Financial Shocks in Production Chains

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Limits to Length of Production Chains

• Technological

• Bargaining and incentives
  – “Disorganization” in the former command economies (Blanchard and Kremer (1997), Marin and Schnitzer (2004))
  – Evidence in Gofman (2009)

• Net working capital is the “glue” that binds firms in a production chain
  – Net working capital is equity stake in the production chain as a whole
  – Delay in payment builds up net working capital
Developed Country Corporate Balance Sheets

Rajan and Zingales (J. of F. 1995)
Production Chain

Final output sold by firm 0 at price $q$.

Firm $i + 1$ supplies intermediate good to firm $i$.

There is a “time to build” in production process.

Success of project depends on effort of all firms in the production chain.
### Cash Flows before Transfers

<table>
<thead>
<tr>
<th>date ( t )</th>
<th>Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 0 )</td>
<td>0</td>
</tr>
<tr>
<td>( 1 )</td>
<td></td>
</tr>
<tr>
<td>( \vdots )</td>
<td></td>
</tr>
<tr>
<td>( N-1 )</td>
<td>( -w_1 )</td>
</tr>
<tr>
<td>( N )</td>
<td>( -w_0 )</td>
</tr>
<tr>
<td>( N+1 )</td>
<td>( q-w_0 )</td>
</tr>
<tr>
<td>( N+2 )</td>
<td>( q-w_0 )</td>
</tr>
<tr>
<td>( \vdots )</td>
<td>( \vdots )</td>
</tr>
</tbody>
</table>

Wage cost \( w_i \) cannot be deferred, and must draw on firm \( i \)'s cash holdings.
Technology

• In each period, firm $i$ chooses from \{high effort, low effort\}

• Private benefit from low effort, $bw_i$ ($b > 0$)

• Probability of failure
  - 0 if all exert high effort, $\varepsilon$ if one or more exert low effort
  - Borrowing rate $r$ used to discount cashflows
  - Zero liquidation value of firms
Recursive Moral Hazard

Payment $p_i$ to firm $i$ by firm $i-1$ for intermediate good.

Deviations from high effort deterred by large enough “skin in the game” (Kim and Shin (2012), multi-firm version of Holmstrom and Tirole (1997))

\[ p_i \geq p_{i+1} + (1 + b_i) w_i \quad \text{(IC)} \]

where

\[ b_i = \frac{b \cdot r (1 + r)^i}{\varepsilon} \]
Recursive Moral Hazard

\[ p_i \geq \sum_{k=i}^{N} (1 + b_k) w_k \]

- Prices \( \{p_i\} \) incorporate rents \( \{b_k w_k\} \) for all the upstream firms \( k \) along the production chain.

- Chain unravels unless \( q \geq \sum_{k=0}^{N} (1 + b_k) w_k \)

- Parallels with “disorganization” (Blanchard and Kremer (97))
**Working Capital as “Glue”**

Firm \( i \) receives payment from firm \( i - 1 \) after delay of \( d_i \) periods.

Accounts payable amortized at constant rate \( a_i p_i \) (actuarially fair).

Distinction between

- **invoice price** \( (1 + a_i) p_i \)
- **fundamental price** \( p_i \).

Incentive compatibility constraint with accounts receivable/payable

\[
(1 + a_i) p_i \geq (1 + a_{i+1}) p_{i+1} + (1 + b_i) w_i
\]
Hurdle prices

\[ p_i \geq \frac{1}{1 + a_i \sum_{k=i}^{N} (1 + b_k) w_k} \]  

(IC)

IC constraint can be relaxed by accumulating receivables.

But IR constraint limits how far IC constraint can be relaxed.
Optimal Contract

Maximize surplus for firm 0 subject to (IC) and (IR) for upstream firms.

Production chain is *sustainable* if expected profit of firm 0 is non-negative under the optimal contract.

\[
a_i p_i - a_{i+1} p_{i+1} = -(1 + r) w_i - r p_{i+1} + (1 + b_i) w_i
\]

\[
= \left( b_i - r \frac{p_{i+1}}{w_i} - r \right) w_i
\]

\[
= \left( \frac{b (1 + r)^i}{\varepsilon} - \frac{p_{i+1}}{w_i} - 1 \right) r w_i
\]
Net Working Capital

Evaluating flows as perpetuities, receivables \((R_i)\) and payables \((P_i)\) satisfy

\[
R_i - P_i = \left( \frac{b(1 + r)^i}{\epsilon} - \frac{p_{i+1}}{w_i} - 1 \right) w_i
\]

Expression in brackets is

- increasing in \(i\) ("upstreamness")
- increasing in \(r\) (financial tightness)
- but there is fundamental constraint given by \(p_0 \geq q\)
Empirical Hypotheses

Proposition 1. Net receivables relative to $w_i$ is higher for upstream firms.

Proposition 2. Net working capital is increasing in $r$ for low values of $r$. However, if $r > r^*$ for threshold $r^*$, net working capital is declining in $r$. 
**Upstreamness**


Input-Output matrix; sector-level measure:

\[ U_i = 1 + \sum_{j=1}^{N} \frac{d_{ij}Y_j}{Y_i} U_j \]

\(d_{ij}Y_j/Y_i\) is share of sector \(i\)’s total output purchased by sector \(j\).
Data

- OECD input-output tables for 16 countries
  - Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, Germany, Greece, Hungary, Italy, Netherlands, Portugal, Slovakia, Slovenia, Spain, and United States

- 18 sub-industries of manufacturing

- Annual firm-level data from ORBIS; sample 2000 ~ 2009

- > 150,000 firms, > 600,000 firm-year observations
Figure 1. Median normalized end-year working capital for US firms classified into upstream, downstream and all firms.
## Dependent variables

<table>
<thead>
<tr>
<th></th>
<th>$(REC/OR)$</th>
<th>$(PAY/OR)$</th>
<th>$(N_{-}REC/OR)$</th>
<th>$(WC/OR)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPS</td>
<td>0.014***</td>
<td>0.005***</td>
<td>0.009***</td>
<td>0.013***</td>
</tr>
<tr>
<td></td>
<td>(47.29)</td>
<td>(21.23)</td>
<td>(31.65)</td>
<td>(32.62)</td>
</tr>
</tbody>
</table>

| Country fixed effects | yes | yes | yes | yes |
| Year fixed effects   | yes | yes | yes | yes |

Adjusted $R^2$ |
- 0.335
- 0.318
- 0.079
- 0.097

| Obs. | 609497 | 600425 | 599886 | 599032 |
## Dependent variables

<table>
<thead>
<tr>
<th></th>
<th>(\frac{REC}{OR})</th>
<th>(\frac{PAY}{OR})</th>
<th>(\frac{N-REC}{OR})</th>
<th>(\frac{WC}{OR})</th>
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<tbody>
<tr>
<td>UPS</td>
<td>0.015***</td>
<td>0.005***</td>
<td>0.010***</td>
<td>0.011***</td>
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<tr>
<td></td>
<td>(47.77)</td>
<td>(20.13)</td>
<td>(33.24)</td>
<td>(27.42)</td>
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<tr>
<td>UPS \times spread</td>
<td>0.018***</td>
<td>0.017***</td>
<td>0.010***</td>
<td>0.007***</td>
</tr>
<tr>
<td></td>
<td>(8.52)</td>
<td>(8.32)</td>
<td>(6.23)</td>
<td>(5.06)</td>
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<tr>
<td>UPS \times spread^2</td>
<td>-0.004***</td>
<td>-0.004***</td>
<td>-0.003***</td>
<td>-0.007***</td>
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<tr>
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<td>(-6.87)</td>
<td>(-7.13)</td>
<td>(-6.32)</td>
<td>(-8.11)</td>
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<td>yes</td>
<td>yes</td>
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<td>year fixed effects</td>
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<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>sector fixed effects</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Adjusted (R^2)</td>
<td>0.335</td>
<td>0.342</td>
<td>0.318</td>
<td>0.079</td>
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<tr>
<td>Obs.</td>
<td>609497</td>
<td>609497</td>
<td>600425</td>
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</table>
### Panel A: Dependent variable, average growth of $\frac{WC}{OR}$ (04–06) UPS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-value</th>
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<tbody>
<tr>
<td>UPS</td>
<td>0.029*</td>
<td>(1.80)</td>
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Country fixed effects: yes

Adjusted $R^2$: 0.018

Observations: 47,414

### Panel B: Dependent variable, average growth of $\frac{WC}{OR}$ (07–09) UPS

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-value</th>
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</thead>
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<tr>
<td>UPS</td>
<td>-0.045***</td>
<td>(-2.83)</td>
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Country effects: yes

Adjusted $R^2$: 0.017

Observations: 47,414
<table>
<thead>
<tr>
<th>Dependent variable, average growth of $\frac{WC}{OR}$ (07–09)</th>
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<tbody>
<tr>
<td>average growth of $\frac{WC}{OR}$ (04–06)</td>
<td>-0.013**</td>
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<td></td>
<td>(-2.57)</td>
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<td>Country fixed effects</td>
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<tr>
<td>Sector fixed effects</td>
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<tr>
<td>Clustered std. errors by</td>
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<tr>
<td>Adjusted $R^2$</td>
<td>0.011</td>
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<tr>
<td>Obs.</td>
<td>47860</td>
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</table>
How can developing countries with poorly capitalized firms achieve lengthening of production chain?

Two hurdles:

- Working capital to finance the initial “triangle of costs”
- Sustaining long production chain

Both can be solved if firms have sufficient initial capital (by using IR slack to relax IC)

Both are problematic when firms are poorly capitalized
Comparative Industrial Structure

- Financial interlinkages in supply chain through accounts receivables and payables may mitigate inefficiency due to bargaining and incentives

- Efficiency through delayed settlement
  - Possible explanation for why accounts receivable and payable are so large?

- Downside of delayed settlement is large demands on working capital
  - Equity capital accumulation brings economic efficiency gains