The Productivity Effect of Markups: Evidence from Chilean Plants

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Motivation

- Recent research shows plants' profitability key for growth
- Important dimension: plant-level markups
  - Reflect competitive position
  - Effect on aggregate productivity: unproductive firms shrink/go bankrupt with competition $\Rightarrow$ economy-wide efficiency rises due to reallocation *across* firms/plants
  - Within firms/plants: affect incentives of plants/firms to engage in innovation activities $\rightarrow$ effect on physical productivity (TFPQ)
- Despite the relevance of markups, little evidence on their role in explaining plants' growth and efficiency

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  - Within firms/plants: affect incentives of plants/firms to engage in innovation activities $\rightarrow$ effect on physical productivity (TFPQ)
- Despite the relevance of markups, little evidence on their role in explaining plants' growth and efficiency
- **This paper**: Do markups matter for plants' efficiency?
  - Studies direct impact on productivity and assess effect on innovation incentives
  - Policy implication: competition and aggregate efficiency

Competition and innovation
Hypothesis and implications

Two main views:

1. Competition foster innovation (threat to monopoly rents)
    - Incumbent firms innovate more in order to escape competition
2. Competition reduce incentives to innovate (lower rents)
    - Besides: innovation typically has high financial needs
      $\longrightarrow$ require relatively high margins

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     $\rightarrow$ require relatively high margins

- If competition does hurt laggard business' incentives to innovate:
  - Trade-off between short-run and long-run effect of competition
  - Long-run: increase in market power of current leading companies

How economists think about efficiency...

- Physical output $Y = A \cdot f$(capital, labor, materials...)
  - A: "true" efficiency
  - Typically: do not observe Y but $\mathbf{p} \cdot \mathbf{Y}$ = product revenue
  - The revenue production function is then $p \cdot Y = p \cdot A \cdot f$(capital, labor, materials...)

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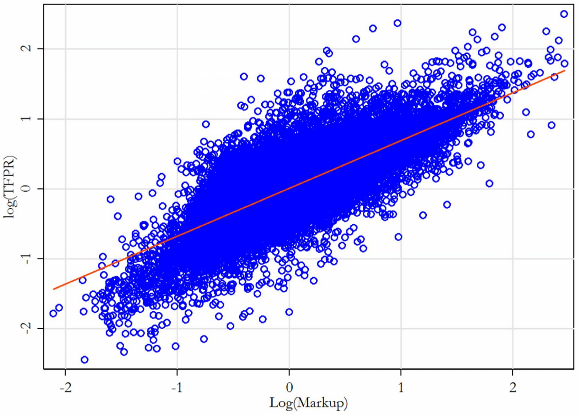
- Most papers analyze **revenue productivity** ($p \cdot A$, TFPR).
- Issues:
  - Unrelated to "true" efficiency under mild conditions (CRS)
  - Reflect differences in markups and input prices
  - Thus: mechanical positive relation bt. markups and TFPR

Plant-level Markups and TFPR in Chile

Cross-sectional dispersion; Correlation coefficient: .84



Markups and Plant-efficiency:
Empirical challenges (and solutions)

1. Find efficiency measure not affected by price bias
   - Solution: Construct plant-level price deflators, and compute physical productivity (real output as dependent variable – TFPQ)

▸ Markups ▸ TFP Estimation ▸ Price Index

2. Deal with reverse causation from efficiency $\rightarrow$ markups
   - More efficient plants capture a larger share of the market and are able to charge higher markups
   - Solution: source of exogenous demand variation in markups (unrelated to plants' technology)

Markups and Plant-efficiency:

Instrumental variables approach

- Idea: demand shocks to competitors unrelated to plant-efficiency
- Thus, use average markup of competitors as instrument
  - First stage:
$$\log(\mu_{is,t-1}) = \alpha_{st} + \beta_1 \log(\overline{\mu}_{-is,t-1}) + \gamma_1 X_{ist} + \varepsilon_{ist}$$
  - Second stage:
$$\ln TFPQ_{ist} \quad = \quad \delta_{st} + \beta_2 \ln\widehat{(\mu_{is,t-1}})} + \gamma_2 X_{ist} + \vartheta_{ist}$$

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  - Second stage:

$$\ln TFPQ_{ist} = \delta_{st} + \beta_2 \ln(\widehat{\mu_{is,t-1}}) + \gamma_2 X_{ist} + \vartheta_{ist}$$

- Data: Panel of Chilean manufacturing plants, period 1996-2007
  - Covers universe of manufacturing plants with $\geq$10 workers
  - 4,800 plants p/year, 20% exporters, 2/3 of all plants are small ($\leq$ 50 employees)

Details TFP Distribution Correlations

Markups and productivity: IV results

Baseline

Dep. Variable	OLS (1) $\ln(TFPQ_{ist})$	First Stage (2) $\ln(\mu_{is,t-1})$	2SLS (3) $\ln(TFPQ_{ist})$	Red. Form (4) $\ln(TFPQ_{ist})$
$\ln(\mu_{is,t-1})$	.0501***	—	.189***	—
	(.0102)		[.000]	
$\log(\mu_{-is,t-1})$	—	.440***	—	.0834***
		(.0242)		(.0233)
First Stage F-Stat	—	331.0	—	—
Industry-year FE	✓	✓	✓	✓
Observations	25,404	25,404	25,404	25,404

Notes: This table examines the effect markups on TFPQ. The OLS regression between of TFPQ on markups are reported in column 1. Column 2 reports first-stage results, together with the (cluster-robust) Kleibergen-Paap rK Wald F-statistic. The corresponding Stock-Yogo value for 10% (15%) maximal IV bias is 16.4 (8.96). Second stage results (column 3) report the p-values [in square brackets] for the Anderson-Rubin (Chisquare) test of statistical significance (heteroskedasticity-robust). This test is robust to weak instruments (see Andrews and Stock, 2005, for a detailed review). All regressions are run at the plant-year level, control for the logarithm of employment and for initial plant-level physical productivity, and include industry-year (at the 2-digit level) fixed-effects. Standard errors are clustered at the industry-year level. Key: ** significant at 1%; ** 5%; * 10%.

Robustness

Results: Taking stock

- Markups positively related to both TFPR and TFPQ:
  - TFPR varies hand-in hand with markups
  - Positively related to TFPQ, strong relation:
    - Moving a plant from 25^{th} to 75^{th} percentile of markup distribution related to about 9% additional TFPQ

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  - Positively related to TFPQ, strong relation:
    - Moving a plant from 25^{th} to 75^{th} percentile of markup distribution related to about 9% additional TFPQ
- Questions:
  1. What's the mechanism? Theory suggests that the positive link between markups and TFPQ occurs through investment in R&D and technology
  2. Heterogeneity: Does the effect differ in leading vs. laggard plants?

1. Why do markup increases lead to higher TFPQ?

Markups, R&D and technological investment (IV regressions, in logs)

- Data: Chilean Technological Innovation Survey (EIT)
  - Non-repeated cross-sections for 1997-98, 2000-01 and 2003-07
  - Covers about 1/5 of plants in ENIA (from 8% in '97, to 28% in '07)

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Dependent Variable	(1) $\ln(TFPQ_{ist})$	(2) R&D Expenditure: Overall	(3) R&D Expenditure: In-House	(4) Patents Licenses	(5) Machinery & Equipment: Innovative	(6) Machinery & Equipment: General
$\log(\mu_{ij,t-1})$	.570***	4.038***	3.122***	2.658***	2.062**	3.000***
	[.000]	[.0002]	[.0019]	[.0018]	[.0319]	[.0023]
First Stage F-Stat	256.8	271.1	271.1	271.1	271.1	271.1
Industry-year FE	✓	✓	✓	✓	✓	✓
Observations	3,428	3,428	3,428	3,428	3,428	3,428

Notes: Dependent variable 'x' in columns 2-6 are log(1+x) to include zeros. All regressions controls for the initial physical productivity, size and for industry-year fixed effects. The first-stage statistic corresponds to the (cluster-robust) Kleibergen-Paap rK Wald F-statistic. The corresponding Stock-Yogo value for 10% (15%) maximal IV bias is 16.4 (8.96). P-values [in square brackets] are for the Anderson-Rubin (Chi-square) test of statistical significance (heteroskedasticity-robust). Standard errors are clustered at the industry-year level. Key: ** significant at 1%; ** 5%; * 10%.

2. Leading vs laggard plants

Markups, R&D and technological investment (IV regressions, in logs)

Dependent Variable	Physical Productivity		R&D Expenditure	
	(1)	(2)	(3)	(4)
$log(\mu_{is,t-1})$	.576***	-.511	3.060***	-4.170
	(.0804)	(.373)	(1.037)	(3.480)
$log(\mu_{is,t-1}) \times TFPQ^{GAP}_{is,t-1}$	—	.142**	—	1.554*
		(.0717)		(.809)
$TFPQ^{GAP}_{is,t-1}$	—	-.719***	—	.543**
		(.0362)		(.255)
First Stage F-Statistic	276.5	26.57	281.3	28.33
Industry-year FE	✓	✓	✓	✓
Observations	3,344	3,344	3,344	3,344

Notes: Dependent variable 'x' in columns 2-6 are log(1+x) to include zeros. All regressions controls for the initial physical productivity, size and for industry-year fixed effects. The first-stage statistic corresponds to the (cluster-robust) Kleibergen-Paap rK Wald F-statistic. The corresponding Stock-Yogo value for 10% (15%) maximal IV bias is 16.4 (8.96). P-values [in square brackets] are for the Anderson-Rubin (Chi-square) test of statistical significance (heteroskedasticity-robust). Standard errors are clustered at the industry-year level. Key: ** significant at 1%; ** 5%; * 10%.

Concluding Remarks

1. This paper: relationship bt. markups & productivity
   - Empirical issues: measurement (TFPR vs. TFPQ) and identification
   - "Productivity effect of markups": Moving a plant from 25^{th} to 75^{th} percentile of markup distribution related to 9% additional TFPQ

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2. Positive link occurs through investment in R&D and technology
   - Markup increases related to higher investm't in R&D and techn.
   - Higher spending in R&D and techn. $\rightarrow$ higher TFPQ
   - Back-of-the-envelope calculation: same order of magnitude than TFPQ–markup reduced form

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2. Positive link occurs through investment in R&D and technology
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   - Higher spending in R&D and techn. $\rightarrow$ higher TFPQ
   - Back-of-the-envelope calculation: same order of magnitude than TFPQ–markup reduced form
3. Effect mostly accounted by laggard plants:
   - Competition hurt laggard business' incentives to innovate
   - Long-run implication: competition increase market power of current leading companies and hurt productivity dynamic in laggard plants

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BACKUP

Markups and its relationship with Productivity

Simple Framework

- Use $p = \mu \cdot MC$, μ: Markup

$$\text{TFPR} = \mu \cdot MC(A, \mathbf{w}) \cdot A$$

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- Let $\triangle$ represent log changes:

$$\triangle\text{TFPR} = \triangle\mu + \triangle MC(A, \mathbf{w}) + \triangle A$$

Markups and its relationship with Productivity

Simple Framework

- Use $p = \mu \cdot MC$, μ: Markup

$$\text{TFPR} = \mu \cdot MC(A, \mathbf{w}) \cdot A$$

- Let $\triangle$ represent log changes:

$$\triangle\text{TFPR} = \triangle\mu + \triangle MC(A, \mathbf{w}) + \triangle A$$

- Assume:
  - CRS $\Rightarrow \triangle MC(A, \mathbf{w}) = \triangle\phi(\mathbf{w}) - \triangle A$

- This implies: $\boxed{\triangle\text{TFPR} = \triangle\mu + \triangle\phi(\mathbf{w})}$

Markups and its relationship with Productivity

Main conclusion

$$\boxed{\triangle \text{TFPR} = \triangle \mu + \triangle \phi(\mathbf{w})}$$

Thus:

- Efficiency gains only show on TFPR if it affects markups (mkt. power) of input prices (quality?)
- However, it may also reflect spurious gains due to demand-induced increases in markups

Empirical Approach for Measuring TFP and Markups

Markups: De Loecker and Warzynski (2012) Methodology

- Producers minimize costs ($\mathbf{V_{it}}$: variable inputs, $\mathbf{K_{it}}$: dynamic inputs):

$$\mathcal{L}(\mathbf{V_{it}}, \mathbf{K_{it}}, \lambda_{it}) = \sum_{\nu=1}^{V} P_{it}^{\nu} V_{it}^{\nu} + \mathbf{r}_{it} \mathbf{K}_{it} + \lambda_{it} [Q_{it} - Q_{it}(\mathbf{V_{it}}, \mathbf{K_{it}}, A_{it})]$$

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$$\text{F.O.C.:} \quad \frac{\partial \mathcal{L}}{\partial V_{it}^{\nu}} = P_{it}^{\nu} - \lambda_{it} \frac{\partial Q_{it}(\cdot)}{\partial V_{it}^{\nu}} = 0$$

$$\Rightarrow \frac{P_{it}^{\nu} V_{it}^{\nu}}{Q_{it}} = \frac{P_{it}}{\mu_{it}} \frac{\partial Q_{it}(\cdot)}{\partial V_{it}^{\nu}} \frac{V_{it}^{\nu}}{Q_{it}}$$

$$\Rightarrow \text{Markup:} \quad \mu_{it} = \underbrace{\theta_{it}^{\nu}}_{\text{Output Elast.}} \cdot \underbrace{\left[\frac{P_{it}^{\nu} V_{it}^{\nu}}{P_{it} Q_{it}}\right]^{-1}}_{\text{Expendit. Share}}$$

- Independent of demand side

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Empirical Approach for Measuring TFP and Markups

Production Function Estimation

- Cobb-Douglas production function with labor (l), capital (k) and materials (m) as inputs:

$$q_{it} = \beta_l^s l_{it} + \beta_k^s k_{it} + \beta_m^s m_{it} + \omega_{it} + \varepsilon_{it}$$

Empirical Approach for Measuring TFP and Markups

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$$q_{it} = \beta_l^s l_{it} + \beta_k^s k_{it} + \beta_m^s m_{it} + \omega_{it} + \varepsilon_{it}$$

- Allow for IRS/DRS
- The estimation of β follows Ackerberg et al (2006)
  - Correct for endogeneity in input choice
  - Allow productivity to be affected by previous export-status:

$$\omega_{it} = g(\omega_{it-1}, d^x_{it-1}, d^i_{it-1}) + \xi_{it}$$

  - d^x_{it}: export dummy, d^i_{it} dummy for investment in physical capital (De Loecker, AEJM 2013)
  - Deals with potential misidentification of the labor coefficient in Olley and Pakes (1996) and Levinsohn and Petrin (2003)

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Empirical Approach for Measuring TFP and Markups

Plant-Level Price Indexes

- For TFPQ, we need plant-level price deflators
- Approach: Tornqvist price indexes
  - Log-change in plant-level prices Δp_{it} for plant i in period t:

$$\Delta p_{it} = \sum_{\upsilon \in \Phi_{\upsilon}} \phi_{i\upsilon} (\ln P_{i\upsilon t} - \ln P_{i\upsilon, t-1})$$

  - Given Δp_{it}, price index can be computed recursively as:

$$\ln P_{it} = \ln P_{i,t-1} + \Delta p_{it}$$

  - Initial period: weighted average of log-deviations from product average for each product

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Data

The ENIA

- Panel of Chilean manufacturing plants, period 1996-2007
- Covers universe of manufacturing plants with $\geq$10 workers
  - 4,800 plants p/year, 20% exporters, 2/3 of all plants are small ($\leq$ 50 employees)
- Standard plant-level information (size, revenues, sector...). Plus:
  - Value and quantity of all products
  - Variable cost for each product
  - Value and quantity of all inputs

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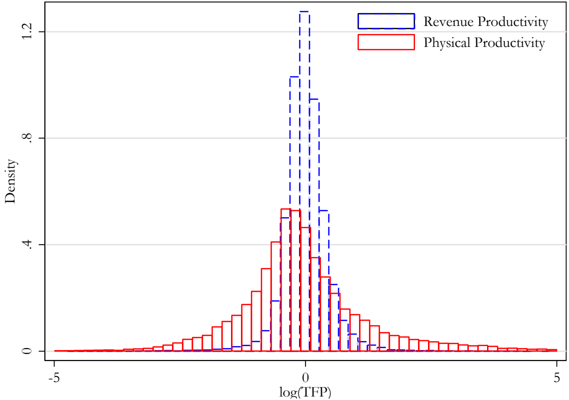
Overview: Productivity Distributions

Physical productivity shows higher dispersion than revenue productivity



Notes: This figure shows the distribution of physical productivity and revenue productivity ("TFPR", blue-dashed bars) over a sample of 46,058 plant-year observations over 1996-2007. All variables are measured in logarithms, and are demeaned with respect to the respective (2-digit) sector-year averages.

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Overview: Summary Statistics

Correlations	Price	TFPQ	TFPR	Markup
Price	1.0000			
Physical TFPQ	−0.8737	1.0000		
Revenue TFP	0.0201	0.4432	1.0000	
Markups	0.0043	0.3895	0.8426	1.000
Standard Deviation	0.9155	1.0329	0.4927	0.5468

Notes: This table shows correlations and standard deviations for plant-level variables over 1996-2007. All variables are measured in logarithms, and are demeaned with respect to the respective sector-year averages.

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Three observations:

- Strong negative correlation between TFPQ and prices
- Markup variation translates almost 1-to-1 into TFPR ▸ Markup vs. TFPR
  - Markups (not input prices) captures most of variation in TFPR
- Markups as correlated as TFPR with TFPQ

▸ TFPR vs. TFPQ ▸ Markup vs. TFPQ

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Robustness Checks

1. Reported "markups": Price over average variable cost; results not driven by estimation of markups
2. Plant-level input prices: TFPQ measure using both input and output prices (reduced sample, 2/3 of ttl plant-year obs.),
3. Single vs. multi-product Producers: No aggregation needed when constructing price index for SP plants

Robustness: Alternative Specifications

Specification	(1) Input & Output Prices	(2) Reported AV Margin	(3) Single-product plants
$\log(\mu_{ij,t-1})$	.124**	.725***	.213**
	[.0494]	[.000]	[.0143]
First Stage F-Stat	202.0	80.71	299.0
Industry-year FE	✓	✓	✓
Observations	16,955	25,120	8,352

Notes: This table examines the effect markups on TFPQ. The OLS regression between of TFPQ on markups are reported in column 1. Column 2 reports first-stage results, together with the (cluster-robust) Kleibergen-Paap rK Wald F-statistic. The corresponding Stock-Yogo value for 10% (15%) maximal IV bias is 16.4 (8.96). Second stage results (column 3) report the p-values [in square brackets] for the Anderson-Rubin (Chisquare) test of statistical significance (heteroskedasticity-robust). This test is robust to weak instruments (see Andrews and Stock, 2005, for a detailed review). All regressions are run at the plant-year level, control for the logarithm of employment and for initial plant-level physical productivity, and include industry-year (at the 2-digit level) fixed-effects. Standard errors are clustered at the industry-year level. Key: ** significant at 1%; ** 5%; * 10%.

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TFPQ and investment on R&D and technology (I)

Intensive+Extensive (logarithms)

	(1)	(2)	(3)	(4)	(5)	(6)
Overall R&D Exp.	.0082***	—	—	—	.0073***	—
	(.0020)				(.0020)	
In-House R&D Exp.	—	.0064***	—	—	—	.0041*
		(.0024)				(.0024)
Innovative Maq.& Equip.	—	—	.0066***	—	—	.0043**
			(.0020)			(.0021)
General Maq.& Equip.	—	—	—	.0081***	.0067***	.0072***
				(.0025)	(.0025)	(.0026)
Industry-year FE	✓	✓	✓	✓	✓	✓
Observations	3,428	3,428	3,428	3,428	3,428	3,428
R^2	.612	.611	.611	.611	.613	.613

TFPQ and investment on R&D and technology (II)

Extensive Margin (investment dummies)

	(1)	(2)	(3)	(4)	(5)	(6)
Overall R&D Exp.	.0855***	—	—	—	.0808***	—
	(.0226)				(.0229)	
In-House R&D Exp.	—	.0531**	—	—	—	.0328
		(.0258)				(.0263)
Innovative Maq.& Equip.	—	—	.0619***	—	—	.0457*
			(.0228)			(.0233)
General Maq.& Equip.	—	—	—	.0558**	.0465*	.0505**
				(.0234)	(.0238)	(.0239)
Industry-year FE	✓	✓	✓	✓	✓	✓
Observations	3,428	3,428	3,428	3,428	3,428	3,428
R^2	.612	.610	.611	.611	.612	.612