Information, Misallocation and Aggregate Productivity

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This paper

"Misallocation," i.e., dispersion in MP's $\Rightarrow$ large losses in TFP and output

- But sources of distortions still unclear...
- Role of imperfect information? Informational role of financial markets?

1. What we do
    - Heterogeneous firms choose inputs under imperfect info
    - Firms learn from internal/private sources and noisy asset prices
    - Quantify frictions using stock market/production data in US, China, India
2. What we find
    - Significant micro-level uncertainty, esp. in China and India
      $\rightarrow$ accounts for 20-50% (+...) of MRPK dispersion
    - Sizable aggregate impact
      $\rightarrow$ TFP losses: 7-10% in China and India, 4% in US; can be much larger...
    - Only limited learning from markets; firm internal sources are key

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Simplified model

Homogeneous good, only capital, no agg. risk

- Continuum of producers: $Y_{it} = A_{it} K_{it}^{\alpha}, \qquad a_{it} \sim iid,\ \mathcal{N}\left(0, \sigma_{\mu}^{2}\right)$

Input choice under incomplete info:

- Choice of K_{it} conditional on info $\mathcal{I}_{it}$, $a_{it} | \mathcal{I}_{it} \sim \mathcal{N}\left(\mathbb{E}_{it} a_{it}, \mathbb{V}\right)$

$\mathbb{V}$ is key object:

- Misallocation: $\sigma_{mpk}^{2} = \mathbb{V}$
- *TFP* : $a = a^{*} - \frac{1}{2}\frac{\alpha}{1-\alpha}\sigma_{mpk}^{2} = a^{*} - \frac{1}{2}\frac{\alpha}{1-\alpha}\mathbb{V}$

$\Rightarrow$ *TFP* $\searrow$ in $\mathbb{V}$; effect of poor info $\nearrow$ in α

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Characterizing $\mathbb{V}$

The firm's information set $\mathcal{I}_{it}$

1. Private signal: $s_{it} = a_{it} + e_{it}, \quad e_{it} \sim \mathcal{N}\left(0, \sigma_e^2\right)$
2. Stock price: p_{it}
   - Equivalent to signal $a_{it} + \eta_{it}, \quad \eta_{it} \sim \mathcal{N}\left(0, \sigma_\eta^2\right)$
3. For now: $(a_{it}, e_{it}, \eta_{it})$ mutually independent

$\Rightarrow$ Sharp characterization of $\mathbb{V}$:

$$\mathbb{V} = \frac{1}{\frac{1}{\sigma_\mu^2} + \frac{1}{\sigma_e^2} + \frac{1}{\sigma_\eta^2}}$$

Identifying info frictions - simplified model

1. General strategy:
   - Measure σ_μ^2 directly: $(a_{it} = y_{it} - \alpha k_{it})$
   - Use (ρ_{pk}, ρ_{pa}) to infer $\left(\sigma_e^2, \sigma_\eta^2\right)$ or equiv $\left(\mathbb{V}, \sigma_\eta^2\right)$

$$\rho_{pa} = \frac{1}{\sqrt{1 + \frac{\sigma_\eta^2}{\sigma_\mu^2}}} \qquad \frac{\mathbb{V}}{\sigma_\mu^2} = 1 - \left(\frac{\rho_{pa}}{\rho_{pk}}\right)^2$$

2. Some appealing properties:
   - Unaffected by correlations in firm and market signals
   - Unaffected by 'correlated' distortions
   - Conservative estimate if 'uncorrelated' distortions

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Quantitative model

1. Monopolistic competition: $Y_t = \left(\int A_{it} Y_{it}^{\frac{\theta-1}{\theta}} di \right)^{\frac{\theta}{\theta-1}}$
2. Production: $Y_{it} = K_{it}^{\alpha_1} L_{it}^{\alpha_2}$
   - Case 1: both factors chosen under imperfect info
   - Case 2: only K chosen under imperfect info, L adjusts ex-post

$\Rightarrow$ Preserves $\max_{K_{it}} \Pi \mathbb{E}_{it} [A_{it}] K_{it}^{\alpha} - RK_{it}$; with α in case 1 $>$ α in case 2

3. Persistence in A_{it}: $a_{it} = \rho a_{it-1} + \mu_{it}, \quad \mu_{it} \sim \mathcal{N}(0, \sigma_\mu^2)$
4. Explicit model of stock market trading
   - Same info in p_{it}

$\Rightarrow$ Preserves $\mathbb{V} = \frac{1}{\frac{1}{\sigma_\mu^2} + \frac{1}{\sigma_e^2} + \frac{1}{\sigma_\eta^2}}$

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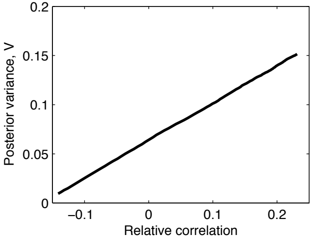
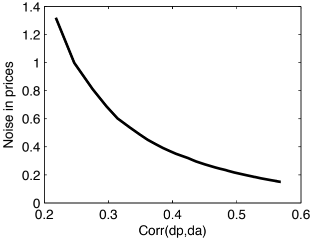
Identifying info frictions - quantitative model





$\Rightarrow$ Same intuition as simple model:

- $\rho_{pa} \;\rightarrow\;$ noise in prices
- ρ_{pi} relative to $\rho_{pa} \;\rightarrow\; \mathbb{V}$

General parameters

Parameter	Description	Target/Value
	Time period	3 years
β	Discount rate	0.90
α_1	Capital share	0.33
α_2	Labor share	0.67
θ	Elasticity of substitution	6

- If K and L both chosen under imperfect information (case 1)

  $\rightarrow \quad \alpha = \frac{\theta-1}{\theta} = 0.83$

- If only K chosen under imperfect information (case 2)

  $\rightarrow \quad \alpha = 0.62$

The impact of informational frictions

	$\frac{\mathbb{V}}{\sigma^2_{\mu}}$	$\frac{\mathbb{V}}{\sigma^2_{mrpk}}$	$a^* - a$
Case 2 ($\alpha = 0.62$)			
US	0.41	0.22	0.04
China	0.63	0.34	0.07
India	0.77	0.48	0.10
Case 1 ($\alpha = 0.83$)			
US	0.63	0.35	0.40
China	0.65	0.39	0.55
India	0.86	0.56	0.77

- Substantial posterior uncertainty (US firms best informed)
  $\Rightarrow$ significant misallocation, losses in TFP and output
- Effects increase with α

Case 1 vs. Case 2

Quantitative impact sensitive to this assumption

- Interpret our results as bounds
- But can we say anything more...?

A suggestive statistic:

- Case 2 $\rightarrow \frac{\sigma^2_{mrpl}}{\sigma^2_{mrpk}} = 0$; case 1 $\rightarrow \frac{\sigma^2_{mrpl}}{\sigma^2_{mrpk}} = 1$
- In US data: $\frac{\sigma^2_{mrpl}}{\sigma^2_{mrpk}} = 0.57$

Decomposing $\mathbb{V}$: the contribution of learning and its sources

		Share from source	
	Δa	Private	Market
Case 2			
US	5%	92%	8%
China	4%	96%	4%
India	3%	89%	11%
Case 1			
US	23%	91%	9%
China	30%	96%	4%
India	12%	96%	4%

1. Significant learning $\Rightarrow$ significant aggregate gains
2. Learning is primarily from private sources

   Interpretation? Manager skill/incentives, info collection/processing...
3. Only small role for market-generated info $\Rightarrow$ just too much noise in prices

Effect of US information structure

	Case 2	Case 1
	Δa	Δa
Market Information		
China	1%	2%
India	1%	4%
Private Information		
China	3%	6%
India	5%	26%
Shocks		
China	1%	10%
India	2%	20%

1. Gains from US private info $>$ US market info
2. Differences in fundamentals $\rightarrow$ differential impact of friction

Conclusion

Theory linking micro uncertainty to misallocation and aggregates

- Substantial uncertainty and associated aggregate losses
- Limited informational role for stock markets
- Significant role for private learning $\Rightarrow$ drives cross-country differences

Where next?

- Entry/exit
- Other frictions...

Related literature

Misallocation

- Hsieh and Klenow (09), Restuccia and Rogerson (08),...
- Financial frictions: Buera, Kaboski and Shin (11), Midrigan and Xu (13),...
- Adjustment costs: Asker, Collard-Wexler and De Loecker (13)
- Information frictions: Jovanovic (13)

Stock price informativeness

- Morck, Yeung and Yu (00), Durnev, Yeung and Zarowin (03),...

The "feedback" effect (Bond, Edmans and Goldstein (12))

- Investment: Chen, Goldstein and Jiang (07), Bakke and Whited (10), Morck, Schleifer and Vishny (90)
- R&D spending: Bai, Philippon and Savov (13)
- Mergers and acquisitions: Luo (05)

Full-info TFP

Simplified model:

$$a^* = \frac{1}{2}\frac{\sigma_\mu^2}{1-\alpha}$$

General model:

$$a^* = \frac{1}{2}\left(\frac{\theta}{\theta-1}\right)\frac{\sigma_a^2}{1-\alpha}$$

▸ simple model ▸ general model

The stock market

Unit measure of firm equity traded by 2 type of agents

1. Investors: Can purchase up to single unit at price p_{it}
2. Noise traders: purchase random quantity $\Phi\left(z_{it}\right)$, $z_{it} \sim \mathcal{N}\left(0, \sigma_z^2\right)$

Information of investors:

- History: a_{it-1}
- Private signal: $s_{ijt} = a_{it} + v_{ijt}$, $v_{ijt} \sim \mathcal{N}\left(0, \sigma_v^2\right)$
- Stock price: p_{it}

Trading: buy asset if $E_{ijt}\Pi_{it} \geq p_{it}$ or $s_{ijt} > \widehat{s}_{it}$

Market clearing: $$\underbrace{1 - \Phi\left(\frac{\widehat{s}_{it} - a_{it}}{\sigma_\nu}\right)}_{\text{Investors}} + \underbrace{\Phi\left(z_{it}\right)}_{\text{Noise traders}} = 1$$

$\Rightarrow$ Info in price: $\widehat{s}_{it} = a_{it} + \sigma_\nu z_{it}$ $\left[\sigma_\eta^2 = \sigma_v^2 \sigma_z^2\right]$

general model

Identification with iid shocks

$$\rho_{pa} = \frac{1}{\sqrt{1 + \frac{\sigma_v^2 \sigma_z^2}{\sigma_\mu^2}}} \qquad (\searrow \text{ in } \sigma_v \sigma_z)$$

$$\rho_{pk} = \frac{1}{\sqrt{\left(1 + \frac{\sigma_v^2 \sigma_z^2}{\sigma_\mu^2}\right)\left(1 - \frac{\mathbb{V}}{\sigma_\mu^2}\right)}} \qquad (\nearrow \text{ in } \mathbb{V})$$

$$\sigma_p^2 = \left(\frac{1-\beta}{1-\alpha}\right)^2 \left(\frac{\sigma_z^2 + 1}{\sigma_z^2 + \frac{1}{\rho_{pa}^2}}\right)^2 \frac{1}{\rho_{pa}^2} \sigma_\mu^2 \qquad (\nearrow \text{ in } \sigma_z)$$

ident

Identification with permanent shocks

$$\frac{\mathbb{V}}{\sigma_\mu^2} = \frac{\rho_{pk} - \rho_{pa}}{\eta} \quad \text{where} \quad \eta = \frac{1}{1-\alpha}\frac{\sigma_\mu}{\sigma_p}$$

$$\frac{\sigma_v^2 \sigma_z^2}{\sigma_\mu^2} = \frac{\left(1-\eta^2\right)}{2\rho_{pa}^2} + \frac{\eta}{\rho_{pa}} - 1$$

$$\frac{\sigma_z^2 + 1}{\sigma_z^2 + 1 + \frac{\sigma_v^2 \sigma_z^2}{\sigma_\mu^2}} = \frac{1}{\eta}$$

ident

Step 1. $cov\,(p,k) = cov(p,a)$.

- follows from $k = E\,(a|p,s_i)$
- and since we can write $a = E\,(a|p,s_i) + \varepsilon$
- $cov\,(a,p) = cov\,(E\,(a|p,s_i)\,,p) + cov\,(\varepsilon,p) = cov\,(k,p)\,.$

Step 2. divide both sides by $\sigma_a\sigma_p$ so we get

$$\frac{[cov\,(p,k)]^2}{(\sigma_a\sigma_p)^2} = \rho\,(p,a)^2 \tag{1}$$

Step 3. By the law of total covariance, $\sigma_a^2 = \sigma_k^2 + V$ so

$$\frac{\sigma_k^2}{\sigma_a^2} = 1 - \frac{V}{\sigma_a^2} \tag{2}$$

Substituting (2) in (1) we get

$$\left(1 - \frac{V}{\sigma_a^2}\right) = \left(\frac{\rho\,(p,a)}{\rho\,(p,k)}\right)^2$$

identical to our identification equation. ▸ ident

Measuring $\mathbb{V}$ with other frictions - simplified model

Introduce alternative 'distortions' into capital choice:

$$\tau_{it} = \gamma\mu_{it} + \varepsilon_{it}, \quad \varepsilon_{it} \sim \mathcal{N}\left(0, \sigma_\varepsilon^2\right)$$

$$\Rightarrow k_{it} = \frac{(1+\gamma)\,\mathbb{E}\left[\mu_{it}\right] + \varepsilon_{it}}{1-\alpha}$$

1. 'Correlated' distortion ($\gamma \neq 0, \sigma_\varepsilon^2 = 0$)

   $\Rightarrow \sigma_{mrpk}^2 = \gamma^2\left(\sigma_\mu^2 - \mathbb{V}\right) + \mathbb{V} > \mathbb{V}$

   But, our measure $1 - \left(\frac{\rho_{pa}}{\rho_{pk}}\right)^2 = \frac{\mathbb{V}}{\sigma_\mu^2}$ still valid!

2. 'Uncorrelated' distortion ($\gamma = 0, \sigma_\varepsilon^2 \neq 0$)

   $\Rightarrow \sigma_{mrpk}^2 = \mathbb{V} + \sigma_\varepsilon^2 > \mathbb{V}$

   Our measure $1 - \left(\frac{\rho_{pa}}{\rho_{pk}}\right)^2 = \frac{\mathbb{V}}{\sigma_\mu^2} - \frac{\sigma_\varepsilon^2}{\sigma_\mu^2}$ is conservative...

▸ ident

Investment-Q regressions

Model has reduced-form representation:

$$\Delta k_{it} = \lambda_1 \left(\Delta \mu_{it} + \Delta e_{it}\right) + \lambda_2 \Delta p_{it}$$

Use model to derive:

$$\lambda_2 \;\propto\; \frac{\mathbb{V}}{\sigma_\eta^2}$$

Intuition: $\lambda_2 \nearrow$ in $\mathbb{V}$, $\searrow$ in σ_η^2

But, regression ID's λ_2 only if $\Delta e_{it} \perp \Delta \mu_{it}, \Delta p_{it}$

- Violated if correlated signals, correlated distortions...

ident

Data and parameter values

	Target moments			Parameters				
	ρ_{pi}	ρ_{pa}	σ_p^2	ρ	σ_μ	σ_e	σ_v	σ_z
Case 2								
US	0.23	0.18	0.23	0.92	0.45	0.39	0.37	3.50
China	0.16	0.06	0.14	0.78	0.51	0.67	0.74	4.24
India	0.25	0.08	0.23	0.93	0.53	1.04	0.69	4.36
Case 1								
US	0.24	0.10	0.23	0.88	0.46	0.63	0.65	3.16
China	0.15	0.02	0.14	0.75	0.53	0.74	1.18	3.14
India	0.26	0.00	0.22	0.88	0.55	1.39	1.69	4.14

Data source: Compustat NA and Compustat Global.

- Cross-country variation in moments $\Rightarrow$ variation in parameters
- US : less fundamental uncertainty, better private info, less noise in markets

results

Transitory vs. permanent MRPK deviations

- Information speaks to dispersion in transitory component
- In US data: transitory $\approx$ one-third of total
- US $\mathbb{V}$ accounts for 60% in case 2; entirety in case 1

results

Robustness: adjustment costs

Are we simply labeling adj. costs as info frictions?

- Simulate moments from full-info (for firms) adj. cost model
- Do we estimate large $\mathbb{V}$ with these moments?

	Adj. Cost $\mathbb{V}$	Baseline $\mathbb{V}$
US	0.03	0.08
China	0.06	0.16
India	0.08	0.22

- $\mathbb{V}$ (and agg effects) about 1/3 of baseline estimates

$\Rightarrow$ Unlikely that we are reading adj. costs as info frictions!

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Robustness: correlated information

How would correlation between firm and investors' signals affect results?

- Correlation $\rightarrow \nearrow \rho_{pk} \rightarrow \nearrow \mathbb{V}$?
- Re-estimate assuming $s_{ijt} = s_{it} + v_{ijt} = a_{it} + e_{it} + v_{ijt}$

	$\frac{\mathbb{V}}{\sigma_\mu^2}$ w corr. info	$\frac{\mathbb{V}}{\sigma_\mu^2}$ baseline
Case 2 ($\alpha = 0.62$)		
US	0.41	0.41
China	0.58	0.63
India	0.68	0.77

$\Rightarrow$ Results quite close to baseline!

ident

Full-information adjustment cost model

- Value function

$$V\left(\tilde{A}_{it}, K_{it-1}\right) = \max_{K_{it}, N_{it}} G\tilde{A}_{it}K_{it}^{\tilde{\alpha}} - I_{it} - H\left(I_{it}, K_{it-1}\right) + \beta\mathbb{E}V\left(\tilde{A}_{it+1}, K_{it}\right)$$

where $I_{it} = K_{it} - (1-\delta)K_{it-1}$ and $H\left(I_{it}, K_{it-1}\right) = \zeta K_{it-1}\left(\frac{I_{it}}{K_{it-1}}\right)^2$

- Solve numerically for joint distribution of $\tilde{A}_{it}, K_{it}$ in GE
- Target $\left(\rho_{pa}, \sigma_p^2, \sigma_k^2\right)$
- Simulate data to compute ρ_{pi} and relative correlation

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