## Imperfect Competition and Rents in Labor and Product Markets:

The Case of the Construction Industry

Kory Kroft, Yao Luo, Magne Mogstad, Bradley Setzler
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Furthermore, we characterize rents, rent-sharing, and the incidence of government procurements in an environment with both sources of market power.

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Furthermore, we characterize rents, rent-sharing, and the incidence of government procurements in an environment with both sources of market power.

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

## This Paper (1/2)

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.
- Counterfactual changes to power in either market.


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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.


## This Paper (2/2)

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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- 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


## Related Literature

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


## Outline

1. Framework with Labor and Product Market Power
2. Double Market Power
3. Data Sources
4. Recovering Key Model Parameters
5. Estimates of Double Market Power
6. Estimates of Rents and Incidence
7. Counterfactual Labor and Product Market Power

## Model

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

The model serves several purposes:

- Distinguish supply and demand factors in both markets.
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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


## Labor Market

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

$$
\begin{equation*}
\mathcal{U}_{i t}\left(j, W_{j t}\right)=\log W_{j t}+\log G_{j t}+\eta_{i j t} \tag{1}
\end{equation*}
$$

- $G_{j t}$ is common, gives rise to vertical differentiation
- $\eta_{i j t}$ is idiosyncratic to worker $i$, gives horizontal differentiation


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Firm-specific labor supply curve:

$$
\begin{equation*}
W_{j t}=L_{j t}^{\theta} U_{j t} \quad \Longrightarrow \quad w_{j t}=\theta \ell_{j t}+u_{j t} \tag{2}
\end{equation*}
$$

where $1 / \theta$ is the LS elasticity and $U_{j t}$ 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,

$$
\begin{equation*}
Q_{j t}=\min \left\{\Omega_{j t} L_{j t}^{\beta_{L}} K_{j t}^{\beta_{K}}, \beta_{M} M_{j t}\right\} \exp \left(e_{j t}\right) \tag{3}
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Composite Production If capital market is perfect, simplifies to

$$
\begin{equation*}
Q_{j t}=\min \left\{\Phi_{j t} L_{j t}^{\rho}, \beta_{M} M_{j t}\right\} \exp \left(e_{j t}\right) \tag{4}
\end{equation*}
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where $\rho$ is composite labor returns and $\Phi_{j t}$ is composite TFP.

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Optimal intermediate inputs Defining $X_{j t} \equiv p_{M} M_{j t}$, the Leontief FOC and competitive market for intermediate inputs gives,

$$
\begin{equation*}
X_{j t}=\frac{p_{M}}{\beta_{M}} L_{j t}^{\rho} \Phi_{j t} \quad \Longrightarrow \quad x_{j t}=\kappa_{X}+\rho \ell_{j t}+\phi_{j t} \tag{5}
\end{equation*}
$$

## Firm's Problem

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

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


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Private Market Firms face downward-sloping demand, $P_{j t}^{H}=p_{H}\left(Q_{j t}^{H}\right)^{-\epsilon} \Longrightarrow R_{j t}^{H}=p_{H}\left(Q_{j t}^{H}\right)^{1-\epsilon} \Longrightarrow r_{j t}^{H}=\kappa_{R}+(1-\epsilon) q_{j t}^{H}$ where $1 / \epsilon$ is the price elasticity of demand

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Firm's Problem Given $Q_{j} \geq \bar{Q}^{G} d$ and auction outcome $D_{j}=d$,

$$
\begin{equation*}
\max _{L_{d j t}, K_{d j t}, M_{d j t}} \pi_{d j t}^{H}=R_{d j t}^{H}-W_{d j t} L_{d j t}-p_{M} M_{d j t}-p_{K} K_{d j t} \tag{7}
\end{equation*}
$$

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

## Government Market for Procurements

Opportunity Cost Given private market profits $\pi_{d j t}^{H}$ if $D_{j t}=d$,

$$
\begin{equation*}
\sigma_{u}\left(\phi_{j t}\right)=\pi_{0 j t}^{H}-\pi_{1 j t}^{H}>0, \tag{8}
\end{equation*}
$$

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

$$
\begin{equation*}
\max _{Z_{j t}} \underbrace{\left(Z_{j t}-\sigma_{u}\left(\phi_{j t}\right)\right)}_{\text {payoff }} \times \underbrace{\operatorname{Pr}\left(D_{j t}=1 \mid Z_{j t}\right)}_{\text {probability of winning }} \tag{9}
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Optimal bid Unique symmetric equilibrium is defined by,
$s_{u}\left(\phi_{j t}\right)=\sigma_{u}\left(\phi_{j t}\right) \delta_{u}\left(\phi_{j t}\right), \delta_{u}\left(\phi_{j t}\right) \equiv 1+\frac{\int_{\sigma_{u}\left(\phi_{j t}\right.}^{\bar{\sigma}}\left[1-F_{u}(\tilde{\sigma})\right]^{I-1} d \tilde{\sigma}}{\sigma_{u}\left(\phi_{j t}\right)\left[1-F_{u}\left(\sigma_{u}\left(\phi_{j t}\right)\right)\right]^{I-1}}$
where $I$ is number of bidders and $\delta$ is markup on opportunity cost

## Defining Worker Rents

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

$$
\underbrace{\mathcal{U}_{i t}\left(j, W_{j t}-V_{i t}\right)}_{\begin{array}{c}
\text { utility at current employer } \\
\text { net of worker rents }
\end{array}}=\underbrace{\max _{j^{\prime} \neq j} \mathcal{U}_{i t}\left(j^{\prime}, W_{j^{\prime} t}\right)}_{\begin{array}{c}
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Sum of Worker Rents Using our functional form to simplify,

$$
\begin{equation*}
V_{j t} \equiv \sum_{i} V_{i j t}=\frac{B_{j t}}{1+1 / \theta} \tag{10}
\end{equation*}
$$

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

## Rents and Incidence

## Incidence of Procurements

$\underbrace{V_{\Delta j t}}_{\text {Incidence }}=\underbrace{V_{1 j t}}_{\text {Rents for winners }}-\underbrace{V_{0 j t}}_{\text {Rents for losers }}=\frac{B_{1 j t}-B_{0 j t}}{1+1 / \theta}$

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\end{equation*}
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Incidence for Incumbents and New Hires

$$
\underbrace{V_{\Delta j t}}_{\text {Incidence }}=\underbrace{L_{0 j t}\left(W_{1 j t}-W_{0 j t}\right)}_{\text {Incidence for incumbents }}+\underbrace{W_{1 j t}\left(L_{1 j t}-L_{0 j t}\right)-\frac{B_{1 j t}-B_{0 j t}}{1+\theta}}_{\text {Incidence for new hires }}
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Firm Rents

$$
\begin{equation*}
\underbrace{\pi_{\Delta j t}}_{\text {Incidence on firms }}=\underbrace{\pi_{1 j t}}_{\text {Rents for winners }}-\underbrace{\pi_{0 j t}}_{\text {Rents for losers }} \tag{12}
\end{equation*}
$$

## Outline

1. Framework with Labor and Product Market Power

## 2. Double Market Power

3. Data Sources
4. Recovering Key Model Parameters
5. Estimates of Double Market Power
6. Estimates of Rents and Incidence
7. Counterfactual Labor and Product Market Power

## First-order Condition

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

$$
\max _{L_{j t}, K_{j t}, M_{j t}} \pi_{j t}=Q_{j t} P_{j t}-W_{j t} L_{j t}-p_{M} M_{j t}-p_{K} K_{j t}
$$

subject to the constraints,
Flexible prod. func.: $\quad Q_{j t}=f_{j t}\left(L_{j t}, K_{j t}, M_{j t}\right)$
Monopolistic comp.: $\quad P_{j t}=p_{H}\left(Q_{j t}\right)^{-\epsilon}$
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First-order Condition w.r.t. Labor:

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

where $\mathrm{MPL}_{j t} \equiv \frac{\partial Q_{j t}}{\partial L_{j t}}, \mathrm{MRPL}_{j t} \equiv \frac{\partial\left(P_{j t} Q_{j t}\right)}{\partial L_{j t}}$, and $\mathrm{MCL}_{j t} \equiv \frac{\partial\left(w_{j t} L_{j t}\right)}{\partial L_{j t}}$.

## Double Market Power

$$
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Markdown and Markup: Rearranging the FOC,

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

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Double markdown: Substituting into the wage expression,

$$
\begin{equation*}
W_{j t}=\underbrace{\overbrace{(1+\theta)^{-1}}^{\text {markdown }} \times \overbrace{(1-\epsilon)}^{\text {inverse markup }}}_{\text {double markdown }} \times \underbrace{P_{j t} \mathrm{MPL}_{j t}}_{\text {value of } \mathrm{MPL}} \tag{14}
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$$

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\end{equation*}
$$

Double markup: Substituting into the price expression,

$$
\begin{equation*}
P_{j t}=\underbrace{\overbrace{(1-\epsilon)^{-1}}^{\text {markup }} \times \overbrace{(1+\theta)}^{\text {inverse markdown }}}_{\text {double markup }} \times \underbrace{\frac{W_{j t}}{M_{j L_{j t}}}}_{\text {prod.-adjusted wage }} \tag{15}
\end{equation*}
$$

## Single Markdown

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


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

## Double Markdown

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


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

## Single Markup

$\frac{\mathrm{MCL}}{\mathrm{MPL}}=(1+\theta) \times \frac{\text { Wage }}{\mathrm{MPL}}, \quad \frac{\mathrm{MRPL}}{\mathrm{MPL}}=(1-\epsilon) \times$ Price


## Double Markup

$\frac{\mathrm{MCL}}{\mathrm{MPL}}=(1+\theta) \times \frac{\text { Wage }}{\mathrm{MPL}}, \quad \frac{\mathrm{MRPL}}{\mathrm{MPL}}=(1-\epsilon) \times$ Price


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## Data Sources (1/2)

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
- excludes durables, overhead, labor 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
- No evidence of collusion ${ }_{\text {test results }}$


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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


## Descriptive Statistics for the Linked Sample

|  |  |  | Share of the <br> Construction Sector |
| :--- | :---: | :---: | :---: |
| Number of Firms | 7,876 | $0.9 \%$ |  |
| Somple Size |  | $11.7 \%$ |  |
|  | 46 | Share of the |  |
|  | Value Per Firm |  | Sharer Firm |
| ( millions $)$ | Mean of the Log | Construction Sector (\%) |  |
| Sales | 19.927 | 15.061 | $12.1 \%$ |
| EBITD | 9.159 | 14.075 | $9.6 \%$ |
| Intermediate Costs | 14.661 | 14.719 | $12.4 \%$ |
| Wage bill | 2.737 | 13.549 | $13.4 \%$ |

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


## Outline

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## Recovering Key Model Parameters

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)


## Labor Supply Elasticity (1/4)

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

Model: Log inverse labor supply curve is,

$$
\begin{equation*}
w_{j t}=\theta \ell_{j t}+u_{j t}=\theta \ell_{j t}+\psi_{j}+\xi_{t}+\nu_{j t} \tag{16}
\end{equation*}
$$

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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)

$$
\begin{equation*}
\Delta w_{j t}=\theta \Delta \ell_{j t}+\Delta \xi_{t}+\Delta \nu_{j t} \tag{17}
\end{equation*}
$$

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

## Labor Supply Elasticity (2/4)

Difference-in-differences. Consider the DiD estimator,

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

DiD Identification. If $D_{j t} \perp \Delta \nu_{j t}$, then $\theta_{\mathrm{DiD}}=\theta$.
Possible justification: $\Delta \nu_{j t}$ 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 $\Delta \nu_{j t}$ ?


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- Time delay assumptions are standard for identification in empirical IO (Ackerberg et al 2015; Gandhi et al 2020).

Important to emphasize what is not restricted by this assumption:

- no additional restrictions on joint dist of $\left(Z_{j t}, D_{j t}, \phi_{j t}, \psi_{j}, \xi_{t}\right)$.
- allows $\operatorname{Var}\left(\Delta \nu_{j t}\right)>0$, clear step forward in this literature.
- allows $\Delta \ell_{j t}, \Delta w_{j t}$ to depend on $\Delta \nu_{j t}$, no time delay here.


## Sequence of Events within Time Period $t$



## Labor Supply Elasticity (3/4)

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

$$
\theta_{R D D}(\bar{\tau}) \equiv \frac{\mathbb{E}\left[\Delta w_{j t} \mid \tau_{j t}=0\right]-\mathbb{E}\left[\Delta w_{j t} \mid 0<\tau_{j t} \leq \bar{\tau}\right]}{\mathbb{E}\left[\Delta \ell_{j t} \mid \tau_{j t}=0\right]-\mathbb{E}\left[\Delta \ell_{j t} \mid 0<\tau_{j t} \leq \bar{\tau}\right]}
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where $\bar{\tau}$ is the maximum distance from winner-loser threshold.

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$$

where $\bar{\tau}$ is the maximum distance from winner-loser threshold.
Limit around the discontinuity:

$$
\lim _{\bar{\tau} \rightarrow 0^{+}} \theta_{R D D}(\bar{\tau})=\theta+\lim _{\bar{\tau} \rightarrow 0^{+}} \underbrace{\frac{\mathbb{E}\left[\Delta \nu_{j t} \mid \tau_{j t}=0\right]-\mathbb{E}\left[\Delta \nu_{j t} \mid 0<\tau_{j t} \leq \bar{\tau}\right]}{\mathbb{E}\left[\Delta \ell_{j t} \mid \tau_{j t}=0\right]-\mathbb{E}\left[\Delta \ell_{j t} \mid 0<\tau_{j t} \leq \bar{\tau}\right]}}_{\text {winning due to amenity shock }}
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$$

RDD Identification: $D_{j t} \perp \Delta \nu_{j t} \mid\left(Z_{j t}\right) \Longrightarrow \lim _{\bar{\tau} \rightarrow 0^{+}} \theta_{R D D}(\bar{\tau})=\theta$.

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


## Sequence of Events within Time Period $t$



## Labor Supply Elasticity (4/4)

Results using multiplicity of approaches:

- DiD Estimator: $1 / \theta=4.1$, markdown $=0.80$
- RDD Estimator: $1 / \theta=3.5$, markdown $=0.78$
- Estimator of Lamadon Mogstad Setzler (2022) panel-IV for full construction sample: $1 / \theta=4.0$, markdown $=0.80$


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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 $1 / \theta$ :


## Robustness: Wage Markdown Specifications

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


## Technology and Product Demand Elasticities (1/2)

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

$$
\begin{equation*}
x_{j t}=\kappa x+\rho \ell_{j t}+\phi_{j t} \tag{18}
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Challenge: $\log$ TFP $\phi$ is a determinant of both $\log \operatorname{labor} \ell$ and $\log$ intermediate input expenditures $x$.

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Recovering amenities: Given the estimate of the labor supply elasticity $\widehat{\theta}$, we can recover amenities as $\widehat{u}_{j t}=w_{j t}-\widehat{\theta} / j t$.

Identification: Controlling for $\left(Z_{j t}, u_{j t}\right)$ controls for $\phi_{j t}$ :

$$
\begin{equation*}
\frac{\operatorname{Cov}\left[x_{j t}, \ell_{j t} \mid \widehat{u}_{j t}, Z_{j t}\right]}{\operatorname{Var}\left[\ell_{j t} \mid \widehat{u}_{j t}, Z_{j t}\right]}=\frac{\operatorname{Cov}\left[x_{j t}, \ell_{j t} \mid \widehat{u}_{j t}, \phi_{j t}\right]}{\operatorname{Var}\left[\ell_{j t} \mid \hat{u}_{j t}, \phi_{j t}\right]}=\rho \tag{19}
\end{equation*}
$$

## Sequence of Events within Time Period $t$



## 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 $(\theta>0)$ :

$$
\overbrace{(1-\epsilon)}^{\text {markup }^{-1}}=\frac{\overbrace{(1+\theta)}^{\text {markdown }^{-1}}}{\beta_{L}} \frac{B_{j t}}{R_{j t}}+\frac{X_{j t}}{R_{j t}}=\overbrace{(1+\theta)}^{\text {markdown }^{-1}} \frac{s_{L}}{\beta_{L}}+s_{M}
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$$

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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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).

- 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.


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## Estimates: Double Markdown

$W_{j t}=\overbrace{(1+\theta)^{-1}}^{\text {markdown }} \times \mathrm{MRPL}_{j t}$

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)


## Estimates: Double Markdown

$$
W_{j t}=\overbrace{(1+\theta)^{-1}}^{\text {markdown }} \times \mathrm{MRPL}_{j t}=\overbrace{\underbrace{\text { markdown }}_{\text {double markdown }} \times \overbrace{(1-\epsilon)}^{\text {inverse markup }} \times \underbrace{P_{j t} \mathrm{MPL}_{j t}}_{\text {Value of } \mathrm{MPL}}}^{\overbrace{1-\theta)^{-1}} \times \overbrace{(1-\infty}}
$$

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

But MRPL depends on product market power

- Special case w/o intermediate inputs: MRPL equals inverse markup times the value of the marginal product of labor $(M P L)$ at fixed prices, so higher markup $\Longrightarrow$ lower wage


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

But MRPL depends on product market power

- Special case w/o intermediate inputs: MRPL equals inverse markup times the value of the marginal product of labor $(M P L)$ at fixed prices, so higher markup $\Longrightarrow$ 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

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

A natural measure of monopoly power is the markup

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


## Estimates: Double Markup

A natural measure of monopoly power is the markup

- 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 $\Longrightarrow$ Higher price


## Estimates: Double Markup

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\text { prod-adjusted } \\
\text { wage }
\end{array}}
$$

A natural measure of monopoly power is the markup

- 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 $\Longrightarrow$ 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


## Summary: Estimates of Double Market Power

| Panel A. | Components of the Double Markdown of the Wage |  |
| :--- | :---: | :---: | :---: |

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## Estimates of Baseline Rents

| Actual | Counterf. | Difference |  |
| ---: | ---: | ---: | ---: |
|  |  | $d=0$ |  |

Labor market

| $L_{j t}$ | Employment (\#) | $\mathbf{2 4 . 7}$ | 12.8 | 11.9 | $92.7 \%$ |
| :--- | :--- | ---: | ---: | ---: | ---: |
| $W_{j t}$ | Wage $(\$ 1 \mathrm{~K})$ | $\mathbf{5 9 . 1}$ | 50.4 | 8.8 | $17.4 \%$ |
| $B_{j t}$ | Wage bill $(\$ 1 \mathrm{~K})$ | $\mathbf{1 , 4 5 9 . 6}$ | 645.2 | 814.4 | $126.2 \%$ |

## Rents

| $V_{j t}$ | Worker rents $(\$ 1 \mathrm{~K} / L)$ | $\mathbf{1 1 . 6}$ | 5.1 | 6.5 | $126.2 \%$ |
| :--- | :--- | :--- | ---: | ---: | ---: |
| $\pi_{j t}$ | Firm profits $(\$ 1 \mathrm{~K} / L)$ | $\mathbf{4 3 . 1}$ | 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.

## Estimates of Marginal Rents from Procurements

|  | Actual$d=1$ | Counterf.$d=0$ | Difference |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  |  | Level | Relative |
| Labor market |  |  |  |  |
| $L_{j t}$ Employment (\#) | 24.7 | 12.8 | 11.9 | 92.7\% |
| $W_{j t} \quad$ Wage (\$1K) | 59.1 | 50.4 | 8.8 | 17.4\% |
| $B_{j t} \quad$ Wage bill (\$1K) | 1,459.6 | 645.2 | 814.4 | 126.2\% |
| Rents |  |  |  |  |
| $V_{j t} \quad$ Worker rents (\$1K/L) | 11.6 | 5.1 | 6.5 | 126.2\% |
| $\pi_{j t} \quad$ Firm profits $(\$ 1 \mathrm{~K} / L)$ | 43.1 | 33.4 | 9.6 | 28.7\% |

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$d=1$ | Counterf.$d=0$ | Difference |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  |  | Level | Relative |
| Input Expenditures |  |  |  |  |
| $B_{j t} \quad$ Wage bill ( $\$ 1 \mathrm{~K}$ ) | 1,459.6 | 645.2 | 814.4 | 126.2\% |
| $X_{j t} \quad$ Intermediate inputs (\$1K) | 4,715.1 | 2,308.6 | 2,406.5 | 104.2\% |
| $p_{K} K_{j t} \quad$ Capital rentals ( $\$ 1 \mathrm{~K}$ ) | 1,724.7 | 762.4 | 962.3 | 126.2\% |
| Total production |  |  |  |  |
| $Q_{j t} \quad$ Output (\#) | 38.3 | 18.7 | 19.5 | 104.2\% |
| $R_{j t} \quad$ Revenue ( $\$ 1 \mathrm{~K}$ ) | 8,962.1 | 4,541.6 | 4,420.5 | 97.3\% |
| Private production |  |  |  |  |
| $Q_{j t}^{H} \quad$ Output (\#) | 13.7 | 18.7 | -5.1 | -27.0\% |
| $R_{j t}^{H} \quad$ 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.

## Outline

1. Framework with Labor and Product Market Power
2. Double Market Power
3. Data Sources
4. Recovering Key Model Parameters
5. Estimates of Double Market Power
6. Estimates of Rents and Incidence
7. Counterfactual Labor and Product Market Power

## Theory: Impacts of Labor Market Power (1/3)

Effect of interest: Increase labor market power, all else equal.

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Solution: When increasing $\theta$, also adjust the amenity $\left(U_{j t}\right)$ 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 $\Longrightarrow$ flat MRPL curve
- More labor market power $\Longrightarrow$ steeper MCL (red) $\Longrightarrow$ less employment, greater wage markdown


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



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


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



Alternate Labor Supply Elasticity $1 / \theta$

- Wage - Output $\otimes$ Profit
- Labor + Capital $*$ Price

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 $\downarrow 15 \%$, wages $\downarrow 9 \%$, profits $\uparrow 1 \% \Longrightarrow$ 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.

## Falsification using Pre-period

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


$\square$ BeforeAfter

## Bandwidths in the RDD estimator

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


## Stayers and Tenure Samples (1/2)

Labor supply elasticity by stayer spell:


## Stayers and Tenure Samples (2/2)

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)


## 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) Back


## 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 |  |  | 0.081 |  |
|  | $(0.019)$ |  |  | $(0.023)$ |  |
| Log Earnings per Worker: | 0.020 | 0.023 |  | 0.023 | 0.027 |
|  | $(0.008)$ | $(0.006)$ |  | $(0.010)$ | $(0.007)$ |
| 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 |

## Prevailing Wage: Effects of Davis-Bacon Repeals

| Total | Wage | Non-wage | Share Non-wage |
| :---: | :---: | :---: | :---: |
| Compensation | Compensation | Fringe Benefits | 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 and Violations

|  | OSHA Investigations |  | OSHA Violations |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Probability | Count | Probability | Count |
| Observed Average: | Occurrence |  |  |  |
|  | 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) |

## Measurement Error Orthogonality

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

$$
r_{j t}=\kappa_{R}+(1-\epsilon) x_{j t}+(1-\epsilon) e_{j t}
$$

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

$$
\operatorname{Cov}\left(x_{j t}, e_{j t}\right)=0
$$

This orthogonality condition is satisfied under the assumption by Ackerberg et al. (2015) that the firm has no information about $e_{j t}$ at the time inputs are chosen:
"The $\left[e_{j t}\right]$ represent shocks to production or productivity that are not observable (or predictable) by firms before making their input decisions at $t \ldots\left[e_{j t}\right]$ can also represent (potentially serially correlated) measurement error in the output variable." Ackerberg et al. (2015, ECMA)

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

## Composite Production Function

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.
- 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 ${ }_{j t}$ denote the total compensation offered by the firm (inclusive of wages and amenities).

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

$$
\widetilde{\theta}=\frac{\mathbb{E}\left[\Delta \log \operatorname{Comp}_{j t} \mid \tau_{j t}=0\right]-\mathbb{E}\left[\Delta \log \operatorname{Comp}_{j t} \mid 0<\tau_{j t} \leq \bar{\tau}\right]}{\mathbb{E}\left[\Delta \ell_{j t} \mid \tau_{j t}=0\right]-\mathbb{E}\left[\Delta \ell_{j t} \mid 0<\tau_{j t} \leq \bar{\tau}\right]}
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$$

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

$$
\lambda \equiv \frac{\mathbb{E}\left[\Delta \log \operatorname{Comp}_{j t} \mid \tau_{j t}=0\right]-\mathbb{E}\left[\Delta \log \text { Comp }_{j t} \mid 0<\tau_{j t} \leq \bar{\tau}\right]}{\mathbb{E}\left[\Delta \log W_{j t} \mid \tau_{j t}=0\right]-\mathbb{E}\left[\Delta \log W_{j t} \mid 0<\tau_{j t} \leq \bar{\tau}\right]}-1
$$

$\lambda \times 100 \%$ 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)



Percent Increase in Compensation relative to Wages
Estimator — DiD -- RDD

Elasticity estimates remain in our preferred 3-5 range.

