Credit Chains and Sectoral Comovement: Does the Use of Trade Credit Amplify Sectoral Shocks?

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Abstract

This paper provides evidence of the presence and relevance of the credit-chain propagation and amplification mechanism described by Kiyotaki and Moore (1997) by looking at its implications for the correlation of industries. In particular, it tests the hypothesis that an increase in the use of trade-credit along the input-output chain linking two industries results in an increase in their output correlation using detailed data on the correlations and input-output relations of 378 manufacturing industry-pairs across 43 countries with different degrees of use of trade credit. The results provide strong support for this hypothesis and indicate that the mechanism is quantitatively relevant.

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1 Introduction

Trade credit is an important source of short-term financing for firms in the US and around the world (Petersen and Rajan, 1997; Rajan and Zingales, 1995; Demirguc-Kunt and Maksimovic, 2001). Accounts payable are more important than bank credit for short-term financing in 60 percent of the countries covered by Worldscope, and worldwide surveys conducted by the World Bank indicate that firms typically finance about twenty percent of their working capital with trade credit.[1] In addition to extensively using trade credit as a source of funds, most firms simultaneously grant credit to their customers (McMillan and Woodruff, 1999; Fabbri and Klapper, 2008), becoming, therefore, exposed to default risk .

These characteristics of trade credit financing have led some authors to propose it as a mechanism for the propagation and amplification of idiosyncratic shocks. The intuition is straightforward: a firm facing a default by its customers may run into liquidity problems and default on its own suppliers. This sequence of defaults propagates the shock through the supply chain and may eventually amplify it, as the chain of defaults advance and the customers of the initial defaulting firm are themselves unable to pay their accounts, starting a new round of partial defaults. Therefore, in a network where firms borrow from each other, a temporary shock to the liquidity of some firms may cause a chain reaction in which other firms also get in financial difficulties, resulting in a large and persistent decline in aggregate activity. This idea was first formalized by Kiyotaki and Moore (1997) in a partial equilibrium setting, and recently extended to a general equilibrium environment by Cardoso-Lecourtois (2004) and Boissay (2006). Beyond the transmission of shocks from customers to suppliers emphasized by these papers, trade credit may also help propagate shocks downstream if suppliers facing liquidity problems reduce their trade credit to customers (Coricelli and Masten, 2004), or, alternatively, if suppliers stop offering trade credit to customers in distress even before they actually default.

Anecdotal evidence suggests that this mechanism is likely to be relevant. Non-payment by customers is listed as a major cause of distress in several studies on the causes of bankruptcy among US firms (Bradley and Rubach, 2002; Bradley and Cowdery, 2004), and there is also widespread evidence that firms typically respond to late payment by customers by delaying payments to their trade creditors (Chittenden and Bragg, 1997; McMillan and Woodruff, 1999; Boissay and Gropp, 2007; Fabbri and Klapper, 2008). Moreover, the role of trade credit is frequently mentioned in the business press as a source of distress propagation. For instance, a recent article in the *New York Times* on the consequences of bankruptcy by any of the big three US auto makers notes that *"a bankruptcy filing by even one of the Big Three would probably set in motion a cascade of smaller bankruptcies by suppliers of car parts, as the money the company owed them (which would be classified as an unsecured claim) could not be paid until it exited bankruptcy"*. Also, emphasizing the other side of transmission, the *Washington Post* reported that VeraSun, one of the largest ethanol producers in the US recently filed for Chapter 11 because *"Beginning in the third quarter, worsening capital market conditions and a tightening of trade credit resulted in severe constraints on the Company's liquidity position."* [2]

Despite this anecdotal evidence and the intuitive appeal of the credit-chain mechanism, there is so far no formal, systematic empirical evidence of the presence and importance of the transmission of shocks through credit chains, most likely because the detailed data on trade credit relations among individual firms required for a direct test of the mechanism is typically unavailable.

This paper addresses this empirical gap and provides systematic evidence of the presence and relevance of credit-chains for the transmission and amplification of shocks. It does so by taking an indirect approach that exploits the implications of the mechanism for the comovement of industries. The motivation for following this approach is that although the detailed relations among individual firms are typically unknown, trade relations among industries are well documented in standard input-output matrices. The paper combines these input-output data with firms' balance sheet information to measure the use of trade credit along the supply chain connecting two industries, which I call their *credit-chain linkage*, and shows that, under the hypothesis of credit-chain transmission, this measure should be positively related to their output correlation.

The paper tests this hypothesis by running a set of regressions of the output correlation of 378 manufacturing industry pairs in a sample of 43 countries during 1980-2004 against their credit-chain linkages and a number of controls that include country and industry-pair fixed-effects. Assuming, for data availability reasons, that input-output relations and the sectoral use of trade credit are mainly technologically determined, the credit-chain linkages are constructed using firm-level data on the ratio of accounts payable to the cost of goods sold from Worldscope and Compustat, and data on input-output relations among industries from the US Bureau of Labor Statistics.

Consistently with the hypothesis of credit-chain propagation, the results show that an increase in the use of trade credit along the chain linking two industries, i.e. an increase in their credit-chain linkage, significantly increases their output correlation. A one-standard-deviation increase in the credit-chain linkage of a pair of industries would increase the correlation of their value-added growth in four percentage points, which corresponds to 16 percent of the standard deviation of sectoral correlations observed in the data (0.27).[3] At the aggregate level, if the average sample country increased its ratio of accounts payables to the cost of goods sold from 7 to 33 percent–a movement from the lowest to the highest level observed in the sample, the variance of its manufacturing sector will increase in about 20 percent. These magnitudes are meaningful and should be considered lower bounds of the true economic relevance of the credit-chain amplification mechanism because measurement error and asymmetric transmission likely bias downwards the estimated coefficients. A battery of robustness tests shows that the main result of the paper is robust to changes in the sample, to changes in the measures of correlation and trade credit use, and to the consideration of a broad set of alternative explanations for the findings.

Additional findings shed further light on the working of the mechanism. According to Kiyotaki and Moore (1997), the presence of firms with enough resources to absorb defaults without transmitting them upstream along the supply-chain, which they label *deep pockets* and associate with financial intermediaries, weakens the credit-chain propagation mechanism. In line with this prediction, the empirical analysis shows that an increase in the use of bank credit relative to trade credit along the supply-chain linking two industries reduces their comovement. The results also highlight the importance of indirect links across industries for the transmission of shocks; the use of trade credit not only increases the comovement between industries directly related in the supply chain, but also between those that are indirectly linked through other industries.

This paper contributes to several strands of literature. It provides systematic empirical evidence of the presence and relevance of the mechanism described in the theoretical literature on credit-chain amplification (Kiyotaki and Moore, 1997; Cardoso-Lecourtois, 2004; Boissay, 2006). It also shows that the mechanism is empirically robust to theoretical possibility that liquidity could be preserved by a coordinated default across the whole supply-chain suggested by the small net trade credit positions typically observed in firms across countries (Calvo and Coricelli, 1996; Coricelli and Masten, 2004). The paper contributes as well to the recent financial literature on the relation between the availability of trade credit financing and the real economy (Fisman and Love, 2003; Love et al., 2007) by presenting evidence of an additional mechanism by which the use of trade credit itself has macroeconomic consequences. The paper also relates to the literature on sectoral and firm comovement. On the macroeconomic side, a long literature has proposed that input-output linkages are important for the transmission of shocks across industries (see Long and Plosser, 1983; Horvath, 2000; Shea, 2002, among others). On the financial side, several recent papers have provided empirical evidence that a firm's stock-price returns respond to events affecting its customers and suppliers, such as bankruptcy filings (Menzly and Ozbas, 2006; Hertzel et al., 2008; and Cohen and Frazzini, 2008). Complementing this literature, this paper provides new evidence of the importance of input-output linkages for the transmission of shocks and sectoral comovement in a large sample of countries and industries, and shows that the use of trade credit matters for this transmission channel. Finally, work by Nilsen (2002) suggests that trade credit can substitute for bank credit during periods of tight money and attenuate monetary policy shocks. The results presented here indicate that this dampening effect crucially depends on the survival of those firms that substitute trade credit for bank credit, since the cyclical increase in the use of trade credit makes the economy more vulnerable to a chain of defaults.

The rest of the paper is structured as follows. Section 2 discusses the empirical implementation of the test and presents the different specifications. Section 3 explains the manner in which the different variables included in the empirical specifications are measured and the different data sources used for this purpose. Section 4 presents the main results. Section 5 explores the robustness of these results. Section 6 concludes.

2 Empirical approach

The empirical approach of the paper is based on the observation that the firms modeled by Kiyotaki and Moore (1997) can be interpreted as representative firms from different industries. Therefore, the hypothesis that the use of trade credit contributes to propagate and amplify shocks can be indirectly tested by looking at the implications of this mechanism for sectoral comovement.[4] Focusing on industries instead of firms disregards valuable information contained in firm's idiosyncratic fluctuations, but only requires data on linkages among industries that are normally available from input-output matrices. The strength of these linkages and the use of trade credit determine the relative exposure of one sector to another, the transmission of shocks across industries, and their comovement. Thus, the empirical relevance of the mechanism can be assessed by testing whether an increase in the use of trade credit along the supply-chain linking two industries raises their correlation.

The rest of this section constructs a test of this hypothesis by adding trade credit amplification to a simple multisectoral model based on Long and Plosser (1983) and Shea (2002), which yields an estimable empirical relation between a specific measure of the use of trade credit along the whole chain of sectors linking two industries and their comovement.

Consider Shea (2002)'s description of the evolution of sectoral output in a multisector economy without trade credit and with upstream transmission of shocks through input-output linkages:

$$y_t = D\,\lambda_t, \tag{1}$$

where $y = (y_1, \ldots, y_N)'$ is a vector of sectoral output fluctuations (sectors 1 to N), $\lambda = (\lambda_1, \ldots, \lambda_N)'$ is a vector of sectoral shocks, and D is a matrix of backward linkages whose d_{ij} element is the share of sector j in the total demand for industry i 's goods through direct and indirect linkages.[5] This structural equation can be written in reduced form as

$$y_t = By_t + \lambda_t, \tag{2}$$

where the elements of $B = I - D^{-1}$ measure the share of total demand for industry i's good *directly* attributable to sector j.

A simple modification to equation (2) introduces the possibility that the use of trade credit may affect the propagation of sectoral fluctuations. Let P_{ij} be the fraction of the direct demand, b_{ij}, supplied through trade credit (accounts payable), so that $b_{ij} = P_{ij}b_{ij} + (1 - P_{ij})b_{ij}$. If this fraction had an additional effect on the transmission of shocks, the coefficient of direct linkages would be $b_{ij}(1 + \alpha P_{ij})$ instead of b_{ij}, with α parameterizing the importance of trade credit. Further assuming, for data availability reasons, that P_{ij} is constant across suppliers ($P_{ij} = P_j \; \forall i$),[6] the reduced form and structural relations among sectors would respectively correspond to

$$\begin{aligned} y_t &= B(I + \alpha\mathcal{P})y_t + \lambda_t, && (3) \\ &= A(\alpha, B, \mathcal{P})\lambda_t, && (4) \end{aligned}$$

where the matrix $\mathcal{P}$ has the fraction of inputs purchased on trade credit by sector j, P_j, in its main diagonal, and the matrix $A = (I - B(I + \alpha\mathcal{P}))^{-1}$. If the use of trade credit does not matter for the transmission of shocks ($\alpha = 0$) this expression corresponds to the structural equation (1).

The matrix A embodies the effect of standard input-output linkages and the credit chain. This can be seen by taking a linear approximation to A around $\alpha = 0$ to obtain

$$A \simeq D + \alpha\Gamma, \tag{5}$$

where D is the demand matrix defined above, and $\Gamma = D(B\mathcal{P})D$ captures the effect of trade credit operating through the credit-chain.

Assuming for simplicity that sectoral shocks λ_i are i.i.d., equation (4) implies that the correlation between sectors i and k is

$$\rho_{ik} = \frac{\sum_j a_{ij}a_{kj}}{\left(\sum_j a_{ij}^2 \sum_j a_{kj}^2\right)^{1/2}},$$

where a_{ij} is the (i,j) element of the matrix A. This correlation depends on a complex non-linear manner on the coefficient α, but to a first order approximation it corresponds to

$$\rho_{ik} \approx \frac{\sum_j d_{ij}d_{kj}}{\left(\sum_j d_{ij}^2 \sum_j d_{kj}^2\right)^{1/2}} + \alpha \sum_j \frac{d_{ij}d_{kj}(\tilde{c}_{ij} + \tilde{c}_{kj})}{\left(\sum_l d_{il}^2 \sum_l d_{kl}^2\right)^{1/2}}, \tag{6}$$

where

$$\tilde{c}_{ij} = \frac{d_{ij}\Gamma_{ij}}{d_{ij}^2} - \frac{\sum_l d_{il}\Gamma_{il}}{\sum_l d_{il}^2}, \forall\, i,\ j,$$

measures the use of trade credit along the credit-chain linking i and j, relative to the chains linking i and all other sectors (Γ_{ij} is the (i,j) element of Γ).

The first term of equation (6), which I label the *input-output linkage* between two industries, corresponds to the correlation between industries i and k in absence of trade-credit amplification, and depends only on the strength of their linkages–including indirect linkages through other industries. The second term of the equation, which I label *credit-chain linkage* and denote C_{ik}, is a weighted average of the relative use of trade credit across all sectors j linking industries i and k, where the weights are determined by the product of the direct and indirect linkages between sectors j, i, and k. Intuitively, shocks to sector j increase (decrease) the correlation between industries i and k if the use of trade credit along the chain linking j and these industries is higher (lower) than average and if the linkages between j and both industries are important.[7]

Equation (6) suggests that the hypothesis that the use of trade credit along the supply chain linking two industries affects the transmission of shocks (i.e. whether $\alpha = 0$ in equation (4)) can be tested by checking whether the correlation between a pair of sectors i and k depends on their credit-chain linkage, C_{ik}. This test can be implemented by estimating the parameters of the following equation:

$$\rho_{ik}^{c} = \theta_c + \theta_{ik} + \ \alpha C_{ik}^{c} + \beta W_{ik}^{c} + \epsilon_{ik}^{c}, \tag{7}$$

where θ_{ik} captures the input-output linkages and other fixed determinants of the correlation between a pair of industries, θ_c is a country fixed-effect that captures, among other things, differences in the relative importance of aggregate shocks, and W_{ik}^{c} includes other determinants of sectoral correlation. The variable of interest is C_{ik}^{c}, the credit-chain linkage between industries i and k in country c.

If shocks are independent but not identically distributed, the approximation in equation (6) contains an additional term that depends on the variances of the different sectors relative to the average, and if there is an aggregate shock, the approximation includes a term that is a function of the distances and the shock's variance. These additional terms cannot be directly computed from the data because the variances of the real shocks are unknown, but I will address concerns that their presence may significantly bias the estimation of equation

(7) by building proxies for them that I will include in W_{ik}^c in some specifications.

A similar derivation can be used to test the hypothesis that the use of credit from financial intermediaries (deep pockets) relative to trade credit reduces the transmission of shocks. Assuming that the fraction of purchases financed by bank credit weakens the transmission, and taking a linear approximation of the resulting reduced-form relation around a relative use of formal credit equal to zero, the coefficient of direct linkages becomes $b_{ij}(1 - \alpha s_{ij})$, where s_{ij} is the ratio of formal credit to trade credit as sources of financing the purchases of inputs. The rest of the derivation is analogous and leads to a credit-chain linkage measure capturing the use of formal credit relative to trade credit as source of financing.

Through most of the paper, the ratio of an industry's use of trade credit to the average use in a country (P_i^c/P^c) is assumed constant across countries, so the elements of $\mathcal{P}$ in a given country can be expressed as the product of this ratio, P_i, and the country's use of trade credit: $P_i^c = P_i \times P^c$. Under this assumption, the credit-chain linkage between two industries in a given country can be written as the product of their *generic credit-chain linkage* C_{ik}, which depends only on the relative ratios and does not vary across countries, and the country's typical use of trade credit $C_{ik}^c = C_{ik} \times P^c$.

3 Measuring sectoral comovement, input-output linkages, and the use of trade credit

3.1 The use of trade credit

The main measure of the intensity of use of trade credit is the ratio of accounts payable to the cost of goods sold, P, (henceforth *payables financing*) which is the inverse of the *payables turnover ratio* widely used in financial analysis.[8] For a given firm and year, it corresponds to the average of the accounts payable at the end of years t and $t-1$ divided by the total cost of goods sold in year t, and measures the fraction of input purchases financed with supplier's credit.[9]

As discussed above, the model of Kiyotaki and Moore (1997) suggests that the use of financial intermediaries as a source of finance for the purchase of intermediate inputs could attenuate the transmission of shocks through credit chains. The relative use of intermediaries versus suppliers as sources of short-term financing is measured by the ratio of *short term debt to accounts payable*, S. A high value of this ratio indicates that a firm obtains most of its short term financing from the financial system.

The empirical analysis requires representative values of these two measures for all manufacturing sectors in several countries, which are obtained by aggregating these ratios within firms, industries, and countries as follows. First, a firm-level representative measure of payables financing is obtained by taking the median of P across time for each manufacturing firm reporting data to the *Worldscope* database. Only firms with more than five years of (annual) data during 1990-2005 are kept in the sample to reduce the impact of cyclical fluctuations. Second, within each country c (except the US), the median of the representative ratios of those firms located in c is used as a country-level representative value of payables financing (P^c).[10] The measure for the US (P^{US}) is similarly built using data from *Compustat*,[11] which are also used to construct representative ratios for each three-digit ISIC manufacturing industry i in the US (P_i^{US}) by taking the median ratio across US firms within the industry. Finally, assuming that an industry's relative ratio of payables financing is constant across countries, the representative measure of P for industry i in country c, P_i^c, is estimated as the product of the relative ratio of industry i measured in the US, $P_i = P_i^{US}/P^{US}$, and country c overall median, $P_i^c = P_i \times P^c$.

Several aspects of this procedure require further discussion. The assumption of constant relative ratios across countries is equivalent to assuming that some industries tend to rely relatively more on trade credit than other for technological reasons that do not vary substantially across countries. This assumption was previously used by Fisman and Love (2003), who provide a series of theoretical and empirical justifications for it, and is consistent with results from Burkart et al. (2007), who show that the provision and use of trade credit in the US is significantly related to the type of good produced by a firm. The motivation for this assumption in this paper is mainly data availability: Worldscope 2006 contains data on about 10,500 manufacturing firms in 58 countries, but there are not enough firms for meaningful aggregation at 3-digit ISIC in most developing countries included. Only 21 countries report more than five firms in more than ten industries, and 11 of them are developed countries. Nevertheless, there are three reasons to believe this assumption is unlikely to importantly affect the results. First, available evidence suggests that the relative use of trade credit across industries is, to an important degree, technologically determined. The ratios computed for industries with more than 20 firms in a country from Worldscope are significantly correlated with the ratios computed for the US: the coefficient of a pooled regression of the available country-level ratios against the US ratios is 0.92, significant at the 1 percent level. Second, to the extent that this assumption introduces classical measurement error to the measure of the use of trade credit at the country-industry level, it will result on a downward bias on the coefficient of interest. Finally, using the available data to estimate the use of trade credit at the country-industry level produces similar results to those obtained under the assumption of constant relative ratios (see section 5).

Another concern is that both data sources (Worldscope and Compustat) only contain information of publicly listed companies. This could bias the estimates of a country's overall use of trade credit for two reasons: firms included in Worldscope and Compustat may be different from the average listed firm, and listed firms may be different from the rest. The first concern is likely to be irrelevant since both data sources cover most, and in many cases all listed firms. The second concern is more pertinent, since public firms tend to be larger than private ones, and the use of trade credit may depend on a firm's size.[12] Nevertheless, as long as the variation in the use of trade credit across countries is mainly determined by their structural characteristics, the bias introduced by the use of public companies would affect the level of the measures but not their relative position across countries. Evidence from European companies suggests this is the case. For these countries it is possible to compute the values of payables financing P^c using data from the *Amadeus* database, which has almost universal coverage of listed and unlisted firms. The rank correlation between the Worldscope and the Amadeus measures is 0.66, significant at the 1 percent level.[13] Also, as it will be shown below, using the measures obtained from Amadeus for these countries does not significantly change the conclusions. On a more pragmatic note, to my knowledge, there are no better comprehensive data sources available.

The measures of *payables financing* (P) and *short term debt to payables* (S) for the sample countries are presented in Panel A of Table 1. The sample includes 43 countries; 22 developed, and 21 developing ones (including 3 low income). The most represented regions are Western Europe, with 15 countries, followed by East Asia and Pacific with 10, and the least represented are Sub-Saharan Africa, South Asia, and North America, with only two countries each. The main constraint to the sample is the availability of data on the use of trade credit; there are only ten countries where trade credit data are available but the sectoral correlation data described below are not.[14] Column (3) indicates whether the measures of trade credit were built using data only from manufacturing firms (quality 1) or from the whole corporate sector (quality 2). In most countries (36) there were enough manufacturing firms (10 firms) with more than five years of data to build the manufacturing specific measure, but in a few countries with less than this number non-manufacturing firms were also included in the measure. Nevertheless, all the results discussed below carry to the subsample of high quality countries (see section 5).

Firms in the average sample country finance about 15 percent of inputs' cost with trade credit (see the mean value at the bottom of column (1)). The distribution of this ratio across countries is symmetric around this mean and there is reasonable variation that puts the 25th and 75th percentiles at 12 and 18 percent. The typical country also uses credit from financial intermediaries and suppliers in roughly equal proportions (see the bottom of column (2) where the mean and median of the ratio are close to 1), but there is important degree of variation around the central tendency, with the 25th and 75th percentile values located at 0.6 and 1.6, respectively. As expected, the correlation between the two measures of trade credit use is negative but small (-0.32).

The relative measures (i.e. the ratios with respect to the mean across industries) of payables financing (P_i) and short term debt to payables (S_i) for the 28 ISIC industries in the US are reported in Table 2. The median in column (1) is close to 1, which suggests that the distribution of payables financing across industries is relatively symmetric because the mean is one by construction. In contrast, the median in column (2) is below one, indicating that the distribution is skewed to the left. As it was with the country level variables, the degree of variation across industries is reasonable but not large. The 25th and 75th percentiles of P_i across industries correspond to 0.87 and 1.21, respectively. Again, this variation is slightly larger for S_i, with the corresponding figures at 0.71 and 1.15.

3.2 Sectoral correlations

The main measure of sectoral comovement is the correlation of the growth rates of real value added across 28 three-digit ISIC manufacturing industries covering the complete manufacturing sector. The data used to build these correlations come from the United Nations Industrial Development Organization (2005), Industrial Statistics Database (henceforth UNIDO), and corresponds to the period 1980-2003, so that the comovement is measured at about the same period where trade credit data is available.

Following Rajan and Zingales (1998), real value added for each of the 28 industries in each country included in UNIDO is obtained by deflating the data on nominal value added using the country's overall Producer Price Index from International Monetary Fund (2005). In each country, only industries with at least 15 observations of the growth rate of real value added are kept in the sample to avoid having a short rank correlation matrix,[15] and their within-country, across-years correlation is computed as

$$r_{ij}^{c}=\frac{\left(\sum_{t=1}^{T}(g_{ict}-\bar{g}_{ic})(g_{jct}-\bar{g}_{jc})\right)T_{ij}^{-1}}{\left(\sum_{t=1}^{T}((T_i-1)/T_i)(g_{ict}-\bar{g}_{ic})^2\sum_{t=1}^{T}((T_j-1)/T_j)(g_{jct}-\bar{g}_{jc})^2\right)^{1/2}}, \tag{8}$$

where r_{ij}^{c} is the correlation between industries i and j in country c, g_{ict} is the growth rate of industry i in country c between years $t-1$ and t, $\bar{g}_{ic}$ is the time-average of g_{ict}, T_{ij} is the number of observations with data for sectors i and j, and T_i is the number of observations in sector i.

Several other measures of comovement are computed for robustness. One potential problem with the baseline measure is the use of a common deflator: in presence of significant heterogeneity in the evolution of prices across industries, the correlations computed with a common deflator may be driven by the correlation of relative inflation rates instead of the correlation of real output growth. This concern can be addressed by using the correlation of the growth rates of the index of industrial production, also reported in UNIDO. Results obtained using this measure are not affected by the relative price problem, but results obtained using real value added are preferable because the production index data are of lower quality and smaller coverage than the value added data.[16] Nevertheless, as it will be shown below, this choice does not affect the results.

The average correlations across manufacturing sectors for the 43 countries in the sample, as well as the number of industry pairs with data are reported in Panel B of Table 1. Consistently with the extensive evidence of positive comovement across sectors during the business cycle, the average correlation of real value added and industrial production growth across sectors is always positive and around 0.25, with inter-quartile ranges between 0.2 and 0.36 for value added growth; and 0.22 and 0.43 for the index of industrial production. The summary statistics are similar for the two measures, whose averages, reported in the table, are also positively and significantly correlated (correlation of 0.39 significant at the 2 percent level). As mentioned above, the coverage is better for the measure based in value added, for which there are 13,182 industry pairs, compared to 12,548 for the measure based in industrial production. Both measures of correlation are positively but not significantly correlated with the average level of GDP per capita during 1980-2000. The positive correlation may indicate that idiosyncratic sectoral shocks are relatively more important in poorer countries. This issue will be addressed in the empirical analysis.

3.3 Input-Output linkages

A central assumption of this paper is that input-output linkages between industries are largely technologically determined. Starting from this assumption, linkage measures obtained in a country with good available information, like the US, can be extrapolated to the rest of the countries in the sample. The main reason for assuming a constant distance across industry pairs is the lack of comparable information on input-output relations for a broad set of countries at a good level of aggregation; OECD data on input-output matrices cover only 20 countries and 20 manufacturing sectors, and data from Olarreaga and Nicita (2004) *Trade and Protection Database*, while covering a larger number of countries, divide manufactures in only 17 sectors and lack some key variables required to construct the distance matrices. Nevertheless, this assumption should be relatively uncontroversial because, by construction, input-output matrices reflect technological links across sectors, so their variation across countries is likely to be limited. In fact, most of the variance of the *Direct Requirement Matrices*, a crucial input on the construction of the distance measures (see appendix), obtained from Olarreaga and Nicita (2004) for 67 countries, comes from the within-country, across industry-pairs dimension. Also, the correlation between the *input-output linkage* built using US data as described below and the same distances estimated using UK data is 0.98.

Under the assumption of technologically determined links, I build the matrix D of contemporaneous transmission described in section 2 (see Eq. [1]) using information from the 1992 commodity-by-industry (USE) and industry-by-commodity ($MAKE$) matrices produced by the US Bureau of Economic Analysis (BEA) and a correspondence between the

BEA industry classifications and the 28 three-digit ISIC manufacturing industries. The appendix describes the construction of this matrix in detail. After building the D matrix, the input-output and (generic) credit-chain linkages across industry pairs are computed as described in equation (6).

Since the sectoral classification consists of 28 industries at three-digit ISIC level, the C matrix of credit-chain linkages contains 378 different distances (the distance between a sector and itself is normalized to 100). The distribution of the distances is significantly skewed with most of its mass close to zero (around 40 percent) because of the well-known sparsity of input-output matrices.[17]

Table 3 shows the twenty industry-pairs with the strongest generic credit-chain linkages (C_{ik}), which represent about five percent of the total number of pairs. The pairs are intuitive: the two pairs with the smaller distances are the ones formed by the Textiles and Wearing Apparels industries and Transport Equipment and Fabricated Metal Products industries. Although pairs with strong generic credit-chain linkages also tend to have strong input-output linkages, there is some important variation between these measures of similarity: only half of the pairs reported in Table 6 are also among the 20 with the closest input-output distance, and the rank correlation between them is only 0.17. The overall correlation between both linkage measures is 0.66, but it is mainly driven by the difference between the group of industries with small linkages and the rest; in fact, the correlation drops to 0.5 when looking only to those industry-pairs with input-output linkages above the median.

4 Results

This section presents the results of the test of the hypothesis that the intensity of use of trade credit along the chain linking two industries increases their correlation. Following the empirical approach outlined in section 2, this hypothesis is tested by estimating the parameters of equation (7) and testing whether the coefficient of the interaction of the generic credit-chain linkage and the use of trade credit in the country (α) is significantly positive (negative when using the short term debt to payables ratio). The coefficients obtained by ordinary least squares (OLS) for various versions of equation (7) that include different sets of additional controls are presented in Table 4, where the dependent variable is the correlation of growth rates of real value-added between industry-pairs in different countries. The estimated coefficients for the parameter of interest are reported in the first two rows of the table.

The main result of the paper can be seen in the regression reported in column (1), which includes only the credit-chain linkage (i.e. the interaction of the generic credit-chain linkage C_{ik} and a country's payables financing ratio) and a set of industry-pair and country fixed-effects. The coefficient obtained for the credit-chain linkage is positive and strongly significant. A shock to a downstream industry produces a stronger response in an upstream sector linked to the downstream industry through a series of sectors with high use of trade credit. This, in turn, translates in a higher correlation between them.

The basic result survives the addition of variables capturing the size and the first two moments of the growth performance of the different sectors across countries (columns (2) and (3)). The regressions in column (2) adds two measures of the size of each industry included in a country pair: the (log) average number of firms during the period, and the average share of total manufacturing value added. The number of firms controls for the effect of diversification on sectoral correlation: assuming that there are both aggregate and firm-level shocks, an increase in the number of firms in all industries results in a relatively larger role for aggregate shocks and, therefore, more correlated sectors. The share of total manufacturing value-added of each of the industries in a pair controls for the possibility of aggregate spillovers. As noticed by Shea (2002), in presence of external economies of scale, such as those suggested by Baxter and King (1991), larger industries will generate larger spillovers to the rest of the economy, and will be more correlated with all other sectors. The results show that controlling for these variables does not affect the coefficient obtained for the main interaction. As expected, the coefficients obtained for the (log) number of firms in each of the industries are positive and significant, indicating that industries with more firms are more correlated with the rest of the economy and among themselves. The coefficients obtained for the industry shares are significantly negative, but this is because the regressions are already controlling for the number of firms, which correlates with the industry share. Regressions including only the shares yield positive coefficients (not reported). Since, after controlling for the number of firms, the share of an industry is a measure of value added or output per firm, the results indicate that industries whose firms are relatively more productive (in the sense of having a higher level of output per firm) are typically less correlated with the rest of the economy. Henceforth, the specification reported in column (2) will be used as baseline.

The regression in column (3) adds the average and standard deviation of the growth rate of each industry included in a pair to control for the possibility that industries with similar trends or shocks can be more correlated within and across countries. The results indicate that industries that grow relatively faster and are more volatile are less correlated with the rest of the sectors, but, again, adding these controls does not substantially affect the sign, magnitude, or significance of the coefficient of credit-chain linkages.[18]

Figure 1 illustrates the differential effect of the use of trade credit across industry-pairs with different credit-chain linkages. Panel A shows the relation between a country's level of payables financing and the correlation of the Iron and Steel and Transport Equipment industries (ISIC codes 371 and 384, respectively). The positive relation is apparent; for this industry pair, an increase in the use of trade credit increases the correlation. Panel B shows the same relation for the pair formed by the Tobacco and Footwear industries (ISIC 314 and 324, respectively), which have almost no credit chain linkages. In this case there is no association between trade credit use and correlation. These are the differences captured by the interaction variable in the regression. Panels C and D show that this effect is not exclusive to the pairs of industries just described. Panel C plots the relation between payables financing and sectoral correlation for the 20 industry pairs with the strongest credit-chain linkage and panel D does the same for the 20 industry pairs with the weakest linkages. Again, the panels show that an increase in the use of trade credit increases the correlation of those industry pairs with a high C_{ik} but has no effect on those that are far in the credit-chain sense.[19]

In terms of economic magnitude, the baseline point estimates (column (2)) indicate that a one-standard-deviation increase in credit-chain linkages C_{ik}^{c} results in an increase in correlation of four percentage points, or 16 percent the standard deviation of industry-pair correlations within and across countries (0.27). In terms of relative differences, an increase in payable financing from the 25th to the 75th percentile level would increase the correlation of the industry pair at the 75th percentile of generic credit-chain linkage in almost two percentage points more than that of the pair at the 25th percentile, or about ten percent of the interquartile range of average sectoral correlations (0.16). These magnitudes are economically meaningful and also likely to be conservative for several reasons. First, the coefficients likely suffer from attenuation bias because of measurement error in the use of trade credit. The size of the bias will depend on the unknown variance of the measurement error, but Montecarlo simulations using the sample standard deviation of payables financing across countries as a proxy indicate that it may be as large as 60 percent of the coefficient.[20] Second, in the traditional credit-chain amplification mechanism emphasized in the literature, the correlation across industries increases as a result of negative shocks. If the role of trade credit in the transmission of positive shocks is weaker or absent, using the unconditional correlation as dependent variable will lead to attenuation bias. Third, the sectoral correlations were estimated using a small number of observations and exhibit considerable sample variability, even after accounting for country- and industry-specific components. Thus, the sample variability of the dependent variable used above is a tough metric to assess the economic significance of a coefficient.

The estimated impact of an increase in a country's overall use of trade credit on aggregate volatility offers a different measure of the aggregate implications of the mechanism . This can be easily estimated by noticing that a country's aggregate manufacturing variance (σ_Y^2) can be written as

$$\sigma_Y^2 = \omega' \Omega^{\frac{1}{2}} R \, \Omega^{\frac{1}{2}} \omega,$$

where ω is a vector containing the share of each manufacturing sector on total manufacturing value added, Ω is a matrix that has the variance of each manufacturing sector in the diagonal (and zero elsewhere), and R is the correlation matrix between the different manufacturing sectors, such that $R_{ij} = \rho_{ij}$. Thus, from equation (7)

$$\frac{\partial \sigma_Y^2}{\partial P} = \alpha \omega' \Omega^{\frac{1}{2}} \tilde{C} \; \Omega^{\frac{1}{2}} \omega,$$

where $\tilde{C}$ is a matrix containing the generic credit-chain linkages C_{ik}, and the partial derivative indicates that the expression only corresponds to the impact of trade-credit use through changes in correlations. Evaluating this expression for a country with the average sectoral shares and variances yields that an increase in the aggregate (country level) payables financing ratio from the 25^{th} to the 75^{th} percentile level (from 12 to 18 percent) would increase the variance of value-added growth in the manufacturing sector of the average country by five percent. A bigger increase from the lowest to the highest level of payables financing in the sample (from 7 to 33) would increase this variance in 20 percent.[21] Moreover, as discussed above, these magnitudes are likely to be a lower bound of the true effect on aggregate variance. Overall, the evidence suggests that the credit-chain amplification mechanism is quantitatively relevant.

Similar results are obtained using the ratio of *short term debt to payables* of the different industries and countries to compute the credit-chain linkage C_{ik}^c, a different, albeit complementary, measure of the use of trade credit. This can be seen in columns (4) to (6) of Table 4. Since this variable measures how important is bank credit relative to trade credit, the credit-chain mechanism predicts a negative coefficient (see the discussion in section 2). Consistently, in all the regressions the coefficient is negative and strongly significant; an increase in the relative importance of bank credit vis-à-vis trade credit along the credit chain reduces the transmission of shocks. This is consistent with Kiyotaki and Moore (1997)'s idea that the presence of "deep pockets" along the chain can dampen the transmission of shocks. Intuitively, firms that finance a high fraction of their material purchases through bank credit will either not propagate a default by their customers if they can tap that source of finance again, or will do it in a weaker form because a higher fraction of their default will be absorbed by banks, which under normal conditions will simply absorb the shock.

The economic magnitude of the coefficient associated with this measure of trade credit use is smaller than that obtained when using payables financing, but still non-negligible. A one standard deviation increase in this measure of credit-chain linkages reduces the correlation of real value added growth in two percentage points; half the reduction obtained with the baseline measure. Moreover, despite its smaller magnitude, the attenuation of sectoral comovement resulting from an increase in the use of formal financing is largely complementary to the one resulting from an overall decrease in the use of trade credit, as shown in Column (7). The regressions reported in this column includes both measures of credit-chain linkage simultaneously, and shows that the coefficients associated with the payables financing measure slightly decline with respect to those previously reported, and that the coefficients of short term debt to payables are mostly unaffected. This indicates that the use of trade credit relative to both, other sources of short term financing and total input costs are important for amplification. Consequently, a reduction in the use of trade credit as a fraction of the cost of inputs that is compensated with an increase in the use of intermediary financing has a much larger impact on reducing sectoral comovement. Evaluated at the median level of short term debt to payables, the same increase in payable financing from the 25th to the 75th percentile discussed above would increase the correlation of the industry pair at the 75th percentile of credit-chain linkage in almost 2.5 percentage points more than that of the pair at the 25th percentile; this is fifty percent larger than the direct effect without changing the use of short term debt, and about 15 percent of the interquartile range of average sectoral correlations.

5 Robustness

This section explores the robustness of the main result to variations in the sample of countries and industry-pairs included, the use of different measures of correlation and credit-chain linkage, and alternative explanations associated with potential omitted variables.

5.1 Sample issues

A first concern regarding the baseline results is that they may be driven by special observations. This concern is valid considering the skewness of the distribution of the measures of credit-chain linkages and trade credit use, but it turns out to be unimportant.

First, no individual country or industry-pair is driving the results, as shown in Figure 2. Panel A reports the distribution of the 43 coefficients for the credit-chain linkage (α) obtained by re-estimating the baseline regression after dropping one country at a time. All coefficients are positive, statistically significant at the one percent level, and tightly distributed around the median coefficient of 1.98 (the smallest coefficient (1.36) is obtained when Japan is excluded from the sample). The histogram presented in Panel B addresses the robustness to the exclusion of specific industry-pairs in a similar manner; all the 378 coefficients are significant and similar to the coefficient of the baseline regression.

Second, no particular group of observations is driving the findings. The regressions presented in Panel A of Table 5 check for various of these possibilities. Row (1) reports the results obtained using only the sample of 39 "high quality" countries where the use of trade credit of the manufacturing sector could be computed. Row (2) shows the coefficients obtained after dropping transition economies from the sample (China, Hungary, and Poland). Row (3) presents results obtained after dropping the ten percent of countries with the highest and lowest levels of payables financing (i.e. dropping 20 percent of the sample in total). Row (4) shows similar results after dropping the 5 percent of industry pairs with the highest and lowest generic credit-chain linkages (10 percent of sample), and Row (5) reports the results obtained using a robust estimation method.[22] In all cases and in both panels the coefficient of the credit-chain linkage is not importantly affected.

5.2 Measurement

The regressions reported so far have used the correlation in the growth rates of real value added and industrial production index as measures of comovement. The exercises presented in Panel B, rows (6) to (9) of Table 5 consider four potential concerns with these measures. First, since real sectoral value added is obtained applying a common deflator to nominal value added series, the correlation of real value added growth between sectors may be just capturing correlations in relative inflation rates. To deal with this concern, the regression reported in Row (6) uses as dependent variable the correlation of the growth rates of the index of industrial production of each pair of sectors. Second, growth rates may not properly clean for trends in sectoral output, resulting in spurious sectoral correlations. So, the regression in Row (7) uses the correlation of real value added de-trended using the Hodrik-Prescott filter as dependent variable. Third, since correlations take values between -1 and 1 by construction, the residuals in the baseline specification can suffer from heteroskedasticity. Row (8) uses as dependent variable a transformation of the correlation of the growth rate of real value added aimed to tackle this problem. The transformed correlations are $\tilde{r}^c_{ik} = \ln(r^c_{ik}+1) - \ln(1-r^c_{ik})$, which assumes a parametric non-linear relation between the correlations r^c_{ik} and the variables of the model (see Otto et al., 2001). Finally, the regression in Row (9) uses a robust measure of correlation to address concerns about the impact of outliers.[23] In all four cases, the coefficient for the credit-chain linkage remains positively significant.

The last set of regressions presented in Table 5 checks the robustness of the results to changes in the measure of credit-chain linkage. Row (10) reports the results obtained after relaxing as much as possible the assumption of fixed relative use of trade credit across industries introduced in section 3.1, and using the available country-specific measures of sectoral use of trade credit that can be obtained from Worldscope. The measure of credit-chain linkage applied in this column uses the country-industry value of payables financing, P_i^c, measured directly from Worldscope for all country-industries with data on more than five firms (395 cases in the sample), and the product of the US relative ratio and the corresponding country median ($P_i^c = P_i \times P^c$) in the remaining cases (1305 cases). Row (11) explores the sensitivity of the main coefficient to the particular choice of the US as baseline country for measuring the input-output relations across industries and uses instead credit-chain linkages computed from UK input-output matrices. In both cases the coefficient is of the right sign, significance, and only marginally smaller.

The regressions in rows (12) and (13) check whether using only data on publicly listed companies biases the measures of the use of trade credit. In Row (12) the sample is restricted to those European countries where the payables financing ratio could be computed using comprehensive data from Amadeus, and the Worldscope measure of payables financing was replaced by the one obtained from Amadeus to address the potential bias of the measures of payables financing obtained from Worldscope. The regression in Row (13) takes an indirect approach and adds the interaction of the industry pair credit-chain linkage and a country's stock market capitalization (as a fraction of GDP) to control for the representativeness of listed companies in terms of economic activity. The coefficient for the credit-chain linkage is not significantly affected in any of these regressions.

Since the paper assumes that the relative use of trade credit varies systematically across industries, differences in the industry composition of firms included in Worldscope across countries could bias the measures of average use of trade credit. To tackle this concern, the regression in Row (14) uses a measure of credit-chain linkage built using an average country use of trade credit that controls for the industry composition of firms in Worldscope. This average is obtained by running a regression of all available country-industry measures of payables financing from Worldscope on a set of country and industry fixed effects. The estimated country fixed-effects in this regression measure the average country use of trade credit after cleaning for industry composition. As in the previous cases, controlling for this possibility does not importantly affect the results.

Throughout the paper, the intensity of use of trade credit has been measured as the ratio of accounts payable to the cost of goods sold, which not only considers material inputs but also labor costs. Thus, differences in the measure across countries or sectors may not necessarily be related to the fraction of intermediate inputs bought on trade credit, but may instead be driven by differences in labor costs. The reason for using payables financing is twofold. First, the measure is directly related to the Payables Turnover Ratio typically used in financial analysis. Second, data on material costs are much less available than data on the costs of goods sold. For instance, in Compustat, the ratio of accounts payables to the cost of goods sold can be computed in at least five years for 3911 manufacturing firms; the ratio of accounts payables to material costs can be computed only for 362. In Worldscope, the payables to cost of goods sold ratios can be computed for 5468 manufacturing firms, while the ratio of payables to material costs only for 987. Nevertheless, it is possible to complement the little information available in Worldscope with data from the World Bank Investment Climate Surveys to build a rough estimate of the median ratio of accounts payables to material costs for 31 countries in the sample, and compute the credit-chain linkage across sectors using this measure to check the importance of this choice.[24] The results, presented in Row (15), show that measuring the intensity of trade credit use as the fraction of material costs financed on credit produces similar results to those obtained using payables financing and does not affect the main findings of the paper.

The linkage matrix derived by Shea (2002) and used in this paper has the advantage of being derived from a fully specified general equilibrium model, but it is also related to the traditional measure of backward linkages used in input-output analysis: the Leontieff inverse of the matrix of direct cost shares (Rasmussen, 1956; and Miller and Blair, 1985; see appendix for the exact relation). The regression presented in Row (16) checks the robustness of the results to using this traditional linkage measure to compute the credit-chain linkages. The results are similar to those obtained using the D matrix demonstrating that this specific choice is not crucial for the outcome. However, the baseline measure of credit-chain linkages conveys more information on the transmission of shocks across sectors than the traditional measure and is a better predictor of sectoral correlation; when the baseline measure of credit-chain linkages is included together with the traditional measure the latter is no longer statistically significant (not reported).

5.3 Are industries with strong credit-chain linkages similar in other dimensions?

Industries with strong credit-chain linkages may also be similar in other dimensions, such as technologies, degrees of external financial requirements, liquidity needs, capital intensity, and stage of production. To the extent that these other dimensions of similarity are emphasized by country characteristics related to the use of trade credit, the results could be spuriously related to the omission of these potential determinants of comovement. The regressions presented in Table 6 explore several of these possibilities.

The measure of credit-chain linkage could be capturing technological similarities across industries that buy (sell) comparable proportions of goods from (to) other industries, shown by Conley and Dupor (2003) to be related to the comovement of productivity in the US. To check this concern, the regression in Column (1) adds to the baseline specification the interaction of the measures of BUY and $SELL$ distances between industries of Conley and Dupor (2003) and a country's payables financing.[25] The main coefficient is not importantly affected and the results indicate that only industries that sell goods to similar sectors in similar proportions are significantly more correlated in countries with higher payables financing. This suggests that a higher use of trade credit increases the relevance of backward linkages as sources of comovement, consistently with the upward transmission of shocks emphasized by the credit-chain mechanism.

In countries with underdeveloped financial systems, shocks may affect relatively more those industries with high degrees of external financial requirements or liquidity needs. Since a country's use of trade credit may be related to financial development, it is necessary to control for this potential source of comovement. The degree of financial development of a country can also be related to the availability of capital, which can induce comovement across industries with similar capital intensities. All these possibilities are considered in the regression reported in Column (2) that adds to the baseline specification the interaction of a measure of a country's level of financial development with measures of the similarity of an industry-pair in terms of external financing requirements (measured as in Rajan and Zingales, 1998) and liquidity needs (measured as in Raddatz, 2006), as well as the product of an industry-pair's similarity in terms of capital intensity (measured as in Raddatz, 2006) and a country's (log) aggregate capital per worker. Along each dimension, the degree of similarity is computed as the absolute value of the difference between each industry's measure. The degree of financial development is measured as the (log) average private credit to GDP ratio during 1980-2000 from Beck et al. (2001), and capital per-worker is the average for the same period from Heston et al. (2002) *Penn World Tables* (henceforth PWT). The results show that industries with similar liquidity needs are less correlated in financially developed countries, suggesting that the increased access to financing eases the response of industries with high liquidity needs to negative shocks and reduces the resulting correlation,[26] but this channel does not importantly affect the coefficient associated with credit-chain linkage.

Sectors producing goods with similar degrees of complexity can also be relatively more correlated. For instance, Clark (1999) and Huang (2001) have documented that the response of quantities versus prices in response to a monetary policy shock vary with the stage of production. Therefore, sectors at comparable stages of production will exhibit more coordinated responses in quantities than sectors at different stages. The regression presented in Column (3) uses the Gini coefficient of the distribution of input costs to capture the complexity/stage of production of the goods produced by an industry (see Blanchard and Kremer, 1997 and Kremer, 1993), and adds to the main specification the interaction of the absolute value of the difference in the Gini coefficient of each industry pair (obtained from Cowan and Neut,

2002) and the overall country volatility measured by the standard deviation of the growth rate of real GDP per capita. Although, consistently with this mechanism, sectors producing goods of similar complexity are indeed more correlated in more volatile countries, the result regarding the role of credit-chains remains unaltered.

The derivation of equation (6) assumed that sectoral shocks were independent and identically distributed. Relaxing this assumption would result in additional terms in the linear approximation that will also be a function of the elements of the D matrix, raising the possibility that the credit-chain linkage could be capturing the effect of one of these omitted variables. One possible deviation from this assumption comes from differences in the variance of the shocks across industries. In this case, the linear approximation (6) would include a term that is a function of the coefficients of the D matrix and the relative variances of the sectoral shocks. This term cannot be directly computed because these variances are unobserved, so the regression in Column (4) adds a proxy built using the relative variances of the output of the various industries instead. Although imperfect, this measure should properly capture the correlation coming from the input-output linkages, which is the source of concern. The results clearly indicate that this concern is not relevant for the main findings. Another possibility is the presence of aggregate shocks. In the model of section 2, sectoral shocks result in aggregate fluctuations because of the input-output linkages, therefore, aggregate shocks are not necessary to generate comovement. Nevertheless, the presence of aggregate shocks would add a term to the linear approximation that would depend on the input-output linkages and the variance of the aggregate shock, but whose exact form would depend on specific assumptions regarding the transmission of these shocks. The regression in Column (5) controls for this potential source of bias in a general manner by adding the interaction of a country's overall volatility and the generic credit-chain linkage, which maximizes the potential correlation with the component of the transmission of aggregate shocks that is a function of input-output linkages. As before, the main findings of the paper are largely unaffected.

5.4 Alternative explanations and further evidence on the mechanism

Since the measure of credit-chain linkage was constructed using US data, one possible interpretation of the findings is that they are simply indicating that input-output linkages can better explain sectoral comovement in countries that are similar to the US. This is unlikely because the US is not atypical in its level of trade credit use (payables financing in the US is 0.13, just below the sample median of 0.14). Nevertheless, I check for this possibility by adding to the baseline specification the interaction of the generic credit-chain linkage and the (log) average real GDP per capita (from PWT) during 1980-2000. The results, reported in column (1) of Table 7, show that linkages are indeed more important in developed countries, but this does not significantly affect the findings regarding credit chains and sectoral comovement. Column (2) shows similar results when also controlling for a country's overall degree of volatility (as measured by the standard deviation of the growth rate of real value added during 1980-2003).

The results obtained using the ratio of short term debt to payables (see Table 4, columns (4) to (7)) indicate that the actual use of formal financing from financial intermediaries vis-a-vis supplier credit partly alleviates the transmission of shocks through credit chains. Building on these results, column (3) checks whether the overall availability of formal financing affects the importance of the credit-chain mechanism by allowing the parameter α to depend on a country's degree of financial development, which amounts to add a triple interaction term. The results indicate that the credit chain mechanism is stronger in more financially developed countries.[27] A possible interpretation of this finding is that overall financial development also increases the supply of trade credit, which would be consistent with Demirguc-Kunt and Maksimovic (2001) who maintain that these sources of financing are complements. If this were the case, overall financial development would measure the absolute availability of formal short term financing, but it would be a poor proxy of the *relative* importance of this source of funds. The evidence supports this explanation; in the sample of countries used in this paper, overall financial development is significantly *negatively* correlated with the country level ratio of short term debt to payables, S_c. Also, adding the interaction of this ratio and credit chain linkages to the baseline specification, which allows the parameter α to depend on this measure of relative use of formal financing, results in a significantly negative coefficient that indicates that an increase in the relative use of formal financing weakens the credit-chain mechanism, as predicted by the theory. This finding is confirmed when running a horse race between financial development and S_c as measures of the importance of financing from intermediaries: while the coefficient of the interaction of credit-chain linkages with S_c remains significantly negative, the coefficient of the interaction with financial development stops being statistically significant (not reported).

Shocks to *domestic* downstream producers are unlikely to affect firms that sell their intermediate goods to foreign producers. This observation suggests that the relevance of the credit chain mechanism may depend on a country's degree of trade openness. The exercise presented in column (5), which includes the interaction between an industry pair's generic credit-chain linkage and a country's degree of trade openness (measured as the log ratio of exports plus imports to GDP), shows that indeed input-output linkages are less important in more open countries but that this finding is not behind the main result of the paper. This result is robust to controlling for the overall level of development (not reported).

The credit-chain linkage between two industries can be decomposed in various forms that shed light on the mechanism and the sources of identification. The regression reported in column (6) determines the relative importance of direct and indirect linkages (first and higher round effects in the transmission of shocks) by computing the credit-chain linkage resulting from first round effects only and adding it to the baseline specification.[28] The results show a higher and statistically significant coefficient for the distance related to first round effects than for the overall distance, which suggests that the marginal impact of direct linkages on sectoral correlations is higher. However, the overall contribution of these linkages to differences in correlation is smaller because their sample variation is an order of magnitude smaller than that of the overall distance. Therefore, indirect linkages are qualitatively and quantitatively important for the mechanism. It is also possible to disentangle the contribution to sectoral correlations of differences in the use of trade credit across industries from the contribution of the average industry use. The credit-chain linkage in equation (6) can be trivially written as the distance when all industries use the average level of trade credit plus the contribution of the industries' deviations from that average. These two components (that add to the credit-chain linkage) are separately included in the regression in column (8). The results show that it is the average use of trade credit along the chain of industries linking two sectors that is behind the result of this paper. The differences across industries do not contribute significantly and, if anything, tend to reduce the correlation. The lack of significance is not surprising because input-output linkages have much larger variation than the relative use across industries. The negative sign indicates that industries strongly connected to the rest of the economy use relatively less trade credit.

6 Concluding remarks

This paper has provided indirect evidence of the presence and quantitative importance of the credit-chain amplification mechanism first described in Kiyotaki and Moore (1997) by looking at its implications for the comovement of industries within and across countries. The results, which exploit the variation in correlations of industry-pairs and use of trade credit across countries, robustly indicate that, consistently with the presence of a credit-chain amplification mechanism, an increase in the intensity of use of trade credit along the input-output chain linking two industries augments the correlation between them.

In terms of economic significance, the evidence indicates that, without being a first order determinant of comovement and volatility, the credit-chain amplification mechanism is quantitatively relevant. Moreover, there are several reasons to consider the estimates as conservative.

In addition to the possible causes of attenuation already discussed in the paper, there are at least three other dimensions that deserve to be considered in future work. First, one possible cause of the limited variation in the measures of distances across industry pairs is the level of aggregation used in this paper. At a lower level of aggregation, it may be possible to capture more of the local interactions between similar industries that are now part of the "diagonal" terms of the distance matrices. The reason for not working at a lower level of aggregation in this paper is the exponential increase in the number of observations in the time dimension that are required to satisfy the order condition in the computation of the correlation matrices, but this restriction may become less important as the time coverage of existing datasets increases. Second, the data used in this paper do not include the non-manufacturing sectors, such as retailing and wholesale, that are important users of trade credit and likely a major contributor to credit chain amplification (see Burkart et al., 2007). Finding ways of including these sectors is likely to be relevant to quantify the real importance of this mechanism. Finally, for data availability reasons and to avoid endogeneity problems, this paper's analysis focused on the unconditional correlations, despite that according to theory the standard credit-chain amplification mechanism affects mainly the comovement resulting from negative shocks. As discussed in the paper, the presence of this asymmetry may weaken the tests and bias downwards the estimates of the relevance of the mechanism. Addressing some of the issues should form part of future research.

Appendix

A Building the Ultimate Demand Requirements Matrix DEM

Following Shea (1990, 2002) the D matrix for the 28 three-digit ISIC industries is constructed using information from the 1992 commodity-by-industry (USE) and industry-by-commodity ($MAKE$) matrices produced by the US bureau of economic analysis (BEA) and a correspondence between the industry classification used by the BEA and ISIC. The first step in the construction of this matrix is the computation of the *Direct Cost Share Matrix* (DCS) whose i,j element is the amount of industry i input required per dollar of industry j's output. This matrix can be directly computed from the US benchmark-input-output matrices by multiplying the $MAKE$ and USE matrices to obtain each industry's use (in dollars) of goods produced by other industries, dividing each column by the total value of the output produced by that particular industry to obtain the *Direct Requirement Matrix* (DRQ), and then correcting this matrix for the presence of non-zero terms in the diagonal resulting from aggregation,

$$DCS = (I - diag(DRQ))^{-1}(DRQ - diag(DRQ)),$$

where the $diag()$ operator extracts the main diagonal of a matrix. The $COST$ matrix, whose i,j element is the ultimate dollar requirement of good j per dollar sold of good i, is simply the part corresponding to the ISIC manufacturing industries of the transpose of the Leontieff inverse of the DCS matrix $(I - DCS')^{-1}$. Finally, the *Ultimate Demand Requirement Matrix* (D) corresponds to

$$D_{ik} = COST_{ki}a_k / \left(\sum_{z=1}^{N} COST_{zi}a_z \right),$$

or, in matrix notation,

$$D = diag(COST\ Diag(a))^{-1} COST'\ Diag(a), \tag{9}$$

where a_k is the steady-state share of good k in overall consumption, $a = (a_1, ..., a_N)$, and the $Diag()$ operator takes a vector and places it in the main diagonal of a matrix. Following Shea (2002), the industry k's final demand is the sum of purchases from consumption, government, and other non-manufacturing industries. The matrix for the UK used in the robustness section was built in the same manner.

In traditional input-output analysis, the transpose of the $COST$ matrix is used as a measures of backward linkages. Therefore, equation (9) shows that D is a normalization of this traditional measure.

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Notes

[1]Data available at http://www.enterprisesurveys.org.

[2]"For Detroit, Chapter 11 Would Be the Final Chapter", *The New York Times*, November 24, 2008, Late-Edition, Final. "VeraSun Files for Chapter 11 After a Bad Bet on Corn Futures", *The Washington Post*, November 1, 2008, Final.

[3]The terms *industry* and *sector* are used interchangeably throughout the paper.

[4]A stylized model that formalizes this intuition is presented in (Raddatz, 2008)

[5]This matrix is not arbitrary but derived by Shea (2002) from a standard multisector general equilibrium model,

[6]I discuss in detail the consequences of this assumption in section 3.1

[7]The derivation above assumes for simplicity that trade credit use equally amplifies positive and negative shocks. If the trade credit mechanism is asymmetric, the exact expression will be such that the term multiplying the credit-chain linkage will be a function of α and specific parameters of the distribution of shocks. For instance, when the mechanism operates only for negative shocks and shocks are normally distributed with mean zero and variance σ^2 the coefficient multiplying the credit-chain linkage is $\alpha/2$, which means that neglecting this assymetry may result in downward biased estimated coefficients..

[8]For a recent application of this measure to analyze the determinants of trade credit use, see Demirguc-Kunt and Maksimovic (2001).

[9]This is a measure of the gross use of trade credit, but notice that the sectoral model described in equation (2) considers all interactions between pairs of sectors, so it already incorporates the fact that a sector's account payables are another sector's account receivables.

[10]In a few countries non-maunfacturing firms were considered to increase the sample coverage.

[11]My data from Compustat covers only until 2000. The measures were computed using data from 1980-1989 and 1980-1999 obtaining similar results. Reported ratios correspond to those obtained for 1980-1989.

[12]The evidence on this regard is ambiguous. For instance, while Demirguc-Kunt and Maksimovic (2001) find that smaller listed firms use more trade credit, Burkart et al. (2007) finds no relation between Payables Turnover and firm size, and Fabbri and Klapper (2008) find that in China trade credit use is more prevalent among large firms.

[13]Amadeus is a firm-level database that covers most listed and unlisted companies in Western and Eastern Europe, reaching almost universal coverage. Results are based on the 2007 version of the database containing balance sheet information for 2000-2006. Although the firm registry reported by Amadeus has almost universal coverage, the coverage of specific variables is much reduced, especially for variables related to trade

credit. The final dataset used contains about 4 million observations (firm-years) in the 17 European countries included in the paper sample.

Data from the World Bank Investment Climate Surveys (ICS) can be combined with Amadeus to extend the comparison beyond Europe, obtaining similar results. In this broader sample the rank correlation between the Worldscope and the broader measures is 0.64, significant at 1 percent. This result yields support to the findings from Amadeus, but has to be taken with caution because, in contrast to Amadeus, the ICS report a single year observation for this variable, and the response rate for the use of trade credit and the cost of goods sold is small.

[14]These countries are Argentina, Brazil, Czech Republic, New Zealand, Pakistan, Russia, Switzerland, Slovakia, Slovenia, and Thailand. The main reason why these countries are excluded is that they do not count with 15 observations of the growth rate during 1980-2003 to construct the correlation matrices.

[15]With N sectors and T observations, there are $N(N-1)/2$ correlation coefficients to be estimated from NT observations. The order condition, therefore, requires that $T \geq (N-1)/2$ for a full rank matrix. With 28 sectors, this requires 14 observations as a minimum. I allowed for one more than that.

[16]According toYamada (2005), reported indexes are inconsistent over time and across industries (in terms of ISIC aggregation) in many cases. Also, most developing countries report fixed-weight Laspeyres indexes that are inadequate for computing growth rates (chain-indexes being the correct ones).

[17]According to Horvath (1998, 2000) this sparsity is crucial to understand why the law of large numbers does not necessarily apply to models where transmission of shocks is given by input-output relations.

[18]Similar results are obtained when adding the difference in average and standard deviation between the two industries instead of adding the values for each industry separately (not reported).

[19]The results reported in the figure are robust to excluding Italy (ITA) from the sample.

[20]The details of the simulations are reported in Raddatz (2008).

[21]Seven and 25 percent of the inter-quartile range of variance of aggregate manufacturing value added growth.

[22]Stata command rreg.

[23]The specific measure is the weighed correlation between two industries, where the weights are obtained from a robust regression (Stata rreg) between the two growth rate series.

[24]Data from Worldscope was used for 19 countries and data from the World Bank Investment Climate Surveys (ICS) for 12. ICS are partly aimed to measure productivity, so they have better coverage on material costs and cost of goods sold than on accounts payables and receivables. Thus, data from the ICS were used to estimate the ratio of material costs to cost of goods sold, which can be combined with the ratio of accounts payables to cost of goods sold from Worldscope to obtain an estimate of the ratio of accounts payables

to material costs. In addition to having to use the information from the ICS in an indirect manner, the information from these surveys is usually available for a single year and it should be taken with caution.

[25]Let $\Phi(i,j)$ be the dollar value of compensation to sector i for goods used in industry j obtained directly from the input output tables. An industry's fraction of the costs and demand of other sector are obtained by normalizing the Φ matrix across rows and columns to obtain $B(i,j) = \Phi(i,j)/\sum_k \Phi(k,j)$ and $\Psi(i,j) = \Phi(i,j)/\sum_k \Phi(i,k)$. The BUY and $SELL$ distances correspond to the Euclidean distance of the vectors of costs and demand shares between two industries and correspond to $BUY(i,j) = \left[\sum_k (B(k,i) - B(k,j))^2\right]^{\frac{1}{2}}$ and $SELL(i,j) = \left[\sum_k (\Psi(i,k) - \Psi(j,k))^2\right]^{\frac{1}{2}}$.

[26]For the relation between liquidity needs and vulnerability to financial underdevelopment see Raddatz (2006).

[27]This finding is robust to controlling for the simple interaction between financial development and GDP per capita and generic credit-chain linkage.

[28]Iterating on the reduced form equation (2) yields the recursive representation of equation (4), $y = (\tilde{B} + \widetilde{B}^2 + \tilde{B}^3 + \ldots + \tilde{B}^N)\lambda + \tilde{B}^{N+1}y$, which shows that the structural form corresponds to the sum of the first, second, and higher order rounds of effects of the shocks. The first order effect is given by $\widetilde{B}\lambda$ and the resulting correlation matrix is derived as in section 2.

Table 1. Trade credit use, average correlations and number of observations in sample countries

Country	A. Trade Credit Use Measures			B. Sectoral Correlations and Income Levels				
	Payables Financing	Short Term Debt to Payables	Quality Trade Credit Data	Average corr. of VA growth	No. ind. pairs with VA growth	Average corr. of IIP growth	No. ind. Pairs with IIP growth	Average GDP Per capita 1980-2000
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Australia	0.13	0.24	1	0.22	190	0.35	190	20,483
Austria	0.11	1.60	1	0.13	378	0.23	378	19,220
Belgium	0.15	0.91	1	0.07	91	0.15	231	19,290
Canada	0.19	0.25	1	0.17	378	0.46	378	21,974
Chile	0.11	1.86	1	0.26	378	0.36	378	6,861
China	0.20	2.73	1	0.48	231	--	--	2,133
Colombia	0.07	2.45	1	0.15	378	0.29	378	4,897
Denmark	0.10	1.00	1	0.29	378	0.23	378	21,853
Egypt	0.18	3.04	2	0.03	378	0.14	378	3,226
Spain	0.20	0.79	1	0.23	351	0.25	351	14,062
Finland	0.10	1.20	1	0.13	378	0.30	378	18,726
France	0.17	0.55	1	0.77	325	0.23	325	19,028
United Kingdom	0.16	0.42	1	0.32	378	0.54	378	17,888
Greece	0.14	1.78	1	0.20	210	0.00	210	12,185
Hong Kong, China	0.15	1.21	1	--	--	0.49	322	20,416
Hungary	0.13	0.87	1	0.69	325	0.57	351	9,093
Indonesia	0.12	3.26	1	0.20	276	0.20	276	2,889
India	0.17	0.89	1	0.14	378	0.11	378	1,705
Ireland	0.15	0.56	1	0.11	325	0.27	325	14,819
Iceland	0.15	1.85	2	0.06	231	--	--	20,625
Israel	0.18	0.58	1	0.11	253	0.36	231	14,005
Italy	0.33	0.81	1	0.40	325	0.22	377	18,505
Jordan	0.13	1.26	2	0.05	325	0.09	120	3,962
Japan	0.24	0.76	1	0.31	378	0.39	378	20,773
Korea	0.13	2.15	1	0.38	378	0.46	378	10,010
Sri Lanka	0.08	3.09	2	0.32	325	--	--	2,564
Morocco	0.21	0.27	2	0.03	66	0.07	136	3,418
Mexico	0.14	1.12	1	0.10	325	0.65	325	7,587
Malaysia	0.12	1.94	1	0.16	378	0.19	325	7,001
Netherlands	0.12	0.61	1	0.28	276	0.16	275	19,206
Norway	0.10	0.31	1	0.14	325	0.17	377	21,372
Peru	0.11	2.36	1	0.31	378	0.60	378	4,404
Philippines	0.18	1.29	1	0.29	378	0.12	378	3,075
Poland	0.14	0.78	1	0.53	45	0.65	215	7,001
Portugal	0.12	1.53	1	0.17	351	0.17	378	11,815
Singapore	0.15	0.82	1	0.24	276	0.22	276	16,627
Sweden	0.11	0.31	1	0.49	378	0.21	378	19,878
Turkey	0.13	1.10	1	0.15	378	0.23	378	5,630
Taiwan, China	0.12	1.98	1	0.29	378	0.26	378	10,732
United States	0.13	0.40	1	0.41	378	0.43	378	26,235
Venezuela, RB	0.20	1.25	2	0.31	378	--	--	7,090
South Africa	0.19	0.21	1	0.26	253	0.39	253	7,645
Zimbabwe	0.08	0.92	2	0.15	300	0.29	253	2,721
Mean	0.15	1.24	--	0.25	314	0.30	322	12,154
Median	0.14	1.00	--	0.22	338	0.25	377	11,815
St. Dev.	0.05	0.83	--	0.17	88	0.16	75	7,347
Percentile 25	0.12	0.59	--	0.14	276	0.18	276	5,264
Percentile 75	0.18	1.82	--	0.31	378	0.39	378	19,213

In Panel A, *Payables Financing* is the ratio of accounts payables to the cost of goods sold; *Short Term Debt to Payables* is the ratio of short term debt to accounts payables. The figures reported for each country correspond to the median level of each ratio across all manufacturing firms in Worldscope in the country, except for the countries where quality equals 2 (column (3)), where it corresponds to the ratio across all Worldscope firms. For each firm, each measure is the median across the years with data during the period 1980 to 2005. Only firms with more than 5 years of data are included in the computation of the country median and only countries with more than 10 of these firms are included in the sample.

In Panel B, column (4) reports the average correlation of value added growth among industry pairs (excluding the correlation between an industry and itself). Column (5) displays the number of non-repeated industry pairs for which there are data on the correlation of value-added growth per country (a given industry pair is counted only once). Columns (6) and (7) present similar information for the correlation of the growth of the industrial production index. Column (8) shows the average real GDP per capita of each country during the period 1980-2000.

Table 2. Relative use of trade credit across U.S. manufacturing industries

ISIC code	Industry	Relative Payables Financing (1)	Relative Short Term Debt to Payables (2)
311	Food products	0.82	1.01
313	Beverages	1.37	0.55
314	Tobacco	0.92	0.92
321	Textiles	0.93	0.94
322	Wearing apparel, except footwear	0.93	1.92
323	Leather products	0.69	2.10
324	Footwear, except rubber or plastic	0.73	1.27
331	Wood products, except furniture	0.62	1.16
332	Furniture, except metal	0.77	0.75
341	Paper and products	0.86	0.57
342	Printing and publishing	0.95	0.87
351	Industrial chemicals	1.23	0.56
352	Other chemicals	1.51	0.58
353	Petroleum refineries	1.27	0.43
354	Misc. petroleum and coal products	1.02	0.97
355	Rubber products	0.87	0.85
356	Plastic products	1.01	0.72
361	Pottery, china, earthenware	0.58	0.88
362	Glass and products	0.94	1.35
369	Other non-metallic mineral products	1.06	0.67
371	Iron and steel	0.94	0.70
372	Non-ferrous metals	0.95	1.18
381	Fabricated metal products	0.97	1.15
382	Machinery, except electrical	1.32	0.80
383	Machinery, electric	1.27	1.03
384	Transport equipment	0.90	0.78
385	Professional & scientific equipment	1.36	0.90
390	Other manufactured products	1.20	2.00
	Median	0.95	0.89
	Percentile 25	0.87	0.71
	Percentile 75	1.21	1.15
	Correlations		
	Relative Payables Financing	1	
	Relative Short Term Debt to Payables	-0.32	1

Column (1) reports the ratio of accounts payable to cost of goods sold in a given manufacturing industry in the U.S. to the overall U.S. mean in manufactures. Similar ratios are reported for short-term debt to payables (column (2)). The values of each measure for a given industry correspond to the median across all U.S. firms in that industry included in Compustat during 1980-1989. The value for the U.S. manufacturing sector as a whole corresponds to the median across industries. For a given firm, the ratios correspond to their median across the years in which the firm reported data.

Table 3. Industry pairs with the strongest credit-chain linkages

ISIC code industry 1	Industry 1	ISIC code industry 2	Industry 2	Credit-Chain Linkage	Ranking
321	Textiles	322	Wearing apparel, except footwear	90.67	1
381	Fabricated metal products	384	Transport equipment	63.17	2
351	Industrial chemicals	352	Other chemicals	63.06	3
356	Plastic products	384	Transport equipment	61.31	4
351	Industrial chemicals	384	Transport equipment	60.15	5
362	Glass and products	384	Transport equipment	59.47	6
356	Plastic products	372	Non-ferrous metals	54.15	7
351	Industrial chemicals	372	Non-ferrous metals	53.30	8
323	Leather products	324	Footwear, except rubber or plastic	49.27	9
362	Glass and products	372	Non-ferrous metals	49.11	10
356	Plastic products	371	Iron and steel	48.90	11
351	Industrial chemicals	371	Iron and steel	47.18	12
355	Rubber products	384	Transport equipment	46.95	13
351	Industrial chemicals	356	Plastic products	44.69	14
341	Paper and products	342	Printing and publishing	43.77	15
362	Glass and products	371	Iron and steel	42.99	16
356	Plastic products	383	Machinery, electric	40.30	17
355	Rubber products	372	Non-ferrous metals	39.77	18
362	Glass and products	383	Machinery, electric	39.28	19
371	Iron and steel	384	Transport equipment	39.24	20

The table shows the *credit-chain linkages* of the twenty industry pairs with the smallest (generic) credit-chain distances computed using the 1992 U.S. input-output matrices. The first four columns of the table describe the names and ISIC codes of the industries that comprise each pair. The column labeled *Credit-Chain Linkage* displays the estimated value of the linkage. A higher value represents a stronger linkage. The last column indicates the ranking of each industry pair according to credit-chain linkage across the whole set of 378 possible pairs.

Table 4. Credit chains and sectoral correlations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Credit-Chain Linkage (Payables Financing)	1.978***	2.058***	1.927***	--	--	--	1.798***
	(0.327)	(0.327)	(0.327)	--	--	--	(0.343)
Credit-Chain Linkage (Short Term Debt to Payables)	--	--	--	-0.097***	-0.092***	-0.099***	-0.065**
	--	--	--	(0.021)	(0.021)	(0.023)	(0.022)
(log) Number of establishments industry 1	--	0.024***	0.019***	--	0.023***	0.018***	0.023***
	--	(0.004)	(0.004)	--	(0.004)	(0.004)	(0.004)
(log) Number of establishments industry 2	--	0.024***	0.022***	--	0.024***	0.021***	0.024***
	--	(0.004)	(0.004)	--	(0.004)	(0.004)	(0.004)
Share of manufacturing VA industry 1	--	-0.239**	-0.305**	--	-0.224**	-0.295**	-0.245**
	--	(0.098)	(0.098)	--	(0.098)	(0.098)	(0.098)
Share of manufacturing VA industry 2	--	-0.669***	-0.672***	--	-0.667***	-0.675***	-0.684***
	--	(0.104)	(0.105)	--	(0.105)	(0.105)	(0.104)
Average growth industry 1	--	--	-0.131*	--	--	-0.141*	--
	--	--	(0.073)	--	--	(0.073)	--
Average growth industry 2	--	--	-0.004	--	--	0.001	--
	--	--	(0.074)	--	--	(0.073)	--
Standard deviation growth industry 1	--	--	-0.205***	--	--	-0.212***	--
	--	--	(0.027)	--	--	(0.027)	--
Standard deviation growth industry 2	--	--	-0.102***	--	--	-0.103***	--
	--	--	(0.022)	--	--	(0.022)	--
Observations	13182	12683	12683	13182	12683	12683	12683
R-squared	0.344	0.346	0.352	0.344	0.345	0.351	0.347
Industry pair FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The dependent variable is the correlation of real value added growth of each industry-pair in each sample country. *Credit-Chain Linkage (Payables Financing)* is the measure of the intensity of use of trade credit in the chain linking two industries based on the *Payable Financing* ratio. *Credit-Chain Linkage (Short Term Debt to Payables)* is the intensity of use of trade credit in the chain linking two industries based on the *Short-term debt to payables ratio. (log) Number of establishments industry 1 (2)* is the log of the average number of firms in the first (second) industry in the corresponding industry pair. *Share of total manufacturing VA industry 1 (2)* is the average share of the first (second) industry pair on total manufacturing value added. *Average growth industry (1)* is the average growth of real value added in the first (second) industry in the pair. *Standard deviation growth industry 1 (2)* is the standard deviation of the growth of real value added in the first (second) industry in the pair. All averages mentioned above are computed over the period 1980-2000. All regressions include country and industry-pair fixed effects. Standard errors are robust to heteroskedasticity.

* = Significant at 10 percent level, ** = Significant at 5 percent level, *** = Significant at 1 percent level.

Table 5. Robustness to variations in the sample, correlation measure, and linkage measure

Specification	Credit-Chain Linkages Coefficient		Obs.	R-squared	Ind. pair FE	Country FE	No. estab. & share of manuf. VA
	Point Estim.	Std. Dev					
A. Sample Issues							
(1) High Quality Sample	2.323***	(0.340)	10680	0.360	Yes	Yes	Yes
(2) Dropping Transition Economies	2.058***	(0.329)	12082	0.315	Yes	Yes	Yes
(3) Dropping Extreme Trade Credit	1.846**	(0.660)	9804	0.372	Yes	Yes	Yes
(4) Dropping Extreme Distances	2.952***	(0.561)	11431	0.351	Yes	Yes	Yes
(5) Robust Estimation	1.895***	(0.373)	12683	0.351	Yes	Yes	Yes
B. Measurement							
Varying Correlation Measures							
(6) Correlation of IIP	1.504***	(0.372)	11146	0.404	Yes	Yes	Yes
(7) Using HP Filter	1.745***	(0.368)	10194	0.318	Yes	Yes	Yes
(8) Transformed Correlation	4.592***	(0.805)	12651	0.382	Yes	Yes	Yes
(9) Robust Correlation	1.722***	(0.393)	12683	0.329	Yes	Yes	Yes
Varying Linkages Measures							
(10) Using country level information	1.871***	(0.306)	12683	0.346	Yes	Yes	Yes
(11) Using UK input-output data	1.618***	(0.293)	12683	0.346	Yes	Yes	Yes
(12) Using data from Amadeus	1.142***	(0.330)	3832	0.466	Yes	Yes	Yes
(13) Controlling for Stock Market Cap.	1.927***	(0.324)	12683	0.347	Yes	Yes	Yes
(14) Country Usage FE	1.828***	(0.340)	10680	0.359	Yes	Yes	Yes
(15) Using Payables to Material Costs	0.897***	(0.231)	9608	0.367	Yes	Yes	Yes
(16) Using IO Backward Linkages	2.468***	(0.547)	12683	0.345	Yes	Yes	Yes

Columns (1) and (2) report the point estimate and standard deviation of the coefficient estimated for the measure of *Credit-Chain Linkages,* respectively. The different rows present results for several specifications that vary the sample of countries (rows (1) to (5)), the measure of correlation used as dependent variable (rows (6) to (9)), or the measure of credit-chain linkages (rows (10) to (16)). The regression in row (1) uses the high quality sample of 39 countries (column (1)), row (2) drops transition economies (China, Hungary, and Poland) from the baseline sample, row (3) excludes the countries where the corresponding measures of trade credit were below the 5th and above the 95th percentile levels observed in the main sample, and row (4) drops those industries where the corresponding measures of the generic credit chain linkages were below the 5th and above the 95th percentile levels observed in the set of industry pairs. The coefficient reported in Row (5) was obtained in a robust regression (Stata rreg command).

In the regressions reported in rows (6) to (9), the dependent variables are the correlation of the series of the index of industrial production, real value added detrended using the Hodrik-Prescott filter, the Otto et al. (2001) transformation of the correlation of the growth rate of real value, and a robust measure of the correlation of real value added growth between the industries in a pair, respectively.

Regressions in rows (10) to (12) present results obtained using a measure of credit-chain linkage that exploits the existing information on industry level use of trade credit across countries, a measure based on the UK input-output matrices, and a measure of payables financing obtained from the Amadeus database, respectively. All averages mentioned above were computed over the period 1980-2000. The regression in row (13) uses the baseline measure of credit-chain linkages but adds the interaction of the generic credit-chain linkage and a country stock market capitalization (as a fraction of GDP) to control for potential biases arising from using a sample of listed firms. The results presented in row (14) use a measure of credit-chain linkage constructed using an index of payables financing that controls for differences in sectoral composition across countries. The regression in row (15) replaces the baseline credit-chain linkage measure with one built using the ratio of accounts payables to material costs instead of payables financing. Row (16) reports results obtained using a measure of credit-chain linkages constructed from a traditional backward linkages matrix instead of Shea (2002)'s. All regressions include country and industry pair fixed effects, and control for the (log) number of establishments and share of total manufacturing value added of both industries in a country pair. Standard errors are robust to heteroskedasticity.

* = Significant at 10 percent level, ** = Significant at 5 percent level, *** = Significant at 1 percent level.

Table 6. Other dimensions of similarity across industry pairs

	(1)	(2)	(3)	(4)	(5)
Credit-Chain Linkage (Payables Financing)	2.177***	2.037***	2.036***	2.063***	1.900***
	(0.345)	(0.337)	(0.328)	(0.328)	(0.338)
BUY distance X Payables Financing	-0.723	--	--	--	--
	(0.484)	--	--	--	--
SELL distance X Payables Financing	0.563**	--	--	--	--
	(0.229)	--	--	--	--
Dist. lexternal finance X Financial Development	--	-0.000	--	--	--
	--	(0.014)	--	--	--
Dist. liquidity needs X Financial Development	--	-0.437***	--	--	--
	--	(0.129)	--	--	--
Dist. capital per employee X Capital per Worker	--	0.001	--	--	--
	--	(0.023)	--	--	--
Dist. Gini intermediary shares X Overall Volatility	--	--	21.047*	--	--
	--	--	(10.763)	--	--
Correlation from differences in shocks volatilities	--	--	--	0.006	--
	--	--	--	(0.013)	--
Generic Credit-Chain Link. X Overall Volatility	--	--	--	--	-2.408*
	--	--	--	--	(1.447)
Observations	12683	10241	12683	12683	12683
R-squared	0.347	0.341	0.346	0.346	0.346
Number of establishments both industries	Yes	Yes	Yes	Yes	Yes
Share of total manufacturing VA both industries	Yes	Yes	Yes	Yes	Yes
Industry pair FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes

The dependent variable is the correlation of growth rates of real value added between industry-pairs in different countries. *Credit-Chain Linkage* is the measures of the intensity of use of trade credit in the chain linking two industries based on *Payable Financing*. *BUY (SELL) distance X Payables Financing* is the interaction between Conley and Dupor (2003)'s measure of similarity between two industries in terms of suppliers (customers) and a country's median level of payables to cost of goods sold. *Dist. external finance X Financial Development* is the interaction of the absolute value of an industry pair's difference in external financial requirements (Rajan and Zingales, 1998) and a country's level of *Financial Development* measured as the (log) average ratio of Private Credit to GDP. *Dist. liquidity needs X Financial Development*, *Dist. capital per employee X Capital per Worker*, and *Dist. Gini intermediary shares X Overall Volatility* are computed analogously. *Correlation from differences in shocks volatility* is the contribution of differences in the volatility of shocks to various industries to an industry pair correlation. *Generic Credit-Chain Link. X Overall Volatility* is the interaction of an industry pair's generic credit-chain linkage and a country's standard deviation of real GDP per capita growth. All averages and standard deviations mentioned above are computed over the period 1980-2000. All regressions include country fixed effects and control for the average number of firms and share of total manufacturing value added of each industry in the pair. Standard errors are robust and clustered at the industry-pair level. * = Significant at 10 percent level, ** = Significant at 5 percent level, *** = Significant at 1 percent level.

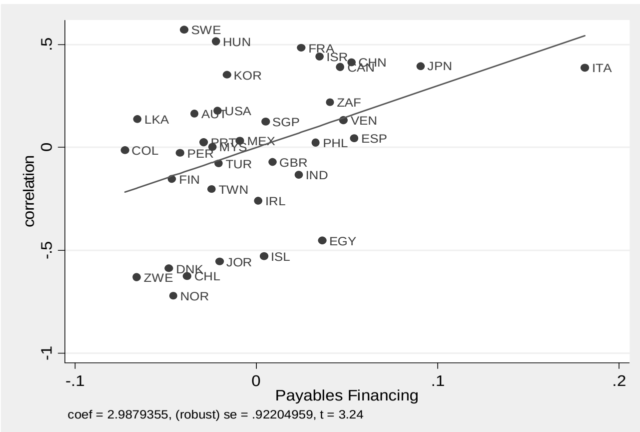
Table 7. Alternative explanations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Credit-Chain Linkage (Payables Financing)	1.924***	1.886***	2.272***	2.357***	1.867***	2.034***	--
	(0.332)	(0.341)	(0.330)	(0.334)	(0.331)	(0.328)	--
Generic Credit-Chain Linkage X (log) GDP per capita	0.070**	0.064**	--	--	--	--	--
	(0.023)	(0.024)	--	--	--	--	--
Generic Credit-Chain Linkage X Growth Volatility	--	-0.732	--	--	--	--	--
	--	(1.544)	--	--	--	--	--
Credit-Chain Linkage X Financial Development	--	--	0.810***	--	--	--	--
	--	--	(0.210)	--	--	--	--
Credit-Chain Linkage X Short Term Debt to Payables	--	--	--	-0.603***	--	--	--
	--	--	--	(0.154)	--	--	--
Generic Credit-Chain Linkage X Trade Openness	--	--	--	--	-0.086**	--	--
	--	--	--	--	(0.030)	--	--
Direct Credit-Chain Linkage (Payables Financing)	--	--	--	--	--	7.427**	--
	--	--	--	--	--	(2.988)	--
Credit-Chain Linkage (Differential use)	--	--	--	--	--	--	-2.697
	--	--	--	--	--	--	(2.465)
Credit-Chain Linkage (Common use)	--	--	--	--	--	--	2.294***
	--	--	--	--	--	--	(0.345)
Observations	12683	12683	12683	12683	12683	12683	12683
R-squared	0.347	0.347	0.347	0.347	0.347	0.347	0.346
Number of establishments both industries	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Share of total manufacturing VA both industries	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry pair FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

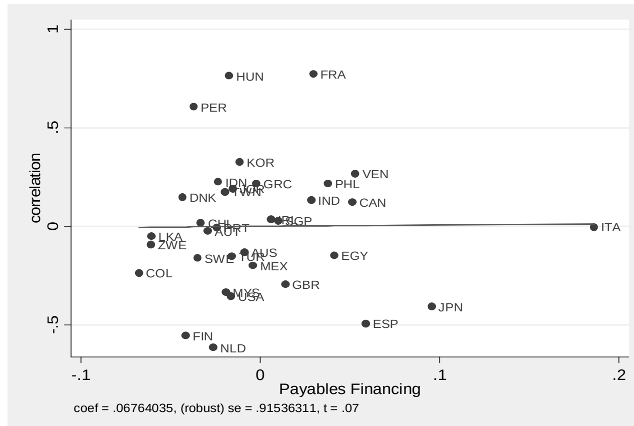
Credit-Chain Linkage (Payables Financing) is the measures of the intensity of use of trade credit in the chain linking two industries based on the ratio of payables to cost of goods sold. *Generic Credit-Chain Linkage x (log) GDP per capita*, *Generic Credit-Chain Linkage x Growth Volatility*, and *Generic Credit-Chain Linkage X Trade Openness* are the interactions between an industry pair's generic credit-chain linkage and a country's (log) GDP per capita, standard deviation of the growth of real GDP per capita, and the log average ratio of total exports to GDP. *Credit-Chain Linkage X Financial Development* and *Credit-Chain Linkage X Short-Term Debt to Payables* are the interactions between these two variables. *Direct-Credit Chain Linkage* is the credit chain linkage computed considering only the direct linkages among industries. *Credit-Chain Linkage (Common Use)* is the linkage computed using the average payable financing of all industries, and *Credit-Chain Linkage (differential use)* is the linkage computed using the industries deviations from that average only. These two linkage measures add to the baseline measure of C*redit-Chain Linkage*. All averages mentioned above are computed over the period 1980-2000. All regressions include country fixed effects and control for the average number of firms and share of total manufacturing value added of each industry in the pair. Standard errors are robust to heteroskedasticity. * = Significant at 10 percent level, ** = Significant at 5 percent level, *** = Significant at 1 percent level.

Figure 1. Differential effect of trade credit use in sectors with small and large distances

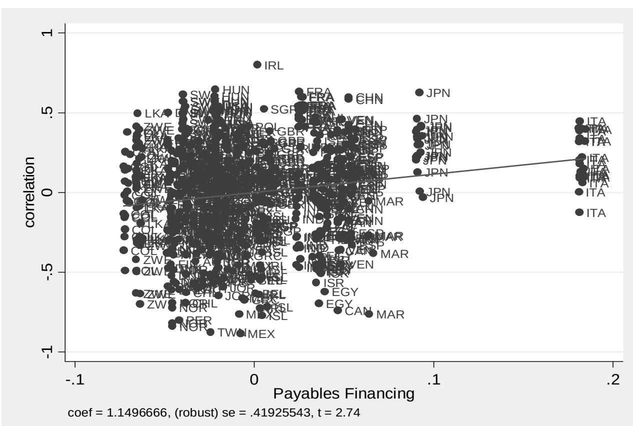
Panel A. Payables financing and the correlation between Iron and Steel and Transport Equipment industries (strong linkages)



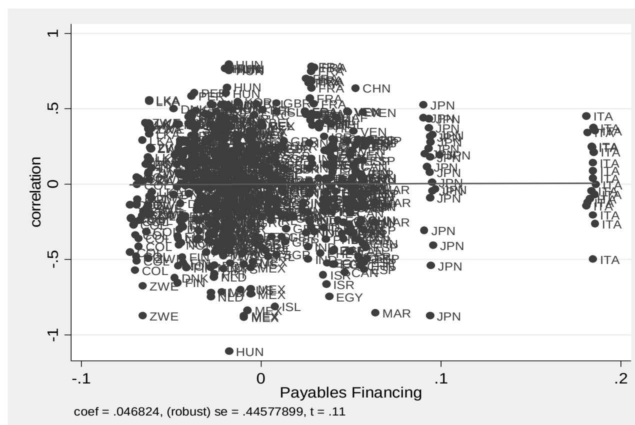
Panel B. Payables financing and the correlation between Tobacco and Footwear industries (weak linkages)



Panel C. Payables financing and the correlation between 20 industry pairs with strongest linkages



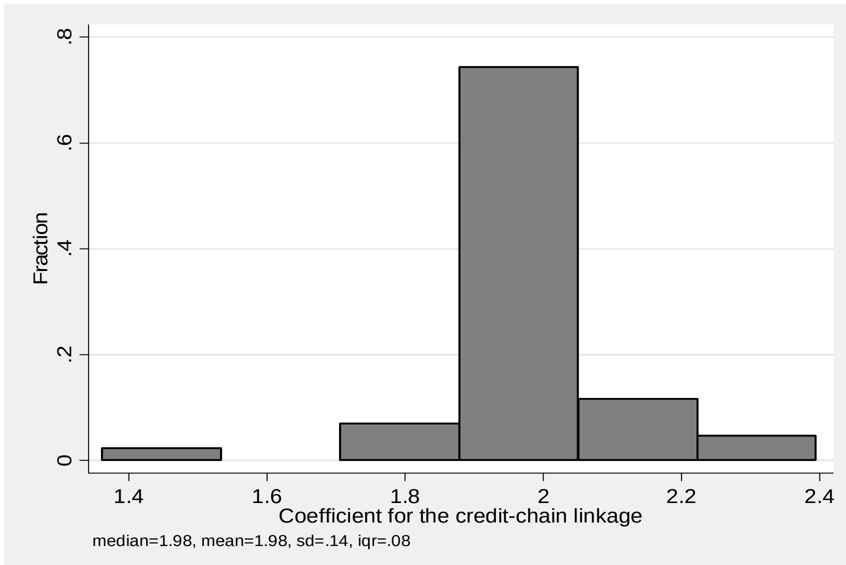
Panel D. Payables financing and the correlation between 20 industry pairs with weakest linkages



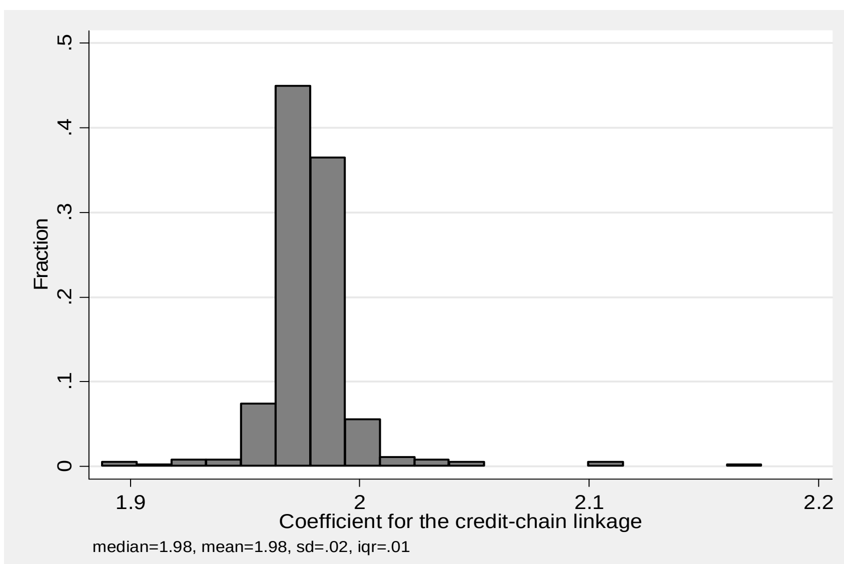
The figures in Panels A to D show the relation between the median level of Payables Financing among manufacturing firms and the correlation of real value added growth in the industry pair formed by the Iron and Steel and Fabricated Metal Product industries, the industry pair formed by the Tobacco and Footwear industries, the 20 industry pairs with stronger credit-chain linkages, and the 20 industry pairs with the weakest credit-chain linkage, respectively. Each figure reports the coefficient (coef) of an OLS regression between the measures of correlation and payables financing (plus an industry-pair fixed effect in panes C and D) for the industry pairs considered in each case. The reported standard errors and t-statistics (se and t) are clustered at the country level.

Figure 2. Distribution of main coefficient after dropping countries and industries

Panel A. Distribution of main coefficient after dropping one country at a time



Panel B. Distribution of main coefficient after dropping one industry-pair at a time



The figure in Panel A shows the distribution of the OLS coefficient of credit-chain linkage obtained after dropping one country of the sample at a time. Panel B shows a similar histogram obtained after dropping one industry-pair at a time