# Intermediate Goods and Misallocation in China's Manufacturing Sector

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# Motivation

Evidence of substantial measured misallocation of inputs across firms for many developing countries

- gap between output, and potential output if marginal products of inputs equalized across firms [Hsieh and Klenow (2009)]

Intuition:

- high productivity firms, too few inputs
- low productivity firms, too many

# Motivation

Existing literature: value added (output) misallocation

- capital and labor re-allocated from low value-added productivity firms to high ones
- implicitly assume intermediate goods efficiently allocated

Potential problem: if intermediates are misallocated,

- ignore gain in re-allocating intermediate goods
- value added misallocation mis-measured
    - distortions on intermediates bias value-added productivity measure
    - e.g. underestimated for firms constrained in intermediates

Alternative starting point: gross output misallocation

# Importance of Intermediate Goods

In China's Industrial Enterprise Survey (CIES) data,

- intermediates 74% of gross output revenue
- more than twice the share of capital and labor combined

Intermediate good purchases need to be financed

- purchased long time *before* receiving sales revenue
  - 90 to 180 days in working capital management studies [e.g. Deloof (2003)]

This paper: borrowing constraints on intermediates & misallocation in China

- apply to other countries with under-developed financial system

# What I Do: Data

Use China Industrial Enterprise Survey, 1998-2007

- firm-level data for manufacturing sector

Compute gross output misallocation

Quantify contributions of

1. intermediate goods
2. capital
3. labor

in measured gross output & value added misallocation

# What I Find: Data

Misallocation of intermediate goods: large

1. gross output gain
   - 35% by re-allocating intermediates *alone*, fixing capital and labor as in data
   - 6% for capital, 2% for labor
2. value added gain
   - 135% by re-allocating intermediates *alone*, fixing capital and labor as in data
     - 98% by re-allocating capital and labor in Hsieh and Klenow (2009)'s approach, ignoring misallocation of intermediates
   - 22% for capital, 9% for labor

Re-allocate intermediates, capital and labor *simultaneously*:

- gross output gain 138%
- value added gain **551%**
  - much greater than **98%** by value added approach in literature

# What I Do: Model & Numerical Expeirments

Model: extend standard firm investment model *with capital adjustment costs* [Cooper and Haltiwanger (2006); Khan and Thomas (2003)]

1. pre-pay for a fraction of intermediates a period *ahead*
2. endogenous borrowing constraints on intermediates and capital

Calibrate to key moments in China.

Numerical Experiments:

1. Contributions of borrowing constraints on intermediates, on capital, and capital adjustment costs to measured gross output misallocation in China?
2. Bias of value added misallocation measure in literature by ignoring misallocation of intermediates?

# What I Find: Numerical Experiments

Model accounts for 69% of gross output misallocation in China:

1. half from intermediate goods frictions
   - borrowing constraints on intermediates: **23%**
   - pre-pay: 11%
2. half from capital adjustment costs: 35%
3. borrowing constraints on capital unimportant: **1%**
   - consistent with Midrigan and Xu (2014)

Why borrowing constraints matter with intermediates?

- increased borrowing needs every period
- lower recovery rate of cash than capital upon default

Value added approach **underestimates** misallocation in model:

- 67% $<$ 203% value added gain by re-allocating all three inputs
- underestimated value-added productivity for constrained firms

# Literature Review

1. Firm-level productivity and misallocation in developing countries
   - Hsieh and Klenow (2009), Brandt, Van Biesebroeck and Zhang (2012)
   - Brandt, Tombe and Zhu (2013), Tombe and Zhu (2015), Brandt, Kambourov and Storesletten (2016), Bai, Lu and Tian (2016)
   - Bils, Klenow and Ruane (2016)

2. Capital misallocation across firms
   (1) capital adjustment costs: Bartlesman, Haltiwanger and Scarpetta (2013), Asker, Collard-Wexler and De Loecker (2014)

   (2) financial frictions on capital investment: Moll (2014), Buera and Shin (2013), Midrigan and Xu (2014) etc.

# Intermediate Goods in Data

Annual China Industrial Enterprise Survey, 1998-2007

- Ideal: rich firm-level information
- Widely used in literature [e.g. Hsieh and Klenow (2009); Brandt et al. (2012)]

Which input most important in measured gross output misallocation?

- largest gross output gain by re-allocating that input *alone across firms, holding the other two as observed in data*

Gross output misallocation:

- gross output gain by re-allocating capital, labor and intermediates across firms

# China Industrial Enterprise Survey

Firm-level annual balance sheet, income and cash flow statements

- *Cross-sectional* firm-level data
- 29 CIC 2-digit (3-digit NAICS equivalent) manufacturing industries
- Include all state-owned firms, and private- and foreign- owned firms with sales above 800 thousand U.S. dollars
    - ≈ 20% of manufacturing firms, 70% employment, 90% gross output, 97% export values (NBS, 2004)

More

Variables:

- "Demographics": firm name and I.D., ownership, opening year, industry
- Production: gross output $y$, book value of capital $k$, employment, wage bill $l$, intermediates input $m$, value of export, inventory, account receivables
    - real capital stock: perpetual inventory method
    - $y$, $k$, $m$ deflated by industry specific deflators [Brandt et al. (2012)]

Construct unbalanced panel

- link firms over years by I.D., company name, name of legal representatives, postal code, industry and main products
- following Brandt et al. (2012)

# High Intermediate Goods (Revenue) Share

- Intermediate goods (revenue) share for sector $s$:

$$\frac{\text{Total Value of Input for Sector } s}{\text{Total Value of Gross Output for Sector } s}$$

  - include materials, energy, fuel etc.

- High intermediate goods share: 74%
  - OECD average, 53%; South Korea and Japan in 1970s, 60-80% [Jones (2011)]
  - ranges from 0.54 (wood product) to 0.95 (nonferrous metal)

By ownerships & exporter status Across industries

# Misallocation of Intermediate Goods

Within 2-digit CIC industries, compute:

1. dispersion (CV) in marginal products of intermediates
2. gross output gain by re-allocating intermediates *alone, holding capital & labor as observed in data*

Cobb-Douglas production function: $y = exp(z)k^{\alpha_k^s} l^{\alpha_l^s} m^{\alpha_m^s}$

- $y$, gross output; $k$, capital; $l$, labor; $m$, intermediate goods

Firm-level productivity $z_i$ for firm $i$ in industry $s$

$$z_i = logy_i - \alpha_k^s logk_i - \alpha_l^s logl_i - \alpha_m^s logm_i$$

$\alpha_l^s$, $\alpha_m^s$ median firm-level input shares $\alpha_l^{is}, \alpha_m^{is}$ within 2-digit CIC industries

- $\alpha_k^s = 0.85 - \alpha_l^s - \alpha_m^s$

1. Marginal product of input $x$ at firm $i$ in industry $s$:

$$MP_{i,x} = \alpha_x^s \frac{y_i}{x_i}, \quad x \in \{k, l, m\}$$

2. Gross output gain by re-allocating intermediate goods *alone* for industry $s$

$$\frac{\sum_{i \in s} exp(z_i)(k_i^d)^{\alpha_k^s}(l_i^d)^{\alpha_l^s}(m_i^1)^{\alpha_m^s} - \sum_{i \in s} y_i^d}{\sum_{i \in s} y_i^d}$$

- $y_i^d$, $k_i^d$, $l_i^d$: gross output, capital and labor in data
- $m_i^1$ hypothetical intermediate goods: $MP_{im}^1 = \alpha_m^s \frac{y_s}{m_i^1} = constant$ and $\sum_{i \in s} m_i^1 = \sum_{i \in s} m_i^d$
- similar exercise for capital *alone* & labor *alone*

# Misallocation of Intermediates

Dispersion in Marginal Products and Output Gains by Reallocating One Input within CIC 2-digit Industries, Output Weighted, 1998-2007 Average

| | Intermediates | Capital | Labor |
|---|---|---|---|
| CV | 0.25 | 1.69 | 1.16 |
| Gross output gain | **34.81%** | 5.66% | 2.46% |
| Value added gain | **135.01%** | 21.83% | 9.49% |

Compared to capital and labor, intermediates

- $1/7 \sim 1/5$ dispersion of marginal products
- but $6 \sim 15$ times of potential gross output & value added gain

Value added gain $\approx \frac{1}{1-0.74} \times$gross output gain

# Gross Output & Value Added Misallocation

Output Gains by Re-allocating Capital, Labor and Intermediates *Simultaneously* within CIC 2-digit Industries, Output Weighted, 1998-2007 Average

| | Gross output approach | Value added approach in literature |
|---|---|---|
| Gross output gain | 138.01% | - |
| Value added gain | 550.74% | 98.12% |

How-to

Gross output misallocation in China **138%**

- input complementarity: greater than 35% (intermediates)+6% (capital) +2% (labor)

Value added approach in literature **underestimates** misallocation

- ignore misallocation of intermediate goods

# Data Summary

Substantial mesured misallocation of intermediate goods in China:

1. 35% gross output & 135% value added gain by re-allocating intermediates
   - 6% & 22% for capital, 2% & 9% for labor

2. value added misallocation by literature approach: 98%, underestimates misallocation
   - 551% when misallocation of intermediates taken into account

# Quantitative Exercises

Model: incorporate borrowing constraints on intermediate goods into

- standard firm-level investment model *with capital adjustment costs* [Cooper and Haltiwanger (2006); Khan and Thomas (2003)]

Calibrate to China. Quantify

1. how much can
   (1) borrowing constraints on intermediates
   (2) borrowing constraints on capital
   (3) capital adjustment costs

   account for measured misallocation in China

2. bias of value added misallocation in literature due to misallocation of intermediates? Source of this bias?

# Borrowing Constraints on Intermediates

Model set-up:

- firm pre-pay a fraction of intermediate goods a period (annual) *ahead*
- intermediates and capital subject to endogenous borrowing constraints

Motivation for pre-pay constraint in data:

- intermediates purchased several months before production & receiving sales revenue from buyers
- a.k.a *Operating Cycle* in trade credit and working capital management literature [e.g. Jose, Lancaster and Stevens (1996)]

# Pre-pay Constraint

For firm $i$, operating cycle $OC$

$$OC_i = \overbrace{\frac{\text{Inventory}_i}{\text{Sales}_i} * 365}^{\textbf{DI: } \text{Days in Inventory}} + \overbrace{\frac{\text{Account Receivables}_i}{\text{Sales}_i} * 365}^{\textbf{DR: } \text{Days in Receivables}}$$

| | $OC$ | $DI$ | $DR$ |
|---|---|---|---|
| Mean | **161.20** | **86.39** | 74.81 |
| Median | 107.89 | 46.94 | 42.92 |

Mean and median $OC$, $DI$ and $DR$ are calculated across firms in each year, and then average out over 1998-2007.

China: in range of 90-180 days in literature [Hager(1976), Deloof(2003), Garcia-Teruel and Martinez-Salano(2007)]

ownerships, exporter status

# Model Overview

Infinite horizon economy, $t = 0, 1, 2, ...$

Financial intermediaries:

- charge break-even interest rates that reflect firms' default probabilities

$M_t$ firms at time $t$:

- Firms choose inputs to maximize NPV of dividends, given
  - pre-pay constraint on intermediates and capital adjustment costs
  - borrowing constraints arise because firms
    1. can default
    2. cannot issue equity

New entrants and equilibrium of loanable funds market
$\Rightarrow$ long-run stationary firm size distribution

# Firms

Firm $i$ at time $t$ characterized by $(z_{it}, k_{it}, m_{it}, b_{it})$

- $z_{it}$ exogenous stochastic productivity
- $k_{it}$ capital
- $m_{it}$ intermediate goods
- $b_{it}$ debt $(> 0)$ / savings $(< 0)$.

Decreasing return to scale technology for gross output production

$$y_{it} = exp(z_{it}) k_{it}^{\alpha_k} l_{it}^{\alpha_l} m_{it}^{\alpha_m}$$

- $\alpha_k + \alpha_l + \alpha_m < 1$
- AR(1) process for $z_{it}$: $z_{it+1} = \rho z_{it} + (1 - \rho)\mu_z + \epsilon_{it+1}$ where $\epsilon_{it+1} \sim N(0, \sigma_\epsilon^2)$

# Intermediate Goods: Pre-pay

Firms pay intermediate goods $m_t$ a period ahead

- payment at $t-1$: $\omega m_t$
- rest at $t$: $(1\text{-}\omega)m_t$
- $\omega$ captures *average* time length to pre-pay

Period $t$ starts, $z_t$ realizes:

- firms choose intermediate goods usage $\bar{m}_{it}$ up to pre-determined $m_{it}$

Choices of $\bar{m}_{it}$ and $l_{it}$: static to maximize profit $\Pi_t$

$$\Pi_t(z_{it}, k_{it}, m_{it}) = \max_{\bar{m}_{it} \leq m_{it}, l_{it}} y_{it}(z_{it}, k_{it}, \bar{m}_{it}, l_{it}) - l_{it} - (1-\omega)m_{it} + (m_{it} - \bar{m}_{it})$$

End of production net worth in $t$:

$$\overbrace{\Pi_t - b_t}^{\textit{Cash}} + \overbrace{(1-\delta)k_t}^{\textit{Capital}}$$

# Capital Adjustment Costs

Firms invest / divest capital subject to scale-dependent adjustment costs:

$$C(k,k'|\Theta) = \begin{cases} \xi k + \frac{\theta(k'-(1-\delta)k)^2}{2(1-\delta)k} & \text{if } \overbrace{k' \notin [(1-\delta-\zeta)k,(1-\delta+\zeta)k]}^{\text{Type Construction},\Theta=tc}, \\ \frac{\theta(k'-(1-\delta)k)^2}{2(1-\delta)k} & \text{if } \overbrace{k' \in [(1-\delta-\zeta)k,(1-\delta+\zeta)k]}^{\text{Type Maintenance},\Theta=tm} \end{cases}$$

- Standard in literature [Cooper and Haltiwanger (2006); Khan and Thomas (2008)]

# Timing

$t$ begins — productivity $z_t$ realized

firm $(z_t, k_t, m_t, b_t)$ choose intermediate goods $\leq m_t$, labor $l_t$

produce, profit $\Pi(z_t, k_t, m_t)$

Exit

default and liquidate asset

Continue

pay operating cost, choose $b_{t+1}, k_{t+1}, m_{t+1}$

$t$ ends

# Exit and Default

Firms endogenously exit $\chi(z, b, k, m) = 1$ *after production* and asset liquidation takes place.

Liquidation process costs:

- $1 - \gamma_2$ cash
- $1 - \gamma_1$ capital

i.e. $\gamma_2$ cash and $\gamma_1$ capital split between firms and financial intermediaries

- default when liquidated asset cannot cover debt

Firm's value of exit $V^x$

$$\max\{\gamma_2[\Pi(z, k, m) - b\mathbb{1}(b \leq 0)] + \gamma_1(1-\delta)k - b\mathbb{1}(b > 0), 0\}$$

Financial intermediary's loss: $\min\{b - \gamma_2\Pi(z, k, m) - \gamma_1(1-\delta)k, 0\}$

# Financial Intermediaries

Competitive risk-neutral intermediaries in a small open economy

- take deposits at $r_1$
- lend at $r_2$ with intermediation cost $c_I$ per dollar

Given debt price schedule $q'(z, b', k', m')$, intermediaries choose $b'$ to maximize expected profit:

$$\max_{b'} \quad E_{z'|z}\{\chi'(z', b', k', m')(b' - \gamma_2 \Pi(z', k', m') - \gamma_1(1-\delta)k')\} + \{1 - E_{z'|z}\chi'(z', b', k', m')\}b' - (1 + r_1 + c_I)q'b'$$

$\Rightarrow$ supply of funds $b'^s = b'^s(z, k', m'; q')$

Special case: zero expected default probability $E_{z'|z}\chi'$

- competitiveness implies $q' = \frac{1}{1+r_1+c_I}$
- $r_1 + c_I$ *prime borrowing interest rate*

# Firm's Borrowing Constraint

Firms cannot issue new equity, i.e. nonnegative per period dividend $d$

$$\begin{aligned} d(z, b, k, m, b', k', m', \Theta; q') = \Pi_t(z, k, m) + (1-\delta)k - \omega m' - k' \\ - C(k, k'|\Theta) - b + q'(z, b', k', m')b' - c_o \geq 0 \end{aligned}$$

where $\Theta$ is investment type, $c_o$ operating cost

# Value of Continuation

Given state variables $(z, b, k, m)$ and bond price schedules $q'(z, b', k', m')$, firms maximize value of continuation:

$$V^c(z, b, k, m) = \max_{b', k', m', \Theta \in \{tc, tm\}} d(z, b, k, m, b', k', m', \Theta; q')$$

$$+ \beta E_{z'|z} V(z', b', k', m')$$

$$s.t. \quad d(z, b, k, m, b', k', m', \Theta; q') \geq 0$$

$$b' \leq \bar{b} \qquad \text{(Debt Limit)}$$

$\Rightarrow$ Demand for borrowing/saving: $b'^d = b'^d(z, b, k, m; q')$

Capital: $k' = k'(z, b, k, m; q')$

Intermediate goods: $m' = m'(z, b, k, m; q')$

# Entrants

Mass of $\mu_{ent} M_t$ firms exogenously enter every period

- initial productivity $z_0 \sim N(\mu_z, \sigma_z^2)$
- initial net worth $b_0$ from Pareto distribution

$$g(-b_0) = \begin{cases} \frac{\alpha a_{\min}^{\alpha}}{(-b_0)^{\alpha+1}} & \textit{if } -b_0 \geq a_{\min} \\ 0 & \textit{if } -b_0 < a_{\min} \end{cases}$$

$a_{min}$ minimum wealth, $\alpha$ Pareto shape

One period to set-up, i.e. $k_0 = 0, m_0 = 0$

Value function upon entry:

$$V_{ent}(z_0, b_0, 0, 0) = \max_{b', k', m'} -\omega m' - k' - b_0 + q'(z, b', k', m')b'$$
$$- c_o + \beta E_{z'|z_0} V(z', b', k', m')$$
$$s.t. -\omega m' - k' - b_0 + q'(z, b', k', m')b' - c_o \geq 0$$
$$b' \leq \bar{b} \qquad \text{(Debt Limit)}$$

Firm $i$ enter in $t$ and start to produce in $t+1$

# Equilibrium

Debt price function $q'(z, b', k', m')$, policy functions of incumbents $b'^d(z, b, k, m; q')$, $k'(z, b, k, m; q')$ and $m'(z, b, k, m; q')$, transition indicator functions for incumbents $\mathbb{T}(z, b, k, m; b', k', m')$, policy functions of entrants $b'_{ent}(z_0, -b_0, 0, 0; q')$, $k'_{ent}(z_0, -b_0, 0, 0; q')$ and $m'_{ent}(z_0, -b_0, 0, 0; q')$, exit rule $\chi(z, b, k, m)$, transition indicator function for entrants $\mathbb{T}_{ent}(z, b, 0, 0; b', k', m')$, supply function of funds $b^s(z, k', m'; q')$, endogenous mass of firms $M'$ and distribution of firms $f'(z', b', k', m')$ such that

1. given debt price function, policy functions solve problems of incumbents and entrants
2. given debt price function the supply function of funds solves lenders' problem
3. debt price function clears supply and demand of funds at the firm-level
4. distribution and mass of firms $f'$ and $M'$ evolve recursively

Stationary distribution defined as $f'(z, b, k, m) = f(z, b, k, m)$ for any state $(z, b, k, m)$

# Quantitative Analysis

Calibrate model to China' data

Quantitative contribution of

1. borrowing constraints on intermediates and capital
2. capital adjustment costs

in measured gross output misallocation in China

Value added misallocation:

- when intermediates are reallocated, compared to Hsieh and Klenow (2009) approach

# Mapping Model to Data

Problem in CIES: 800 thousand U.S. dollars threshold sales for private-owned firms $\approx$ top 20% firms in sales

- entry and exit in CIES not entry and exit in manu. sector / model
- growing incumbents among CIES entrants; vice versa for exiters

more

Model analog of threshold sales $y_c$

Numerical:

1. given a set of parameters, compute model implied stationary distribution of firms $f(z, b, k, m)$
2. sample 630,000 firms from the distribution
3. choose $y_c$ as top 20% of sales and compute key moments in $y > y_c$ subsample
4. choose parameters to match moments in China's data

# Parameters in Borrowing Constraints

Recovery rates $\gamma_1 = 0.3$, $\gamma_2 = 0.1$

- capital: 37%
- cash: 22% [Fan and Morck (2012, p.85)]

Fraction of pre-paid intermediate goods $\omega = 60\%$

- calibrated jointly with other 10 parameters
- $\omega$ affects bindingness of borrowing constraints $\Rightarrow$ firm growth
- $\frac{\text{Market share of data entrants age} \geq 5}{\text{Market share of data entrants age} < 5}$ most sensitive to $\omega$

# Parametrization

| Parametrized | | | Calibrated | | |
|---|---|---|---|---|---|
| Parameter | | Value | Parameter | | Value |
| Discounting factor | $\beta$ | 0.94 | Return to Scale | $\eta$ | 0.85 |
| Depreciation rate | $\delta$ | 0.09 | Labor share | $\alpha_l$ | 0.05 |
| *Capital Adjustment Cost* | | | Intermediate goods share | $\alpha_m$ | 0.70 |
| Fixed cost | $\xi$ | 0.039 | fraction of intermediate goods in advance | $\omega$ | 60% |
| Fixed cost free band | $\zeta$ | 0.09 | Debt limit | $log(\bar{b})$ | 6.10 |
| Convex cost | $\theta$ | 0.049 | Threshold sales | $y_c$ | 436.30 |
| *Interest Rates* | | | Operating cost | $c_o$ | 5.00 |
| Saving rate | $r_1$ | 0.03 | *Productivity Process* | | |
| Prime borrowing rate | $r_2$ | 0.06 | Population persistence of productivity | $\rho_z$ | 0.70 |
| *Recovery Rates* | | | Population S. D. of productivity | $\sigma_z$ | 0.70 |
| Cash | $\gamma_2$ | 0.10 | Unconditional mean | $\mu_z$ | 0.90 |
| Capital | $\gamma_1$ | 0.30 | *Initial Wealth Distribution of Entrants* | | |
| | | | Mass of entrants | $\mu_{ent}$ | 0.17 |
| | | | Pareto Shape | $\alpha$ | 0.60 |
| | | | Min. Wealth | $a_{min}$ | 20.00 |

# Moments Targeted

| Moments | Data | Model |
|---|---|---|
| Market share by firms of top 10% sales | 84.5% | 87.5% |
| Population exit rate* | 8% | 5.80% |
| Frac. of firms above threshold | 20.00% | 20.00% |
| Frac. of firms with debt* | 34.29% | 34.60% |
| Mean productivity (Top 20% firms) | 1.82 | 1.80 |
| SD of productivity (Top 20% firms) | 0.45 | 0.42 |
| *5-year Horizon* | | |
| Frac. of data exiters in $t$ | 59% | 57.88% |
| Frac. of data entrants in $t+5$ | 67.89% | 72.20% |
| Market share of data exiters in $t$ | 40.09% | 41.29% |
| Market share of data entrants in $t+5$ | 49.14% | 56.38% |
| $\frac{\text{Market share of age } (\leq 5) \text{ data entrants}}{\text{Market share of age } (>5) \text{ data entrants}}$ | 1.30 | 1.29 |

Moments except for * are from CIES data 1998-2003. Population exit rate from survival analysis of Chinese firms by State Administration for Industry and Commerce. Fraction of firms with debt from World Bank Enterprise Survey 2011.

Out of model fits

# Misallocation in Simulation

Model:

- 96% gross output gain when re-allocate intermediates, capital and labor
- **69%** of measured gross output misallocation in data

For intermediate goods alone,

- **61%** misallocation in data

Dispersion in Marginal Products and Output Gain by Reallocating One Input, Model vs Data

| | Intermediate Goods | | Capital | |
|---|---|---|---|---|
| | CV | Gross Output Gain | CV | Gross Output Gain |
| Model | 0.47 | **21.18%** | 1.07 | 8.79% |
| Data | 0.25 | **34.81%** | 1.69 | 5.66% |

# Decomposing Misallocation

Counterfactuals: decompose misallocation contributed by each friction

Order of removing frictions:

1. intermediate goods frictions first
2. a model with capital frictions alone resembles that in literature:
   - e.g. Asker et al. (2014) (Exp. 3), Midrigan and Xu (2014) (Exp. 2 without capital adj. costs)

Model Specifications of Counterfactual Experiments

| Friction | Benchmark | Exp. 1 | Exp. 2 | Exp. 3 |
|---|---|---|---|---|
| Capital adjustment costs | ✓ | ✓ | ✓ | ✓ |
| Borrowing constraints on capital | ✓ | ✓ | ✓ | |
| Pre-pay on intermediates | ✓ | ✓ | | |
| Borrowing constraints on intermediates | ✓ | | | |

# Exp. 1 Removing Borrowing Constraints on Intermediates

No default on intermediate goods $\omega m'$ , i.e. fully recoverable

$$V^c(z,b,k,m) = \max_{b',k',m',x\in\{ct,mt\}} \Pi(z,k,m) + (1-\delta)k - \omega m' - k'$$
$$- C(k,k'|\Theta) - b + q'(z,b',k',m')b' - c_o + \beta E_{z'|z} V(z',b',k',m')$$
$$s.t.$$
$$\Pi(z,k,m) + (1-\delta)k - k' - C(k,k'|\Theta) - b + q'(z,b',k',m')b' - c_o \geq 0$$

Payment for next period intermediate goods, $\omega m'$

- not into borrowing constraint
- e.g. intermediate goods from suppliers in processing trade

# Gross Output Misallocation in Counterfactuals

| | Benchmark | | Exp. 1 | | Exp. 2 | | Exp. 3 | |
|---|---|---|---|---|---|---|---|---|
| | Level | % of Data | Level | % of Data | Level | % of Data | Level | % of Data |
| Gross output gain when re-allocate $k, l, m$ | 0.96 | 69.34% | 0.64 | 46.69% | 0.49 | 35.62% | 0.48 | 34.75% |
| 1. Borrowing constraints on intermediate goods | 0.32 | **22.65%** | | | | | | |
| 2. Pre-pay on intermediate goods | | | 0.15 | **11.07%** | | | | |
| 3. Borrowing constraints on capital | | | | | 0.01 | **0.87 %** | | |
| 4. Capital adjustment costs | | | | | | | 0.48 | **34.75%** |

Intermediate goods frictions, 34% of misallocation in China

- borrowing constraints more important than pre-pay

Capital frictions, 35%

- small by borrowing constraints, as in Midrigan and Xu (2014)
    - robustness: 8% when removed first

Sensitivity to $\omega$

# Borrowing Constraints on Intermediates: Mechanisms

Channels: borrowing constraints on intermediates cause misallocation

1. pre-payment for next period intermediates $\omega m_{t+1}$ increases borrowing need and tightens constraint
2. crowd out $k_{t+1}$; decreases future collateral; further tightens borrowing constraints
3. firms in $t+1$ cannot respond to high productivity shocks by having intermediate goods usage beyond pre-ordered $m_{t+1}$
4. 3 worsens Channels 1 & 2; firms are constrained longer than without intermediates frictions

Capital Growth

# Value Added Misallocation

Value added approach in literature **underestimates** value added misallocation in data & model.

| | Value added approach in literature | | Gross output approach | |
|---|---|---|---|---|
| | Data | Model | Data | Model |
| Value added gain | 98.12% | 66.76% | 550.74% | 203.48% |

Source of bias in model:

(1) high gross output productivity firms borrowing constrained in $m \Rightarrow$ low value added productivity $\Rightarrow$ low $k, l$ re-allocated to them Plot

(2) ignore misallocation of $k, l$ "because of" misallocation of $m$ via complementarity

# Summary of Quantitative Analysis

Model generates 61% of intermediate goods misallocaiton in China's data

Model generates 69% gross output misallocation:

- half by intermediate goods frictions, mainly borrowing constraints on intermediate goods
- half by capital frictions, most capital adjustment costs

Value added misallocation based on value added productivity underestimates misallocation.

# Conclusion

Intermediate goods important for measured gross output misallocation.

This paper

1. document gross output misallocation in intermediate goods in China's data
2. quantitatively assess how borrowing constraints on intermediate goods accounts for gross output misallocation
   - 34% of misallocation of China's data
   - quantitatively as important as capital adjustment costs
3. traditional approach on value added misallocation under-estimates misallocation by ignoring misallocation of intermediates

Applicable to other countries with under-developed financial system, e.g. India and Mexico

# Thank You!

Table 1: Aggregate Statistics of Above & Below 5 Million Sale Manufacturing Firms

| | Number | Gross Output (billion) | Total Wage (billion) | Employment (10,000) |
|---|---|---|---|---|
| 2004 | | | | |
| Below | 1,001,587 | 1,867.76 | 196.54 | 2413.28 |
| Above | 256,999 | 17,528.35 | 791.97 | 5667.34 |
| **% of above size firms** | **20.42%** | **90.37%** | **80.12%** | **70.13%** |
| 2008 | | | | |
| Below | 1,356,124 | 3,318.36 | 382.68 | 2889.91 |
| Above | 396,950 | 44,135.83 | 2,678.62 | 7,731.57 |
| **% of above size firms** | **22.64%** | **93.01%** | **87.50%** | **72.79%** |

Current price. Source: The First and Second Economic Census (2004,2008), National Bureau of Statistics

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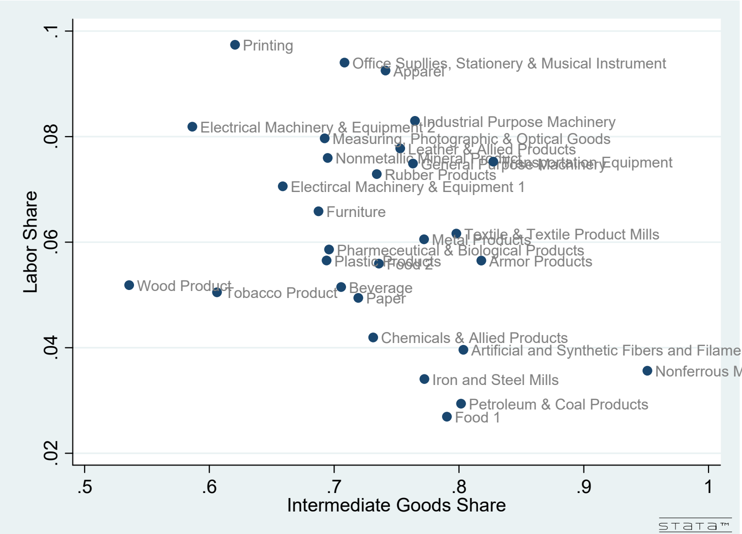
Figure 1: Share of Intermediate Goods and Labor, 2-digit CIC Industry




Source: China Industrial Survey Data 1998-2007

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Table 2: Intermediate Goods Share, CIES 1998-2007

| | |
|---|---|
| All | 74.17% |
| *By Ownership* | |
| State | 74.38% |
| Private | 76.02% |
| Foreign | 72.27% |
| *By Exporter Status* | |
| Exporter | 73.59% |
| Non-exporter | 74.82% |

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Table 3: Operating Cycles, Days in Inventory and Days in Receivables, CIES 1998-2007

| | All | Ownership | | | Exporter Status | |
|---|---|---|---|---|---|---|
| | | Private | State | Foreign | Exporter | Non-exporter |
| *OC* | | | | | | |
| Mean | **161** | 134 | 204 | 155 | 166 | 149 |
| Median | 108 | 97 | 130 | 120 | 108 | 107 |
| *DI* | | | | | | |
| Mean | **86** | 69 | 113 | 81 | 88 | 81 |
| Median | 47 | 41 | 57 | 54 | 45 | 51 |
| *DR* | | | | | | |
| Mean | **75** | 65 | 91 | 74 | 77 | 68 |
| Median | 43 | 39 | 49 | 51 | 43 | 43 |

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Table 4: Growth in Mean Productivities in the CIES, 1998-2007

| Year | Mean Productivity $\bar{z}$ | Mean Productivity Relative to 1998 $\Delta z$ |
|---|---|---|
| 1998 | 1.82 | 0 |
| 1999 | 1.84 | 0.02 |
| 2000 | 1.89 | 0.07 |
| 2001 | 1.90 | 0.08 |
| 2002 | 1.92 | 0.10 |
| 2003 | 1.97 | 0.15 |
| 2004 | 1.98 | 0.16 |
| 2005 | 2.04 | 0.22 |
| 2006 | 2.09 | 0.27 |
| 2007 | 2.12 | 0.30 |

Source: China Industrial Survey Data 1998-2007

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Figure 2: Diff. in Log Capital of 1998 Cohort Compared to All Firms above Cutoff, Data vs Model

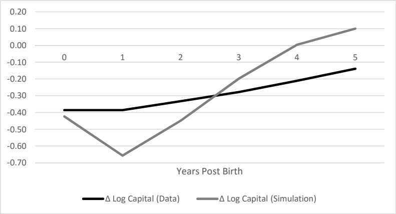


Figure 3: Diff. in Log Sale of 1998 Cohort Compared to All Firms above Cutoff, Data vs Model

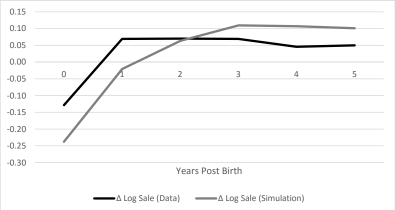

Figure 4: Diff. in Log Productivity of 1998 Cohort Compared to All Firms above Cutoff, Data vs Model


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# Table 5: Data Entry and Exit in Above Cutoff Sample: Simulated Data vs CIES Data

| Model: Given One Birth Cohort | | | | | | | |
|---|---|---|---|---|---|---|---|
| Years Post Birth | | No. of Firms in Data | Data Exit | Exit % | Data Enter | Enter % | Enter-Exit |
| 0 | | 2246 | | | | | |
| 1 | | 3075 | 656 | 29.21% | 1485 | 66.12% | 36.91% |
| 2 | | 3862 | 860 | 27.97% | 1647 | 53.56% | 25.59% |
| 3 | | 4177 | 1232 | 31.90% | 1547 | 40.06% | 8.16% |
| 4 | | 4374 | 1264 | 30.26% | 1461 | 34.98% | 4.72% |
| 5 | | | 1298 | 29.68% | 1411 | 32.26% | 2.58% |
| **Data: 1998 Cohort** | | | | | | | |
| Years Post Birth | Year | No. of Firms in Data | Data Exit | Exit % | Data Enter | Enter % | Enter-Exit |
| 0 | 1998 | 5024 | | | | | |
| 1 | 1999 | 7430 | 801 | 15.94% | 3038 | 60.47% | 44.53% |
| 2 | 2000 | 9622 | 1031 | 13.88% | 2888 | 38.87% | 24.99% |
| 3 | 2001 | 11886 | 1871 | 19.45% | 3706 | 38.52% | 19.07% |
| 4 | 2002 | 12870 | 1425 | 11.99% | 2395 | 20.15% | 8.16% |
| 5 | 2003 | 13308 | 1736 | 13.49% | 2079 | 16.15% | 2.67% |

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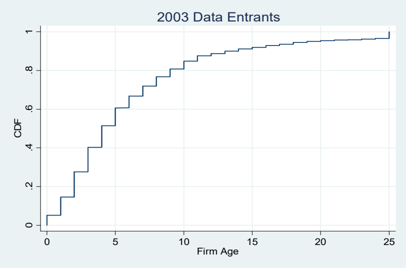
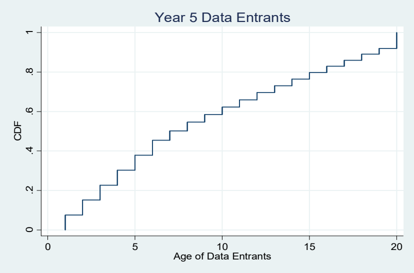
# Age Profile of Entrants over 5 Years

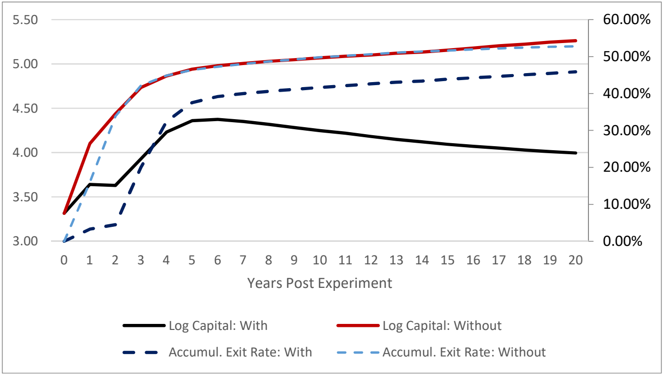
Figure 5: Age Distribution of Data Entrants



# Capital Accumulation With and Without Intermediate Goods Frictions

Average Log Capital Among Stayers and Accumulated Exit Rate, With and Without Intermediates Frictions




$t = 0$: 30,000 firms from stationary distribution $f(z, b, k, m)$

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# Complementary Misallocation

When re-allocate intermediate goods, *holding capital and labor fixed*

- complementarity among inputs not captured
  - e.g. low productivity firms still assigned with many intermediates "because of" high capital and labor

**Complementary Misallocation** $g^s_{kl,m}$ captures misallocation in capital and labor "because of" misallocation in intermediates. For industry $s$:

$$g^s_{kl,m} = g^s_{klm} - g^s_{kl} - g^s_m \tag{1}$$

- $g^s_{klm}$ gross output gain by re-allocating $k, l, m$
- $g^s_{kl}$ gross output gain by re-allocating $k, l$

# Complementary Misallocation

Gross Output Gain by Reallocating Inputs, Output Weighted, 1998-2007 Average

| Reallocate Inputs | Gross Output Gain | |
|---|---|---|
| | Average 2-digit | Median 2-digit |
| 1. $k, l$ | 8.69% | 6.18% |
| 2. $m$ | 34.81% | 28.31% |
| 3. $k, l, m$ | 138.72% | 145.91% |
| Compl. Misallocation=3-(1+2) | **95.22%** | **111.41%** |

Complementary misallocation, 95.22%

- 3 times of $g_m^s$, 11 times of $g_{kl}^s$

$\Rightarrow$ crucial interactions between distortions in intermediates and capital & labor

# Sensitivity to Pre-pay Fraction of Intermediates $\omega$

Measures of Misallocation: Output Gain by Re-allocating $k$, $l$, $m$

| | Benchmark | $\omega = 40\%$ | $\omega = 20\%$ |
|---|---|---|---|
| Gross output | 96% | 94% | 83% |
| Value added | 203% | 198% | 195% |

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# Bias from Value Added Misallocation

Suppose firm $i$ face distortion on intermediate goods $\tau$.

$$max_{m_i} exp(z_i) k_i^{\alpha_k} m_i^{\alpha_m} l_i^{\alpha_l} - (1+\tau_i) p_m m_i \tag{2}$$

FOC implies optimal choice of $m_i$

$$m_i^* = [\frac{(1+\tau_i)p_m}{\alpha_m exp(z_i) k_i^{\alpha_k} l_i^{\alpha_l}}]^{\frac{1}{\alpha_m - 1}} \tag{3}$$

Value added

$$Y - m^* = exp(z_i)[\frac{\alpha_m exp(z_i)}{p_m(1+\tau_i)}]^{\frac{\alpha_m}{1-\alpha_m}} k_i^{\frac{\alpha_k}{1-\alpha_m}} l_i^{\frac{\alpha_l}{1-\alpha_m}} \tag{4}$$

Log value-added productivity =

$$\frac{1}{1-\alpha_m} z_i \overbrace{- \frac{\alpha_m}{1-\alpha_m} log(1+\tau_i)}^{BiasTerm} + \frac{\alpha_m}{1-\alpha_m} log \alpha_m \tag{5}$$

In HK exercise

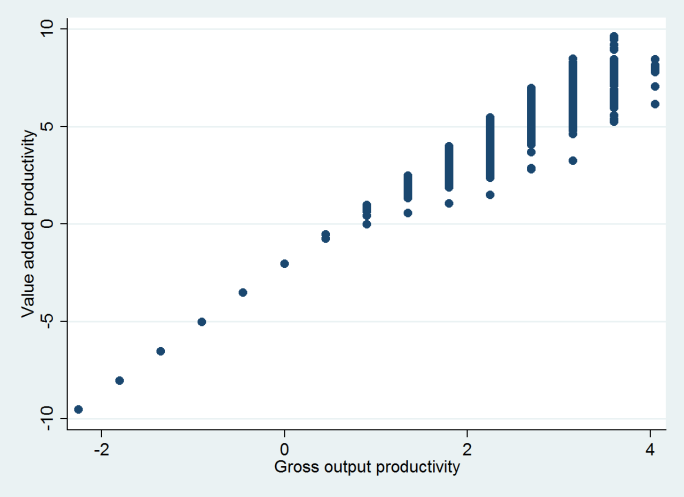
- if $corr(\tau_i, z_i) > 0$ (as in the model), capital and labor are not reallocated to productive firm $i$ because of high $\tau_i$.
- bias larger when $\alpha_m$ larger

# Misallocation of Intermediates, Simulation

Gross Output Misallocation & Complementary Misallocation: Model 69% of Data

| Reallocate Inputs | Gross Output Gain | |
|---|---|---|
| | Data | Model |
| 1. $k, l$ | 8.69% | 8.79% |
| 2. $m$ | 34.81% | 21.18% |
| 3. $k, l, m$ | **138.72%** | **96%** |
| Compl. Misallocation=3-(1+2) | **95.22%** | **66.03%** |

# Lower Value Added Productivity: Constrained Firms

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Dispersion in Marginal Products and Output Gains by Reallocating One Input within CIC 2-digit Industries, Output Weighted, 1998-2007 Average

| | Intermediates | | Capital | | Labor | |
|---|---|---|---|---|---|---|
| | Median 2-digit | Average 2-digit | Median 2-digit | Average 2-digit | Median 2-digit | Average 2-digit |
| CV | 0.22 | 0.25 | 1.65 | 1.69 | 1.13 | 1.16 |
| Gross output gain | 28.31% | **34.81%** | 2.59% | 5.66% | 2.41% | 2.46% |

## Output Gains by Reallocating All Inputs within CIC 2-digit Industries, Output Weighted, 1998-2007 Average

| | Gross output approach | Value added approach in literature |
|---|---|---|
| Gross output gain | 138.01% | - |
| Value added gain | 550.74% | 98.12% |
| How-to | (i) reallocate $k, l, m$ based on gross output productivity<br>(ii) compute gross output gain & value added gain | (i) compute value added $y_i - \bar{m}_i$ & value added productivity<br>(ii) reallocate $k, l$ based on value added productivity<br>(iii) compute value added gain |

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