Misallocation and Capital Market Integration: Evidence From India

Natalie Bau
UCLA

Adrien Matray
Princeton University

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Motivation

- Key role of **misallocation** in productivity differences across production units

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- Despite appeal, **two key challenges**:
  1. **Practical / Policy Oriented**
     - ”Residual approach”: cannot identify **sources of distortions** (e.g. Syverson, 2011)

Motivation

- Key role of **misallocation** in productivity differences across production units
- Despite appeal, **two key challenges**:
  1. **Practical / Policy Oriented**
     - "Residual approach": cannot identify **sources of distortions** (e.g. Syverson, 2011)
  2. **Measurement errors**: distortions likely overestimated
     - Measurement error (Rotemberg and White, 2017; Udry and Gollin, 2019)
     - Model mis-specification error (Haltiwanger et al., 2018)
     - Volatility of productivity and costly adjustment of inputs (Asker et al., 2014)
     - Informational frictions and uncertainty (David et al, 2016; David and Venkateswaran, 2019)

This Paper

1. **Policy** problem:

2. **Measurement** problem:

This Paper

✓ **Policy** problem:

- Identify ***specific*** policy lever: **foreign capital liberalization**
  - *Within-country* variation across industries-time ⇒ fix country-level institutions

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- Estimate *relative* changes in firm inputs' **wedges** with **natural experiment**

⇒ **Aggregation** with DiD?

This Paper

✓ **Policy** problem:

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  - *Within-country* variation across industries-time ⇒ fix country-level institutions

✓ **Measurement** problem:

- Estimate *relative* changes in firm inputs' **wedges** with **natural experiment**

- **Bonus:** new methodology to **aggregate reduced-form estimates** of changes in wedges and provide lower-bounds

Why Capital Liberalization?

- **Imperfect capital markets**: very likely candidate source of capital misallocation, particularly in developing countries
  - Political capture with state-owned banks
  - Domestic regulation

"Banks are considered to be very high cost and inefficiently run... Enabling [Indian banks] to allocate credit to the most productive users, rather than by government allocation, would make a considerable contribution to the Indian economy's growth potential."

–Anne Krueger, then deputy managing director of the IMF

Why Capital Liberalization?

"Simpler" lever: Opening up to foreign capital?

Why Capital Liberalization?

- Role of foreign capital is ex-ante **ambiguous**
  - Foreign capital not bound by historical, political, regulatory or institutional domestic constraints
  - But lower ability at **processing** and **monitoring** soft information?

Settting: staggered liberalization across industries $\Rightarrow$ **lower misallocation**

Contribution to the Literature

1. **Effects of financial frictions on misallocation.** Buera, Kaboski, and Shin; 2011; Midrigan and Xu, 2014; Moll, 2014; Bai, Carvalho and Phillips, 2018, Catherine, Chaney, Huang, Sraer, and Thesmar, 2018)

2. **Effects of financial frictions on development.** (Banerjee, Duflo, and Munshi, 2003; Banerjee and Duflo, 2014; Banerjee and Munshi, 2004; Cole, 2009).

3. **Capital account liberalization.** Alfaro, Chanda, Kalemli-Ozcan, and Sayek, 2004; Gopinath, Kalemli-Ozcan, Karabarbounis, and Villegas-Sanchez, 2017; Varela, 2017; Larrain and Stumpner; 2017; Saffie, Varela, and Yi, 2018).

Roadmap

1. Institutional and Theoretical Background
2. Empirical Strategy and Data
3. Reduced-Form Effects
4. Aggregate Effects

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Indian Context

- Initially a closed, socialist economy
- Foreign investment regulated by “Foreign Exchange Regulation Act” (1973)
  - All foreign investment required individual government approval
  - Foreign ownership restricted to below 40%
- **1991**: Balance of payment crisis. → structural reforms (IMF, World Bank)
  - First round of in 1991
    - Up to 51% of equity: foreigners approved via automatic approval route
  - Trade liberalization (e.g. Goldberg et al. (2010), Topalova and Khandelwal (2011))
  - Dismantling “license raj” (Aghion et al., 2008)

Policy: Second Wave of Liberalization, 2001, 2006

- Hand-collected data on FDI liberalizations at the 5-digit industry-level from *Handbook of Industrial Policy and Statistics*
  - Typically, up to 51% of equity approved via automatic approval route
- Affected 10% of manufacturing firms

Affected Industries

NIC 5-Digit Industry Classification	Reform Year
Manufacture of 'ayurvedic' or 'unani' pharmaceutical preparation	2001
Manufacture of allopathic pharmaceutical preparations	2001
Manufacture of medical impregnated wadding, gauze, bandages, dressings, surgical gut string etc.	2001
Manufacture of homoeopathic or biochemic pharmaceutical preparations	2001
Manufacture of other pharmaceutical and botanical products n.e.c. like hina powder etc.	2001
Manufacture of rubber tyres and tubes n.e.c.	2006
Manufacture of essential oils; modification by chemical processes of oils and fats (e.g. by oxidation, polymerization etc.)	2006
Manufacture of various other chemical products	2006
Manufacture of rubber tyres and tubes for cycles and cycle-rickshaws	2006
Manufacture of distilled, potable, alcoholic beverages such as whisky, brandy, gin, 'mixed drinks' etc.	2006
Coffee curing, roasting, grinding blending etc. and manufacturing of coffee products	2006
Retreading of tyres; replacing or rebuilding of tread on used pneumatic tyres	2006
Manufacture of chemical elements and compounds doped for use in electronics	2006
Manufacture of country liquor	2006
Manufacture of matches	2006
Manufacture of rubber plates, sheets, strips, rods, tubes, pipes, hoses and profile -shapes etc.	2006
Distilling, rectifying and blending of spirits	2006
Manufacture of bidi	2006
Manufacture of catechu(katha) and chewing lime	2006
Stemming and redrying of tobacco	2006
Manufacture of other rubber products n.e.c.	2006
Manufacture of rubber contraceptives	2006
Manufacture of other tobacco products including chewing tobacco n.e.c.	2006
Manufacture of pan masala and related products.	2006

Brief Conceptual Framework

- Misallocation = wedges on inputs $\Rightarrow$ Firm i pays for input $x \in \{K, L, M\}$:

$$(1 + \tau_i^x)\, p^x$$

- Single product firm's profit function is:

$$\pi_i = p_i f_i(K_i, L_i, M_i) \; - \sum_{x \in \{K,L,M\}} (1 + \tau_i^x) p^x x_i$$

Brief Conceptual Framework

- FOC about x_i consumption:

$$\underbrace{\frac{p_i \partial f_i(K_i, L_i, M_i)}{\partial x_i}}_{\text{Marginal Revenue Returns}} = \underbrace{(1 + \tau_i^x) p^x}_{\text{Cost}}$$

- E.g. **misallocation of capital**:
  - Higher capital wedges $\Rightarrow$ higher marginal revenue products on capital ("MRPK")
  - $\downarrow$ in high τ_i^k = $\downarrow$ in misallocation
    - MRPK fall for these firms
    - Capital, labor, and revenues increase

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Firm-level Data: Prowess Data Set

- 66,654 large and medium-sized firm-year observations in India
  - Account > 70% of India's economic activity, 75% of corporate tax revenues
- Focus on 1995–2015
  - Post major reform period episode
  - Coverage of database stabilizes

Firm Characteristics

	Obs.	Mean	p10	p50	p90
Treated During Study Period (%)	66,654	10	0	0	0
Private, Domestic (%)	66,654	57	0	100	100
Private, Foreign (%)	66,654	5	0	0	0
State Owned (%)	66,654	4	0	0	0
Firm Age	66,654	26	8	21	52
Gross Fixed Assets (M$)	63,950	23	0	3	37
Sales (M$)	62,784	58	1	11	107
Salaries (M$)	49,090	3	0	1	6

Empirical Strategy: Average Effect

$$Y_{ijt} = \beta_1 Reform_{jt} + \alpha_i + \delta_t + X_{ijt} + \epsilon_{it}$$

- With:
  - Y_{ijt}: log(capital), log(wages), log(sales), log(MRPK), and log(TFPR)
  - *Reform*$_{jt}$: industry j reformed $\geq t$
  - X_{ijt}: firm controls (baseline: age fixed effects)

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  - $Reform_{jt}$: industry j reformed $\geq t$
  - X_{ijt}: firm controls (baseline: age fixed effects)
- **Pb:** potentially mask large distributional effects $\Rightarrow$ is misallocation reduced?
  - Identify ex-ante constrained firms (high MRPK)
  - Test if misallocation is reduced

Empirical Strategy: Distributional Effect

$$Y_{ijt} = \beta_1 \, Reform_{jt} + \beta_2 \, Reform_{jt} \times High\ MRPK_i + \alpha_i + \delta_t + X_{ijt} + \epsilon_{it}$$

- High MRPK$_i$: Firm's MRPK average > 2-digit industry median in 1995-2000
  - Exploit *within-industry* variations
- *Reform*$_{jt}$:
  - Deregulated industry-wide specific shocks partialed out
  - ⇒ **Weaker** identification assumptions than standard difference-in-differences
- Most conservative specification: X_{ijt} includes 5-digit industry×year FE

Estimating MRPK

- Three methods to estimate the marginal revenue product of capital, all assuming

$$Y_{ijt} = A_{it} K_{ijt}^{\alpha_{jk}} L_{ijt}^{\alpha_{jl}} M_{ijt}^{\alpha_{jm}}$$

1. Main Method: Exploit the fact that $MRPK \propto \frac{Y}{K}$ *within* an industry
2. Estimate the production function using Levinsohn and Petrin (2003)
3. Estimate the production function using Ackerberg, Caves, and Frazer (2015)

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Average Effect

Dep. Var.	Revenues	Capital	Wages	MRPK	TFPR
	(1)	(2)	(3)	(4)	(5)
$Reform_{jt}$	0.22***	0.29***	0.14	-0.18	-0.08
	(0.07)	(0.10)	(0.11)	(0.11)	(0.06)
Observations	62,439	62,116	47,339	59,462	59,462
Firm FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
Age FE	✓	✓	✓	✓	✓

Heterogeneity by Pre-treatment MRPK (Y/K Calculation)

- Growth concentrated in **in MRPK firms**

Dep. Var.	Revenues	Capital
	(1)	(2)
Reform$_{jt} \times I_i^{High\ MRPK}$	0.18***	0.60***
	(0.05)	(0.07)
Reform$_{jt}$	0.12	-0.04
	(0.08)	(0.09)
Observations	62,439	62,116
Firm FE	✓	✓
Year FE	✓	✓
Age FE	✓	✓

Heterogeneity by Pre-treatment MRPK (Y/K Calculation)

- Growth concentrated in **in MRPK firms**
- Some complementarities capital-labor

Dep. Var.	Revenues	Capital	Wages
	(1)	(2)	(3)
$Reform_{jt} \times I_i^{High\ MRPK}$	0.18***	0.60***	0.26**
	(0.05)	(0.07)	(0.11)
$Reform_{jt}$	0.12	-0.04	-0.01
	(0.08)	(0.09)	(0.09)
Observations	62,439	62,116	47,339
Firm FE	✓	✓	✓
Year FE	✓	✓	✓
Age FE	✓	✓	✓

Heterogeneity by Pre-treatment MRPK (Y/K Calculation)

- Growth concentrated in **in MRPK firms**
- Decline in MRPK dispersion ⇒ misallocation ↓

Dep. Var.	Revenues	Capital	Wages	MRPK
	(1)	(2)	(3)	(4)
$Reform_{jt} \times I_i^{High\ MRPK}$	0.18***	0.60***	0.26**	-0.43***
	(0.05)	(0.07)	(0.11)	(0.08)
$Reform_{jt}$	0.12	-0.04	-0.01	0.07
	(0.08)	(0.09)	(0.09)	(0.12)
Observations	62,439	62,116	47,339	59,462
Firm FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Age FE	✓	✓	✓	✓

Heterogeneity by Pre-treatment MRPK (Y/K Calculation)

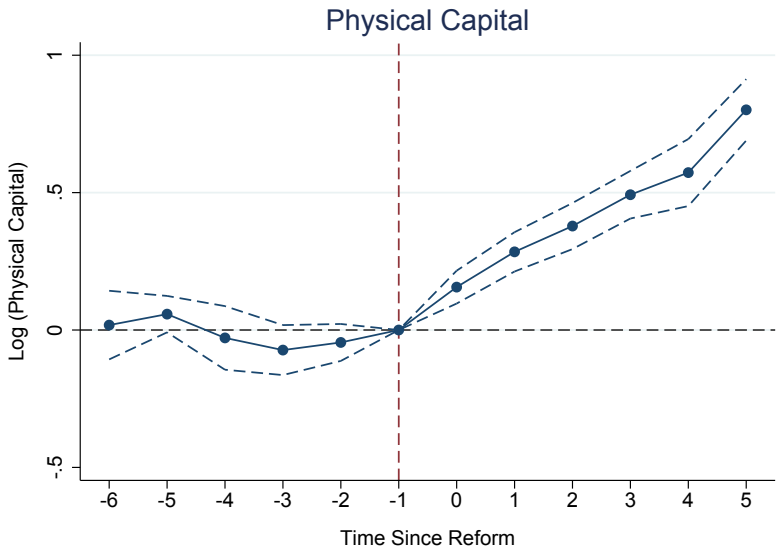
- Growth concentrated in **in MRPK firms**
- Decline in MRPK dispersion ⇒ misallocation ↓
- ∅ *within* firm productivity: efficiency gains from **reallocation of inputs** ≠ faster within productivity

Dep. Var.	Revenues	Capital	Wages	MRPK	TFPR
	(1)	(2)	(3)	(4)	(5)
$Reform_{jt} \times I_i^{High\ MRPK}$	0.18***	0.60***	0.26**	-0.43***	-0.07
	(0.05)	(0.07)	(0.11)	(0.08)	(0.06)
$Reform_{jt}$	0.12	-0.04	-0.01	0.07	-0.04
	(0.08)	(0.09)	(0.09)	(0.12)	(0.08)
Observations	62,439	62,116	47,339	59,462	59,462
Firm FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
Age FE	✓	✓	✓	✓	✓

5 Dig. Industry×Year FE

Dep. Var.	Revenues	Capital	Wages	MRPK
	(1)	(2)	(3)	(4)
$Reform_{jt} \times I_i^{High\ MRPK}$	0.32***	0.74***	0.43***	-0.40***
	(0.05)	(0.08)	(0.11)	(0.10)
Observations	52,097	52,616	42,705	41,797
Firm FE	✓	✓	✓	✓
Ind×Year FE	✓	✓	✓	✓
Age FE	✓	✓	✓	✓

Yearly Response to Treatment: No Pre-Trend



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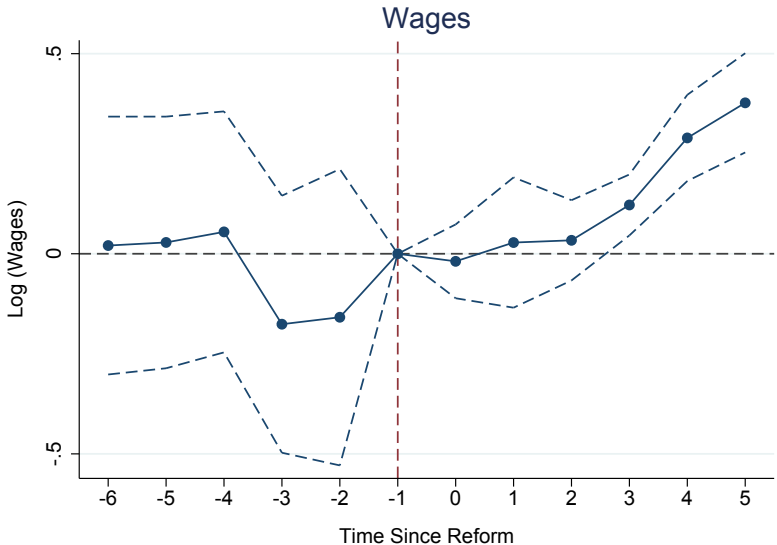
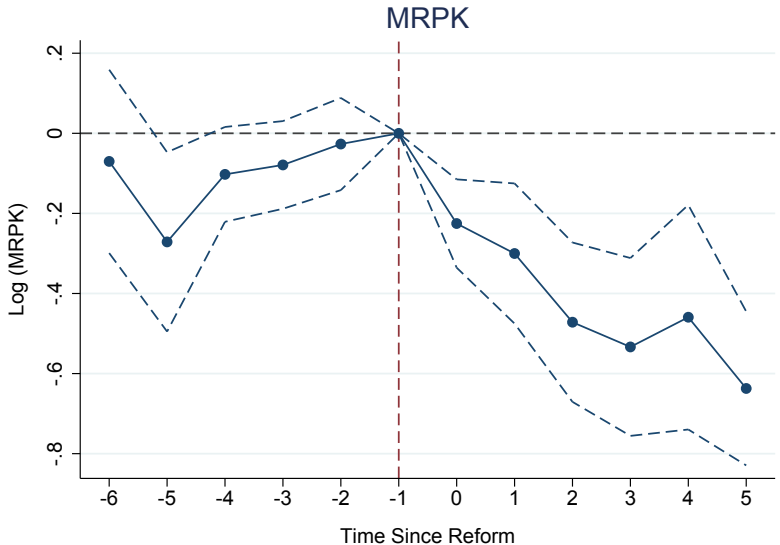


Yearly Response to Treatment: No Pre-Trend



Additional Robustness Tests

- Calculating MRPK with LP, ACF, quantities instead of revenues
- Restricting to a balanced panel of firms/testing for effects on exit and entry
- Controlling for:
  - input-output spillovers
  - tariff policy
  - reservation policy
  - state location
  - size difference

Heterogeneity by Local Financial Development

- Does foreign capital liberalization **substitutes** for an efficient local banking sector?

- Heterogeneity in **state-level** development of banking sector
  - Assembled state-level data on average total bank credit 1995–2000
  - *Local Credit Market Development* = log of all bank credit

Heterogeneity by Financial Development

- Better state-level banking sector = lower effect of Reform

Dep. Var.	Revenues	Capital	Wages	MRPK
	(1)	(2)	(3)	(4)
$Reform_{jt} \times I_i^{High\ MRPK}$	0.17***	0.60***	0.26**	-0.44***
	(0.00)	(0.00)	(0.03)	(0.00)
$Reform_{jt} \times I_i^{High\ MRPK}$	-0.15**	-0.27***	-0.16***	0.08*
$\times\ Local\ Credit\ Market\ Development$	(0.02)	(0.00)	(0.00)	(0.05)
Observations	52,097	52,616	42,705	41,797
Firm FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Age FE	✓	✓	✓	✓

Heterogeneity by Financial Development: MRPK Magnitudes

- State at **25th** percentile: MRPK $\Downarrow$ **51%**

- State at **75th** percentile: MRPK $\Downarrow$ **34%**

Gain For Consumers? Product-level Outcomes

- Product-level data: **sales** and **quantities** ⇒ get **unit price** and **output**
  - Examine whether the same pattern holds for these outcomes
  - Include product×year FE ⇒ *within* product comparison
- Why effect on prices?
  - Lower **frictions** ⇒ lower **marginal costs**: passed on to the consumer?
  - Competition effect

Product-Level Outcomes: Price Effects

Dep. Var.	Log Unit Price		
	(1)	(2)	(3)
$Reform_{jt}$	-0.09*	-0.03	-0.06
	(0.05)	(0.04)	(0.04)
$Reform_{jt} \times I_i^{High\ MRPK}$ (Y/K)		-0.09**	
		(0.04)	
$Reform_{jt} \times I_i^{High\ MRPK}$ (LP)			-0.03***
			(0.00)
Observations	149,867	149,867	124,212
Firm-Product FE	✓	✓	✓
Year FE	✓	✓	✓
Age FE	✓	✓	✓

Product-Level Outcomes: Output

Dep. Var.	Log Output		
	(1)	(2)	(3)
$Reform_{jt}$	0.23***	0.14**	0.07
	(0.08)	(0.06)	(0.07)
$Reform_{jt} \times I_i^{High\ MRPK}$ (Y/K)		0.13*	
		(0.08)	
$Reform_{jt} \times I_i^{High\ MRPK}$ (LP)			0.27*
			(0.16)
Observations	149,867	149,867	124,212
Firm-Product FE	✓	✓	✓
Year FE	✓	✓	✓
Age FE	✓	✓	✓

Did the Policy Also Reduce Labor Misallocation?

- **Timing mismatch** between labor costs and cash flows (fixed cost, training, etc.)

  $\Rightarrow$ **Financial constraints** can affect **labor misallocation**

  - e.g. Chodorow-Reich (2014), Schoefer (2015), Benmelech, Bergman, and Seru (2015), Fonesca and Doornik (2019)

- Same strategy with MRPL instead of MRPK

Reduction in Labor Misallocation: Y/L Classification

- Largest effect on wages ≠ capital (opposite for MRPK)

Dep. Var.	Revenues	Capital	Wages
	(1)	(2)	(3)
$Reform_{jt} \times I_i^{High\ MRPL}$	0.15	0.29*	0.32***
	(0.11)	(0.15)	(0.08)
$Reform_{jt}$	0.17***	0.19***	-0.00
	(0.05)	(0.05)	(0.10)
Observations	52,097	52,616	42,705
Firm FE	✓	✓	✓
Year FE	✓	✓	✓
Age FE	✓	✓	✓

Reduction in Labor Misallocation: Y/L Classification

- Drop in MRPL dispersion = ↓ misallocation

Dep. Var.	Revenues	Capital	Wages	MRPL
	(1)	(2)	(3)	(4)
$Reform_{jt} \times I_i^{High\ MRPL}$	0.15	0.29*	0.32***	-0.35***
	(0.11)	(0.15)	(0.08)	(0.09)
$Reform_{jt}$	0.17***	0.19***	-0.00	0.15
	(0.05)	(0.05)	(0.10)	(0.10)
Observations	52,097	52,616	42,705	41,797
Firm FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Age FE	✓	✓	✓	✓

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Aggregate Effect: the plan

- **Step 1**: reduced-form estimates: causal **relative changes** in firms' wedges, purged from cross-sectional measurement errors
  - **But:** Aggregate effect?
    - Ex: $\Uparrow$ constrained firms might imply $\Downarrow$ unconstrained firms
    - $\Rightarrow$ We **cannot** just sum the relative effect!

Aggregate Effect: the plan

- **Step 1**: reduced-form estimates: causal **relative changes** in firms' wedges, purged from cross-sectional measurement errors
  - **But:** Aggregate effect?
    - Ex: $\Uparrow$ constrained firms might imply $\Downarrow$ unconstrained firms
    - $\Rightarrow$ We **cannot** just sum the relative effect!
- **Step 2**: build an aggregator
  - First order approximation of aggregate effect of wedges on Solow residual (Petrin and Levinsohn, 2012; Baqaee and Farhi, 2019)
  - Method to leverage D-i-D to get a **lower bound** (+6.5%)
    - More stable than cross-sectional variations in measured wedges (10 to over 100%)

Effect on the Solow Residual: Strategy

First order approximation effect of policy (Petrin and Levinsohn, 2012 ; Baqaee and Farhi, 2019)

$$\Delta Solow_{I,t} \approx \sum_{i \in I} \lambda_i \Delta \log A_i \quad + \quad \sum_{\substack{i \in I \\ x \in \{k,l,m\}}} \lambda_i \, \alpha_i^x \, \tau_i^x \, \Delta \, \log x_i$$

- i = producers, I = industry, t = year
- $\Delta \log A_i$: firm-specific change in total factor productivity
- λ_i: producer's sales as a share of industry net-output
- α_i^x: output elasticity of i for input x
- τ_i^x: wedge on input x for firm i
- $\Delta \log x_i$: change in input consumption x_i

(derivation)

Effect on the Solow Residual: Strategy

$$\Delta Solow_{I,t} \approx \sum_{i \in I} \lambda_i \Delta \log A_i \quad + \quad \sum_{\substack{i \in I \\ x \in \{k,l,m\}}} \lambda_i \, \alpha_i^x \, \tau_i^x \, \Delta \, \log x_i$$

- Does not assume:
  - Constant returns to scale
  - Any specific aggregator
  - Any specific input-output structure
- Does assume Cobb-Douglas

Effect on the Solow Residual: Strategy

$$\Delta Solow_{I,t} \approx \sum_{i \in I} \lambda_i \Delta \log A_i \quad + \quad \sum_{\substack{i \in I \\ x \in \{k,l,m\}}} \lambda_i \, \alpha_i^x \, \tau_i^x \, \Delta \, \log x_i$$

$\Rightarrow$ Several components easily identifiable

Effect on the Solow Residual: Strategy

$$\Delta Solow_{I,t} \approx \sum_{i \in I} \lambda_i \Delta \log A_i \quad + \quad \sum_{\substack{i \in I \\ x \in \{k,l,m\}}} \lambda_i \, \alpha_i^x \, \tau_i^x \, \Delta \, \log x_i$$

- $\Delta \log A_i \to 0$

Effect on the Solow Residual: Strategy

$$\Delta Solow_{I,t} \approx \sum_{i \in I} \lambda_i \Delta \log A_i \quad + \quad \sum_{\substack{i \in I \\ x \in \{k,l,m\}}} \lambda_i \, \alpha_i^x \, \tau_i^x \, \Delta \, \log x_i$$

- $\Delta \log A_i \to 0$
- λ_i: Sum manufacturing total sales + information from India's input-output table
- α_i^x: Production function estimates (LP or other)
- $\Delta \log x_i$: Reduced-form estimate from difference-in-differences regression

Effect on the Solow Residual: Strategy

$$\Delta Solow_{I,t} \approx \sum_{i \in I} \lambda_i \Delta \log A_i \quad + \quad \sum_{\substack{i \in I \\ x \in \{k,l,m\}}} \lambda_i \, \alpha_i^x \, \tau_i^x \, \Delta \, \log x_i$$

- $\Delta \log A_i \to 0$
- λ_i: Sum manufacturing total sales + information from India's input-output table
- α_i^x: Production function estimates (LP or other)
- $\Delta \log x_i$: Reduced-form estimate from difference-in-differences regression
- Pb: how to estimate τ_i^x with minimal measurement error?

Effect on the Solow Residual: Lower Bound Approach

$$\Delta Solow_{I,t} \approx \sum_{\substack{i \in I \\ x \in \{k,l,m\}}} \lambda_i \, \alpha_i^x \, \tau_i^x \, \Delta \, \log x_i$$

- Policy effect increases in size of baseline wedges $\Rightarrow$ measurement errors create **huge differences** in estimation
- So far: use of **cross-sectional variation** in MRPK, MRPL, and MRPM in the last pre-treatment year
  - Likely to inflate our estimates (e.g. Rotemberg and White, 2017; Haltiwanger, Kulick, and Syverson, 2018; Asker, Collard-Wexler, and De Loecker, 2014; Gollin and Udry, 2019)

Lower Bound τ_i^x

- Two assumptions:
  1. Policy does not *subsidize* treated firms $\Rightarrow \tau_{post}^x \geq 0$
  2. Policy only affected treated firms = no spillover
     - Standard difference-in-differences assumption
- Minimum possible baseline wedges: policy-induced reduction in wedges

$$\tau_{post}^x = \tau_{pre}^x + \Delta\tau^x$$

→ Estimate at the firm-level using the difference-in-differences strategy

▸ Details

Estimation τ_i^x

$$\begin{aligned}\log MRPK_{ijt} =& \beta_1 Reform_{jt} + \beta_2 Reform_{jt} \times I_i^{High\ MRPK} + \beta_3 Reform_{jt} \times I_i^{High\ MRPM} \\ &+ \beta_4 Reform_{jt} \times I_i^{High\ MRPL} + \Gamma X_{it} + \alpha_i + \delta_t + \epsilon_{ijt}\end{aligned}$$

$$\begin{aligned}\widehat{\log(1+\tau_i^k)} =& \hat{\beta}_1 Reform_j + \hat{\beta}_2 Reform_j \times I_i^{High\ MRPK} + \hat{\beta}_3 Reform_j \times I_i^{High\ MRPM} \\ &+ \hat{\beta}_4 Reform_j \times I_i^{High\ MRPL}\end{aligned}$$

Key Estimates: Wedges

Dep. Var.	Log MRPK	Log MRPL	Log MRPM
	(1)	(2)	(3)
$Reform_{jt}$	0.30*	0.30*	0.18***
	(0.16)	(0.18)	(0.06)
$Reform_{jt} \times I_i^{High\ MRPK}$	-0.56***	-0.21***	0.01
	(0.09)	(0.05)	(0.10)
$Reform_{jt} \times I_i^{High\ MRPL}$	-0.14*	-0.35***	-0.12***
	(0.08)	(0.09)	(0.03)
$Reform_{jt} \times I_i^{High\ MRPM}$	-0.07	-0.09	-0.23***
	(0.10)	(0.07)	(0.04)
Observations	42,705	42,705	42,705
Set Fixed Effects	✓	✓	✓

Estimation changes in inputs

$$\Delta Solow_{I,t} \approx \sum_{\substack{i \in I \\ x \in \{k,l,m\}}} \lambda_i \, \alpha_i^x \, \tau_i^x \, \Delta \, \log x_i$$

Key Estimates: Δ Inputs

Dep. Var.	Log Assets	Log Salaries	Log Materials
	(1)	(2)	(3)
$Reform_{jt}$	0.03	-0.12	-0.09
	(0.08)	(0.11)	(0.14)
$Reform_{jt} \times I_i^{High\ MRPK}$	0.47***	0.31***	0.05
	(0.14)	(0.09)	(0.08)
$Reform_{jt} \times I_i^{High\ MRPL}$	0.22*	0.30***	0.22*
	(0.13)	(0.11)	(0.12)
$Reform_{jt} \times I_i^{High\ MRPM}$	-0.10	-0.07	0.05
	(0.10)	(0.10)	(0.10)
Observations	42,705	42,705	42,705
Set Fixed Effects	✓	✓	✓

Aggregate Effect on the Solow Residual

- Our baseline lower bound: **+6.5%**

- Attributing *all* within-5 digit industry variation in 2000 in MRPK, MRPM, and MRPL to misallocation: **+159%**

- Measurement error correction (dropping top and bottom 15%): **+10%**

Conclusion

- Foreign capital liberalization can play an important role in **reducing** capital and labor misallocation
- Policy increased capital for high MRPK firms, particularly in states with less-developed banking sectors
- Exploit natural experiment to identify the **aggregate effects** of the policy
  - Reform applied to only 10% of manufacturing and raised manufacturing productivity by at least **6.5%**
  - Methods for measuring the effects of misallocation that do not exploit the natural experiment deliver widely-varying results

Thank you!

Balanced Sample (Y/K Assignment)

Dep. Var.	**Revenues**	**Capital**	**Wages**	**MRPK**
	(1)	(2)	(3)	(4)
$Reform_{jt} \times I_i^{High\ MRPK}$	0.25*	0.47***	0.04	-0.24**
	(0.14)	(0.05)	(0.09)	(0.10)
$Reform_{jt}$	0.03	0.04	0.08	-0.10
	(0.15)	(0.12)	(0.09)	(0.12)
Observations	29,975	29,640	23,601	29,131
Firm FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Age FE	✓	✓	✓	✓

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Effects on Exit and Entry

Dep. Var.	**Number of Exits**			**Number of Entrants**		
	(1)	(2)	(3)	(4)	(5)	(6)
$Reform_{jt}$	0.16	0.06**	0.04	-0.01***	-0.01	-0.01
	(0.34)	(0.03)	(0.06)	(0.00)	(0.01)	(0.01)
$Reform_{jt} \times I_i^{High\,MRPK}$ (Y/K)		-0.03			-0.00	
		(0.03)			(0.00)	
$Reform_{jt} \times I_i^{High\,MRPK}$ (LP)			-0.00			0.00
			(0.02)			(0.00)
Observations	8,190	12,411	11,025	8,190	12,411	11,025
Industry Fixed Effects	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓
High MPRK Control	–	✓	✓	–	✓	✓

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LP Classification

Dep. Var.	**Revenues**	**Capital**	**Wages**	**MRPK**	**TFPR**
	(1)	(2)	(3)	(4)	(5)
$Reform_{jt} \times I_i^{High\ MRPK}$	0.23**	0.46***	0.31**	-0.56***	-0.13
	(0.09)	(0.15)	(0.11)	(0.11)	(0.08)
$Reform_{jt}$	-0.06	0.08	-0.01	0.19	-0.00
	0.12	0.08	-0.01	0.19	-0.00
	(0.08)	(0.07)	(0.09)	(0.12)	(0.09)
Observations	50,070	50,478	41,035	38,613	38,613
Firm FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
Age FE	✓	✓	✓	✓	✓

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ACF Classification

Dep. Var.	**Revenues**	**Capital**	**Wages**	**MRPK**
	(1)	(2)	(3)	(4)
$Reform_{jt} \times I_i^{High\ MRPK}$	0.19	0.65***	0.37***	-0.52***
	(0.16)	(0.16)	(0.09)	(0.16)
$Reform_{jt}$	0.27*	0.07	0.13	0.08
	(0.14)	(0.13)	(0.11)	(0.22)
Observations	18,378	18,613	16,286	12,356
Firm FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Age FE	✓	✓	✓	✓

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2-Digit Industry by Year FE

Dep. Var.	**Revenues**	**Capital**	**Wages**	**MRPK**
	(1)	(2)	(3)	(4)
	Panel A: Y/K Classification			
$Reform_{jt} \times I_i^{High\,MRPK}$	0.20***	0.61***	0.29**	-0.40***
	(0.05)	(0.08)	(0.11)	(0.09)
$Reform_{jt}$	0.01	-0.13	-0.11	0.13
	(0.11)	(0.14)	(0.11)	(0.13)
Observations	64,009	63,697	48,968	61,061
Firm FE	✓	✓	✓	✓
2-Digit Industry–Year FE	✓	✓	✓	✓
Age FE	✓	✓	✓	✓

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Input-Output Spillovers

$$Upstream_{k,t} = \sum_l \left(Input\%_{l \to k}^{2000} - \mathbf{1}_{l=k} \right) \times Reform_{l,t}$$

Dep. Var.	**Revenues**	**Capital**	**Wages**	**MRPK**
	(1)	(2)	(3)	(4)
$Reform_{jt} \times I_i^{High\ MRPK}$	0.18***	0.60***	0.26**	-0.44***
	(0.05)	(0.07)	(0.11)	(0.08)
$Reform_{jt}$	0.11	-0.05	-0.02	0.06
	(0.08)	(0.09)	(0.08)	(0.13)
$Upstream_{jt}$	-0.12	0.14	-0.00	-0.25*
	(0.22)	(0.16)	(0.16)	(0.13)
$Downstream_{jt}$	0.33	0.09	0.25	0.26
	(0.29)	(0.19)	(0.30)	(0.17)
Observations	51,541	51,244	37,598	49,026
Firm FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Age FE	✓	✓	✓	✓

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Controlling for Tariff Policies

Dep. Var.	**Revenues**		**Capital**		**Wages**		**MRPK**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Reform_{jt} \times I_i^{High\ MRPK}$	0.17***	0.13**	0.59***	0.57***	0.24**	0.19**	-0.43***	-0.41***
	(0.05)	(0.06)	(0.07)	(0.08)	(0.11)	(0.08)	(0.08)	(0.13)
$Reform_{jt}$	0.24**	0.30*	0.12	0.13	0.20*	0.17	-0.03	0.09
	(0.10)	(0.15)	(0.11)	(0.17)	(0.11)	(0.13)	(0.13)	(0.13)
Observations	64,022	64,022	63,704	63,704	48,983	48,983	61,081	61,081
Output Tariff Controls	✓	✓	✓	✓	✓	✓	✓	✓
Input Tariff Controls	–	✓	–	✓	–	✓	–	✓
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Age FE	✓	✓	✓	✓	✓	✓	✓	✓

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Controlling for Size and State

Dependent Variable	**Revenues**		**Capital**		**Wages**		**MRPK**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Reform_{jt} \times I_i^{High\ MRPK}$	0.16***	0.24***	0.56***	0.51***	0.22*	0.22**	-0.42***	-0.31***
	(0.06)	(0.06)	(0.14)	(0.07)	(0.11)	(0.10)	(0.09)	(0.12)
$Reform_{jt}$	0.12	0.10	0.00	0.06	0.01	0.03	0.04	-0.06
	(0.09)	(0.08)	(0.09)	(0.08)	(0.018	(0.09)	(0.13)	(0.13)
$Reform_{jt} \times Log(Size)$		-0.03		-0.01		-0.00		0.00
		(0.02)		(0.02)		(0.02)		(0.03)
Observations	64,009	64,009	63,697	63,697	48,968	48,968	61,061	61,061
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
State×Year FE	✓	–	✓	–	✓	–	✓	–
Size Decile×Year FE	–	✓	–	✓	–	✓	–	✓
Age FE	✓	✓	✓	✓	✓	✓	✓	✓

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Controlling for Reservation Laws

Dependent Variable	**Revenues**		**Capital**		**Wages**		**MRPK**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Reform_{jt} \times I_i^{High\ MRPK}$	0.20***	0.19***	0.67***	0.55***	0.41***	0.25**	-0.48***	-0.38***
	(0.03)	(0.05)	(0.05)	(0.10)	(0.09)	(0.12)	(0.06)	(0.11)
$Reform_{jt}$	0.22**	0.13	0.00	-0.02	-0.00	-0.01	0.06	0.04
	(0.08)	(0.09)	(0.09)	(0.07)	(0.11)	(0.09)	(0.13)	(0.12)
Sample: No dereservation	✓	–	✓	–	✓	–	✓	–
Dereservation Controls	–	✓	–	✓	–	✓	–	✓
Observations	28,987	64,022	28,760	63,704	22,110	48,983	27,496	61,081
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Age FE	✓	✓	✓	✓	✓	✓	✓	✓

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Quantity Production Function

Dependent Variable	**Revenues**	**Capital**	**Wages**	**MRPK**
	(1)	(2)	(3)	(4)
$Reform_{jt} \times I_i^{High\ MRPK}$	0.21**	0.45***	0.15*	-0.49***
	(0.09)	(0.12)	(0.08)	(0.10)
$Reform_{jt}$	0.18	0.20*	0.15	0.18**
	(0.11)	(0.11)	(0.11)	(0.07)
Observations	32,339	32,557	26,257	19,605
Firm FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Age FE	✓	✓	✓	✓

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Aggregate Estimator: Producer

- Firm i produces gross output y_i by using input y_{ij} with technology

$$y_i = A_i f(y_{ij})$$

- Firm-level net output c_i $c_i = y_i - \sum_{j \in I} y_{ij}$
- Assume firms minimize costs

$$\mathcal{C}_i(p, y_i) = \sum_j p_j y_{ij} + \gamma_i (y_i - A_i f_i(y_i)) \qquad with\ \gamma_i : Lagrangian$$

- From FOC, get markup (output wedge)

$$\mu_i = \frac{p_i}{\partial \mathcal{C} / \partial y_i} = \frac{p_i}{\gamma_i}$$

Aggregate Estimator: Perturbation Around Equilibrium

$$d\log y_i = \sum_j \frac{\partial \log f_i}{\partial \log y_{ij}} d\log y_{ij} + d\log A_i$$

And in net output

$$d\log c_i = \frac{y_i}{c_i} d\log y_i - \sum_{j\in I} \frac{y_{ij}}{c_i} d\log y_{ij}$$

Define total industry-level output $PC = \sum_{i\in I} p_i c_i$

$$d\log C = \sum_i \frac{p_i c_i}{PC} d\log c_i = \sum_i \left(\frac{p_i y_i}{PC} d\log y_i - \sum_{j\in I} \frac{p_i y_{ij}}{PC} d\log y_{ij} \right)$$

Aggregate Estimator: Approximation of Solow Residual

$$\Delta Solow_I \approx d\log C - \sum_{i\in I}\sum_{j\notin I}\frac{p_j y_{ij}}{p_i y_i}\frac{p_i y_i}{PC} d\log y_{ij}$$

$$\Delta Solow_I \approx \sum_{i\in I}\lambda_i(1-\frac{1}{\mu_i})(d\log y_i - d\log A_i) + \sum_{i\in I}\lambda_i d\log A_i$$

- Transformation / definition:
  - output wedge into input wedges: $\mu_i^x = 1 + \tau_i^x$
  - α_i^x: output elasticity of input i wrt input $x \Rightarrow d\log y_i - d\log A_i = \sum_{x\in\{k,l,m\}} \alpha_i^x$

$$\Delta Solow_{I,t} \approx \sum_{i\in I}\lambda_i \Delta\log A_i \quad + \sum_{\substack{i\in I \\ x\in\{k,l,m\}}} \lambda_i\ \alpha_i^x\ \tau_i^x\ \Delta\log x_i$$

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Lower Bound τ_i^x

- Post-policy wedge: $\tau_{post}^x = \tau_{pre}^x + \Delta\tau^x$
  - $\Delta\tau^x$: Change in τ^x due to the policy.
- Then

$$\min_{\tau_{post}^x \geq 0} \tau_{pre}^x = -\Delta\tau^x$$

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Deriving Estimates of Lower Bound τ_i^x

Focus on case of capital:

- Define $\log(MRPK_{it}) = \log(mrpk_{it}) + \mu_i + \eta_t + \epsilon_{it}$,
  - $MRPK_{it}$: measured MRPK
  - $mrpk_{it}$: true MRPK
- For pre-treatment or untreated firms:

$$\log(mrpk_{ijt}) = \log(1 + \tau_{it}^k) + \log(p_t^k)$$

- For post-treatment firms,

$$\log(mrpk_{ijt}) = \log(p_t^k).$$

Deriving Estimates of Lower Bound τ_i^x

If $Reform_j = 0$ or $Reform_j = 1$ and $t < T_j$:

$$\log(MRPK_{ijt}) = \log(1 + \tau_{it}^k) + \log(p_t^k) + \mu_i + \eta_t + \epsilon_{it}$$

For firms where $Reform_j = 1$ and $t \geq T_j$:

$$\log(MRPK_{ijt}) = \log(p_t^k) + \mu_i + \eta_t + \epsilon_{it}$$

Deriving Estimates of Lower Bound τ_i^x

Now, consider the difference-in-differences regression

$$\log MRPK_{ijt} = g_i(\textit{Reform}_{jt}) + \mathbf{\Gamma X_{it}} + \alpha_i + \delta_t + \epsilon_{ijt}$$

Then:

$$E(\log(1+\tau_i^k)|g(\textit{Reform}_{jt})) = E(\hat{g}_i(1)),$$

allowing us to predict $\widehat{\log(1+\tau_i^k)}$

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