Measuring Imperfect Competition in Product and Labor Markets. An Empirical Analysis.

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Labor Lunch Seminar

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Introduction

- The question of whether markets are "imperfectly competitive" has a long tradition in Economics
- IO and trade: markups can account for macroeconomic secular trends (Hall, 1988; DeLoecker and Eeckhout, 2017)
  - $\downarrow$ in labor share
  - slowdown in aggregate output
- Labor: monopsony could rationalize differences in wages of similar workers across firms (Card et al., 2016; Manning, 2003)
- Many recent papers estimating **markups**; fewer estimating **markdowns**
  - Moreover, the standard method to estimate markups in the trade and IO literature assumes that labor markets are perfectly competitive
- More generally, measurement of market power of firms in output and input markets has typically been done separately for each market

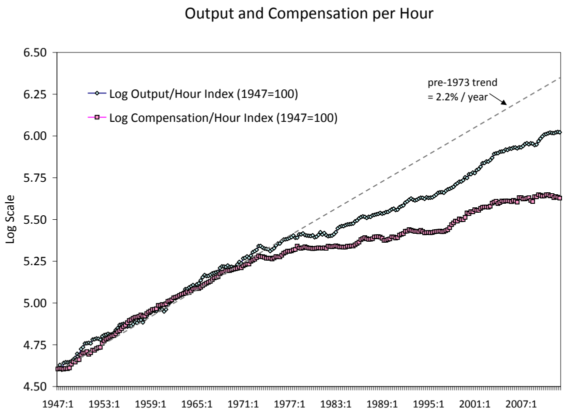
This paper

- We fill this gap by approaching this question from a joint perspective (product and labor markets)
- We combine classic ideas from the theory of monopoly and monopsony (Robinson, 1933) with recent methods from IO and labor economics
- We derive an equation of **combined market power** in both markets similar to DeLoecker and Warzynski (AER 2012)
- We propose different methods to separate this measure into output vs labor market power
  - We developed 4 different methods (today we focus on one)
- We use a rich panel of Colombian manufacturing plants for 2002-2012

Why do we care

- Markups are a key element in drawing a picture of the competitiveness of an industry
- Markdowns help identify foci of frictions that give employers monopsony power in labor markets
- Labor market and product market policies are very different
  - Target policies more effectively (antitrust, employment protection, etc.)
- Market power enables a better understanding of market outcomes
  - **Wage Inequality and Labor Share**
    Gains in productivity and declining labor share
  - **TFP and Resource Misallocation**
    Market power is a source of production misallocation
    $P_i/MR_i = wedge_i^P$ and/or $W_i/MRPL_i = wedge_i^L$
    The ability of firms to set W_i and P_i is disciplined by market competition

Wage Inequality



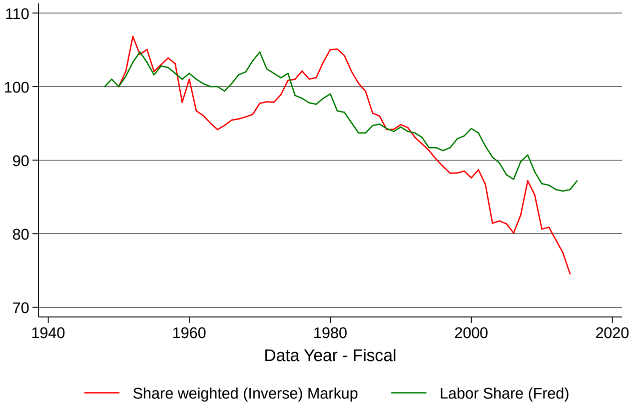
Source: D. Card's lecture 7 (250A) based on Fleck, Glaser and Sprague (2011)

"Ignoring the existence of employer market power could lead to incorrect conclusions on the driving force behind changes in wage inequality" (Manning, 2003)

Measuring the elasticity of LS to the firm *"turns out to be substantively important for understanding the sources for wage inequality"* (Card et al., 2016)

Labor Share

Evolution of the labor share and inverse of the markup in the U.S.



Source: De Loecker and Eeckhout (2017)

THE WALL STREET JOURNAL.

OPINION | COMMENTARY

Why Aren't Americans Getting Raises? Blame the Monopsony

Instead of bidding up wages, firms collude to keep pay low and enforce noncompete clauses.

PHOTO: GETTY IMAGES

By **JASON FURMAN** and **ALAN B. KRUEGER**
Nov. 3, 2016 7:33 p.m. ET

Pat Cason-Merenda had worked as a registered nurse at the Detroit Medical Center for four years, unaware that she was being underpaid. That changed when a class-action

Date: November 3, 2016

An old idea: Exploitation Rate

In **The Economics of Imperfect Competition**, Joan Robinson states:

"It is commonly said that exploitation (the payment to labour of less than its proper wage) arises from the unequal bargaining strength of employers and employed, and that it can be remedied by the action of trade unions, or of the State, which places the workers upon an equality in bargaining with the employers. Bargaining strength, as we shall define, is important in many cases, but the fundamental cause of exploitation will be found to be the lack of the perfect elasticity in the supply of labour or in the demand for commodities."

J. Robinson, 1933, p. 281

Outline of the talk

- Model (Cost minimizing firm and upward-sloping labor supply)
- Empirical strategy
    - Combined measure of market power
    - Source of market power (labor and products)
- Data
- Results
    - Production function estimation
    - Market power estimation
    - Labor supply elasticity
    - Markups, Markdowns, and plant characteristics
- Conclusion and next steps

Firm's problem

Suppose there is a cost-minimizing firm free of any adjustment cost using the following production technology:

$$Q_{it} = Q_{it}(X_{it}^1, ..., X_{it}^{V-1}, L_{it}, K_{it}, \omega_{it})$$

- X_{it}^v: variable input v (V variable inputs)
- L_{it}: labor
- K_{it}: capital stock
- ω_{it}: productivity measure

The associated lagrangian $\mathcal{L}(X_{it}^1, ..., X_{it}^{V-1}, L_{it}, K_{it}, \omega_{it})$ is:

$$\sum_{v=1}^{V-1} P_{it}^v X_{it}^v + w_{it}(L_{it})L_{it} + r_{it}K_{it} + \lambda_{it}(Q_{it} - Q_{it}(\cdot))$$

Firm's problem

FOC w.r.t. labor (or any other variable input):

$$\underbrace{w_{it}\left(1+\frac{1}{\epsilon_{it}^{Lw}}\right)}_{1/MD_{it}} = \lambda_{it}\frac{\partial Q_{it}(\cdot)}{\partial L_{it}}$$

Rearranging terms and using $\lambda_{it} = P_{it}/MU_{it}$

$$\frac{w_{it}L_{it}}{MD_{it}} = \frac{P_{it}Q_{it}}{MU_{it}}\underbrace{\left(\frac{\partial Q_{it}(\cdot)}{\partial L_{it}}\frac{L_{it}}{Q_{it}}\right)}_{\theta_{it}} \rightarrow \frac{MU_{it}}{MD_{it}} = \theta_{it}\underbrace{\frac{P_{it}Q_{it}}{w_{it}L_{it}}}_{1/\alpha_{it}^{L}}$$

Combined measure of market power is

$$\boxed{MP_{it} \equiv \frac{MU_{it}}{MD_{it}} = \frac{\theta_{it}}{\alpha_{it}^{L}}}$$

MAIN EQUATION

Where

$$MU_{it} \equiv \frac{p_{it}}{mc_{it}} = \frac{|\epsilon_{it}^{p}|}{|\epsilon_{it}^{p}|-1} \qquad MD_{it} \equiv \frac{w_{it}}{MRPL_{it}} = \frac{\epsilon_{it}^{Lw}}{\epsilon_{it}^{Lw}+1}$$

Empirical strategy

[1] Combined market power: can be deduced as soon as α_{it}^{v} and θ_{it}^{v} are pinned down

- Estimate θ_{it}^{v} using standard production function estimation techniques from IO literature
- Use the main equation to compute combined market power MP_{it}

[2] Source of market power: either ϵ_{it}^{p} or ϵ_{it}^{Lw} need to be estimated as well

- Estimate the elasticity of the labor supply to the individual firm ϵ_{it}^{Lw}
- Pin down markdowns MD_{it}
- Then back out markups MU_{it} using our main equation and **[1]**

Alternatives (in progress): note our model is over-identified

- θ_{it}^{v} could be estimated with a reduced-form labor approach (scale effect)
- ϵ_{it}^{p} could be estimated with a classic BLP framework
- Different instruments to identify ϵ_{it}^{Lw}

[1] Combined market power

- α_{it}^L: wage bill as a share of value added is directly observed in the data
- θ_{it}^L: output elasticity of labor estimated using "proxy methods" of Ackerberg, Caves, and Frazer (2015)
- We consider Cobb-Douglas and Translog value-added specifications:

$$\begin{aligned} y_{it} = & \quad \beta_l l_{it} + \beta_k k_{it} + \omega_{it} + \eta_{it} \\ \implies & \quad \theta_{it}^L = \beta_l \\ y_{it} = & \quad \beta_l l_{it} + \beta_{ll} l_{it}^2 + \beta_k k_{it} + \beta_{kk} k_{it}^2 + \beta_{lk} l_{it} k_{it} + \omega_{it} + \eta_{it} \\ \implies & \quad \theta_{it}^L = \beta_l + 2\beta_{ll} l_{it} + \beta_{lk} k_{it} \end{aligned}$$

- We estimate these functions by 2-digit industries
- Compute market power as: $MP_{it} = \theta_{it}^L / \alpha_{it}^L$

[1] Digression: PF estimation (ACF, ECMA 2015)

- **(1)** Invert materials' demand function to control for unobserved productivity: $m_{it} = f_t(k_{it}, l_{it}, \omega_{it})$. Then, $\omega_{it} = f_t^{-1}(k_{it}, l_{it}, m_{it})$

$$
\begin{aligned}
y_{it} &= \beta_l l_{it} + \beta_k k_{it} + f_t^{-1}(k_{it}, l_{it}, m_{it}) + \eta_{it} \\
y_{it} &= \Phi_t(k_{it}, l_{it}, m_{it}) + \eta_{it}
\end{aligned}
$$

- **(2)** Productivity follows a Markov process $p(\omega_{it+1}|\omega_{it})$:

$$
\begin{aligned}
\omega_{it} &= E(\omega_{it}|\omega_{it-1}) + \xi_{it} = g(\omega_{it-1}) + \xi_{it} \\
\omega_{it} &= \gamma_1\omega_{it-1} + \gamma_2\omega_{it-1}^2 + \gamma_3\omega_{it-1}^3 + \xi_{it}
\end{aligned}
$$

$$
\begin{aligned}
\xi_{it}(\beta) &= (\phi_{it} - \beta_l l_{it} - \beta_k k_{it}) - \gamma_1(\phi_{it-1} - \beta_l l_{it-1} - \beta_k k_{it-1}) \\
&- \gamma_2(\phi_{it-1} - \beta_l l_{it-1} - \beta_k k_{it-1})^2 \\
&- \gamma_3(\phi_{it-1} - \beta_l l_{it-1} - \beta_k k_{it-1})^3
\end{aligned}
$$

- Solve with NLGMM the following moment conditions:

$$
E\left[\xi_{it}(\beta)\begin{pmatrix} l_{it-1} \\ k_{it} \end{pmatrix}\right] = 0
$$

[2] Labor supply elasticity and markdown

- We pin down markdowns by estimating the elasticity of the labor supply to the individual firm:

$$MD_{it} = \epsilon_{it}^{Lw} / (\epsilon_{it}^{Lw} + 1)$$

- Wage-posting model (based on Card et al. 2016): assumes that for any worker n, the indirect utility of working at firm i is given by:

$$U_{nit} = x_{it}\gamma + \beta w_{it} + \psi_i + e_{it} + \epsilon_{nit}$$

- Assuming that ϵ_{nit} are independent draws from a type I EV distribution, the labor share working at firm i is:

$$s_{it} = \frac{\exp(x_{it}\gamma + \beta w_{it} + \psi_i + e_{it})}{\sum_k \exp(x_{kt}\gamma + \beta w_{kt} + \psi_k + e_{kt})}$$

- Taking logs, we arrive to the estimating equation:

$$\ln s_{it} = x_{it}\gamma + \beta w_{it} + \psi_i + \gamma_{m(i,t)} + e_{it}$$

- Markets are defined as region-industry-year dummies: $\gamma_{m(i,t)}$

[2] Labor supply elasticity and markdown

- The **labor supply elasticity** is:

$$\frac{\partial s_{it}}{\partial w_{it}} \frac{w_{it}}{s_{it}} \equiv \epsilon_{it}^{Lw} = \beta w_{it}(1 - s_{it})$$

- **OLS** leads to a biased β because the wage that firm i posts is correlated with the error term (e.g. firms with better amenities)

- We rely on **IV regressions** and instrument w_{it} with materials, electricity, and number of inputs used in the production process

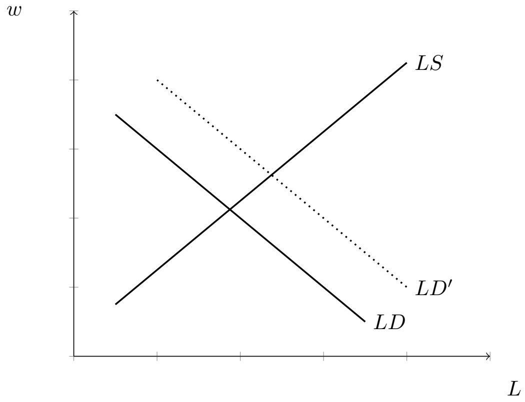
- Same proxy for productivity shocks as the production function literature

- **Exclusion restriction**: after controlling for firm fixed effects
    - workers don't supply labor to firms based on the use inputs
    - labor supply shocks do not affect use of intermediate inputs

- Can be estimated for different types of workers (e.g. by skill group)

Identification of labor supply

TFP shocks $\longrightarrow \uparrow$ intermediate inputs $\longrightarrow \uparrow$ labor demand



Data: Colombia's EAM panel

- We use plant-level data from Colombia's Encuesta Anual Manufacturera (EAM) from 2002 to 2012
- The EAM is a uniquely rich census of manufacturing plants with +10 workers that provides information on:
  - Sales and Value added
  - Input use: Quantity vs Costs
  - Output produced: Quantity vs Prices
  - Employment and earnings: Blue collar and white collar
  - Exports and Imports
- We observe approximately 5000-7000 plants each year producing 4,000 distinct eight-digit product codes.
- Manufacturing represents 20% of total employment in Colombia.
- This data has been used by other papers as well: Fieler et al. (2016); Kuegler & Verhoogen (2012); Eslava et al. (2004).

Summary statistics

Variable	Mean	Std. Dev.	10th Perc.	50th Perc.	90th Perc	N
Labor force	74.74	135.58	8	27	178	80329
Skilled	26.39	51.29	2	8	66	80329
Unskilled	46.59	87.73	4	16	43	80329
Share Skilled	37.09%	0.22	11.76%	33.33%	68.00%	80329
Wage per worker	16.73	9.89	8.53	14.01	27.45	80329
Wage per skilled worker	23.24	19.36	7.48	18.39	44.52	80329
Wage per unskilled worker	13.44	11.06	8.14	11.77	19.35	80329
Materials (% Revenue)	55.07%	0.19	29.78%	54.96%	81.33%	80329
Electricity (% Revenue)	2.18%	0.032	0.60%	1.22%	4.91%	80329
Capital (% Revenue)	42.41%	3.53	4.60%	21.61%	78.53%	80329
Revenue (million pesos)	13106	37437	299	1728	28888	80329
VA per worker (million pesos)	52.14	136.64	9.56	27.99	97.27	80329
Single product	32.87%	0.47	0	0	1	80329
Number of products	3.56	3.53	1.00	2.00	8.00	80329
Importer	0.18	0.39	0.00	0.00	1.00	80329
Exporter	0.24	0.43	0.00	0.00	1.00	80329

Industry composition

	ISIC (1)	N (2)	(%) (3)	Labor share (4)	Wagebill /VA (5)
Food products and Beverages	15	15743	19.60%	22.55%	0.422
Textiles	17	3701	4.61%	7.00%	0.517
Wearing apparel, dressing and dyeing of fur	18	8285	10.31%	10.84%	0.527
Leather and leather products	19	3459	4.31%	3.21%	0.496
Wood, cork, and straw products	20	1537	1.91%	0.92%	0.509
Paper and paper products	21	2119	2.64%	3.28%	0.445
Publishing, printing and media	22	5310	6.61%	4.81%	0.482
Coke and refined petroleum products	23	452	0.56%	0.42%	0.296
Chemicals	24	6849	8.53%	10.31%	0.394
Rubber and plastic	25	6565	8.17%	7.88%	0.479
Non-metallic mineral products	26	4007	4.99%	5.68%	0.453
Basic metals	27	1567	1.95%	2.40%	0.477
Fabricated metal products	28	5442	6.77%	4.81%	0.499
Machinery and equipment	29	4799	5.97%	4.45%	0.515
Office, accounting and computing machinery	30	34	0.04%	0.02%	0.413
Electrical machinery and apparatus	31	1663	2.07%	2.23%	0.475
Radio, TV and communication equipment	32	185	0.23%	0.20%	0.542
Medical, precision and optical instruments	33	664	0.83%	0.56%	0.496
Motor vehicles, trailers and semi-trailers	34	1865	2.32%	2.37%	0.499
Other transport equipment	35	501	0.62%	0.87%	0.502
Furniture	36	5526	6.88%	4.93%	0.509
Total		80329		100%	0.471

Outline

- Model (Cost minimizing firm and upward-sloping labor supply)
- Empirical strategy
  - Combined measure of market power
  - Source of market power
- Data
- **Results**
  - **[1] Production function estimation**
  - **[2] Market power estimation**
  - **[3] Labor supply elasticity**
  - **[4] Markups, Markdowns, and plant characteristics**
- Conclusion and next steps

[1] Production function estimation

Table: Output elasticities-Varying coefficients

	OLS	FE	ACF
	(1)	(2)	(3)
Panel A: Cobb-Douglas			
Labor	0.859	0.622	0.900
	(0.012)	(0.033)	(0.105)
Capital	0.203	0.073	0.200
	(0.009)	(0.023)	(0.120)
Observations	71,928	71,928	56,146
RTS	1.062	0.695	1.100
Panel B: Translog			
Labor	0.848	0.629	0.904
	(0.117)	(0.068)	(0.138)
Capital	0.209	0.075	0.212
	(0.105)	(0.032)	(0.089)
Observations	71,928	71,928	56,146
Average RTS	1.057	0.704	1.117

Note: Elasticities are computed by industries and then averaged.

[2] Market power estimation (MP=MU/MD)

Table: Market Power - Summary Statistics

	Mean	St. Dev.	p25	p50	p75
Market Power (Cobb-Douglas)	2.24	0.78	1.73	2.02	2.50
Market Power (Translog)	2.20	0.70	1.74	2.03	2.46
Correlation			0.938		

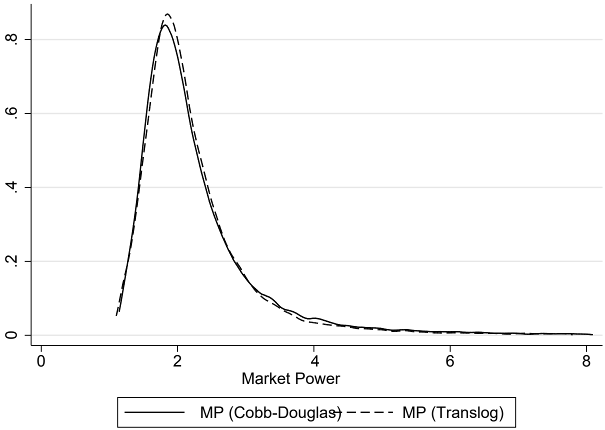
Note: Outliers above and below the 2nd and 98th percentiles are trimmed.

Compared to other papers using the same approach...

- DLW (2012) find median MP 1.17-1.28 for Slovenian manufacturing firms
- DL et al (2016) find mean and median markups of 2.70 and 1.34 for Indian manufacturing firms
- DL-Eeckhout (2017) find mean markup of 1.67 for U.S. firms in 2014
- Lamorgese et al (2014) find mean markups by sector between 1.32 and 1.88 for Chilean firms
- Substantial variation across sectors and across firms within sectors

[2] Market power estimation

Figure: Distribution of market power



The results are very similar for the CD and TL specifications.
We stick to CD from now onwards

[3] Labor supply elasticity

Table: Pool of workers

	First Stage		OLS		IV	
	(1)	(2)	(3)	(4)	(5)	(6)
Dep variable	Wage		Labor Market Share		Labor Market Share	
Panel A: Instrument Materials (log)						
Materials (log)	2.1563***	0.3374***				
	0.0645	0.038				
Wage			0.0555***	-0.0128***	0.2007***	0.5563***
			0.000	0.000	0.001	0.006
F statistic-FS	20592	1820.44				
N	77989	77989	77989	77989	77989	77989
Panel B: Instrument Electricity (log)						
Electricity (log)	2.4255***	0.3813***				
	0.0599	0.0512				
Wage			-	-	0.2248***	0.5746***
			-	-	0.0057	0.0789
F statistic-FS	1626.64	57.76				
N	79503	79503	-	-	79503	79503
Panel C: Number of Inputs (log)						
Number of inputs	1.7970***	0.0978				
	0.1197	0.0952				
Wage			-	-	0.2569***	12.312
			-	-	0.0148	12.070
F statistic-FS	225.368	1.05504				
N	78000	78000	-	-	78000	78000
Market fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	No	Yes	No	Yes	No	Yes

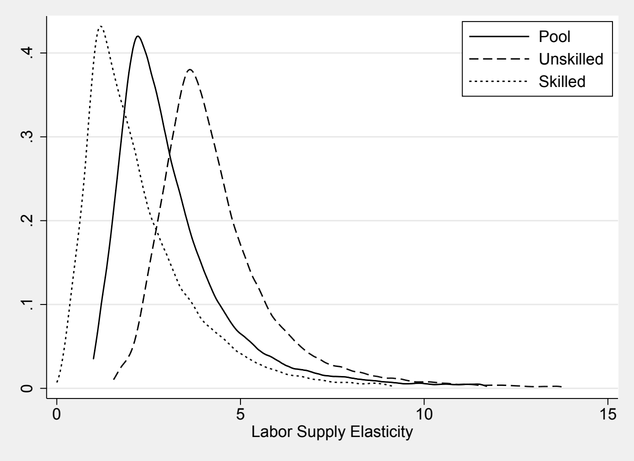
[3] Labor supply elasticity

- **First stage**: strong, positive, and similar in magnitude
- **Second stage**: the three IV estimates give a positive and significant effect
- **Heterogeneity of labor supply**: separate into skilled and unskilled workers
  Surprisingly, much larger labor supply coefficients for unskilled workers
- We focus the attention to the LS estimates instrumented with materials
- We use $\hat{\beta}$ to compute labor supply elasticities to the individual firm

$$\frac{\partial s_{it}}{\partial w_{it}} \frac{w_{it}}{s_{it}} \equiv \hat{\epsilon}_{it}^{Lw} = \hat{\beta} w_{it}(1 - s_{it})$$

[3] Labor supply elasticity

Figure: Distribution of labor supply elasticity to the individual firm



Note: median elasticity (market FE) of 2.74 (pool), 1.86 (skilled), 4.00 (unskilled)

[3] Labor supply elasticity

- Pool of workers: median elast of 2.74 (market FE) and 7.62 (firm FE)
- Relatively little variation across industries
- Labor supply relatively more elastic for unskilled workers in manufacturing
    - One would expect frictions to affect strongly unskilled workers
    - Minimum wage generates perfectly elastic labor supply curves in some range of workers' wages and it is typically more binding for unskilled workers
      Link: Formally
    - Operating mechanisms are subject of future research
- Our estimates are an order of magnitude higher than other papers but still reject the assumption of perfect competition in labor markets
- We next compute markdowns as $MD_{it} = \epsilon_{it}^{Lw}/(\epsilon_{it}^{Lw} + 1)$ and using our main equation we back out markups as $MU_{it} = MP_{it} \times MD_{it}$

[4] Markups and Markdowns

Table: Imperfect Competition in Product and Labor Markets - Summary Statistics

	(1) MP	(2) MU	(3) MD	(4) MD-Unskilled	(5) MD-Skilled
All industries	**2.02**	**1.78**	**0.89**	**0.90**	**0.77**
Food products and Beverages	2.09	1.83	0.89	0.91	0.76
Textiles	1.82	1.62	0.89	0.91	0.80
Apparel	1.96	1.68	0.86	0.89	0.73
Leather and leather products	2.04	1.75	0.86	0.89	0.71
Wood, cork, and straw products	1.94	1.68	0.87	0.90	0.72
Paper and paper products	2.27	2.01	0.90	0.91	0.82
Publishing, printing and media	2.21	1.98	0.90	0.91	0.77
Rubber and plastic	1.93	1.72	0.90	0.91	0.80
Basic metals	2.07	1.82	0.89	0.91	0.80
Fabricated metal products	1.98	1.76	0.89	0.91	0.79
Machinery and equipment	2.03	1.79	0.89	0.90	0.78
Electrical machinery and apparatus	2.04	1.82	0.90	0.91	0.80
Medical instruments	1.91	1.66	0.89	0.90	0.77
Motor vehicles and trailers	2.03	1.78	0.89	0.90	0.77
Other transport equipment	2.03	1.75	0.88	0.90	0.75
Furniture	2.03	1.77	0.87	0.90	0.74

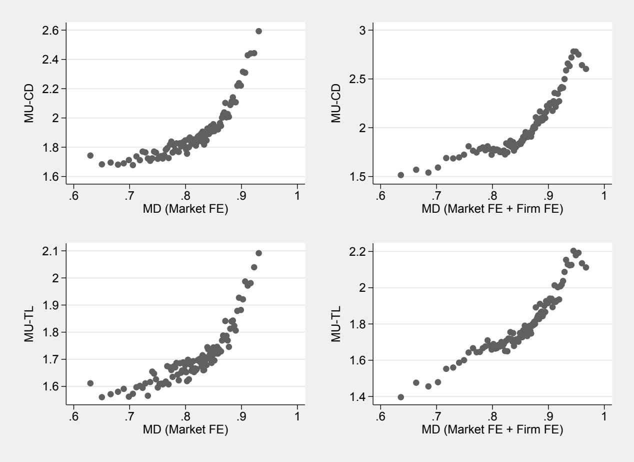
Note: This table reports the median of our different measures of market power

[4] Markups and Markdowns

- Manufacturing workers are paid a wage that is 11% lower than MRPL (10% for unskilled workers and 23% for skilled workers)
- Little variation of elasticities across industries. Could suggest that policies set at the national level, like the minimum wage, could be optimal
- Colombian manufacturing plants set prices 78% higher than marginal cost
- There is more variation in markups across industries than markdowns
- Both markets exhibit imperfect competition, but variation across industries is driven by the ease of firms to set prices above marginal costs

[4] Markups and Markdowns

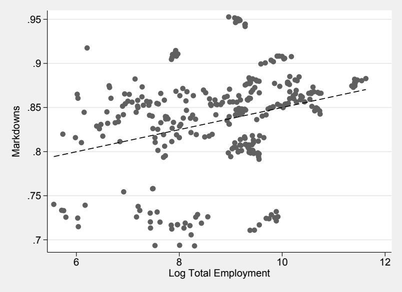
Figure: Correlation of Markups and Markdowns

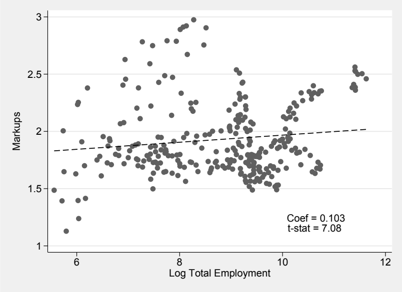


- Markups and Markdowns positively correlated $\Longrightarrow$ firms that have more market power in product markets share more rents with their workers

Market power and Market Size

"All labor markets are monopsonistic but less so in agglomerations" (Manning, 2010)





- low productive firms sort into small markets with more labor frictions and it is more difficult for workers to move across firms
- larger firms locate in more productive locations and they enjoy more market power

[4] Market power and plant characteristics

	MP (1)	MU (2)	MD (3)
Size (log sales)	0.0668	0.1026	0.0150
	(0.008)	(0.009)	(0.00008)
TFP (logs)	0.0660	0.7878	-0.0032
	(0.004)	(0.004)	(0.00006)
VA per worker (logs)	0.1889	0.3026	0.0225
	(0.001)	(0.002)	(0.0001)
Exporter	0.0466	0.1169	0.0310
	(0.003)	(0.004)	(0.0004)
Importer	0.1097	0.1519	0.0338
	(0.004)	(0.005)	(0.0004)
Skilled/Unskilled	-0.0055	-0.0083	0.0051
	(0.0016)	(0.0019)	(0.0001)
Observations	43,666	43,666	77,120

Note: dependent variable is log marketpower. MP: combined market power, MU: markups, MD: markdowns. Each entry corresponds to a separate regression. All the specifications include industry and year effects. Standard errors are clustered at the plant level.

Conclusion

- Analysis confirms product and labor markets (in manufacturing) are not perfectly competitive
- Manufacturing firms enjoy more market power in product than in labor markets
- Little variation of labor MP across industries $\Longrightarrow$ Homogeneous policies could be optimal (e.g. minimum wages)
- A negative correlation between product and labor market power. This pattern may be explained by the agglomeration story of Manning (2010)
- A positive (negative) correlation between product MP (labor MP) and:
    - Firm size, Productivity, Exporter status, Importer status

Next steps

(1) Other instruments: Bartik shocks using input-product prices and quantities Link

(2) Estimate output elasticity of labor θ_{it}^{L} through the "scale effect" Link

(3) Counterfactuals Link:

- Borrow from the classic framework of Hsieh and Klenow (2009)
- Simple idea: in a world with variable MU and MD, MRPL and MRPK may differ across firms diminishing TFP due to resource misallocation
- Eliminate variable market power and measure TFP gains at the sector level

(4) Estimate price demand elasticity, get MU_{it}, then back out MD_{it} Link

(5) Exploit the information of prices and quantities:

- Construct a Price Index at the firm level (physical quantities)
- Estimate markups by product

Many thanks!

Any feedback is very welcome:

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Other Instruments

Back to Slide

- Labor supply shocks correlated with materials violate our exclusion restriction
- Therefore, we have thought in other instruments:
  - 1. Bartik shocks using leave-out mean of input and product prices

$$\Delta \ln s_{it} = \Delta x_{it}\gamma + \beta \Delta w_{it} + e_{it}$$

$$\Delta w_{it} = \alpha + \theta \text{Instr.}_{it} + \nu_{it}$$

$$\text{Instr.}_{it} = \sum_{k}^{K} \omega_{ik,t-1} \Delta p_{k,-i,t}$$

    where k denotes product or input

  - 2. Bartik shocks using customs data and changes in the exchange rate

$$\text{Instr.}_{it} = \sum_{k}^{K} \psi_{it}^{k} \sum_{n}^{N} \omega_{ikn,t-1} \Delta rer_{n,t}$$

    where n is country and rer is the real exchange rate between country n and Colombia.

The scale effect

Back to Slide

- Another way to estimate the output-labor elasticity is to estimate a labor-demand type specification

$$\ln L_{it} = \alpha_0 + \alpha_1 \ln VA_{it} + \epsilon_{it}$$

where $\alpha_1 = \frac{1}{\theta_L}$

- We can use the exchange rate instrument for value added to identify α_1

Resource Misallocation

Back to Slide

- Using the framework developed by Hsieh and Klenow (2009) we can run different counterfactuals of reducing market power:

- For example, constant markups or markdowns across firms

- We will be able to estimate the relative gains on TFP of reducing market power in product vs labor markets:

$$\mathsf{TFP}_s \equiv \left[\sum_{i=1}^{M_s} \left(A_{si} \cdot \frac{\overline{\mathsf{TFPR}}_s}{\mathsf{TFPR}_{si}} \right)^{\sigma-1} \right]^{\frac{1}{\sigma-1}} \tag{1}$$

- At the social optimum TFPR_{si} should be equalized across firms. With variable markups it takes the following functional form:

$$\mathsf{TFPR}_{si} \propto \frac{MU_{si}}{MD_{si}^{1-\theta_{L,s}}}$$

Alternative approach: Price demand elasticity

- We could estimate price demand elasticities. For single-product firms (33% of the sample):

$$MU_{it} = \frac{|\epsilon_{it}^{D}|}{|\epsilon_{it}^{D}| - 1}$$

- For multi-product firms (67% of the sample):

$$\text{Substitutes: } MU_{irt} > \frac{|\epsilon_{irt}^{D}|}{|\epsilon_{irt}^{D}| - 1}$$

$$\text{Complements: } MU_{irt} < \frac{|\epsilon_{irt}^{D}|}{|\epsilon_{irt}^{D}| - 1}$$

  r is a product subindex.

- To avoid this problem we can follow Balat et al. (2016) to express output of a firm in same units (transformation rates)

- This strategy is similar to De Loecker et al. (2016) that consider only single-product firms for the production function estimation

Transformation rates

- The production function is a two tier structure
- In the upper-tier there is a composite input that is transformed into different products
- We assume that the composite input can be transformed into product r at a constant rate μ_t^r:

$$\exp(q_{itr}) = \mu_t^r \exp(y_{itr})$$

- We can write the production function as:

$$\log \left(\sum_{r \in R_{it}} \frac{\exp(q_{itr})}{\mu_t^r} \right) = f(l, k, \mathbf{m}, \omega; \beta)$$

- To estimate transformation rates we will use single product firms

Transformation rates estimation

Back to Slide

- Using single-product firms we estimate

$$q_{irt} = \sum_{r \in R_t} \log \mu_t^r D_{irt} + \beta_l l_{it} + \beta_k k_{it} + \omega_{it} + \epsilon_{it}$$

where D_{irt} is a dummy variable that takes the value of one if single-product firm i produces product r

- After we estimate μ_t^r we can construct the output level produce by all firms in the connected set of products of single product firms in the same units

- We can estimate the price demand elasticity at the firm level using a similar argument that with the labor supply elasticity

- We can use materials as an instrument for price

Minimum Wage

Back to Slide

- If the restriction of a minimum wage $\hat{w}_{it}$ is binding, then firm i takes the wage as given. The FOC is

$$\hat{w}_{it} = \lambda \frac{\partial Q_{it}}{\partial L_{it}}$$

$$MU_{it} = \frac{\theta^L_{it}}{\alpha^L_{it}}$$

where $\hat{w}_{it}$ is the minimum wage

- In other words, our measure of market power corresponds to markup if the minimum wage is binding

- Something we could do: group firms based on exposure to the MW (e.g. average wage per worker relative to the MW) and estimate our LS model