Financial Shocks in Production Chains*

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Abstract

Interlocking balance sheets through accounts receivable and accounts payable provides incentives necessary to sustain long production chains. We construct a model of incentives in production chains which has the implication that upstream firms in the chain have higher accounts receivable. Further, the working capital of upstream firms are relatively more sensitive to the availability of credit. Using a large firm-level dataset for 15 European OECD countries and the United States, 2000-2009, combined with sector-level measures of relative position in production chains ("upstreamness"), we find strong empirical support for the model. Lack of credit matters for amplifying recessions in economies with long production chains.

*Preliminary version. Comments are most welcome.

1 Introduction

Production takes time, especially when conducted through long production chains. The time dimension of production introduces a waiting period between the point when a cost is incurred and when cash flow materializes. Working capital provides the financial resources which fill this gap.

Our main hypothesis is that working capital is the "glue" that binds firms together in a production chain. We address the financial counterparts of the production relationships between firms as suppliers and customers in the production chain. A firm's accounts receivable are claims against customer firms in the production chain—the downstream firms. The flip-side of this relationship is that the downstream firms' accounts *payable* is a liability of the firm backed by its assets, including its own accounts receivable against customers yet further down the chain. Drawing on the insights of Merton (1974), we may think of a firm's accounts payable as defaultable debt backed by its assets.

Accounts receivable and payable generate a chain of interlocking claims and obligations that bind the interests of the firms within the production chain. Because accounts receivable are very junior claims their value is sensitive to the financial strength of the debtor firm. When the final product generates healthy cash flows, the value of accounts receivable as an asset will be high, to the benefit of all the firms (directly and indirectly) in the production chain. In effect, each firm is a stake-holder in the cash flows generated by the production chain as a whole.

We use a multi-stage generalization of the moral hazard model of Holmstrom and Tirole (1997) to develop three empirical hypotheses, which are then examined using a large dataset of firms from OECD countries. The sample covers the recent crisis period, and our focus is on the impact of financial shocks on working capital.

The first hypothesis is that upstream firms (i.e. supplier firms) have higher working capital compared to down-stream firms (final product firms). The reason is that upstream firms are more remote from the direct consequences of their actions. The time to produce and the more numerous intervening firms in the chain entail a higher discount rate on costs and benefits of actions. In order to elicit high effort, the upstream firm's "skin in the game" must be larger relative to revenues than for downstream firms. Net working capital serves as the equity of the firm - its "skin in the game" - in the production chain.

The second, related hypothesis is that upstream firms' working capital is more sensitive to fluctuations in financial conditions than it is for downstream firms. The intuition is that the market interest rate serves as the discount rate that firms use to evaluate the costs and benefits of working capital. When interest rates are high, the direct consequences of shirking become smaller due to the higher discount rates. Therefore, firms need to hold more equity - more skin in the game - in order to satisfy the incentive compatibility constraint.

There is, however, a sting in the tail, and this leads to our third hypothesis. When the interest rate becomes too high, the viability of the production chain itself becomes problematic, and the chain itself starts to unravel. We therefore predict that the working capital of firms is non-monotonic with respect to the interest rate. For low levels of the interest rate, working capital is increasing in the interest rate, but beyond a threshold point, the working capital declines with the interest rate. This is our third hypothesis.

Our questions bear on the recent paper by Bigio and La'O (2013), who have examined the impact of financial frictions in production networks. Bigio and La'O (2013) model financial frictions by introducing collateral constraints on input purchases. Firms' expenditures on inputs are constrained so that their expenditure is less than a given fraction of their revenue. In a production chain, downstream firms face a tighter constraint, as they must pay for intermediate inputs as well as for labor and direct inputs. In contrast, our model imposes tighter constraints on *upstream firms*. Bigio and La'O (2013) do not pose their hypothesis directly in terms of balance sheet quantities, and so the implications of their model for working capital would need to be developed separately. In this context, one guiding question would be whether downstream firms or upstream firms have higher working capital.

We use firm-level data from ORBIS, a commercial dataset provided by Bureau van Dijk (BvD), which contains administrative data on millions of firms worldwide. The accounting information in ORBIS is initially collected by local Chambers of Commerce and in turn, is relayed to BvD through some 40 different information providers. The dataset provides financial and foreign ownership information for each firm, starting in 2000. Our measure of "upstreamness" draws on sectoral interlinkages from input-output matrices developed by

Fally (2011), Antras, Chor, Fally and Hillberry (2012) and Antras and Chor (2013).

We find support for all three of our hypotheses. First, upstream firms hold more working capital. Second, upstream firms display higher procyclicality of working capital. As predicted by the model, firms that are higher up in the production chain are more sensitive to fluctuations in the interest rate. Finally, we estimate a quadratic relationship between working capital and the interest rate and find that the estimates are consistent with the non-monotonic relationship suggested by our third hypothesis.

The importance of production chains and complementarities are classic themes in economics, with antecedents in Leontief (1936) and Hirschman (1958). In the same spirit, development economists have studied the technological challenges in sustaining complex production processes. The O-ring theory of Kremer (1993) and the role of intermediate goods and complementarity discussed by Antonio Ciccone (2002) and Charles I. Jones (2011) are examples. As well as these technological constraints, our focus is on the incentive structure of production chains. One motivating example is the breakdown of production chains in the post-Soviet economies in the 1990s. Blanchard and Kremer (1997) and Marin and Schnitzer (2005) attribute the drastic fall in output to hold-up problems and the recursive nature of the rent-seeking along the production chain that undermined pre-existing production chains of the Soviet-era command economy.

The mutual 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-shareholding 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.

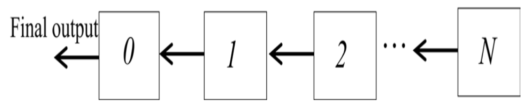
Our framework sheds light on a puzzle raised in the trade credit literature—namely, why firms persist in maintaining large stocks of accounts payable, even though some industries have substantial discounts for prompt cash settlement (see the survey evidence in Ng, Smith and Smith (1999)). A common invoicing 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 annual interest rate for the additional 20 days of credit comes out is over 40% and, everything else equal, it is hard to comprehend why a firm would borrow at such a high rate of interest. However, within our framework, a firm may have an incentive to maintain accounts payable if early redemption raises the probability of failure for the chain by lessening the incentives of upstream firms. If upstream firms (suppliers) paid in advance then they might have a lower incentive in keeping the production chain going.[1] We will show that the upstream firm have positive net receivables so he is a net creditor.

Working capital is more familiar to the literature on financial crises, especially those in emerging economies. Calvo, Izquierdo and Talvi (2006) document several stylized facts which appear consistently during financial crises, for example that credit and total factor productivity drop sharply with the onset of the crisis but that employment drops to a lesser extent. Our model addresses these features, and our deliberately stark modeling choices enable a relatively clean identification of the working capital channel of financial shocks. Neumeyer and Perri (2005) and Mendoza (2009) have emphasized working capital shortages in their models of fluctuations in emerging economics. although their modeling relies on quantitative constraints on firms' financing. Raddatz (2006, 2010) presents cross-section evidence using firm level data that financial shocks affect firm level financing needs as revealed through components of working capital.

Our paper contributes to an active debate on how macroeconomic activity is affected by fluctuations in the interest rate faced by corporate borrowers. Gilchrist, Yankov and Zakrajsek (2009) and Gilchrist and Zakrajsek (2012) document that credit spreads have substantial effect on macro activity measures. The contribution of our paper is to highlight the working capital channel of financial frictions, and show how financing cost can impact output even in a model without physical capital or labor/product market distortions.

[1] 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.

Figure 1



2 Model

Our model builds on Kim and Shin (2012), which in turn is a multi-stage version of Holmstrom and Tirole's (1997) model of moral hazard. The model is built around a production chain as depicted in Figure 1. Firm 0 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 $t \in \{0, 1, 2, \cdots\}$. 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, and so this feature corresponds to the assumption that firms cannot borrow from workers.

Each firm has the choice of high effort or low effort. If all firms exert high effort, then the output of the production chain can be sold at price $q_N > 0$ with certainty. However, if one or more firms exert low effort, there is a probability $\varepsilon > 0$ that the product fails, and the production chain must be dismantled. 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 in the spirit of Holmstrom and Tirole (1997).

Conditional on the product not failing, the cash flows of the firms (before any transfers

Table 1: Cashflows 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	$-w_0$	$-w_1$	$\cdots$	$-w_{N-1}$	$-w_N$
	$N+1$	$q_N - w_0$	$-w_1$	$\cdots$	$-w_{N-1}$	$-w_N$
	$N+2$	$q_N - w_0$	$-w_1$	$\cdots$	$-w_{N-1}$	$-w_N$
	$\vdots$	$\vdots$	$\vdots$		$\vdots$	$\vdots$

take place) can be depicted as in Table 1. Once the final product begins to generate a cash flow, the revenue cascades back up the production chain instantaneously. Denote by p_i the per-period payment to firm i from firm $i-1$ for the intermediate good. In turn, firm i pays p_{i+1} to its own supplier, firm $i+1$. All firms face the interest rate r, which reflects the cost of credit to the firm. The firm discounts future payoffs at interest rate r.

By exerting low effort, firm i enjoys per-period private benefit of

$$bw_i \tag{1}$$

where $b > 0$ is common to all firms. If firm i exerts low effort today, the probability of product failure is ε when 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

$$(p_i - p_{i+1} - w_i) \sum_{\tau=0}^{\infty} \frac{1}{(1+r)^{\tau}} \tag{2}$$

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

$$bw_i + (p_i - p_{i+1} - w_i) \left(\sum_{\tau=0}^{i} \frac{1}{(1+r)^{\tau}} + (1-\varepsilon) \sum_{\tau=i+1}^{\infty} \frac{1}{(1+r)^{\tau}} \right) \tag{3}$$

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

$$p_i \geq p_{i+1} + (1 + b_i)\, w_i \tag{4}$$

where b_i is the positive constant

$$b_i = \frac{b \cdot r\,(1+r)^i}{\varepsilon} \tag{5}$$

As well as the one period deviation, the firm has other possible deviations but it can be shown that the incentive compatibility constraint (4) is sufficient to rule out all other possible deviations from high effort (see Kim and Shin (2012)).

The constraint (4) 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 payments $\{p_i\}$ that make the incentive compatibility constraints bind are given by

$$p_i = \sum_{k=i}^{N} (1 + b_k)\, w_k \tag{6}$$

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 $q_N \geq \sum_{k=0}^{N} (1 + b_k)\, w_k$. Equation (6) points to the possibility that long production chains may break down, not only because of the technological/logistical concerns[2] but also because of the viability of production in the face of incentive problems.

However, interlocking balance sheets through accounts receivable can improve the allocation, at the expense of requiring greater working capital for the firms. Suppose that firm i maintains accounts receivable R_i from firm $i-1$, and maintains accounts payable of P_i to firm $i+1$. The receivables and payables are inter-firm credit, and they are amortized as perpetuities. Thus, R_i is amortized with constant payment $a_i p_i$. The per-period payment

[2]The fragility of long production chains has received much attention from development economists (see Kremer (1993) and Jones (2009)).

from $i-1$ to i gross of the underlying sale price is:

$$(1+a_i)\,p_i \tag{7}$$

In the presence of amortization payments, the incentive compatibility constraint with working capital is given by:

$$(1+a_i)\,p_i \geq (1+a_{i+1})\,p_{i+1} + (1+b_i)\,w_i \tag{8}$$

When the incentive compatibility constraints bind, the payments $\{p_i\}$ along the chain satisfy:

$$p_i = \frac{1}{(1+a_i)} \sum_{k=i}^{N} (1+b_k)\,w_k \tag{9}$$

By holding a sufficiently large account receivable R_i, the amortization payment can be made large, and so the fundamental price p_i can be made as low as desired. We search for a solution to the optimal contracting problem where the underlying price p_i satisfies the participation constraint; the discounted sum of wage costs. In other words, the underlying fundamental prices satisfy

$$p_i = \sum_{k=i}^{N} (1+r)^{k-i+1}\,w_k \tag{10}$$

The incentive compatibility constraint binds in the optimal contract, so that from (8) and (10) we have

$$\begin{aligned} a_i p_i - a_{i+1} p_{i+1} &= p_{i+1} - p_i + (1+b_i)\,w_i \\ &= -(1+r)\,w_i - r p_{i+1} + (1+b_i)\,w_i \\ &= \left(b_i - r\frac{p_{i+1}}{w_i} - r\right) w_i \end{aligned} \tag{11}$$

Substituting (5) into (11) we have

$$a_i p_i - a_{i+1} p_{i+1} = \left(\frac{b\,(1+r)^i}{\varepsilon} - \frac{p_{i+1}}{w_i} - 1\right) r w_i \tag{12}$$

Equation (12) gives the net interest payment received by firm i. For ε small enough, the net interest payment is positive, reflecting the fact that the firm is a net lender along the chain, which is to say that its *net receivables* are positive. Note that $R_i = \sum_{\tau=1}^{\infty} \frac{a_i p_i}{(1+r)^{\tau}} = \frac{a_i p_i}{r}$ and $P_i = \sum_{\tau=1}^{\infty} \frac{a_{i+1} p_{i+1}}{(1+r)^{\tau}} = \frac{a_{i+1} p_{i+1}}{r}$. So we have

$$R_i - P_i = \left(\frac{b\,(1+r)^i}{\varepsilon} - \frac{p_{i+1}}{w_i} - 1 \right) w_i \tag{13}$$

The first term inside the parenthesis of equation (13) is increasing in i and the second term is decreasing in i, which implies that $R_i - P_i$ is increasing in i. We thus have the following result.

Proposition 1. *The net receivables of firm i relative to w_i is higher for upstream firms.*

In other words, the working capital of upstream firms is higher than the working capital of downstream firms. The incentive compability constraints bind harder for upstream firms compared to downstream firms. Note from (13) that for ε small enough the net receivables of any firm is increasing in the interest rate r, provided that the production chain remains viable in the sense that $q_N \geq p_0 = \frac{1}{(1+a_0)} \sum_{k=0}^{N} (1 + b_k)\, w_k$. However, since $\{b_k\}$ are increasing in r, when r reaches a threshold level r^* that is high enough (to ensure $q_N = \frac{1}{(1+a_0)} \sum_{k=0}^{N} \left(1 + \frac{b \cdot r^* (1+r^*)^i}{\varepsilon}\right) w_k$), the production chain is no longer economically viable and breaks down. The most upstream firm N then falls out of the chain and produces as a stand-alone firm. We thus have the following proposition, which gives our main empirical hypothesis.

Proposition 2. *The net working capital of firm i is non-monotonic in interest rate r. For small increases, net working capital increases. However, if $r > r^*$ for some threshold r^*, firm i's net working capital falls.*

A clear empirical prediction is that firms that are higher up the chain are more sensitive to the fluctuations in the interest rate. When credit conditions are permissive, so that r falls, then longer production chains become viable, so that more firms enter the production chain as upstream firms. However, when the interest rate rises during crises, the production chain shortens and upstream firms exit from the chain.

3 Measuring Sector-Level Upstreamness

3.1 Conceptual Measures of Upstreamness

We construct an industry-level measure of firms' typical location in the production chain based on Antras and Chor (2011) and Fally (2011).[3] We first outline the main features of these measures and then give further details on how we calculate our measures.

Fally (2011) proposes a measure which proxies the distance from final-good production. The intuitive logic of this measure is that industries selling a disproportionate share of their output to relatively upstream industries should be relatively upstream themselves.

The measure is defined as:

$$U_i = 1 + \sum_{j=1}^{N} \frac{d_{ij} Y_j}{Y_i} U_j \tag{14}$$

where $d_{ij}Y_j/Y_i$ is the share of sector i's total output that is purchased by industry j. It is clear that $U_i \geq 1$. The corresponding upstreamness values for each industry are placed in the matrix U, which is equal to $[I - \Delta]^{-1}\mathbf{1}$ where Δ is the matrix with $d_{ij}Y_j/Y_i$ in entry (i,j) and $\mathbf{1}$ is column vector of ones.

3.1.1 Economic Interpretation of Measures of Upstreamness

Antras et al. (2012) show that this measure (and the equivalent measure suggested by Antras and Chor (2011)) have the following interpretations: a) Holding constant the final-use vector

[3] There are other studies that develop measures of upstreamness: Bigio and La'O (2013) employs for U.S. firms an industry-level measure of upstreamness constructed using Input-Output (I-O) tables compiled by the Bureau of Economic Analysis. Gofman (2013) constructs a firm-level measure of upstreamness using a novel database that provides information on supplier-customer relationships for 990 U.S. firms.

F and off diagonal elements of the matrix D, we have the following expression:

$$U_i = \frac{1}{Y_i} \sum_{j=1}^{N} \frac{\partial Y_i}{\partial d_{jj}} \tag{15}$$

so U_i equals the semi-elasticity of an industry's output to a uniform change in input-output linkages within industries. Intuitively, when the extent to which industries rely on inputs from their own sector increases, this will tend to increase output in all industries, but one would expect the effect to be disproportionately larger in upstream industries via a multiplier effect. and b) Holding constant allocation matrix Δ, we have the following expression:

$$U_i = \sum_{j=1}^{N} \frac{\partial Y_i}{\partial V_i} \tag{16}$$

where V_i refers to value added in industry i. Thus, U_i turns out to equal the dollar amount by which output of all sectors increases following a one dollar increase in value added in sector i.

3.2 Upstreamness in an Open Economy

In an open economy context, (13) is modified to the following expression:

$$Y_i = F_i + Z_i = F_i + \sum_{j=1}^{N} d_{ij} Y_j + X_i - M_i \tag{17}$$

The share of a country's gross output in industry i that is used as intermediate input in industry j (at home or abroad) is given by the ratio:

$$\delta_{ij} = \frac{d_{ij} Y_j + X_{ij} - M_{ij}}{Y_i} \tag{18}$$

where the following assumption i.e. $\delta_{ij} = X_{ij}/X_i = M_{ij}/M_i$ is imposed. Because in practice, information on international interindustry flows i.e. X_{ij} and M_{ij} is missing. Thus, d_{ij} is modified to:

$$\widehat{d_{ij}} = d_{ij} \frac{Y_i}{Y_i - X_i + M_i} \tag{19}$$

It can be easily verified that two measures of upstreamness given in (15) and (16) stay equal after replacing d_{ij} with $\widehat{d_{ij}}$.

3.3 How to Measure Upstreamness in OECD Countries?

We use the OECD STAN database, which provides input-output (I-O) tables for many countries. Following Antras et al. (2012), we focus on the 16 OECD countries that, as of 2005, reported data using the same industry classification, namely, Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, Germany, Greece, Hungary, Italy, Netherlands, Portugal, Slovakia, Slovenia, Spain, and the United States.[4] The countries have common industry classifications for 41 sub-industries, 18 of which are in manufacturing.[5] Thus, we focus on 18 sub-industries of manufacturing that share an exact aggregation of the data for 2005.

We use the detailed Supplementary Use Tables after redefinitions whose $(i,j)^{th}$ entry reports the value of inputs of commodity i used in the production of industry j in the given country's economy. Taking the open-economy adjustment in (21) into account, we construct the related square matrix Δ for each individual country in the OECD sample. The numerator of the $(i,j)^{th}$ entry of Δ; i.e., $d_{ij}Y_j$ is precisely the value of commodity i used in j's production. We therefore plug in the $(i,j)^{th}$ entry from the Use Table for this numerator. The denominator $Y_i - X_i + M_i$ is in turn calculated as the sum of values in row i of the Use Table, less that recorded under net exports and net changes in inventories. With this Δ, the formula $[I - \Delta]^{-1}\mathbf{1}$ then delivers a column vector whose i^{th} entry is the upstreamness value for industry i of the given country.

Using the above-mentioned methodology, we calculate the upstreamness values for each

[4] Different from Antras et al. (2012), Luxembourg is excluded from our analysis. See the following data section for details about sample selection criteria.

[5] We have to exclude the sectors that are not reported in Eurostat from our analysis. We assume that those sectors have been merged into other sectors by Eurostat. The excluded sectors are: "pharmaceuticals," "non-ferrous metals," "railroad equipment and transport equipment," "aircraft and spacecraft," "manufacture of gas," "steam and hot water supply," and "household and social work."

given country-industry pair in our OECD sample.[6] We first check the joint correlation of upstreamness values across all countries in our OECD sample through a principal component analysis. We find that 79 percent of the cross-country variation in upstreamness values is captured by a single component suggesting that upstreamness values are jointly correlated to a high degree.

Table 2 displays the mean upstreamness values by sub-industries of manufacturing industry. Each individual mean upstreamness value is obtained by averaging the corresponding upstreamness values of the given sub-industry over all countries in our OECD sample.[7] Those mean values reveal that sub-industries of manufacturing industry vary considerably in terms of their average production line position. The mean upstreamness value across those 18 sub-industries ranges from a minimum of 1.84 (Food products, beverages and tobacco) to a maximum of 3.97 (Iron and steel). That is, on average, "food products, beverages and tobacco" is the the most downstream industry with most of its output going directly to the end-user, while "iron and steel" is most upstream industry operating to manufacture raw materials. Across those sub-industries, we find a mean upstreamness of 2.53, and a standard deviation of 0.56. The average sub-industry in manufacturing industry therefore enters into use in production processes roughly more than two stages before final consumption or investment.

4 Measuring Firm-Level Accounts

Our analysis exploits cross-country firm-level data from ORBIS, focusing on OECD countries. ORBIS is a commercial dataset provided by BvD, which contains administrative data on millions of firms worldwide. The financial and balance sheet information is initially collected by local Chambers of Commerce and in turn, is relayed to BvD through some 40 different information providers. For European countries the data goes back to 1996 but for most

[6] We replicate Table 3 in Antras et al. (2012) to verify the consistency of industry upstreamness values across our countries. Similarly, we conduct a Spearman rank correlation test among all countries in our OECD sample. For each individual country, the rank correlation is large and positive, which is significantly different from zero with p-value of 0.01. Those correlations can be requested from the authors.

[7] The upstreamness values we calculate for each individual country-industry pair are available from the authors.

countries most reliable data starts in 2000 (for U.S. in 2005). Further details about our data and preliminary data cleaning are available in Kalemli-Ozcan, Sørensen, and Volosovych (2013) and Kalemli-Ozcan, Sørensen, and Yesiltas (2012).

The dataset provides financial and ownership information for each firm. We use an unbalanced panel of firms and ascertain that the panel does not suffer from survivorship bias by assembling our data from historical, archived releases of the database.

4.1 Sample Selection Criteria

Focusing only on the manufacturing firms from our 16 OECD countries, we have medium/large/very large firms from different sub-industries, which are classified according to two-digit NACE Revision 1.1. Primary codes.[8] We apply the following sample selection criteria to obtain our final sample:

- We drop firms that have inconsistent information on any generic variables such date of establishment/type of company/template etc.
- We drop firm-year observations with negative values of all types of assets/liabilities.
- We drop firm-year observations with negative values on employment, sales and operating revenue.
- We keep the firms with non-missing information on key variables such as accounts payable, accounts receivable, working capital and operating revenue between 2000–2009.
- We first trim both 1% tails of distribution of "accounts payable to operating revenue," "accounts receivable to operating revenue," "net accounts receivable to operating revenue," and "working capital to operating revenue."

[8] BvD defines medium, large and very large firms as firms with employees more than 15, 150, and 1000, respectively.

- In the cross-section regressions where we use growth values of "working capital over operating revenue" as dependent variables, we also drop the firm-year observations of the respective dependent variables whose z-scores are greater than 5 in absolute value.[9]

After this, we continue our analysis with countries having at least 1000 observations between 2000 and 2009 and we exclude Luxembourg. Of note, U.S. firms have limited data for 2000-2003, thus we only use the period 2004–2009 for the United States throughout the empirical analysis.

Table 3 displays the list of countries in our sample. We have over 150 thousand manufacturing firms (over 600 thousand firm-year observations). Table 4 presents the number of observations by firm types: medium/large/very large, listed/unlisted, and young/mature. Our sample is heterogeneous in terms of firm type as most of our firms are medium unlisted mature manufacturing firms.[10]

4.2 Definitions of Firm-level Variables

The key financial variables we use are accounts receivable, accounts payable, stocks (inventories), working capital, operating revenue, total assets, short-term debt, bank debt, long-term debt, and total debt. We use Total Assets (TA) and Operating Revenue (OR) to normalize the financial variables that we use in our empirical analysis.[11] Our theoretical model uses inter-firm credit figures relative to production cost. We used such figures (accounts receivable, accounts payable, working capital) relative to wage bill, total input cost and also

[9]We construct the z-scores as $|\frac{x_{it}-m}{sd}|$ where x, m, and sd refer to the value, mean, and standard deviation of the corresponding growth variable.

[10]ORBIS is not fully representative because smaller and younger firms are under-represented and more so in some countries than in others. Various methods have been used in the literature to address this issue. For example, Andrew and Cingano (2012) align the sample of firms with the distribution of firm populations as reflected in the OECD Structural Demographic Business Statistics (SDBS), which is based on confidential national business registers. They use re-sampling weights, based on the number of employees in each SDBS industry-size class cell, which essentially scales-up the number of observations in each cell so that they match those observed in the SDBS. Kalemli-Ozcan et al. (2013) do another adjustment using propensity score matching on the data used in this paper and observe no differences in the results between the full dataset and the dataset constructed to be representative across countries.

[11]We convert all financial data into "2005 PPP dollars" using yearly GDP deflators with 2005 base from the World Bank and 2005 end-of-year US dollar exchange rates.

operating revenue obtaining similar results. Since normalizing inter-firm claims by operating revenue maximizes number of observations we opt for that.

Accounts Receivable (REC): Total book value of trade receivables (credit extended to customers).

Accounts Payable (PAY): Total book value of trade debt to suppliers.

Net Accounts Receivable (N_REC): It is calculated as "Accounts Receivable minus Accounts Payable."

Stocks: Total book value of total inventories (raw materials+ plus goods in progress plus finished goods).

Working Capital (WC): Stocks plus Accounts Receivable minus Accounts Payable. Other short term assets such as other current assets, prepaid expenses, deferred Charges and other current liabilities such as other short term debt, other creditors are not included.

Short-term Debt: Total book value of short-term financial debt to credit institutions, and all debt to trade creditors.

Bank Debt: Total book value of short-term and long-term financial debt to banks.

Total Debt: Total book value of short-term and long-term financial debt to credit institutions.

Operating Revenue (OR): Total operating revenue (Net Sales plus Other Operating Revenues plus Stock Variations). The figures do not include VAT, excise taxes, or similar obligatory payments.

Total Assets (TA): Total book value of tangible and intangible fixed assets.

5 Empirical Analysis

5.1 Financing Choice of Firms: Inter-firm Financing Patterns

Table 5 provides the descriptive statistics of pooled OECD sample. All financial variables are normalized by Total Assets (TA) to be comparable. We further normalize accounts payable, accounts receivable, net accounts receivable, and working capital also by Operating Revenue (OR) because this is how they are used in the regression analysis and present those numbers in the last four rows of Table 5. The mean values of the financial ratios suggest that inter-firm financial contracting are important financing choices of the manufacturing firms in the OECD sample. On average, trade credit and provisions constitute a large part of their balance sheet. Accounts payable and accounts receivable (23% and 33% of total assets, respectively) are comparable to the level of short-term debt and total debt (36% and 46% of total assets, respectively). In fact, for the manufacturing firms in the OECD sample, on average the level of accounts payable is higher than the size of external finance from banks as total bank debt constitutes 22% of total assets.[12]

The above statistics suggest that trade credit usage and provision levels are important. Can this pattern be explained by firms lacking access to external finance? To answer this question, we check trade credit usage and provision levels of potentially financially constrained/unconstrained firms in our sample. We follow the financing constraints literature which suggests that mature, large, and/or listed firms are the least likely to be constrained.[13] Given this stylized fact, we group the manufacturing firms in our OECD sample according to their size, age, and legal status.

Table 6 displays the descriptive statistics of accounts receivable and accounts payable for different firm types. As reported, medium, young and unlisted manufacturing firms, which are more likely to be financially constrained, provide trade credit to their customers (mean ratios of accounts receivable to total assets are 0.34, 0.33, and 0.35, respectively) while they borrow from their suppliers (mean ratios of accounts payable to total assets are 0.24, 0.23, 0.28, respectively.) In the same manner, very large, mature and listed manufacturing firms, which are more likely to be financially unconstrained use trade credit (mean ratios of accounts payable to total assets are 0.14, 0.09, and 0.22, respectively) whereas they lend to their customers (mean ratios of accounts receivable to total assets are 0.21, 0.16, and 0.32,

[12]The mean values are consistent with those presented in the pioneering study of Rajan and Zingales (1995). In their paper, they study the balance sheets of non-financial firms in the G7 countries, of which 3 are included in our analysis. They find that the level of accounts receivable and accounts payable in United States, Germany and Italy (17.8%, 26.9%, 29%; 15%, 11.5%, 14.7% of total assets, respectively) are comparable to the level of total liabilities (66.1%, 72%, 67.4% of total assets, respectively)

[13]See Hubbard (1998), and Bond and Van Reenen (2007) for comprehensive surveys.

respectively).[14] These patterns therefore imply simultaneous usage and provision of trade credit at a level which is not simply a reflection of lacking bank credit. We further check the correlation between accounts receivable and accounts payable and find a correlation between accounts payable (normalized by total assets) and accounts receivable (normalized by total assets) of 53%, statistically significant at the 1% level. This indicates that manufacturing firms in our OECD sample simultaneously borrow from their suppliers and lend to their customers.[15]

5.2 Testing Proposition 1

The magnitude of the moral hazard problem varies with the vertical position of the firm in the supply chain. Firms at a higher position in the supply chain are less sensitive to the success of final product, because their cost of low effort is going to be realized at a later stage while the private benefit is realized instantaneously. The optimal level of incentives therefore increases with the vertical position of the firms in the supply chain as stated in Proposition 1. We test this proposition by examining the relation between upstreamness and accounts payable (PAY), accounts receivables (REC), net accounts receivable (N_REC), and working capital (WC)—all normalized by operating revenue (OR). The prediction of Proposition 1 is that the latter two variables are positively correlated with upstreamness. We estimate the following equation:

$$F_{i,s,t,c} = \beta_0 + \beta_1 \text{UPS}_{s,c} + \mu_c + \mu_t + \varepsilon_{i,s,t,c} \ , \tag{20}$$

where $F_{i,s,t,c}$ is one of four firm-level financial variables examined. $\text{UPS}_{s,c}$ refers to upstreamness value that proxies the vertical position of firms in the supply chain. The measure is constructed for each individual industry-country pair, but only available in 2005. A positive β_1 implies that firms with higher upstream values have higher values of the financial variables F, on the left-hand side. μ_c and μ_t represent country and year dummies (fixed effects),

[14] We implement independent group t-tests within each group to compare the mean values of the financial ratios across the respective two types. In each t-test, we have quite high t-statistics, which in turn suggests that the difference in means is statistically significantly different from zero at 1% level.

[15] Gofman (2013) conducts the same type of analysis using a subset of U.S. non-financial firms and finds patterns of trade credit consistent with our model.

respectively. The parameter of interest is the OLS coefficient β_1, in particular, a test of $\beta_1 = 0$ for the cases of net accounts receivable and working capital is a test of Proposition 1.

Table 7 displays OLS panel regression results for the estimation of equation (22). We find that the relationship between upstreamness and accounts payable is positive and highly significant and even larger and highly significant for accounts receivable. Because the latter correlation is higher the correlation between upstreamness and net accounts payable is also positive with very strong statistical significance as indicated by the t-statistic of 31.65. As net accounts receivable is a component of working capital, Proposition 1 implies that the relationship between working capital and upstreamness should be positive and the fourth column verifies this hypothesis, again with a t-statistic over 30.

5.3 Testing Proposition 2

The moral hazard problem as articulated in our model is that firms in the production chain may choose to exert low effort to economize on their production cost and use the resulting savings in alternative ways that bring them private benefit. When discount rates are high, firms bear less of the direct consequences of their actions, and so the incentive compability constraint implies a higher "skin in the game" when interest rates are high. Provided that the production chain remains viable, as interest rates increase, higher incentives are needed to overcome moral hazard problem. However, when interest rates becomes high enough, the chain start breaking down and the most upstream firms fall out. The relationship between needed incentives are there non-monotonic, as stated in Proposition 2. We test this prediction by estimating the following equation:

$$F_{i,s,t,c} = \beta_0 + \beta_1(\mathrm{UPS}_{s,c} \times \mathrm{spread}_t) + \beta_2(\mathrm{UPS}_{s,c} \times \mathrm{spread}_t^2) + \mu_c + \mu_s + \mu_t + \varepsilon_{i,t} \ . \tag{21}$$

The variables are as previously defined, except we add Spread_t which refers to the Bank of America (BofA) Merrill Lynch US Corporate AA Option-Adjusted Spread in a given year.[16]

[16]The Option-Adjusted Spread (OAS) of the BofA Merrill Lynch US Corporate AA Index is a subset of the BofA Merrill Lynch US Corporate Master Index that tracks the performance of U.S. dollar denominated

Annual spread values used in our estimation are constructed by collapsing daily time series into annual time series. Spread^2 is the square of the spread. The interaction variables are constructed by the multiplication of (spread-$\overline{\text{spread}}$), (UPS-$\overline{\text{UPS}}$) and (spread^2-$\overline{\text{spread}^2}$), (UPS-$\overline{\text{UPS}}$); respectively, where $\overline{\text{X}}$ is the mean of any generic variable X. μ_c, μ_s, and μ_t represent country, sector and year dummies (fixed effects), respectively. The level (direct) effects of spread and spread squared are absorbed by the time dummies.

The parameters of interest are the OLS coefficients β_1 and β_2: a positive β_1 implies that upstreamness displays a positive correlation with the spread while a negative β_2 implies that the relation is non-monotonic in the spread. Table 8 displays the results: for both accounts receivable and accounts payable, we find with high statistically significance that the impact of small interest rate spreads is relatively stronger for upstream firms—with accounts receivable displaying a larger effect implying, as seen in the third column, that net receivables are stronger affected by the spread in upstream firms. Further, the negative (significantly) estimated β_2 coefficient implies that net accounts receivable are non-monotonically related to interest rate spreads for upstream firms, exactly as predicted by Proposition 2. If we test Proposition 2 using working capital, rather than net accounts receivable, we confirm the proposition with even higher significance.

In fact we plot the median firm's working capital in US against the spread in figure 2. Figures 3 and 4 plots the 25th and 75th percentile firm. There is a clear hump shaped relation only for upstream firms.

5.4 Upstream Working Capital in Booms and Busts

At the onset of the Great Recession credit spreads increased dramatically and credit tightened with substantial effects on output. If the length of production chains increased during the boom and shortened during the contraction, according to our model of incentives, we would observe that working capital increased relatively more for upstream firms during the boom and declined relatively more for upstream firms during the contractions. In order to

investment grade rated corporate debt publicly issued in the U.S. domestic market. This subset includes all securities with a given investment grade rating AA. The BofA Merrill Lynch OAS is the spread between a computed OAS index of all bonds in a given rating category and a spot Treasury rate.

Figure 1: Median Firm

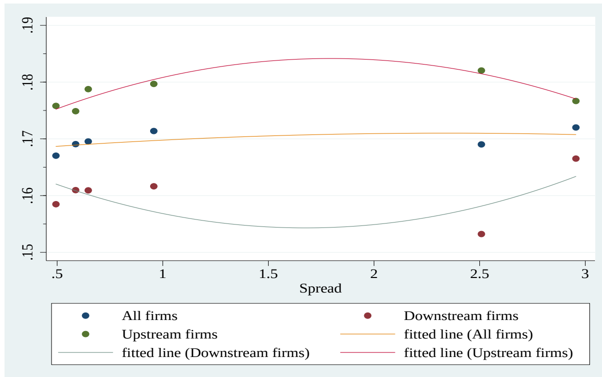
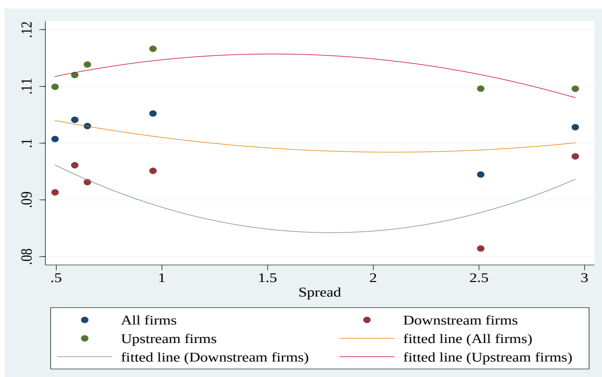


Figure 2: 25th Percentile Firm



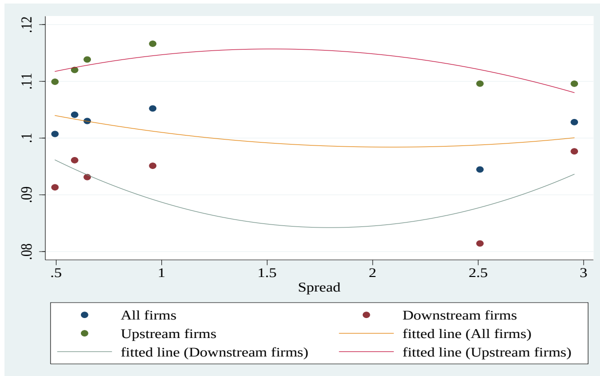
test this, we split our sample into two sub-periods, 2004-2006 and 2007-2009, which might be interpreted as "good times before the Great Recession" and "bad times in the Great Recession," respectively.

Using those sub-periods, we estimate the equations:

$$\text{avg growth } WC/OR_{i,04-06} = \beta_0 + \beta_1 \text{UPS}_{c,s} + \mu_c + \varepsilon_{i,t} \tag{22}$$

$$\text{avg growth } WC/OR_{i,07-09} = \beta_0 + \beta_1 \text{UPS}_{c,s} + \mu_c + \varepsilon_{i,t} \tag{23}$$

Figure 3: 75th percentile Firm



where avg growth $WC/OR_{i,07-09}$ and avg growth $WC/OR_{i,04-06}$ refer to the average growth rate of working capital normalized by operating revenue averaged over the periods 2007–2009 and 2004–2006, respectively. For any firm in our sample, the respective growth rates are constructed as the first difference of logarithmic values of WC/OR in 2007 and 2009 and as the first difference of logarithmic values of WC/OR in 2004 and 2006, respectively. $UPS_{c,s}$ refers to upstreamness value that proxies the vertical position of firms in supply chain in given country-sector pair. μ_c represents country dummies (fixed effects).

Table 9 displays OLS results. In Panel A, we find a positive and significant β_1, which implies that firms that are higher up in the production chain expand working capital during the high growth period. In Panel B, we find a negative and significant β_1, which suggests that firms higher up in the production chain contract working capital in the Great Recession. These results provides powerful indirect evidence of the necessity of a stronger role for incentives as production chains becomes longer or shorter following the business cycle.

Finally, we ask if the firms which increased working capital during the boom years, typically contracted working capital during the Great Recession. To examine this question, we estimate the regression

$$\text{avg growth } WC/OR_{i,07-09} = \beta_0 + \beta_1 \text{avg growth } WC/OR_{i,04-06} + \mu_c + \mu_s + \varepsilon_{i,t} \ , \qquad (24)$$

where avg growth $WC/OR_{i,07-09}$ and avg growth $WC/OR_{i,04-06}$ refer to the average growth rate of working capital normalized by operating revenue averaged over the periods 2007–2009 and 2004–2006, respectively. For any firm in our sample, the respective growth rates are constructed as the first difference of logarithmic values of WC/OR in 2007 and 2009 and as the first difference of logarithmic values of WC/OR in 2004 and 2006, respectively. μ_c represents country dummies and μ_c represents sector dummies (fixed effects).

The results, presented in Table 10, indicate that firms that expanded working capital in the boom, contracted working capital in the Great Recession. The relation is statistically significant at the 5 percent level, but the coefficient of -0.012 is not very large.

6 Concluding Remarks

This paper has argued that working capital is the "glue" in production chains. When credit conditions are permissive in good times and interest rates are low, longer production chains become viable and more firms enter the production chain as upstream firms. However, when the interest rate rises dramatically during crises, the production chain shortens and upstream firms exit from the production chain. We have formulated a theoretical model and derive predictions for the relations between upstreamness and working capital and show how this relation is a function of interest rates.

Using a large-scale dataset from ORBIS, we verify that upstream firms hold higher levels of working capital and (equivalently) net accounts receivable. We further verify the sharp theoretical prediction that the higher level of working capital in upstream firms is increasing in low interest rates but eventually decreasing as rates get high enough. We further demonstrate that upstream firms increased working capital in the high growth period of 2004-2006 and decreased working capital in the great recession. Finally, we show that the firms that increased working capital the more in the boom decreased working capital more in the recession.

There are many avenues for further research. One potential avenue 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. Some European countries (notably Italy) and Japan have large and influential SME sectors while the United States is more vertically integrated. Korea may be an even more glaring example of an economy with extensive vertical integration. Of the forces that drive the push toward greater vertical integration, a shortage of working capital, implying a lack of incentives for upstream firms, may be one.

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Table 2: Mean Upstreamness Values of the OECD sample by Manufacturing Industries

NACE Rev 1.1. Code	Industry	Upstreamness (UPS)
15,16	Food products, beverages and tobacco	1.84
34	Motor vehicles, trailers and semi-trailers	1.88
33	Medical, precision and optical instruments	1.98
36	Manufacturing nec; recycling (include Furniture)	1.99
35	Building and repairing of ships and boats	2.03
29	Machinery and equipment, nec	2.04
30	Office, accounting and computing machinery	2.05
17,18,19	Textiles, textile products, leather and footwear	2.09
32	Radio, television and communication equipment	2.46
31	Electrical machinery and apparatus, nec	2.76
23	Coke, refined petroleum products and nuclear fuel	2.78
24	Chemicals excluding pharmaceutical	2.86
26	Other non-metallic mineral products	2.92
21,22	Pulp, paper, paper products, printing and publishing	2.93
28	Fabricated metal products, except machinery and equipment	2.97
20	Wood and products of wood and cork	3.10
25	Rubber and plastics products	3.11
27	Iron and steel	3.77

Notes: The table displays mean upstreamness values by sub-industries of manufacturing industry. UPS is an industry measure of relative production-line position. We construct this value for each sub-industry of manufacturing industry for the given country in the OECD sample using the 2005 OECD Input-Output Tables from OECD STAN Database. Each individual mean upstreamness value is obtained by averaging the corresponding upstreamness values of the given sub-industry over all countries in the OECD sample. The sample consists of European OECD countries and the United States. The included European countries are Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, Germany, Greece, Hungary, Italy, Netherlands, Portugal, Slovakia, Slovenia and Spain. The first column presents the corresponding 2 digit NACE Revision 1.1 Primary Codes for the respective sub-industry of manufacturing industry.

Table 3: Firms Across Countries, 2000-2009: Number of Observations/Firms by Country

Country	Firm-Year	Number of Firms
Austria	1247	665
Belgium	30343	5495
Czech Republic	27792	7528
Denmark	4887	1515
Estonia	9141	1613
Finland	30633	5407
Germany	38527	14335
Greece	22128	6451
Hungary	10886	3539
Italy	282404	67605
Netherlands	3504	1076
Portugal	44378	11358
Slovakia	8305	2513
Slovenia	8814	1688
Spain	52436	10357
United States	40929	15723
Total	616354	156868

Notes: The table displays the number of observations/firms from ORBIS with some financial data from selected OECD countries. Countries: Austria (AT), Belgium (BE), Czech Republic (CZ), Denmark (DK), Estonia (EE), Finland (FI), Germany (DE), Greece (GR), Hungary (HU), Italy (IT), Netherlands (NL), Portugal (PT), Slovakia (SK), Slovenia (SI), Spain (ES), the United States (US). Financial Data: All companies with a known value of 1) Operating revenue; and 2) Total assets; and 3) Accounts Payable; and 4) Accounts Receivable; and 5) Working Capital.

Table 4: Firms Across Countries, 2000-2009: Number of Observations/Firms by Type

Type	Firm-Year	Number of Firms
All	616354	156868
Medium	436963	114400
Large	140208	33742
Very Large	39183	8726
Listed	13094	2834
Unlisted	451594	107732
Young	72260	30107
Mature	530662	124472

Notes: The table gives a breakdown of our sample into medium/large/very large; listed/unlisted; young/mature firms and provides the number of firm-year observations and the number of firms for each type. BvD defines medium, large, and very large firms as firms with employees more than 15, 150, and 1000, respectively. Listed firms are the firms quoted on a stock exchange. Mature firms are the firms that have been actively operating for at least ten years. Few firms do not have information on their legal status and/or date of incorporation, this explains why the numbers in the related groups do not add up to total number of firm-year observations and total number of firms.

Table 5: Descriptive Statistics: OECD Sample, 2000–2009

Variable	Obs.	Mean	Median	St. dev.	Min.	Max	Kurtosis
Payable/TA	606558	0.23	0.2	0.16	0.01	0.67	3.15
Receivable/TA	615650	0.33	0.31	0.19	0.02	0.76	2.45
Net Receivable/TA	606018	0.1	0.09	0.16	-0.29	0.5	3.11
Working Capital/TA	605153	0.28	0.28	0.19	-0.1	0.7	2.45
Short-term Debt/TA	595210	0.36	0.33	0.23	0.02	0.85	2.16
Bank Debt/TA	569870	0.22	0.20	0.19	0.00	0.68	2.25
Total Debt/TA	569757	0.46	0.47	0.24	0.03	0.91	1.99
Payable/OR	606722	0.18	0.16	0.12	0.01	0.52	3.2
Receivable/OR	615814	0.26	0.24	0.16	0.02	0.67	2.78
Net Receivable/OR	606182	0.08	0.07	0.13	-0.19	0.42	3.15
Working Capital/OR	605317	0.23	0.21	0.18	-0.07	0.74	3.33

Notes: The table displays descriptive statistics for a pooled sample of European OECD countries and the United States, 2000–2009. The included European countries are Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, Germany, Greece, Hungary, Italy, Netherlands, Portugal, Slovakia, Slovenia, and Spain. The financial variables are divided by Total Assets (TA) or Operating Revenue (OR) to obtain the above ratios. All ratios are winsorized at 2% and 98%. See the data section for details on the definitions of those financial variables.

Table 6: Descriptive Statistics by Firm Types: OECD Sample, 2000–2009

Firm Type	Variable	Obs.	Mean	Median	St. dev.	Min	Max
Medium							
	Receivable/TA	436423	0.34	0.32	0.19	0.02	0.76
	Payable/TA	430238	0.24	0.21	0.16	0.01	0.67
	Receivable/OR	436587	0.27	0.26	0.16	0.02	0.67
	Payable/OR	430402	0.19	0.18	0.12	0.01	0.52
Large							
	Receivable/TA	140093	0.31	0.29	0.18	0.02	0.76
	Payable/TA	137753	0.21	0.19	0.14	0.01	0.67
	Receivable/OR	140093	0.24	0.22	0.15	0.02	0.67
	Payable/OR	137753	0.16	0.15	0.11	0.01	0.52
Very Large							
	Receivable/TA	39134	0.21	0.18	0.16	0.02	0.76
	Payable/TA	38567	0.14	0.1	0.13	0.01	0.67
	Receivable/OR	39134	0.18	0.15	0.12	0.02	0.67
	Payable/OR	38567	0.12	0.09	0.09	0.01	0.52
Unlisted							
	Receivable/TA	451376	0.33	0.32	0.19	0.02	0.76
	Payable/TA	443721	0.23	0.21	0.16	0.01	0.67
	Receivable/OR	451376	0.26	0.24	0.16	0.02	0.67
	Payable/OR	443721	0.18	0.17	0.12	0.01	0.52
Listed							
	Receivable/TA	13072	0.16	0.14	0.11	0.02	0.76
	Payable/TA	12930	0.09	0.07	0.09	0.01	0.67
	Receivable/OR	13072	0.17	0.15	0.11	0.02	0.67
	Payable/OR	12930	0.1	0.07	0.08	0.01	0.52
Young							
	Receivable/TA	72095	0.35	0.34	0.21	0.02	0.76
	Payable/TA	71004	0.28	0.25	0.19	0.01	0.67
	Receivable/OR	72127	0.26	0.23	0.17	0.02	0.67
	Payable/OR	71036	0.2	0.18	0.14	0.01	0.52
Mature							
	Receivable/TA	530142	0.32	0.3	0.18	0.02	0.76
	Payable/TA	522173	0.22	0.2	0.15	0.01	0.67
	Receivable/OR	530274	0.26	0.24	0.16	0.02	0.67
	Payable/OR	522305	0.18	0.16	0.12	0.01	0.52

Notes: The table displays descriptive statistics for our OECD sample, 2000–2009, by firm types. BvD defines medium, large, and very large firms as firms with employees more than 15, 150, and 1000, respectively. Listed firms are the firms quoted on a stock exchange. Mature firms are the firms that have been actively operating for at least ten years. The financial variables are divided by OR (Operating Revenue) and Total Assets (TA) to obtain the above ratios. All ratios are winsorized at 2% and 98% before splitting into groups. We implement independent group t-test within each group to compare the mean values of the financial ratios across the respective two types. In each t-test, we have quite high t-statistics, which in turn suggest that the difference in means is statistically significantly different from zero at 1% level. See data section for the details on the definitions of those financial variables.

Table 7: Testing Proposition 1

Dependent variables				
	$(\frac{REC}{OR})$	$(\frac{PAY}{OR})$	$(\frac{N\_REC}{OR})$	$(\frac{WC}{OR})$
UPS	0.014***	0.005***	0.009***	0.013***
	(47.29)	(21.23)	(31.65)	(32.62)
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

Notes: The table displays OLS results of panel regressions for a pooled sample of European OECD countries and the United States, 2000–2009. The included European countries are Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, Germany, Greece, Hungary, Italy, Netherlands, Portugal, Slovakia, Slovenia, and Spain. Dependent variables $\frac{REC}{OR}$, $\frac{PAY}{OR}$, $\frac{N\_REC}{OR}$, and $\frac{WC}{OR}$ are calculated as "Accounts Receivable over Operating Revenue," "Accounts Payable over Operating Revenue," "Net Receivables (Accounts Receivable minus Accounts Payable) over Operating Revenue," and "Working Capital (Account Receivable plus Stock minus Account Payable) over Operating Revenue," respectively. UPS is an industry measure of relative production-line position. We construct this value for each sub-industry of manufacturing industry for the given country in the OECD sample using the 2005 OECD Input-Output Tables from OECD STAN Database. In all regressions, nonpermanent samples are used. Standard errors are robust and t-statistics are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 8: Testing Proposition 2

Dependent variables	$(\frac{REC}{OR})$		$(\frac{PAY}{OR})$		$(\frac{N\_REC}{OR})$		$(\frac{WC}{OR})$	
UPS	0.015***		0.005***		0.010***		0.011***	
	(47.77)		(20.13)		(33.24)		(27.42)	
UPS×spread	0.018***	0.017***	0.010***	0.010***	0.008***	0.007***	0.014***	0.015***
	(8.52)	(8.32)	(6.23)	(6.25)	(3.70)	(3.46)	(5.06)	(5.44)
UPS×spread^2	-0.004***	-0.004***	-0.003***	-0.003***	-0.001*	-0.001**	-0.006***	-0.007***
	(-6.87)	(-7.13)	(-6.32)	(-6.20)	(-1.96)	(-2.29)	(-7.22)	(-8.11)
country fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
sector fixed effects	no	yes	no	yes	no	yes	no	yes
Adjusted R^2	0.335	0.342	0.318	0.320	0.079	0.086	0.097	0.108
Obs.	609497	609497	600425	600425	599886	599886	599032	599032

Notes: The table displays OLS results of panel regressions for a pooled sample of European OECD countries and the United States, 2000–2009. The included European countries are Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, Germany, Greece, Hungary, Italy, Netherlands, Portugal, Slovakia, Slovenia, and Spain. Dependent variables $\frac{REC}{OR}$, $\frac{PAY}{OR}$, $\frac{N\_REC}{OR}$, and $\frac{WC}{OR}$ are calculated as "Accounts Receivable over Operating Revenue," "Accounts Payable over Operating Revenue," "Net Receivables (Accounts Receivable minus Accounts Payable) over Operating Revenue," and "Working Capital (Accounts Receivable plus Stock minus Accounts Payable) over Operating Revenue," respectively. spread refers to BofA Merrill Lynch US Corporate BBB Option-Adjusted Spread value. Annual spread values are constructed by collapsing daily time series into annual time series. spread^2 is square of spread figure. UPS is an industry measure of relative production-line position. We construct this value for each sub-industry of manufacturing industry for the given country in the OECD sample using the 2005 OECD Input-Output Tables from OECD STAN Database. The interaction variables are constructed by the multiplication of (spread-$\overline{\text{spread}}$), (UPS-$\overline{\text{UPS}}$) and (spread^2-$\overline{\text{spread}^2}$), (UPS-$\overline{\text{UPS}}$), respectively where $\overline{\text{X}}$ refers to the mean of the corresponding variable over all firms in the pooled sample. In all regressions, nonpermanent samples are used. Standard errors are robust and t-statistics are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 9: Cross-Section Regressions: OECD sample, 2004-2009

Panel A: Dependent variable, average growth of $\frac{WC}{OR}$ (04–06)	
UPS	0.029*
	(1.80)
Country fixed effects	yes
Adjusted R^2	0.018
Obs.	47414
Panel B: Dependent variable, average growth of $\frac{WC}{OR}$ (07–09)	
UPS	-0.045***
	(-2.83)
Country effects	yes
Adjusted R^2	0.017
Obs.	47414

Notes: The table displays OLS results of cross-sectional regressions for OECD sample, which consists of U.S. and European OECD countries such as Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, Germany, Greece, Hungary, Italy, Netherlands, Portugal, Slovakia, Slovenia and Spain. Panel A & B report the results of corresponding cross-sections, which cover the periods 2004–2006 and 2007–2009, respectively. In Panel A, the dependent variable; i.e., average growth rate of $\frac{WC}{OR}$ (04–06) refers to the growth rate of $\frac{WC}{OR}$ that is averaged in the period 2004–2006. The corresponding growth rate of $\frac{WC}{OR}$ is constructed as the first difference of logarithmic values of $\frac{WC}{OR}$ in 2004 and 2006. In the same manner, in Panel B, the dependent variable i.e. average growth rate of $\frac{WC}{OR}$ (07–09) refers to the growth rate of $\frac{WC}{OR}$ that is averaged in the period 2007–2009. The corresponding growth rate of $\frac{WC}{OR}$ is constructed as the first difference of logarithmic values of $\frac{WC}{OR}$ in 2007 and 2009. $\frac{WC}{OR}$ is calculated as "Working Capital over Operating Revenue." UPS is an industry measure of relative production-line position. We construct this value for each sub-industry of manufacturing industry for the given country in the OECD sample using the 2005 OECD Input-Output Tables from OECD STAN Database. In all regressions, nonpermanent samples are used. Standard errors are robust and t-statistics are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 10: Cross-Section Growth Regressions: OECD sample, 2004–2006

Dependent variable, average growth of $\frac{WC}{OR}$ (07–09)			
average growth of $\frac{WC}{OR}$ (04–06)	-0.013**	-0.012**	-0.012**
	(-2.57)	(-2.43)	(-2.38)
Country fixed effects	yes	yes	yes
Sector fixed effects	no	yes	yes
Clustered std. errors by	no	no	country
Adjusted R^2	0.011	0.018	0.018
Obs.	47860	47860	47860

Notes: The table displays OLS results of cross-sectional growth regressions for pooled sample of European OECD countries and the United States. The included European countries are Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, Germany, Greece, Hungary, Italy, Netherlands, Portugal, Slovakia, Slovenia, and Spain. The dependent variable i.e. average growth rate of $\frac{WC}{OR}$ (07–09) refers to the growth rate of $\frac{WC}{OR}$ that is averaged in the period 2007–2009. The corresponding growth rate of $\frac{WC}{OR}$ is constructed as the first difference of logarithmic values of $\frac{WC}{OR}$ in 2007 and 2009. In the same manner, average growth rate of $\frac{WC}{OR}$ (04–06) refers to the growth rate of $\frac{WC}{OR}$ that is averaged in the period 2004–2006. The corresponding growth rate of $\frac{WC}{OR}$ is constructed as the first difference of logarithmic values of $\frac{WC}{OR}$ in 2004 and 2006. $\frac{WC}{OR}$ is calculated as "Working Capital over Operating Revenue." In all regressions, non-permanent samples are used. Standard errors are robust and t-statistics are reported in parentheses. The standard errors are also clustered by country in the last column. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.