

Industrial Structure and Corporate Finance*

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Abstract

Instead of focusing on a single firm as the unit of analysis in corporate finance, we look to the relationships *between* firms in determining corporate financial decisions. Interlocking balance sheets through accounts receivable and payable reflect the incentive structure in complex production chains. We formulate a theoretical framework, and document the cross-country empirical evidence. Firms that borrow more from other firms are also those that lend more to other firms. The elasticity of receivables with respect to payables reflect the length of complex production chains.

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1 Introduction

The conventional approach to corporate finance based on the principal-agent model takes the single firm as its unit of analysis. We take a different tack in this paper. We will address the issue of how corporate financial decisions are arrived at as the result of the *interaction* among firms, and thus how corporate financial decisions and industrial structure are determined jointly.

When considering the composition of corporate balance sheets, our focus on the interactions among firms would be more than justified. In cross-country empirical studies of corporate balance sheets, the assets and liabilities that reflect the interactions among firms (as suppliers and customers) constitute a very significant portion of a company's balance sheet. Rajan and Zingales (1995, p. 1428) report that accounts receivable (money owed to the firm by others) constitute 18% of total assets for U.S. firms, and the figures are higher for Germany (27%), France (29%), Japan (23%), and the United Kingdom (22%).

In this paper, we argue for a corporate finance rationale for the special status of accounts receivable as an asset class. The literature on trade credit has sought to explain the large size of accounts receivable on company balance sheets by pointing to the comparative advantage that a supplier firm has in acting as a creditor to the downstream firm (as compared to a bank or other third party creditors). Biais and Gollier (1997), Cuñat (2006) and Burkart and Ellingsen (2004) give an overview of the rationales put forward to date. In addition, a large empirical literature on trade credit has sought to disentangle the competing hypotheses by examining the empirical determinants of a company's accounts receivable based on the company's individual characteristics (see Petersen and Rajan (1997), Fisman and Love (2003), Giannetti, Burkart and Ellingsen (2006) and the references therein).

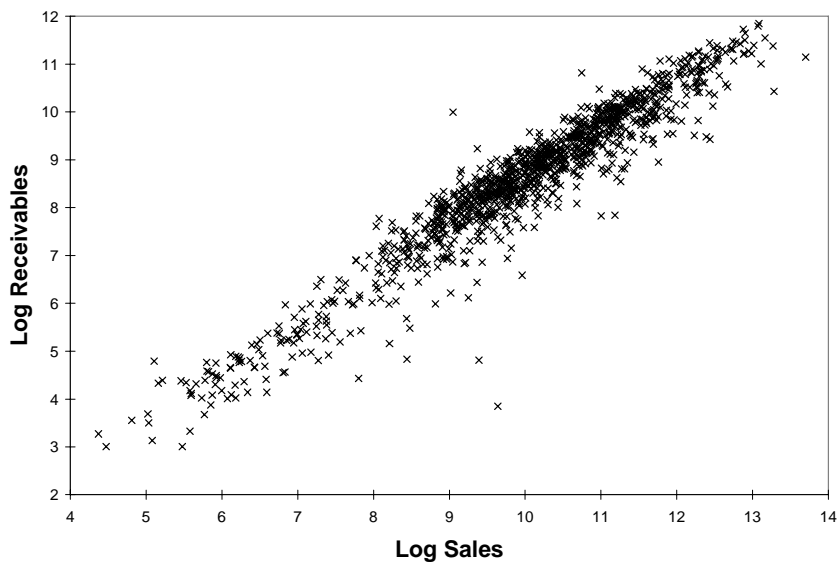


Figure 1: Scatter chart for manufacturing firms in Japan in 2003

However, many questions remain. By taking a bilateral contracting perspective between creditor and debtor, we may slip into the presumption that firms fall into two groups - creditor firms and debtor firms. However, the evidence paints a very different picture. We will examine the empirical evidence more systematically in the main body of our paper, but we highlight some salient facts here so as to motivate our analysis.

Begin with figure 1, which shows a scatter chart of the log of accounts receivable against log of annual sales for manufacturing firms in Japan. The data are from the Compustat Global database of firms (on which more later) drawing on the financial accounts of 2003. There are 1198 firms in the sample.

The slope¹ of the OLS regression is very close to 1, suggesting that the

¹The slope is 0.9996 with standard error 0.009.

hypothesis of a proportional relationship between accounts receivable and sales may be a good place to start. If the economy as a whole had a fixed, conventional invoicing period that all firms adhered to, then total sales would explain accounts receivable.

Now consider how accounts *payable* might enter as an additional explanatory variable. The bilateral contracting perspective on trade credit might suggest that firms that lend more are those that borrow less (i.e. firms with large accounts receivable are those with small accounts payable). However, the evidence points to the opposite. When receivables are regressed on payables (normalized by sales), we obtain

$$\log\left(\frac{\text{receivable}}{\text{sales}}\right) = -0.63 + 0.40 \log\left(\frac{\text{payable}}{\text{sales}}\right) \quad (1)$$

(0.04) (0.020)

with standard errors in brackets (and $R^2 = 0.25$). The coefficient on payables is positive and highly significant. Firms that lend more to other firms are also those that *borrow* more from other firms. Not only is the estimate significant in a statistical sense (the t score exceeds 20), it is also economically significant in terms of the magnitude. Even controlling for sales, receivables increase with payables in cross-section with an elasticity of 40%.

The analogous regression for manufacturing firms in the United States (again, from the same Compustat Global dataset for 2003) gives a coefficient of 0.19 with standard error 0.025. Although the coefficient for U.S. firms is significant in a statistical sense, the magnitude is smaller, suggesting an elasticity of only 19% for the U.S., much lower than the 40% elasticity for Japan.

Even this cursory brush with the empirical evidence suggests that there is much to be explained. Our task in this paper is to formulate an analytical framework that can address how finance and industrial structure are interrelated. We address the following questions.

- Why do some firms simultaneously borrow more *and* lend more?
- What accounts for the difference across countries in the cross-section elasticity of receivables with respect to payables?
- What are the implications for the role of finance in industrial development?

In addressing these questions, our focus will be on the financial counterparts of the production relationships between firms as suppliers and customers in the production chain. A firm's accounts receivable is a claim against customer firms in the production chain; i.e. the downstream firms. Equivalently, the downstream firm's accounts *payable* is a liability backed by its assets, including its own accounts receivable against firms yet further down the production chain. In this way, accounts receivable and payable generate a chain of interlocking claims and obligations that bind the interests of the firms within the production chain. The fact that accounts receivable are junior claims makes their value sensitive to the success of the project as a whole. In effect, each upstream firm is a stake-holder in the project that results in the sale of the final good.

The interlocking stakes held by firms in the production chain differ in important ways from the cross-holding of shares. First, accounts receivable mirror exactly the production relationships within the chain. Cross-holding of shares is a blunter device that lag the shifts in the underlying production relationships. Second, and more important, accounts receivable are held by *upstream* firms (often, small and medium sized firms) against their *downstream* counterparts (final goods manufacturers). This is in the opposite direction from the archetypal picture of the large, final goods firm holding equity stakes in its smaller suppliers in a vertically integrated production

structure.

The Japanese *keiretsu* mode of industrial structure has been the topic of a large literature in management and industrial organization, and can further be distinguished between the *horizontal keiretsu*, where a group of loosely affiliated firms across diverse industries are arranged around the group's "main bank" at the center, and the *vertical keiretsu* where firms are tied tightly together into the production process into a multi-layered set of sub-contracting relationships².

An example made famous from business school case studies is the contrast between the so-called Toyota model of production³, where a multi-layered set of sub-contracting firms contribute over 70% of the value-added of the finished automobile produced by Toyota, to the case of General Motors, where the proportions are reversed, and the value-added of subcontractors is less than 30%. To the extent that industrial structures differ across countries in the *same* industry, the reasons for the differences should be of interest. Our claim is that the diversity of balance sheets and industrial structure reflects the different ways of meeting the challenge of organizing the production of complex, high value goods.

The implications of our analysis on vertical integration shed light on an issue that may at first seem unrelated. The most extreme form of vertical integration is the centrally planned economy. Blanchard and Kremer (1997) coined the term "disorganization" to describe the drastic fall in output and the breakdown of complex production relationships in the countries of the former Soviet Union after 1991 (see also Marin and Schnitzer (2004)). Blan-

² Among the many works on the topic are Aoki (1988), Hoshi, Kashyap and Scharfstein (1991), Hoshi and Kashyap (2001), Gilson and Roe (1993), and Miwa and Ramseyer (2002).

³See, for instance, Jeffrey Liker and James Choi "Building Deep Supplier Relationships" Harvard Business Review, December 2004.

chard and Kremer attribute the fall in output to hold-up problems arising from bargaining between newly decentralized firms, and the recursive nature of the rents along the production chain that undermine complex production relationships. The phenomenon of disorganization can be understood within our theoretical framework, as we argue below.

The prescription that firms should hold interlocking claims against each other is feasible only if they have sufficient resources to maintain production in the initial period while the receivables (essentially, the unpaid invoices) mount up. Some recurring obligations, most notably the wage bill, cannot be deferred and must draw on the firm's cash holdings. The firm must have sufficient working capital to meet such obligations during the initial build-up phase. Receivables can sometimes be sold to (discounted by) specialist factoring firms that purchase the unpaid invoices, and take on the rights to the future cash flows.⁴ However, there are limits in principle to how much working capital can be freed up without loosening the "glue" that binds the production chain together. Accounts receivable have greatest value when held by a firm *within* the production chain, than by an outside owner.

The outline of our paper is as follows. In the next section, we present a theoretical framework for the role of interlocking claims and obligations within a production chain. In section 3, we present cross-country empirical evidence on the way that corporate balance sheets mirror industrial structure. In section 5, we address the financing of working capital, and possible financial innovations that can meet the challenge. In this connection, we discuss the experience of Korea and the financial instruments known as transferable promissory notes. We attempt to give some rationale for the evidence on the special nature of Korean firms' balance sheets. Both the rapid industri-

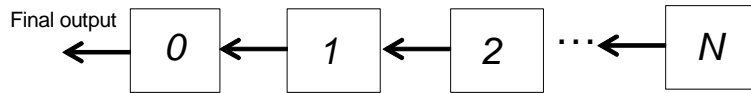
⁴ See Brealey, Myers and Allen (2005, ch. 30).

alization of Korea, and also the virulence of its financial crisis of 1997 cannot be understood without recognizing the unique financial structure of Korean firms. There are important lessons for other developing countries.

2 Model

We present an analysis of a linear hierarchical industrial structure where firms are arranged into a single chain. Suppose there is a new opportunity for a group of firms to produce a final good for sale.

There is one firm, labelled as firm 0, that sells the final output. The other firms produce intermediate inputs that are necessary in the production of the final good. Firm $i + 1$ supplies its output to firm i . In addition to firm 0, there are N upstream firms.



There is a “time to build” element in the production. Each step of the production process takes precisely one period of time, where time is indexed by $t \in \{0, 1, 2, \dots\}$. Firm i incurs a production cost of w_i , which must draw on the firm’s cash holdings, and cannot be deferred. We may interpret w_i as the wage costs of firm i .

One unit of the final good can be sold every period indefinitely into the future for the price $q > 0$, but there is a probability that the product becomes obsolete. When the product becomes obsolete, the cash flow ceases and all firms in the chain have liquidation value of zero.

The probability of obsolescence depends on the effort exerted by the firms in the production chain. If all firms exert high effort, then the probability of obsolescence is π^H , but if one or more firms exert low effort, the probability

increases to π^L , where $\pi^L > \pi^H$. Conditional on the product not being obsolete, the cash flows of the firms (before any transfers take place) can be depicted as follows.

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

Table 1. Cashflows before transfers

We examine two related issues. The first is the financing of the working capital necessary to pay for the initial “triangle” of costs from date 0 to date N . The second is the *sustainability* of the production chain once the final product begins earning cash flow from date $N + 1$ onwards.

2.1 Recursive Moral Hazard

Once the final product begins to generate a cash flow, the revenue cascades back up the production chain. A firm has the choice of two actions - high effort or low effort. Low effort by firm i can be interpreted as the decision to economize on the cost of producing firm i 's intermediate good, and to divert the resulting cost saving to alternative uses that result in private benefit, but is detrimental to the success of the final output.⁵

⁵ See Holmstrom and Tirole (1997) and Tirole (2005) for developments of such models in the bilateral contracting context.

Denote by p_i the per-period payment received by firm i from firm $i - 1$ for delivery of the intermediate good. In turn, firm i pays p_{i+1} to its own supplier, firm $i + 1$. By exerting low effort, firm i enjoys per-period private benefit of

$$bw_i \tag{2}$$

where $b > 0$ is common to all firms. If firm i exerts low effort today, the probability of obsolescence increases to π^L once the final good goes on sale $i + 1$ periods ahead. When firm i has exerted high effort at every date in the past, the expected payoff from exerting high effort at all subsequent dates is

$$(p_i - p_{i+1} - w_i) \sum_{\tau=0}^{\infty} (1 - \pi^H)^\tau \tag{3}$$

The payoff to deviating to low effort today for one period is

$$bw_i + (p_i - p_{i+1} - w_i) \left(\sum_{\tau=0}^i (1 - \pi^H)^\tau + (1 - \pi^L) \sum_{\tau=i}^{\infty} (1 - \pi^H)^\tau \right) \tag{4}$$

So, the incentive compatibility constraint against a one period deviation to low effort is

$$p_i \geq p_{i+1} + (1 + b_i) w_i \tag{5}$$

where b_i is the positive constant defined as

$$\begin{aligned} b_i &\equiv b \cdot \frac{1}{(\pi^L - \pi^H) \sum_{\tau=i}^{\infty} (1 - \pi^H)^\tau} \\ &= b \cdot \frac{\pi^H}{(\pi^L - \pi^H) (1 - \pi^H)^i} \end{aligned} \tag{6}$$

As well as the one period deviation, the firm has other possible deviations (for instance, a permanent deviation to low effort). It turns out, however, that the incentive compatibility constraint (5) is sufficient to rule out all other possible deviations from high effort. The appendix provides the argument.

The constraint (5) captures the *recursive moral hazard* inherent in our model. The moral hazard is recursive in the sense that the payment to firm i must be sufficiently large so as to induce it not to take the private benefit, but the payment to firm i also includes the rent that is due to its supplier firm, $i + 1$. In turn, the payment p_{i+1} includes rents that accrue to suppliers further up the chain.

The optimal contract solves for the prices $\{p_i\}$ that maximize the expected surplus of firm 0, subject to the incentive compatibility constraints (5) for all upstream firms, and the participation (break-even) constraints of all upstream firms. Equivalently, we can think of the problem as a sequence of overlapping bilateral contracting problems, where firm i acts as principal with respect to firm $i + 1$, but acts as agent with respect to firm $i - 1$.

The participation constraint for firm i is that it breaks even in expected terms. The financing of the initial triangle of costs before cash flows materialize will necessitate compensation for working capital. We will postpone the discussion of the participation constraint until we have introduced accounts receivable. For now, we note that the payments $\{p_i\}$ that maximize the discounted expected profit for firm 0 subject only to the incentive compatibility constraints are given by

$$p_i = \sum_{k=i}^N (1 + b_k) w_k \quad (7)$$

The prices $\{p_i\}$ incorporate rents $\{b_k w_k\}$ for all the upstream firms k along the production chain. Production of the final good is feasible only when $q \geq p_1 + w_0$, and the optimal contract minimizes p_1 subject to the constraints. Equation (7) suggests that long production chains are difficult to sustain, not only because of the technological/logistical concerns⁶ but also because

⁶The fragility of long production chains has received much attention from development economists (see Kremer (1993) and Jones (2006)).

of the viability of production in the face of incentive problems. Interlocking balance sheets through accounts receivable can improve the allocation, as we now show.

2.2 Accounts Receivable

Suppose that firm $i - 1$ begins to pay its supplier firm (firm i) after a delay of d_i periods after the delivery of the first batch of the intermediate good, and that the accounts payable are amortized by means of a perpetuity with constant payment $a_i p_i$. In this way, the expected present value of firm i 's accounts payable is kept constant over time, as long as the final product continues to generate cash. The per-period payment from $i - 1$ to i gross of the underlying sale price is:

$$(1 + a_i) p_i \tag{8}$$

In the presence of amortization payments, the incentive compatibility constraint is given by

$$(1 + a_i) p_i \geq (1 + a_{i+1}) p_{i+1} + (1 + b_i) w_i \tag{9}$$

or

$$p_i \geq \frac{1}{1 + a_i} \sum_{k=i}^N (1 + b_k) w_k \tag{10}$$

Our model has the feature that the incentive compatibility (IC) constraint and the participation (IR) constraint are linked. If the IR constraint is slack, it is possible to relax the IC constraint by raising a_i - that is, by allowing the accumulation of larger accounts receivable. The economic intuition is that the accounts receivable of firm i constitutes a stake held by firm i in the project as a whole, thereby binding the interests of the firm to the production chain as a whole. By choosing a high enough stake, the

incentive compatibility constraint can be relaxed as long as there is slack in the participation constraint.

The participation constraint for firm i requires that it breaks even in expected terms. Since there is positive probability that the project fails before cash flows materialize, the underlying sale prices $\{p_i\}$ incorporate a premium to compensate for the possible loss.

To state the participation constraint more formally, consider the net present value of firm i 's cash flows viewed from the first date that it incurs cost of production. Firm i 's cash flows are the combination of three risky perpetuities.

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

Thus, the expected net present value of firm i 's cash flows is

$$V_i \equiv -\frac{w_i}{\pi^H} + (1 - \pi^H)^{d_i} \frac{(1 + a_i)p_i}{\pi^H} - (1 - \pi^H)^{d_{i+1}-1} \frac{(1 + a_{i+1})p_{i+1}}{\pi^H} \quad (11)$$

The participation constraint for firm i requires that $V_i \geq 0$. Letting (10) hold with equality and substituting into the expression for V_i , the participation constraint can be expressed as:

$$b_i \geq \gamma_i(d_i, d_{i+1}) \quad (12)$$

where $\gamma_i(d_i, d_{i+1})$ is defined as:

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

γ_i is increasing in d_i and decreasing in d_{i+1} . The optimal pattern of delays $\{d_i\}_{i=1}^N$ can be solved recursively, starting with firm N . The optimal contract solves for longest delay d_i which satisfies (12) given d_{i+1} for its upstream firm. If b_i is strictly larger than γ_i , this is due to the discrete time nature of our model and the fact that $\{d_i\}$ are integers. If we neglect the integer constraint, the participation constraints (12) hold with equality. For values of π^H close to 0, this approximation is a good one.

3 Empirical Implications

We now explore the implications of our model for the cross-section elasticity of receivables with respect to payables. Neglecting the integer constraints on $\{d_i\}$, we can approximate the participation constraint for firm i by setting the net present value (11) of firm i to zero. That is, by setting

$$V_i = 0 \tag{13}$$

Rearranging (13), we have:

$$\begin{aligned} a_i p_i &= a_{i+1} p_{i+1} + \gamma_i (\delta_i, \delta_{i+1}) w_i + (p_i - p_{i+1} - w_i) \\ &= a_{i+1} p_{i+1} + b_i w_i + (p_i - p_{i+1} - w_i) \end{aligned} \tag{14}$$

where the second line follows from (12) when the IR constraint binds with equality. Define δ_i so that

$$\delta_i w_i \equiv p_i - p_{i+1} - w_i \tag{15}$$

In other words, δ_i is the premium in the per-period payment received by firm i that compensates it for the fair value of working capital invested in accounts receivable, where this premium is expressed as a fraction of its cost

w_i . Then (14) can be written more succinctly as

$$a_i p_i = a_{i+1} p_{i+1} + \beta_i w_i \quad (16)$$

where β_i is defined as

$$\beta_i \equiv b_i + \delta_i \quad (17)$$

Equation (16) plays a key role in our paper. Note that it implies a positive relationship between accounts receivable and payable, as seen in the data. The larger is accounts payable (i.e. the larger is $a_{i+1} p_{i+1}$) the larger is accounts receivable.

Now, consider an economy that has many production chains, where each production chain is a scaled replica of the linear production chain that we have considered in the previous section. By normalizing the quantities in each production chain by the respective scaling constants, we can make all chains identical in the normalized units. Now, consider the elasticity of accounts receivable of firm i with respect to its accounts payable. Denote by ρ_i firm i 's accounts receivable. Then firm i 's accounts *payable* is ρ_{i+1} . From (16) we can write the elasticity of ρ_i with respect to ρ_{i+1} as

$$\begin{aligned} \varepsilon_i &= \frac{d\rho_i}{d\rho_{i+1}} \frac{\rho_{i+1}}{\rho_i} \\ &= \frac{1}{1 + \frac{\beta_i w_i}{\beta_{i+1} w_{i+1} + \dots + \beta_N w_N}} \\ &= \frac{1}{1 + \kappa_i} \end{aligned} \quad (18)$$

where κ_i is defined as

$$\kappa_i \equiv \frac{\beta_i w_i}{\beta_{i+1} w_{i+1} + \dots + \beta_N w_N} \quad (19)$$

If $\kappa_i = \kappa$ for all i , then the constant κ reflects the degree of vertical integration in the production chain. The constant κ is the ratio of the rents received by

firm i relative to the total rents of all firms that are upstream from i . Thus, high κ reflects a high degree of vertical integration. In particular, when κ is constant along the production chain,

$$\beta_i w_i - \beta_{i+1} w_{i+1} = \kappa \beta_{i+1} w_{i+1}$$

so that

$$\begin{aligned} \beta_i w_i &= (1 + \kappa) \beta_{i+1} w_{i+1} \\ &= (1 + \kappa)^{N-i} \beta_N w_N \end{aligned} \tag{20}$$

In other words, the rents increase at the rate $1 + \kappa$ going downstream in the production chain. For a highly vertically integrated chain, the size of the downstream firms are much larger than the upstream firms, and κ is large.

From (18) and (20), when κ is constant, the elasticity ε_i does not depend on the index i , and so we have a relationship between the elasticity of receivables and the degree of vertical integration.

$$\varepsilon_i = \varepsilon = \frac{1}{1 + \kappa} \tag{21}$$

Greater vertical integration is associated with a lower elasticity of receivables with respect to payables. This hypothesis relies on being able to scale the production chains so that they look identical in the normalized units. If total sales of each firm is used as an approximate scaling factor, we obtain from (16) that

$$\log \left(\frac{\text{receivables}}{\text{sales}} \right) \simeq \alpha + \varepsilon \log \left(\frac{\text{payable}}{\text{sales}} \right)$$

from which we obtain the Cobb-Douglas representation of receivables:

$$\log(\text{receivables}) \simeq \alpha + \varepsilon \log(\text{payables}) + (1 - \varepsilon) \log(\text{sales}) \tag{22}$$

Taken together with (21), we have our key empirical hypothesis.

Hypothesis. The coefficient on $\log(\text{payables})$ in the Cobb-Douglas regression (22) is small for manufacturing sectors with greater vertical integration.

We pursue this theme in a cross-country study. Our dataset is the Compustat Global database of firms, drawing on the accounting numbers for 2003. The Compustat Global database has good coverage for traded firms in the United States and Japan, but is less comprehensive for other countries. The results reported below should be viewed with this in mind.

Drawing on the Cobb-Douglas representation of receivables (22), we ran cross-section OLS regressions for manufacturing firms (NAICS codes 31 - 33) of the form:

$$\log(\text{receivables}) = \alpha + \beta \log(\text{payables}) + \gamma \log(\text{sales}) \quad (23)$$

for 9 countries. They include the seven countries examined by Rajan and Zingales in their 1995 paper (Canada, France, Germany, Italy, Japan, U.K. and U.S.), plus Korea and Taiwan. The reasons for the choice of Korea and Taiwan will become clear shortly. Receivables and payable are those for trade debtors and creditors (data items 64 and 97, respectively). We removed inactive firms from the sample, as well as those that did not report figure for either receivables or payables. The parameter estimates (standard errors in brackets) and other details are given in table 1.

Dependent variable: log receivables				
	log payable	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
Table 1: Cross-section regression results				

The coefficient on log payable is positive for all countries, as predicted by the theory. The numerical magnitudes differ widely across the various countries in ways that are consistent with the received wisdom on the degree of vertical integration in these countries. Figure 2 plots the coefficients for ease of reference. The standard errors are indicated by the crosses. We note the following observations.

1. The estimates for most countries lie on, or close to the diagonal line in figure 2, suggesting that the Cobb-Douglas representation of receivables with constant returns to scale may be a promising basis for more detailed investigations.
2. Countries that have conventionally been associated with small and medium sized enterprises, and with correspondingly low degrees of vertical integration (such as Japan, Taiwan and Italy) have higher coefficients for log payable, consistent with equation (21) on the inverse relationship between ε and the degree of vertical integration.
3. In contrast, the “Anglo-Saxon” countries (U.S., Canada and the U.K.)

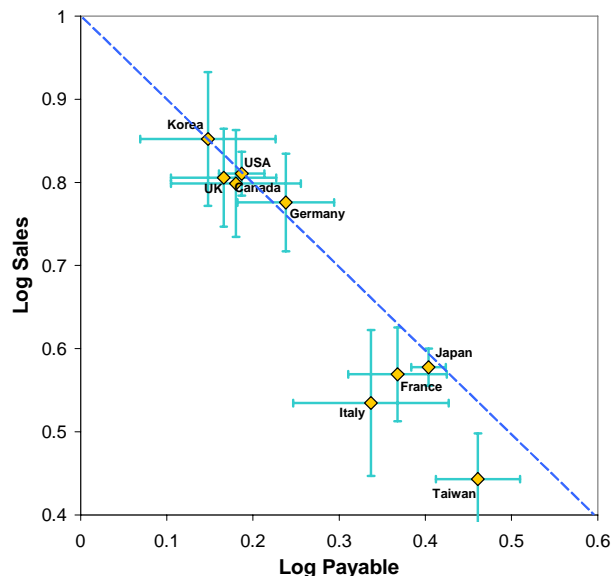


Figure 2: Coefficients of cross-section regressions (standard errors as crosses)

have lower estimates of ε , again consistent with the received wisdom that these countries have a greater degree of vertical integration.

4. The most conspicuous case is Korea. It has the lowest estimate of the elasticity ε , suggesting a high degree of vertical integration. The contrast between Korea and Taiwan is especially notable.

One of the pitfalls of cross-country studies such as above is that industry composition is not controlled for. One way to take account of industry composition is to study subsamples for a particular industry. As an illustration of our approach, we compare Japan and the United States across two industries - the computing equipment industry (NAICS classification 334, “computer and electronic product manufacturing”) and the automobile industry (NAICS 3361– 3, “motor vehicle, body, trailer, and parts manufacturing”).

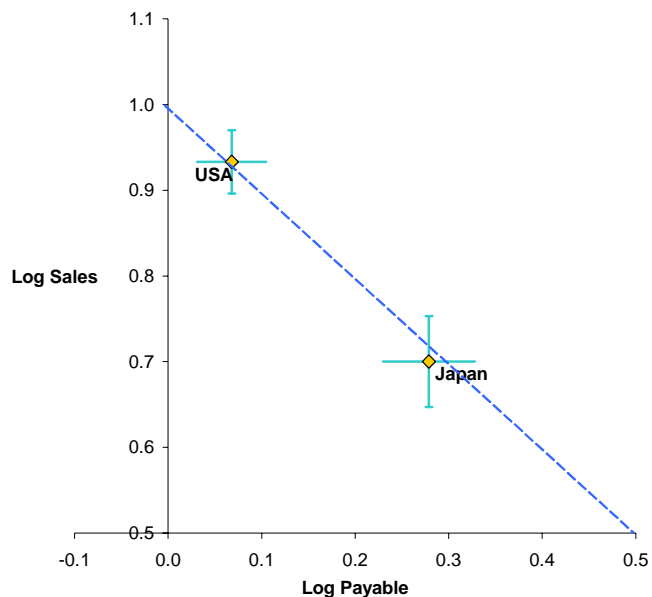


Figure 3: Elasticities in the computers and electronics industry

Electronics Industry

The elasticities from the cross-section regression (23) confined to the subsample of firms in NAICS 334 in Japan and the U.S. are as below (standard errors in brackets).

	log payable	log sales	R^2	obs	Herfindahl
Japan	0.279 (0.053)	0.700 (0.049)	0.957	198	0.017
USA	0.068 (0.037)	0.933 (0.037)	0.952	360	0.047
Table 2. Computers and electronics industry					
Dependent variable: log receivable					

Figure 3 plots the elasticities with their standard errors as crosses. Again, Japan shows high elasticity with respect to accounts payable, while the U.S. shows low elasticity. The coefficient estimates line up along the diagonal

line in figure 3, as suggested by the theory. We also report the Herfindahl index for sales, defined as $\sum_i s_i^2$ where s_i is the sale of firm i as a proportion of total sales in the sample for that country. The index is higher for the U.S. than for Japan, consistent with the evidence from the elasticities that small and medium sized firms play a more prominent role in Japan.

Automobile Industry

The elasticities for the automobile industry in the United States and Japan are obtained from regressions of the form (23) for firms in NAICS category 3361–3, and are reported below in table 3.

	log payable	log sales	R^2	obs
Japan	0.492 (0.136)	0.494 (0.137)	0.956	91
USA	0.104 (0.217)	1.105 (0.248)	0.932	41
Table 3. Automobile Industry				
Dependent variable: log receivable				

The elasticity of receivables with respect with payables in Japan is almost 50% in the auto industry - living up to the received wisdom of the multi-layered production chains of the “Toyota model”. However, the regression results for the United States is out of line with all the other regressions so far. The elasticity with respect to sales exceeds 1, and the sum of elasticities exceeds 1.2. To get a sense of why the results are so out of kilter with the rest of our results, we plot below the accounts receivable and payable for the auto industry in the U.S. and Japan.

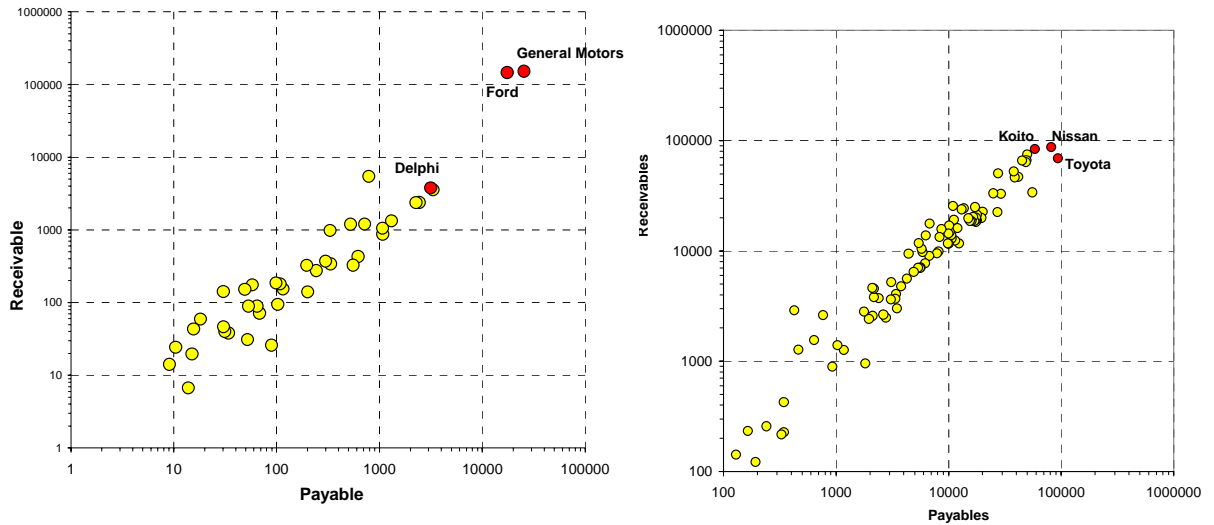


Figure 6: Automobile Industries for United States and Japan

The scatterplot for the U.S. highlights the role of General Motors and Ford. Each firm's accounts receivable are approximately 30 times as large as the third highest firm (the plots are in logarithmic scale). The dominance of General Motors and Ford in the U.S. auto industry is well known, but both have the unusual feature that accounts receivable are many times larger than accounts payable, and almost as large as annual sales⁷. For GM, receivables are 6 times payables and 83% of annual sales. For Ford, receivables are over 8 times payables and 89% of annual sales.

A closer look highlights the special nature of the two firms' businesses. Both firms have large financial subsidiaries and receivables include the large loan portfolio on the asset side of the financial subsidiary's balance sheet. In effect, Ford and GM are banks, as well as car makers. When finance receivables are excluded, accounts receivable only amount to \$5.9 billion for

⁷GM's receivables are \$151.3bn, payables are \$25.4bn, and annual sales are \$182bn.. Ford's receivables are \$145.4bn, payables are \$17.4bn, and annual sales are \$164.2bn.

Ford and \$20.5bn for GM.⁸ However, these smaller numbers would not be fully comparable to the receivables in our theoretical framework, as a large part of the financial receivables are loans extended to dealers.⁹ For these reasons, the U.S. auto industry may not be a good fit for our theory.

4 Balance Sheet Size

We now examine the implications of our approach for the size and composition of corporate balance sheets for the two countries for which our dataset has the largest coverage - namely, the U.S. and Japan. In particular, we will examine two issues: (i) the size of company balance sheets relative to their real activity, and (ii) the size of net accounts receivable held by firms as an indicator of the stake that each individual firm holds in the production chain as a whole.

We consider first the size of corporate balance sheets by examining the distribution of the ratio of receivables to total assets. Figure 4 plots the distribution of the ratio of receivables to total assets for firms in the U.S. and Japan. The evidence points to Japanese firms having higher receivables relative to total assets than their U.S. counterparts. Figure 5 presents the same information in cumulative form, confirming that the distribution for Japanese firms dominates U.S. firms in the sense of first-degree stochastic dominance.

Our model has some potential to shed light on the observed patterns of balance sheet size. Recall equation (16) for accounts receivable and payable, which states

$$a_i p_i = a_{i+1} p_{i+1} + \beta_i w_i \tag{24}$$

⁸Ford Motor Company annual report for 2004, p. 57, General Motors annual report for 2004, p. 62.

⁹Ford 2004 annual report, p. 61.

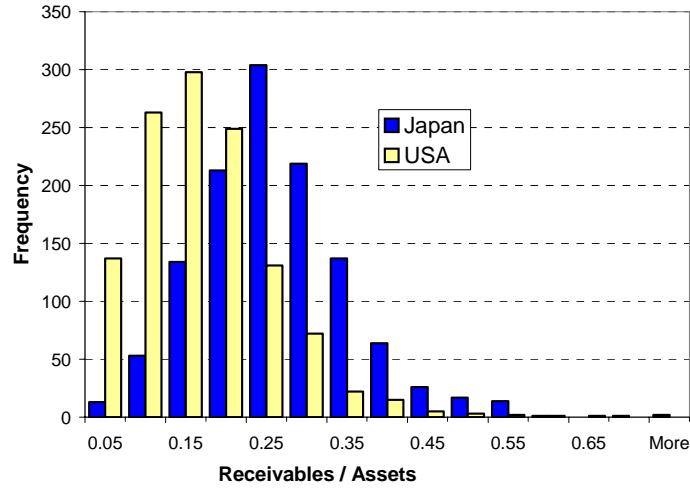


Figure 4: Distribution of receivables/assets for Japan and the United States

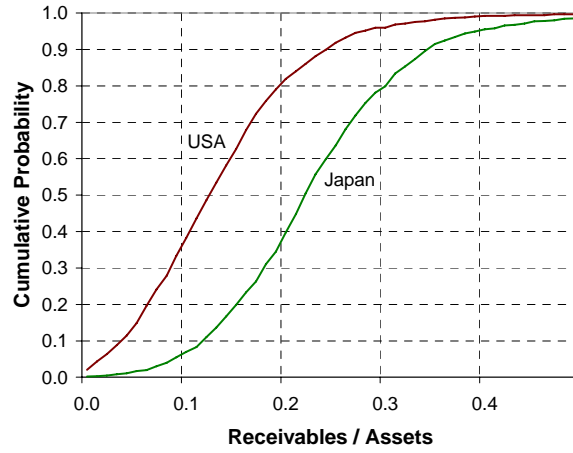


Figure 5: Cumulative distribution of receivables/assets

where $\beta_i = \gamma_i + \delta_i$. Consider the ratio of firm i 's accounts payable to its wage costs. This ratio is proportional to

$$\frac{a_{i+1}p_{i+1}}{w_i} \quad (25)$$

Similarly, the ratio of firm i 's accounts receivable to its wage cost is proportional to

$$\frac{a_{i+1}p_{i+1}}{w_i} + \beta_i \quad (26)$$

Now, consider the following comparative statics exercise. Fix the production chain upstream from firm i , hence fixing its accounts payable. Then, both (25) and (26) are increasing as w_i becomes small. For two firms at similar positions in their respective production chains, the firm with smaller w_i has larger accounts receivable and payable relative to its real activity, as measured by its wage costs. To the extent that the total assets of a firm also correspond to a measure of the size of a firm's real economic activity, our model can shed light on the greater receivables to assets ratio of Japanese firms. At the level of the production chain as a whole, the production chain that consists of many layers of intermediate goods producing firms will have larger balance sheets for any given size of real economic activity. Our model therefore has some potential to explain the differences in balance sheet size between the U.S. and Japan.

We now turn to the *net* accounts receivable of firms. Net accounts receivable represents the stake held by each individual firm in the production chain as a whole. From (24) above, we have

$$\begin{aligned} \frac{\text{net receivable}}{\text{wage cost}} &= \frac{a_i p_i - a_{i+1} p_{i+1}}{w_i} \\ &= \beta_i \end{aligned}$$

The variable β_i was defined earlier in our paper in equation (17) and is given

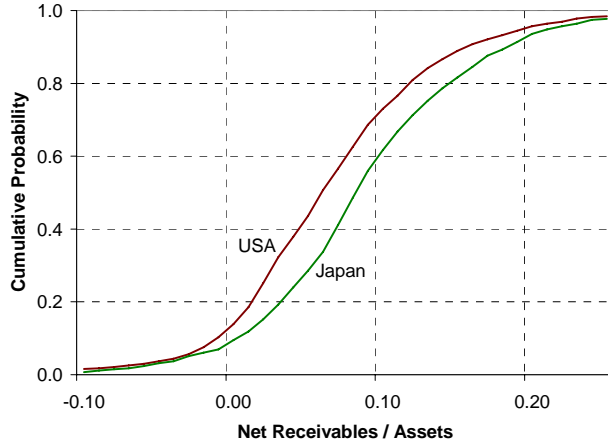


Figure 6: Cumulative distribution of net receivables/assets

by

$$\beta_i = b_i + \delta_i \quad (27)$$

The constant b_i is the coefficient that determines the rent earned by firm i due to its option of exerting low effort in the production chain and δ_i is the per-period premium necessary to satisfy the IR constraint, and will be small for durable production chains associated with low probabilities of obsolescence π^H . We showed earlier that b_i is increasing in i , reflecting the fact that upstream firms are more “remote” from the final product, and hence require sharper incentives. Thus, provided that δ_i is small, β_i will be increasing in i also. For economies with longer production chains, the incidence of upstream firms is higher as compared with more vertically integrated economies. This suggests the hypothesis that economies with longer production chains have higher net receivables. This hypothesis appears to be borne out in the comparison between Japan and the U.S.

Figure 6 plots the cumulative distribution of net receivables to total as-

sets for our sample of U.S. and Japanese firms. The cumulative density for Japanese firms dominates that for the U.S. in the sense of first-degree stochastic dominance, so that Japanese firms carry more net accounts receivable (i.e. hold larger stakes in the production chain). Our model attributes the higher working capital to the greater role of smaller firms and longer production chains in Japan. Our preliminary observations suggest that this is a promising hypothesis to explore further in more systematic empirical studies what reconstruct the web of manufacturing relationships.

5 Working Capital

So far, we have taken for granted that firms in the production chain can find enough working capital to finance the initial costs of production (the “triangle” of costs), and to build up accounts receivable. However, the lack of working capital will be a constraint on setting up multi-layered production hierarchies, even if such a production hierarchy has positive net present value. The constraint will bind especially hard for firms in developing countries.

External finance is unlikely to fill the gap, given the difficulties in raising finance from outside sources. Some evidence for developed countries is provided by Berger and Udell (1995) for the United States, Voordeckers and Steijvers (2005) for Belgium and Poutziouris et al. (2005) for the United Kingdom. However, the constraint on raising outside finance is especially important in emerging market countries, where the factors that limit financing of firms in advanced countries can be expected to bite much harder. From their survey of firms in India, Allen et al. (2005) note the overwhelming importance of funding from family and close friends for firms that are in their expansion stages. More to the point, the constraints on raising outside finance can be expected to bind particularly hard for the purpose of raising

working capital, given the imperfect pledgability of accounts receivable and inventories as collateral against loans.

The important role of fixed capital (of plant and machinery) in the production process is well recognized by economists. Perhaps less attention has been devoted to the importance of working capital in the production process. A lesson we should draw is that working capital is just as important as fixed capital. Working capital is the glue that binds the constituent firms, and holds the production process together.

However, the resources needed for working capital are huge. Consider the receivables to sales ratio. The outstanding stock of accounts receivable relative to annual sales for our sample of Japanese manufacturing firms is around 25%, suggesting an implied delay in payment of invoices of approximately three months. If the production chain were to start from scratch, firms would need to find resources to pay workers and replace depreciating capital equipment during this three month period. For developed countries, the resources needed for working capital have been accumulated over many decades, and indeed centuries. Developing countries lack the accumulated equity capital that they can draw on. However, the experience of Korea suggests that there are possible development strategies for dealing with the shortage of working capital.

5.1 Case of Korea

Korea's experience is instructive. At the beginning of its period of rapid growth in the 1960s, Korea ranked among the poorest of developing countries, with a rudimentary manufacturing sector. In making the transition from basic manufactured goods into increasingly sophisticated goods - migrating up the value chain from shoes to computer chips - the demands on working

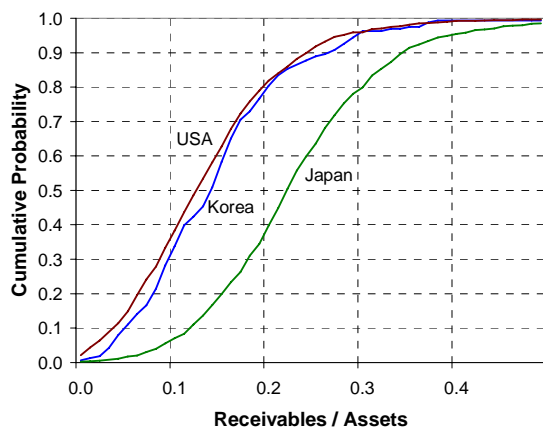


Figure 7: Receivables/assets for Korean firms

capital would have been very considerable. How was Korea able to overcome the financing constraints? In particular, how was Korea able to finance the large working capital requirements?

In answering these questions, first consider some evidence on Korean firms' balance sheets. Figure 7 adds the cumulative distribution of Korean firms' receivables/assets to those of the U.S. and Japan (already seen in figure 5). On this measure, Korean firms lie between Japan and the U.S., but closer to the U.S. However, the striking evidence comes from the distribution of *net* accounts receivable. Figure 8 superimposes the cumulative distribution curve for net accounts receivable (i.e. working capital) for Korean firms on those for the U.S. and Japan as seen already in figure 6. Korean firms carry much smaller net accounts receivable as compared to Japan and the United States. The ranking between Korea and the U.S. is reversed, with Korean firms having much smaller net accounts receivable. In particular, around 20% of Korean firms in our sample have negative working capital in the sense that accounts payable exceed accounts receivable.

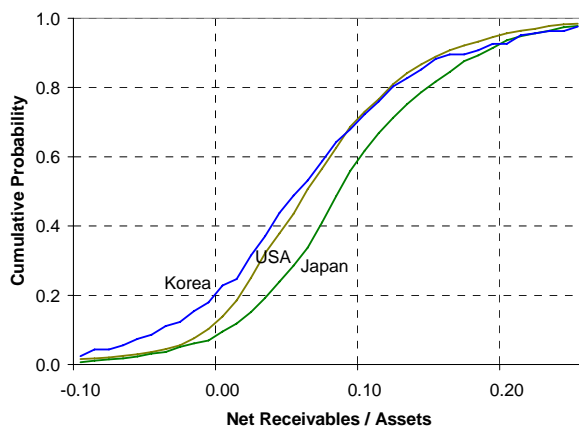


Figure 8: Working capital for Korean firms

The evidence from figures 7 and 8 suggests that Korean firms have managed to operate with very slender working capital. The low working capital of Korean firms highlights two features: vertical integration and financial innovation

The first has been much discussed, and is well known. Korea's industrial structure stands at the opposite end of the spectrum from the Toyota model in terms of the dominant position of the *Chaebol* firms in Korea, and the comparatively much weaker small firm sector there. The term *Chaebol* refers to the large, vertically-integrated conglomerate firms in Korea where a tightly-knit group of family members related to the original founder of the firm still exercise considerable influence, or outright control. Their dominant position in the Korean corporate sector (and the political economy of the country more widely) has attracted considerable criticism and debate, especially after the 1997 financial crisis.

The second element - financial innovation - is perhaps less well known, and we will devote some space to it here. We highlight the role played by fi-

nancial instruments known as *transferable promissory notes*.¹⁰ Transferable promissory notes have a long history in Korea stretching back several hundred years, comparable to the origin of bills of exchange in Europe. However, the modern version of these notes saw their heyday in the period of rapid industrialization in Korea, backed by laws amended or newly promulgated in the 1960s.¹¹

Transferable promissory notes are short-term corporate liabilities that have the legal provisions of *endorsement*, *transferability*, and the *possibility of discount*. They are similar to bills of exchange in terms of their legal provisions, but differ from them in that promissory notes are *promises to pay*, rather than an *order to pay* that has been formally accepted by a bank. This legal difference, although seemingly minor, turns out to be important when considering the incentive effects within the production chain. Their use in Korea has been very substantial even as recently as the 1990s, as we will see shortly.

In essence, transferable promissory notes act as a device in which a creditworthy firm can make its creditworthiness available to other firms in the production chain. The mechanics are best explained through an example. Consider a production chain with three firms - firms 0, 1 and 2. Suppose that only firm 0 has sufficient collateral assets to be creditworthy. Firms 1 and 2 cannot borrow from outside sources, and neither do they have enough working capital to finance an expansion in production. Firms 1 and 2 must incur wage costs of $w > 0$, and each step in the production chain takes one time period. The final product can be sold for $q > 3w$, so that there is

¹⁰Known as *Uh-um* (어음) in Korean, and in particular the subclass of uh-um known as *promissory uh-um*.

¹¹The text (in Korean only) of the relevant laws on promissory notes can be found at <http://lawpia.com/html7/bill.htm>. We are not aware of any English translations, but we welcome suggestions from readers for possible sources.

positive surplus in the project. Suppose for simplicity that the surplus is shared equally among the firms so that the (net) payment received by all three firms is $p = q/3 > w$.

How can the three firms find a way to overcome the lack of working capital to expand production? Transferable promissory notes issued by firm 0 is one way to achieve this. The table below illustrates the cash flows.

		Firms			
		0	1	2	Bank
date	t			$p - w$	$-p$
	$t + 1$		$p - w$		$-p$
	$t + 2$	$-w$			
	$t + 3$	$3p - 2p$			$2p$
working capital		$w + 2p$	0	0	

Mechanics of Transferable Promissory Notes

At date $t - 1$ (before any costs are incurred), firm 0 secures a credit line at its main clearing bank for the amount $2p$. Then, firm 0 issues transferable promissory notes with face value $2p$, and pays firm 1 this amount in return for the promise to deliver the intermediate output. Firm 1, in turn, pays face value p of the promissory notes to firm 2, in return for the promise to supply 2's intermediate good to 1.

At date t , firm 2 discounts the promissory note. The discount can take place at any bank, but suppose that the discount takes place at the main clearing bank that has supplied the credit line to firm 0. For the purpose of illustration, let us abstract away from credit risk and suppose that firm 2 obtains cash of p from the discounting bank. With this cash, firm 2 pays its wage bill of w , and produces its intermediate good.

At the beginning of date $t+1$, firm 2 delivers its intermediate good to firm 1, who then discounts its holding of promissory notes at the bank, obtaining cash of p . This cash is used to pay its wage bill of w , and firm 1 is able to produce its intermediate good. This intermediate good is delivered to firm 0 at the beginning of date $t+2$.

At date $t+2$, firm 0 incurs cost of w to produce the final good. This final good yields revenue of $3p$ at date $t+3$. At this date, firm 0 redeems the promissory notes discounted by firms 1 and 2, and repays the bank the amount $2p$.

In this way, firm 0 can make its creditworthiness available to upstream firms, enabling them to economize on their working capital. However, the flip-side of this arrangement is that firm 0 must borrow on behalf of the whole production chain, rather than simply for its own operation. Firm 0 ends up with very high levels of leverage. In the run-up to the 1997 financial crisis in Korea, *Chaebol* firms had debt to equity ratios of 300% or more - many times the OECD average. Promissory notes also enabled the *Chaebol* firms to exploit their bargaining position to extract the surplus from their relationship with subcontracting firms, further entrenching their dominance. The 1997 crisis exposed the fragility of the financial system built on promissory notes.

Given our focus on the role of moral hazard in the production chain, the financing of the triangle of costs via promissory notes raises the issue of how moral hazard can be addressed. To put it another way, how are promissory notes different from cash?

The system of promissory notes replaces the carrot of accounts receivable with the stick of contingent liability arising from the contractual feature of endorsement. Before the note can be transferred to another firm, it must be

endorsed by the transferring firm. By endorsing the note, the transferring firm guarantees to take on the obligation of redeeming the note in case the original issuer defaults. Thus, the potential liability of the transferring firm is related to the total face value of the notes (and hence total sales), which may be much larger than the size of the economic surplus arising from the relationship between the two firms. In our illustration above, when firm 0 defaults with large debts, firms 1 and 2 must meet the liabilities of firm 0.

Also, when the issuer of the note defaults, *all* of the endorsing firms become liable at the same time, and the holder of the note can demand payment from any of the endorsers. The order in which the note was endorsed has no bearing on the sequence in which firms are liable. The economic rationale for making the endorsers jointly liable is clear. By imposing joint liability, the endorser cannot refuse payment by citing some other firm as being “more liable” for the payment of the note, and exploiting the uncertainties surrounding the true ability to pay of those further up the liability chain.¹²

To illustrate the effects of contingent liability, consider a production chain where all upstream firms are financially constrained initially, and must pay for intermediate inputs by transferring the promissory notes of firm 0 with endorsement. We will consider a variation of our earlier model with a finite horizon, given by T . The current date is $t < T$. If the project fails before the terminal date T , then the final product firm (firm 0) fails and there follows a post-default game in which all upstream firms are jointly liable for the liabilities of firm 0. Suppose that the expected cost for an upstream firm arising from contingent liability in the post-default game is C . We do not model the post-default game explicitly here, since the basic tradeoffs will not

¹²The rules governing endorsement are similar to those governing bills of exchange. See Schnabel and Shin (2004) for a discussion of the legal underpinnings of bills of exchange in Europe in the 18th century.

be affected by the fine details of the game. For our purposes, let us take C as given.

If the terminal date T is reached without the failure of firm 0, then the project is wound up without the costs associated with contingent liability. Upstream firms have an incentive to exert effort to avoid early failure, and thus avoid the penalty C associated with contingent liability.

The increased probability of default before date T resulting from low effort by firm i from t onwards is

$$\Delta\pi \equiv (1 - \pi^H)^i \sum_{\tau=0}^{T-t} [(1 - \pi^L)^\tau \pi^L - (1 - \pi^H)^\tau \pi^H] > 0 \quad (28)$$

The expected value of private benefit by exerting low effort from date t is

$$bw_i \left(\sum_{\tau=0}^i (1 - \pi^H)^\tau + (1 - \pi^H)^i \sum_{\tau=1}^{T-t-i} (1 - \pi^L)^\tau \right) \quad (29)$$

Exerting high effort is optimal when $\Delta\pi \cdot C$ is large relative to (29). Promissory notes overcome moral hazard through the “stick” of contingent liability implied by endorsement, rather than the carrot of higher amortization cash flows when firms have accounts receivable.

5.2 Descriptive Statistics

Until the 1990s, promissory notes were an important means of payments between firms in Korea, especially for small firms. Promissory notes accounted for almost 50% or more of all payments made to Korean SME firms until the crisis of 1997, as shown below.

Share of total payments received by SMEs (%)			
Year	Cash*	Prom. Notes	Trade Credit**
1992	34.0	59.2	6.8
1993	29.4	56.2	14.4
1994	28.2	56.6	15.2
1995	30.3	57.5	12.2
1996	29.4	55.7	14.9
1997	28.2	59.5	12.3
1998	32.0	53.6	14.4
1999	34.4	49.8	15.8
2000	38.9	43.1	18.0

Source: Korea Federation of Small and Medium Business,
Survey of Small and Medium Firms, (1992 - 2000)

* Cash refers to cash and checks received within 30 days of sales of goods.

** Trade credit refers to cash and checks received after 30 days of sales of goods.

Another notable feature is the small proportion of notes that are held to maturity. The survey referred to in the table above also reports that in 1998, only 26 percent of promissory notes were held by the original recipients until its maturity. Promissory notes are discounted primarily by banks, accounting for close to 90% of all notes discounted in 1998. However, other non-bank financial institutions or lenders in the unregulated private curb markets discounted 3.8%, and the private curb market accounted for 5% of face value. Annualized discount rates are high, as shown below with the median being in the range of 18 - 30%. The crisis year of 1997 stands out particularly starkly.

Distribution of annualized discount rates (% of total)								
	< 12%	12– 18%	18– 24%	24– 30%	30– 36%	36– 42%	> 42%	average annualized discount rate (%)
1995	4.0	13.1	46.6	30.3	5.5	0.5	0	24.3
1996	0.4	17.5	42.5	32.8	6.1	0.3	0.4	25.3
1997	5.1	3.5	16.4	26.4	25.8	7.9	14.9	34.5
1998	10.7	26.7	18.0	20.9	21.1	1.4	1.2	24.5
1999	20.9	3.7	33.0	24.0	17.6	0.8	0	23.3

Source: Kookmin Bank, Survey of SMEs' Financial Standing, 1995 -1999.

The financial crisis of 1997 exposed the fragility of the financial system built on contingent liability, and policy has since aimed at replacing promissory notes with conventional financing methods. However, the Korean experience is instructive in how financial innovation can overcome the shortage of working capital. In this respect, there are important lessons for other developing countries in their policies toward their own financial development.

6 Concluding Remarks

We have argued for the importance of the interactions between corporate finance and industrial structure. The common thread linking these two notions is the importance of working capital.

Blanchard and Kremer's (1997) concept of disorganization can be understood in terms of our framework as the case where a complex production economy makes a sudden transition from one that is under central direction to a decentralized network of firms. The transition takes place without the benefit of large interlocking balance sheets. The result is a breakdown of incentives, undermining the complex production chain.

Our framework also sheds light on a puzzle raised in the trade credit

literature - namely, why firms persist in maintaining large stocks of accounts payable, even though some industries have substantial discounts for prompt cash settlement (see the survey evidence in Ng, Smith and Smith (1999)). A commonly encountered invoicing practice among U.S. firms is the so-called “2-10 net 30” contract, meaning that if the invoice is settled within ten days, there is a discount of 2%, and otherwise the invoice must be paid within 30 days (without discount). The implied interest rate for the additional 20 days of credit comes out at over 40% in annualized terms. However, within our framework, a firm may have an incentive to maintain accounts payable if early redemption raises the probability of failure through the violation of the incentive constraints of upstream firms.

There are many avenues of further research. One strand is the role of finance in economic development. In an economy where the SME sector is well capitalized, and financially sound, our model predicts that there are beneficial incentive effects of the SMEs supporting large balance sheets. As well as Japan, some European countries (notably Italy) have large and influential SME sectors. In contrast, the U.S. is known to be more vertically integrated than Japan or some of the European countries. In this context, Korea may be an even more glaring example of an economy that has extensive vertical integration. Of the forces that drive the push toward greater vertical integration, the incentive to overcome the shortage of working capital may be one of them.

Our paper represents a small step in the study of the interactions between industrial structure and corporate finance. The next steps are to use the insights we can gain in order to address the the diversity seen in cross-country studies of corporate balance sheets. The message of our paper is that industrial structure and corporate finance are inextricably linked.

Appendix

The incentive compatibility constraint (5) against a single period deviation from high effort is sufficient to rule out other possible deviations from high effort. We argue in two steps. First, consider the deviation when firm i switches to permanently low effort. The expected payoff from permanently low effort is

$$\frac{b}{\pi^L} w_i + (p_i - p_{i+1} - w_i) \left(\sum_{\tau=0}^i (1 - \pi^H)^\tau + (1 - \pi^H)^i \sum_{\tau=1}^{\infty} (1 - \pi^L)^\tau \right) \quad (30)$$

The payoff to exerting high effort at all future dates is

$$(p_i - p_{i+1} - w_i) \sum_{\tau=0}^{\infty} (1 - \pi^H)^\tau$$

The incentive compatibility constraint against a permanent deviation to low effort is

$$p_i \geq p_{i+1} + \left(1 + \hat{b}_i\right) w_i \quad (31)$$

where \hat{b}_i is the positive constant defined as

$$\begin{aligned} \hat{b}_i &\equiv \frac{b}{\pi^L} \cdot \frac{1}{(1 - \pi^H)^i \sum_{\tau=1}^{\infty} [(1 - \pi^H)^\tau - (1 - \pi^L)^\tau]} \\ &= b \cdot \frac{\pi^H}{(1 - \pi^H)^i [\pi^L (1 - \pi^H) - \pi^H (1 - \pi^L)]} \\ &= \frac{b \pi^H}{(1 - \pi^H)^i (\pi^L - \pi^H)} \end{aligned}$$

which is identical to the constant b_i defined in (6) for the one period deviation. Thus, the incentive compatibility constraint for the permanent deviation is identical to the one-period deviation.

Now consider any deviation other than a permanent deviation. There must then be a last period of low effort, beyond which the firm exerts high effort. When the firm arrives at this last period of deviation, the choice between low and high effort is identical to the choice between a one period deviation and high effort at all future dates, except for the recent history. Since the sign of the payoff difference is not affected by the recent history, the incentive compatibility constraint against the one period deviation suffices to deter the firm from going ahead with low effort. Thus, the incentive compatibility constraint against a *one period deviation* suffices as the incentive compatibility constraint against *any deviation*.

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