Trade Credit Linkages along a Supply Chain: Evidence for the Italian Textile sector

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ABSTRACT

We examine the trade credit linkages among firms within a supply chain to reckon the effect of such linkages on the propagation of liquidity shocks from downstream to upstream firms. We choose a sample appropriate for this task, consisting of a large data set of Italian firms from the textile industry, a well known example of a comprehensive manufacturing cluster featuring a large number of small and specialized firms at each level of the supply chain.

The results of the analysis indicate that the level of trade credit that firms provide to their suppliers is positively related to the level of trade credit granted to their clients: when the level of trade credit granted to clients divided by sales goes up by 1, the level of trade credit provided to suppliers divided by cost-of-goods-sold goes up by an amount that varies between 0,22 and 0,52. Since all firms along the chain are linked by trade credit relationships, an increase in the level of trade credit granted by wholesalers generates a liquidity cascade throughout the chain. We designate the overall increase in the level of trade credit among all firms in the chain as a result of a unitary impulse in the level of trade credit granted by wholesalers as the multiplier effect of trade credit for the industry chain. We estimate such multiplier to vary between 1.28 and 2.04.

We also investigate the effect of final demand on the level of trade credit sourced by firms at various levels of the chain and, in particular, whether such effect is amplified for firms further up in the chain as a result of liquidity propagation via trade credit linkages. We uncover evidence of such amplification when the links of liquidity transmission along the chain are individually modeled and estimated. An unitary increase in wholesalers' sales is found to produce an effect on trade payables among firms at the top of the chain (i.e., Preparers and Spinners) that is more than twice as big as the corresponding effect among firms at the bottom of the chain (i.e., Wholesalers).

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1. Introduction

Trade credit has long been a subject of interest to financial economists. At the theoretical level, various explanations have been offered to account for the optimal choice of trade credit made by firms. The empirical research has followed this lead, examining in detail the cross-sectional determinants of trade credit among firms.[1]

Much less attention has been given to the dynamics properties of trade credit. Yet such dynamic properties are important if as a result of external liquidity shocks, the level of trade credit taken by firms takes extended walks away from their optimal levels. That is likely to be the case at least for small firms since trade credit is likely to be their major source of external funds. Indeed, for small firms trade credit may well play the critical role of a plug variable that balances firms' cash position when hit by external liquidity shocks.

We investigate this dynamic role of trade credit by empirically analyzing a set of firms linked through an industry supply chain. At each level of the chain, firms obtain credit from their suppliers and grant credit to their clients. Such a setup allows us to measure, at each level of the chain, the degree of transmission of liquidity shocks from clients to suppliers. Moreover, since all firms along the industry chain are linked by trade credit relationships, we are able to examine how shocks are propagated all the way through the chain, and compute what one may call the "multiplier effect" of trade credit for the supply chain. The multiplier effect provides a summary indicator of the effect of trade credit linkages on the propagation of liquidity shocks.

A related issue of interest is the effect of demand for the industry's final good on the level of trade credit sourced by firms at various levels of the chain. One well known result from operations' management is the so-called bullwhip effect, which refers to the

[1] Many theories of trade credit have been proposed; a few examples are: Ferris [1981], Biais and Gollier [1997], Brennan, Maksimovic and Zechner [1988], Burkart and Ellingsen [2004] and Wilner [2000]. Among empirical contributions, some salient examples are Mian and Smith [1992], Petersen and Rajan [1997] and Burkart, Ellingsen and Giannetti [2006].

amplification of demand order variability from downstream to upstream firms.[2] In the same vein, we want to know whether a similar bullwhip effect occurs with respect to trade credit. Specifically, we seek to answer the question: Do trade credit relationships cause firms further up in the chain to experience greater variations in trade payables as a result of liquidity shocks arising from shifts in the industry's final demand?

To address these issues we collect a large sample of firms in the textile sector in Italy. The textile sector in Italy is a well known case of a large and comprehensive industry cluster, featuring all the various levels of the supply chain. At each level of the supply chain, a large number of specialized companies – typically of small size and family owned - purchase industry-specific inputs from suppliers located at the next upstream level of the chain and sell industry- specific intermediate goods to clients located at the next downstream level of the chain. Given the small size of companies and the geographic concentration of the cluster, firms tend to maintain durable business relationships with clients and suppliers, encompassing the granting of trade credit to the former and the sourcing of trade credit from the latter. These characteristics of the Italian textile cluster make it an ideal sample to study the dynamics of trade credit in a supply chain.

The empirical analysis shows that firms propagate variations in the level of trade credit granted to clients into the level of trade credit given to suppliers. Specifically, we estimate that a variation in the level of trade credit offered to clients (as a fraction of sales) equal to one yields an increase in the level of trade credit sourced from suppliers (as a fraction of cost-of-goods-sold) ranging between 0.22 and 0.52 depending on the estimation method employed. This result is consistent with Banerjee et al. [2004] who, in their study of US manufacturing firms, find evidence of a casual relationship from accounts receivable to accounts payable which is robust to various methodological specifications. Moreover, taking the perspective of the chain as a whole, we estimate that a variation of one in the level of trade credit granted by wholesalers to retailers yields a variation in the overall level of trade credit in the chain between 1.28 and 2.04. These

[2] See, for example, H.Lee, V., Padmanabhan, and S. Whang [1997].

numbers show that the cascade of trade credit relationships within a chain has the potential to generate significant seizures in liquidity throughout the chain when downstream firms delay payments to their suppliers.

As for the estimation of the bullwhip effect, we use a reduced-form and a structural-form approach too. Under the former, we regress the level of trade payables at each level of the chain on a proxy for the industry's final demand; under the latter, we model and estimate individually the sequence of effects mediating the transmission of liquidity from downstream demand to the level of trade payables at successive upstream levels of the chain. Although we fail to detect a bullwhip effect under the reduced-form estimation approach, we find it under the structural form approach. Our structural estimates indicate that an unitary increase in the level of sales made by wholesalers produces a negative effect on the level of trade payables among firms at the top of the chain (i.e., Preparers and Spinners) that is more than twice as big (in absolute value) as that felt by firms at the bottom of the chain (i.e., Wholesalers).

The rest of the paper is organized as follows. Section 2 reviews the most relevant literature; section 3 presents the sample and descriptive statistics of the data; section 4 estimates the multiplier effect of trade credit; section 5 examines the bullwhip effect; section 6 concludes.

2. Literature review

To our knowledge, no research work has been done on the role of trade credit as a mechanism of propagation of liquidity shocks along a supply chain. Among existing research, the closest we could find to this subject are contributions that model and measure the impact of trade credit on the transmission of financial distress at the aggregate level of the economy. Here we provide a brief review of such contributions.

Boissay [2006] develops a macroeconomic model of financial contagion across a network of firms linked by trade credit relationships, in which the default of one firm may cause a chain reaction of defaults throughout the network. Firms are identical ex-ante, live for one period, invest at the initial date in a project with random returns and borrow from and grant credit to each other. When faced with a negative return on the project, some firms may be unable to repay their trade payables, thereby causing a negative wealth effect to their suppliers; these, in turn, may default on the debt due to their own suppliers thus propagating the shock. Boissay [2006] calibrates the parameters of the model with US aggregate data and runs simulations to assess the overall impact of the trade credit linkage on financial distress at the level of the US economy. His results show that a significant proportion of otherwise sound firms become entangled in financial distress as a result of financial contagion, yielding a non-trivial effect on the level of GDP.

The model of Boissay [2006] draws on earlier unpublished work by Kiyotaki and Moore [1997]. These authors were the first to recognize that trade credit may propagate liquidity shocks within a network of financially constrained firms. Their model consists of a large set of small firms run by entrepreneurs who are unable to raise finance from outside investors, because they cannot precommit not to default, and because they don't have any collateral to offer by way of security. Their only source of finance is trade credit, because suppliers can withdraw firm-specific supplies in case of default. These assumptions provide a set up in which firms simultaneously borrow from suppliers of firm-specific inputs and lend to clients purchasing firm-specific inputs. As in Boissay [2006], the authors investigate how a small and temporary liquidity shocks to some firms may cause a chain reaction in financial distress, thus generating a large and persistent fall in aggregate economic activity. One key finding is that it is bilaterally efficient for creditors and debtors to postpone delinquent debt, rather liquidating the assets held by the debtor. Hence, when clients fail to pay, the best choice for the firm granting the credit is to postpone the debt until clients have enough cash to pay it back, and seek alternative liquidity by defaulting on the debt taken from their own suppliers. The upshot is that there is no diminution of the initial shock through the credit chain, because there are no liquidations to inject fresh cash. An important conclusion is that an economy with credit chains reacts more strongly and persistently to shocks than an economy in which the market for loans is anonymous on the supply side (such as in banking).

Building on the intuition of the model of Kiyotaki and Moore [1997], Giesecke and Weber [2006] propose a reduced-form contagion model to empirically measure the effects of credit contagion on the volatility of losses on large portfolios of financial positions. The analysis assumes a large network of homogeneous firms, linked by business relationships, borrowing and lending from each other in a credit chain, and facing identical exogenous liquidity risk. The local interactions between firms are modeled statistically using insights drawn from the basic voter model (see Zahle [2001]), which allows the authors to characterize the distribution of aggregate losses.

Another line of empirical research has focused on the importance of trade credit over time, as a function of monetary policy and the economic cycle. Nilsen [2002] shows that both small and large but unrated firms use greater amounts of trade credit during monetary contractions. His interpretation for such finding is that in a monetary contraction, small firms and large but unrated firms are more adversely affected by the reluctance of banks to extend credit, and thus are forced to seek alternative credit from suppliers. Related results are provided by Jaffee [1971] and Duca [1986] who uncover evidence of the redistribution hypothesis advanced by Meltzer [1960], which asserts that when access to bank credit is tight (such as in monetary contractions), more-liquid firms pass funds via trade credit to their less-liquid clients.

The review of the extant research thus confirms there is a gap on the literature concerning the dynamic properties of trade credit along supply chains. This paper aims to fill that gap.

3. Sample and empirical methodology

3.1. Data sources and characterizations of levels of supply chain

The primary financial data is from the 2007 version of Amadeus (Analyse Major Database from European Sources) database by Bureau Van Dijk, updated number 1550[3]. Several selection criteria were imposed for inclusion in the sample. First, only firms from Italy and belonging to the manufacture and wholesale of textiles are included. We follow the NACE Rev. 1.1, a 2 to 4 digit activity code developed by the European Union (codes 1700 to 1772 – manufactures of textiles – and 5141 wholesale of textiles). Amadeus database provides 3,088 manufacturing firms and 606 wholesalers.

[PLEASE insert Figure 1 here]

Figure 1 shows the textile production chain. Manufacturing firms are divided in four distinct groups: i) Finishing textiles (NACE 173), ii) Manufacture of made-up textile articles, except apparel; manufacture of other textiles; manufacture of knitted and crocheted fabrics and manufacture of knitted and crocheted hosiery (NACE 174-177), iii) Textile weaving (NACE 172), and, iv) Preparation and spinning of textile fibers (NACE 171). Therefore, firms with NACE 171 are the providers of goods to firms with NACE 172, which in turn sell their output to firms with NACE 174-177 and so on.

3.2 Sample Selection

[PLEASE insert Table 1 here]

[PLEASE insert Table 2 here]

Table 1, panel A (*wholesalers*) and Table 2 panels A to D (*Finishing of Textiles, Manufacture of textiles, Textile Weaving and Textile weaving and preparation and spinning of textile fibers*) shows the number of firms under the successive steps undertaken according to the criteria selection in eight different columns. The first column presents the total number of firms that Amadeus database provides without any

[3] For more information see www.amadeus.bvdep.com

restriction. There are 606 wholesalers firms, and 385, 1,248, 867 and 588 firms from Finishing textiles, Manufacture of textiles, Textile weaving and preparation and spinning of textile fibers, respectively. In column two, one excludes firm-year observations without any available information. With this procedure 25 percent of the firm-year observations were lost, on average. In addition, firm-year observations with blanks for: sales, creditors, debtors and cost of goods sold were eliminated (steps 3 to 6). Finally, when creditors and debtors are higher than the cost of goods sold (step 7) and sales (step 8) respectively, are excluded. Our final sample features 24,923 firm-year observations, divided into 2,053 for the *Wholesalers*, 1,653 for *Finishing Textiles*, 4,988 *Manufacture of Textiles*, 4,261 for *Textile Weaving* and 2,831 for *Preparation and Spinning of Textile Fibers*. On average, the number of firm-year observations lost is 47 percent, with a highest value of 62.2 percent (wholesalers) and lowest of 46.0 percent (textile weaving). To reduce survival bias, firms are allowed to leave and enter the dataset over time. Therefore, the sample is unbalanced as there are more observations for some firms than for others.

3.3. Descriptive statistics

[PLEASE insert Table 3 here]

In this sub-section the variables creditors over cost of goods sold and debtors over sales are presented. Table 3 reports descriptive statistics (i.e., mean, median, standard deviation, etc) by level in the supply chain and year. The results show higher average values for creditors over cost of goods sold than debtors over sales. However, if one calculates the relative magnitude of the two ratios excluding the first and last level in the supply chain, we find them to be quiet similar (e.g., 1.01, 0.99 and 1.1 for *Finishing Textile*, *Manufacture and Textile Weaving*, respectively). The number of firms in the sample steadily increases over the years. The reduction in the number of firms in 2006 is explained by the fact that at the time the data was collected some firms had not yet reported the information for 2006.

[PLEASE insert Figure 2 here]

Figure 2 plots the average creditors over cost of goods sold (thereafter COGS) and debtors over sales for different levels in the supply chain and years. The ratio debtors over sales shows a negative time trend across all levels of the chain whereas the ratio creditors over COGS shows no discernible growth pattern. As for their levels, the ratio debtors over sales is homogeneous across the various thresholds of the supply chain; in contrast, the level of the ratio creditors over COGS is significantly higher among firms from *Manufacture and Textile Weaving*. More importantly for the purpose of this paper, the ratios appear to move in a similar fashion over time for all levels of the supply chain, thus suggesting the transmission of liquidity via trade credit linkages.

[PLEASE insert Table 4 here]

Table 4 shows the correlation matrix among CGS and Sales. The cells of the matrix report correlation coefficients between CGS, at each level of the chain, and Sales at further upstream levels of the chain. The diagonal cells correspond to adjacent levels of the chain whereas off-diagonal cells corresponds to non-adjacent levels, with the distance between levels growing as we move either to the right or up in the table.

Except for *Finishing Textiles*, the correlation coefficients for adjacent levels of the chain are quite high (between 0.71 and 0.95), evidencing strong input-output linkages and thus giving us the assurance that the data is meaningfully capturing a supply chain.[4]

4. Trade credit multiplier effect

In this section we examine how trade credit propagates liquidity shocks along a supply chain. We use two approaches to estimate such effect: a firm-level approach; and chain-

[4] Given the low levels of correlation between firms from *Finishing Textiles* and firms from other thresholds of the chain , as a matter of precaution we also run the empirical analysis excluding the *Finishing Textiles* threshold (thus linking wholesalers directly to manufacturers in the supply chain). The results are qualitatively the same and thus we don't report them in the paper.

threshold level approach. At the firm level approach, we measure how the level of trade credit sourced by a firm from its upstream suppliers varies as a function of the level trade credit granted by the firm to its downstream clients; at the chain-threshold level, we investigate how the average level of trade credit sourced by firms at one level of the chain varies (over time) as a function of the average level of trade sourced by firms at the next downstream level of the chain. In either case, the presumed casual relationship is that liquidity shocks are transmitted from downstream to upstream firms, perhaps as a result of exogenous shifts in the level of the final demand faced by wholesalers.

4.1. Firm level results

The empirical analysis assumes that liquidity shocks borne by firms either originate from customers (as they postpone their payment of trade debts) or from the firm's own operating activity (i.e., reduction in operating cash-flow). A firm bearing these shocks, if liquidity constrained, is forced to propagate them to its suppliers by postponing the payment of its own trade debt.

[PLEASE insert Table 5 here]

Table 5 regresses the trade credit sourced from suppliers on the trade credit granted to customers and operating cash-flow, using firm-level observations. Variables are appropriately scaled to account for differences in size among firms. We refer to this regression equation as the *Within-Firm Liquidity Transmission Equation*, because it captures, at the firm level, the transmission of liquidity shocks from shifts in the payment patterns of customers and operating cash flow to the amount of funds borrowed from suppliers.

At every level of the chain, the level of trade credit granted to clients is shown to have a statistically and economically significant positive effect on the level of trade credit sourced from suppliers. An increase in the ratio of credit granted to clients to sales of one percentage point yields an increase in the ratio of trade sourced from suppliers to cost-of-goods-sold ranging between 0.13 percentage points among firms of level of *Finishing*

Textiles to 0.28 percentage points among wholesalers. In the pooled regression, the corresponding "average" coefficient for the entire chain is estimated to be equal to 0.22 percentage points.

These results are consistent with those of Benerjee et al. [2004] who, for a large sample of US manufacturing firms, find that the level of trade payables is negatively influenced by cash flow (i.e., Income before Extraordinary Items + Depreciation & Amortization) and positively influenced by the level of trade receivables. Both effects are highly significant.

Using the estimates from Table 5 we may compute a multiplier effect of trade credit for the supply chain. This concept corresponds to the overall increase in the level of trade debt borrowed from suppliers along the entire chain resulting from an increase in the level of trade credit granted by wholesalers to retailers of one percentage point. Using individual coefficients estimated for each level of the chain, such multiplier may be computed as

$$\mathrm{M1} = 1 + 0.28 + 0.28 \times 0.13 + 0.28 \times 0.13 \times 0.23 + 0.28 \times 0.13 \times 0.23 \times 0.23 + 0.28 \times 0.13 \times 0.23 \times 0.23 \times 0.18 = 1.33$$

If instead we use the "average" coefficient for the chain from the pooled regression, the estimated multiplier is equal to:

$$\mathrm{M2} = 1 + 0.22 + 0.22^2 + 0.22^3 + 0.22^4 + 0.22^5 = 1.28$$

Table 5 also shows that operating profits have a significant negative effect on trade credit, thus suggesting that liquidity shocks stemming from shifts in the level of operating cash flow are transmitted to suppliers via trade credit as well.

The regressions in Table 5 are based on the levels of the variables. Since the data set is the panel type, the coefficients might be capturing cross-sectional effects (i.e., effects stemming from the cross-sectional distribution of trade credit among firms) rather than the dynamic effects we are seeking to measure. To make sure that the coefficients are reflecting the time-series properties of trade credit, we run again the regressions of Table 5 using changes in the variables from their previous year rather than their levels. The results are reported in Table 6.

[PLEASE insert Table 6 here]

Table 6 shows that, at every level of the chain, a change in the level of credit granted to clients yields a strong positive change in the level of trade credit borrowed from suppliers; a change in the level of operating profits, on the other hand, is associated with a negative change in the level of trade credit. Inspection of the coefficients shows that the estimates of the multiplier effect are even bigger than those indicated by Table 5: if we compute the multiplier effect of trade credit using threshold-level regressions we obtain the estimate

M3 = 1+ 0,32 + 0,32X0,31 + 0,32X0,31X0,38 + 0,32X0,31X0,38X0,48 + 0,32X0,31X0,38X0,48X0,38 = 1.48

Alternatively, using the "average" coefficient from the pooled regression we obtain

$$M4 = 1 + 0.39 + 0.39^{2} + 0.39^{3} + 0.39^{4} + 0.39^{5} = 1.63$$

We further investigate whether the transmission of shocks along the chain depends on the access of firms to other sources of short-term liquidity such as bank debt. Firm size is likely to be a good measure of firm's access to such sources.[5]

[5] The level of cash and marketable securities, which one might consider as an alternative proxy for the firm's access to sources of short-term funds other than trade credit is an endogenous variable, chosen by the firm taking into account its ability to tap bank debt, at a reasonable cost, on a short notice; firms with high liquidity balances may actually be those that are screened out of bank financing.

To test the conjecture that access to bank debt mitigates the liquidity contagion effect of trade credit, we rank firms by size using volume of sales. At each level of the supply chain, two subgroups are selected for analysis: the bottom quartile and the upper quartile of the size distribution. Table 7 replicates the regressions of Table 5 for these two extreme size quartiles.

[PLEASE insert Table 7 here]

In general the coefficients in Table 7 are bigger (in absolute value) and more significant among small firms. The R^2 are also bigger for small firms at every level of the supply chain. The pooled regression further confirms these results. Overall we find evidence that the simple empirical model of liquidity transmission from downstream to upstream firms via trade credit is more appropriate for small firms, as conjectured.

4.2. Chain-threshold level results

An alternative approach explored in this section is to see how the average level of trade credit at one level of the chain varies as a function of (1) the average level of operating cash flow at that very same level of the chain and (2) the average level of trade credit at the next downstream level of the chain. This approach captures the chain-level equivalent to the firm-level propagation of liquidity relationship – i.e., what we refer to as the *Within-Firm Liquidity Transmission Equation* - reported in Table 5. The results are shown in Table 8.

[PLEASE insert Table 8 here]

We can see that the average level of trade credit at one level of the chain significantly impacts the average level of trade credit at the next upstream level of the chain; although the regressions for individual thresholds have only nine observations each, three out of four exhibit a significantly positive slope coefficient. The pooled regression further confirms the strong positive relationship between the average levels of trade credit at adjacent thresholds of the chain. The effect of the average operating cash-flow, however, has the predicted sign but is only marginally significant.

Taking as a reference the pooled regression, we may compute yet another estimate of the multiplier effect of trade credit as:

$$\text{M5} = 1 + 0.52 + 0.52^2 + 0.52^3 + 0.52^4 + 0.52^5 = 2.04$$

The range of estimated multipliers suggests that as the level of trade credit sourced by retailers from wholesalers goes up by one (as a fraction of CGS), the overall amount of trade credit along the chain goes up by a minimum of 1,28 to a maximum of 2,04. These numbers indicate that trade credit plays an economically significant role in the propagation of liquidity shocks within supply chains.

5. The bullwhip effect in trade credit

5.1. Structural versus reduced form estimation

Our second line of investigation gauges how a demand shock to the industry – i.e., a shock to the level of demand faced by wholesalers that ripples through the chain impacting demand at successive upstream levels of the chain – affects the amount of trade credit sourced by firms at each level of the chain. Our concern is to determine whether trade credit relationships amplify or mitigate the liquidity effects resulting from shocks to final demand. One well known result from operations is the so-called bullwhip effect, which refers to the amplification of demand order variability from downstream to upstream firms. In the same vein, we want to know whether a bullwhip effect of a similar sort occurs with respect to trade credit.

To assess empirically the effect of final demand on the level of trade payables throughout the supply chain one may either adopt a “reduced form” or a “structural form” approach. Under the former one simply regresses the amount of trade payables at each level of the chain on some proxy for final demand; the bullwhip effect, in this case, would manifest itself by a tendency of the estimated coefficients to increase as one moves further away from downstream demand.

Under a "structural form" approach, in contrast, one seeks to identify and estimate the individual equations that capture the "structural" links in the sequence of relationships that connect the level of trade credit at each level of the chain to the industry's final demand. Under this approach, one would find evidence of the bullwhip effect if the estimated coefficients from the structural equations, once suitably interacted to capture the sequence of effects mediating the initial exogenous shift in final demand and its final impact on trade payables, show an amplification of impact further up in the chain.

Of course, under suitable conditions, the reduced form and the structural approach should yield similar conclusions. However, given the limitations of our sample, the reduced form approach is likely to perform poorer in detecting the bullwhip effect. There are several reasons to think so. First, since each link of causality in the sequence of effects is itself noisy, the estimated coefficients of the reduced form will be subjected to large estimation errors due to the collective noise resulting from the long chain of causality embedded in the reduced form specification.

Second, the effects take time to propagate throughout the chain. For example, a negative shock to final demand is first felt by wholesalers, who then react by reducing orders and delaying payments to their suppliers (i.e., the finishers). The finishers, in turn, feeling the pinch from reduced orders and delayed payments from clients, transmit the negative shock to manufacturers, cutting down their orders and postponing payments. And so on until we reach the top of the chain. Hence, as we move further upstream in the chain the impact of a shift in final demand on trade credit takes longer to be felt. Moreover, since firms react and propagate stimuli at different speeds, the effect seeps in the data gradually over time thus diluting its punch.

Finally, the supply chain featured in this paper has substantial "leaks" to external trade – i.e., firms sell both to Italian and non-Italian clients and buy from Italian and non-Italian suppliers as well – which tends to attenuate the propagation of demand shocks throughout the chain among sample firms (which are all Italian). As we later show, this effect will tend to be more severe among firms further up in the chain since more leaks to external trade will tend to occur between their own sales and sales made by wholesalers.

In sum, all three arguments suggest that a reduced form approach to test the relationship between the level of trade credit sourced by firms from their suppliers and the level of final demand features an increasing downward bias in the estimated coefficients – vis-à-vis the true coefficients – as one moves upstream in the supply chain. This tendency works against the detection of the bullwhip effect, which predicts an amplification in the estimated coefficients. The estimated coefficients will thus reflect the countervailing influences of the bullwhip effect and the downward bias inherent to the estimation approach.

Table 9 reports the results from the "reduced form" approach. Panel A features the firm-level regression:

$$\text{(Trade Payables/Cost of Goods Sold)}_{\text{firm } i, \text{ level } k, \text{ year } t} = \alpha + \beta_1 \text{ Average Sales of Wholesalers}_{\text{year } t} + \beta_2 \, k \text{ Average Sales of Wholesalers}_{\text{year } t} + u \quad (1)$$

[PLEASE insert Table 9, panel A here]

whereas panel B reports the corresponding chain-level regression:

$$\text{Average Trade Payables}_{\text{level } k, \text{ year } t} = \alpha + \beta_1 \text{ Average Sales of Wholesalers}_{\text{year } t} + \beta_2 \, k \text{ Average Sales of Wholesalers}_{\text{year } t} + u \quad (2)$$

[PLEASE insert Table 9, panel B here]

In this specification, k is an integer variable measuring the distance between the firm and the level of demand faced by wholesalers. The variables "Average Sales of Wholesalers" and "Average Trade Payables" are indexed to mitigate scale effects, taking a value equal to 100 in the year 2000.

The evidence from both panels is consistent with a negative effect of final demand on trade credit sourced by firms from suppliers, that is attenuated as we move upstream in the supply chain. For firms furthest upstream in the chain (code 171, *Preparation and spinning*), the effect of final demand on trade credit is indistinguishable from zero. We interpret this result as evidence that the attenuation bias induced by the "reduced form" approach dominates the bullwhip effect. As we will see next, the evidence gathered from the "structural" equation approach supports such interpretation.

5.2. The structural equation approach

To carry out a structural estimation of the bullwhip effect one has first to identify the chain of structural relationships linking the final demand faced by wholesalers to the level of trade credit sourced from suppliers at each level of the chain. Figure 3 represents the various channels through which final demand impacts on trade credit. In this representation, final demand impacts the level of trade credit sourced by firm i, located at level K of the chain, through two distinct channels:

[PLEASE insert Figure 3, here]

1. Demand channel

A shift in the final demand (k=0) impacts the demand faced by firms in level k=1 of the supply chain, which in turn impacts de demand faced by firms in level k=2 of the chain, and so on, until it hits the demand faced by firms in the level K; the shift in demand experienced by level-K firms is then transmitted to the operating cash flow of firm i (and to all other firms at level K); finally, firm i accelerates or delays payments to suppliers in response to the variation in its operating cash flow.

2. Trade credit channel

Firms make a further adjustment to the level of trade credit sourced from suppliers in response to shifts in the payment patterns of clients arising from the demand channel.

To model the two channels of influence of final demand on trade credit, we consider the following set of structural equations:

Output- Imput Demand Transmission Equation

Demand faced by firms (level k, year t) = a_0+b_0* Demand faced by firms (level k-1, year t) (3)

Demand - Operating Cash Flow Transmission Equation

Operating Cash Flow of firm i (level k, period t) = a_1+b_1* Demand faced by firms (level k, year t) (4)

Within-Firm Liquidity Transmission Equation

Trade Credit sourced from suppliers by firm i (level k, year t) = a_2 + b_2*Trade Credit granted to clients by firm i (level k,year t) + c_2*Operating Cash Flow of firm i (level k,year t) (5)

The first two equations pertain solely to the demand channel. The last equation captures the last link of causality in the demand channel (i.e., the effect of operating cash flow on trade payables) and the trade credit channel.

To fit equations (3) and (4) we need a proxy for the level of demand faced by firms at level k of the chain, in sample year t. Two possible proxies are the "average level of sales among firms of level k, in year t" and the "average level of Cost of Goods Sold among firms in level k-1 (i.e., firms at the next downstream level of the chain), in year t". We report results based on Sales although they don't change if we use Cost of Goods Sold instead. To measure Operating Cash Flow in equation (4) we use, as we did in the previous section, firms' EBITDA. Equation (5) has already been fitted in the previous section (see Table 5 for firm-level results and Table 8 for chain-level results).

[PLEASE insert Figure 4, Panel A here]

Because firms only report their total sales and purchases (i.e., they don't discriminate the foreign and domestic components of their sales and purchases), the estimation of the *Output-Imput Demand Transmission* equation will tend to underestimate the propagation of demand shocks across successive layers of the chain. To see this, consider the following numerical example. Suppose that every firm in the sample sells 50% of its output to foreign clients and buys 10% of its inputs from foreign suppliers. Additionally, suppose that final demand (represented by the total sales made by wholesalers) is initially equal to 100 monetary units and that one monetary unit of inputs is required to produce (and sell) one monetary unit of output at each level of the chain (in other words, firms make zero profits and purchase solely industry-specific variable inputs).[6] Panel A of Figure 4 depicts the flows of domestic and foreign sales and domestic and foreign purchases throughout the chain under this numerical example.

[PLEASE insert Figure 4, Panel B here]

Now consider what happens to the flows of sales and purchases throughout the chain as final demand (measured by total sales of wholesalers) goes up by one unit (1%). The outcome is reported in Panel B of Figure 4. Comparing Panel A and Panel B of Table 4, one may compute the absolute and relative variations in total sales and total purchases experienced by firms at each level of the chain. The results are reported in Table 10.

[PLEASE insert Table 10, here]

If one would fit the *Output-Imput Demand Transmission equation* using "Total Sales" or "Total Sales per Firm" at each level of the chain as a proxy for chain-level demand, it would estimate a slope coefficient of less than 1. Specifically, it would estimate a coefficient of 0,9 if the regression was run in monetary units and 0,5 if it was run in percentage units. Similar results would obtain under either the "Total Cost of Goods

[6] Results don't change qualitatively if firms make positive profits and use general imputs in addition to industry-specific imputs.

Sold" proxy or the "Total Cost of Goods Sold per Firm" proxy.[7]This example shows that the downward bias in the estimated coefficients is proportional to the imports-total purchases ratio if the regression is run in monetary units and proportional to the exports-total sales ratio if it's run in percentage units.

The estimated coefficients resulting from fitting such regression to our sample bear out this conjecture. Table 11 reports results from estimating the *Output-Imput Demand Transmission equation* with the variable "Average Sales of firms from level k in year t" proxying for "Demand faced by firms from level k in year t". Variables are indexed - taking the value 100 in year 2000 – to run the regression in percentage units. To capture chain-threshold fixed effect, the estimation is run with intersect dummies for the various levels of the chain.

[PLEASE insert Table 11 here]

The estimated slope coefficient in Table 11 is 0.69, providing evidence of a substantial "leakage" of sales within the chain to foreign clients. This is consistent with data from the Italian National Association of Textile and Clothing Industry (*Sistema Moda Italia, SMI*), which reports high export-to-sales ratios for the industry as a whole and across all levels of the supply chain. Table 12 provides data for 2006 gathered from scattered publications of the SMI.

[PLEASE insert Table 12 here]

If one assumes a conservative ratio of exports to total sales of 40% at each level of the chain, then a rough estimate of the true coefficient of demand propagation across consecutive levels of the supply chain is (1/0.6)*0.69 = 1.15. A coefficient greater than one is consistent with the standard bullwhip effect reported in the operations'

[7] As far as the Demand-Operating Cash Flow Transmission equation is considered, its estimated coefficient will only biased downward if the regression is based on Cost of Goods Sold. If one uses Sales (or average Sales) no external trade-induced bias should occur.

management literature, which posits an amplification of demand shocks along a supply chain .[8] In the rest of the paper, we designate this value as the “external trade-adjusted” estimated coefficient of demand propagation.

[PLEASE insert Table 13, Panel A here]

[PLEASE insert Table 13, Panel B here]

Table 13 reports results from fitting the *Demand - Operating Cash Flow Transmission Equation*. In Panel A we present firm-level regressions of EBITDA –scaled by the firm’s total assets – on average firm Sales in the corresponding level of the chain. The latter variable is indexed, taking the value 100 in year 2000. Panel B contains chain-level regressions of average firm EBITDA on average firm Sales. Both variables are indexed, taking the value 100 in year 2000.

The results show that at each level of the chain aggregate sales have a significantly positive impact on firms’ operating flow, as expected.

The last missing link the “structural” approach is the *Within-Firm Liquidity Transmission Equation*. However, this equation has already been estimated in section 3 of the paper – see Table 5 for firm-level results and Table 8 for chain-level results - when we were seeking to pin down the multiplier effect of trade credit.

We may now bring together the separate pieces, interacting the three structural equations to gauge the impact of final demand – i.e., the demand faced by wholesalers – on the level of trade credit sourced from suppliers at each level of the chain. We evaluate such impact using both the firm-level approach and the chain-level approach explained before, relying whenever possible on the estimated coefficients from pooled regressions.

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[8] Evidence of amplification of demand variability along a supply chain has been found for the automobile industry (Blanchard, [1983]), the machine tool industry (Anderson et al., [2000]) and the semiconductor industry (Terwiesch at al., [2005]).

The firm-level approach, however, requires one more assumption to be operative. The *Within Firm Liquidity Transmission Equation* posits that the level of trade credit sourced by an individual firm from its suppliers depends on the level of trade credit granted by the firm to its customers (i.e., the so-called Trade Debit). To capture the interconnection of trade credit along the supply chain we need to establish the linkage between the trade credit granted to customers by individual firms at one level of the chain and the trade credit sourced from suppliers by individual firms at the next downstream level of the chain. One simple assumption is that

$$\text{Trade Debit/Sales}_{\text{firm i,level k}} = a_k + \text{TradeCredit/COGS}_{\text{firm j, level k-1}} + u \qquad (6)$$

where i an j are two randomly selected firms from adjacent levels of the chain (k and k-1) and u is a random variable with an expected value equal to zero.

Under this assumption, an increase of one unit in the ratio TradeCredit/CGS of a randomly selected firm from level k-1 of the chain produces, on average, an increment of one unit on the ratio Trade Debit/Sales of a randomly selected firm form level k of the chain (i.e., the next upstream level of the chain).[9]

[PLEASE insert Table 14, here]

Table 14 summarizes the overall effect of an unitary increase in the aggregate sales of wholesalers on the level of trade payables at successive upstream levels of the chain. Panel A reports results using the firm-level estimation approach whereas Panel B reports results under the chain-level approach.

---

[9] Notice that such an assumption is not required under the chain-level estimation approach since, by definition, the aggregate amount of trade credit granted to customers by firms at one level of the chain ought to be equal to the aggregate amount of trade credit sourced from suppliers by firms at the next downstream level of the chain.

The last column in either panel – labeled Total Impact – adds up the direct impact arising from the demand channel:

final demand→level-k demand→level-k operating cash flow→level-k trade payables (7)

with the indirect impact arising from the upstream propagation of liquidity shocks via the trade credit channel, i.e.:

level-k-1 trade payables→level-k trade payables (8)

In either case we see evidence of a bullwhip effect, with firms further upstream in the chain experiencing greater reductions in trade payables (as a fraction of CGS). The effect is also economically significant: a unitary increase in wholesalers' sales produces an effect on the trade payables of firms at the top of the chain (i.e., Preparers and Spinners) that is more than twice as big as the corresponding effect on firms at the bottom of the chain (i.e., Wholesalers).

The intuition for this result is simple. An increase in the demand for the industry's final good raises the demand for all intermediate goods. As sales at all levels of the chain go up, operating cash flow goes up as well thus generating extra liquidity which firms use to reduce their trade payables to suppliers. This is the direct effect. Firms, however, further reduce the credit sourced from suppliers as their customers cut down their own demand for credit. This is the indirect effect. Hence, if the direct effect hits all firms along the chain in a similar fashion, the indirect effect guarantees that firms further up in the chain undergo a greater contraction in trade payables. That means we could reduce the "external trade-adjusted" coefficient of demand propagation from 1,15 to 1 and still find evidence of a bullwhip effect, which provides some comfort as to the robustness of the result.

6. Conclusions

To the best of our knowledge, this is the first paper that examines the trade credit linkages among firms within a supply chain and reckons the effect of such linkages on the propagation of liquidity shocks from downstream to upstream firms. We chose a sample appropriate for this task, consisting of a large data set of Italian firms from the textile industry, a well known example of a comprehensive manufacturing cluster featuring a large number of small and specialized firms at each level of the manufacturing process.

The results of the analysis indicate that the level of trade credit that firms provide to their suppliers is positively related to the level of trade credit granted to their clients: when the level of trade credit granted to clients divided by sales goes up by 1, the level of trade credit provided to suppliers divided by cost-of-goods-sold goes up by an amount that varies between 0.22 and 0.52. Since all firms along the chain are linked by trade credit relationships, an increase in the level of trade credit granted by wholesalers generates a liquidity cascade throughout the chain. We designate the overall increase in the level of trade credit among all firms in the chain as a result of a unitary impulse in the level of trade credit granted by wholesales as the multiplier effect of trade credit for the industry chain. We estimate such multiplier to vary between 1.28 and 2.04.

We further investigate how shocks to the industry's final demand impact on the amount of trade credit sourced by firms at various levels of the chain. Specifically, we examine whether a bullwhip effect occurs such that firms further up in the chain see wider swings in trade payables than their downstream counterparts. Although we fail to detect such an effect using a reduced-form estimation approach, under a structural-equation approach in which the links of liquidity transmission along the chain are modeled and individually estimated we find evidence of it in the data. Our structural estimates indicate that the effect of a unitary increase in wholesalers' sales on the trade payables of firms at the top of the chain (i.e., Preparers and Spinners) is more than twice as big as the corresponding effect on firms at the bottom of the chain (i.e., Wholesalers).

Directions for future empirical research are at two levels: 1) split the data over different Italian regions given it is more likely to find and examine the trade credit linkages within a supply chain to consider the effect of such linkages on the propagation of liquidity shocks from downstream to upstream firms. Specially the North of Italy (Emilia-Romagna, Lombardia, Trentino-Alto Adige, Friuli, Liguria, Piemonte and Veneto) where more than 70 percent of textile firms are located. It this procedure more accurate results could be obtained. 2) Exclude from the supply chain analysis the *Finishing Textiles* level for two main reasons: a) it is the level with the lowest number of firms in the sample, which can induce that other firms in different levels over the supply chain could already include this "service", b) as it can be seen from the correlation matrix is the level with lowest relationship with the upstream and downstream levels of the supply chain. With this procedure is it expected the results to be more robust.

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Figure 1: Textile Production Chain

171 Preparation and spinning of textile fibres

↑

172 Textile weaving

↑

174 Manufacture of made-up textile articles, except apparel;
175 Manufacture of other textiles;
176 Manufacture of knitted and crocheted fabrics
177 Manufacture of knitted and crocheted hosiery

↑

173 Finishing Textiles

↑

5141 Wholesale of Textiles

Table 1: Number of firm year observations by Year

The panel data set is unbalanced as there are more observations for some firms than for others. The table shows the number of observations by year and steps

Wholesales of Textiles

Steps	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Years								
1998	606	332	330	194	194	188	181	180
1999	606	356	356	196	195	187	178	178
2000	606	399	397	213	209	201	196	196
2001	606	411	409	217	215	204	199	197
2002	606	480	476	234	230	219	214	211
2003	606	495	489	275	271	259	246	243
2004	606	552	550	242	241	229	223	221
2005	606	562	555	476	472	451	432	431
2006	606	280	280	219	215	204	196	196
All	5454	3867	3842	2266	2242	2142	2065	2053

Table 2: Manufacture of Textiles

The panel data set is unbalanced as there are more observations for some firms than for others. The table shows the number of observations by year and steps

Panel A: Finishing textiles (NACE 173)

Steps Years	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1998	385	239	237	171	171	170	170	169
1999	385	258	255	173	173	171	168	167
2000	385	281	279	183	178	176	172	171
2001	385	286	284	184	179	179	174	174
2002	385	322	320	192	192	191	187	187
2003	385	325	323	217	216	216	200	200
2004	385	360	359	192	191	190	179	178
2005	385	364	364	314	312	310	293	290
2006	385	161	161	118	118	118	117	117
All	3,465	2,596	2,582	1,744	1,730	1,721	1,660	1,653

Panel B: Manufacture of made-up textile articles, except apparel; manufacture of other textiles; manufacture of knitted and crocheted fabrics manufacture of knitted and crocheted hosiery (NACE 174-177)

Steps Years	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1998	1,248	713	703	476	474	466	457	457
1999	1,248	779	775	522	519	514	502	502
2000	1,248	840	835	521	518	513	504	504
2001	1,248	873	868	529	526	521	511	510
2002	1,248	1030	1023	582	575	567	551	545
2003	1,248	1043	1038	640	630	623	583	579
2004	1,248	1151	1146	604	600	594	571	566
2005	1,248	1149	1146	991	983	973	924	917
2006	1,248	519	519	425	421	417	409	408
All	11232	8097	8053	5290	5246	5188	5012	4988

Panel C: Textile weaving (NACE 172)

Steps	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Years								
1998	867	608	606	452	450	446	432	431
1999	867	660	658	487	483	480	461	461
2000	867	697	696	475	466	459	445	445
2001	867	704	702	486	483	479	471	471
2002	867	762	761	500	497	495	485	484
2003	867	774	772	542	541	539	502	501
2004	867	813	810	489	489	488	478	478
2005	867	820	820	745	745	738	706	706
2006	867	374	374	297	297	292	285	284
All	7,803	6,212	6,199	4,473	4,451	4,416	4,265	4,261

Panel D: Preparation and spinning of textile fibres (NACE 171)

Steps	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Years								
1998	588	411	407	315	313	308	302	302
1999	588	439	438	323	321	318	310	309
2000	588	461	457	312	309	305	301	301
2001	588	475	473	324	317	311	307	306
2002	588	511	507	327	321	315	311	308
2003	588	516	515	370	365	358	337	337
2004	588	546	543	336	334	328	319	319
2005	588	543	542	489	483	474	445	444
2006	588	269	269	214	209	209	206	205
All	5,292	4,171	4,151	3,010	2,972	2,926	2,838	2,831

Table 3: Statistical Analysis

The table presents the mean, median, standard deviation, maximum and minimum by level in the supply chain (*wholesalers, Finishing Textiles, Manufacture of Textiles, Textile Weaving and Preparation and Spinning of Textile Fibres*)

		Creditors / Cost of Goods Sold						Debtors / Sales					
Wholesalers	Years	Nr Firms	Mean	Median	Std Dev	Max	Min	Nr Firms	Mean	Median	Std Dev	Max	Min
	1998	180	0.347	0.328	0.190	0.880	0.014	180	0.293	0.291	0.146	0.973	0.004
	1999	178	0.375	0.362	0.192	0.892	0.010	178	0.317	0.323	0.154	0.920	0.003
	2000	196	0.391	0.361	0.203	0.938	0.013	196	0.319	0.318	0.155	0.915	0.003
	2001	197	0.372	0.340	0.207	0.995	0.014	197	0.313	0.307	0.156	0.937	0.002
	2002	211	0.334	0.310	0.199	0.942	0.014	211	0.314	0.310	0.158	0.984	0.005
	2003	243	0.375	0.364	0.209	0.990	0.001	243	0.327	0.324	0.170	0.991	0.006
	2004	221	0.341	0312	0.201	0.969	0.003	221	0.314	0.309	0.159	0.956	0.000
	2005	431	0.361	0.338	0.199	0.997	0.002	431	0.314	0.307	0.172	0.954	0.000
	2006	196	0.339	0.321	0.182	0.905	0.011	196	0.325	0.340	0.150	0.821	0.002

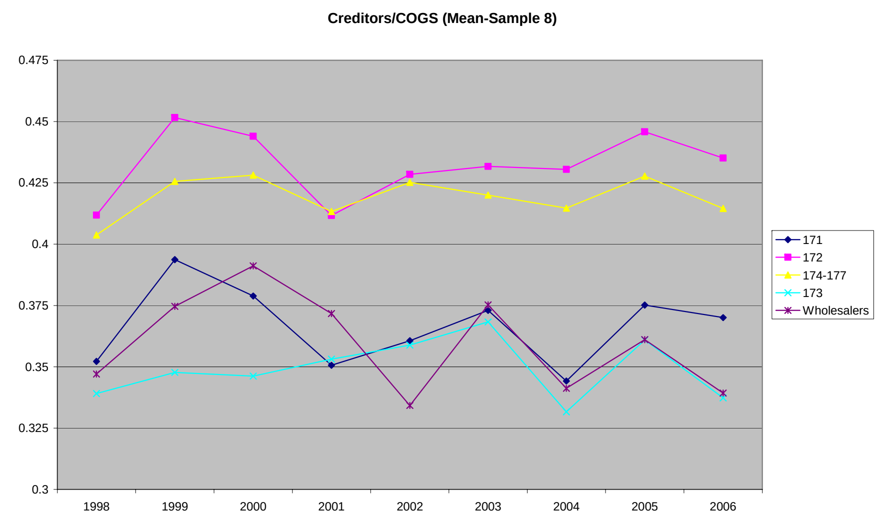
NACE	Years	Nr Firms	Mean	Median	Std Dev	Max	Min	Nr Firms	Mean	Median	Std Dev	Max	Min
Finishing Textiles	1998	169	0.339	0.314	0.152	0.917	0.098	169	0.296	0.307	0.136	0.657	0.008
	1999	167	0.348	0.321	0.155	0.910	0.055	167	0.310	0.323	0.146	0.773	0.008
	2000	171	0.346	0.321	0.148	0.917	0.066	171	0.319	0.337	0.135	0.643	0.002
	2001	174	0.353	0.322	0.154	0.950	0.045	174	0.315	0.340	0.141	0.922	0.001
	2002	187	0.359	0.331	0.175	0.990	0.040	187	0.320	0.337	0.153	0.966	0.000
	2003	200	0.368	0.316	0.194	0.996	0.041	200	0.310	0.318	0.140	0.709	0.001
	2004	178	0.332	0.299	0.157	0.963	0.059	178	0.329	0.348	0.138	0.722	0.002
	2005	290	0.361	0.321	0.172	0.972	0.049	290	0.331	0.333	0.140	0.833	0.001
	2006	117	0.337	0.305	0.152	0.836	0.112	117	0.365	0.364	0.157	0.863	0.002

		Creditors / Cost of Goods Sold						Debtors / Sales					
Manufacture of Textiles	Years	Nr Firms	Mean	Median	Std Dev	Max	Min	Nr Firms	Mean	Median	Std Dev	Max	Min
	1998	457	0.404	0.381	0.176	0.936	0.031	457	0.299	0.290	0.141	0.859	0.005
	1999	502	0.426	0.405	0.173	0.957	0.033	502	0.316	0.309	0.144	0.798	0.002
	2000	504	0.428	0.408	0.172	0.982	0.008	504	0.318	0.312	0.144	0.857	0.000
	2001	510	0.413	0.397	0.177	0.986	0.034	510	0.315	0.300	0.157	0.958	0.003
	2002	545	0.425	0.400	0.188	0.999	0.037	545	0.324	0.305	0.158	0.983	0.001
	2003	579	0.420	0.391	0.186	0.995	0.012	579	0.329	0.313	0.160	0.942	0.003
	2004	566	0.415	0.383	0.195	0.993	0.024	566	0.337	0.329	0.161	0.968	0.002
	2005	917	0.428	0.399	0.198	0.999	0.014	917	0.346	0.331	0.165	0.989	0.001
	2006	408	0.415	0.381	0.198	0.993	0.016	408	0.340	0.329	0.159	0.899	0.003

Textile Weaving	Years	Nr Firms	Mean	Median	Std Dev	Max	Min	Nr Firms	Mean	Median	Std Dev	Max	Min
	1998	431	0.412	0.401	0.186	0.990	0.012	431	0.294	0.287	0.124	0.881	0.000
	1999	461	0.452	0.442	0.190	0.971	0.017	461	0.315	0.306	0.133	0.871	0.001
	2000	445	0.444	0.435	0.183	0.965	0.024	445	0.313	0.307	0.124	0.841	0.000
	2001	471	0.412	0.393	0.181	0.952	0.006	471	0.293	0.288	0.126	0.762	0.000
	2002	484	0.429	0.407	0.190	0.982	0.025	484	0.307	0.295	0.129	0.849	0.001
	2003	501	0.432	0.410	0.199	0.989	0.015	501	0.317	0.312	0.127	0.915	0.001
	2004	478	0.431	0.408	0.194	1.000	0.011	478	0.324	0.321	0.130	0.841	0.002
	2005	706	0.446	0.422	0.205	0.997	0.016	706	0.334	0.321	0.152	0.974	0.000
	2006	284	0.435	0.417	0.203	0.994	0.007	284	0.330	0.330	0.146	0.885	0.004

		Creditors / Cost of Goods Sold						Debtors / Sales					
Preparation and Spinning	Years	Nr Firms	Mean	Median	Std Dev	Max	Min	Nr Firms	Mean	Median	Std Dev	Max	Min
of Textile fibres	1998	302	0.352	0.330	0.179	0.963	0.034	302	0.278	0.277	0.137	0.691	0.001
	1999	309	0.394	0.358	0.197	0.964	0.000	309	0.310	0.309	0.148	0.854	0.001
	2000	301	0.379	0.349	0.186	0.997	0.062	301	0.309	0.307	0.146	0.919	0.001
	2001	306	0.351	0.335	0.165	0.949	0.059	306	0.295	0.287	0.140	0.891	0.001
	2002	308	0.361	0.332	0.168	0.979	0.021	308	0.303	0.306	0.132	0.780	0.001
	2003	337	0.373	0.336	0.195	0.970	0.049	337	0.314	0.310	0.153	0.999	0.000
	2004	319	0.344	0.335	0.164	0.909	0.041	319	0.326	0.328	0.145	0.846	0.000
	2005	444	0.375	0.347	0.192	0.954	0.011	444	0.338	0.335	0.162	0.997	0.001
	2006	205	0.370	0.339	0.186	0.996	0.030	205	0.332	0.318	0.154	0.878	0.001

Figure 2


Creditors/COGS (Mean-Sample 8)
0.475
0.45
0.425
0.4
0.375
0.35
0.325
0.3
1998
1999
2000
2001
2002
2003
2004
2005
2006
171
172
174-177
173
Wholesalers

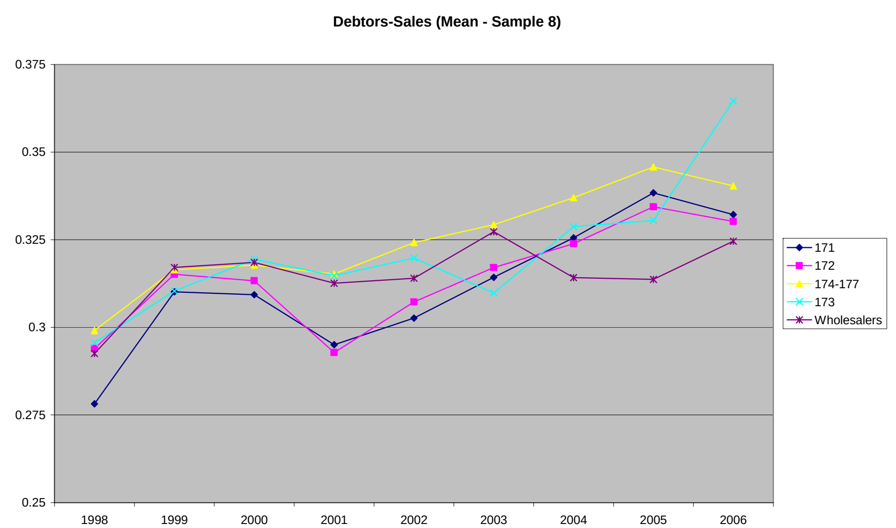

Debtors-Sales (Mean - Sample 8)
0.375
0.35
0.325
0.3
0.275
0.25
1998
1999
2000
2001
2002
2003
2004
2005
2006
171
172
174-177
173
Wholesalers

Table 4: Correlation Matrix

The table shows the correlation coefficients between Cost-of-Goods-Sold, at each level of the chain, and Sales at further upstream levels of the chain. The diagonal cells correspond to adjacent levels of the chain whereas the off-diagonal cells correspond to non-adjacent levels of the chain.

SALES *COGS*	Finishing Textiles	Manufacture of Textiles	Textile Weaving	Preparation and spinning of textile fibres
Wholesalers	0.3834	0.7159	0.7666	0.7794
Finishing Textiles		0.3008	0.2693	0.5950
Manufacture of Textiles			0.9505	0.6901
Textile Weaving				0.8016

Table 5: Within-Firm Liquidity Transmission Equation (variables levels)

This table regresses trade credit sourced from suppliers on the trade credit granted to customers and with the operating cash-flow, using firm-level observations.
The model is written as:

$(\text{Trade Credit/CGS})_{it} = \alpha + \beta_1(\text{Trade Debit/Sales})_{it} + \beta_2 (\text{EBITDA/Total Assets})_{it} + u_{it}$

Regressions by level of supply chain

	A	**β_1**	**β_2**	**N**	**Adj. R^2**
Wholesalers	0,29	0,28	-0,3	2,053	7%
	(26)	(9,2)	(-5,2)		
Finishing Textiles	0,3	0,13	0,02	1,653	2%
	(27)	(4,7)	(0,5)		
Manufacture of Textiles	0,37	0,23	-0,24	4,988	6%
	(53)	(13,5)	(-8,2)		
Textile Weaving	0,38	0,23	-0,23	4,261	4%
	(41,7)	(10)	(-5,4)		
Preparation and Spinning of Textile Fibres	0,34	0,18	-0,35	2,831	5%
	(33)	(6,9)	(-8,1)		

t-statistics in parentheses

Pooled regression (all firms, with intersect dummies for the various levels of the supply chain; dummy coefficients not reported)

	A	β_1	β_2	N	Adj. R^2
All Firms		0,22 (20,7)	-0,22 (-11,5)	15,786	8%

t-statistics in parentheses

Table 6: Within-Firm Liquidity Transmission Equation (variables changes)

This table regresses for every level of the chain, the change in the level of credit granted to clients in the level of trade credit borrowed from suppliers.

The Model is written as:

$$(\text{Trade Credit/CGS})_{it} - (\text{Trade Credit/CGS})_{i\ t-1} = \alpha + \beta_1 [(\text{Trade Debit/Sales})_{it} - (\text{Trade Debit/Sales})_{i\ t-1}] + \beta_2 [(\text{EBITDA/Total Assets})_{it} - (\text{EBITDA/Total Assets})_{i\ t-1}] + u_{it}$$

Regressions by level of supply chain

	α	β_1	β_2	N	Adj. R^2
Wholesalers	-0.00 (-1.07)	0.32 (5.66)	-0.10 (-1.36)	1,387	7%
Finishing Textiles	-0.00 (-0.21)	0.31 (5.65)	0.16 (1.57)	1,222	7%
Manufacture of Textiles	-0.00 (-2.61)	0.38 (12.38)	-0.12 (-3.22)	3,640	9%
Textile Weaving	-0.00 (-0.26)	0.48 (12.83)	-0.07 (-1.35)	3,241	12%
Preparation and Spinning of Textile Fibres	-0.00 (-1.28)	0.38 (7.09)	-0.19 (-3.98)	2,152	9%

t-statistics in parentheses

Pooled regression (all firms, with intersect dummies for the various levels of the supply chain; dummy coefficients not reported)

	A	**B_1**	**β_2**	**N**	**Adj. R^2**
All Firms	-0.00 (-0.93)	0.39 (19.75)	-0.08 (-2.65)	11,642	9%

t-statistics in parentheses

Table 7: Liquidity Contagion Effect of Trade Credit (Quartiles)

This table tests whether the access to bank debt mitigates the liquidity contagion effect of trade credit. Firms are ranked using the volume of sales.

The model is written as
$(\text{Trade Credit/CGS})_{it} = \alpha + \beta_1 (\text{Trade Debit/Sales})_{it} + \beta_2 (\text{EBITDA/Total Assets})_{it} + u_{it}$

Regressions by level of supply chain

	α	**β_1**	**β_2**	**N**	**Adj. R^2**
Wholesalers					
top quartile of sales	0,26 (11,9)	0,23 (3,8)	-0,22 (-3,3)	513	5%
bottom quartile of sales	0,32 (19,2)	0,25 (4,7)	0,18 (-2,1)	513	6%
Finishing Textiles					
top quartile of sales	0,29 (11,1)	0,14 (2,7)	0,14 (1,2)	413	1,4%
bottom quartile of sales	0,28 (12,9)	0,27 (4,3)	0,03 (0,5)	413	4,5%
Manufacture of Textiles					
top quartile of sales	0,35 (25)	0,21 (6,4)	-0,25 (-4,8)	1,247	6,2%
bottom quartile of sales	0,38 (28,9)	0,24 (6,9)	-0,32 (-7,3)	1,247	7,6%

Textile Weaving top quartile of sales					
	0,35	0,15	-0,08	1,066	1,1%
	(18,2)	(2,9)	(-1,2)		
bottom quartile of sales	0,38	0,29	-0,23	1,066	6%
	(24,9)	(7,1)	(-3,7)		
Preparation and Spinning of Textile Fibres	0,27	0,16	0,004	708	1,6%
top quartile of sales	(13,5)	(3,1)	(0,04)		
bottom quartile of sales	0,36	0,17	-0,38	708	6,6%
	(19,6)	(3,6)	(-4,8)		

t-statistics in parentheses

Pooled regression (all firms, with intersect dummies for the various levels of the supply chain; dummy coefficients not reported)

	α	**β_1**	**β_2**	**N**	**Adj. R^2**
Top quartile of sales	0,27	0,19	-0,12	3949	6%
	(27,7)	(8,8)	(-3,0)		
Bottom quartile of sales	0,33	0,25	-0,23	3946	8,5%
	(33,6)	(12,1)	(-8,5)		

t-statistics in parentheses

Table 8: Chain-threshold level Results

This table captures how the average level of trade credit at one level of the chain varies with the average level of trade credit at the next downstream level of the chain

The model is written as:
$(\text{Average Trade Credit/CGS})_{\text{level } k,t} = a + \beta_1(\text{average Trade Credit/CGS})_{\text{level } k+1,t} + \beta_2 (\text{EBITDA/Total Assets})_{\text{level } k,t} + u_{it}$

Regressions by level of supply chain

	A	β_1	β_2	N	Adj R^2
k= Finishing Textiles	0.27	0.25	-0.000	9	23.6%
k+1= Wholesalers	(2.98)	(0.97)	(-1.36)		
k= Manufacture Textiles	0.30	0.35	-0.000	9	25.8%
k+1= Finishing Textiles	(4.58)	(1.82)	(-0.03)		
k= Textile Weaving	-0.12	1.36	-0.000	9	60.5%
k+1= Manufacture Textile	(-0.96)	(4.57)	(-1.16)		
k= Preparation and Spinning if Textile Fibres	-0.092	1.02	0.000	9	64.8%
	(-1.21)	(6.77)	(1.44)		
k+1 = Textile Weaving					

t-statistics in parentheses

Pooled regression (all levels, with intersect dummies for the various levels of the supply chain; dummy coefficients not reported)

	α	β_1	β_2	N	Adj R^2
All levels	0,17	0,52	-0.0001	36	93%
	(1,95)	(3,04)	(-1.71)		

t-statistics in parentheses

Table 9 - Reduced form estimation of the bullwhip effect of trade credit

Panel A: Firm Level Approach

$(\text{Trade Payables/Cost of Goods Sold})_{\text{firm } i, \text{ level } k, \text{ year } t} = \alpha + \beta_1$ Average Sales of $\text{Wholesalers}_{\text{year } t} + \beta_2$ k Average Sales of $\text{Wholesalers}_{\text{year } t} + u$

	A	β_1	β_2	N	Adj R^2
Trade Credit	0.464 (14.221)	-0.149 (-4.221)	0.030 (17.22)	12,955	2.38%

t-statistics in parentheses

Panel B: Chain-Level Approach

Average Trade $\text{Payables}_{\text{level } k, \text{ year } t} =$

$\alpha + \beta_1$ Average Sales of $\text{Wholesalers}_{\text{year } t} + \beta_2$ k Average Sales of $\text{Wholesalers}_{\text{year } t} + u$

	A	β_1	β_2	N	Adj R^2
Trade Credit	0.413 (3.73)	-0.060 (-0.51)	0.010 (2.67)	45	14.00%

t-statistics in parentheses

Figure 3 – Impact of Final Demand on Trade Credit Sourced by Firms from Suppliers at Each Level of the Supply Chain

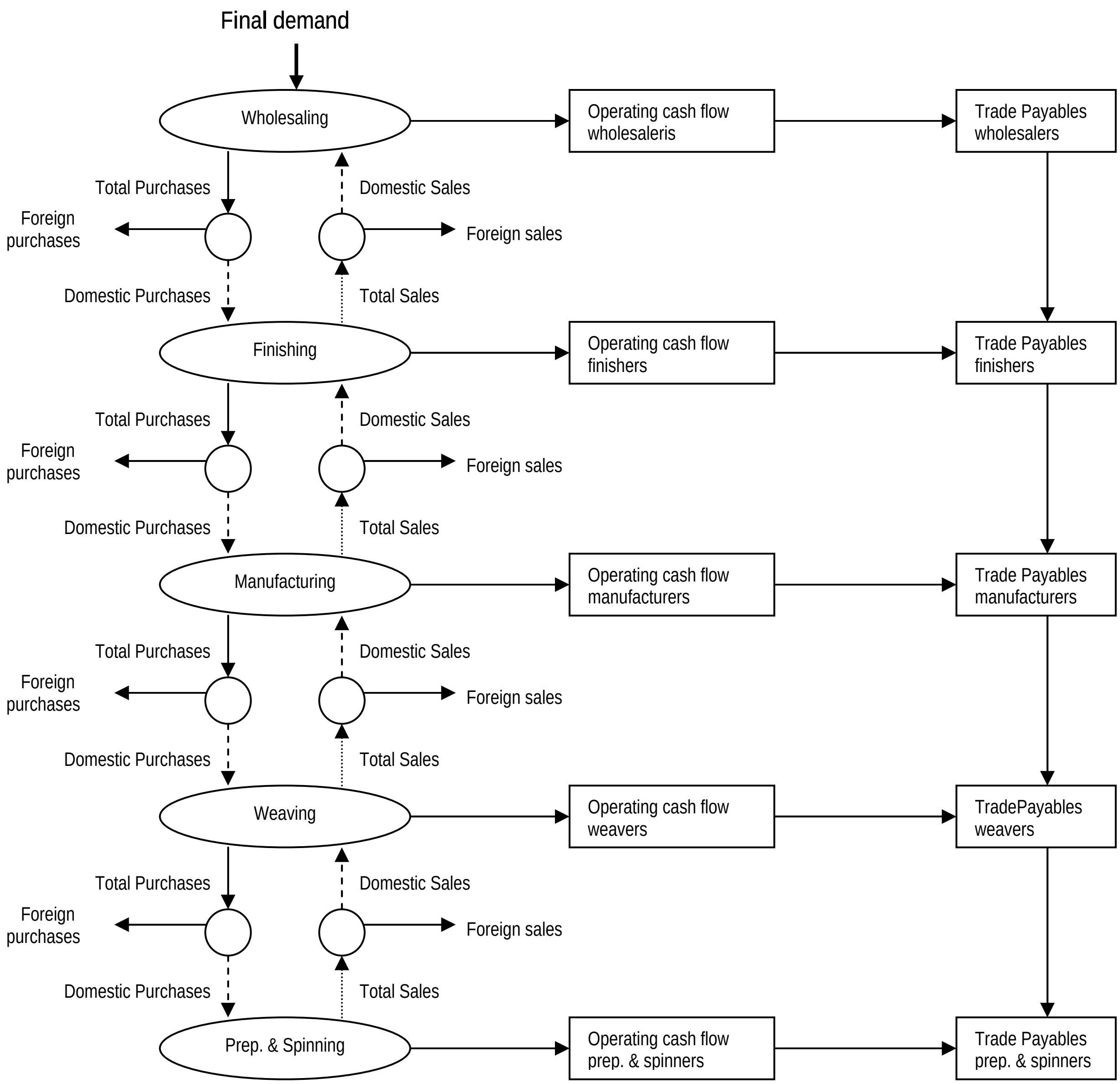


Figure 4 - Numerical Example of External Trade Leakages in the Supply Chain

It is assumed that (i) all imputs used by firms are variable and industry specific; (ii) firms make zero profits; (iii) firms export 50% of output; and (iv) firms import 10% of imputs. Final Demand is initially equal to 100 m.u. (Panel A), increasing to 101 m.u.in Panel B.

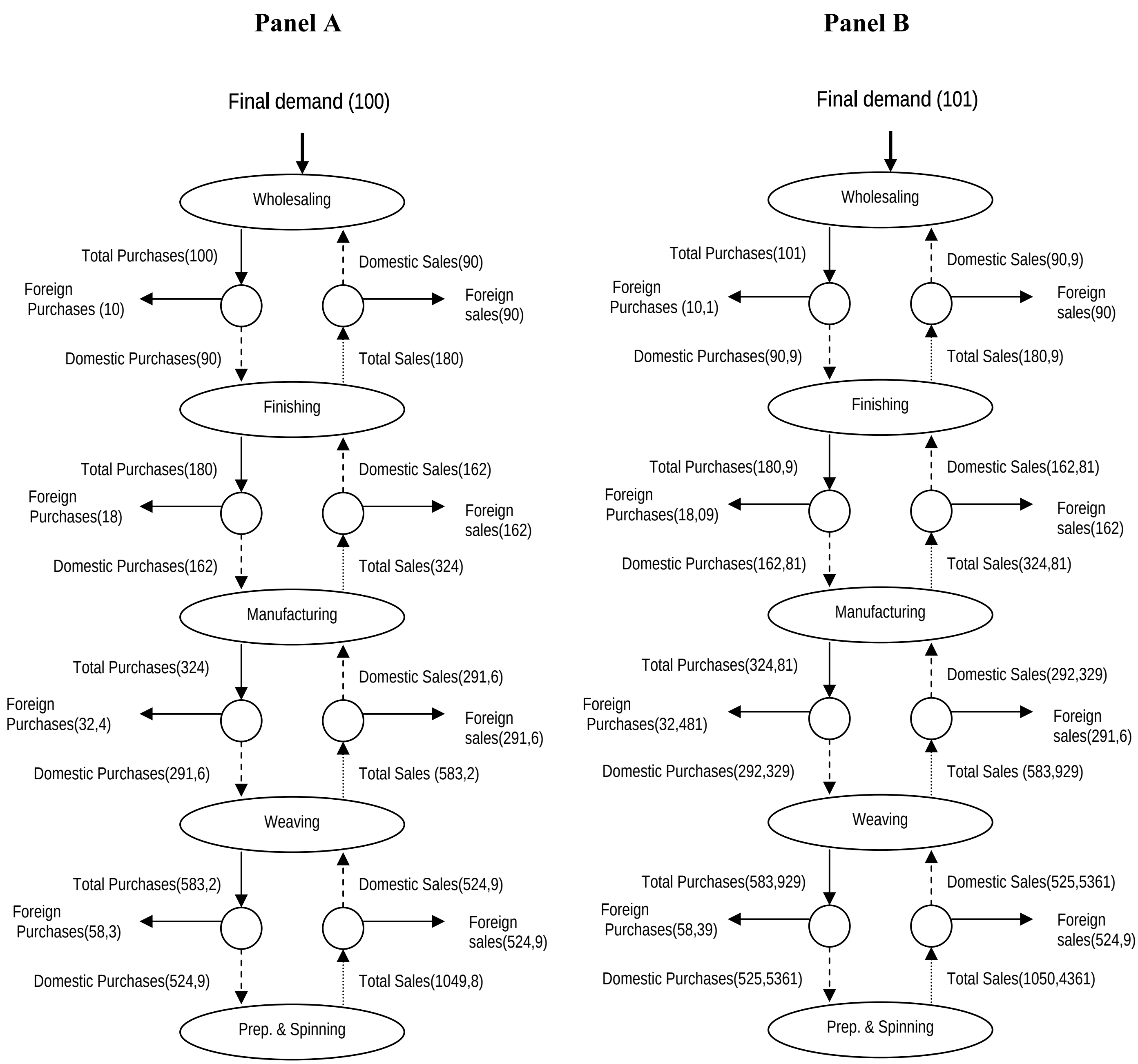


Table 10 - Effect of a variation in "Aggregate Sales of Wholesaling Firms" on the level of "Aggregate Sales" and "Aggregate Purchases" at successive upstream levels of the supply chain

Level of Supply Chain	Variation Total Sales (domestic+foreign)	Variation Total Purchases (domestic+foreign)
Wholesalers	1 m.u. (1%)	1 m.u. (1%)
Finishers	0,9 m.u. (0,5%)	0,9 m.u. (0,5%)
Manufacturers	0,81 m.u. (0,25%)	0,81 m.u. (0,25%)
Weavers	0,729 m.u. (0,125%)	0,729 m.u. (0,125%)
Spinners	0,6561 m.u. (0,0625%)	0,6561 m.u. (0,0625%)

Table 11: Output-Imput Demand Transmission Equation

This table reports the results from estimating the output-input demand transmission equation with the variable "Average Sales of firms from level K in year t".

The model can be written as:

$$\text{Average Sales}_{k,t} = \alpha_k + \beta \text{ Average Sales}_{k-1,t} + u_{it}$$

(Intersect dummies used for the various levels of the supply chain; dummy coefficients not reported)

A	β	N	Adj. R^2
	0,69 (6,4)	36	47%

t-statistics in parentheses

Table 12: Turnover and Export Data for the Italian Textile&Clothing Industry in 2006 (Turnover and Exports in billions of euros)

	Turnover	Exports	Exports/Turnover
Spinning (filature)	3,4	1,12	33%
Yarn or thread of cotton, wool and linen			
Weaving (tessitura)	9,1	6	66,5%
Fabrics of cotton, wool, linen, silk.			
Manufacturing			
• Clothing (clothing items, knitwear, hosiery)	30	16	53%
• Cotton home textiles	5,3	0,5	10%
Total Manufacturing	35,3	16,5	46,7%
Finishing	4,8	4	83%
Total Industry (excludes wholesaling)	53	27,6	52,2%

Source: *Sistema Moda Italia* (Centri Studi)

Table 13: Demand-Operating Cash Flow Transmission Equation

The model can be written as:
$(\text{EBITDA/Total Assets})_{i,k,t} = \alpha_k + \beta \text{ Average Sales}_{k,t} + u_{it}$

Panel A: Firm Level Estimation

Regressions by level of supply chain

	α	β	N	Adj. R^2
Wholesalers	0.030	0.0006	2,053	0.6%
	(1.911)	(3.312)		
Finishing Textiles	0.097	0.0001	1,653	0%
	(4.15)	(0.745)		
Manufacture of Textiles	0.067	0,0002	4,988	0.1%
	(7.038)	(2.42)		
Textile Weaving	0.020	0.0007	4,261	0.66%
	(1.53)	(5.088)		
Preparation and Spinning of Textile Fibres	-0.013	0.001	2,831	0.93%
	(-0.752)	(5.63)		

t-statistics in parentheses

Pooled regression (all firms, with intersect dummies for the various levels of the supply chain; dummy coefficients not reported)

	α	**β**	**N**	**Adj. R^2**
All Firms	0.039	0.0005	15,786	1,4%
	(6.35)	(6.82)		

t-statistics in parentheses

Panel B: Chain-level Threshold Estimation

Model: Average $EBITDA_{k,t} = \alpha_k + \beta$ Average $Sales_{k,t} + u_{it}$

(Intersect dummies used for the various levels of the supply chain; dummy coefficients not reported)

A	**β**	**N**	**Adj. R^2**
-0.69	0.93	45	29.8%
(-0.03)	(4.16)		

t-statistics in parentheses

Table 14 - Effect of a unitary increase in aggregate sales of wholesalers on the level of trade credit sourced from suppliers (ratio Trade Payables/CGS) at successive upstream levels of the supply chain

Panel A - Firm-level approach

Level of the chain (k)	Direct impact of final demand on trade credit sourced by firms at level k of the supply chain				Indirect impact of final demand on trade credit sourced by firms at level k of the supply chain, arising from trade credit propagation				Total Impact
	Impact of Wholesaler's Demand on level-k Demand (Table 11 with coefficient adjusted for external trade bias) (A)	Impact of level-k Demand on ratio (Operating Cash Flow / Assets) of firm i at level k of chain (Table 13 – Panel A; pooled regression) (B)	Impact of ratio (Operating Cash Flow/Assets) on ratio (TradeCredit/CGS) for firm i at level k of chain (Table 5; β_2 pooled regression) (C)	Direct Impact (D) = (A)(B)(C)	Direct impact of Final Demand on ratio (Trade Payables/CGS) of firm i at level k-1 of the chain (E)	Impact of ratio (TradeCredit/CGS) of random firm from level k-1 of chain on ratio (Trade debit/Sales) of random firm from level k of chain (Equation (6)) (F)	Impact of ratio (Trade Debit/Sales) on ratio (Trade Credit/CGS) for random firm from level k of the chain (Table 5; β_1 pooled regression) (G)	Indirect Impact (H) = (E)(F)(G)	(I) = (D)+(H)
Wholesalers (k=0)	1	0,0005	-0,22	-0,00011	0	1	0,22	0	-0,00011
Finishers (173; k=1)	1,15	0,0005	-0,22	- 0,0001265	-0,00011	1	0,22	-0,0000242	-0,000151
Manufacturers (174/177; k=2)	$1,15^2$	0,0005	-0,22	- 0,0001454	-0,0001265	1	0,22	-0,0000278	-0,000173
Weavers (171; k=3)	$1,15^3$	0,0005	-0,22	- 0,0001672	-0,0001454	1	0,22	-0,0000319	-0,000199
Preparers & Spinners (172; k=4)	$1,15^4$	0,0005	-0,22	-0,0001922	- 0,0001672	1	0,22	-0,0000367	-0,000229

Panel B – Chain-level approach

Level of the chain (k)	Direct impact of final demand on trade credit sourced by firms at level k of the supply chain				Indirect impact of final demand on trade credit sourced by firms at level k of the supply chain, arising from trade credit propagation			Total Impact
	Impact of Wholesaler's Demand on level-k Demand (Table 11 with coefficient adjusted for external trade bias) (A)	Impact of level-k Demand on average Operating Cash Flow among level-k firms (Table 13 – Panel B) (B)	Impact of average Operating Cash Flow among level-k firms on average ratio (Trade Credit/CGS) among level-k firms (Table 8; β_2 pooled regression) (C)	Direct Impact (D) = (A)(B)(C)	Direct impact of Final Demand on average ratio (TradeCredit/CGS) among (k-1)-level firms (E)	Impact of average ratio (TradeCredit/CGS) among (k-1)-level firms on average ratio (TradeCrdit/CGS) among k-level firms (Table 8; β_1 pooled regression) (F)	Indirect Impact (G) =(E)(F)	(H)=(D)+(G)
Wholesalers (k=0)	1	0,93	-0,0001	-0,000093		0,52	0	-0,000093
Finishers (173; k=1)	1,15	0,93	-0,0001	-0,000107	-0,000093	0,52	-0,000048	-0,000155
Manufacturers (174/177; k=2)	$1,15^2$	0,93	-0,0001	-0,000123	-0,000107	0,52	-0,000056	-0,000179
Weavers (171; k=3)	$1,15^3$	0,93	-0,0001	-0,000141	-0,000123	0,52	-0,000064	-0,000205
Preparers & Spinners (172; k=4)	$1,15^4$	0,93	-0,0001	-0,000162	-0,000141	0,52	-0,000073	-0,000235