Do Financial Frictions Explain Chinese Firm Saving and Misallocation?

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Motivation

• Literature emphasizes that financial frictions:
  - Generate high saving and outflow of capital
    - Song et al. (2011), Buera and Shin (2010), Mendoza et al. (2009)
  - Generate misallocation and low TFP
    - Hsieh and Klenow (2009), Midrigan and Xu (2014)

• We revisit the question: do financial frictions explain China’s high saving and capital misallocation?

• Literature either uses aggregate data or ignores firms’ financing patterns
This Paper

- Use micro-level Chinese data to quantify financial frictions
- Study its implications on firms saving and capital misallocation
  - Focus on firm: firms saving account for 50 percent of total saving in China
- In terms of misallocation and TFP
  - Examine model generated MPK
  - Dispersion of MPK is not enough to measure misallocation
  - We argue that covariance between marginal product capital (MPK) and firm size matters for misallocation
    - Restuccia and Rogerson (2008): large TFP losses must be associated with positively correlated taxes and firm productivity
Empirical Findings

• Compared to SOE, POE
  • Have lower leverage
  • Pay higher interest rate
  • Grow faster
  • Have higher MPK

• Among POEs, relative to large firms, small firms
  • Have lower leverage
  • Pay higher interest rate
  • Grow faster
  • Have higher MPK

Note that these patterns are not easily reconcile with exogenous borrowing constraints, for example collateral constraints
Model with Endogenous Borrowing Constraints

- We develop a model with heterogeneous firms and financial frictions including
  - Endogenous default risk
  - Fixed credit cost of borrowing

- Default risk generates endogenous borrowing constraints and differential interest rates across firms

- Higher credit cost leads to more correlated leverage and size
Quantify Financial Frictions in China

- We estimate the model with observed firm financing patterns and firm distribution.
- Financial frictions can explain aggregate firm saving and co-movement between saving and investment across firms.
- Financial frictions generate 60% of observed MPK dispersion, but an opposite MPK-size relationship.
  - TFP loss depends on both dispersion and covariance.
  - Intuitively, given the same MPK dispersion, whether subsidize small and tax large firms, or subsidize large and tax small, have different implications on TFP loss.
Literature

• Saving: Song et al. (2011), Buera and Shin (2010), Mendoza et al. (2009)


• Firm dynamics and financial frictions: Cooley and Quadrini (2001), Arellano, Bai, and Zhang (2010)

This paper: use micro level data and firm financing patterns to discipline financial frictions
Data
Chinese Manufacturing Firms

- Balance sheet data 1998-2006
  - SOE: State Owned enterprises, including sole state funded, state joint ownership and state and collective joint ownership
  - POE: private enterprises, including sole private, private partnership, private limited liability and private shareholding corporations
Chinese Manufacturing Firms

- Key variables:
  - Leverage = \( \frac{\text{liability}}{\text{asset}} \)  
  - Interest rate = \( \frac{\text{interest payment}}{\text{liability}} \)
  - Marginal product of capital

\[
\log[MPK_{ij}] = \log(\alpha_j) + \log\left(\frac{Y_{ij}}{K_{ij}}\right)
\]

\( \alpha_j \): sector j average capital share or industry fixed effect

\[
\log[MPK_{ij}] - \log[\overline{MPK}_{j}] = \log\left(\frac{Y_{ij}}{K_{ij}}\right) - \log\left(\frac{\overline{Y}_j}{\overline{K}_j}\right)
\]

\( Y_{ij} \): value added of firm i at sector j  
\( K_{ij} \): fixed asset of firm i at sector j  
\( \frac{\overline{Y}_j}{\overline{K}_j} \): sector j’s average value added-capital ratio
Leverage and Size

Leverage vs Asset by Sector

Note: Year 2006
Interest Rate and Size

Interest rate vs Asset by Sector

Note: Year 2006
Growth Rate and Size

Motivation

Data Model

Quantification

Sensitivity Analysis

Growth Rate

\[
\begin{array}{c|ccccc}
\text{lnasset} & -0.2 & 0 & 0.2 & 0.4 & 0.6 \\
\hline
\text{SOE} & 6 & 8 & 10 & 12 & 14 \\
\text{POE} & \end{array}
\]

Growth Rate vs lnasset (SOE vs POE)
MPK and Size

LogMPK vs Asset by Sector

Note: Year 2006
### Regression, Year 1999

<table>
<thead>
<tr>
<th></th>
<th>Leverage</th>
<th>Interest Rate</th>
<th>Growth Rate</th>
<th>log MPK</th>
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<tbody>
<tr>
<td>lnasset</td>
<td>.036***</td>
<td>-.019***</td>
<td>-.029***</td>
<td>-.446***</td>
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<tr>
<td></td>
<td>(6.65)</td>
<td>(-6.99)</td>
<td>(-3.87)</td>
<td>(-17.63)</td>
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<tr>
<td>SOE</td>
<td>.57***</td>
<td>-.215***</td>
<td>-.595***</td>
<td>-3.52***</td>
</tr>
<tr>
<td></td>
<td>(9.38)</td>
<td>(-8.23)</td>
<td>(-7.63)</td>
<td>(-14.77)</td>
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<tr>
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<td>-.039***</td>
<td>.020***</td>
<td>.045***</td>
<td>0.261***</td>
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<tr>
<td></td>
<td>(-7.35)</td>
<td>(7.36)</td>
<td>(5.4)</td>
<td>(9.94)</td>
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<td>47,542</td>
<td>47,542</td>
<td>38,572</td>
<td>47,542</td>
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<tr>
<td>Industry FE</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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</tbody>
</table>

Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1
## Regression, Year 2006

<table>
<thead>
<tr>
<th></th>
<th>Leverage</th>
<th>Interest Rate</th>
<th>Growth Rate</th>
<th>log MPK</th>
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<tr>
<td>lnasset</td>
<td>.018***</td>
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<tr>
<td>SOE</td>
<td>.566***</td>
<td>-.089***</td>
<td>-.475***</td>
<td>-2.37***</td>
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<td>(11.58)</td>
<td>(-5.07)</td>
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<tr>
<td>SOE*lnasset</td>
<td>-.036***</td>
<td>.006***</td>
<td>.033***</td>
<td>0.181***</td>
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<td></td>
<td>(-7.92)</td>
<td>(4.20)</td>
<td>(5.02)</td>
<td>(8.49)</td>
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<td>142,009</td>
<td>112,368</td>
<td>142,009</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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</table>

Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Summary of Firm Level Data

- Compared to SOE, POE
  - Have lower leverage
  - Pay higher interest rate
  - Grow faster
  - Have higher MPK

- Among POEs, relative to large firms, small firms
  - Have lower leverage
  - Pay higher interest rate
  - Grow faster
  - Have higher MPK

- These patterns also hold for other years
Model

- Note that these patterns are not easily reconcile with exogenous borrowing constraints

- Build a model with endogenous borrowing constraints
  - Discipline the model with firms financing patterns

- Examine firms saving, the MPK and misallocations under the model
  - The observed MPK could be affected by many other distortions
A Simple Theory on Misallocation

- Heterogenous firms with \( y_i = z_i^{1-\alpha} k_i^\alpha \)

- From definition of \( MPK \), \( k_i = (\alpha)^{\frac{1}{1-\alpha}} z_i MPK_i^{\frac{1}{\alpha-1}} \)

- TFP

\[
TFP = \frac{Y}{K^\alpha} = \frac{\int_i z_i MPK_i^{\frac{\alpha}{\alpha-1}} d_i}{\left( \int_i z_i MPK_i^{\frac{1}{\alpha-1}} d_i \right)^\alpha}
\]

- Efficient TFP: \( MPK_i = MPK_j \)

\[
TFP^e = \left( \int_i z_i d_i \right)^{1-\alpha}
\]

- TFP loss

\[
TFP \text{ loss} = \log(TFP^e) - \log(TFP)
\]
Model
Model

- Heterogenous firms in two sectors: SOE and POE
- Firms produce with DRS technology and finance investment and dividend payouts with internal funds and loans from banks
- Financial market is imperfect
  - Firms can only borrow state-uncontingent bond
  - SOEs are not allowed to default as long as they are able to repay their debts
  - POEs can default on their loans
  - Banks provide debt schedules taking into account default risks of firms and fixed cost of issuing loans
Firms produce output using capital as input,

\[ y = z k^\alpha \]

\( z \) have a constant growth rate, a permanent component \( A_i \), and an idiosyncratic component

\[ z_{it} = (1 + g)^t A_i \nu_{it} \]

\( \nu \): following a Markov process given by \( f(\nu'; \nu) \)
POE Firms’ Problem

- POEs can default over their loans $b$; after default
  - Still operate, but productivity reduced by $\gamma$ fraction
  - Lose access to financial markets, $\lambda$ prob. regain access

- Default decision
  \[
  V(z, k, b) = \max_{d \in \{0, 1\}} (1 - d) V^c(z, k, b) + dV^d(z, k)
  \]

- $d = 0$ not default

- Defaulting value
  \[
  V^d(z, k) = \max_{x, k'} x + \beta E \left[ (1 - \lambda) V^d(z', k') + \lambda V^c(z', k', 0) \right]
  \]
  \[
  s.t. \quad x = (1 - \gamma)zk^\alpha + (1 - \delta)k - k' - \phi(k, k') \geq 0
  \]
POE Firms’ Problem

- Repaying value

\[ V^c(z, k, b) = \max_{x, k', b'} x + \beta EV(z', k', b') \]

\[ s.t \quad x = zk^\alpha + (1 - \delta)k - b + q(z, k', b')b' - k' - \phi(k, k') \geq 0 \]

- Debt price schedule \( q(z, k', b') \) reflects default risk
SOE Firms

- SOE firms never default

\[
W(z, k, b) = \max_{x, k', b'} x + \beta EW(z', k', b')
\]

\[
st \quad x = z k^\alpha + (1 - \delta)k - b + q(z, k', b')b' - k' - \phi(k, k') \geq 0
\]

\[
b' \leq \bar{B}(z, k')
\]

- Nature borrow constraint guarantees the firms with the maximum borrowing limits are able to repay their debt
Banks

- Banks are competitive and risk neutral. Banks need to pay a fixed cost $\xi$ for every loan they offer, which captures banks’ overhead cost and the cost for obtaining information for each loan.

- For SOEs:
  \[ q(z, k', b') + \xi = \frac{1}{1 + r}. \]
Banks

- For POEs,

- When saving $b' \leq 0$
  \[ q = \frac{1}{1 + r} \]

- When lending, have to pay a fixed cost $\xi$
- Prices reflect both default risk and fixed cost
  \[ q(z, k', b')b' + \xi = \frac{b'}{1 + r} \left[ 1 - \int d(z', k', b') f(z'; z) \, dz' \right]. \]
Equilibrium

Definition: A recursive equilibrium consists of decision rules and value functions of firms, and bond price schedule $q(z, k', b')$ such that

1. Given the bond price schedule, the decision rules and the value functions solve each firm’s problem.

2. Given interest rate and the decision rules, the bond price schedule makes banks break even in expected value.
Debt Price Schedule

- Small loans have high interest rate due to fixed cost
- Very large loans also have high interest rate due to default
Quantification
Shock structure

A firm’s productivity

\[ z_{it} = (1 + g)^t A_i \nu_{it} \]

- Permanent \( A_i \) follows Pareto distribution

\[ Pr(A_i \leq x) = 1 - x^{-\mu} \]

- Idiosyncratic component \( \nu_{it} \)

\[ \log(\nu_{it}) = \rho \log(\nu_{it-1}) + \sigma \varepsilon_{it}, \quad \varepsilon_{it} \sim N(0, 1) \]
## Calibration

<table>
<thead>
<tr>
<th>Calibrated Parameters</th>
<th>Value</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>0.33</td>
<td>production function curvature</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>0.1</td>
<td>reentry probability</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.1</td>
<td>depreciation rate</td>
</tr>
<tr>
<td>$r$</td>
<td>0.05</td>
<td>riskfree rate</td>
</tr>
<tr>
<td>$\rho$</td>
<td>0.85</td>
<td>persistence of productivity shock</td>
</tr>
<tr>
<td>$g$</td>
<td>0.07</td>
<td>growth rate</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Estimated Parameters</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>0.94</td>
<td>discount factor</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>0.3</td>
<td>output loss</td>
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<tr>
<td>$\xi$</td>
<td>0.012</td>
<td>fixed credit cost</td>
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<tr>
<td>$\phi$</td>
<td>1.3</td>
<td>capital adjustment cost</td>
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<tr>
<td>$\sigma$</td>
<td>0.76</td>
<td>shock standard deviation</td>
</tr>
<tr>
<td>$\mu$</td>
<td>1.30</td>
<td>shape parameter for permanent $A$</td>
</tr>
<tr>
<td>$A_6$</td>
<td>0.8</td>
<td>the second largest value of $A$</td>
</tr>
<tr>
<td>$A_7$</td>
<td>0.92</td>
<td>the largest value of $A$</td>
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</table>
## Model vs Data

<table>
<thead>
<tr>
<th>Target Moments</th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leverage</td>
<td>0.56</td>
<td>0.58</td>
</tr>
<tr>
<td>Leverage-Asset pct Slope</td>
<td>0.17</td>
<td>0.17</td>
</tr>
<tr>
<td>Interest-Asset pct Slope</td>
<td>-0.12</td>
<td>-0.08</td>
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</table>

**Growth of value added**

<table>
<thead>
<tr>
<th></th>
<th>Model</th>
<th>Data</th>
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</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.14</td>
<td>0.13</td>
</tr>
<tr>
<td>Var</td>
<td>0.40</td>
<td>0.40</td>
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</table>

**Distribution of value added**

<table>
<thead>
<tr>
<th>TOP Percentiles</th>
<th>Fraction of value added</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.34</td>
</tr>
<tr>
<td>10</td>
<td>0.48</td>
</tr>
<tr>
<td>20</td>
<td>0.66</td>
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</table>
Leverage and Size

Leverage vs Asset POE

<table>
<thead>
<tr>
<th>Leverage</th>
<th>Asset quantiles</th>
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<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

- **Model**
- **Data**
Interest Rate and Size

Interest Rate vs Asset POE
Sales Distribution

Share of sales by quantiles

![Graph showing share of sales by quantiles with model and data lines.](image)
Model Implications on Saving

<table>
<thead>
<tr>
<th>Non-Targeted Moments</th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate Statistics:</td>
<td></td>
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</tr>
<tr>
<td>Gross investment rate</td>
<td>0.15</td>
<td>0.18</td>
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Correlations

<table>
<thead>
<tr>
<th>Saving rate, Investment rate</th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net saving rate, ln(asset)</td>
<td>0.16</td>
<td>0.15</td>
</tr>
</tbody>
</table>

- Model generates co-movement of saving and investment
- Model matches well the co-movement of net saving and firms size
Investment, Saving and Size (Data)

Note: Year 1998-1999
Investment, Saving and Size (model)
Model Implications on MPK and Misallocation

<table>
<thead>
<tr>
<th>Non-Targeted Moments</th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate Statistics:</td>
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<tr>
<td>Dispersion of MPK</td>
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<td>1.12</td>
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<tr>
<td>Correlations</td>
<td></td>
<td></td>
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<tr>
<td>MPK, asset</td>
<td>0.20</td>
<td>-0.36</td>
</tr>
<tr>
<td>MPK, leverage</td>
<td>0.36</td>
<td>0.01</td>
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</table>

- Model generates 60% of the observed MPK dispersion
- In the model, large firms have higher MPK. In the data, small firms have higher MPK due to other reasons
How MPK varies with size: rough intuition

\[ E[MPK] = r + \delta + \phi f(K_{-1}, K) + \mu(A, K) \]

- Marginal adjustment cost \( \phi f(K_{-1}, K) \) increases with \( K \)
- Financial friction \( \mu(A, K) \) could
  - Increase with \( K \): higher default incentive
  - Decrease with \( K \): relax limited liability condition
MPK across $\nu$ and $A$

- For each $\nu$ and $A$, MPK is downward sloping
- Within $A$, for different $\nu$, MPK is upward sloping
Fixed Issuing Cost

In the data, small firms’ change of debt are more lumpy
Large Firms are also Distorted

Note: Year 1998-1999
Sensitivity Analysis

In our model, financial friction generate 4.14% of TFP loss due to misallocation.

- **Span of Control and Labor Market**
  - In our benchmark $\alpha = 0.33$, freely adjusted labor
  - $\alpha = 0.85$ (larger loss)

- **Capital adjustment cost**
  - In our benchmark, convex adjustment cost (we leave firms investment rates for out of sample test) could generate too small variance of investment rate and too small TFP loss.
  - In the data, lumpy investment

- **Misallocation between SOE and POE**

- **Large amount of entrants**
Conclusion

- We document debt financing, interest spread, and growth of Chinese firms relate to firms size

- We use firm level data to quantify the effects of financial frictions on firm saving and misallocation

- We find that financial frictions
  - play important role in firms saving and investment decisions
  - generate capital misallocation (although not all the dispersion in the data)
Appendix

Saving Rates by Sectors

Note: NBS
A Simple Theory on Misallocation

- Literature: $z_i$ and $MPK_i$ jointly log-normally distributed

\[
\text{TFP loss} = \frac{1}{2} \frac{\alpha}{1 - \alpha} \text{var}(\log MPK_i)
\]

- TFP loss only depends on dispersion of $MPK$

- Generally covariance of $z$ and $MPK$ also matters

Eg: Assume $MPK$ is Pareto distributed with parameter $\gamma$, and $z = MPK^\rho$

\[
\text{TFP loss} = \frac{\gamma - \rho - \frac{\alpha}{\alpha - 1}}{(\gamma - \rho)^{1-\alpha} \left(\gamma - \rho - \frac{1}{\alpha - 1}\right)^\alpha}
\]
Example: TFP Loss Under Pareto Distribution

- Same dispersion of MPK, but TFP loss varies with size-MPK correlation

- High $\rho$ leads to large TFP loss since high $z$ accounts more for output