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Inventory investment and financial constraints in the Italian manufacturing industry: a panel data GMM approach

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Abstract

Three large unbalanced panels of Italian manufacturing firms observed over the period 1991-2009 are employed to assess, by mean of a dynamic GMM approach, whether the existence of financial frictions is suitable to explain deviations of inventories from their long-run path. A negative response of inventory investment to the presence of financial burdens might provide evidence of a significant role played by the financial framework in conditioning the real side of the economy, especially during recession years, when liquidity problems arise. The negative effect is found over the entire analyzed period, with firms' dimensional aspects accounting more than risk characteristics to explain the phenomenon, but the inclusion of recessionary dummies into the model leads to controversial and puzzling results. A significant recessionary effect is found during the Nineties, accounting for inventories being more sensitive to financial frictions during the main recessionary peaks, 1993 and 1996. The result is not confirmed by the most recent estimates, especially the ones referring to the 2008-2009 recessionary shock, whose effects are investigated for the first time by a paper addressing the inventory investment-financial constraints subject. Alternative hypothesis for the proposed results have been tested on data. Firms were found to rely to inventory decumulation to a lesser extent compared to the past, to generate internal financing. More specifically, disinvestments in financial assets were found to represent, as a matter of fact, one of the main drivers adopted to ease liquidity tensions: a negative and strongly significant relationship with inventory investment was detected, after controlling for short-run liquidity constraints at firm level. By contrast, only a weak negative relationship was established with fixed capital during the same recessionary biennium.

JEL Classification numbers: D92, E52, F14.
Keywords: Financial constraints, Panel data, Inventory investment.

1. Introduction

Inventory movements proved to be strongly related to output fluctuations during the past. It is widely accepted that they are useful indicators of business activities, in the sense of being precursors, at certain stages, of output downward corrections at macro level.

A flourishing literature has documented that firm inventories tend to be proportional to sales in the long-run but the relation is violated in the short-run, when a sort of trade-off between inventory investment and sales takes place. Financial constraints faced by firms are found to be one of the main determinants of downward corrections in inventories. The negative response of inventory investment to the presence of financial boundaries might provide evidence of a significant role played by the financial framework in conditioning the real side of the economy, especially during recession years, when liquidity problems arise.

The present paper addresses this issue by exploiting three large unbalanced panels of Italian manufacturing firms observed over the period 1991-2009. The selected period includes two severe recessionary episodes for the Italian economy: the early Nineties recession and the 2008-2009 shock. This is, as far as I know, the first paper on the subject analyzing the effects of the latter recession over the Italian manufacturing sector. A dynamic approach is adopted to shed light on peculiarities of the phenomenon that may rely to intrinsic riskiness of firms, to the role played by sectorial effects or to different reactions to monetary policy stances during the past years, especially as far as the liquidity accumulation attitude is concerned.

The remainder of this paper is organized as follows. The next section presents and briefly discusses the theoretical background on inventory behavior. Section 3 describes the empirical specification of the model, both the baseline specification and the related variants. Section 4 is devoted to data description while empirical econometric results and further tests are discussed in section 5. The main conclusions are summarized in the final section 6.

2. Theoretical background on inventory behavior

With the attempt of investigating what factors determine the short-run variability of inventories with respect to sales, several models have been formalized and tested on both macro and micro-data.

Target adjustment models (Lovell, 1961; Blanchard, 1983), production smoothing models (Blinder and Maccini, 1991) and production-cost smoothing models (Blinder, 1986; Eichenbaum, 1989; West, 1990) have been developed in earlier studies on the subject to capture these patterns. More specifically, target adjustment models are set to explain a reverting behavior of firm inventories towards a 'target level' because of the rising of adjustment costs when, for some reasons, the fixed proportion 'inventories to sales' is overcome. Production smoothing models, instead, posit that inventories react negatively to demand shocks in the context of profit-maximizing firms who tend to smooth production relative to fluctuations at demand side. More generally, inventories respond negatively to cost shocks affecting the operational ground of industrial firms.

A second strand of the literature analyses the sensitivity of firm inventories to liquidity shocks and constraints in order to provide an alternative explanation for their short-run dynamics. In this case firm inventories are modeled like investment variables and, particularly, investment-type variables which are subject to lower adjustment costs with respect to fixed assets. This allows firms to strongly react in terms of inventory decumulation as soon as external shocks require the adoption of smoothing strategies and fosters inventories to be more volatile than sales, especially during recessionary periods. Firms who are financially constrained - in the sense of being in difficulty in catching more credit from the market - or are more likely to suffer from problems of informational asymmetry tend to utilize the inventory channel to generate internal liquidity as fast as possible while facing contingencies.

Evidences of binding financial constraints for inventory investment were found in a lot of studies focused on American data. Kashyap, Stein and Wilcox (1993) and Gertler and Gilchrist (1994) make use of time series data on credit to sustain the hypothesis that financial variables are good proxies to explain inventory over-decumulation in most periods of slowdown of the American economy. The same view is supported by Carpenter, Fazzari and Petersen (1994, 1998) and by Kashyap, Lamont and Stein (1994), who based their empirical research on micro-data, either cross-section regressions or panel regressions. Emphasis is posed on small firms and on firms without bond ratings, who turn out to be much more exposed to the phenomenon. A panel data approach is employed also in selected works on the European manufacturing industry. Reference is made to Guariglia (1999, 2000, 2010), who focuses on the UK industry and to Bagliano and Sembenelli (2004). The latter authors make use of annual data on firms' balance sheets to study the effects of the early Nineties' recession on inventory investment in Italy, France and United Kingdom. By mean of proxies for financial pressure at firm level a higher sensitivity of inventory investment is detected for small and young manufacturing firms. As far as Italian firms are specifically concerned, an additional recessive effect is found, acting in the sense of amplifying inventory investment variability. This supports the view of a 'financial accelerator channel' emphasizing the transmission of monetary effects to the real side of the economy.

Financial constraints were analyzed, at this stage, in the context of fixed investment regressions - in levels - augmented with financial variables. Other studies make instead use of a more dynamic approach. Error-correction inventory investment equations augmented with a financial composition variable are exploited to capture both the influence of a long-run relationship between inventories and sales and the response of inventory-investment to financial pressure in the short-run. More precisely, Choi and Kim (2001) from International Monetary Fund apply this approach on quarterly panel data of US firms to argue that inventory investment has been

liquidity constrained in most periods of the American economic history but not necessarily during recessionary episodes. An explanation for that was found in the deep accumulation of liquidity monitored at firm level in the period preceding the fall into recession. Guariglia and Mateut (2010) explore for the first time the link between firms' global engagement and their financial health in the context of inventory investment regressions, using panel data for UK firms. They argue that smaller, younger and riskier firms, from the one hand and firms that do not export and are not foreign owned, from the other, exhibit higher sensitivities. Global engagement acts instead in substantially reducing the response of firms' investment to financial boundaries.

In the present paper a dynamic framework is adopted, similar to the one described in Guariglia *et al.*, to find evidence of the existence of a negative linkage between inventory investment and financial variables in the Italian manufacturing industry. The focus is especially on testing the presence of the above mentioned 'recessionary financial accelerator channel' during the 2009 severe slowdown. Moreover, the length of the period covered by our data (from 1991 onwards) makes it possible the detection of peculiarities of the phenomenon with respect to past recessionary episodes for the Italian economy. At this purpose, we exploit a large information set on firms, including data on intrinsic riskiness, proxies for financial pressure and qualitative variables, like the ones identifying the belonging to an industrial district or to a Pavitt cluster for industrial activities[1].

[1] According to the Pavitt taxonomy firms' sectors of activity are classified as traditional, scale intensive, high-tech and specialised suppliers. See Pavitt (1984).

3. Empirical model specification and estimation methodology

3.1 Baseline specification of the model

The model employed in the empirical testing is a variant of the Lovell's target adjustment model (1961), which makes use of a proxy for the strength of financial constraints faced by firms. This dynamic inventory adjustment model applied on panel data is set to account for both a long-term relation between inventories and sales and the effects of short-run factors in boosting a deviation of inventories from their long-run path.

Denoting with *Inv* the logarithm of firm inventories[2] and with *Sales* the logarithm of sales, both in real terms[3] and defined at the end of the period, the basic equation for inventory investment takes the form:

$$\Delta Inv_{it} = \alpha + \beta_0 * \Delta Inv_{i,t-1} + \beta_1 * \Delta Sales_{it} + \beta_2 * \Delta Sales_{i,\,t-1} + \beta_3 * (Inv_{i,\,t-1} - Sales_{i,\,t-1}) + \\ + \beta_4 * Fin_{i,\,t-1} + \mu_i + \mu_t + \mu_j + u_{it,} \qquad (1)$$

where the subscript i stands for the panel variable (firms), the subscript t indexes the time variable and the subscript j refers to "industries" (2-digt industrial sectors, Ateco_2002) in the dataset we are considering.

The ratio behind the selected model is that firms tend to keep inventories stable relative to sales in the long-run (target level of inventories) and to adjust inventories relative to such a 'desired stock' in the short-run. ΔInv_{it} (our dependent variable) represents, as a matter of fact, the fraction of investment necessary for a firm to adjust its stock of inventories to the 'equilibrium level'. The only partial adjustment towards the target level, which takes place in the short-run, is driven by the presence of adjustment costs. We assume that financial frictions faced by firms – and proxied by *Fin* – account to amplify this phenomenon. Furthermore, such a slow adjustment path for inventories is modeled by considering an auto-regressive distributed lag specification for both the inventory investment and the growth in sales variables (the lag t-1 of both the variables is present in the equation)[4].

Note that the term $(Inv_{i,\,t-1} - Sales_{i,\,t-1})$ gives the selected model an error-correction format: if the stock of inventories in t-1 ($Inv_{i,\,t-1}$) is lower than the desired one – which is in turn a function of sales – than the future inventory investment ΔInv_{it} would be higher, or conversely a decumulation of inventories is required if the actual stock overcomes the desired one. To be consistent with these findings, the coefficient associated to the 'error-correction' term in the regression equation should be negative.

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[2] Inventories are the sum of raw materials, intermediate inputs and finished products. It is worth noting that raw materials account only for a minimum part in the variable definition.

[3] The variables are deflated using a 3-digit production price index coming from the Prometeia SpA econometric forecasting model for industrial sectors' performances.

[4] Other preliminary versions of the model are estimated in order to assess the long-run relationship between inventories and sales, as well as the persistency of the inventory path.

Long run relationship between inventories and sales: $Inv_{it} = \alpha + \beta_0 * Sales_{it} + u_{it}$

The variant 'in levels' of the original model:

$Inv_{it} = \alpha + \beta_0 * Inv_{i,t-1} + \beta_1 * Sales_{it} + \beta_2 * Sales_{i,\,t-1} + \beta_3 * Fin_{i,\,t-1} + \mu_i + \mu_t + \mu_j + u_{it}$

The adoption of the GMM 'Fist difference' Arellano-Bond technique (1991) is requested in this case - as detailed in the second part of this section – exploiting all the available set of instruments for the variables inventories and sales. The variable that proxies for financial pressure is considered exogenous.

To control for sales separately from inventories in the regression equation allows also to account for the buffer stock role of the former or, in other words, for situations where inventories play a crucial role in smoothing the effects on production of unpredictable demand shocks.

As already mentioned, the variable *Fin* identifies the reaction of inventory investment to financial frictions. To proxy for a situation of financial pressure at firm level three different measures have been considered, such as leverage (the ratio of short and long term debt to total liabilities, including debt and shareholders' funds), short term leverage and debt maturity (the ratio of short term debt to total debt). The effects of leverage on inventory investment have been long established in the literature. However, the definition of leverage we account for in the present paper is augmented (in its short-term component) of trade debt. The choice moves from considering that this form of financing is widely used in the Italian industrial framework[5], especially in periods characterized by a slowdown of the economy and scarcity of liquidity. Moreover, data observation has demonstrated that the extended terms of payment which characterize the operational ground of Italian firms, both at supply and customer side, are more the result of habits and of sectorial-based functioning mechanisms, rather than being a choice induced by bank credit rationing (despite it's quite obvious to argue that scarce liquidity and widespread difficulties within the economy may boost a lengthening of the terms of payment). A lot of studies have documented, on the contrary, that in some other industrial realities the higher costs associated to trade debt make it less preferable with respect to bank debt and, therefore, firms should refer to the former only when facing severe contingencies (see for example Kashyap *et al.* (1993), Hoshi *et al.* (1993), Huang (2003) and Guariglia *et al.* (2010)).

We have discarded 'a priori' the inclusion of other proxy variables to identify financial constraints at firm level, such as the cash flow, that sometimes recurred in the literature on inventory investment. The reasons underlying this exclusion refer mainly to the collinearity effects that arise with Sales in the model. The same collinearity effects arise when the regression model is augmented for the 'coverage ratio' (the ratio of interests paid on debt to Ebitda[6] - the ratio will be recalled so far in the paper while discussing the strength of financial constraints for riskier firms). Moreover, proxy variables which make use of liquidity measures are more likely to refer to short-run tensions at firm level and not necessarily to the existence of solid financial constraints.

To avoid a simultaneity bias, each selected proxy for financial constraints is evaluated at time t-1. The choice can be motivated also by assuming that stock-out phenomena in inventories should be more pronounced for such firms who enter a contingency period while facing already binding financial constraints. The set-up of the variables (see Appendix B for further details) allows to make an exogeneity assumption in the estimation procedure. In order to detect a negative effect of financial burdens on firm inventory investment, we expect a negative coefficient associated to the variable *Fin* in the regression equation.

The error term in the regression equation (1) is made up of four components:

- an idiosyncratic error term u_{it};
- a firm-specific component μ_i that encompasses the time invariant influence of unobservable variables on individual firms' behavior;

[5] Trade debt is a form of financing generated automatically by the system when customers delay the payment of their bills to their suppliers.

[6] Earnings before interests, taxes, depreciation and amortization.

- a time-specific component μ_t accounting for business-cycle effects and for 'not firm-specific' effects due to improvements in the way of treating inventories (such as the diffusion of the 'just-in-time' technique during the Nineties);
- an industry specific component μ_j capturing sectorial peculiarities of the inventory behavior.

We control for firm fixed effects μ_i by estimating the model in first-differences, for the time-specific component μ_t by including time dummies (year dummies) and for the industry component μ_j by including industry dummies (2-digit sectorial level, Ateco_2002[7]). More specifically, the inclusion of industry dummies into the analysis ensures that the presented estimates are not simply the result of cross-industry variations.

3.2 Proxies to identify risky firms

In order to explore in detail whether the sensitivity of inventory investment to financial constraints may differ among groups of firms displaying different risk characteristics, we allow the coefficient associated to the financial proxy *Fin* in the regression equation (1) to vary across firms segmented by risk separation criteria.

The traditional way to account for risk heterogeneity is to split the original sample by mean of dimensional dummies. Small firms are, as a matter of fact, more likely to display vulnerabilities, as well as a greater exposition to financial constraints. Dimensional clusters are assigned on the basis of statistics on real sales at firm level[8]. Moreover, three different measures of risk, or better proxies to identify riskier firms, are exploited with the purpose of constructing a dummy *Risk* (that equals 1 if a firm is classified 'risky' and 0 otherwise), to be interacted with the financial proxy *Fin*:

$$\Delta Inv_{it} = \alpha + \beta_0 * \Delta Inv_{i,t-1} + \beta_1 * \Delta Sales_{it} + \beta_2 * \Delta Sales_{i,t-1} + \beta_3 * (Inv_{i,t-1} - Sales_{i,t-1}) +$$
$$+ \beta_4 * Fin_{i,t-1} * Risk_{it} + \beta_5 * Fin_{i,t-1} * (1 - Risk_{it}) + \mu_i + \mu_t + \mu_j + u_{it} \qquad (2)$$

Two out of the three selected proxies come from the balance sheets: the 'coverage ratio' and the 'acid test ratio'. The third one is a multivariate proxy for risk: the CEBI rating (Centrale dei Bilanci)[9].

The 'coverage ratio' is calculated as the ratio of interests paid on debt to Ebitda[10] and measures the capability of a firm to cover its interest-related expenses. If the ratio is greater than 1 a firm is not profitable enough to face its debt burden. The first method to detect 'risky' firms is therefore to generate a dummy that equals 1 when the 'coverage ratio' is greater than 1 (and 0 otherwise).

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[7] See section 4, data description and Appendix A for more detailed information. Firms are segmented in 22 industrial sectors belonging to the manufacturing industry, according to the Ateco_2002 classification of economic activities (codes from 15 to 36). Ateco_2002 is the Italian version of the NACE Rev.1.1 classification, defined by the European Union.

[8] From 1991 to 1999 (data in Euro millions):
Small firms: 1,5 ≤ sales < 7
Medium-size firms: 7 ≤ sales < 40
Large firms: sales ≥ 40

From 2000 onwards (European Commission's thresholds, in Euro millions):
Small firms: 2 ≤ sales < 10
Medium-size firms: 10 ≤ sales < 50
Large firms: sales ≥ 50

[9] The CEBI rating is in fact available only for the most recent years, since 2004 onwards.

[10] Earnings before interests, taxes, depreciation and amortization.

The 'acid test ratio' exploits information on current assets and current liabilities at firm level: it is defined as the ratio of current assets, net of inventories, to current liabilities and determines whether a firm has enough short-term assets to cover its immediate liabilities without selling inventories. Therefore, it is suitable to detect liquidity tensions (at least temporary) that may arise at firm level. A firm is assumed to be 'risky' from this point of view (dummy 'risk' equal to 1) when the ratio is less than 1 (i.e. current assets net of inventories are lower than current liabilities).

The CEBI rating is instead the expression of the likelihood of company failure in the twelve months following the date of release of the score. It is an assessment of the credit worthiness of corporations calculated periodically by the main collector of firms' balance sheets in Italy, Centrale dei Bilanci, on the basis of both economic and financial characteristics of firms under scrutiny. In this sense it may be considered a multivariate measure of risk (see Bottazzi et al., 2010). A firm is considered 'risky' (dummy 'risk' equal to 1) for the scope of our analysis when the score varies between 5 (vulnerability) and 9 (very high risk) - according to the ranking detailed in Appendix B.

By exploiting such interacted variables (both dimensional and risk dummies are interacted with *Fin*), we are able to better discriminate between firms that are actually financially constrained from those firms that, although displaying financial vulnerabilities from a leverage or a debt maturity point of view, are more likely to repay their interest expenses or benefit from a good liquidity position. In light of the above, we expect a higher negative elasticity of inventory investment to financial frictions for such firms.

Last but not least, sectorial aspects of the inventory investment/financial constraints phenomenon can be explored by interacting financial variables with specific dummies that account for, respectively, the belonging to Pavitt clusters of industrial activities and to industrial districts. The construction of such variables will be discussed in detail in the next coming sections.

3.3 The inclusion of recessionary dummies

The inclusion of recessionary dummies *Recess* may provide additional interest to our investigation. A severe slowdown of the output is expected to exacerbate financial distress and to boost the volatility of inventories with respect to sales. The focus is especially on testing what happened during the 2008-2009 recessionary shock, compared to the past.

Two are the main recessionary episodes that hurt the Italian economy since the early Nineties: the main business cycle peaks date back 1993 and 2009. The 1993 recession generated a deep occupational crisis within the country, accelerating changes in the industrial model of 'doing business' in Italy. Step by step, larger companies had been replaced by more dynamic and less 'verticalized' companies, characterized by lower dimensions. The 2008-2009 recession, that comes from a deep disequilibrium in financial markets[11], has produced severe effects on the real side of the economy, in terms of both output growth and occupational statistics. For the sake of completeness, it is worth noting that also the 1996 year and the 2002-2003 biennium

[11] See also Caivano, Rodano and Siviero (2010). The authors explore the contribution of different channels of transmission of global shocks to the Italian real economy during the 2009 severe slowdown, by concluding that the worsening of the international context represented the main driver for recessive effects. The credit crunch and the confidence crises that followed the burst of the crisis played instead only a secondary role.

represented periods of slowdown for the economy, even if less pronounced[12]. The latter was mainly the result of imported uncertainty from international markets, due to the bubble burst on 'internet stocks' and to the attack to the Twin Towers. The former was instead induced by a period of prolonged tightening monetary policy in Italy, when the country was involved in the process of fulfilling the strict parameters imposed to join the Monetary Union.

The choice to split the original panel 1991-2009 of firms data into three distinct datasets – that will be motivated in detail in the next coming section – has induced, as a matter of fact, the construction of three differently specified recessionary dummies. The first two recessionary years (1993 and 1996) belong to the first panel of firms (that spans from 1991 to 1997) the 2002-2003 biennium belongs to the second panel (ranging from 1998 to 2003) and the 2008-2009 recessionary episode is covered by data in the last panel (ranging from 2004 to 2009). This allows also a separate analysis of the effects of the three recessionary shocks.

To isolate the impact of the recessionary dummies on the inventory path, an interaction is made with the variable that proxies for financial pressures at firm level, *Fin*.

$$\Delta Inv_{it} = \alpha + \beta_0 * \Delta Inv_{i,t-1} + \beta_1 * \Delta Sales_{it} + \beta_2 * \Delta Sales_{i,t-1} + \beta_3 * (Inv_{i,t-1} - Sales_{i,t-1}) + \\ + \beta_4 * Fin_{i,t-1} + \beta_5 * Fin_{i,t-1} * Recess_{it} + \mu_i + \mu_t + \mu_j + u_{it} \qquad (3)$$

Moreover, alternative equations have been estimated with the purpose of analyzing the effects of recessionary periods on smaller firms (i.e. by interacting recessionary dummies and dimensional dummies) and on riskier firms only (i.e. by interacting the recessionary dummies with both the *Fin* variable and the dummy variable *Risk,* that segments firms on the basis of different risk criteria).

$$\Delta Inv_{it} = \alpha + \beta_0 * \Delta Inv_{i,t-1} + \beta_1 * \Delta Sales_{it} + \beta_2 * \Delta Sales_{i,t-1} + \beta_3 * (Inv_{i,t-1} - Sales_{i,t-1}) + \\ + \beta_4 * Fin_{i,t-1} * Risk_{it} * Recess_{it} + \beta_5 * Fin_{i,t-1} * Risk_{it} * (1-Recess_{it}) + \beta_6 * Fin_{i,t-1} * (1-Risk_{it}) + \\ + \mu_i + \mu_t + \mu_j + u_{it} \qquad (4)$$

3.4 Estimation methodology

The presence of the lagged dependent variable $Inv_{i,t-1}$ into the model biases all the standard estimators for panel data because of the violation of the assumption of strict exogeneity between the error term and the regressors. Moreover, it is worth considering the variable *Sales* as predetermined (i.e. potentially influenced by current and past shocks).

The adoption of the dynamic GMM approach developed by Arrellano and Bond (1991) is therefore required in order to obtain unbiased estimates. The 'GMM First Difference' exploits the sequential exogeneity assumption for the error term to generate a set of linear moment conditions that are function of the parameters to be estimated. More precisely, under such an assumption lagged values of the dependent variable and of the endogenous/predetermined variables in the original model are valid instruments for the endogenous first differences in the transformed model. A first difference transformation of the original model is in fact performed to remove individual effects.

[12] See also Baffigi and Bassanetti (2004) for a complete analysis of the main business cycle peaks and thoughts of the Italian production-growth cycle.

In this paper we make use of the entire set of instruments available (from t-2 backwards) for the variables inventories, sales and for the error-correction term, to deal with the above mentioned problems of endogeneity. At this purpose, the unbalanced panels of firms are set to preserve a continuity of 4 years in the data. More specifically, we have chosen the two-step version of the GMM estimator which, upon the application of the Windmeijer correction for standard errors, is assumed to be the most efficient way to estimate the parameters. Being the inventory investment path a persistent series but far from a process displaying near unit root properties (i.e. random walk), the application of the Blundell and Bond (1998) System-GMM is not strictly required[13]. In order to perform a robustness check the model is estimated also through Pooled OLS and 'Within group' estimators. Both the estimators produce biased estimates under sequential exogeneity but good lower and upper bounds to evaluate the estimated GMM coefficient associated to the lagged dependent variable, who should place in the middle (the asymptotic bias is upward in the case of the Pooled OLS and downward in the case of the WG estimator). The variables that proxy for financial pressures and the dummy variables in the model are considered exogenous and thus are treated itself as instrumental variables.

[13] The application of the System GMM to our data did not provide a consistent gain in terms of estimated coefficients and standard errors. Results are available on request.

4. Data description and summary statistics

We make use of three large unbalanced panels of Italian manufacturing firms extracted from the Intesa Sanpaolo Research Department's database on corporate customers. The reference period spans from 1991 to 2009. Recursive screening procedures have been implemented in order to achieve data comparability and to add stability to the analysis. A firm enters the sample only if inventories, sales and the main variables of interest (i.e. the ones that proxy for financial pressures at firm level and the variables who enter the computation of the dummy 'risk') are reported for at least 4 consecutive years. After the screening step, we are left with unbalanced panels containing 10,564 firms for the period 1991-1997, 11,443 firms in the 1998-2003 period and 11,226 firms in the remaining time period 2004-2009 (Tables 1 and 2).

Each dataset is made up of manufacturing firms in 22 industries categorized by 2-digit Ateco_2002 industrial classification codes[14]. In addition, firms are assigned a dimensional cluster (small, medium and large firms[15]), a Pavitt industrial cluster and a dummy identifying the belonging to an industrial district. It is worth stressing that the adoption of unbalanced datasets makes it possible to preserve more variability within the cluster of small firms. The former would be in fact the most penalized one in terms of variability once the sample is forced to be balanced (i.e. including only the firms with observations in each year of the analyzed period) because of frequent entrances of new firms and exits of bad-performer firms from the market. Appendix A reports more detailed information on the construction of the datasets.

Table 1 – The composition of the unbalanced datasets by size of firms

	Whole sample	Small firms	Medium-size firms	Large firms
	1991-1997			
Number of firms	10,564	4,484	5,036	1,044
Number of observations	59,270	23,742	29,226	6,302
	1998-2003			
Number of firms	11,443	4,937	5,396	1,110
Number of observations	63,775	28,324	29,420	6,031
	2004-2009			
Number of firms	11,226	4,860	5,191	1,175
Number of observations	61,972	28,153	27,594	6,235

Notes: refer to note 8 for a definition of the dimensional thresholds.

Table 2 – The structure of the unbalanced datasets

Number of continuous observations per firm in each panel:	1991-1997		1998-2003		2004-2009	
	Frequency	%	Frequency	%	Frequency	%
7	4,009	37.95	-	-	-	-
6	1,115	10.55	7,974	69.68	7,413	66.03
5	2,757	26.08	1,111	17.96	2,252	14.23
4	2,596	24.57	944	0.95	1,561	5.83
Total	10,564	100.00	11,443	100.00	11,226	100.00

Tables 3 and 4 display summary statistics as far as the variables real sales, inventories (as a ratio to sales), leverage, short term leverage and debt maturity are concerned. It is worth noting that small and medium-size firms show a higher degree of leverage with respect to large firms in the

[14] Ateco_2002 is the Italian version of the NACE Rev.1.1 classification, defined by the European Union.

[15] Please refer to note number 9.

sample, in each of the selected time periods. The most recent sample shows leverage values of 0.77 (in median terms) for smaller firms, 0.73 for medium-size ones and 0.67 for larger firms.

The inclusion of trade debt in the leverage definition (i.e. by utilizing a definition of leverage 'augmented' for trade debt) makes it less visible the decreasing trend in debt accumulation - and therefore in the leverage variable - that one would expect to find in the data, because of the receipt of changes in taxation policies that should have induced firms to rely to external debt to a lesser extent compared to the past[16].

Conversely, no evidence is found of a discordant behavior of larger firms with respect to smaller ones from a debt maturity point of view (measured in terms of short term leverage and ratio of short term debt to total debt). Both the categories rely on short term debt in a similar fixed proportion: debt maturity is in fact around 0.80 (in median terms) in each selected time period and for each dimensional cluster of firms.

Table 3 - Statistics on real sales (€ millions)

	Whole sample	Small firms	Medium-size firms	Large firms
		1991-1997		
Mean	27.99	5.06	17.41	163.47
1st quartile	5.53	3.59	10.14	55.55
Median	9.67	4.90	14.32	78.24
3rd quartile	20.25	6.34	21.97	137.28
		1998-2003		
Mean	27.65	5.37	19.35	172.77
1st quartile	5.58	3.54	11.72	60.30
Median	10.23	5.16	16.15	84.28
3rd quartile	20.61	6.95	24.25	146.03
		2004-2009		
Mean	28.37	4.82	18.65	177.70
1st quartile	4.70	3.05	11.35	56.89
Median	9.74	4.38	15.51	79.18
3rd quartile	19.81	6.26	23.16	135.86

Notes: refer to note 8 or to Appendix A for a definition of the dimensional thresholds. Sales have been deflated by means of a 3-digit production price index coming from the forecasting model for industrial sectors' performances developed by Prometeia SpA.

[16] Reference is made to the introduction of the DIT and the super-DIT taxation policies in the Italian industrial framework.

Table 4 – Summary statistics: inventories (as a ratio to sales) and variables that proxy for financial pressure at firm level

	1991-1997				1998-2003				2004-2009			
	Inventories	Leverage	Short-term leverage	Debt maturity	Inventories	Leverage	Short-term leverage	Debt maturity	Inventories	Leverage	Short-term leverage	Debt maturity
Whole sample												
Mean	0.18	0.71	0.56	0.78	0.18	0.71	0.56	0.78	0.19	0.71	0.54	0.77
1st quart	0.09	0.61	0.43	0.70	0.08	0.60	0.42	0.69	0.08	0.59	0.40	0.67
Median	0.15	0.74	0.57	0.82	0.15	0.75	0.57	0.81	0.15	0.74	0.55	0.80
3rd quart	0.24	0.84	0.70	0.91	0.24	0.86	0.71	0.91	0.25	0.85	0.69	0.90
Small firms												
Mean	0.18	0.71	0.56	0.77	0.17	0.73	0.57	0.77	0.18	0.73	0.56	0.76
1st quart	0.08	0.61	0.42	0.68	0.07	0.62	0.43	0.67	0.07	0.62	0.42	0.66
Median	0.14	0.75	0.57	0.81	0.14	0.77	0.58	0.80	0.14	0.77	0.57	0.79
3rd quart	0.25	0.85	0.70	0.90	0.24	0.87	0.72	0.90	0.24	0.87	0.71	0.90
Medium-size firms												
Mean	0.18	0.71	0.57	0.79	0.18	0.71	0.56	0.79	0.20	0.69	0.54	0.78
1st quart	0.09	0.61	0.44	0.71	0.09	0.60	0.43	0.71	0.10	0.58	0.40	0.69
Median	0.15	0.74	0.59	0.83	0.16	0.75	0.58	0.82	0.17	0.73	0.55	0.81
3rd quart	0.24	0.84	0.71	0.91	0.25	0.85	0.71	0.91	0.26	0.84	0.68	0.90
Large firms												
Mean	0.16	0.67	0.53	0.79	0.17	0.66	0.51	0.78	0.18	0.64	0.49	0.77
1st quart	0.09	0.56	0.39	0.70	0.09	0.53	0.38	0.69	0.09	0.52	0.36	0.67
Median	0.14	0.70	0.54	0.82	0.15	0.69	0.52	0.81	0.15	0.67	0.49	0.80
3rd quart	0.21	0.80	0.66	0.92	0.22	0.80	0.65	0.91	0.23	0.79	0.63	0.91

Notes: 1st quart refers to first quartile and 3rd quart to third quartile. Please refer to note 8 for a definition of the dimensional thresholds and to Appendix B for a definition of the main variables of interest in the table (inventories, leverage, short-term leverage and debt maturity).

5. Regression results

5.1 Estimates from a baseline specification of the model

We begin by estimating[17] an error correction inventory investment model augmented with a financial composition variable, like the one presented in equation (1)[18]. From now on we focus on the leverage variable as the reference measure for financial pressure at firm level and make instead use of short term leverage and debt maturity variables to provide robustness checks. In light of the above, only empirical results on leverage are reported in the paper (Table 5)[19]. Estimates for the 2004-2009 time period, the reference one, are compared to the ones obtained from testing the same model on the other two datasets (1991-1997 and 1998-2003).

Lagged inventory investment $\Delta Inv_{i,t-1}$ is assigned a negative and statistically significant coefficient in each time period, after controlling for common patterns on the way of treating inventories and for business-cycle effects by including year dummies (the presence of jointly significant time effects is tested by means of a Wald test, in each of the selected time periods). The significance of the $\Delta Inv_{i,t-1}$ coefficient is nevertheless decreasing over time, thus indicating a loss in the intensity of the adjustment path. Once controlling for size (i.e. by introducing dimensional dummies in the regression equation), a positive effect on smaller firms is detected, forcing the above-mentioned negative elasticity to be lower for such firms. Smaller firms may benefit in fact from a more dynamic production function, thus making them less dependent from medium-term inventory investment strategies.

The elasticity of inventory investment to current sales' growth $Sales_{it}$ is positive and precisely determined. The magnitude of the coefficient provides clear evidence of the role played by inventories in accompanying production targeting strategies and in buffering production shocks (production smoothing argument), once demand expectations are not fulfilled by current market conditions. Nevertheless, the auto-regressive distributed lag specification of sales is preserved only in the first panel dataset (1991-1997); the coefficient associated to the $\Delta Sales_{it-1}$ variable proves to be not-significant in the most recent datasets. The influence of a long-run target inventory level in conditioning firms' behavior is captured by the negative and statistically significant coefficient associated to the error-correction term ($Inv_{i,t-1} - Sales_{i,t-1}$) in each of the selected time periods, thus indicating the speed of adjustment towards the desired stock of inventories.

The coefficient of the leverage variable $Fin_{i,t-1}$, which is our main interest, is also negative and strongly significant. We may interpret this as an evidence of inventory investment being conditioned by financial constraints in the analyzed period. These results, as well as the previous findings, are confirmed also in the case of adoption of the short term leverage and the debt maturity variables as alternative proxies to measure the existence of financial constraints at firm level[20].

[17] Estimates are performed through Stata 12 software.

[18] As a preliminary step to the application of the dynamic model described in equation (1), we in fact begin by assessing the linkage between inventories and sales in levels and the persistency of the inventory path (reference is made to the models described in note 5). A positive relation is detected between the stock of inventories at time t (the dependent variable) and both the stock of inventories at time t-1 and the level of contemporary sales (all the variables were expressed in logarithms). The coefficient on the lagged depvar is around 0.50 thus supporting our findings as far as the application of a two-step version of the GMM 'first difference' is concerned.

[19] The other results are available on request.

[20] Preliminary results obtained from testing the model over an extended panel of firms data (inclusive of the 2010 year) confirm the previous findings as well.

Table 5 – Standard estimates: inventory investment and financial constraint, model (1)

Parameter	1991-1997 Coefficient		Std. Err.	1998-2003 Coefficient		Std. Err.	2004-2009 Coefficient		Std. Err.
$\Delta Inv_{i,t-1}$	-0.087	**	0.018	-0.099	**	0.026	-0.063	**	0.031
$\Delta Sales_{i,t}$	0.872	**	0.229	0.947	**	0.447	0.801	**	0.356
$\Delta Sales_{i,t-1}$	-0.108	**	0.027	-0.011		0.022	-0.051		0.038
$Inv_{i,t-1}$ - $Sales_{i,t-1}$	-0.454	**	0.056	-0.427	**	0.059	-0.422	**	0.072
$Fin_{i,t-1}$	-0.398	**	0.034	-0.280	**	0.030	-0.334	**	0.033
Observations	27,578			29,446			28,304		
Number of firms	10,564			11,443			11,226		
m1 (p)	0.000			0.000			0.000		
m2 (p)	0.388			0.323			0.266		
Hansen (p)	0.703			0.201			0.571		
W_t (p)	0.000			0.000			0.000		

Notes: ** 5% significance level. Standard errors robust to heteroskedasticity (Windmeijer correction) in parentheses. For all the tests p-values are reported. The Fin variable refers to leverage. Results as far as short term leverage and debt maturity are concerned are provide upon request[21].

As far as testing procedures are specifically concerned, note that the m2 test for the absence of second-order residual serial correlation[22] is always fulfilled. It is worth stressing that testing for the absence of second order serial correlation in the differenced residuals (the ones deriving from the transformed model in a 'first difference' GMM context) is like testing for the absence of serial correlation in the original model. In other words, it is the fastest way to assess the validity of the sequential exogeneity assumption[23], which in turn implies the consistency of the GMM 'first difference' developed by Arellano and Bond. As an implication of this, lags from t-2 backwards of the dependent variable are valid instruments to solve the endogeneity problems discussed in the previous sections. In addition, an Hansen test of overidentifying restrictions has been performed to test the validity of the instrument sets for both the sales growth variables and the error correction term[24]. Last but not least, the magnitude of the estimated coefficient associated to the lagged dependent variable $\Delta Inv_{i,t-1}$ in each of the three selected time periods is assessed by mean of a comparison with the estimates obtained from testing the dynamic model proposed in equation (1) through Pooled OLS and Within Group estimators. As expected (and

[21] All estimations are performed through GMM fist-difference specification, two-step version. See Arellano and Bond (1991). Time dummies (year dummies) and industry dummies are included in all the equations, both as regressors and as instruments. m1 and m2 are tests for the presence of first order and second order residual correlation in differenced residuals, asymptotically distributed as N(0,1) under the null of no serial correlation. The Hansen test is a test of overidentifying restrictions, distributed as chi-square under the null of valid instruments. We make use of the entire set of instruments for endogenous and predetermined variables: $\Delta Inv_{i,t-2}$, ...; $\Delta Sales_{i,t-2}$, ...; $Inv_{i,t-2}$ - $Sales_{i,t-2}$, ...
W_t is a Wald test for the joint significance of time dummies. For all the tests, p-values are reported.

[22] The m2 test makes use of the standardised average residual autocovariance - distributed asymptotically as a standard normal N(0,1) under the null of no serial correlation - to test the absence of second-order serial correlation in the residuals of the transformed model. The first difference transformation of the original model, required by the application of the GMM 'first difference', implies instead that differenced residuals are pairwise-joint and that first order serial correlation is present in the data. The m1 test is suitable to shed light on this phenomena (we expect, at this stage, a rejection of the null hypothesis of no serial correlation).The application of this testing procedure implies a length of the panel almost equal to 5 years (or time periods, depending on the definition of the panel time variable). See Baltagi (2008).

[23] No serial correlation is in fact an implication of the validity of the sequential exogeneity assumption in dynamic models for panel data.

[24] Note that the standard Sargan test for overidentifying restrictions is biased by the presence of heteroskedasticity in the data. The Hansen test, performed automatically by the Stata command implementing the Arellano-Bond procedure (xtabond2), is therefore to be preferred. It is asymptotically distributed as a Chi-square under the null hypothesis of the validity of the instrument set, with as many degrees of freedom as overidentifying restrictions. See Baltagi (2008).

discussed in Section 3), the elasticity estimated through GMM approach falls in between the estimates resulting from the application of such standard estimators for panel data (Table 6).

Table 6 – Lagged dependent variable (inventory investment): a comparison between the coefficients estimated through the GMM first-difference technique and the ones obtained applying standard panel data estimators

	1991-1997		1998-2003		2004-2009	
Pooled OLS	-0.159	**	-0.156	**	-0.167	**
GMM first_difference	-0.087	**	-0.099	**	-0.063	**
Within Group	0.015	**	0.043	**	0.077	**

Notes: ** 5% significance level.

5.2 Estimates from the adoption of risk separation criteria

As a second step, we have tested differences in the financial pressure coefficient *Fin* between risky and risk-free firms by interacting the variable with a 'risk' dummy: the separation criteria described in Section 3 (coverage ratio, acid test ratio and CEBI rating) are alternatively exploited to segment firms on the basis of their risk characteristics. Reference is made to the model proposed in equation (2). The leverage variable is still adopted as the reference proxy to obtain estimates for the *Fin* coefficient in the regression equation (Table 7).

Estimates provide evidence that, as a general practice, the negative elasticity of inventory investment to financial burdens is higher for riskier firms. The difference in the *Fin* coefficients between risky and risk-free firms is particularly pronounced in the early Nineties. Moreover the acid test ratio and the CEBI rating separation criteria act in the sense of better isolating firms that are actually financially constrained, with respect to the coverage ratio approach (we should recall that CEBI ratings are available only for the most recent dataset). We acknowledge, in fact, a reduction in the discriminating power of the coverage ratio 'interacted variable' in the last panel, the one covering the period 2004-2009. Being the coverage ratio a synthetic measure of the capability of a firm to repay its debt-related expenses, a reason for that may be found in the widespread difficulties faced by the Italian firms during the severe 2008-2009 recessionary episode. The fall in interest rates that followed the burst of the crisis was in fact accompanied by a fall in gross operating profits (Ebitda), causing the coverage ratio remaining above pre-crisis levels. A confirmation in this sense comes from the statistics released by the Bank of Italy, in both the Financial stability report and the Annual report focused on 2009[25].

Alternatively to 'risk' dummies, dimensional dummies can be exploited to isolate firms that are more likely to face financial constraints in a traditional sense. In fact, it is possible to detect a dimensional side of the phenomenon of sensitivity of inventory investment to the presence of financial frictions: smaller firms are assigned a higher *Fin* coefficient with respect to the other firms in each panel dataset. This is consistent with Bagliano *et al.* results.

Moreover, the dimensional aspect is preserved in case additional variability is introduced in the *Fin* coefficient, by interacting dimensional dummies and 'risk' dummies. Bigger risky firms are assigned a lower (or at least equal) coefficient with respect to small risk-free firms in the sample (Table 8).

Dimensional effects are also employed to explain the results obtained from testing the inventory investment model over subsets of firms segmented by Pavitt clusters of industrial activities (Table 9) and by industrial districts (Table 10).

[25] Reference is made to the first and the second reports on financial stability issued on December 2010 and on November 2011 and to the annual reports released in the same years.

Despite controlling for size in the regression equation, it is worth noting how such separation criteria are likely to emphasize, in any case, differences in the exposition to financial frictions that may rely to dissimilarities in the structure of the relevant production-base. Traditional sectors of activity (i.e. clothing industry, textile, food and beverage, furniture sector etc.), which are typically associated to the Italian industrial districts' framework, are in fact more likely to rely to small firms – the ones that were found to show a greater sensitivity to the financial frictions/inventory investment phenomenon - while big firms are concentrated within high-tech sectors and scale intensive sectors. The above considerations may help explaining why a more pronounced sensitivity of inventory investment to financial frictions is found for firms belonging to traditional sectors of production or, simultaneously, for firms belonging to industrial districts. By contrast, firms who operate in the high-tech sectors are more likely to show lower elasticities. Moreover, it is worth noting how the existence of solid inter-firm cooperation linkages within industrial districts might provide additional explanation for the phenomenon, because of the greater exposure to trade credit fluctuations[26]. One of the main peculiarities of the industrial districts' operational framework is in fact the extensive recourse to de-verticalised production chains, by mean of the presence of subcontractors and suppliers.

[26] The definition of leverage variable we account for in the analysed framework is inclusive of trade debt, being it an important source of financing in the Italian operational ground.

Tab 7 - Inventory investment and financial constraints: firms segmented by risk separation criteria

	1991-1997				1998-2003				2004-2009					
	$Risk_{it}$= f ($Coverage\ ratio_{it}$)		$Risk_{it}$= f ($Acid\ test\ ratio_{it}$)		$Risk_{it}$= f ($Coverage\ ratio_{it}$)		$Risk_{it}$= f ($Acid\ test\ ratio_{it}$)		$Risk_{it}$= f ($Coverage\ ratio_{it}$)		Riskit= f ($Acid\ test\ ratio_{it}$)		$Risk_{it}$= f ($CEBI\ rating_{it}$)	
Parameter	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
$\Delta Invi_{t-1}$	-0.087 **	0.018	-0.090 **	0.018	-0.098 **	0.025	-0.099 **	0.026	-0.062 **	0.031	-0.062 **	0.031	-0.063 **	0.031
$\Delta Sales_{i,t}$	0.869 **	0.227	0.872 **	0.227	0.938 **	0.443	0.944 **	0.445	0.794 **	0.353	0.759 **	0.354	0.791 **	0.356
$\Delta Salesi_{,t-1}$	-0.107 **	0.026	-0.110 **	0.026	-0.011	0.022	-0.016	0.021	-0.050	0.038	-0.055	0.038	-0.049	0.038
$Invi_{,t-1}$ - $Sales_{i,t-1}$	-0.453 **	0.057	-0.457 **	0.056	-0.426 **	0.050	-0.424 **	0.058	-0.422 **	0.071	-0.413 **	0.072	-0.418 **	0.072
$Fini_{,t-1}$*$Risk_{it}$	-0.509 **	0.062	-0.623 **	0.038	-0.368 **	0.076	-0.453 **	0.033	-0.322 **	0.063	-0.532 **	0.039	-0.537 **	0.039
$Fin_{i,t-1}$*(1-$Risk_{it}$)	-0.395 **	0.035	-0.260 **	0.034	-0.279 **	0.030	-0.170 **	0.031	-0.335 **	0.034	-0.202 **	0.032	-0.292 **	0.034
Observations	27,578		27,578		29,446		29,446		28,304		28,304		28,304	
Number of firms	10,564		10,564		11,443		11,443		11,226		11,226		11,226	
m1 (p)	0.000		0.000		0.000		0.000		0.000		0.000		0.000	
m2 (p)	0.413		0.450		0.327		0.327		0.266		0.241		0.282	
Hansen (p)	0.703		0.738		0.199		0.200		0.573		0.509		0.527	
W_t (p)	0.000		0.000		0.000		0.000		0.006		0.006		0.007	

Notes: ** 5% significance level. Standard errors are robust to heteroskedasticity (Windmeijer correction). For all the tests p-values are reported. The *Fin* variable refers to leverage. Results as far as short term leverage and debt maturity are concerned are provide upon request. Refer to note 21 for estimation details.

Tab 8 - Dimensional aspects of the linkage between inventory investment and financial constraints: variants of models (1) and (2)

	1991-1997						1998-2003						2004-2009					
	(1) Dimensional dummies			(2) Dimensional dummies and $Risk_{it}$= f (Acid test $ratio_{it}$)			(1) Dimensional dummies			(2) Dimensional dummies and $Risk_{it}$= f (Acid test $ratio_{it}$)			(1) Dimensional dummies			(2) Dimensional dummies and $Risk_{it}$= f (Acid test $ratio_{it}$)		
Parameter	Coefficient		Std. Err.	Coefficient		Std. Err.	Coefficient		Std. Err.	Coefficient		Std. Err.	Coefficient		Std. Err.	Coefficient		Std. Err.
$\Delta Inv_{i,t-1}$	-0.089	**	0.019	-0.092	**	0.018	-0.097	**	0.025	-0.099	**	0.025	-0.057	**	0.029	-0.057	**	0.029
$\Delta Sales_{i,t}$	0.876	**	0.231	0.891	**	0.230	0.931	**	0.436	0.940	**	0.433	0.733	**	0.319	0.705	**	0.317
$\Delta Sales_{i,t-1}$	-0.111	**	0.027	-0.114	**	0.027	-0.012		0.021	-0.017		0.021	-0.052		0.037	-0.057		0.037
$Inv_{i,t-1}$ - $Sales_{i,t-1}$	-0.450	**	0.057	-0.458	**	0.056	-0.433	**	0.060	-0.427	**	0.059	-0.428	**	0.071	-0.419	**	0.071
$Fin_{i,t-1}$	-0.245	**	0.062				-0.051	**	0.091				-0.195	**	0.095			
$Fin_{i,t-1\_small}$	-0.304	**	0.083				-0.376	**	0.145				-0.247	**	0.119			
$Fin_{i,t-1\_medium}$	-0.095	**	0.039				-0.130	**	0.059				-0.051		0.066			
$Fin_{i,t-1}$*$Risk_{it\_small}$				-0.861	**	0.057				-0.670	**	0.082				-0.694	**	0.057
$Fin_{i,t-1}$*$Risk_{it\_medium}$				-0.543	**	0.048				-0.335	**	0.055				-0.431	**	0.057
$Fin_{i,t-1}$*$Risk_{it\_large}$				-0.351	**	0.069				-0.111	**	0.090				-0.292	**	0.106
$Fin_{i,t-1}$*$(1-Risk_{it})_{\_small}$				-0.365	**	0.044				-0.285	**	0.063				-0.281	**	0.041
$Fin_{i,t-1}$*$(1-Risk_{it})_{\_medium}$				-0.209	**	0.038				-0.086	**	0.046				-0.118	**	0.044
$Fin_{i,t-1}$*$(1-Risk_{it})_{\_large}$				-0.147	**	0.060				-0.009		0.093				-0.112		0.092
Observations	27,578			27,578			29,446			29,446			28,304			28,304		
Number of firms	10,564			10,564			11,443			11,443			11,226			11,226		
m1 (p)	0.000			0.000			0.000			0.000			0.000			0.000		
m2 (p)	0.464			0.507			0.305			0.315			0.312			0.274		
Hansen (p)	0.691			0.741			0.204			0.192			0.666			0.612		
W_t (p)	0.000			0.000			0.000			0.000			0.004			0.004		

Notes: ** 5% significance level. Standard errors are robust to heteroskedasticity (Windmeijer correction). For all the tests p-values are reported. The *Fin* variable refers to leverage. Results as far as short term leverage and debt maturity are concerned are provide upon request. Refer to note 8 or Appendix A for a definition of the dimensional threshold and to note21 for estimation details.

Tab 9 - The inclusion of Pavitt clusters' dummies in the linkage between inventory investment and financial constraints: variants of models (1) and (2)

	1991-1997				1998-2003				2004-2009			
	(1) Pavitt clusters		(2) Pavitt clusters and $Risk_{it}$= f (Acid $test_{it}$)		(1) Pavitt clusters		(2) Pavitt clusters and $Risk_{it}$= f (Acid $test_{it}$)		(1) Pavitt clusters		(2) Pavitt clusters and $Risk_{it}$= f (Acid $test_{it}$)	
Parameter	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
$\Delta Inv_{i,t-1}$	-0.088 **	0.019	-0.087 **	0.018	-0.099 **	0.026	-0.099 **	0.025	-0.064 **	0.031	-0.062 **	0.031
$\Delta Sales_{i,t}$	0.870 **	0.229	0.864 **	0.228	0.952 **	0.446	0.944 **	0.440	0.816 **	0.354	0.795 **	0.350
$\Delta Sales_{i,t-1}$	-0.107 **	0.027	-0.106 **	0.026	-0.012	0.021	-0.012	0.022	-0.052	0.038	-0.051	0.038
$Inv_{i,t-1}$ - $Sales_{i,t-1}$	-0.451 **	0.057	-0.452 **	0.057	-0.427 **	-0.059	-0.426 **	0.058	-0.421 **	0.071	-0.425 **	0.071
$Fini_{,t-1\_high\ techonology}$	-0.192 **	0.087			-0.211 **	0.104			-0.244 **	0.069		
$Fin_{i,t-1\_scale\ intensive}$	-0.345 **	0.051			-0.272 **	0.051			-0.207 **	0.046		
$Fini_{,t-1\_specialised\ suppliers}$	-0.386 **	0.082			-0.395 **	0.062			-0.355 **	0.052		
$Fin_{i,t-1\_traditional}$	-0.482 **	0.051			-0.238 **	0.049			-0.423	0.053		
$Fini_{,t-1}$*$Risk_{it\_high\ technology}$			-0.514 **	0.108			-0.434 **	0.208			-0.450 **	0.163
$Fin_{i,t-1}$*$Risk_{it\_scale\ intensive}$			-0.398 **	0.086			-0.302 **	0.087			-0.266 **	0.089
$Fini_{,t-1}$*$Risk_{it\_specialised\ suppliers}$			-0.587 **	0.133			-0.445 **	0.098			-0.313 **	0.092
$Fin_{i,t-1}$*$Risk_{it\_traditional}$			-0.545 **	0.064			-0.359 **	0.092			-0.354 **	0.068
$Fin_{i,t-1}$*(1-$Risk_{it}$)			-0.394 **	0.035			-0.279 **	0.030			-0.335 **	0.034
Observations	27,578		27,578		29,446		29,446		28,304		28,304	
Number of firms	10,564		10,564		11,443		11,443		11,226		11,226	
m1 (p)	0.000		0.000		0.000		0.000		0.000		0.000	
m2 (p)	0.393		0.401		0.310		0.311		0.267		0.267	
Hansen (p)	0.698		0.710		0.205		0.199		0.615		0.598	
W_t (p)	0.000		0.000		0.000		0.000		0.005		0.005	

Notes: ** 5% significance level. Standard errors are robust to heteroskedasticity (Windmeijer correction). For all the tests p-values are reported. The *Fin* variable refers to leverage. Results as far as short term leverage and debt maturity are concerned are provide upon request. Refer to note 21 for estimation details.

Table 10 – The inclusion of district dummies in the linkage between inventory investment and financial constraints: a variant of model (1)

Parameter	1991-1997 Coefficient		Std. Err.	1998-2003 Coefficient		Std. Err.	2004-2009 Coefficient		Std. Err.
$\Delta Inv_{i,t-1}$	-0.087	**	0.019	-0.099	**	0.026	-0.065	**	0.031
$\Delta Sales_{i,t}$	0.872	**	0.230	0.950	**	0.449	0.832	**	0.355
$\Delta Sales_{i,t-1}$	-0.108	**	0.027	-0.011		0.022	-0.054		0.038
$Inv_{i,t-1}$ - $Sales_{i,t-1}$	-0.454	**	0.057	-0.427	**	0.059	-0.419	**	0.072
$Fin_{i,t-1\_ \text{industrial districts}}$	-0.481	**	0.099	-0.317	**	0.066	-0.453	**	0.089
$Fin_{i,t-1\_ \text{rest of the sample}}$	-0.382	**	0.034	-0.272	**	0.034	-0.311	**	0.032
Observations									
Number of firms	27,578			29,446			28,304		
m1 (p)	10,564			11,443			11,226		
m2 (p)	0.000			0.000			0.000		
Hansen (p)	0.402			0.323			0.268		
W_t (p)	0.000			0.000			0.005		

Notes: ** 5% significance level. Standard errors are robust to heteroskedasticity (Windmeijer correction). For all the tests p-values are reported. The *Fin* variable refers to leverage. Results as far as short term leverage and debt maturity are concerned are provide upon request. Refer to note 21 for estimation details.

5.3 Estimates from the inclusion of recessionary dummies and further tests

To explore more in detail how the link between inventory investment and financial constraints behaved during recessionary periods the introduction of recessionary dummies has been considered. As already mentioned in Section 3, recessionary dummies equal 1 in the years 1993, 1996, 2002, 2003, 2008 and 2009 and 0 otherwise.

To isolate the impact of recessionary dummies on the inventory path, an interaction is made with the variable *Fin*. Reference is made to model (3).

In line with the findings from Bagliano *et al.*, regression results for the first panel dataset (1991-1997) show that the effects on firms being financially constrained are higher during the early Nineties' recessionary peaks (1993 and 1996) than during non-recessionary years in the same panel, while implications from the other variables remain the same (Tables 11a and 11b). Being the early Nineties recession triggered by tightening monetary policy, this may support the thesis of the existence of a 'financial accelerator channel' acting in the sense of amplifying the effects of financial frictions over the real side of the economy. The phenomenon is particularly evident for small firms and for firms segmented by risk separation criteria, that act in the sense of better identifying firms that are actually financial constrained (Table 12). Reference is made to model (4).

The application of models (3) and (4) to the other more recent datasets reveals instead a not significant effect of recessionary dummies in capturing additional inventory investment variability. The result is preserved also in case of interaction with extra dummies (dimensional dummies and risk dummies): firms, especially smaller and riskier ones, are still in a position to show a negative elasticity of inventory investment to financial frictions but no additional effects are found during recessionary peaks, acting in the sense of boosting stock-out phenomena in inventories, with respect to other non-recessionary years in the sample. Preliminary results obtained from testing the inventory investment framework over a panel dataset including the 2010 year confirm the before-presented estimates.

This prepares the ground for different interpretations. First of all, it should be noted how the 2002-2003 biennium did represent a period of soft slowdown of the Italian economy if

compared to the deep crisis that characterized instead the early Nineties. This is the reason why it is sometimes hardly to be defined a real recessionary shock. The fast recovery that followed may in fact have partly offset the liquidity tensions and, in turn, the effects over the decreasing trend in inventories. By contrast, the deep crisis that affected Italy during the 2008-2009 biennium is assigned several peculiarities with respect to the previous-analyzed recessionary shocks. It found its roots in big disequilibria in international financial markets. Moreover, it occurred after a period of prolonged growth in the Italian industrial manufacturing production, so it might be considered, from the one hand, a more unexpected shock compared to other recessionary shocks in the past. Before the burst of the 1993 crisis, Italy was instead involved in the process of fulfilling the conditions required to join the Monetary Union and restrictive monetary policies were in place. The arguments called into question to explain a failure of recession dummies in capturing additional inventory reaction to financial frictions are twofold: either banks did not change their behavior compared with expansion years (i.e. they kept granting credit to firms deserving it) or firms used inventory decumulation to generate internal financing to a lesser extent compared to the past. The first hypothesis is quite hard to be trust. If it is true that several interventions did characterize that recessionary period, with the aim of supporting small and medium-size enterprises in the process of restructuring their credit lines, and reducing so far liquidity tensions, it should be noted how widespread difficulties in entering new credit did affect firms, especially the smallest ones. Confirmations in this respect came from the results of the several surveys conducted in those months by the Bank of Italy. Furthermore, according to the Bank Landing Survey conducted by the European Central Bank, the 2008-2009 biennium did represent, as a matter of fact, a period of harsh conditions on the credit market. To test the second hypothesis (i.e. the fact that firms might have referred to inventory stock-out to a lesser extent during the 2008-2009 crisis, to generate liquidity) a revised version of our baseline model (1) has been tested on the last panel dataset, with a proxy for liquidity frictions in place of the variable *Fin* (the one identifying the strength of financial constraints). As stated previously in the paper, proxy variables which make use of liquidity measures are likely to refer to short-run tensions at firm level. The selected proxy is the ratio of cash and marketable securities to total assets, defined at the beginning of the period (t-1, exogeneity assumption) to avoid simultaneity problems ($LIQ_{i,t-1}$). All the other variables and implications from the baseline model considered so far in the paper remained the same. The approach is similar to the one followed by Choi *et al.* We expect a positive coefficient associated to the liquidity proxy in order for the inventory investment to be liquidity constrained. Furthermore, in order to investigate whether or not there was room for firms to generate liquidity from internal sources either than inventories, we tested the presence of a significant negative relationship between inventories and alternative classes of firm capital, like fixed capital and financial assets, in addition to the liquidity proxy[27]. See Fazzari *et al.* (1993). Both fixed capital and financial assets were scaled by total assets when included in the regression equation. Further interactions were performed with the proxies described so far (*LIQ*, financial assets and fixed capital) and the recession dummy to isolate recessionary effects.

$$\Delta Inv_{it} = \alpha + \beta_0 * \Delta Inv_{i,t-1} + \beta_1 * \Delta Sales_{it} + \beta_2 * \Delta Sales_{i,t-1} + \beta_3 * (Inv_{i,t-1} - Sales_{i,t-1}) +$$

$$+ \beta_4 * LIQ_{i,t-1} + \beta_5 * Financial\_assets_{it} + \beta_6 * Fixed\_capital_{it} + \mu_i + \mu_t + \mu_j + u_{it} \qquad (5)$$

Regression results (Table 13) found evidence of a positive and statistically significant coefficient associated to the proxy $LIQ_{i,t-1}$ in the analyzed period (2004-2009). Moreover, when allowing for the effects of the liquidity proxy to vary over time, just interacting *LIQ* with the recession dummy, evidence was found of a higher sensitivity of inventory investment to liquidity tensions

[27] Both the proxies for financial assets and fixed capital are included in the model at time t. Being considered at least predetermined, they have been instrumented with lags t-2 backward in the GMM-routine.

in the 2008-2009 biennium. In addition, we found evidence of a negative and significant relationship between inventory investment and financial assets, which was higher during the 2008-2009 recessionary shock. Evidences of the above considerations are present in the Annual Report released by the Bank of Italy on May 2010, where it is clearly stated that huge disinvestments in financial assets (around 21 billions for the Italian firms belonging to the non-financial sector) did characterize the 2008-2009 biennium. The inclusion of fixed capital among the regressors resulted into the identification of a weak negative relationships with inventory investment, which was significant only during the before mentioned recessionary biennium. In light of the above, we may argue that disinvestments in financial assets did represent in that period one of the main drivers adopted to ease liquidity tensions at firm level. Another alternative or complementary explanation for the proposed results encompasses the harshness of the 2008-2009 recessionary shock for the Italian economy. It might be that it affected the manufacturing framework in such an unpredictable way to cause a paralysis of the system - at least during the first stage of the recession phase – and to prevent a sudden reaction in terms of inventory decumulation. Prolonged recessionary effects were induced over the international commerce of manufacturing goods, with a substantial reduction in commercial flows and firms, even the most open to international trade, found it difficult to adopt effective strategies to contrast the falls in sales and production. In correspondence to some manufacturing sectors of activity, in fact, the descending trend in inventories kept being visible even in the first quarter of 2010. This may corroborate, as a matter of fact, our previous findings as far as financial disinvestments are concerned. Nevertheless, the lack of quarterly data on balance sheets[28] makes it difficult to test this hypothesis.

[28] The majority of the Italian firms belonging to the manufacturing sector are requested to provide only certified annual data.

Tab11a - Inventory investment and financial constraints: the inclusion of recessionary dummies, models (3) and (4) - panel (1), 1991-1997 and panel (2), 1998-2003

	1991-1997						1998-2003					
	(1) Recessionary dummies			(2) Recessionary dummies and $Risk_{it}$= f (Coverage $ratio_{it}$)			(3) Recessionary dummies and $Risk_{it}$= f (Acid $test_{it}$)			(1) Recessionary dummies			(2) Recessionary dummies and $Risk_{it}$= f (Coverage $ratio_{it}$)			(3) Recessionary dummies and $Risk_{it}$= f (Acid $test_{it}$)		
Parameter	Coefficient		Std. Err.	Coefficient		Std. Err.	Coefficient		Std. Err.	Coefficient		Std. Err.	Coefficient		Std. Err.	Coefficient		Std. Err.
$\Delta Inv_{i,t-1}$	-0.087	**	0.018	-0.087	**	0.018	-0.090	**	0.018	-0.098	**	0.025	-0.098	**	0.025	-0.095	**	0.025
$\Delta Sales_{i,t}$	0.858	**	0.229	0.868	**	0.227	0.876	**	0.227	0.929	**	0.440	0.937	**	0.442	0.924	**	0.438
$\Delta Sales_{i,t-1}$	-0.106	**	0.027	-0.107	**	0.026	-0.111	**	0.026	-0.011		0.022	-0.113		0.022	-0.017		0.021
$Inv_{i,t-1}$ - $Sales_{i,t-1}$	-0.448	**	0.057	-0.454	**	0.057	-0.460	**	0.056	-0.427	**	0.058	-0.427	**	0.058	-0.436	**	0.057
$Fin_{i,t-1}$	-0.390	**	0.034							-0.276	**	0.035						
$Fin_{i,t-1}$*$Recess_{it}$	-0.039	**	0.012							-0.004		0.019						
$Fin_{i,t-1}$*$Risk_{it}$*$Recess_{it}$				-0.544	**	0.070	-0.635	**	0.039				-0.337	**	0.079	-0.404	**	0.036
$Fin_{i,t-1}$*$Risk_{it}$*(1-$Recess_{it}$)				-0.473	**	0.064	-0.612	**	0.039				-0.407	**	0.090	-0.484	**	0.035
$Fin_{i,t-1}$*(1-$Risk_{it}$)				-0.394	**	0.035	-0.257	**	0.033				-0.279	**	0.030	-0.160	**	0.030
Observations	27,578			27,578			27,578			29,446			29,446			29,446		
Number of firms	10,564			10,564			10,564			11,443			11,443			11,443		
m1 (p)	0.000			0.000			0.000			0.000			0.000			0.000		
m2 (p)	0.403			0.411			0.457			0.312			0.323			0.292		
Hansen (p)	0.691			0.702			0.751			0.203			0.202			0.238		
W_t (p)	0.000			0.000			0.000			0.000			0.000			0.000		

Notes: ** 5% significance level. Standard errors are robust to heteroskedasticity (Windmeijer correction). For all the tests p-values are reported. The *Fin* variable refers to leverage. Results as far as short term leverage and debt maturity are concerned are provide upon request. Refer to note 21 for estimation details. Recessionary dummies equal 1 in 1993 and 1996 for panel (1) and in the 2002-2003 biennium for panel (2). Refer to Appendix B for a definition of the main variables of interest in the table.

Table 11b - Inventory investment and financial constraints: the inclusion of recessionary dummies, models (3) and (4) – panel (3) 2004-2009

	(1) Recessionary Dummies			(2) Recessionary Dummies and $Risk_{it}$= f(Coverage $ratio_{it}$)			(3) Recessionary Dummies and $Risk_{it}$= f(Acid test $ratio_{it}$)			(4) Recessionary Dummies and $Risk_{it}$= f(CEBI $rating_{it}$)		
Parameter	Coefficient		Std. Err.	Coefficient		Std. Err.	Coefficient		Std. Err.	Coefficient		Std. Err.
$\Delta Inv_{i,t-1}$	-0.061	**	0,031	-0,062	**	0,031	-0,058	**	0,031	-0,062	**	0.031
$\Delta Sales_{i,t}$	0.779	**	0.354	0.794	**	0.353	0.752	**	0.353	0.791	**	0.356
$\Delta Sales_{i,t-1}$	-0.052		0.038	-0.051		0.038	-0.054		0.038	-0.049		0.038
$Inv_{i,t-1}$ - $Sales_{i,t-1}$	-0.425	**	0.072	-0.422	**	0.071	-0.425	**	0.070	-0.421	**	0.070
$Fin_{i,t-1}$	-0.316	**	0.037									
$Fin_{i,t-1}$*$Recess_{it}$	-0.026	**	0.014									
$Fin_{i,t-1}$*$Risk_{it}$*$Recess_{it}$				-0.320	**	0.066	-0.514	**	0.040	-0.532	**	0.042
$Fin_{i,t-1}$*$Risk_{it}$*(1-$Recess_{it}$)				-0.326	**	0.082	-0.549	**	0.041	-0.542	**	0.045
$Fin_{i,t-1}$*(1-$Risk_{it}$)				-0.335	**	0.034	-0.200	**	0.032	-0.291	**	0.034
Observations	28,304			28,304			28,304			28,304		
Number of firms	11,226			11,226			11,226			11,226		
m1 (p)	0.000			0.000			0.000			0.000		
m2 (p)	0.266			0.266			0.253			0.283		
Hansen (p)	0.573			0.573			0.479			0.524		
W_t (p)	0.004			0.006			0.006			0.008		

Notes: ** 5% significance level. Standard errors are robust to heteroskedasticity (Windmeijer correction). For all tests p-values are reported. The *Fin* variable refers to leverage. Results as far as short term leverage and debt maturity are concerned are provide upon request. Please refer to note 21 for estimation details. Recessionary dummies equal 1 in the biennium 2008-2009. Refer to Appendix B for a definition of the main variables of interest in the table.

Table 12 – Inventory investment and financial constraints: dimensional and recessionary dummies, variants of model (3)

	1991-1997			1998-2003			2004-2009		
Parameter	Coefficient		Std. Err.	Coefficient		Std. Err.	Coefficient		Std. Err.
$\Delta Inv_{i,t-1}$	-0.086	**	0.019	-0.096	**	0.025	-0.072	**	0.064
$\Delta Sales_{i,t}$	0.821	**	0.222	0.969	**	0.434	0.689	**	0.423
$\Delta Sales_{i,t-1}$	-0.105	**	0.027	-0.018		0.022	-0.047		0.043
$Inv_{i,t-1}$ - $Sales_{i,t-1}$	-0.442	**	0.057	-0.447	**	0.060	-0.359	**	0.182
$Fin_{i,t-1}$	-0.403	**	0.034	-0.276	**	0.035	-0.324	**	0.052
$Fin_{i,t-1}$*$Recess_{it}$	-0.041	**	0.017	0.054		0.030	-0.018		0.027
$Fin_{i,t-1}$*$Recess_{it\ small}$	-0.048	**	0.016	-0.074	**	0.022	-0.057		0.039
$Fin_{i,t-1}$*$Recess_{it\ medium}$	-0.028	**	0.013	0.033		0.022	0.022		0.029
Observations	27,578			29,446			28,304		
Number of firms	10,564			11,443			11,226		
m1 (p)	0.000			0.000			0.000		
m2 (p)	0.440			0.297			0.210		
Hansen (p)	0.681			0.245			0.756		
W_t (p)	0.000			0.000			0.004		

Notes: ** 5% significance level. Standard errors are robust to heteroskedasticity (Windmeijer correction). For all the tests p-values are reported. The *Fin* variable refers to leverage. Results as far as short term leverage and debt maturity are concerned are provide upon request. Please refer to note 21 for estimation details and to note 8 or Appendix A for a definition of the dimensional thresholds. Recessionary dummies equal 1 in 1993 and 1996 (first panel), in the 2002-2003 biennium (second panel) and in the 2008-2009 biennium (third panel).

Table 13 - Inventory investment and liquidity constraints: the role of financial assets and fixed capital during the 2008-2009 recessionary shock: panel (3), 2004-2009

Parameter	Coefficient		Std. Err.
$\Delta Inv_{i.t-1}$	-0.081	**	0.044
$\Delta Sales_{i.t}$	0.712	**	0.088
$\Delta Sales_{i.t-1}$	-0.059		0.033
$Inv_{i.t-1}$ - $Sales_{i.t-1}$	-0.322	**	0.162
$LIQ_{i.t-1}$*$Recess_{it}$	0.875	**	0.173
$LIQ_{i.t-1}$*No_Recess_{it}	0.644	**	0.148
Financial $assets_{i.t}$*$Recess_{it}$	-0.548	**	0.138
Financial $assets_{i.t}$*No_Recess_{it}	-0.477	**	0.144
Fixed $capital_{i.t}$*$Recess_{it}$	-0.046	**	0.010
Fixed $capital_{i.t}$*No_Recess_{it}	-0.015		0.009
Observations	28,304		
Number of firms	11,226		
m1 (p)	0.000		
m2 (p)	0.288		
Hansen (p)	0.931		
W_t (p)	0.004		

Notes: ** 5% significance level. Standard errors are robust to heteroskedasticity (Windmeijer correction). For all the tests p-values are reported. The Recession dummy is equal to 1 in the 2008-2009 biennium. Please refer to note 21 with estimation details. Both the variables financial assets and fixed capital are treated as predetermined in the regression equation and thus instrumented with lags t-2 backward.

6. Conclusive remarks

We have exploited three large unbalanced panel datasets of Italian manufacturing firms observed over the period 1991-2009 to assess whether the existence of financial constraints is suitable to explain short-run deviations of inventory investment from its long-run path.

In line with previous studies on the subject, empirical results suggest that financial constraints affect negatively the inventory investment behavior once controlling for sales, for the influence of a long-run target inventory level (which gives the model an error-correction format) and for other control variables (i.e. time dummies). The results are robust to the adoption of different definitions of the variable that proxies for financial burdens at firm level (leverage, short-term leverage and debt maturity). We discarded 'a priori' the inclusion of proxies for the strength of financial constraints based on the cash flow variables, due to collinearity effects with the Sales variables in our error-correction model, as well as of proxies which make use of liquidity measures - being more suitable to identify short-run tensions at firm level.

Moreover, in order to explore in detail whether the sensitivity of inventory investment to financial constraints may differ among groups of firms displaying different risk characteristics, we allowed the coefficient associated to our financial proxy to vary across firms segmented by risk separation criteria. Dimensional dummies are suitable to identify firms that are more likely to face financial constraints in a traditional sense. Inventory investment was found to be more sensitive to financial frictions in correspondence to small firms in the sample. Moreover, firms were assigned a risk dummy on the basis of three additional separation criteria: the first two variables come from the balance sheets (the coverage ratio and the acid test ratio) and the third one is a multivariate proxy for risk (CEBI-Centrale dei Bilanci ratings). Estimates provide evidence that, as a general practice, the negative elasticity of inventory investment to financial burdens is higher for riskier firms, despite the reduced discriminating power of the coverage ratio in isolating financially constrained firms in the last panel dataset. The widespread difficulties faced by firms during the 2008-2009 recessionary shock might provide an explanation for the result. The dimensional aspect of the inventory investment-financial constraints linkage was preserved also in case additional variability was introduced in the financial proxy, i.e. by interacting dimensional dummies and risk dummies. Bigger firms were assigned a lower (or at least equal) coefficient with respect to small risk-free firms in the sample.

Dimensional effects were also employed to explain the results obtained from testing the inventory investment model over subsets of firms segmented by Pavitt clusters of industrial activities and by industrial districts. A more pronounced sensitivity of inventory investment to financial frictions was found for firms belonging to traditional sectors of activity - that typically rely to the industrial districts agglomeration economies in the Italian manufacturing framework - whose production base composition is more likely to be affected by the presence of small firms.

To explore more in detail how the link between inventory investment and financial constraints behaved during recessionary periods the introduction of recessionary dummies was considered. The inclusion of such dummies was suitable to detect a greater sensitivity of inventory investment to financial frictions during the early Nineties recession (additional recessionary effects during the 1993 and the 1996 peaks). To the extent that the early Nineties recession was triggered by monetary policy tightening, these findings may support the 'financial accelerator' argument of an active role played by financial frictions in amplifying recessionary effects over the real side of the economy. By contrast, the phenomenon was found to be almost absent during the most recent recessionary episodes (the 2002-2003 biennium and the 2008-2009 phase): recessionary dummies failed in capturing additional inventory investment variability, despite being inventory investment still suitable to show a negative linkage with financial frictions over the entire analyzed period (1998-2009). The results were preserved also in the case of

exploitation of dimensional dummies and of dummies representing intrinsic riskiness of firms. It should be noted how the less pervasive feature of the 2002-2003 economic slowdown might have reflected in less pronounced liquidity tensions at firm level, especially because of the fast recovery that followed in terms of industrial production. By contrast. the deep crisis that occurred in the 2008-2009 biennium was marked by peculiarities that might prepare the ground for different interpretations of the results. Despite the several interventions that took place in the credit market in order to ease liquidity tensions, an hypothesis of financial constraints whose strength kept remaining unaltered during such a severe recessionary shock is quite hard to be trust. In light of the above, we tested the alternative hypothesis that firms relied to inventory decumulation to a lesser extent with respect to the past, because of the adoption of buffer strategies involving other types of firm capital. In particular, we tested a modified version of the error-correction model employed in the previous part of the paper, with a liquidity proxy in place of the variable proxying for financial constraints. Liquidity proxies are suitable to shed light on the existence of short-run liquidity tensions at firm level. Moreover, the model was augmented for variables capturing the (expected negative) relationship between our dependent variable, inventory investment and both financial assets and fixed capital. As a result of the performed regressions, disinvestments in financial assets were found to represent one of the main drivers for liquidity accumulation during the 2008-2009 recessionary shock. By contrast, only a weak negative relationship was detected between fixed capital and inventory investment.

The challenging exit strategies that are going to influence the Italian economic framework during the next coming years might create room for additional research in this field. The 2012 slowdown of the Italian economy has come after a period characterized by severe reduction in the value of collateralizable assets at firm level, as well as of increased liabilities. It could therefore turn out to be suitable to shed light on differences in terms of inventory investment behavior with respect to the latest analyzed shock.

Appendix A

The construction of the unbalanced panels of firms

As a preliminary step a unique unbalanced panel of Italian manufacturing firms has been constructed for the period 1991-2009, including all the annual balance sheets available in the Intesa Sanpaolo Research Department's database on corporate customers[29]. Consolidated balance sheets have been discarded, as well as micro-firms[30] in order to achieve more stabilization in the data. To isolate manufacturing firms we referred to the Ateco_2002 classification for industrial activities (codes from DA.15 to DN.36)[31].

Data at firm level have been granted a continuity of 4 years in order to make it possible the application of the dynamic GMM 'first-difference'. Firms that were not in a position to satisfy the condition had been removed from the sample. Moreover, the elimination of outliers (1st and 99th percentiles of the distribution of the main variables of interest in our analysis. such as inventories - as a ratio to sales – sales in growth terms and the variables that proxy for financial pressure – leverage, short leverage and debt maturity) have induced a further reduction in the original sample size[32].

At this point, the unique dataset has been split into three distinct datasets, each one referring to a different time period (1991-1997. 1998-2003 and 2004-2009) and each one including one of the recessionary episodes described in the previous sections (and consequently recessionary dummies). By operating with disjoint datasets it is possible to control for errors in collecting qualitative information on firms in the original database on corporate customers (i.e. the 'sector of activity' may erroneously varies in one year with respect to the others) by attributing a unique prevalent 'label' for each qualitative variable in each selected period. More specifically, this approach has been adopted for the variables 'sector of activity' (2-digit Ateco_2002), clusters in the Pavitt classification and industrial districts membership.

Once the label for the prevalent 'sector of activity' has been assigned, the inflationary component has been removed from the inventories and sales series by means of a production price index at 3-digit level, coming from the forecasting model for industrial sectors' performances developed by Prometeia SpA[33]. Moreover, the transformation in logarithms of the variables in the applied econometric model (inventories. sales and proxies for financial pressure) allows the interpretation of the estimated coefficients as elasticities and reduces the problems which may arise in the utilization of different measurement scales.

In addition, firms in each dataset have been segmented on the basis of the amount of sales in each year with the purpose of being assigned a dimensional cluster. The European Commission's thresholds have been adopted to identify small, medium and large firms in the 2000-2009

[29] The Intesa Sanpaolo Research Department's database includes all the balance sheets of Intesa Sanpaolo's corporate customers reclassified according to CEBI (Centrale dei Bilanci) criteria. CEBI is the main collector of Italian firms' balance sheets.

[30] Firms with sales under the threshold of 1.5 Euro millions during the Nineties and 2 Euro millions in the most recent years are referred as 'micro'.

[31] Ateco_2002 is the Italian version of NACE Rev.1.1 classification defined by the European Union.

[32] Firms who presented a negative amount of shareholders' funds have been discarded. Moreover, firms with debt maturity exactly equal to 0 (when short-term debt is 0) or 1 (when long-term debt is 0) have been removed from the sample.

[33] The estimates of the models, as far as the main Italian manufacturing sectors are concerned, are published periodically in the report ASI (Industrial Sectors Analysis) edited by Intesa Sanpaolo SpA and Prometeia SpA.

period while the above mentioned thresholds have been adjusted downward to correctly identify the Italian industrial market structure during the Nineties.

From 1991 to 1999 (data in Euro millions):

- Small firms: $1.5 \leq \text{sales} < 7$
- Medium-size firms: $7 \leq \text{sales} < 40$
- Large firms: $\text{sales} \geq 40$

From 2000 onwards (European Commission's thresholds. in Euro millions):

- Small firms: $2 \leq \text{sales} < 10$
- Medium-size firms: $10 \leq \text{sales} < 50$
- Large firms: $\text{sales} \geq 50$

Last but not least, a stratification of firms by 'sector of activity' (2-digit Ateco_2002) has been performed, in order to make datasets comparable each other. More specifically, the original datasets (panels 1998-2003 and 2004-2009) were characterized by a proliferation of small and medium-size firms with respect to the situation during the Nineties. To smooth such a phenomenon, a random sampling by 'sector of activity' has been performed, as far as these two clusters of firms are concerned. In other words, we have forced sectorial variability in the two most recent panels to be comparable to the one in the first panel of firms (1991-1997).

At the end we were left with three unbalanced datasets of 10.564 manufacturing firms (for the period 1991-1997), 11.443 firms (1998-2003) and 11.226 firms (2004-2009).

Appendix B

Definition of the main variables of interest in the analysis (numbers refer to the Centrale dei Bilanci framework)

Acid test ratio: the ratio of current assets (item 3.22) net of inventories (items 3.12 and 3.13, raw materials, intermediate inputs and finished products) to current liabilities (item 4.35).

CEBI (Centrale dei Bilanci) rating: the expression of the likelihood of company failure in the twelve months following the date of release of the score. It is, as a matter of fact, an assessment of the credit worthiness of corporations calculated periodically by the main collector of firms' balance sheets in Italy (Centrale dei Bilanci) on the basis of both economic and financial characteristics of the firms under scrutiny. A firm is considered 'risky' when the score varies between 5 (vulnerability) and 9 (very high risk) according to the following ranking:

1. High credit worthiness;
2. Good credit worthiness;
3. High solvency;
4. Solvency;
5. Vulnerability;
6. High vulnerability;
7. Risky;
8. High risk;
9. Very high risk.

Coverage ratio: the ratio of the interests paid on debt (item 6.23) to EBITDA[34] (item 6.11).

Debt maturity: the ratio of short term debt (items 4.28 short term financial debt and 4.31 trade credit) to total debt (items 4.24 consolidated debt. 4.28 short term financial debt and 4.31 trade credit).

Financial assets: investment in fixed financial assets (item 3.09). It enters the regression equation scaled by total assets (item 3.23).

Fixed capital: the sum of tangible and intangible assets (items 3.01 and 3.02). It enters the regression equation scaled by total assets (item 3.23).

Inventories: include raw materials, intermediate inputs and finished products (the sum of the items 3.12 and 3.13).

Liquidity proxy: includes cash (item 3.20) and marketable securities (item 3.19). It enters the regression equation scaled by total assets (item 3.23).

[34] Earnings before interests, taxes, depreciation and amortization.

Leverage: the ratio of short and long term debt (items 4.24 consolidated debt. 4.28 short term financial debt and 4.31 trade credit) to total liabilities, including debt and shareholders' funds (items 4.24. 4.28. 4.31. 4.13 approved profits distributions and 4.15 net assets).

Sales: real sales are obtained by deflating the 6.1 item by mean of a 3-digit sectorial production price index coming from the Prometeia SpA econometric forecasting model for industrial sectors' performances.

Short-term leverage: the ratio of short term debt (items 4.28 short term financial debt and 4.31 trade credit) to total liabilities, including debt and shareholders' funds (items 4.28. 4.31. 4.13 approved profits distributions and 4.15 net assets).

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