Land Market Frictions in Developing Countries: Evidence from Manufacturing Firms in India

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July 22, 2022
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Introduction

- Manufacturing firms in developing countries are small (Hsieh & Oklen, 2014)
- Literature Reasons: mismanagement (Bloom et al., 2013), labor frictions (Besley & Burgess, 2004), misallocation (Hsieh & Klenow, 2009)
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- New Reason: land market frictions
  - Small land parcels
    - Inheritance system: land bequeathed from father to all sons
  - Unclear land titles
  - Land aggregation difficult:
    - Hundreds of negotiations, high chances of legal challenges

- Issue in India, Bangladesh, Nepal, Vietnam, Ghana, Ethiopia
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Motivating Example: Land Aggregation US vs. India

► **US:**
  ► Median non-residential land parcel size is 234 acres
  ► GM (Fort Wayne) acquired 937 acres from 29 owners in 2 months

► **India:**
  ► Average parcel: 5.7 acres (1971)
  ► → 2.8 acres (2011)
  ► Tata Nano car plant: aggregated 997 acres from 13,970 parcels
    (12,000 owners) (Ghatak et al., 2013)
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Land Parcels: One Square Mile in U.S. vs India

- Fort Wayne (GM)
- Singur (Tata Nano)

- Average Parcel Size across States over Time
Research Question: What are the costs of land frictions on profits and growth rates of manufacturing establishments in India?
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- **Difficulties in Estimation**:
  - Hundreds of sources of land frictions; no land policy index
  - Land aggregation costs not directly observed (effort, lawyers fees)
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- **Research design**:
  - Novel establishment panel data with land investment info
  - Dynamic structural establishment land acquisition model
    - Infer land aggregation costs from establishment land adjustment behavior (*bite size* and *frequency*) using *revealed preference*
  - Estimate land input elasticity: production function estimation: (Ackerberg et al, 2015)
  - Policy experiments:
    - Eminent domain restrictions in 2015
    - Policy discussion now: land pooling policies
Related Literature

- **Hindrance to growth in Indian manufacturing:** mismanagement (Bloom et al., 2013), labor frictions (Besley & Burgess, 2004), misallocation (Banerjee & Duflo, 2005; Hsieh & Klenow, 2009), land misallocation (Duranton, Ghani, Goswami and Kerr, 2015)

- **Land frictions in India:** agriculture (see Bolhuis et al., 2021; Manjunatha et al., 2013), urban development (Harari, 2020; Gandhi et al., 2021, Gechter & Tsivanidis, 2022), case studies on land aggregation (Ghatak and Mookherjee, 2014; Ghatak et al, 2013)

- **Land fragmentation and property rights across the globe:** development (De Janvry et al., 2015; Feder & Feeny, 1991; Deininger & Feder, 2001), land regulation (Herkenhoff et al, 2018; Glaeser & Ward, 2009, Hsieh & Moretti, 2019)

- **Methodology:** adjustment costs literature (Caballero, 1999; Ryan, 2012), production function estimation (Ackerberg et al, 2015)
Data (1/2)

Combine establishment panel with land adjustments + land parcel distribution

▶ Establishment balance-sheet for manufacturers from Annual Survey of Industries (ASI)
  ▶ Census for employment > 100, 1/3-1/2 sample for emp. > 10
  ▶ Panel of 48,516 establishments [1999-2015]

▶ Features:
  ▶ Sales, labor, material inputs, entry date, other characteristics
  ▶ Location anonymized at state level
  ▶ Ownership structure: private or government affiliated

▶ Key feature: Capital stock disaggregated into land, buildings, plants and machinery, and other fixed assets.
Data (1/2)

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- Key feature: Capital stock *disaggregated* into land, buildings, plants and machinery, and other fixed assets.

* Determination of Baseline Sample
Data (2/2)

- Data on land:
  - Land separate from building
  - Opening and closing book value of land
  - Additions, sales separate from revaluations

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<tr>
<th></th>
<th>Opening Value</th>
<th>Addition</th>
<th>Revaluation</th>
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<td>Est. A</td>
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Paper estimates non-price costs of land aggregation
Can capture friction effects on land prices, not directly estimate it

Size distribution of land parcels across regions
Manufacturing Summary Stats
Land Adjustment over Time
Data (2/2)

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Small Bite Strategy

- Land friction environment differs across:
  1. **Ownerships**: Govt. affiliated establishments (8%) eminent domain (BCG, 2014)
  2. **States**: Heterogeneity in land policies, parcel size, land records

- Hypothesis: land agg. behavior differs across ownerships, regions

- Response of establishments:
  - Hard to get land in one go, aggregate in small bites over time
  - *Small bite strategy*
    - Private establishments
    - Establishments in regions with smaller parcels

- Ownership, regional variation to identify land aggregation costs

- Govt. affiliated establishments as benchmark: outcome with lower frictions
Evidence for Small Bite Strategy and Effect of Frictions

- **Small bite strategy**: smaller bite size, higher bite frequency
  - Bite size: mean land add value

- Land bite strategy different across:
  - Ownership: private establishments follow small bite strategy
  - Smaller parcels in state: small bite strategy

- Aggregation is gradual, can take years:
  - 25% establishments sit on land for 5 years or longer
Government vs Private Discrepancy in Land Bite Strategy

![Graph showing the discrepancy in mean bite size and mean addition instances between government and private land. The x-axis represents mean bite size in 1000 USD, while the y-axis represents mean addition instances. The graph includes a scatter plot with crosses representing government-private instances (3675).]
Government vs Private Discrepancy in Land Bite Strategy

![Graph showing the comparison between government and private land bite strategy.](image-url)
Government vs Private Discrepancy in Land Bite Strategy

Mean Bite Size (1000 USD)

- Vehicles
- Textiles

Govt.-Private (3675)
Private (15,166)
Government vs Private Discrepancy in Land Bite Strategy

The graph illustrates the comparison between government and private strategies in land bite size. The x-axis represents the mean bite size in thousands of USD, while the y-axis shows the mean addition instances. Different categories such as Basic Metals, Textiles, and Vehicles are plotted, with government strategies represented by blue crosses and private strategies by red triangles. There is a noticeable discrepancy in bite size and instances between government and private strategies, with government instances being generally lower.

Key points:
- **Basic Metals**
  - Government instances (Govt.-Private) are approximately 1-1.5
  - Private instances are around 2-2.5
- **Textiles**
  - Government instances are around 0.5-1
  - Private instances are around 1.5-2
- **Vehicles**
  - Government instances are around 0.5-1
  - Private instances are around 1.5-2

The data indicates a significant discrepancy in bite size and instances between government and private strategies, with private strategies generally involving larger bite sizes and instances.
<table>
<thead>
<tr>
<th>State</th>
<th>Mean Parcel Size (acres)</th>
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<tbody>
<tr>
<td>Bihar</td>
<td>0.43</td>
</tr>
<tr>
<td>West Bengal</td>
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<tr>
<td>Uttar Pradesh</td>
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<tr>
<td>Tamil Nadu</td>
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<tr>
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## Land Bite Strategy: Across States

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<tr>
<th>State</th>
<th>Mean Parcel Size (acres)</th>
<th>Mean Bite Size ($1000)</th>
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<tbody>
<tr>
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<td>0.43</td>
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<tr>
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Land bite strategy varies across:
  - Ownership
  - States (land fragmentation)
  - Smaller parcels across states also correlated with:
    - Building additions
    - Establishment size (labor and revenue)

Observe small bite strategy after controlling:
  - Establishment revenue, rural/urban dummy, industry FE, state FE
  - State level controls: fixed capital, workers, output, railway and highway length, electricity deficit, 2001 and 2011 census
  - Credit constraints (Rajan & Zingales, 1998; Duflo & Banerjee, 2014):
    - Establishment loan-to-value and cash-in-hand

Moving forward:
  - Quantify costs of land market frictions
    - Estimate time and effort costs across ownerships and states
  - Policy Experiments: eminent domain restrictions; land pooling
Model Overview

- Study land markets with multiple agents: buyers and sellers
- Focus on demand for land by manufacturing establishments
  - Single agent dynamic discrete choice model
  - Establishments take land market friction environment as given

- Land add decisions: both intensive and extensive margin
- Whether to buy and how much to buy

- Recover land aggregation cost structure using:
  - Revealed preferences: infer from establishment’s land bite strategy
  - Frequency of land bites: fixed costs
  - Size of land bites: convex costs

- Estimate fixed and convex costs across ownerships and locations
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State Variables and Timing

- Time is discrete, each decision period is one year
- State variables are land $\ell$ and plant productivity $z$
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- State variables are land $\ell$ and plant productivity $z$

Timing:
1. State variable land is carried from last period, productivity is realized
2. Land purchase or sale decision shocks are realized
3. Incumbents make land adjustment decisions
4. Land adjusts deterministically if land purchase or sale was made
5. Per period profits are realized
Profit Function

- Production function for establishment $i$ in industry $s$:
  \[ f_{is}(\ell, z; \alpha) = z_i \ell_i^{\alpha_1 s} n_i^{\alpha_2 s} k_i^{\alpha_3 s} e_i^{\alpha_4 s} \]
- $z$: productivity, $\ell$: land, $n$: labor, $k$: capital, $e$: materials, energy, fuel
Profit Function

- Production function for establishment $i$ in industry $s$:

$$f_{is}(\ell, z; \alpha) = z_i^{\alpha_1} \ell_i^{\alpha_2} n_i^{\alpha_3} k_i^{\alpha_4} e_i^{\alpha_5}$$

- $z$: productivity, $\ell$: land, $n$: labor, $k$: capital, $e$: materials, energy, fuel

- Capital $k$ is a free variable

- Establishment pay labor $w$, capital $r$, materials $p_e$

- Payment for land input is done when land is acquired

- Per period profit function:

$$\bar{\pi}_{is}(\ell, z; \alpha) = p_s f_{is}(\ell, z; \alpha) - w_i n_i - r k_i - p_e e_i$$
Land Adjustment Cost Function (1/3)

- $m_{it}$ is total land adjustment in period $t$ by establishment $i$
- Land adjustment cost function at location $j$ is

$$C\left( m_{it}; \gamma_j \right) = \mathbb{1}_{m_{it}>0} \left( \gamma_0 + m_{it}^{1+\gamma_2} \right)$$

- Land cost function captures keys aspects of land frictions:
  - Fixed costs ($\gamma_0$): generate lumpiness, induces decision to adjust; adjustments not made every period
  - Convex parameter ($\gamma_2$): reduces the amount of land investment; difficult to put together land in one go
  - $\gamma_0$, $\gamma_2$ also differ by ownership, but notation suppressed
Land Adjustment Function (2/3)

\[ C(m_{it}; \gamma_j) = \mathbb{1}_{m_{it} > 0} \left( \gamma_0 + m_{it}^{1+\gamma_2} \right) \]

- \( m_{it} \) is value of land
- Effect of frictions on prices is already captured in \( m_{it} \)
- \( \gamma_0, \gamma_2 \) estimate non-price costs of frictions: time, effort costs
- If there were no land market frictions:
  - \( \gamma_0, \gamma_2 = 0 \)
  - \( C(m_{it}; \gamma_j) = m_{it} \)
Land Adjustment Function (3/3)

\[ C(m_{it}; \gamma_j) = \mathbb{I}_{m_{it}>0}(\gamma_0 + m_{it}^{1+\gamma_j}) \]

- Establishments land adjustment decisions induced by:
  - Productivity \( z \): follows a Markov process
  - Extreme value i.i.d logit shock \( \epsilon_{imt} \)
    ▶ Captures cases like land parcel is available for sale next to a establishment, not observed by econometrician
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- Logit shock of land adjustment is associated with both:
  - Intensive margin
  - Extensive margin
- Shock \( \epsilon_{i0} \) is associated with no land investment \( m_{it} = 0 \)
Value Function for Incumbent

\[ V_i(z, \ell) = \max \left\{ \begin{array}{l}
\epsilon(m_i=0) + \bar{\pi}_{ij}(\ell, z; \alpha) + \beta \mathbb{E}_{\epsilon, z} V_i(z', \ell) \\
\max_{m_i > 0} \left( -\gamma_0sj - m_{ist}^{1+\gamma_{2sj}} + \epsilon(m_i>0) \right) + \bar{\pi}_{ij}(\ell + m_i, z; \alpha) + \beta \mathbb{E}_{\epsilon, z} V_i(z', \ell + m_i) \end{array} \right\}, \]

no land adjustment

positive land adjustment
Identification of Land Aggregation Cost Parameters

- Identification: variation in adjustment across ownerships, locations
- 3 establishments in auto industry across locations, same productivity
- Lumpy land adjustments: high fixed costs (Est. A)
- Smaller parcels, add land in small bites: high convexity (Est. B)
- Land adjusted less frequently: high fixed & convex costs (Est. C)
Outline

1 Introduction

2 Data and Descriptive Evidence
   ▶ Data
   ▶ Evidence for Small Bite Strategy

3 Model

4 Estimation and Results
   ▶ Production Function Estimation
   ▶ Estimation of Dynamic Parameters
   ▶ Results

5 Counterfactual Experiments
   ▶ Eminent Domain Restrictions (2015)
   ▶ Land Pooling Policies

6 Conclusion
Empirical Strategy

- Step 1: Estimate production function parameters, productivity using control function approach (Ackerberg et al, 2015)
  - Methodology accounts for endogeneity in land and capital
  - Estimated land coefficient $\hat{\alpha}_1$, other input coefficients $\tilde{\alpha}$
  - Estimated establishment-specific residual $\hat{z}_t$ over time
Empirical Strategy

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  - Estimated establishment-specific residual $\hat{z}_t$ over time

- Step 2: Estimation of land aggregation cost structure
  - Discretize state space $\ell, \hat{z}$
  - Nested Fixed Point MLE

- Estimate parameters for 10 largest industries, 8 largest manufacturing states, and 2 ownerships
Step 2: Specification for Estimation of Land Costs (1/2)

- Each period is one year
- Establishments discount the future at rate $\beta = 0.95$
- Markov process for productivity $z_t$ differs across ownerships
- Continuous decision of how much to invest is discretized
  - Index $b$ ($b = 0, \ldots, B$) corresponds to discrete adjustment levels
  - Establishment draws logit land adjustment draw $\epsilon_{ib}$
  - $\epsilon_{i0}$ is the shock associated with no land investment $m_{ib} = 0$
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- Nested logit:
  - Allow for correlation $\lambda$ across positive land adjustment levels
  - $\lambda = 0$ is simple logit

Details
Step 2: Specification for Estimation of Land Costs (2/2)

- **Baseline Specification:**
  - Estimate fixed cost $\gamma_0$, curvature parameter $\gamma_2$
  - $\gamma_0, \gamma_2$ estimated flexibly without restrictions
  - Adjustment discretized to 5 levels of investment (6 total choices)
  - Nested logit
Step 2: Specification for Estimation of Land Costs (2/2)

- **Baseline Specification:**
  - Estimate fixed cost $\gamma_0$, curvature parameter $\gamma_2$
  - $\gamma_0, \gamma_2$ estimated flexibly without restrictions
  - Adjustment discretized to 5 levels of investment (6 total choices)
  - Nested logit

- **Alternative Specifications:**
  - Adjustment levels also discretized to 7, 9, 11 levels of investment
  - Simple logit ($\lambda = 0$)
Step 1: Production Function Results

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<td>All Industries</td>
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<td></td>
<td>(0.004)</td>
<td>(0.009)</td>
<td>(0.014)</td>
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<tr>
<td>Food Products (10)</td>
<td>0.019</td>
<td>0.005</td>
<td>0.259</td>
<td>23,677</td>
</tr>
<tr>
<td></td>
<td>(0.013)</td>
<td>(0.017)</td>
<td>(0.027)</td>
<td></td>
</tr>
<tr>
<td>Wearing Apparel (14)</td>
<td>0.036</td>
<td>0.109</td>
<td>0.306</td>
<td>3,444</td>
</tr>
<tr>
<td></td>
<td>(0.017)</td>
<td>(0.042)</td>
<td>(0.118)</td>
<td></td>
</tr>
<tr>
<td>Leather (15)</td>
<td>0.038</td>
<td>0.096</td>
<td>0.493</td>
<td>2,466</td>
</tr>
<tr>
<td></td>
<td>(0.021)</td>
<td>(0.034)</td>
<td>(0.029)</td>
<td></td>
</tr>
<tr>
<td>Printing (18)</td>
<td>0.026</td>
<td>0.043</td>
<td>0.255</td>
<td>1,466</td>
</tr>
<tr>
<td></td>
<td>(0.017)</td>
<td>(0.027)</td>
<td>(0.035)</td>
<td></td>
</tr>
<tr>
<td>Chemical Products (20)</td>
<td>0.024</td>
<td>0.083</td>
<td>0.261</td>
<td>6,342</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.032)</td>
<td>(0.073)</td>
<td></td>
</tr>
<tr>
<td>Non-Metallic Minerals (23)</td>
<td>0.035</td>
<td>0.190</td>
<td>0.292</td>
<td>5,372</td>
</tr>
<tr>
<td></td>
<td>(0.016)</td>
<td>(0.061)</td>
<td>(0.078)</td>
<td></td>
</tr>
<tr>
<td>Other Manufacturing (32)</td>
<td>0.084</td>
<td>0.034</td>
<td>0.483</td>
<td>1,629</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.058)</td>
<td>(0.078)</td>
<td></td>
</tr>
</tbody>
</table>
Production Function Results

- Land is significant input: elasticity 0.011 - 0.084

- The capital coefficient *excluding* land is estimated to be 0.14 and labor 0.28
  - All capital: 0.09, labor: 0.27 (Collard-Wexler & De Loecker, 2020)

- Provide a land input production function coefficient for India and other countries at establishment level
  - Estimates at sectoral level (US) is 0.04 - 0.1 (Herrendorf & Valentinyi, 2008; Nordhaus, 1992)
## Land Aggregation Cost Parameters: Across Ownership

### Table: Nested Logit Specification

<table>
<thead>
<tr>
<th>Ownership</th>
<th>Fixed Costs ($\gamma_0$)</th>
<th>Curvature ($\gamma_2$)</th>
<th># Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Govt. Affiliated</td>
<td>19.535</td>
<td>0.0124</td>
<td>5,986</td>
</tr>
<tr>
<td></td>
<td>(1.009)</td>
<td>(0.0021)</td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>42.371</td>
<td>0.0389</td>
<td>56,092</td>
</tr>
<tr>
<td></td>
<td>(0.148)</td>
<td>(0.0015)</td>
<td></td>
</tr>
</tbody>
</table>

$\lambda = 0.58$

(0.027)

---

Note: This table presents estimates of the dynamic parameters across ownership codes pooled over 10 industry codes. Standard errors are in parenthesis. Results evaluated at 1,000 US Dollars in 2005 constant prices.

### Alternative Specifications
Land Aggregation Cost Estimates: Across Ownerships

- Fixed costs ($\gamma_0$): $19,535 for govt. affiliated, $42,371 for private
  - Govt. Affiliated: fixed costs 1.7% of mean land add value
  - Private: fixed costs 14% of mean land add value

- Convex costs ($\gamma_2$): 0.0124 for govt. affiliated, 0.0389 for private
  - Govt. Affiliated: convexity adds 19% extra costs for 90th percentile land add
  - Private: adds 68% extra costs for 90th percentile land add
Land Aggregation Cost Estimates: Across Ownerships

- **Fixed costs ($\gamma_0$):** $19,535 for govt. affiliated, $42,371 for private
  - Govt. Affiliated: fixed costs 1.7% of mean land add value
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- **Convex costs ($\gamma_2$):** 0.0124 for govt. affiliated, 0.0389 for private
  - Govt. Affiliated: convexity adds 19% extra costs for 90th percentile land add
  - Private: adds 68% extra costs for 90th percentile land add

Fitted Values: Land Aggregation Costs across Ownerships
# Land Costs Across State

<table>
<thead>
<tr>
<th>States</th>
<th>Fixed Costs ($\gamma_0$)</th>
<th>Convex Costs ($\gamma_2$)</th>
<th># Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gujarat</td>
<td>17.045</td>
<td>0.0409</td>
<td>6274</td>
</tr>
<tr>
<td></td>
<td>(2.358)</td>
<td>(0.0016)</td>
<td></td>
</tr>
<tr>
<td>Maharashtra</td>
<td>39.713</td>
<td>0.0599</td>
<td>9625</td>
</tr>
<tr>
<td></td>
<td>(1.029)</td>
<td>(0.0023)</td>
<td></td>
</tr>
<tr>
<td>Karnataka</td>
<td>62.396</td>
<td>0.0121</td>
<td>2879</td>
</tr>
<tr>
<td></td>
<td>(2.108)</td>
<td>(0.0028)</td>
<td></td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>58.364</td>
<td>0.0293</td>
<td>8566</td>
</tr>
<tr>
<td></td>
<td>(1.383)</td>
<td>(0.0015)</td>
<td></td>
</tr>
<tr>
<td>Punjab</td>
<td>28.628</td>
<td>0.0321</td>
<td>2768</td>
</tr>
<tr>
<td></td>
<td>(2.381)</td>
<td>(0.0006)</td>
<td></td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>92.763</td>
<td>0.0219</td>
<td>4069</td>
</tr>
<tr>
<td></td>
<td>(2.049)</td>
<td>(0.0029)</td>
<td></td>
</tr>
<tr>
<td>Assam</td>
<td>39.562</td>
<td>0.0517</td>
<td>2437</td>
</tr>
<tr>
<td></td>
<td>(3.739)</td>
<td>(0.0024)</td>
<td></td>
</tr>
</tbody>
</table>

$\lambda = 0.46$

(0.089)
Land Aggregation Cost Estimates: Across State

- Fixed costs ($\gamma_0$): $17,045 - $152,058
  - Gujarat: fixed costs are 2.3% of mean land add value
  - Uttar Pradesh: fixed costs are 18% of mean land add value
  - Rajasthan: fixed costs are 27% of mean land add value
Land Aggregation Cost Estimates: Across State

- **Fixed costs** ($\gamma_0$): $17,045 - 152,058
  - Gujarat: fixed costs are 2.3% of mean land add value
  - Uttar Pradesh: fixed costs are 18% of mean land add value
  - Rajasthan: fixed costs are 27% of mean land add value

- **Curvature parameter** ($\gamma_2$): 0.012 - 0.060; convexity adds:
  - Karnataka: 19% extra costs for 90th percentile land add
  - Assam: 82% extra costs for 90th percentile land add
  - Maharashtra: 119% extra costs for 90th percentile land add

Fitted Values: Land Aggregation Costs across States
Corroborating Evidence for Estimated Parameters

- No data on hundreds of sources of land frictions
- Can corroborate estimated land aggregation costs with:
  - Average land parcel size in state
  - Share of land related court cases in a state
  - State government’s land leasing policy measure
Estimated Costs and Average Land Parcel Size

Note: This figure plots the estimated fixed costs in $1,000 constant prices against the average land parcel size in a state. The data on land parcel size if from Agricultural Census.

Corr = -0.61

Estimated Convex Costs and Land Court Cases

Estimated Fixed Costs and Land Lease Policy
Estimated Curvature Costs and Land Court Cases

- % of land related court cases of civil cases (Boehm & Oberfield, 2018)

![Graph showing the estimated curvature costs against the percent of land related civil court cases in 2015. The data on land court cases is self-collected from National Judicial Data Grid.]

Note: This figure plots the estimated curvature costs against the percent of land related civil court cases in 2015. The data on land court cases is self-collected from National Judicial Data Grid.
Outline

1. Introduction
2. Data and Descriptive Evidence
   ▶ Data
   ▶ Evidence for Small Bite Strategy
3. Model
4. Estimation and Results
   ▶ Production Function Estimation
   ▶ Estimation of Dynamic Parameters
   ▶ Results
5. Counterfactual Experiments
   ▶ Eminent Domain Restrictions (2015)
   ▶ Land Pooling Policies
6. Conclusion
Counterfactual Policy Experiments

- Study effects of two policies:
  1. Eminent domain restrictions (2015)
     - Reduces the scope of eminent domain for manufacturing
  2. Proposed land pooling policies
     - Govt. acting as intermediary to aggregate land for establishments

- Study effect of small, targeted changes for establishments:
  - Land pooling proposals are of modest size
  - Large effect on land aggregation costs for establishments
  - GE effects on land and output prices relatively small

- Effect on:
  - Establishment profits and growth
  - Land misallocation
Effect of Eminent Domain Law Restrictions

- Quantify effect on govt. affiliated establishments post 2015 restrictions (data ends in 2015)

- For govt. affiliated establishments, set land costs:
  - Same as private establishments land aggregation costs
  - $\gamma_0 = 42.371$
  - $\gamma_2 = 0.0389$

- Production function parameters left unchanged

- Compare establishments with same initial productivity level across govt. affiliated and private land aggregation parameters
  - Productivity Markov process across ownerships remains unchanged
## Effect of Eminent Domain Law Restrictions

<table>
<thead>
<tr>
<th>Start Productivity Percentile</th>
<th>Profit $\Delta$</th>
<th>Profit $\Delta\ %$</th>
<th>Growth (10 year) $%$</th>
</tr>
</thead>
<tbody>
<tr>
<td>10th</td>
<td>-1012</td>
<td>-1.07%</td>
<td>-1.81%</td>
</tr>
<tr>
<td>25th</td>
<td>-1733</td>
<td>-1.70%</td>
<td>-2.57%</td>
</tr>
<tr>
<td>50th</td>
<td>-2591</td>
<td>-2.15%</td>
<td>-3.72%</td>
</tr>
<tr>
<td>75th</td>
<td>-3155</td>
<td>-2.41%</td>
<td>-4.23%</td>
</tr>
<tr>
<td>95th</td>
<td>-5083</td>
<td>-3.71%</td>
<td>-5.89%</td>
</tr>
<tr>
<td>99th</td>
<td>-6814</td>
<td>-4.80%</td>
<td>-6.74%</td>
</tr>
</tbody>
</table>

Note: Producer profits are means over different land input values. Results evaluated at 1,000 US Dollars in 2005 constant prices. NPV: net present value.
Effect of Land Pooling Policy

- Quantify effects of land pooling policy on establishment profits, growth rates

- Forward simulate establishment paths under the cost parameters $(\gamma_0, \gamma_2)$ of:
  - Best practices of Gujarat: lowest fixed costs
  - Best practices of Karnataka: lowest convex costs
  - Zero frictions: $\gamma_0 = 0, \gamma_2 = 0$

- Production function parameters left unchanged

- Compare establishments with same initial productivity level for establishments located in Maharashtra
  - Productivity Markov process across states remains unchanged
Land Pooling Policies for Establishments in Maharashtra (Profits)
Land Pooling for Maharashtra Establishments (Growth Rates)

Growth Rate (10 years)
Maharashtra
Gujarat
Karnataka
Land Pooling

Initial Productivity Percentile
5 15 25 35 45 55 65 75 85 95
0
2
4
6
8
10
12
0 2 4 6 8 10 12
5 15 25 35 45 55 65 75 85 95
Growth Rate (10 years)
Initial Productivity Percentile
Outline

1 Introduction

2 Data and Descriptive Evidence
   ▶ Data
   ▶ Evidence for Small Bite Strategy

3 Model

4 Estimation and Results
   ▶ Production Function Estimation
   ▶ Estimation of Dynamic Parameters
   ▶ Results

5 Counterfactual Experiments
   ▶ Eminent Domain Restrictions (2015)
   ▶ Land Pooling Policies

6 Conclusion
Conclusion

- Study the effects of land frictions on Indian manufacturing
  - Use novel data + dynamic structural model
  - Find large costs of land frictions on growth and profits
- Findings:
  - Small bite strategy
  - Estimated land costs differ significantly across states
  - Land costs are *three* times higher for private establishments
  - Land is significant input into manufacturing
- Policy Evaluation:
  - Eminent domain restrictions ↓ lifetime profits, growth, misallocation
  - Land pooling policies ↑ lifetime profits, growth
Appendix
Estimated Land Aggregation Costs across State

Note: This figure plots fitted values of total land aggregation costs against dollar value paid for a land transaction across different states.
### Determination of Base Sample

<table>
<thead>
<tr>
<th>Establishment (Est.) - Year</th>
<th>Dropped Observations</th>
<th>Resulting Sample Size</th>
<th>Resulting Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original ASI data</td>
<td>892,068</td>
<td>287,050</td>
<td></td>
</tr>
<tr>
<td>Non-manufacturing NIC codes</td>
<td>1,740</td>
<td>890,328</td>
<td>286,917</td>
</tr>
<tr>
<td>Closed, Deleted, Non-response</td>
<td>97,763</td>
<td>792,565</td>
<td>254,460</td>
</tr>
<tr>
<td>Missing state codes</td>
<td>50</td>
<td>792,515</td>
<td>254,410</td>
</tr>
<tr>
<td>More than one plant in state</td>
<td>36,602</td>
<td>755,913</td>
<td>250,883</td>
</tr>
<tr>
<td>Missing revenues</td>
<td>149,653</td>
<td>606,260</td>
<td>199,573</td>
</tr>
<tr>
<td>Missing land input</td>
<td>209,971</td>
<td>396,289</td>
<td>125,959</td>
</tr>
<tr>
<td>Establishments with one year only</td>
<td>48,029</td>
<td>348,260</td>
<td>77,930</td>
</tr>
<tr>
<td>Baseline sample</td>
<td>218,296</td>
<td>48,516</td>
<td></td>
</tr>
<tr>
<td>Restricted sample</td>
<td>140,903</td>
<td>28,336</td>
<td></td>
</tr>
</tbody>
</table>
Estimated Land Aggregation Costs across Ownerships

Note: This figure plots fitted values of total land aggregation costs against the dollar value paid for a land transaction across ownerships.
## Land Bite Strategy and Firm Ownership

<table>
<thead>
<tr>
<th>Private</th>
<th>(1) Bites</th>
<th>(2) Bites</th>
<th>(3) Bite Prob.</th>
<th>(4) Bite Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-7,899***</td>
<td>-11,500***</td>
<td>0.185***</td>
<td>0.167***</td>
<td></td>
</tr>
<tr>
<td>(684)</td>
<td>(485)</td>
<td>(0.002)</td>
<td>(0.003)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N</th>
<th>18,749</th>
<th>28,328</th>
<th>120,017</th>
<th>206,864</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>0.018</td>
<td>0.022</td>
<td>0.028</td>
<td>0.028</td>
</tr>
<tr>
<td>$dy/dx$</td>
<td>.024***</td>
<td>.020***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.0002)</td>
<td>(0.0003)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Firm Controls | Y | Y | Y | Y |
| State Controls | Y | Y | Y | Y |
| Loan to Value | Y | N | Y | N |
| Cash in Hand | Y | Y | Y | Y |
| State FE | Y | Y | Y | Y |
| Time Trend | Y | Y | Y | Y |
## Land Bite Strategy and Fragmentation

<table>
<thead>
<tr>
<th></th>
<th>(1) Bites</th>
<th>(2) Bites</th>
<th>(3) Bite Prob.</th>
<th>(4) Bite Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fragmentation</strong></td>
<td>4,506***</td>
<td>4,915***</td>
<td>0.101***</td>
<td>0.165***</td>
</tr>
<tr>
<td>N</td>
<td>(1,060)</td>
<td>(1,034)</td>
<td>(.026)</td>
<td>(.024)</td>
</tr>
<tr>
<td>R²</td>
<td>0.015</td>
<td>0.02</td>
<td>0.026</td>
<td>0.024</td>
</tr>
<tr>
<td>dy/dx</td>
<td></td>
<td></td>
<td>0.014***</td>
<td>0.021***</td>
</tr>
<tr>
<td>Firm Controls</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>State Controls</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Loan to Value</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Cash in Hand</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>State FE</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Time Trend</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

*Back to*
Share of Firms Not Building after Land Expansion

Note: This figure presents share of firms not building after land expansion varied across ownership status [1999-2015]. Establishments are either fully private owned, fully government owned or jointly owned by government and private parties. The data is from ASI.
Firm Growth and Parcel Size Distribution

- Land fragmentation $\rightarrow$ building expansion, firm size

- Empirical model:

$$Y_{ijt} = \beta_0 + \beta_1 \text{avg}_{jt} + \Gamma_1 X_{1it} + \Gamma_2 X_{2jt} + \eta_2 t + \epsilon_{ijt}$$

- $Y_{ijt}$:
  1. Dummy for positive building adjustment by firm $i$ in state $j$
  2. Firm size (log labor or log revenue)


- $X_{1it}$: firm controls, $X_{2it}$: location controls

- If $\beta_1 > 0$, lower land frag positively correlated with firm growth
## Fragmentation and Firm Size and Growth

<table>
<thead>
<tr>
<th></th>
<th>(1) Log Revenue</th>
<th>(2) Log Revenue</th>
<th>(3) Log Labour</th>
<th>(4) Log Labour</th>
<th>(5) Building Added</th>
<th>(6) Building Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fragmentation</td>
<td>0.146** (0.042)</td>
<td>0.288** (0.064)</td>
<td>0.097** (0.04)</td>
<td>0.147** (0.045)</td>
<td>2,844*** (612)</td>
<td>3,234*** (713)</td>
</tr>
<tr>
<td>N</td>
<td>118,994</td>
<td>204,827</td>
<td>119,952</td>
<td>206,300</td>
<td>57,864</td>
<td>90,645</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.228</td>
<td>0.210</td>
<td>0.386</td>
<td>0.396</td>
<td>0.028</td>
<td>0.037</td>
</tr>
<tr>
<td>Firm Controls</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>State Controls</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Loan to Value</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Cash in Hand</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>State FE</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Time Trend</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>
Density of Land Adjustment across Ownership Status

Note: This figure presents the land adjustment density of firms varied across ownership status [1999-2015]. Establishments are either fully private owned or jointly owned by government and private parties. Values are in 2005 constant thousand USD. The figure is truncated on both sides for clarity. The data is from ASI.
Intensive and Extensive Margin Decision of Land Adjustment

- Establishments make land adjustment decisions on the intensive and extensive margins induced by:
  - Productivity $z$ follows a Markov process
  - i.i.d logit structural error
- Curvature: reduces the amount of land investment
- Increase in $\gamma_{1j}$ or $\gamma_{2j}$ results in lower value of land investment
- Fixed costs: generate lumpiness, induces decision to adjust
- Increase in $\gamma_{0j}$ results in fewer land expansions
- Increase in the logit shock $(\epsilon(m_i=0) - \epsilon(m_i>0))$ results in fewer land expansions

- Value Function Incumbent
Value Function for Entrant

\[ V_i^e(z, \ell) = \max \left\{ 0, -\kappa_{ij} + \max_{m_i > 0} \left[ \left( -\gamma_0 s_j - (1 + \gamma_1 s_j) m_{ist}^{1+\gamma_2 s_j} + \epsilon(m_i > 0) \right) \right. \right. \]
\[ \left. \left. + \tilde{\pi}_{ij}(m_i, z; \alpha) + \beta \mathbb{E}_{\epsilon, z} V_i(z', m_i) \right] \right\} \]

\( \kappa_{ij} \) is entry cost
The empirical specification is given by:

\[ V(z, \ell) = \max_b \{ u(z, \ell, b) + \beta \mathbb{E}_{\epsilon, z} V_i(z', \ell', \epsilon') \} \]

where

\[ u(z, \ell, b) = \begin{cases} 
\hat{D}(\ell + m_b) \hat{\alpha}_1 - \gamma_0 sj - m_b^{1+\gamma_2 sj} + \epsilon_{mib>0} + \epsilon_{mib=0} & \text{if } b > 0 \\
\hat{D}(\ell) \hat{\alpha}_1 & \text{if } b = 0 
\end{cases} \]

where \( D \) is other non-land inputs into production function.
## Levinsohn-Petrin Estimated Productivity

<table>
<thead>
<tr>
<th>Industry (NIC Code)</th>
<th>Count</th>
<th>Mean</th>
<th>St. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Products (10)</td>
<td>19026</td>
<td>12.725</td>
<td>1.497</td>
</tr>
<tr>
<td>Textiles (13)</td>
<td>14983</td>
<td>12.036</td>
<td>1.139</td>
</tr>
<tr>
<td>Non-Metallic Mineral (23)</td>
<td>13752</td>
<td>10.551</td>
<td>1.463</td>
</tr>
<tr>
<td>Chemical Products (20)</td>
<td>10114</td>
<td>12.457</td>
<td>1.617</td>
</tr>
<tr>
<td>Basic Metals (24)</td>
<td>8165</td>
<td>12.207</td>
<td>1.383</td>
</tr>
<tr>
<td>Machinery &amp; Equipment (28)</td>
<td>8061</td>
<td>12.936</td>
<td>1.536</td>
</tr>
<tr>
<td>Wearing Apparel (14)</td>
<td>6114</td>
<td>10.634</td>
<td>1.123</td>
</tr>
<tr>
<td>Fabricated metals (25)</td>
<td>6628</td>
<td>12.023</td>
<td>1.372</td>
</tr>
<tr>
<td>Vehicles (29)</td>
<td>6631</td>
<td>11.741</td>
<td>1.253</td>
</tr>
<tr>
<td>Electrical Equipment (27)</td>
<td>6265</td>
<td>13.454</td>
<td>1.610</td>
</tr>
</tbody>
</table>

Note: This table presents the residual productivity estimates from Levinsohn and Petrin (2003) estimation on Indian manufacturing establishment data (1999-2015) using both land and capital as state variables.
Estimated Fixed Costs and Industrial Land Policy

- CSIS index ranks states on government lease terms for industrial purpose and openness to selling state land to private sector buyers (2015)

Note: This figure plots the estimated curvature costs against CSIS state land industrial policy index in 2015.
Motivating Fact 3: Land Fragmentation and Growth

- Correlation between land fragmentation and firm growth
- Regress the amount of building addition by establishment on average parcel size in a state
- The empirical model is given by the equation below:

\[ k_{ijt} = \alpha_0 + \alpha_1 f_{jt} + X_{it}\beta_1 + X_{jt}\beta_2 + \alpha_2\eta_i + \epsilon_{ijt} \]

- \( k_{ijt} \) is building addition by firm \( i \) in state \( j \) at time \( t \)
- \( f_{jt} \) is average land parcel size in state \( j \) at time \( t \)
- \( X_{it} \) and \( X_{jt} \) are firm and state characteristics, respectively.
- Average parcel size of a state for years 1995, 2000, 2005, 2010
- \( \eta_i \) captures firm fixed effects.
Land Input Adjustment in Cross-Section

Note: This figure presents the share of establishment adjusting land in a given cross section year [1999-2015]. The data is from ASI.
## Summary Statistics for Manufacturing Establishments

<table>
<thead>
<tr>
<th>Variable</th>
<th>Less Restrictive Sample</th>
<th>More Restrictive Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Obs.</td>
<td>Mean</td>
</tr>
<tr>
<td>Revenue</td>
<td>215,985</td>
<td>329,710</td>
</tr>
<tr>
<td>Wage Bill</td>
<td>217,611</td>
<td>66,435</td>
</tr>
<tr>
<td>Other Capital</td>
<td>201,726</td>
<td>214,952</td>
</tr>
<tr>
<td>Land</td>
<td>213,234</td>
<td>32,576</td>
</tr>
<tr>
<td>Land Purchase</td>
<td>29,662</td>
<td>23,073</td>
</tr>
<tr>
<td>Land Sales</td>
<td>8,558</td>
<td>14,416</td>
</tr>
<tr>
<td>Percent Govt. Aff.</td>
<td>218,003</td>
<td>7.65</td>
</tr>
<tr>
<td>Percent Urban</td>
<td>218,237</td>
<td>49.15</td>
</tr>
</tbody>
</table>
Average Parcel Size over Time

![Average Parcel Size over Time graph]

- Back to
Note: This figure presents the percent of building events (cumulative density function) preceded by land aggregation over one land bite (or transaction) or more. Building events considered are building events are large building events requiring land.
Production Function Estimation Details

- Take logs of production function:

\[
\log y_{it} = \alpha_0 s + \alpha_1 s \log \ell_{it} + \alpha_2 s \log n_{it} + \alpha_3 s \log k_{it} \\
+ \alpha_4 s \log e_{1it} + \alpha_5 s \log e_{2it} + \alpha_6 s \log e_{3it} + \omega_{it} + \epsilon_{it}
\]

- \( \omega_{it} = \log z_i \), firm’s optimal choice of materials \( e_{1i} \):

\[
\log e_{1i} = g_t(\log \ell_{it}, \log k_{it}, \omega_{it})
\]

\[
g_t(\log \ell_{it}, \log b_{it}, \omega_{it}) = \alpha_0 s + \alpha_1 s \log \ell_{it} + \alpha_3 s \log k_{it} \\
+ \alpha_4 s \log e_{1it} + \omega_{it}(\log \ell_{it}, \log b_{it}, e_{1it}) + \epsilon_{it}
\]

\[
\log y_{it} = \alpha_2 s \log n_{it} + g_t(\log \ell_{it}, \log k_{it}, \omega_{it}) + \alpha_5 s \log e_{2it} \\
+ \alpha_6 s \log e_{3it} + \epsilon_{it}
\]

- The standard errors are estimated using bootstrap method
Table: Baseline Specification 1

<table>
<thead>
<tr>
<th>Ownership</th>
<th>Fixed Costs ($\gamma_0$)</th>
<th>Curvature ($\gamma_2$)</th>
<th># Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Govt. Affiliated</td>
<td>30.655 (1.121)</td>
<td>0.0103 (0.0017)</td>
<td>5,986</td>
</tr>
<tr>
<td>Private</td>
<td>66.660 (0.343)</td>
<td>0.0355 (0.0008)†</td>
<td>56,092</td>
</tr>
</tbody>
</table>

Note: This table presents estimates of the dynamic parameters across ownership codes pooled over 10 industry codes. Standard errors are in parenthesis. Results evaluated at 1,000 US Dollars in 2005 constant prices.
## Land Aggregation Cost Estimates: Across State

### Table: Alternative Specification

<table>
<thead>
<tr>
<th>States</th>
<th>Fixed Costs ($\gamma_0$)</th>
<th>Convex Costs ($\gamma_2$)</th>
<th># Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gujarat</td>
<td>21.934 (1.964)</td>
<td>0.0403 (0.0007)</td>
<td>6274</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>43.602 (0.935)</td>
<td>0.0578 (0.0008) †</td>
<td>9625</td>
</tr>
<tr>
<td>Karnataka</td>
<td>66.408 (1.497)</td>
<td>0.0115 (0.0044)</td>
<td>2879</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>61.453 (0.756)</td>
<td>0.0288 (0.0007)</td>
<td>8566</td>
</tr>
<tr>
<td>Punjab</td>
<td>31.781 (1.692)</td>
<td>0.0313 (0.0019)</td>
<td>2768</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>96.652 (1.212)</td>
<td>0.0208 (0.0010)</td>
<td>4069</td>
</tr>
<tr>
<td>Assam</td>
<td>42.663 (2.026)</td>
<td>0.0508 (0.0017)</td>
<td>2437</td>
</tr>
</tbody>
</table>

Note: This tables presents estimates of dynamic parameters across states pooled over 10 industries. Standard errors are in parenthesis. Results evaluated at 1,000 US Dollars in 2005 constant prices.
Land Misallocation across Ownerships

- Misallocation measure: Olley-Pakes (OP) decomposition

\[
TFP_s = \sum_{i=1}^{n} s_i z_i
\]

- \( s_i \) is land input share of establishment \( i \) in industry \( s \)

\[
TFP_s = \sum_{i=1}^{n} (s_t + \Delta s_{it})(z_t + \Delta z_{it})
\]

\[
= \bar{z}_t + \sum_{i=1}^{n} (s_{it} - \bar{s}_t)(z_{it} - \bar{z}_t)
\]

\[
= \bar{z}_t + n\text{Cov}(s_{it}, z_{it})
\]

- \( \bar{z}_t, \bar{s}_t \): unweighted mean productivity, land share

- Lower the covariance OP term, higher land misallocation
# Land Misallocation across Ownerships

<table>
<thead>
<tr>
<th>Industry</th>
<th>All Establishments</th>
<th>Govt. Affiliated</th>
<th>Private</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Products (10)</td>
<td>56.69</td>
<td>4.94</td>
<td>50.72</td>
</tr>
<tr>
<td>Textiles (13)</td>
<td>14.57</td>
<td>5.57</td>
<td>9.57</td>
</tr>
<tr>
<td>Non-Metallic Mineral (23)</td>
<td>4.50</td>
<td>-0.20</td>
<td>4.04</td>
</tr>
<tr>
<td>Chemical Products (20)</td>
<td>76.17</td>
<td>7.29</td>
<td>64.71</td>
</tr>
<tr>
<td>Basic Metals (24)</td>
<td>82.82</td>
<td>15.17</td>
<td>62.42</td>
</tr>
<tr>
<td>Machinery &amp; Equipment (28)</td>
<td>61.18</td>
<td>22.10</td>
<td>37.97</td>
</tr>
<tr>
<td>Wearing Apparel (14)</td>
<td>45.19</td>
<td>4.71</td>
<td>37.27</td>
</tr>
<tr>
<td>Fabricated metals (25)</td>
<td>41.46</td>
<td>3.35</td>
<td>36.11</td>
</tr>
<tr>
<td>Vehicles (29)</td>
<td>69.09</td>
<td>5.85</td>
<td>59.78</td>
</tr>
<tr>
<td>Electrical Equipment (27)</td>
<td>61.95</td>
<td>11.75</td>
<td>46.51</td>
</tr>
</tbody>
</table>