Sustaining Production Chains Through Financial Linkages

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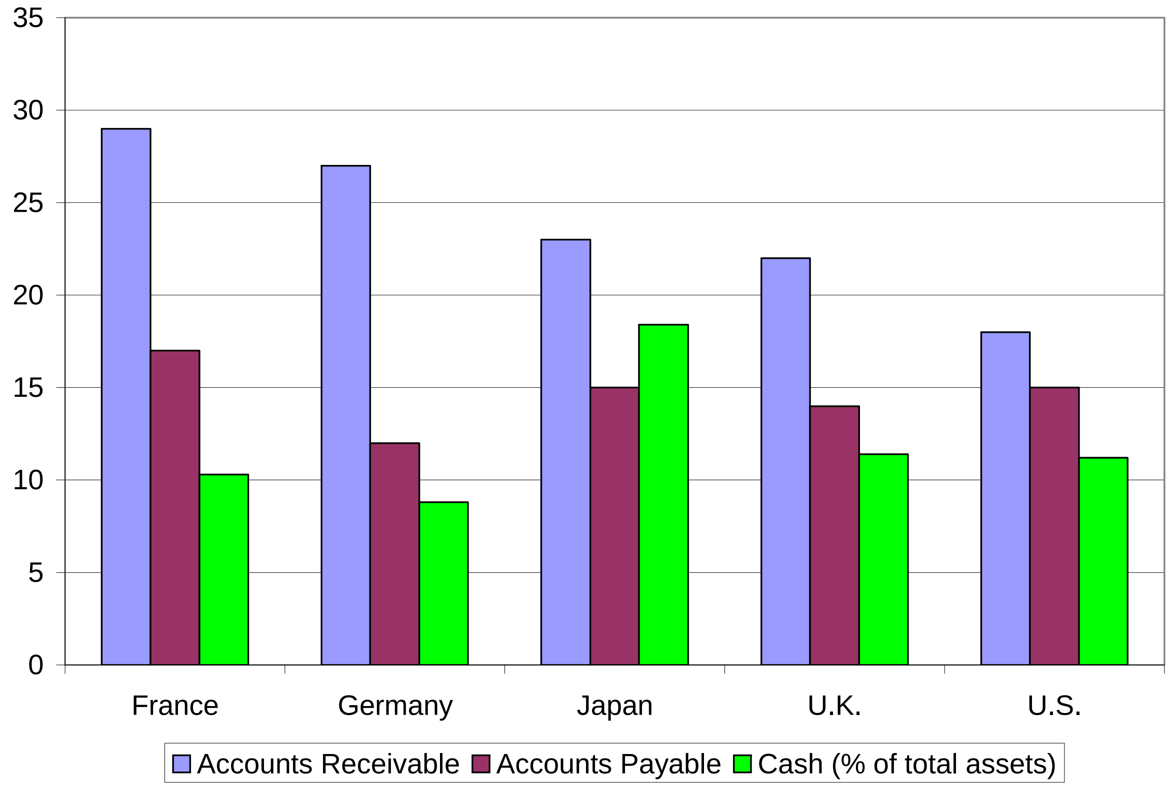
Chicago AEA Meetings 2012

Limits to Length of Production Chains

- Technological
  - Papers in this session
  - Kremer (1993), Jones (2009)
- Bargaining and incentives
  - "Disorganization" in the former command economies
  - Blanchard and Kremer (1997), Marin and Schnitzer (2004)
- Financial interlinkages in supply chain may mitigate latter
  - Efficiency through delayed settlement
  - Downside is large demands on working capital

Developed Country Corporate Balance Sheets



Rajan and Zingales (J. of F. 1995)

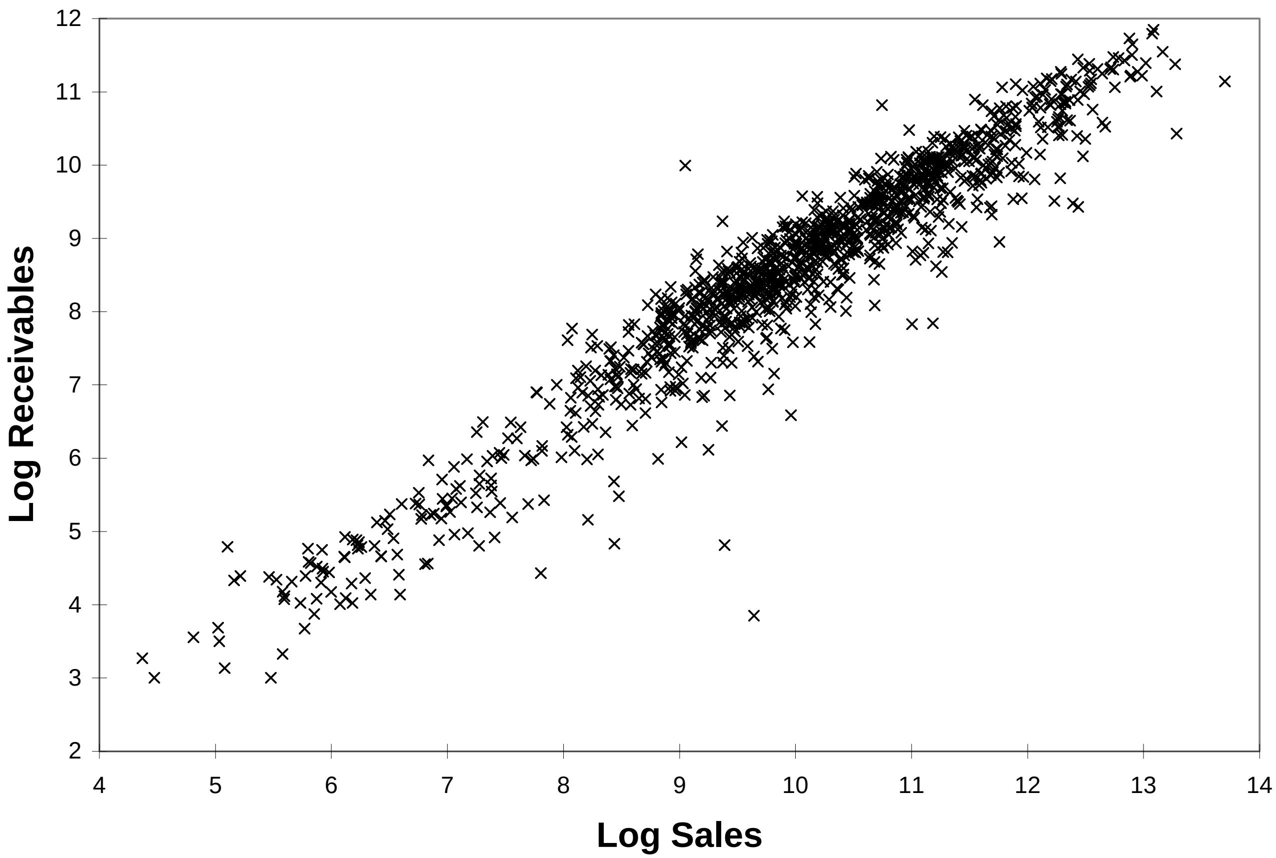
- Why do firms lend and borrow so much from each other?

- Accounts payable seem large, relative to cash holding given discounts for prompt payment of invoices. For Japan, cash holdings exceed accounts payable

- Literature on trade credit has taken a bilateral contracting perspective:
  - Firms borrow from suppliers because they cannot obtain funding from elsewhere
  - Supplier firms have comparative advantage in acting as lenders due to information advantage, etc.

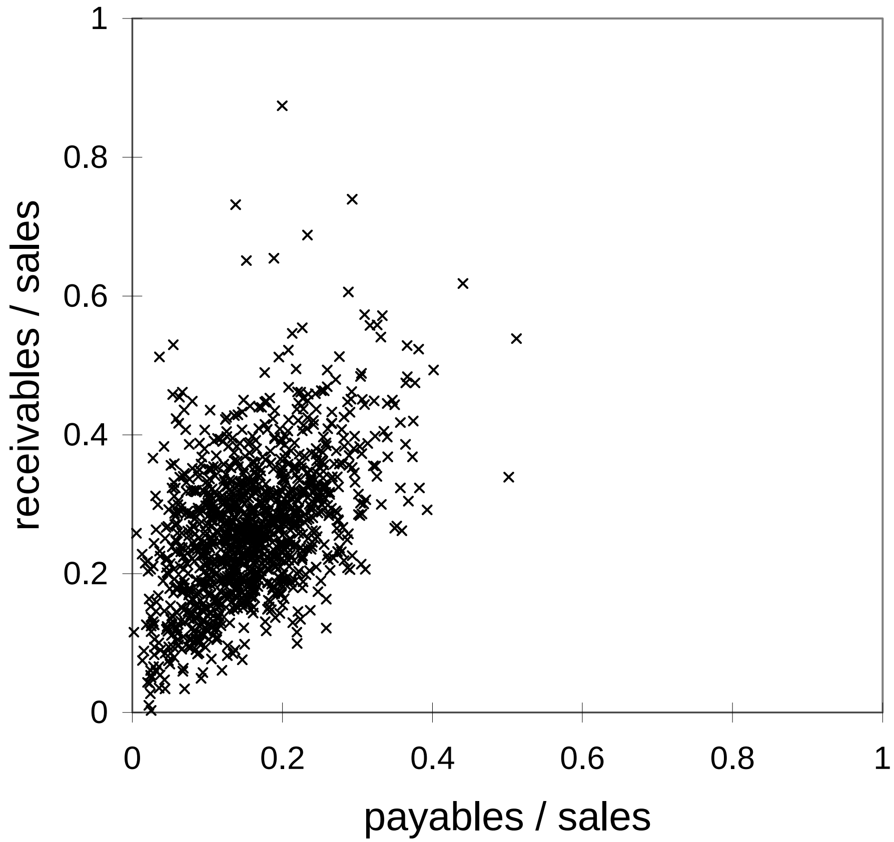
Can we partition firms into *creditor firms* and *debtor firms*?

Manufacturing firms in Japan, 2003 (1198 observations).



Slope of OLS regression ≈ 1.

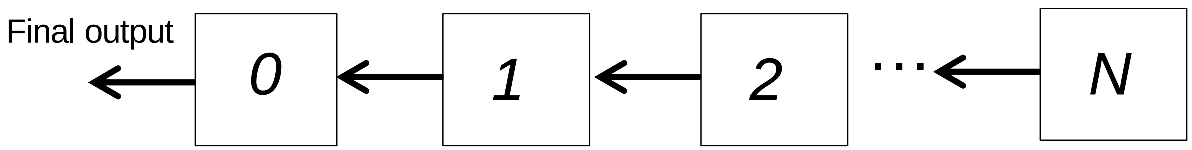
Can we say any more than noting that receivables/sales ratio is constant?



- Firms that *borrow more* are those that *lend more*.
- Most (manufacturing) firms are *net lenders*.

Production Chain

Final output sold by firm 0 at price q.



$\Leftarrow$ downstream upstream $\Rightarrow$

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

		Firms				
		0	1	$\cdots$	$N-1$	N
date t	0					$-w_N$
	1				$-w_{N-1}$	$-w_N$
	$\vdots$			$\cdots$	$-w_{N-1}$	$-w_N$
	$N-1$		$-w_1$	$\cdots$	$-w_{N-1}$	$-w_N$
	N	$-w_0$	$-w_1$	$\cdots$	$-w_{N-1}$	$-w_N$
	$N+1$	$q-w_0$	$-w_1$	$\cdots$	$-w_{N-1}$	$-w_N$
	$N+2$	$q-w_0$	$-w_1$	$\cdots$	$-w_{N-1}$	$-w_N$
	$\vdots$	$\vdots$	$\vdots$		$\vdots$	$\vdots$

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 obsolescence
  - π^H if all exert high effort, π^L if one or more exert low effort, $(\pi^L > \pi^H)$
  - Obsolescence implies zero cash flow forever
  - Zero liquidation value of firms

Efficient Benchmark

Expected present value of wage costs for the production chain

$$\frac{w_n}{\pi^H} + ... + \left(1 - \pi^H\right)^N \frac{w_0}{\pi^H}$$

Expected output of the production chain is

$$\left(1 - \pi^H\right)^{N+1} \frac{q}{\pi^H}$$

Chain is (technologically) viable when

$$\left(1 - \pi^H\right) q \geq \sum_{k=0}^{N} \frac{w_k}{\left(1 - \pi^H\right)^k}$$

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" (multi-firm version of Holmstrom and Tirole (1997))

$$p_i \geq p_{i+1} + (1 + b_i)\, w_i \tag{IC}$$

where

$$b_i = b \cdot \frac{\pi^H}{\left(\pi^L - \pi^H\right)\left(1 - \pi^H\right)^i}$$

Giving

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

- Production chain sustainable only if recursive moral hazard is not too severe.

- Length of production chains limited by recursive moral hazard, as well as logistical/technological problems.

- Parallels with “disorganization” (Blanchard and Kremer (97)).

Achieving Efficiency Through Delays

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

$$p_i \geq \frac{1}{1+a_i} \sum_{k=i}^{N} (1+b_k)\, w_k \tag{IC}$$

IC constraint can be relaxed by accumulating receivables.

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

Participation Constraint

Firm i's cash flows are a combination of three risky perpetuities

- wage cost $-w_i$ per period, starting immediately
- revenue $(1 + a_i)\, p_i$ per period, starting with delay of d_i periods
- input cost $-(1 + a_{i+1})\, p_{i+1}$ per period, starting with delay of $d_{i+1} - 1$ periods.

Participation constraint

$$V_i \equiv -\frac{w_i}{\pi^H} + \left(1 - \pi^H\right)^{d_i} \frac{(1 + a_i)\, p_i}{\pi^H} - \left(1 - \pi^H\right)^{d_{i+1}-1} \frac{(1 + a_{i+1})\, p_{i+1}}{\pi^H} \geq 0$$

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.

Proposition 1. *For any technologically viable production chain, there is a profile of delays* $\{d_i\}_{i=1}^N$ *such that the production chain is sustainable.*

$$d_i = \frac{\ln\left[\sum_{k=i}^{N} \frac{w_k}{\left(1-\pi^H\right)^{k-i}}\right] - \ln\left[\sum_{k=i}^{N} (1+b_k) w_k\right]}{\ln\left(1-\pi^H\right)}$$

$$p_i = \sum_{k=i}^{N} \frac{1}{\left(1-\pi^H\right)^{k-i+1}} w_k$$

Proposition 2. *Working capital is higher for firms that are further upstream.*

In the optimal contract,

$$a_i p_i = a_{i+1} p_{i+1} + \beta_i w_i \tag{1}$$

where

$$\beta_i = b_i - \left(\pi^H / \left(1 - \pi^H\right)\right)$$

Evidence in Gofman (2009)

Cobb-Douglas Representation

$$\log(\text{receivables}) \simeq \alpha + \varepsilon \log(\text{payables}) + (1-\varepsilon)\log(\text{sales})$$

Receivables can be large for two reasons

1. Because payables are large

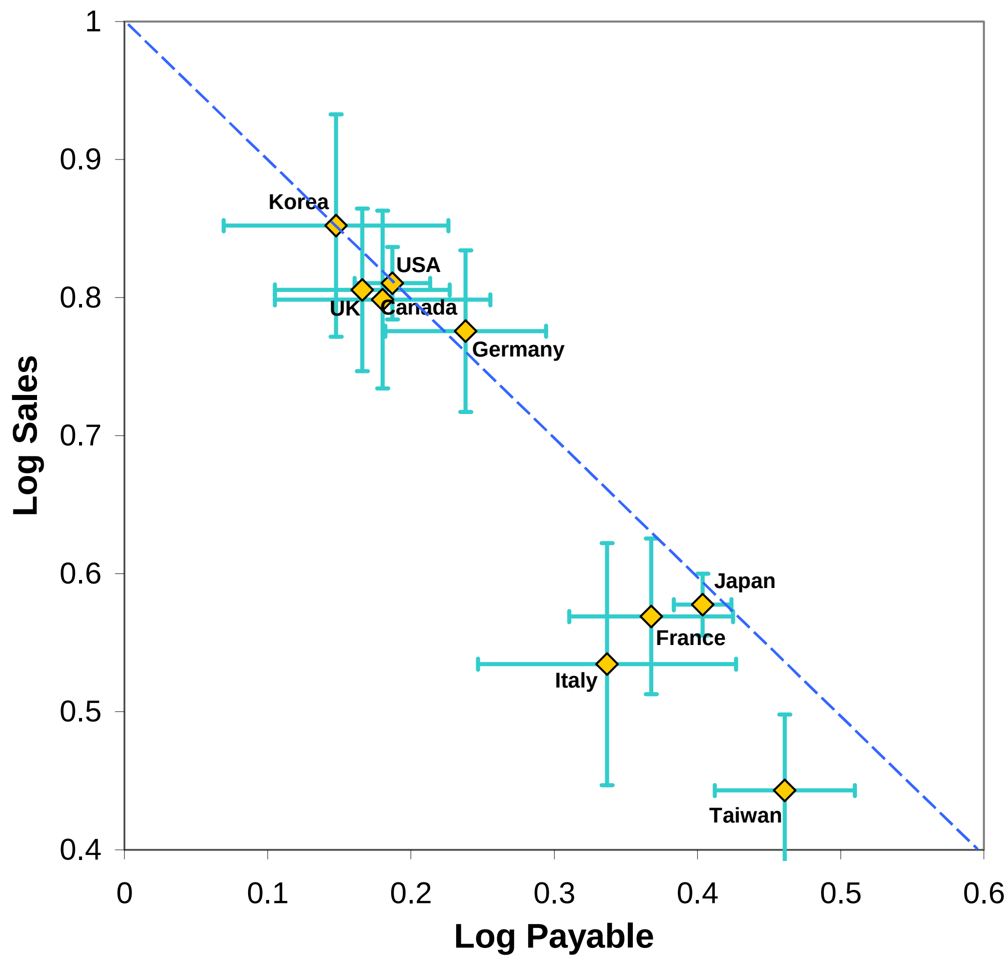
2. Because value-added is large

Elasticity ε is large when a firm's receivables are due mainly to payables to upstream firms, rather than its own value-added

Hypothesis. ε *is large for long production chains consisting of small firms*

Dependent variable: log receivables				
	log payables	log sales	R^2	obs.
Canada	0.18(0.08)	0.80(0.06)	0.90	162
France	0.37(0.06)	0.57(0.06)	0.95	226
Germany	0.24(0.06)	0.78(0.06)	0.93	261
Italy	0.34(0.09)	0.53(0.09)	0.92	93
Japan	0.40(0.02)	0.58(0.02)	0.94	1198
Korea	0.15(0.08)	0.85(0.08)	0.95	162
Taiwan	0.46(0.05)	0.44(0.06)	0.87	223
U.K.	0.17(0.06)	0.81(0.06)	0.91	298
U.S.A	0.19(0.03)	0.81(0.03)	0.92	1199
OLS cross-section regressions				

Source: Compustat Global, manufacturing firms, 2003 accounts.


Korea
USA
UK
Canada
Germany
Japan
France
Italy
Taiwan
Log Sales
Log Payable
1
0.9
0.8
0.7
0.6
0.5
0.4
0
0.1
0.2
0.3
0.4
0.5
0.6

Industrial Development

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