Trade credit and firm comovements

DENNIS BAMS, JAAP BOS and MAGDALENA PISA*

First version: January 30, 2015

This version: September 21, 2015

ABSTRACT

Firms depend heavily on trade credit. In the years 1980-2004 about 60% of all inputs to production were purchased with a delayed payment. This paper provides evidence that trade credit connection plays significant role in the growth stability of customers by reducing the propagation of firm-level shocks from suppliers onto their customers. On average, customer experiences about 20% lower disruption to its sales from a shock to its supplier if credit linkage exists next to production linkage.

In a tight network of customer-supplier relationships, a liquidity shock to one firm triggers a flow of liquidity from other parts of the network. Such a behavior of firms dampens shocks to any of the firms in such a liquidity rich networks. During recession we do not observe this dampening effect anymore. In these periods, firms are short of liquidity and are unable to withstand a drop in trade credit provision.

I Introduction

UNTIL RECENTLY, ECONOMISTS BELIEVED that in the aggregate, idiosyncratic shocks do not matter as they eventually average-out. This view was undermined by work of Long and Plosser (1983), Acemoglu et al. (2012) and Gabaix (2011). For example, Long and Plosser

*Bams and Bos are at Maastricht University, Pisa is at WHU. The authors thank Dimitris Pongas for support and helpful discussions and Yakov Amihud, Gabriela Contreras for useful comments. The present project is supported by the National Research Fund, Luxembourg.

JEL classification: E32, G32, L14.

Keywords: Idiosyncratic shocks, spillover effects, supply chain, trade credit.

(1983) and Acemoglu et al. (2012) discuss a multi-sector economy, in which a business cycle arises as a result of asymmetric production linkages. In such a multi-sector economy, a shock to a central supplier causes more damage to production than a shock to a peripheral firm, and in aggregate, may not average out. This paper continues this strain of thought, and argues that trade credit amplifies this transmission mechanism. We show that production linkages, along with trade credit, are important for the transmission of idiosyncratic shocks in the economy. We build on the idea that trade credit arises along production linkages, and plays significant role in transmission of firm-level shocks between firms.

In the modern economy, suppliers play a dual role: they provide intermediate inputs and extend significant amounts of credit to their customers (Burkart and Ellingsen (2004)). A failure by suppliers often means reduced stock levels and hampered production capacity. During the recent economic slowdown, the fear of disruption to production prompted some firms to give their liquidity-starved suppliers a helping hand. For instance, Bosch, the German car parts and technology firm, managed its supply chain risks by offering forward payments and covering costs of raw materials to its suppliers (Bryant (2013)). Wal-Mart followed suit, and offered earlier payments (10-15 days instead of typical 60-90 days) in exchange for a price discount (The Economist (2010)). Wal-Mart's incentives to support its suppliers might have been stronger as the firm is known to use its suppliers as finance providers. Due to the fact that products at the supermarket can be turned into cash at the check-out counter far in advance the supplier needs to be paid, input suppliers to Wal-Mart are effectively also providers of short-term liquidity.

This paper postulates that, in general, presence of trade credit in a customer-supplier relationship dampens shocks to customer's sales. We also argue that in good times when liquidity is abundant, suppliers can insure their customers against liquidity shocks, as proposed in Cuñat (2007). This insurance ultimately stabilizes a customer's sales, but is in place only during booms when suppliers have enough liquidity to support such insurance provision. We formalize this idea in a multi-sector economy of Acemoglu et al. (2012), in which we allow the products delivered on trade credit to have a different productivity to those delivered directly. We derive a testable hypothesis from the augmented Acemoglu et al. (2012) model to see whether this is the case.

Our contribution to the existing literature is threefold. First, this study explores the role of production networks in the propagation of idiosyncratic shocks throughout the economy. We investigate a mechanism described by Acemoglu et al. (2012), in which a shock to one unit in an economy propagates directly onto its production partners and affects their activity. In particular, our paper deals with a fine-grained economy where such a mechanism exists between firms. Here aggregate fluctuations in firms' activity arise from micro-level shocks that strike firms in the production network.

Secondly, the study examines trade credit as a possible amplification mechanism of idiosyncratic shocks. Although the framework of Acemoglu et al. (2012) does not require any market imperfections to generate aggregate fluctuations, we believe that financial constraints as in Kiyotaki and Moore (1997, 2002) can stimulate even stronger firm co-movements. Given the role of suppliers as input and trade credit providers, a shock to their production technology alters the availability of inputs and also trade credit.

Lastly, in spite of the wealth of research on cross-sector co-movements, there is little empirical evidence at the firm level, in particular on the role of individual firms and their production and trade credit interconnections. Based on a new data set, this study aims to bridge this gap by demonstrating the presence and importance of production and trade credit networks in the propagation of idiosyncratic shocks on a granular (firm) level. The data set covers the years 1980 to 2004, and combines quarterly information on large customers to major U.S. firms from segments information disclosed as part of the Statement of Financial Accounting Standards - SFAS No. 131. This data includes information about the financial position, shocks experienced and sales growth for 2,133 distinct customer-supplier pairs.

To an external observer, co-movements in economic activity seem to originate from large exogenous shocks that affect the entire economy and trigger the business cycle. More recent literature, however, focuses on a second explanation for aggregate fluctuations: the role of disaggregated shocks in aggregate fluctuations. Long and Plosser (1983) derive a theoretical multi-sector model, in which economic activity co-moves as a result of choices of maximizing agents. Shea (2002) and Conley and Dupor (2003) propose sectoral complementarity as the driving force of cross-sector covariance. Also, Horvath (2000) and Holly and Petrella (2012) present evidence that a supplier-customer network propagates sectoral or aggregate shocks through the economy. Importantly, Acemoglu et al. (2012) emphasize that in an economy with asymmetric production linkages, in which one industry plays an important role as a supplier to other industry production process, the diversification argument of Lucas (1977) does not apply. In other words, idiosyncratic shocks do not average-out in the aggregate, but instead cause economic activity to move together across sectors. Yet only Gabaix (2011) and Carvalho and Gabaix (2013) show empirically that a major share of the economic fluctuations can be attributed to firm-level shocks that strike large U.S. firms. The latter studies however neglect the existence of production and trade credit networks.

Imperfections in capital, labor or product markets lay at the root of the third principal explanation for aggregate fluctuations. Important work by Kiyotaki and Moore (1997) discusses a theoretical framework, in which small initial shocks are amplified as a result of credit limits and asset prices. Similarly, Bernanke, Gertler, and Gilchrist (1996) propose that during economic downturns, firms with high agency costs experience greater credit tightening due to creditors' flight to quality. The resulting liquidity shortage is studied also by Cavalcanti (2010) who shows that in general larger anti-creditor bias (measured as the fraction of total assets that courts are unable to retrieve from defaulting debtors) causes a sharper decline in credit supply during recession. This pattern is reversed only in economies with exceptionally high anti-creditor bias, as local firms are less leveraged. In addition, in a context of a network of interbank exposures, Caballero and Simsek (2013) derive a model, in which a complexity in such networks amplifies the perceived counterparty risk and makes banks reluctant to buy risky assets. This in turn leads to fire sales and a drop in asset prices. However, only Raddatz (2010) discusses the role of trade credit alongside production process linkages in generating and amplifying sectoral co-movements. Our study contributes to this literature by adding the aspect of trade credit to the multi-sector economy of Acemoglu et al.

(2012). Also, we provide empirical evidence on the most disaggregated level - the firm-level.

Our study is further motivated by the strand of literature proposing firm-level shocks as a micro-foundation of co-movements in economic activity. Seminal work by Gabaix (2011) shows that due to fat-tailed distribution of firm sizes, independent shocks to small firms cannot compensate for shocks to large firms and thus do not average out in the aggregate. This idea is continued in Carvalho and Gabaix (2013) and di Giovanni, Levchenko, and Méjean (2014). The latter analyze a comprehensive data set of French firms and provide evidence on the role of firm-size distribution and production network, but neglect the trade credit channel as an amplification mechanism. Although firm-level shocks take an important place in economic debate, to date there is no evidence on their role in conjunction with production linkages and trade credit in creating co-movements in the economy.

We provide novel evidence that the use of trade credit between production partners can stabilize customers' growth. The disturbance to customer's sales decreases with the importance of trade credit linkage. This relationship however disappears in bad times when firms are short of liquidity and cannot withstand a drop in trade credit provision.

The paper is organized as follows. The next section introduces the multi-sector model with cascading effects, in which productivity shocks to one firm propagate to the rest of the economy. Section III outlines the empirical design and section IV describes the data used, in particular the matched data set of the Compustat Segment and Compustat. The empirical results are presented in section V, which also summarizes the implications of idiosyncratic shocks for first-order interconnections. Finally, section VI concludes.

II Theory

In this section we illustrate how a structural model with explicit production linkages can be used to determine the effects of direct production process linkages and trade credit linkages. As in Acemoglu et al. (2012), we consider a static version of the multi-sector economy of Long and Plosser (1983). The economy is populated by a representative household with given tastes and production possibilities. The household is endowed with one unit of labor, which is supplied inelastically. At the beginning of each period, the household decides about its consumption as well as commodity and labor inputs to various production transformations to be completed this period. Those choices are constrained by the availability of labor and inputs. As we assume the commodities to be perishable, only the amount produced in a given period can be used as an input in the production process in that period. During the period, the production transformation is subject to various exogenous shocks, which alter the production possibilities and ultimately determine the amount of commodities available for consumption or production input.

Each commodity is produced by a competitive firm and can either be directly consumed or used as an input in the production of another commodity. If used as an input, we follow Raddatz (2010) and allow a fraction β of this input to be purchased on trade credit. We deviate from Acemoglu et al. (2012) in that respect. Then, the fraction $(1-\beta)$ is paid up-front or on delivery while payment of the fraction β is due at a later date and shows up in the customer's balance sheet as an item in accounts payable.

In particular, n firms buy intermediary inputs from one another and firm i produces quantity x_i of commodity i according to a Cobb-Douglas technology with constant returns to scale[1]:

$$\begin{aligned} x_i &= z_i^\alpha l_i^\alpha \prod_{j=1}^{n} x_{ij}^{(1-\alpha)(1-\beta)w_{ij}} x_{ij}^{(1-\alpha)b\beta w_{ij}} \\ &= z_i^\alpha l_i^\alpha \prod_{j=1}^{n} x_{ij}^{(1-\beta+b\beta)(1-\alpha)w_{ij}} \end{aligned} \tag{1}$$

where $z_i = exp(\xi_i)$ is the firm specific productivity shock distributed independently across firms, l_i is the amount of labor hired by firm i, x_{ij} is the amount of commodity j used in the production process of commodity i, parameter α is the output elasticity of labor in the economy and parameter b governs the effect of trade credit. If the parameter b assumes a value greater than one, the inputs purchased on trade credit have greater output elasticity than the inputs purchased directly. In the reverse situation, if b assumes a value less than

[1] From constant returns to scale we have that: $\sum_j w_{ij} = \frac{1}{1-\beta+b\beta}$

one, the inputs purchased directly have greater productivity. The parameter $w_{ij} \geq 0$ denotes an element in the input-output matrix $W_{n \times n}$ that measures the amount spent on input j per dollar of production of firm i. The column sums of W imply the importance of a firm as a supplier to other firms' production processes. At the firm level, the diagonal of W is equal to zeroes since a firm does not deliver to itself. The fact that a firm uses intermediate inputs from other firms is a basis for interconnectedness in this economy. The transmission of idiosyncratic shocks occurs downstream through the input-output matrix from the supplier to its customer.

Let y denote the logarithm of real value added that we call aggregate output for reasons of brevity. In Appendix A we show that the evolution of aggregate output follows:

$$y = \mu + u'\xi \tag{2}$$

where μ is a constant that depends on models parameters only, ξ is a vector of firm specific shocks and u is a vector that governs the transmission of idiosyncratic shocks in the economy. With $\mathbf{1}$ defined as a column vector of ones, we derive the vector u as:

$$\begin{aligned} u &= \frac{\alpha}{n} \left[I - (1-\alpha)(1-\beta+b\beta) W' \right]^{-1} \mathbf{1} \\ \text{or} \quad u &= \frac{\alpha}{n} \left[I - (1-\alpha)(1+\eta\beta) W' \right]^{-1} \mathbf{1} \\ \text{where} \quad & \eta = b - 1 \end{aligned} \tag{3}$$

Equation (2) shows that the fluctuations in aggregate output are a sum of idiosyncratic shocks to firms in the economy with coefficients given by the elements of the u vector. In other words, fluctuations in aggregate output originate from disturbances to a firm's production possibilities. Those disturbances are then weighted by the importance of production and trade credit linkages. Importantly, the parameter η corresponds to the importance of trade credit linkage. If η takes a value greater than zero it amplifies the transmission mechanism that occurs due to direct production process linkage. Values lower than zero decrease this mechanism. If trade credit has no effect on the transmission of idiosyncratic shocks between firms, the parameter η takes a value of zero and the above equation simplifies to the *influence vector* of Acemoglu et al. (2012) given by:

$$v = \frac{\alpha}{n} \left[I - (1-\alpha) W' \right]^{-1} \mathbf{1}, \tag{4}$$

where the aggregate fluctuations arise as a consequence of idiosyncratic shocks and the firms' production network in the economy only.

Similarly as in Raddatz (2010), the vector u reflects both the production network and the trade credit channel in transmitting the idiosyncratic shocks. In particular, by taking a first order Taylor approximation of u around $\eta = 0$, it follows that:

$$\begin{aligned} u \approx & \frac{\alpha}{n} \left[I - (1-\alpha) W' \right]^{-1} \mathbf{1} \\ & + \eta \frac{\alpha}{n} \left[I - (1-\alpha) W' \right]^{-1} (1-\alpha)\beta W' \left[I - (1-\alpha) W' \right]^{-1} \mathbf{1} \\ = & v + \eta \left[I - (1-\alpha) W' \right]^{-1} (1-\alpha)\beta W' v. \end{aligned} \tag{5}$$

It can be seen that elements of the u vector depend on the direct production network linkages (first term) and to some degree on the trade credit channel (second term).[2] Elements of the u vector can be considered as weights. Those weights if applied to firm-level shocks result in aggregate fluctuations. The greater the importance of a firm as an input supplier, the greater the term v and the greater the weight of its shock on its downstream customers. Also, with positive values of η, the larger the share of inputs provided on trade credit (β), the greater the weight applied to a supplier's shock.

For a single customer, equations (2) and (5) imply that customers' activity is subject to its suppliers' economic conditions. And the more strategic is the supplier, i.e. by delivering a large share of inputs (large w_{ij}) or of trade credit (large β), the greater is the customer's

[2]For derivation please refer to Appendix B.

exposure to a supplier's shocks. In Appendix B we show that on a firm level it holds that::

$$y_i = \mu_i + \sum_{j=1}^{n} D_{ji}\xi_j + \eta \sum_{j=1}^{n} \Big[(1-(1-\alpha)W')^{-1}(1-\alpha)\beta W'D\Big]_{ji} \xi_j \tag{6}$$

$$\text{where} \quad D \equiv \frac{\alpha}{n}\left[I-(1-\alpha)W'\right]^{-1}.$$

In the economy described above, we assume the household has a Cobb-Douglass utility function over n distinct commodities:

$$u(c_1, c_2, \ldots, c_N) = \prod_{i=1}^{n} (c_i)^{1/n}, \tag{7}$$

where c_i is the consumption of i's commodity.

III Empirical approach

Our main objective is to determine if disturbances in a customer's sales can be attributed to trade credit exposures that occur along production linkages. To this end, we identify idiosyncratic shocks ξ by means of a strategy proposed by Gabaix (2011). Manski (1993) notices a *reflection problem*: that firms' activity might be volatile due to aggregate shocks, but not necessarily vice versa. To address this reflection problem, we use various measures for the idiosyncratic shocks. We begin with the following representation of firm activity:

$$y_i \equiv ln(sales_i). \tag{8}$$

We motivate this choice by the fact that trade credit is measured as a proportion of sales supplied with a deferred payment. As the trade credit channel is central for our analysis, we refrain from other measures, such as value added per worker (see Gabaix (2011)), total factor productivity (see Carvalho and Gabaix (2013)) or employment (see Moscarini and Postel-Vinay (2012)). Instead, we follow di Giovanni, Levchenko, and Méjean (2014) that also look into the development of sales only.

We quantify ξ_i in a manner similar to Gabaix (2011), that is we set the idiosyncratic shock to be a deviation from a certain benchmark. Similar to Gabaix (2011), we set this benchmark to be equal to average sales in the economy and denote it by $\bar{y}_E$. In particular, this benchmark is computed as an average $ln(sales)$ of all firms in Compustat database. The firm-level shock is then given by a difference between the business' sales and the average sales in the economy:

$$\hat{\xi}_i = y_i - \bar{y}_E. \tag{9}$$

An alternative specification is to measure the deviations relative to an industry or region benchmark where the industry benchmark is given by the average sales of firms in a particular industry. We use the six digit NAICS classification to define an industry. The region benchmark is given by an average of the sales of firms in a region where the region is defined by the zip code of each firm's headquarters. Those specifications make the assumption that the firms respond to the common factors with the same sensitivity.

Due to large firms having the value of y_i persistently above the benchmark, we focus instead on the change in a firm's activity, since this is more appropriate for giving insights into a firm's condition. In particular, if a firm grows at a rate higher than the growth rate of its benchmark, it can give an additional boost to its customers by delivering more inputs or trade credit. That is why we follow the literature (Gabaix (2011), di Giovanni, Levchenko, and Méjean (2014), etc.) and look into the growth rate of firm's activity and in particular into growth rate of sales. So, let the growth rate of sales be given by $g_i = \Delta y_i$ which is the difference in log sales from one year to the other and $\hat{e}_i = \Delta\hat{\xi}_i$ which is the change in log sales from one year to the other relative to the change in the benchmark.[3] To test the hypothesis that trade credit on a firm-level amplifies idiosyncratic shocks to suppliers and transmits them downstream onto production partners, we take the first difference in equation (6):

$$g_i = \underbrace{\sum_{j=1}^{n} D_{ji}\hat{e}_j}_{\text{production process exposures}} + \underbrace{\eta\sum_{j=1}^{n}\left[(1-(1-\alpha)W')^{-1}(1-\alpha)\beta W'D\right]_{ji}\hat{e}_j}_{\text{trade credit exposures}}. \tag{10}$$

The second term, which we call *production process exposures*, depicts the relationship

[3]Note that $\hat{e}_i = \Delta\hat{\xi}_i$ is also equivalent to $\hat{e}_i = \Delta g_i - \Delta g_E$.

between a customer's sales growth and the production linkages in the absence of trade credit linkages, or if trade credit does not matter for transmission of idiosyncratic shocks. It is a weighted sum of firm-level suppliers' shocks, where the weights depend on the relative importance of those suppliers in customer's production. The third term, which we call *trade credit exposures*, is a weighted sum of firm-level suppliers' shocks with weights determined by both suppliers' importance in delivering inputs and their position as trade credit providers.

In that third term, parameter η indicates the importance of the trade credit channel in the transmission of firm-level shocks. Positive values of η amplify the disturbance to the production process while negative values dampen that effect. If $\eta = 0$ the trade credit channel is irrelevant for the transmission of idiosyncratic shocks between firms. We test our hypothesis about the role of trade credit in transmitting idiosyncratic shocks by looking if the parameter η is equal to zero. In general, we expected the estimate of η to be negative and significantly associated with customers' sales growth. We expect this relationship to be negative as trade credit can serve as insurance from liquidity shocks to customers.

To this end we estimate variants of the following specification:

$$g_i = \phi \sum_{j=1}^{n} D_{ji} \hat{e}_j + \eta \sum_{j=1}^{n} \left[\left(1 - (1-\alpha) W'\right)^{-1} (1-\alpha)\beta W' D \right]_{ji} \hat{e}_j + \varepsilon_i. \tag{11}$$

From the theoretical model we expect the estimate of parameter ϕ to be equal to one.

IV Data

At the heart of our data is a list of all customer-supplier linkages. Under the Statement of Financial Accounting Standards - SFAS No. 131 a firm needs to disclose certain information on operating segments. In particular, firms are required to reveal the identity of major customers that correspond to 10% or more of its sales. The customer-supplier linkages are collected from the Compustat Segments from 1980 to 2004. Compustat Segments reports only the name of the major customer and the dollar amount of sales to this customer. In order to match the supplier to financial information on its customers we use the sample provided by Cohen and Frazzini (2008). The sample assigns the Compustat Segments customers to

CRSP's permno. We use this established connection to match the customer-supplier linkages contained in Compustat Segments to CRSP-Compustat's balance sheet information.

We base our analysis on all the customer-supplier pairs established by Cohen and Frazzini (2008) with a match to Compustat balance sheet information and non-missing values of sale in two consecutive years. The final set contains 2,730 unique customer-year observations. Each of these observations is connected on average to 2.4 suppliers with a total of 6,558 unique firm-year customer-supplier relationships that represent 2,133 distinct customer-supplier pairs over the years 1980 to 2004.

The customers reported in Panel A of Table I tend to be larger than the suppliers in Panle B. This discrepancy is partially due to the way the data has been constructed. The customers reported in Compustat Segments, and therefore in the Cohen and Frazzini (2008) sample, are those that correspond to at least 10% of sales. Those firms are inclined to be larger, with assets on average almost 23 times higher and sales 16 times higher than the sample of suppliers. During the entire sample period, both customers and suppliers experience, on average, a positive sales growth rate (g). The average customers' sales growth is illustrated in Figure 1. For most of the time it stays positive with short episodes of negative growth in 1982, 1986 and 2002.

[Figure 1 about here.]

[Table I about here.]

The labor income share denoted by α is assumed to be constant over the whole economy and takes value of 0.61. We compute it from the OECD data on Unit Labor Costs as the average of Labor Income Share (Real ULC) over the years when the statistic is available, that is from 1995 to 2004. Next, the parameter (w_{ij}) is said to capture the amount spent on input j per dollar of production of firm i. On a firm-level we approximate it by the ratio of sales from supplier (firm j) to customer (firm i) over the customer's cost of goods sold (Compustat item *cogs*). It represents the amount the customer i spent on inputs from supplier j per dollar amount of the cost of its production. On average, about 7.10% of customer's inputs come from one of its suppliers. Next, similarly to Raddatz (2010), we measure the share of trade credit received by customer (β) as the ratio of its accounts payable (Compustat item *ap*) over its cost of goods sold (Compustat item *cogs*). It depicts the proportion of purchased inputs with deferred payment and customary reflects the share of goods that the customer purchased in trade credit. Due to data availability, we are not able to distinguish how much of the trade credit comes from which supplier. To this end we assume this proportion to be equal across all its relationships with suppliers. In our sample, customers buy about 46.20% of its inputs on trade credit. The U.S. Census Bureau also confirms this high proportion of products delivered on trade credit. According to its statistics for Trade Accounts and Trade Notes Receivable correspond to about 45.11% value of goods sold in the U.S. As a comparison, U.S. firms in Raddatz (2010) sample rely far less on trade credit with only 13.00% of inputs financed with trade credit.[4].

We identify the shocks ($\hat{e}$) to suppliers as a deviation from a benchmark. The benchmark is given by an average sales growth among a group of firms, to which the supplier belongs. We take the Compustat universe of firms to compute the economy sales growth ($\bar{g}_E$) as the average growth among all the Compustat firms. Next, we categorize firms into industries based on the four digit SIC code to compute the industry benchmark as an average for sales growth among firms in the same industry. We repeat that exercise and compute the state benchmark as an average for sales growth among firms in the same U.S. state and the county benchmark as an average for sales growth among all firms operating in the same county.

V Application and results

In this section, particular interest is paid to the relevance of trade credit linkages along the production process linkages in the propagation of shocks from suppliers to customers. According to our model in section II, a shock to a supplier can be transmitted either in the form of a failure to deliver intermediate inputs, and therefore disrupting customer's production process, or through the trade credit channel that disrupts a customer's liquidity.

[4] Raddatz (2010) sample includes a universe of US firms in Compustat over a similar time period

Before we delve into the role of trade credit as a transmission mechanism, we examine in Table II the correlations between customer and supplier sales growth, and the benchmarks. The correlations are computed from yearly observations pooled across all the customer and supplier firms. At the bottom of column (2) we report the correlations between supplier sales growth and the shocks to customer sales growth using different benchmarks. The high correlation indicates that there is a considerable commonality between disturbance to customer sales growth and their suppliers' sales growth. High deviations of customer sales growth are associated with high supplier sales growth. Also, customer sales growth tends to be correlated with shocks to their suppliers.

[Table II about here.]

The time series evolution of the economy, industry, state and county benchmark is illustrated in Figure 2. Their behavior is related to the average sales growth rate among suppliers and their shock, which we approximate by the deviation from the benchmark. In general, their behavior is closely related, and both values co-move together. For example, during the NBER recessions, illustrated by the shaded areas, both the benchmark and the average behavior of suppliers tend to drop considerably.

[Figure 2 about here.]

Whether those shocks to suppliers are transmitted through the production network, and which part of the production network plays a crucial role, is answered in Table III. We report coefficients on the production process term (ϕ) and on the credit linkage (η). We postulate that the use of credit in the customer-supplier relationship stabilizing a customer's sales. As described in section II, we are able to test this hypothesis by estimating the coefficients in equation (11). The estimated relationship between the production linkage (ϕ) and disruption to customers growth is expected to be positive and significant as the change to customer's sales should be greater with a greater shock to its crucial suppliers of inputs. For the credit linkage (η) the relationship is expected to be negative. Table III confirms that the credit linkage is negatively and significantly related to customers' sales growth (which is given by the negative and significant coefficient on trade credit exposures η). Depending on the specification, a one standard deviation increase in the use of trade credit (β) decreases the customer's sales growth by 3.59-4.27%. The effect is also economically significant, with a one standard deviation increase in the trade credit linkage ($\sum_{j=1}^{n}\left[(1-(1-\alpha)W')^{-1}(1-\alpha)\beta W'D\right]_{ji}\hat{e}_j$) decreases the customer's sales growth by 0.5%. On average, customer experiences about 20% lower disruption to its sales from a shock to its supplier if credit linkage exists next to production linkage.

[Table III about here.]

The positive and significant coefficients on the production exposures and trade credit exposures imply that a shock to downstream suppliers is transmitted through two channels: (1) production channel as a disturbance in input delivery and (2) trade credit channel as a disruption in the use of trade credit. The growth in customers' sales is therefore subject to the state of their suppliers that are vital with respect to delivery of inputs and trade credit. The basic result is robust to alternative benchmarks and to inclusion of firm and annual fixed effects as illustrated in Table IV and in TableBetaZero.

[Table IV about here.]

Note that our matrix of linkages is not exhaustive, and we are missing the customer-supplier linkages that do not pass the 10% threshold to be reported in the Compustat Segments database. However, we believe that it would be acceptable for those connections to be approximated by the industry, state or county benchmark. In turn, this leaves those connections with no impact on the analysis as their shocks are equal to zero.

[Table V about here.]

In the last step, we look at timing of the trade credit channel in transmitting shocks from downstream suppliers to upstream customers. To grasp how the trade credit channel can change with liquidity in the economy, we distinguish between booms and recessions according to the NBER business cycle reference dates. Studies like Gao (2014) show that in a tight network of customer-supplier relationships, a liquidity shock to one firm triggers a flow of liquidity from other parts of the network. An example we mentioned earlier is Bosch that supported its liquidity starved suppliers by offering them forward payments and reimbursement of raw materials. Such behavior by firms can dampen shocks to any of the firms in such liquidity rich networks. On the other hand, if firms depend on the liquidity provided by their production partners, a small shock to one firm in the network can spillover onto their affiliates and cause a larger disruption to the production process than the initial shock. Table VI provides evidence of such supporting behavior during booms (Panel A) when networks are abundant in liquidity. It is given by the negative and significant coefficient on the trade credit term (η) and means that during good times trade credit works as a stabilizer of firms' sales growth. This pattern, however, disappears during recessions (Panel B). At those times, firms are not able to lend a helping hand to their production partners and the existence of trade credit linkage increases the damage to production processes. Similar results can be found in Table VII which distinguished between cash poor customers. To identify those cash poor customer-supplier networks we take the bottom 5% of customers with lowest cash to sales ratio. This way we relate the customers ability to withstand a drop in liquidity provision by its shocked supplier.

[Table VI about here.]

[Table VII about here.]

VI Concluding remarks

This paper provides a framework, in which a transmission of idiosyncratic (firm-level) shocks across firms in the economy occurs along production linkages and trade credit connections. We build on the idea that trade credit arises along production linkages and amplifies idiosyncratic shock as firms may be exposed to not only a shortage of inputs but also liquidity.

We provide novel evidence that use of trade credit between production partners can exacerbate a shock to suppliers and spill-over to their customers. The wider and more important the trade credit linkage, the higher the disturbance to a customer's sales. We find that a customer's sales growth rate changes with shocks to important input suppliers and significant trade credit providers. Also, although the trade credit channel can serve as a stabilizer of customer's sales in good times, this is does not occur in bad times when firms are short of liquidity and so are unable to withstand a drop in trade credit provision.

Appendix A Competitive equilibrium

We derive the competitive equilibrium by following closely Acemoglu et al. (2012). The competitive equilibrium is a set of commodity prices p_i, wage h and consumption choices c_i that satisfy the representative household's utility maximization problem; firms' profit maximization problem subject to condition that the commodity and labor markets clear, that is:

$$c_i + \sum_{j=1}^{n} x_{ij} = x_i \tag{A1}$$

$$\sum_{i=1}^{n} l_i = 1 \tag{A2}$$

From the firm i profit maximization problem subject to labor and input choices, l_i and x_{ij} respectively, we obtain:

$$l_i = \frac{\alpha x_i p_i}{h} \tag{A3}$$

$$x_{ij} = \frac{x_i p_i (1-\alpha)(1-\beta+b\beta)}{p_j} \tag{A4}$$

In the next step we substitute the optimal labor and input choices into the production function. By taking logs and simplifying we arrive at the following expression:

$$\begin{aligned} \alpha ln(h) =& \alpha\xi_i + C + ln(p_i) + (1-\alpha)(1-\beta+b\beta)\sum_{j=1}^{n} w_{ij} ln(w_{ij}) \\ &- (1-\alpha)(1-\beta+b\beta)\sum_{j=1}^{n} w_{ij} ln(p_j) \end{aligned} \tag{A5}$$

where C is a constant independent of prices, wage and consumption defined as:

$$C = \alpha ln(\alpha) + (1-\alpha) ln(1-\alpha) + (1-\alpha) ln(1-\beta+b\beta) \tag{A6}$$

Next we multiply by the ith element of the u vector and we sum over all i.

$$\begin{aligned}\sum_{i=1}^{n} u_i ln(h) = & \sum_{i=1}^{n} u_i \xi_i + \frac{C}{\alpha}\sum_{i=1}^{n} u_i + \frac{1}{\alpha}\sum_{i=1}^{n} ln(p_i) u_i \\ & + \frac{(1-\alpha)}{\alpha}(1-\beta+b\beta)\sum_{i=1}^{n}\sum_{j=1}^{n} u_i w_{ij} ln(w_{ij}) \\ & - \frac{(1-\alpha)}{\alpha}(1-\beta+b\beta)\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij} ln(p_j) u_i\end{aligned} \tag{A7}$$

Denote the vector of logarithm prices by $ln(p)$ then then the expression:

$$\frac{1}{\alpha}\sum_{i=1}^{n} ln(p_i) u_i - \frac{(1-\alpha)}{\alpha}(1-\beta+b\beta)\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij} ln(p_j) u_i \tag{A8}$$

in vector notation is equal to:

$$\frac{1}{\alpha} ln(p) u - \frac{(1-\alpha)}{\alpha}(1-\beta+b\beta) ln(p) W' u = \frac{1}{\alpha} ln(p)\left[I - \frac{(1-\alpha)}{\alpha}(1-\beta+b\beta) W'\right] u \tag{A9}$$

With $u = \frac{\alpha}{n}\left[I - (1-\alpha)(1-\beta+b\beta) W'\right]^{-1}\mathbf{1}$ the expression in (A9) simplifies to:

$$\frac{1}{\alpha} ln(p) u - \frac{(1-\alpha)}{\alpha}(1-\beta+b\beta) ln(p) W' u = \frac{1}{n} ln(p)\mathbf{1} \tag{A10}$$

From constant returns to scale we have that $\sum_{i=1}^{n} u_i = 1$. We use this property to obtain that:

$$y = \mu + u'\xi \tag{A11}$$

$$\text{where} \quad u = \frac{\alpha}{n}\left[I - (1-\alpha)(1-\beta+b\beta) W'\right]^{-1}\mathbf{1} \tag{A12}$$

$$\text{and} \quad \mu = \frac{1}{n}\sum_{i=1}^{n} p_i + \frac{C}{\alpha} + \frac{1-\alpha}{\alpha}(1-\beta+b\beta)\sum_{i=1}^{n}\sum_{j=1}^{n} u_i w_{ij} ln(w_{ij})$$

The aggregate fluctuations are equal to a sum of all idiosyncratic shocks weighted by the importance of firms in their production and trade credit networks.

Appendix B Taylor expansion

We approximate vector u by taking the first order Taylor approximation of u around $\eta = 0$:

$$u \approx u(0) + \frac{u'(0)}{1!}(\eta - 0) = \frac{\alpha}{n}\left[I - (1-\alpha)\,W'\right]^{-1}\mathbf{1} + \eta u'(o) \tag{B1}$$

To differentiate vector u we use the property that a derivative of a matrix inverse is equal to:

$$\frac{dM^{-1}}{d\eta} = -M^{-1}\frac{dM}{d\eta}M^{-1} \tag{B2}$$

With the matrix $M = [I - (1-\alpha)(1+\eta\beta)W']$ we get:

$$\begin{aligned}\frac{dM^{-1}}{d\eta} =& -\left[I - (1-\alpha)(1+\eta\beta)W'\right]^{-1} \\ &\times \frac{d\left[I - (1-\alpha)(1+\eta\beta)W'\right]}{d\eta}\left[I - (1-\alpha)(1+\eta\beta)W'\right]^{-1}\end{aligned} \tag{B3}$$

where the derivative of matrix M with respect to η is given by: $\frac{dM}{d\eta} = -(1-\alpha)\beta W'$. This yields that:

$$\begin{aligned}u \approx& \frac{\alpha}{n}\left[I - (1-\alpha)\,W'\right]^{-1}\mathbf{1} + \eta\frac{\alpha}{n}\left[I - (1-\alpha)\,W'\right]^{-1}(1-\alpha)\beta W'\left[I - (1-\alpha)\,W'\right]^{-1}\mathbf{1} \\ =& v + \eta\left[I - (1-\alpha)\,W'\right]^{-1}(1-\alpha)\beta W' v.\end{aligned} \tag{B4}$$

Appendix C Firm level relationship

We begin from the aggregate output relationship as in equation (2) in the index notation:

$$y = \mu + \sum_{j}^{n} u_j \xi_j, \tag{C1}$$

where u_j is the jth element of vector u defined as in equation (5):

$$u \approx v + \eta \left[I - (1-\alpha) W'\right]^{-1} (1-\alpha)\beta W' v, \tag{C2}$$

and the *influence vector* of Acemoglu et al. (2012) is defined as in equation (4):

$$v = \frac{\alpha}{n} \left[I - (1-\alpha) W'\right]^{-1} \mathbf{1}. \tag{C3}$$

Let us define matrix $D \equiv \frac{\alpha}{n} \left[I - (1-\alpha) W'\right]^{-1}$ such that the *influence vector* of Acemoglu et al. (2012) writes as $v = D\mathbf{1}$, then from (C1), (C2) and (C3) we have:

$$y = \mu + \sum_{j=1}^{n} [D\mathbf{1}]_j \xi_j + \eta \sum_{j=1}^{n} \left[(1-(1-\alpha)W')^{-1} (1-\alpha)\beta W' D\mathbf{1}\right]_j \xi_j, \tag{C4}$$

or summing also in the i dimension:

$$y = \mu + \sum_{i=1}^{n} \sum_{j=1}^{n} D_{ji} \xi_j + \eta \sum_{i=1}^{n} \sum_{j=1}^{n} \left[(1-(1-\alpha)W')^{-1} (1-\alpha)\beta W' D\right]_{ji} \xi_j. \tag{C5}$$

For $y = \sum_{i=1}^{n} y_i$ the expression in (C5) becomes:

$$\sum_{i=1}^{n} y_i = \mu + \sum_{i=1}^{n} \sum_{j=1}^{n} D_{ji} \xi_j + \eta \sum_{i=1}^{n} \sum_{j=1}^{n} \left[(1-(1-\alpha)W')^{-1} (1-\alpha)\beta W' D\right]_{ji} \xi_j. \tag{C6}$$

which at the firm level is equivalent to:

$$y_i = \mu_i + \sum_{j=1}^{n} D_{ji} \xi_j + \eta \sum_{j=1}^{n} \left[(1-(1-\alpha)W')^{-1} (1-\alpha)\beta W' D\right]_{ji} \xi_j. \tag{C7}$$

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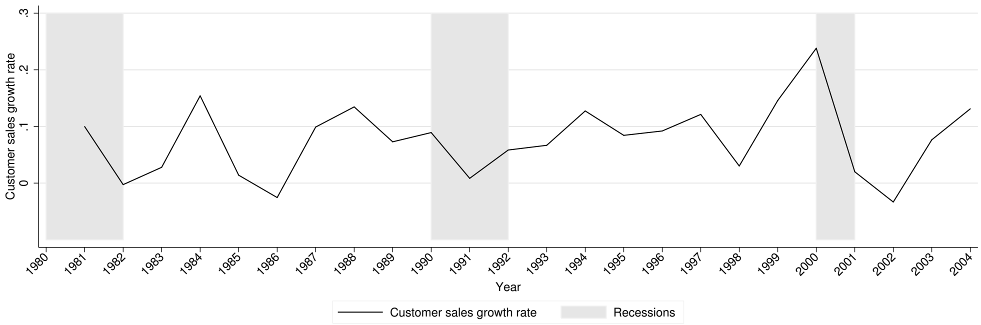
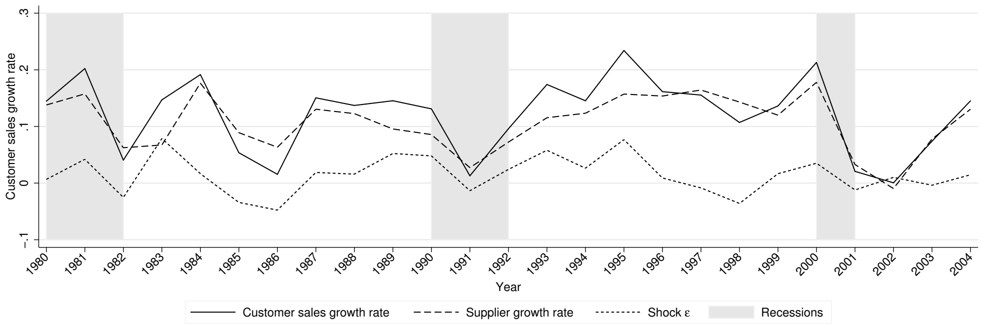
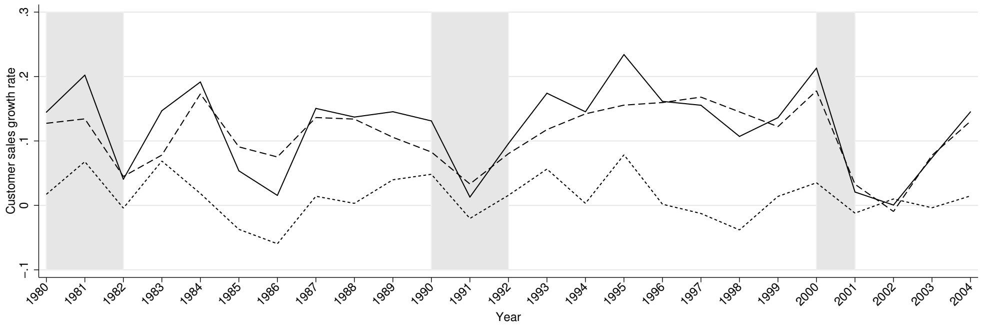


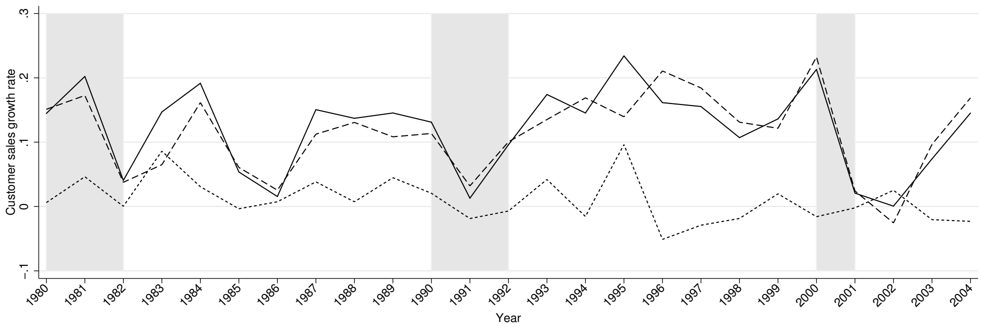
Figure 1: Customers sales growth rate. The figure shows the time series development of the average growth rate of sales among the customers.



(a) Economy benchmark



(b) Industry benchmark



(c) State benchmark

(d) County benchmark

Figure 2: Suppliers sales growth rate and the benchmark

Table I

Descriptive statistics

The sample runs from 1980 to 2004. It covers all the customer-supplier pairs established by Cohen and Frazzini (2008) with a match to Compustat balance sheet information and non-missing values of sale in two consecutive years. Panel A shows the descriptive statistics for the whole sample of customers. Panel B provides statistics for suppliers linked to the customers from Panel A. The production process exposures are computed as $(\sum_{j=1}^{n} D_{ji}\hat{e}_j)$ which is the first term in equation (11) and the trade credit exposures are computed as $(\sum_{j=1}^{n} \left[(1-(1-\alpha)W')^{-1}(1-\alpha)\beta W'D\right]_{ji} \hat{e}_j)$ which is the second term in equation (11).

	N	Mean	SD	Min	Max
Panel A: Customers					
Assets [$ billions]	2,730	25,952.270	82,226.300	0.719	1,484,101.000
EBIT [$ billions]	2,680	1,724.820	3,757.393	-10,537.000	52,205.000
Sales [$ billions]	2,730	15,295.560	27,421.090	0.126	286,103.000
w_{ij}	2,310	0.071	0.567	0.000	17.321
Share of trade credit received β	2,691	0.462	2.246	0.000	39.026
Dependent variable:					
Sales growth rate (g)	2,730	0.080	0.257	-3.417	2.606
Independent variables:					
1) Production process exposures (first term in equation (11)) computed relative to:					
– economy benchmark	2,730	-0.001	0.125	-5.802	1.162
– industry benchmark	2,730	-0.020	1.012	-52.771	0.948
– state benchmark	2,730	-0.003	0.243	-12.370	1.137
– county benchmark	2,730	0.000	0.108	-4.803	1.162
2) Trade credit exposures (second term in equation (11)) computed relative to:					
– economy benchmark	2,730	0.135	7.144	-2.512	373.274
– industry benchmark	2,730	1.242	64.974	-3.173	3394.861
– state benchmark	2,730	0.290	15.230	-2.484	795.758
– county benchmark	2,730	0.112	5.914	-2.061	308.976
Panel B: Boom					
Assets [$ billions]	4,613	1,191.835	3,946.029	0.491	73,634.900
EBIT [$ billions]	4,532	80.432	403.699	-2,285.963	1,0504.000
Sales [$ billions]	4,509	907.607	3,007.936	0.004	47,180.970
Sales growth rate (g)	4,613	0.094	0.426	-2.994	4.057
Shock ($\hat{e}$) computed relative to:					
– economy benchmark	4,613	-0.007	0.421	-3.172	4.067
– industry benchmark	4,613	-0.008	0.399	-3.038	3.873
– state benchmark	4,613	-0.006	0.416	-3.246	3.874
– county benchmark	4,613	-0.004	0.421	-3.172	4.067

Table II

Correlation between customer sales growth and supplier sales growth

Pairwise correlation coefficients are calculated over yearly observations pooled across all the customer and supplier firms. The sales growth among customers is denoted by g_C and among supplier by g_S. The economy benchmark is denoted by $\bar{g}_E$, the industry benchmark by $\bar{g}_I$, the state benchmark by $\bar{g}_S$, and the county benchmark by $\bar{g}_C$. The shock calculated relative to the economy benchmark is denoted by $\hat{e}_E$, relative to the industry benchmark by $\hat{e}_I$, relative to the state benchmark by $\hat{e}_S$, relative to the county benchmark by $\hat{e}_C$

	s_C	s_S	$\bar{g}_E$	$\bar{g}_I$	$\bar{g}_S$	$\bar{g}_C$	$\hat{e}_E$	$\hat{e}_I$	$\hat{e}_S$	$\hat{e}_C$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
g_C	1.000									
g_S	0.195	1.000								
$\bar{g}_E$	0.285	0.157	1.000							
$\bar{g}_I$	0.259	0.353	0.416	1.000						
$\bar{g}_S$	0.272	0.212	0.729	0.407	1.000					
$\bar{g}_C$	0.172	0.172	0.603	0.288	0.469	1.000				
$\hat{e}_E$	0.159	0.991	0.020	0.300	0.114	0.092	1.000			
$\hat{e}_I$	0.092	0.910	-0.015	-0.066	0.046	0.059	0.924	1.000		
$\hat{e}_S$	0.146	0.981	0.014	0.279	0.016	0.084	0.991	0.922	1.000	
$\hat{e}_C$	0.160	0.974	0.023	0.293	0.110	-0.056	0.983	0.909	0.975	1.000

Table III

Trade credit linkages and sales growth

Trade credit channel dampens disturbances to sales growth. The table shows coefficient estimates of the equation (11), in which the dependent variable is the sales growth of a firm. The figures in square brackets represent the economic effect of the production and credit linkages, which is the response in a customer's sales growth to a one standard deviation increase in the shock to one of its suppliers. It is given as the average of: ($\phi D_{ji} SD[\hat{e}_j]$) for production linkage and by ($\eta \left[(1-(1-\alpha)W')^{-1}(1-\alpha)\beta W'D\right]_{ji} SD[\hat{e}_j]$) for trade credit linkage over all suppliers. The sample runs from 1980 to 2004. All regressions include a constant. Significance is denoted by * at the 90% level, ** at the 95% level and *** at 99% level. Standard errors in parenthesis.

	Sales growth (g)			
	Benchmark			
	Economy	Industry	State	County
	(1)	(2)	(3)	(4)
Production linkages (ϕ)	1.191***	1.290***	1.214***	1.219***
	(0.101)	(0.112)	(0.103)	(0.101)
	[0.005]	[0.005]	[0.005]	[0.005]
Credit linkages (η)	-0.123***	-0.123***	-0.128***	-0.121***
	(0.033)	(0.044)	(0.032)	(0.034)
	[-0.001]	[-0.001]	[-0.001]	[-0.001]
Firm F.E.	No	No	No	No
Year F.E.	No	No	No	No
N	3,021	3,021	3,021	3,021
R^2	0.045	0.269	0.269	0.269

Table IV

Trade credit linkages and sales growth - fixed effect models

Trade credit channel amplifies disturbances to sales growth also when controlling for firm, year, industry and state fixed effects. The table shows coefficient estimates of the equation (11), in which the dependent variable is the sales growth of a firm. The figures in square brackets represent the economic effect of the production and credit linkages, which is the response in a customer's sales growth to a one standard deviation increase in the shock to one of its suppliers. It is given as the average of: $(\phi D_{ji} SD[\hat{e}_j])$ for production linkage and by $(\eta \left[(1-(1-\alpha)W')^{-1}(1-\alpha)\beta W'D\right]_{ji} SD[\hat{e}_j])$ for trade credit linkage over all suppliers. The sample runs from 1980 to 2004. All regressions include a constant. Significance is denoted by * at the 90% level, ** at the 95% level and *** at 99% level. Standard errors in parenthesis.

	Sales growth (g)			
	Benchmark			
	Economy	Industry	State	County
	(1)	(2)	(3)	(4)
Panel A: Firm and year fixed effects models				
Production linkages (ϕ)	1.409***	1.449***	1.468***	1.408***
	(0.114)	(0.125)	(0.117)	(0.113)
	[0.006]	[0.006]	[0.006]	[0.006]
Credit linkages (η)	-0.176***	-0.152**	-0.190***	-0.217***
	(0.052)	(0.068)	(0.050)	(0.055)
	[-0.001]	[-0.001]	[-0.001]	[-0.001]
Firm F.E.	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes
Industry F.E.	No	No	No	No
State F.E.	No	No	No	No
N	3,021	3,021	3,021	3,021
R^2	0.328	0.227	0.226	0.226
Panel B: Industry, state, firm and year fixed effects models				
Production linkages (ϕ)	1.413***	1.384***	1.433***	1.406***
	(0.121)	(0.131)	(0.123)	(0.120)
	[0.006]	[0.006]	[0.006]	[0.006]
Credit linkages (η)	-0.238***	-0.255***	-0.240***	-0.238***
	(0.056)	(0.077)	(0.054)	(0.056)
	[-0.002]	[-0.002]	[-0.002]	[-0.002]
Firm F.E.	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes
State F.E.	Yes	Yes	Yes	Yes
N	2,544	2,544	2,544	2,544
R^2	0.341	0.232	0.231	0.231

Table V

Trade credit linkages and sales growth - robustness

The table shows coefficient estimates of the equation (11), in which the dependent variable is the sales growth of a firm. The figures in square brackets represent the economic effect of the production and credit linkages, which is the response in a customer's sales growth to a one standard deviation increase in the shock to one of its suppliers. It is given as the average of: $(\phi D_{ji} SD[\hat{e}_j])$ for production linkage and by $(\eta \left[(1-(1-\alpha)W')^{-1}(1-\alpha)\beta W'D\right]_{ji} SD[\hat{e}_j])$ for trade credit linkage over all suppliers. The sample runs from 1980 to 2004. All regressions include a constant. Significance is denoted by * at the 90% level, ** at the 95% level and *** at 99% level. Standard errors in parenthesis.

	Sales growth (g)			
	Benchmark			
	Economy	Industry	State	County
	(1)	(2)	(3)	(4)
Panel A: Firms with no credit linkages ($\beta = 0$)				
Production linkages (ϕ)	9.455	9.191	9.825	9.455
	6.985	6.909	6.974	6.963
	0.039	0.038	0.041	0.039
Credit linkages (η)	(omitted)	(omitted)	(omitted)	(omitted)
F.E.	No	No	No	No
N	4	4	4	4
R^2	0.217	0.204	0.247	0.220
Panel B: Firms with credit linkage ($\beta \neq 0$)				
Production linkages (ϕ)	1.191	1.290	1.214	1.219
	0.101	0.112	0.103	0.101
	0.005	0.005	0.005	0.005
Credit linkages (η)	-0.123	-0.123	-0.128	-0.121
	0.033	0.044	0.032	0.034
	-0.001	-0.001	-0.001	-0.001
F.E.	No	No	No	No
N	3,017	3,017	3,017	3,017
R^2	0.045	0.044	0.045	0.047
Panel C: Production linkages only				
Production linkages (ϕ)	1.013***	1.152***	1.007***	1.057***
	0.088	0.100	0.089	0.090
	0.004	0.005	0.004	0.004
Credit linkages (η)	No	No	No	No
F.E.	No	No	No	No
N	3,021	3,021	3,021	3,021
R^2	0.041	0.042	0.040	0.043
Panel D: Constrained linear regression				
Production linkages (ϕ)	1	1	1	1
	(constrained)	(constrained)	(constrained)	(constrained)
	0.004	0.004	0.004	0.004
Credit linkages (η)	-0.092***	-0.072	-0.094	-0.088
	0.029	0.040	0.028	0.030
	-0.001	0.000	-0.001	-0.001
F.E.	No	No	No	No
N	3,021	3,021	3,021	3,021
Root MSE	0.269	0.270	0.270	0.269

Table VI

Trade credit linkages and sales growth - different phases of business cycle

Trade credit channel dampens disturbances to sales growth during good times. The table shows coefficient estimates of the equation (11), in which the dependent variable is the sales growth of a firm. The sample runs from 1980 to 2004. Recession years are taken from the NBER business cycle reference dates and cover years: 1980, 1981, 1982, 1990, 1991 and 2001. The boom years cover years: from 1983 to 1989, from 1992 to 2000 and from 2002 to 2004. The figures in square brackets represent the economic effect of the production and credit linkages, which is the response in a customer's sales growth to a one standard deviation increase in the shock to one of its suppliers. It is given as the average of: $(\phi D_{ji} SD[\hat{e}_j])$ for production linkage and by $(\eta \left[(1-(1-\alpha)W')^{-1}(1-\alpha)\beta W'D\right]_{ji} SD[\hat{e}_j])$ for trade credit linkage over all suppliers. The sample runs from 1980 to 2004. All regressions include a constant. Significance is denoted by * at the 90% level, ** at the 95% level and *** at 99% level. Standard errors in parenthesis.

	Sales growth (g)			
	Benchmark			
	Economy	Industry	State	County
	(1)	(2)	(3)	(4)
Panel A: Boom				
Production linkages (ϕ)	1.152***	1.267***	1.185***	1.177***
	0.105	0.114	0.108	0.105
	0.005	0.005	0.005	0.005
Credit linkages (η)	-0.118***	-0.120***	-0.124***	-0.117***
	0.034	0.044	0.032	0.034
	-0.001	-0.001	-0.001	-0.001
Firm F.E.	No	No	No	No
Year F.E.	No	No	No	No
N	2,431	2,431	2,431	2,431
R^2	0.048	0.050	0.049	0.050
Panel B: Recession				
Production linkages (ϕ)	1.491***	1.673***	1.339***	1.545***
	0.347	0.525	0.344	0.347
	0.006	0.007	0.006	0.006
Credit linkages (η)	1.190	-0.296	1.906	1.175
	0.955	2.951	1.416	0.967
	0.008	-0.002	0.012	0.008
Firm F.E.	No	No	No	No
Year F.E.	No	No	No	No
N	590	590	590	590
R^2	0.034	0.015	0.031	0.037

Table VII

Trade credit linkages and suppliers cash reserves

For cash poor suppliers, trade credit channel amplifies disturbances to sales growth. This stems from the positive sign on the interaction term between credit linkage and a dummy for cash poor customers. All regressions include a constant. Significance is denoted by * at the 90% level, ** at the 95% level and *** at 99% level. Standard errors in parenthesis.

	Sales growth (g)			
	Benchmark			
	Economy	Industry	State	County
	(1)	(2)	(3)	(4)
Production linkages (ϕ)	1.188***	1.287***	1.211***	1.216***
	0.101	0.112	0.103	0.101
	0.005	0.005	0.005	0.005
Credit linkages (η)	-0.122***	-0.123***	-0.127***	-0.121***
	0.033	0.044	0.032	0.034
	-0.001	-0.001	-0.001	-0.001
Credit linkages x Bottom 5% cash poor firms	98.570***	121.606***	74.303**	91.964***
	33.262	37.665	29.301	33.244
	0.633	0.781	0.477	0.591
Bottom 5% cash poor firms	0.020	0.018	0.022	0.021
	0.022	0.022	0.022	0.022
Firm F.E.	No	No	No	No
Year F.E.	No	No	No	No
Industry F.E.	No	No	No	No
State F.E.	No	No	No	No
N	3,021	3,021	3,021	3,021
R^2	0.341	0.26908	0.26908	0.26878