma}} [1 - F_{u}(\tilde{\sigma})]^{I-1} d\tilde{\sigma}}{\sigma_{u}(\phi_{jt}) \left[1 - F_{u}(\sigma_{u}(\phi_{jt}))\right]^{I-1}}$$

where I is number of bidders and  $\delta$  is markup on opportunity cost

**Worker Rents** The rents  $V_{it}$  derived by worker *i* from being employed at the preferred firm *j* is defined implicitly by,

$$\underbrace{\mathcal{U}_{it}\left(j, W_{jt} - V_{it}\right)}_{j' \neq j} = \max_{\substack{j' \neq j}} \mathcal{U}_{it}\left(j', W_{j't}\right)$$

utility at current employer net of worker rents

utility at best outside option

Intuition: worker rent is willingness to pay to stay in current firm

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Sum of Worker Rents Using our functional form to simplify,

$$V_{jt} \equiv \sum_{i} V_{ijt} = \frac{B_{jt}}{1 + 1/\theta} \tag{10}$$

where  $B_{jt} = L_{jt} W_{jt}$  is the wage bill and  $1/\theta$  is LS elasticity

## **Rents and Incidence**

#### **Incidence of Procurements**



Incidence

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#### Incidence for Incumbents and New Hires



Intuition: wage increase is pure rents for an incumbent

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#### Firm Rents



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### **First-order Condition**

**Simple Firm's Problem:** Consider a firm that does not participate in procurement auctions. The firm's problem simplifies to,

$$\max_{L_{jt},K_{jt},M_{jt}} \quad \pi_{jt} = Q_{jt}P_{jt} - W_{jt}L_{jt} - p_M M_{jt} - p_K K_{jt}$$

subject to the constraints,

Flexible prod. func.: Monopolistic comp.: Monopsonistic comp.:

$$\begin{aligned} Q_{jt} &= f_{jt}(L_{jt}, K_{jt}, M_{jt}) \\ P_{jt} &= p_H(Q_{jt})^{-\epsilon} \\ W_{jt} &= L_{jt}^{\theta} U_{jt} \end{aligned}$$

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#### First-order Condition w.r.t. Labor:

$$\underbrace{(1-\epsilon) \times P_{jt} \text{ MPL}_{jt}}_{\text{MRPL}_{jt}} = \underbrace{(1+\theta) \times W_{jt}}_{\text{MCL}_{jt}}$$

where MPL<sub>jt</sub>  $\equiv \frac{\partial Q_{jt}}{\partial L_{jt}}$ , MRPL<sub>jt</sub>  $\equiv \frac{\partial (P_{jt}Q_{jt})}{\partial L_{jt}}$ , and MCL<sub>jt</sub>  $\equiv \frac{\partial (W_{jt}L_{jt})}{\partial L_{jt}}$ .
FOC: 
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Markdown and Markup: Rearranging the FOC,

$$W_{jt} = \overbrace{(1+\theta)^{-1}}^{\text{markdown}} \times \text{MRPL}_{jt} \quad \text{and} \quad P_{jt} = \overbrace{(1-\epsilon)^{-1}}^{\text{markup}} \times \frac{\text{MCL}_{jt}}{\text{MPL}_{jt}}$$

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$$W_{jt} = \underbrace{\underbrace{(1+\theta)^{-1}}_{\text{double markdown}}^{\text{inverse markup}}}_{\text{double markdown}} \times \underbrace{P_{jt} \text{ MPL}_{jt}}_{\text{value of MPL}}$$
(14)

Double markup: Substituting into the price expression,



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### Single Markdown

 $MCL = (1 + \theta) \times Wage$ , where  $1/\theta$  is LS elasticity. MRPL =  $(1 - \epsilon) \times P \times MPL$ , where  $1/\epsilon$  is PD elasticity.



Perfect competition in the product market:  $\epsilon = 0$ .

### **Double Markdown**

 $\mathsf{MCL} = (1+ heta) imes \mathsf{Wage}$ , where 1/ heta is LS elasticity.

 $\mathsf{MRPL} = (1 - \epsilon) \times \mathsf{P} \times \mathsf{MPL}$ , where  $1/\epsilon$  is PD elasticity.



Imperfect competition in the product market:  $\epsilon > 0$ .

### Single Markup



### **Double Markup**



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US tax data 2001-15 universe of business and worker tax returns

**Firms:** Business tax returns include balance sheet and other information for C-corps, S-corps, and partnerships

- firm: tax entity (EIN)
- sales: gross receipts from business operations (not dividends)
- profits: EBITD (earnings before interest, taxes, deductions)
- intermediate inputs: COGS (cost of goods sold)
  - includes intermediate goods, transit costs, etc
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Workers: W-2 records on employment and total earnings

- **labor:** link workers to their highest-paying employer with earnings above FTE threshold, restrict to age 25-60
- contractors: also observe indep. contractors (Form 1099)

# Data Sources (2/2)

Auction data Firm-auction records on bids and winners of department of transportation (DOT) procurement contracts

- state DOTs use auctions to procure construction and landscaping work on roads and bridges
- First-price sealed-bid auctions (output price = lowest bid), where we observe bid of each firm, not only the winner
- FOIA or webscraped from BidX.com & state-specific websites
- Cover more than 100,000 auctions by 28 state DOTs, including large states like California, Texas, and Florida
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**Final data** Link tax returns to auction records by fuzzy matching on firm name and address

- Final data: 8,000 unique firms, 360,000 unique workers
- 6 states provide EIN, used for training algorithm & robustness

	Sample Size		Share of the Construction Sector
Number of Firms Workers per Firm	7,876 $46$		$0.9\% \\ 11.7\%$
	Value Per Firm (\$ millions)	Mean of the Log	Share of the Construction Sector (%)
Sales EBITD Intermediate Costs Wage bill	$     19.927 \\     9.159 \\     14.661 \\     2.737 $	$15.061 \\ 14.075 \\ 14.719 \\ 13.549$	$12.1\% \\ 9.6\% \\ 12.4\% \\ 13.4\%$

- Final sample: 8,000 unique firms, 360,000 unique workers
- Average firm has 46 employees and \$9M in profits

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Using the key equations provided by the model that were in **blue** above, we now identify and estimate:

- Labor supply elasticity (4 slides)
- Firm technology & product demand elasticities (2 slides)

**Goal:** Identify the labor supply elasticity,  $1/\theta$ .

Model: Log inverse labor supply curve is,

$$w_{jt} = \theta \ell_{jt} + u_{jt} = \theta \ell_{jt} + \psi_j + \xi_t + \nu_{jt}$$
(16)

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#### Easy to deal with:

- Time-invariant firm-specific amenities  $\psi_j$  (take differences)
- Aggregate labor supply shocks  $\Delta \xi_t$  (add year fixed effects)

$$\Delta w_{jt} = \theta \Delta \ell_{jt} + \Delta \xi_t + \Delta \nu_{jt} \tag{17}$$

**Challenge:** Regression of change in log wage on change in log employment biased for  $\theta$  due to firm-specific amenity shock  $\Delta \nu_{it}$ 

Difference-in-differences. Consider the DiD estimator,

$$\theta_{\mathsf{DiD}} \equiv \frac{\mathsf{Cov}\left[\Delta w_{jt}, D_{jt}\right]}{\mathsf{Cov}\left[\Delta \ell_{jt}, D_{jt}\right]} = \underbrace{\frac{\mathsf{Cov}\left[\theta \Delta \ell_{jt}, D_{jt}\right]}{\mathsf{Cov}\left[\Delta \ell_{jt}, D_{jt}\right]}}_{\theta} + \underbrace{\frac{\mathsf{Cov}\left[\Delta \nu_{jt}, D_{jt}\right]}{\mathsf{Cov}\left[\Delta \ell_{jt}, D_{jt}\right]}}_{\text{winning due to amenity shock}}$$

Difference-in-differences. Consider the DiD estimator,



**DiD Identification.** If  $D_{jt} \perp \Delta \nu_{jt}$ , then  $\theta_{\text{DiD}} = \theta$ .

Possible justification:  $\Delta \nu_{jt}$  not in information set at "First Stage" of *t* when bid is placed in auction.

 Delay is between *estimating* labor cost (bidding at beginning of period t) and actually hiring labor (middle of period t). How well does cost estimation software predict Δν<sub>it</sub>?

Difference-in-differences. Consider the DiD estimator,



**DiD Identification.** If  $D_{jt} \perp \Delta \nu_{jt}$ , then  $\theta_{\text{DiD}} = \theta$ .

Possible justification:  $\Delta \nu_{jt}$  not in information set at "First Stage" of *t* when bid is placed in auction.

- Delay is between *estimating* labor cost (bidding at beginning of period t) and actually hiring labor (middle of period t). How well does cost estimation software predict Δν<sub>it</sub>?
- Time delay assumptions are standard for identification in empirical IO (Ackerberg et al 2015; Gandhi et al 2020).

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$$\theta_{\text{DiD}} \equiv \frac{\text{Cov}\left[\Delta w_{jt}, D_{jt}\right]}{\text{Cov}\left[\Delta \ell_{jt}, D_{jt}\right]} = \underbrace{\frac{\text{Cov}\left[\theta \Delta \ell_{jt}, D_{jt}\right]}{\text{Cov}\left[\Delta \ell_{jt}, D_{jt}\right]}}_{\theta} + \underbrace{\frac{\text{Cov}\left[\Delta \nu_{jt}, D_{jt}\right]}{\text{Cov}\left[\Delta \ell_{jt}, D_{jt}\right]}}_{\text{winning due to amenity shock}}$$

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Important to emphasize what is **not** restricted by this assumption:

- no additional restrictions on joint dist of  $(Z_{jt}, D_{jt}, \phi_{jt}, \psi_j, \xi_t)$ .
- allows  $Var(\Delta \nu_{jt}) > 0$ , clear step forward in this literature.
- allows  $\Delta \ell_{jt}, \Delta w_{jt}$  to depend on  $\Delta \nu_{jt}$ , no time delay here.



Alternative: Leverage auction structure to allow selection. Regression Discontinuity: Consider the estimator,

$$\theta_{RDD}(\overline{\tau}) \equiv \frac{\mathbb{E}\left[\Delta w_{jt} | \tau_{jt} = 0\right] - \mathbb{E}\left[\Delta w_{jt} | 0 < \tau_{jt} \le \overline{\tau}\right]}{\mathbb{E}\left[\Delta \ell_{jt} | \tau_{jt} = 0\right] - \mathbb{E}\left[\Delta \ell_{jt} | 0 < \tau_{jt} \le \overline{\tau}\right]}$$

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#### Limit around the discontinuity:

$$\lim_{\overline{\tau}\to 0^+} \theta_{RDD}(\overline{\tau}) = \theta + \lim_{\overline{\tau}\to 0^+} \underbrace{\frac{\mathbb{E}\left[\Delta\nu_{jt}|\tau_{jt}=0\right] - \mathbb{E}\left[\Delta\nu_{jt}|0<\tau_{jt}\leq\overline{\tau}\right]}{\mathbb{E}\left[\Delta\ell_{jt}|\tau_{jt}=0\right] - \mathbb{E}\left[\Delta\ell_{jt}|0<\tau_{jt}\leq\overline{\tau}\right]}_{\text{winning due to emphisy shock}}$$

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**RDD Identification:**  $D_{jt} \perp \Delta \nu_{jt} | (Z_{it}) \implies \lim_{\overline{\tau} \to 0^+} \theta_{RDD}(\overline{\tau}) = \theta.$ 

- First-price auctions  $\implies$  winning fully determined by bids  $Z_{it}$ .
- Thus, the assumption is always true in first-price auctions!
- Intuition:  $\mathbb{E}[\Delta \nu]$  equal for winners & losers at discontinuity.



### Results using multiplicity of approaches:

- DiD Estimator:  $1/\theta = 4.1$ , markdown = 0.80
- RDD Estimator:  $1/\theta = 3.5$ , markdown = 0.78
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### Sensitivity checks:

- Passes falsification test using DiD or RDD on the pre-period
- No evidence of bias from slow adjustments over time
- No evidence of bias from worker composition changes
- No evidence of bias from local aggregate shocks
- Not sensitive to alternative choices of auction loser sample
- Not sensitive to right-to-work or prevailing wage law coverage
- Not sensitive to alternative parameterizations of Proposition 2
- Various checks using this sample and external BLS and Census wage surveys indicate wage effects not due to hours responses

...

( ► more ) ( ► amenity

## **Robustness: Labor Supply Elasticity Specifications**

### Labor supply elasticity $1/\theta$ :



### Wage markdown $(1 + \theta)^{-1}$ :



**Goal:** Identify the composite returns to labor,  $\rho$ . **Model:** Optimal intermediate inputs imply,

$$x_{jt} = \kappa_X + \rho \ell_{jt} + \phi_{jt} \tag{18}$$

**Challenge:** log TFP  $\phi$  is a determinant of both log labor  $\ell$  and log intermediate input expenditures *x*.

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**Identification:** Controlling for  $(Z_{jt}, u_{jt})$  controls for  $\phi_{jt}$ :

$$\frac{\operatorname{Cov}\left[x_{jt},\ell_{jt}|\hat{u}_{jt},Z_{jt}\right]}{\operatorname{Var}\left[\ell_{jt}|\hat{u}_{jt},Z_{jt}\right]} = \frac{\operatorname{Cov}\left[x_{jt},\ell_{jt}|\hat{u}_{jt},\phi_{jt}\right]}{\operatorname{Var}\left[\ell_{jt}|\hat{u}_{jt},\phi_{jt}\right]} = \rho$$
(19)


# Technology and Product Demand Elasticities (2/2)

**Goal:** Identify the product demand elasticity,  $1/\epsilon$ .

We extend the de Loecker Eeckhout Unger (2020) measure of inverse markups to incorporate labor market power ( $\theta > 0$ ):

$$\underbrace{(1-\epsilon)}^{\text{markup}^{-1}} = \underbrace{\frac{(1+\theta)}{\beta_L}}_{\beta_L} \frac{B_{jt}}{R_{jt}} + \frac{X_{jt}}{R_{jt}} = \underbrace{(1+\theta)}^{\text{markdown}^{-1}} \frac{s_L}{\beta_L} + s_M \qquad (20)$$

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**Product demand elasticity:** We estimate  $1/\epsilon = 7.3$ , which gives a **price markup**,  $1/(1-\epsilon)$ , that is 16% above marginal cost.

**Composite returns to labor:** We estimate  $\rho = 1.09$ , just above **constant returns to scale**, in line with the literature (e.g. Combes Duranton & Gobillon 2021 find CRS in housing construction).

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- Robust to using main identifying moments instead of GMM.
- Robust to Cobb-Douglas instead of Leontief prod function.
- Robust to relaxing the auction symmetry assumption.
- Robust to controlling for aggregate price shocks.

- 1. Framework with Labor and Product Market Power
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#### **Estimates: Double Markdown**

$$W_{jt} = \overbrace{(1+\theta)^{-1}}^{\mathsf{markdown}} \times \mathsf{MRPL}_{jt}$$

A natural measure of monopsony power is the markdown

• We estimate a markdown of 0.80, so workers are paid 20% below the marginal revenue product of labor (MRPL)

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 Special case w/o intermediate inputs: MRPL equals inverse markup times the value of the marginal product of labor (MPL) at fixed prices, so higher markup ⇒ lower wage

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 Special case w/o intermediate inputs: MRPL equals inverse markup times the value of the marginal product of labor (MPL) at fixed prices, so higher markup ⇒ lower wage

We estimate a **double markdown** of 0.69.

- Workers are paid 31% below the value of their MPL
- If we ignored the markup, we would think workers are paid 20% below the value of their MPL

## **Estimates: Double Markup**

$$P_{jt} = \overbrace{(1-\epsilon)^{-1}}^{\text{markup}} \times \frac{\text{MCL}_{jt}}{\text{MPL}_{jt}}$$

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• We estimate a **markup** of 1.16, so prices are 16% above the productivity-adjusted marginal cost of labor.

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But MCL depends on labor market power

• Stronger markdown  $\implies$  Higher price

## **Estimates: Double Markup**



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• We estimate a **markup** of 1.16, so prices are 16% above the productivity-adjusted marginal cost of labor.

But MCL depends on labor market power

• Stronger markdown  $\implies$  Higher price

We estimate a **double markup** of 1.44.

- Prices are 44% above the effective average cost
- If we ignored the markdown, we would think prices are 16% above the value of the effective average cost

Panel A.	Components of the Double Markdown of the Wage				
	$\frac{\text{Markdown}}{(1+\theta)^{-1}}$	Inverse Markup $(1 - \epsilon)$	Double Markdown $(1+\theta)^{-1}(1-\epsilon)$		
Using $\theta_{\text{DiD}}$ :	0.803	0.863	0.693		
Using $\theta_{\text{RDD}}$ :	0.777	0.000	0.671		
	Components of the Double Markup of the Price				
Panel B.	Compone	ents of the Double	Markup of the Price		
Panel B.	$\frac{\text{Compone}}{(1-\epsilon)^{-1}}$	$\begin{array}{c} \text{ints of the Double} \\ \hline \text{Inverse Markdown} \\ (1+\theta) \end{array}$	$\frac{\text{Markup of the Price}}{\text{Double Markup}} \\ (1-\epsilon)^{-1}(1+\theta)$		
Panel B. Using $\theta_{\text{DiD}}$ :	$\frac{\text{Compone}}{(1-\epsilon)^{-1}}$	$\frac{\text{Inverse Markdown}}{(1+\theta)}$ $\frac{(1+\theta)}{1.245}$	$\frac{\text{Markup of the Price}}{\begin{array}{c} \text{Double Markup} \\ (1-\epsilon)^{-1}(1+\theta) \\ \hline 1.443 \end{array}}$		

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		Actual	Counterf.	Difference	
		d = 1	d = 0	Level	Relative
Labo	r market				
$L_{jt}$	Employment $(\#)$	<b>24.7</b>	12.8	11.9	92.7%
$W_{jt}$	Wage (\$1K)	<b>59.1</b>	50.4	8.8	17.4%
$B_{jt}$	Wage bill $(\$1K)$	$1,\!459.6$	645.2	814.4	126.2%
Rents					
$V_{it}$	Worker rents $(\$1K/L)$	11.6	5.1	6.5	126.2%
$\pi_{jt}$	Firm profits $(\$1K/L)$	43.1	33.4	9.6	28.7%

In the actual economy (d = 1), per-capita worker rents  $\frac{W}{1+1/\theta}$  are about \$12,000 per year, less than 1/4 of all rents.

#### **Estimates of Rents and TFP**



Workers' share of rents is smaller at more productive firms.

		Actual	Counterf.	Difference		
		d = 1	d = 0	Level	Relative	
Labo	r market					
$L_{jt}$	Employment $(\#)$	24.7	12.8	11.9	92.7%	
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We simulate winning versus losing an auction among winners.

Hiring to fulfill the government contract leads to bidding up wages, running up worker rents, with only a small increase in firm rents.

## **Estimates of Crowd-out from Procurements**

		Actual	Counterf.	Difference	
		d = 1	d = 0	Level	Relative
Input 1	Expenditures				
$B_{jt}$	Wage bill (\$1K)	$1,\!459.6$	645.2	814.4	126.2%
$X_{jt}$	Intermediate inputs (\$1K)	4,715.1	2,308.6	2,406.5	104.2%
$p_K K_{jt}$	Capital rentals (\$1K)	1,724.7	762.4	962.3	126.2%
Total p	production				
$Q_{jt}$	Output (#)	38.3	18.7	19.5	104.2%
$R_{jt}$	Revenue (\$1K)	8,962.1	$4,\!541.6$	$4,\!420.5$	97.3%
Private production					
$Q_{it}^H$	Output (#)	13.7	18.7	-5.1	-27.0%
$R_{jt}^{H}$	Revenue (\$1K)	$3,\!460.7$	4,541.6	-1,080.9	-23.8%

The government contract nearly doubles the firm's revenues.

However, it crowds out about 1/4 of private sector output.

Note that output declines more than revenues due to markups.

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**Naive solution:** Increase preference dispersion from  $\theta$  to  $\theta'$ , all else equal. This changes markdown from  $1/(1+\theta)$  to  $1/(1+\theta') \implies$  more labor market power.

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**Challenge:** Increasing  $\theta$  affects not only the markdown, but also the level of labor supply at the initial wage. Thus, increasing  $\theta$  fails to define an all-else-equal increase in labor market power.

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**Solution:** When increasing  $\theta$ , also adjust the amenity  $(U_{jt})$  so that the initial (labor, wage) combination is still on the labor supply curve. Analogous to Slutsky compensation, removes the level shift.

## Theory: Impacts of Labor Market Power (2/3)



- No price-setting power  $\implies$  flat MRPL curve
- More labor market power  $\implies$  steeper MCL (red)  $\implies$  less employment, greater wage markdown

## Theory: Impacts of Labor Market Power (3/3)



- Firm has price-setting power  $\implies$  downward-sloping MRPL
- Cut employment  $\implies$  cut output  $\implies$  higher output price  $\implies$  incentive not to cut employment as much

# Model Simulation: Impacts of Labor Market Power (1/2)



Consider reducing LS elasticity  $1/\theta$  in half

- Simulate from estimated model, counterfactually set  $\epsilon = 0$
- Employment  $\downarrow$  27%, wages  $\downarrow$  16%, profits  $\uparrow$  10%

# Model Simulation: Impacts of Labor Market Power (2/2)



- Simulate from estimated model, use estimated  $1/\epsilon = 7.3$
- Employment ↓ 15%, wages ↓ 9%, profits ↑ 1% ⇒ impacts of labor market power mitigated by product market power

## Conclusions

- Developed a framework for jointly analyzing labor and product market power
- Leveraged features of procurement auctions to recover labor supply, technology, and product demand
- We estimate a markdown on MRPL of 20%. Furthermore, we find a **double markdown** on value of MPL of 31%, due to **product** market power
- Firms capture more than 3/4 of rents, high productivity firms share less, but workers capture a high share of marginal rents
- Simulations from estimated model show that impacts of labor market power depend on degree of **product** market power

# Appendix

# Visual test of collusion from Chassang et al (2022)



None of our 28 states has a "missing mass" of close losing bids. Chassang Kawai Nakabayashi Ortner (2022 ECMA) show that such patterns should be found broadly under collusive behavior.

#### Effects on wages (left) and employment (right):



#### Labor supply elasticity for alternative bandwidths $(\bar{\tau})$ :



#### Labor supply elasticity by stayer spell:



#### Labor supply elasticity by tenure length:



# Hours and full-time status (1/2)

Labor supply elasticity by FTE threshold (as % of min. wage):



Other notes:

- US construction industry during 2001-2015 was 4.6% part-time labor vs 13.9% in entire private sector (BLS)
- LMS estimator in Norway: revenue shock pass-through of 0.092 (annual earnings) and 0.091 (hourly wages)

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# Hours and full-time status (2/2)

Wage effects persist over time (inconsistent with over-time pay):



Other notes:

- US construction industry during 2001-2015 was 4.6% part-time labor vs 13.9% in entire private sector (BLS)
- LMS estimator in Norway: revenue shock pass-through of 0.092 (annual earnings) and 0.091 (hourly wages) <br/>
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# Prevailing Wage: Restricting the Sample of Firms

	All States		Prevailing Wage States	
	All Workers	Stayers	All Workers	Stayers
Impacts of Winning an Auction:				
Log Employment:	$0.083 \\ (0.019)$		0.081 (0.023)	
Log Earnings per Worker:	$0.020 \\ (0.008)$	$\begin{array}{c} 0.023 \\ (0.006) \end{array}$	$0.023 \\ (0.010)$	0.027 (0.007)
Implied Labor Parameters:				
Labor Supply Elasticity:	4.084	3.600	3.508	3.054
Markdown relative to MRPL:	0.803	0.783	0.778	0.753


Total	Wage	Non-wage	Share Non-wage			
Compensation	Compensation	Compensation Fringe Benefits				
$(\log)$	$(\log)$	$(\log)$	(fraction)			
Difference-in-Differences for State Davis-Bacon Repeals						
0.009	0.009	0.015	0.000			
(0.026)	(0.029)	(0.031)	(0.005)			



#### Sources of Compensation in the Construction Industry





	OSHA Investigations		OSHA Violations		
	Probability	Count	Probability	Count	
	Occurrence				
Observed Average:	0.075	0.139	0.041	0.110	
	Impacts of Winning a Procurement Auction				
Impact: Before Treatment	0.000	-0.012	0.000	-0.009	
	(0.006)	(0.016)	(0.004)	(0.018)	
Impact: After Treatment	0.009	0.004	0.000	-0.006	
	(0.008)	(0.020)	(0.006)	(0.023)	



The goal is to estimate  $1 - \epsilon$  using the relationship:

$$r_{jt} = \kappa_R + (1 - \epsilon) x_{jt} + (1 - \epsilon) e_{jt}$$

where  $e_{jt}$  is the error in the relationship between log revenues  $r_{jt}$  and log intermediates  $x_{it}$ . The key identifying restriction is,

$$\operatorname{Cov}(x_{jt}, e_{jt}) = 0$$

This orthogonality condition is satisfied under the assumption by Ackerberg et al. (2015) that the firm has no information about  $e_{jt}$  at the time inputs are chosen:

"The  $[e_{jt}]$  represent shocks to production or productivity that are **not observable (or predictable)** by firms before making their input decisions at t...  $[e_{jt}]$  can also represent (potentially serially correlated) measurement error in the output variable." Ackerberg et al. (2015, ECMA)

Indeed,  $x_{jt}$  should be uncorrelated with  $e_{jt}$  if  $e_{jt}$  is completely unpredictable at the time  $x_{jt}$  is chosen.

As far as we know, ours is the first paper with three distinct types of imperfectly competitive markets:

- Input market for workers
- Output market for products
- Government market for procurements

However, we did not relax the standard assumptions that capital and materials markets are competitive.

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• We do not observe capital. By assuming capital is competitive with rental price  $p_K$ , it can be substituted out of the firm's problem. This assumption is especially realistic in construction, which has a massive equipment rental industry.

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- We do not observe capital. By assuming capital is competitive with rental price  $p_K$ , it can be substituted out of the firm's problem. This assumption is especially realistic in construction, which has a massive equipment rental industry.
- We do not observe quantity vs price of materials. Materials are assumed to be competitive with price  $p_M$ . This assumption is especially realistic for construction, e.g., road inputs like lime and asphalt are not differentiated.

Given these assumptions and the Ackerberg et al. (2015) production function, the firm's cost-minimization can be rearranged to show that  $\rho = (1 + \theta)\beta_K + \beta_L$  is the composite returns to labor.

## Compensation with Endogenous Amenity Creation (1/2)

**Alternative Framework:** Suppose the firm can create amenities to offer workers. Let  $Comp_{jt}$  denote the total compensation offered by the firm (inclusive of wages and amenities).

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**Alternative Framework:** Suppose the firm can create amenities to offer workers. Let  $\text{Comp}_{jt}$  denote the total compensation offered by the firm (inclusive of wages and amenities).

**Compensation Elasticity:** If we observed  $\text{Comp}_{jt}$ , we could infer the (inverse) labor supply elasticity with respect compensation:

$$\widetilde{\theta} = \frac{\mathbb{E}\left[\Delta \log \operatorname{Comp}_{jt} | \tau_{jt} = 0\right] - \mathbb{E}\left[\Delta \log \operatorname{Comp}_{jt} | 0 < \tau_{jt} \leq \overline{\tau}\right]}{\mathbb{E}\left[\Delta \ell_{jt} | \tau_{jt} = 0\right] - \mathbb{E}\left[\Delta \ell_{jt} | 0 < \tau_{jt} \leq \overline{\tau}\right]}$$

## Compensation with Endogenous Amenity Creation (1/2)

**Alternative Framework:** Suppose the firm can create amenities to offer workers. Let  $Comp_{jt}$  denote the total compensation offered by the firm (inclusive of wages and amenities).

**Compensation Elasticity:** If we observed  $\text{Comp}_{jt}$ , we could infer the (inverse) labor supply elasticity with respect compensation:

$$\widetilde{\theta} = \frac{\mathbb{E}\left[\Delta \log \operatorname{Comp}_{jt} | \tau_{jt} = 0\right] - \mathbb{E}\left[\Delta \log \operatorname{Comp}_{jt} | 0 < \tau_{jt} \leq \overline{\tau}\right]}{\mathbb{E}\left[\Delta \ell_{jt} | \tau_{jt} = 0\right] - \mathbb{E}\left[\Delta \ell_{jt} | 0 < \tau_{jt} \leq \overline{\tau}\right]}$$

**Calibration:** In practice, however, we only observe wages  $W_{jt}$ , so we use  $\Delta \log W_{jt}$  in place of  $\Delta \log \operatorname{Comp}_{jt}$ . It is useful to define

$$\lambda \equiv \frac{\mathbb{E}\left[\Delta \log \operatorname{Comp}_{jt} | \tau_{jt} = 0\right] - \mathbb{E}\left[\Delta \log \operatorname{Comp}_{jt} | 0 < \tau_{jt} \leq \overline{\tau}\right]}{\mathbb{E}\left[\Delta \log W_{jt} | \tau_{jt} = 0\right] - \mathbb{E}\left[\Delta \log W_{jt} | 0 < \tau_{jt} \leq \overline{\tau}\right]} - 1$$

 $\lambda \times 100\%$  is the percent increase in log compensation relative to log wages. In the following figure, we calibrate  $\lambda \times 100\%$  and examine how our conclusions would change if winning a procurement auction had a causal effect on amenity provision.

# Compensation with Endogenous Amenity Creation (2/2)



Elasticity estimates remain in our preferred 3-5 range.

