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CAPITAL STRUCTURE AND INNOVATION: CAUSALITY AND DETERMINANTS

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Abstract:
It is widely recognized that a firm s financial behaviour is the result of a complex mix of conditions, both internal and external to the firm: these may affect its investment decisions and its growth opportunities. This paper offers a twofold contribution to the empirical debate on the financing of innovation. First of all, it provides a comprehensive descriptions of possible simultaneous patterns which may affect a firm s relevant dimensions, namely innovation inputs, innovation output, leverage and profitability. By using a Granger-Causality framework we will show that a firm s leverage does not cause innovation output, as proxied by a measure of a firm s successful innovation, while it is rather caused by successful innovation and a firm s operating profitability.
The second contribution is an original investigation of the determinants of a firm s capital structure based on a panel dataset which links the third Community Innovation Survey with an administrative data source providing economic and financial information collected from balance sheets and income statements referring to the period 1996-2003.
This paper provides support for the Pecking Order theory as our firms are less indebted when operating profitability increases, but the use of external funding increases with their innovative effort. We also find support for the existence of credit constrains which seem to affect small innovative firms when compared with larger

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Keywords: Capital Structure - Innovation · Profitability - Community Innovation Survey · Panel data

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1. Introduction

The financing of an innovative project may take years before producing economic returns and a firm which is willing to catch growing opportunities through innovation may not have the internal resources needed to cover the entire cost of such an investment. However in an "imperfect" world, dominated by asymmetric information, bankruptcy risks and agency conflicts, external financing may be highly costly. Following this setting, a consistent part of the literature has investigated the relationships between financial factors and a firm's investment decisions. (Fazzari, Hubbard and Petersen, 1988; Hubbard, 1998). It has been argued that financial constrains should affect more

severely R&D investments because of the high degree of uncertainty characterizing innovation output. There is also evidence that such constraints may have different impacts depending on firm specific characteristics such as size and its age or institutional factors (Hall, 2002).

Much of the empirical work on the relationship between a firm's financing and innovation assumes the common wisdom that the direction of causality goes from finance to innovation. However, there is room to believe that the opposite may be at work, given that when innovative projects are able to open up opportunities, there could be a demand for specific financial instruments, thus affecting a firm's capital structure. The possible implications of this opposite interpretation could be of great interest when empirical investigations are specifically focused on the role of equity financing, in particular venture capital. Support for the reverse causation hypothesis, i.e. that innovation Granger causes financial decisions, has been found at both the country and sectoral level (Ueda and Hirukawa (2003); Geronikolaou and Papachristou, 2008). However, further investigation is fundamental, in order to better clarify the inner nature of the financing choice-innovation relationship. In particular, firm-level investigation and the use of different proxies for both financial behaviour and innovation may provide a more clear-cut picture of the possible causality.

Empirical evidence on the determinants of capital structure is extensive (see Harris and Raviv, 1991, for a comprehensive review). One of the most relevant difficulties when studying a firm's capital structure is represented by the choice of the variables which could adequately proxy, on the one hand, a firm's leverage and, on the other, the specific attributes which according to theoretical suggestions may affect that structure. As regards leverage, accounting measures such as the debt-to-assets ratio or the debt-to-equity ratio have been used extensively.

A substantial stream of empirical works has specifically investigated the role of firm- and industry-specific characteristics in determining a firm's leverage (Bradley et al., 1984; Titman and Wessel, 1988), whereas there is relatively little empirical evidence on the role of a firm's innovative behaviour. These models predict that leverage decreases with profitability (Hovakimian et al., 2001; Aghion et al., 2004; Heyman et al., 2008; Magri, 2009) and, also, with alternative measures of internal resources (Colombo and Grilli, 2006). Conversely, the effect of innovation remains ambiguous. Some empirical studies suggest that leverage is negatively related to R&D efforts (Aghion et al.; Hovakimian et al., 2001); however, other investigations support the view of credit rationing as seeming to affect more the small innovative firms compared to larger enterprises within the manufacturing sector (Ughetto, 2008; Magri, 2009; Colombo and Grilli, 2006). Actually, there

is still lack of evidences based on other measures than R&D expenditures, in order to fully capture the effects of a firm's innovative propensity.

One important implication from this strand of empirical literature is suggested by the argument in favour of the 'pecking order' model proposed by Myers and Majluf (1984). More specifically, there is a hierarchy of financing sources available. Firms' preferred option for financing new investments is internal resources, provided that an adequate flow of retained earning is available. When the amount of internally-generated funds is not sufficient and external resources are required, firms prefer debt financing, which is less costly; equity will only be used as the last option.

This paper offers a twofold contribution to the empirical debate on the financing of innovation. First of all, it provides a comprehensive descriptions of possible simultaneous patterns which may affect a firm's relevant dimensions, namely innovation inputs, innovation output, leverage and profitability. By using a Granger-Causality framework we will show that a firm's leverage does not cause innovation output, as proxied by a measure of a firm's successful innovation, while it is rather caused by successful innovation and a firm's operating profitability.

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The paper proceeds as follow. A description of the data is presented in Section Two, together with the presentation of our final panel of firms. The adoption of the debt to assets ratio as a measure for a firm's capital structure is also motivated. In section 3 causality patterns of our relevant variables are explored, while in section 4 we present our empirical model for a firm's capital structure and discuss the econometric results. Section 5 provides a summary of the main findings and concludes the paper.

2. Data description

The main source of information is represented by a panel dataset which links the third Community Innovation Survey (CIS3) with an administrative data source providing economic and financial information collected from balance sheets and income statements referring to the period 1996-2003

for those firms included in the CIS3 sample of respondents. Our final sample is represented by a balanced panel of 2,591 industrial firms, corresponding to 20,728 non-missing observations (see below). The firms' sectoral and geographical distribution is described in Appendix1, where a comparison with the CIS3 sample of respondents is provided. Descriptive statistics of the relevant accounting ratios are provided in Appendix 2.

The process of selecting the firms

n. of observations	n. of firms	
73,336	**9,167**	**industrial firms in the CIS3 sample of respondents**
17,280 (-)	*2,160 (-)*	*of which: with no balance sheet information*
56,056	7,007	firms with at least one year of valid balance sheet information
6,024 (-)	*753 (-)*	*of which: firms entering and/or exiting the market during the period*
50,032	6,254	industrial firms: balanced panel
19,952 (-)	*2,494 (-)*	*firms with missing values during the 1996-2003 period for the set of relevant variables*
30,080	3,760	industrial firms with no missing information
9,352 (-)	*1,169 (-)*	discarded outliers
20,728	**2,591**	**final panel of industrial firms**

In order to derive additional information about the firm's innovative status during the entire time span, the CIS3 sample of respondents was merged with the CIS1 and CIS2 samples of respondents covering, respectively, the periods 1994-96 and 2002-04.

Combining three CIS waves inevitably leads to a considerable drop in the number of firms, as CIS3 and CIS4 samples include the services sector, whereas the CIS2 sample covered exclusively the industrial sector. As we intend to work with the three-wave panel, our attention has to be limited to the industrial sector, which corresponds to 9,197 firms. Beyond this, CIS information for the period 1994-96 and 2002-04 is not available for every firm in the panel. The variable reflecting innovative status is thus available for the entire period for a small subset of the firms in the CIS3 sample of respondents. Limiting analysis to this subset of firms may seriously affect the robustness of results if one is interested in analysing the innovation-performance relationship at the firm level. It was thus decided to estimate the innovative status of the missing observations. This is pursued using a Multiple Imputation approach (Rubin, 1987). [1]

A firm's leverage is defined as the percentage ratio of total debt to total assets. Following the relevant empirical literature, this can be considered a measure of the extent to which a firm uses borrowing instead of equity in order to finance its activity. It is worth recalling that our leverage index does not allow us to distinguish between different categories of debt according to the maturity

[1] The Multiple Imputation Approach to the estimation of missing values for the innovation variable is focused in a specific chapter of my PhD thesis. Further details are available on request.

structure or the typology of lender (banks or other financial institutions). However, we believe this indicator could be adequate for describing the financial choices of our panel of firms. In fact, one should consider the strong relationships which have traditionally characterised Italian industry and the bank system and therefore the possible great relevance of bank debt within our panel, as also confirmed by the Bank of Italy's data.

We also have to stress that our data do not contain information on the possible role of external equity-holders as opposed to both debt financing and self-financing. However, it should be borne in mind that the use of the stock market and the venture capital market by Italian firms is still relatively low compared to other industrialized countries; thus, self-financing is much more relevant with respect to external equity financing in the definition of the equity aggregate.

3. Leverage, Innovation and Profitability: Simultaneity Patterns

The primary interest of this study is to analyse the determinants of a firm's capital structure, with particular focus on its propensity to innovate and profitability. However, as the review of the empirical literature suggests, there is room to believe that causality may be not one-sided as the dynamic relationships between our focus variables may be crucially affected by simultaneity patterns. Thus, we first performed a causality analysis based on the Granger-Causality approach with reference to our panel of industrial firms. Our aim is to identify possible simultaneity patterns, enabling us then to move on to the main focus of our analysis. We use a firm's debt ratio (LEVERAGE), given by the percentage ratio of total debt to total assets, as a proxy for its financial leverage, and the percentage ratio of operating margins to total sales (ROS) as a proxy for its operating profitability; these variables are derived from balance sheet information. We also use a dichotomous variable (INN) as a proxy for a firm's successful innovation; this variable is based on the Community Innovation Survey and assumes a value of one if the firm has introduced technological innovation (product and/or process innovation) and zero otherwise.

We analyse the following pairs of relationships:

Relationship 1: Leverage and Innovation - Does leverage cause innovation or does innovation cause leverage?

Relationship 2: Leverage and Profitability - Does leverage cause profitability or does profitability cause leverage?

3.2 Bivariate causality test: methodology and empirical model

We proceed by applying standard bi-directional Granger-causality tests (Granger, 1969; Sims, 1972) to the issue of the relationships between debt ratio and innovation and debt ratio and profitability. We use a Vector Autoregressive Representation similar to that originally proposed by Holtz-Eakin et al. (1988).

Given two variables y_{it} and x_{it}, we consider the following time-stationary VAR model in order to test whether x_{it} Granger-causes y_{it}:

$$y_{it} = \sum_{k=1}^{K} \alpha_k y_{i,t-k} + \sum_{k=1}^{K} \gamma_k x_{i,t-k} + u_{it} \qquad 3.1)$$

where *i=1, …* , N firms (*N*=2,591) in years *t=1, ..., T* (*T=8*), *K* is the number of lags and

$u_{it} = \mu_i + \lambda_t + v_{it}$ is a two-way error component model. v_{it} is a serially uncorrelated error term and μ_i and λ_t are firm- and time-specific effects. Thus, we allow for the presence of unobserved heterogeneity captured by firm-specific effects, but we impose the strong assumption of homogeneity in the response to changes in the exogenous variable (fixed coefficients).

Similarly, we specify an identical model to that in 3.1) in order to test whether y_{it} Granger-causes x_{it}:

$$x_{it} = \sum_{k=1}^{K} \beta_k x_{i,t-k} + \sum_{k=1}^{K} \delta_k y_{i,t-k} + u_{it} \,. \qquad 3.2)$$

Finally, we test for causality by specifying a test for the joint hypothesis $H_0 : \gamma_1 = ... = \gamma_k = 0$. If the test is rejected, variable *X* will Granger-cause variable *Y*. Similarly, variable *Y* Granger-causes variable *X* if the joint hypothesis $H_0 : \delta_1 = ... = \delta_k = 0$ is rejected.

In the traditional Granger-causality context the choice of the optimal lag-length is important, as it is well-known that lag selection may significantly affect the results. In our case, due to the short time dimension of our panel of firms we decided to adopt an empirical selection method: starting from a

maximum of K=4, we tested for different lag lengths. Results for one to three lags are reported, although two lags seems to be a reasonable selection[2].

The presence of individual heterogeneity modelled as fixed effects and the possible influence of initial conditions due to the short time dimension of our panel, introduce the classical 'incidental parameters' problem (Lancaster, 2000) which may lead to inconsistency in the conventional ML estimator. However, in a linear dynamic context, GMM estimation has increasingly been considered the most suitable approach for overcoming these problems, so we adopt the GMM framework here when the kind of relationship to be tested is linear. More specifically, we use a GMM-sys estimator (Arellano and Bover, 1995; Blundell and Bond, 1998) for the specification both in first differences and in levels. This approach combines a larger set of instruments with respect to a traditional IV estimator or a standard first difference GMM estimator and can therefore result in greater efficiency, provided the assumptions of white noise error and lack of correlation between the set of instruments and the error term are valid; otherwise inconsistent estimates may be generated. We check for serial correlation of the residuals and give the results for first-order (*m1*) and second-order (*m2*) auto-correlations in the tables. In order to be valid, *m1* should be significantly different from zero, while *m2* should not be significantly different from zero, i.e. there should be autocorrelation of first order but not of second order. In addition, we give the results of the *Sargan-tests* for the validity of the over-identifying restrictions of the GMM estimations. These are asymptotically chi-squared distributed tests and turn out to be significantly different from zero when the selected instruments are not correlated with the error process; therefore they are valid instruments.

Unfortunately, the conventional Granger-causality methodology has to be modified in our case, as one of the variables under investigation (innovation) is dichotomous. This means that a dynamic binary model has to be used when testing for causality which runs from the leverage (continuous) variable to innovation. The need to estimate a non-linear dynamic relationship introduces some difficulties into our causality context. On the one hand, no general transformation corresponding to differencing for linear models in order to eliminate the unobserved fixed effects is known in the literature; on the other hand, by opting for a random effects specification, the potential impact of the initial conditions should be considered, given that in a relatively short panel they may play a crucial role in determining the entire path of outcomes.

[2] Bearing in mind the short time span of our panel, we considered the significance of further lags in order to select the appropriate lag structure.

With reference to the first shortcoming we decided to adopt a random effect estimator. Although it rests on more restrictive assumptions compared to a fixed effect estimator, it nevertheless allows us to overcome the incidental parameter problem in a non-linear context. As for the problem of initial conditions, it is quite well established that ignoring the correlation between the initial state of each unit and the firm-specific heterogeneity term, when in fact it is present, may determine problems of consistency in the ML parameter estimates (Anderson and Hsiao, 1982; Nerlove and Balestra, 1996). However, attempts described in the empirical literature available so far typically make strong assumptions about the possible functional form in order to model initial conditions as endogenous, and so the possibility of deriving misleading results is not completely avoided[3]. We decided to avoid the initial conditions problem, for two reasons. Firstly, at this stage our focus is on possible mutual interdependence between selected pairs of variables. We do not intend to estimate a full model for innovation, which would require the inclusion of other possible determinants and control variables. In this context, we believe that the need to model initial conditions is in fact less stringent. Secondly, the statistical techniques typically proposed in empirical applications (Heckman, 1981; Wooldridge, 2005; Stewart, 2007) rely on pre-sample information for modelling initial observations. As information on our sample of firms starts in the first year of the panel, we should remove one year from our time series, thus reducing the reference period for the likelihood estimates to a seven year time-span. This further loss of information could affect the power of our causality tests. Nevertheless, in order to provide more reliable results with respect to the relationships involving the innovation variable, we provide additional causality tests by using an alternative proxy for innovation: the accounting values of intangible assets (INT_ASS). We are interested in testing for this different measure of innovativeness for several reasons: firstly, because it is an input rather than an output measure of innovation, in that this variable includes goodwill, intellectual property rights, patents, trademarks, R&D investments, website domain names and, typically, long-term investments which may describe a firm's innovative effort; secondly, because it is a continuous variable, thus enabling us to test for the sensitivity of our causality tests to changes in the estimation techniques (GMM instead of ML estimations); finally, because information on intangible assets derives from an administrative data source, in contrast with our INN variable which derives from a statistical survey; thus, we can also check for the sensitivity of our results to the use of different sources of information.

[3] Kazemi and Crouchley (2006) provide an historical review of the properties of modelling initial conditions, and also develop an empirical application for a panel of economic growth data, by using a variety of model specifications. They find that even though ignoring initial conditions results in an upward bias of the state dependence and a downward bias in the coefficients of the explanatory variables, models based on different assumptions regarding initial conditions provide rather different estimation results.

3.3 Empirical results

Relationship 1: Leverage and Innovation

Our results indicate that a firm's debt ratio is significantly Granger-caused by innovation (see *test 1*), by considering first innovation as the right-hand-side variable (Table 1a). The Wald statistics of non-causation are strongly rejected in the different specifications, even though the impact of innovation with lags higher than one is found to be no longer significant. The negative coefficients of the INN variable lagged one year indicate that introducing successful innovation has a negative impact on a firm's future leverage. Although limited to a very short time span, this result seems quite robust, as tests for residual autocorrelation and the validity of the instruments used are both satisfactory. We performed an additional causality test (*test 2*) by using INT_ASS as an explanatory (continuous) variable. The causal relationship is confirmed as being strong and the negative sign of the one-lag coefficient reveals that having invested in intangible assets, including R&D and other innovative efforts, again decreases a firm's leverage.

The reverse causality relationship, i.e. considering innovation as caused by leverage, does not hold (Table 1b). Results from the Wald test strongly reject the hypothesis of joint significance of the LEVERAGE coefficient in all the lag specifications adopted. Conversely, the test performed using our alternative (input) measure of innovation tells a rather different story, as variable INT_ASS turns out to be strongly causal. In addition, the one-lag coefficient is significantly negative, thus indicating that firms with a higher proportion of intangible capital are likely to be less leveraged, at least in the short run. Thus the results of these bi-directional causality tests suggest that innovation is causal when it is used as an output (INN). In contrast, our tests provide strong evidence of dynamic feedback effects between innovation and leverage when innovation is used as an input (INT_ASS).

Relationship 2: Leverage and Profitability

Results reported in Table 2a show quite clearly that a firm's profitability, as measured by the return on sales (ROS) index, does cause leverage. This interpretation is strongly confirmed by the Wald statistics associated with the entire set of lag specifications. In accordance with the Pecking Order theory, the effect of profitability on leverage is negative and persists over time. The sign of the coefficients remains significantly negative even after two years in all the dynamic specifications presented.

The reverse relationship is not fully confirmed by the empirical tests, as causality may be observed only in the one-lag specification (Table 2b). Possible simultaneity patterns between LEVERAGE and profitability are limited to the short run, whereas in a longer time span, here necessarily limited to the two- and three-lag specifications, the only confirmed causal relationship runs in the opposite direction.

Our results clearly show that a firm's leverage is caused by innovation as proxied by an output measure (*Relationship 1*). More specifically, the observed negative impact of past innovation on a firm's debt ratio seems to support the view that a firm which innovates successfully is more willing to rely on internal resources in order to invest in new opportunities. The opposite relationship is not significant, thus suggesting that leverage does not cause innovation. However, when a different proxy for innovation is used, i.e. the log value of intangible assets (an input measure), results suggest a bi-directional causality. The suggestion that causality runs from a firm's successful innovation to leverage is also associated with evidence that the latter is caused by profitability (*Relationship 2*), with a significant and negative relationship which also persists after two lags.

These findings support the view that innovation enhances a firm's ability to self-finance when an adequate flow of profits is generated. The different picture which emerges when an input measure of innovation is adopted and when we look at the bi-directional link with the debt ratio variable, is evidence of the possible two-way relationship characterising a firm's financial choice and its engagement in long-term innovative investments, better captured by an input measure. Conversely, no causal effect from a firm's leverage is registered when we adopt the dichotomous INN variable (an output measure), which is thus probably less appropriate for capturing any effect deriving from a firm's financial structure within the short time span of our panel. These results enable us to set up an empirical model which can explain a firm's leverage, as proxied by our debt ratio, where innovation and the firm's profitability enter as explanatory variables, as suggested by our causality tests.

4. The leverage equation

4.1 The dynamic model

In this section the empirical model for a firm's leverage is presented. We start by analysing a dynamic linear model which takes the role of past financial structure into account explicitly when

analysing the impact played by other possible determinants. Infact, descriptive statistics not reported here show quite clearly that financial behaviour was rather conservative during our time span, our industrial firms persistently maintaining a high-leveraged structure This means that the lagged dependent variable will be included among the set of explanatory variables. Therefore, a firm's leverage equation can be specified as follows:

$$Leverage_{it} = \alpha_1 Leverage_{it-1} + \alpha_2 Inn_{it-1} + \alpha_3 Ros_{it} + \alpha_4 Size_{it} + \alpha_5 Age_{it} + \alpha_6, Intang_ta_{it-1} + \alpha_7 IR_{it} + \alpha_8 T_i + \mu_i + v_{it} \qquad 4.1)$$

where the subscripts i and t identify, respectively, firms and calendar time. T_i is a time dummy common to all firms. μ_i is the individual-level effect which represents firm-specific heterogeneity and which may or may not be correlated with the set of explanatory variables, and v_{it} is the usual disturbance term.

We expect a strong positive effect to be exerted by past leverage on a firm's current debt ratio. In addition, in accordance with the relevant literature on the determinants of capital structure, we also expect a firm's characteristics in terms of size, age and asset structure *(intang_ta)* to play an important role, together with its performance in terms of both profitability *(ros)* and innovative propensity *(inn)*. [4]

The adoption of a dynamic specification requires the use of instrumental variables for estimating such an equation and for handling the possible correlation between the lagged dependent variable and the error term. We present a full set of specifications which includes pooled OLS, fixed and random effect estimations, which are noticeably inconsistent due to endogeneity problems but important for comparative purposes, and consistent estimations based on both 2SLS and GMM approaches, the latter being more efficient due to their exploitation of additional moment conditions.

(Table 4.1 about here)

[4] Variable *inn* and *intang_ta* have been lagged one period in order to capture the effects of past decisions on both the investments in intangible assets such as R&D expenditures and the decision to introduce innovation.

Looking at the estimation results, the first important point to emphasise is the large positive coefficient of the lagged leverage variable. The OLS and FE specifications are generally recognised as being biased in opposite directions (Bond, 2002); thus they may provide a plausible range of variation for the 'true' level of leverage persistence. Our estimations confirm this expectation, with a coefficient for lagged leverage equal to 0.9 in the OLS specification and 0.5 in the fixed effect model, while the two RE specifications present coefficients which are in line with those obtained with the pooled OLS model. A fixed effect specification is a plausible choice, as the hypothesis that the constant term is equal across firms is rejected on the basis of an F-test and, in addition, the correlation between firm-specific fixed effects and covariates is quite important (0.61). It is also worth noting that in the GLS estimation, σ_{μ}^{2}, i.e. the variance due to the random effect, is estimated as being equal to zero[5], thus causing the degeneration of the RE estimator to the OLS estimator. For this reason we have provided an RE estimation based on the maximum likelihood approach (model 4), which provides results in line with the GLS results and also a positive estimation for the variance due to the random effect. However, the contribution to total variance of the random effect continues to be very modest $(\rho = 0.005)$, causing doubt as to the appropriateness of a random effect specification. A Lagrange multiplier test does not reject the hypothesis that $\sigma_{\mu}^{2} = 0$.

Bearing in mind this useful information concerning a possible correct model specification, we now proceed to analyse the results based on consistent IV estimations. The effect of past debt structure continues to be very high. The IV specification provides a coefficient of 0.87 for lagged leverage (model 5). According to the relevant literature, significant increases in efficiency may be obtained by exploiting additional moment conditions with a GMM approach, provided that the set of over-identified restrictions is valid. We have estimated three different GMM approaches. In the first (model 6), the Arellano-Bond first-difference estimator is adopted. Here the lagged leverage variable presents a lower estimation with respect to the others; however the Sargan test on the appropriateness of over-identifying restrictions is clearly unsatisfactory, thus casting doubts on the validity of the instruments used for the difference equation. In the second model (model 7), the standard system specification, which uses both lagged levels for the difference equation and lagged differences for the level equation, is presented. Here the lagged leverage coefficient is in line with the 2SLS specification; however, the use of both the lagged levels of the debt ratio for the difference equation and the lagged differences for the level equation continues to be inappropriate, according to the Sargan statistic. We suspect that the high persistency of our leverage indicator

[5] Stata xtreg, re procedure replaces the estimation of σ_{μ}^{2} for zero when it is negative

causes lagged levels of debt ratio to be poor instruments for the difference equation. Thus we have tried to selectively reduce the number of moment conditions. In the 'adjusted' system equation presented in model 8, we use the second lag of both debt and total asset variables as instruments for the difference equation and the differences of these variables in the level equation. Both variables enter the leverage definition, the former being the numerator and the latter the denominator. This choice seem to be appropriate, as suggested by the higher p-values of the Sargan test associated with this specification[6].

In addition to strong persistence in the debt structure, our estimations highlight some important results regarding the role of a firm's performance in terms of innovation and profitability. However, in other cases, results are more uncertain. More specifically, a firm's profitability exerts a negative and relevant impact on leverage decisions even when past debt structure is taken into account. The coefficient of variable *ros* is large and quite stable across the different specifications, thus signalling that a higher level of operating profitability is associated with a lower debt ratio. The view that more profitable firms are more reliant on internal resources with respect to external financing is in line with the theoretical predictions of the pecking order mechanism. In addition, it should be noted that in all the specifications the interest rate payments-to-sales (IR) ratio presents the expected positive sign, as higher debt intensity is likely to be associated with a higher interest burden.

When we move on to analysing the effect of past innovation, we obtain more controversial results. Almost the entire set of specifications, excepting only the FE model, reveals no significant effects of lagged *inn* on a firm's leverage. Nevertheless, the fixed effects model shows a negative and significant coefficient, thus supporting the view that more innovative firms tend to be more reliant on internal resources, possibly due to high uncertainty associated with innovative investments rendering external financing more costly.

The unsatisfactory results provided by the consistent estimations can possibly be explained by the characteristics of our innovation variable, which is dichotomous and therefore not an ideal proxy for a firm's innovation effort. This problem may also be amplified by the strong explanatory power of the lagged dependant variable, which may dampen the direct effect of variable *inn*. However, as leverage-innovation is one of the crucial relationships we hope to confirm, we proceed in the next paragraphs by exploring alternative models, where the effect of the lagged endogenous variable will be removed from the list of regressors.

[6] Debt and total assets lagged two years are used as instruments of lagged leverage in the 2SLS specification as well.

Intangible asset intensity, as proxied by the *intang_ta* ratio, may be considered an alternative (continuous) proxy of a firm's innovative effort, as R&D expenditures are recorded in this balance sheet item. In addition, following the literature on moral hazard and collateral, it may be considered an indicator of the role of immaterial versus physical assets in determining a firm's capital structure. The effect of this variable on leverage is not clearly determined within the empirical debate. Following the literature on collateral, the expected sign is negative, as the higher the immaterial component of a firm's capital structure, the higher one would expect the bankruptcy risk associated with external finance to be. When this variable is assumed as a proxy for the intensity of a firm's innovative effort, the expected sign should be positive in accordance with the pecking order argument, as firms need external financing when innovation efforts are particularly costly and internal funds are not sufficient to cover the entire investment. Results based on the dynamic model show a positive and significant effect of lagged intangible asset intensity on leverage, thus supporting the view that this variable should be considered a proxy for the pecking order mechanism, rather than an indicator of a firm's bankruptcy risk.

This positive effect on leverage is not in contrast with the negative effect shown by the *inn* variable. In fact, these two variables capture different patterns: dichotomous *inn* is a proxy of a firm's innovation success, while continuous *intang_ta* measures the size of the innovation effort. Therefore, although it is correct to expect that a firm which has successfully innovated might have generated internal resources in order to finance future activities, the flow of internal revenues may be insufficient when the size of the investment projects increases, thus making the use of external financing necessary.

As for the role of 'size' and 'age', these are traditionally considered as proxies for a firm's probability of default. The relationship between leverage and different proxies for a firm's reputation or 'quality' may be difficult to assess. In general, the agency costs of debt are expected to be higher for those firms with a lower reputation, such as those which are smaller or less established, and, therefore, a positive relationship between a firm's debt ratio and a measure for credit worthiness such as size or age should be expected, according to this interpretation. However, empirical evidence is not conclusive. Aghion et al. (2004) found a positive relationship between size and the debt ratio, while according to Magri (2009) the effects of both age and size are almost irrelevant in determining a firm's financial leverage. Heyman et al. (2008) found a negative relationship between the debt ratio and size measured by total assets in logarithm terms, while

Titman and Wessels (1988), emphasising the role of debt maturity, found that the relationship between size and a measure of short-term debt is negative, thus implying that small firms tend to use significantly more short-term financing with respect to large firms.

In fact, a negative relationship between leverage and a measure of a firm's reputation is explained on theoretical grounds by the possibly higher agency costs of equity (and long-term debt) with respect the cost of (short-term) debt which may characterise firms with less reputation (Smith and Warner, 1979; Pettit and Singer, 1985). Thus, in accordance with these predictions regarding the determinants of debt maturity, we would expect that small and less established firms prefer to borrow in the short term rather than issuing new equity or even long-term debt. Unfortunately, our data do not allow us to determine the maturity structure of a firm's debt, so we cannot provide evidence on this particular aspect of the empirical debate.

Our results, based on a dynamic specification, show that a firm's leverage is not significantly affected by size; the estimated coefficient is generally either not statistically significant or imprecisely estimated using a GMM system specification. As for a firm's age, the effect is negative and significant in our preferred specifications, as shown by the GMM sys_adj and the FE models, though the coefficient is not always clearly estimated if we turn to the other specifications. We suspect that the strong role exerted by the endogenous variable may partly weaken the effects of both age and size;. therefore we return to these relationships later, when a different specification which does not take the effect of past leverage into account is analysed.

4.2 The static model

In this section we perform a more detailed analysis of the determinants of a firm's capital structure. After estimating a parsimonious dynamic specification of our leverage equation, which takes into account the influence of past leverage on a firm's financial structure, we now focus on the effects of a larger set of determinants. In addition, we want to better understand the influence of innovation propensity and firm size, whose impact turns out to be not clearly determined by using a dynamic model, possible due to the strong influence of the lagged leverage variable. For this reason the lagged dependent variable has been removed from the list of regressors in the leverage equation.

(Table 4.2 about here)

Model 1 in table 4.2 corresponds to the specification adopted in equation 4.1), apart from the effect of lagged leverage, which has been removed. This model is reported in order to provide a direct comparison with the dynamic specification. Instead, in model 2 we have improved our leverage specification with additional information. In particular we want to analyse:

- the effect on a firm's financial structure of its geographical location as proxied by the usual set of area dummies. We expect that firms located in the northern regions (traditionally characterised by higher growth rates) should be able to access external financing under better conditions and thus have higher levels of leverage.
- the possible role played by the institutional context characterising the lending market in the industry sector. This is proxied using the real annual growth rate of bank lending to industrial firms. The *lending_gr* variable may be considered an indicator of credit accessibility, which is crucially linked to the economic cycle. Bank lending slowed down considerably as of the late nineties (see figure 4.1) as a first signal of the early 2000s economic recession. We expect that an increase in the growth of bank lending may boost firms' investment decisions and, through this route, affect their leverage levels positively.

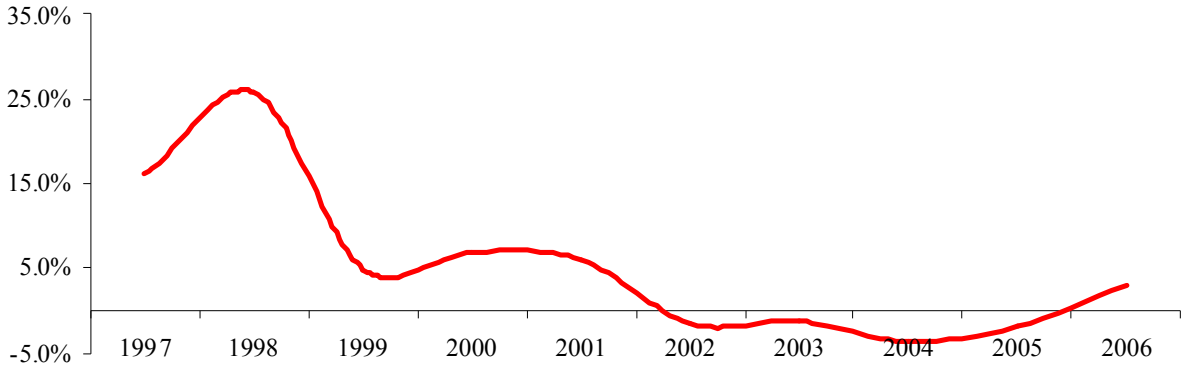
Model 1 provides results which are in line with those obtained with our consistent estimates in the dynamic specification (table 4.1, model 8). Nevertheless, it should be noted that now the effect of past innovative intensity (*intang_ta*) is higher. A firm's profitability and interest burdens are confirmed as being significant determinants with the expected signs. The effect of a firm's age is negative, whereas *size* and past innovation (*inn*) continue to be estimated imprecisely.

When we take industry structure (model 2) into account by including industry dummies, the negative effect of the *inn* variable turns out to be noticeably greater. In addition, it is worth noting the increase in the explanatory power of our model when the sets of regional and industrial dummies are included. The effect of localisation on a firm's leverage is as we expected: firms located in the southern regions are generally less leveraged with respect to their counterparts in the central-northern regions. It is worth noting that the dummy associated with the northwest regions shows a negative coefficient with respect to the northeast, which is the reference dummy. This could be due to the high dynamism which has characterised the north-eastern regions during our time span, and which may have determined favourable access to external financing for those firms in the northeast. The situation of favourable growth in north-eastern industry may explain the higher debt ratio of the firms in our panel compared to the northwest of Italy.

The effect of firm size turns out to be negative and significant, when using the specification in model 2, although the size of the coefficient remains quite small. A possible negative relationship between leverage and factors which are connected with a firm's reputation may be verified on empirical grounds. It has been argued that problems connected with a firm's possible default may be reduced by borrowing short-term (Diamond, 1991). Moreover, in an industrial system based on strong relationships with banks, as in Italy, it may be easier for a firm with a moderate reputation[7] to renegotiate its debt than in a system based on non-bank lenders (Hoshi et al., 1990).

Although given the nature of our data a direct investigation is not possible, we think that the potential role of short-term bank borrowing could explain the negative relationship observed between debt ratio and size (or age) in our panel of firms, thus supporting the view that smaller or younger firms are likely to be more reliant on (short-term) debt. Giving the relevance of this aspect, we have also tried to further investigate the role of firm size by dividing our sample into three size classes[8]. The significance of the split has been tested for by computing the Chow test on the three groups separately.

Figure 4.1 - Real growth rate of bank lending to industrial firms
percentage change on the previous year



Source: Our calculations on Bank of Italy data

[7] It is worth stressing the fact that our data set is based on a balanced panel of firms which have operated continuously in the industrial sector during our time span. This characteristic makes it plausible to assume that our firms are, on average, of relatively good quality.
[8] Small firms are those with no more than 50 employees; medium firms are those with between 50 and 500 employees, and large firms have more than 500 employees. Groups are determined on the basis of the average size during the period 1996-2003. Results do not change when allowing the firms to enter and exit the three size classes.

The most important result observed for the split sample is the effect of innovation on leverage: having introduced innovation negatively affects a firm's debt ratio in the group of small firms but not in the other two groups, where the effect of past innovation on the debt ratio is not significant. It could be useful to analyse this result in association with the effect of our indicator of credit accessibility (*lending_gr*). In general, the effect on leverage is positive, indicating that the more favourable the credit supply, the higher the level of external financing. However, this positive relationship is not verified for small firms, thus indicating that changes in lending conditions do not much affect their financial structure. These results seem to indicate possible difficulties in accessing external financing for small innovative firms, which are more likely to rely to a greater extent on internal finance even when credit accessibility is wider.

Some differences can also be observed between medium and large firms. For example, the impact of credit accessibility on leverage is significant in the group of medium firms, whereas it is not significant for the large firms. This difference in behaviour is possibly explained on the grounds that large firms take advantage of a preferred relationship with the (bank) system compared to the medium firms. In fact our results show that the financial structure of large industrial firms is not sensitive to change in the short-term availability of bank credit, whereas it is for medium firms.

Other evidence which may corroborate the hypothesis of a preferred relationship between large firms and the credit market is to be found in the different role played by those indicators describing a firm's reputation: having 'a long history', as proxied by the variable *age*, does not matter in explaining a firm's leverage for large firms, whereas it does for small and medium firms. However, the sign of the relationship is negative, thus indicating the possible higher relevance of short-term financing for less-established firms within the groups of small and medium firms. [9]

4.3 A further investigation: long-run patterns

In this section we provide further evidence confirming the robustness of the previous results. We estimate an additional model specification based on time averages of our key variables. Although we are aware that our time horizon is relatively short, the intuitive meaning of this additional test is that when the estimated relationships can be confirmed by using a time averaged specification, we can reasonably assume that they should hold in the long run as well.

[9] We achieve the same conclusion by using another specification (not reported) where the variable *size* is included in the set of regressions by size class, as an additional test for the role of a firm's reputation in explaining leverage. We found that the coefficient of *size* is negative and significant for the groups of medium firms, whereas it is not for the group of large firms.

Furthermore, the use of a cross-sectional approach is particularly suited to our purpose, as it allows us to recover additional information from the Community Innovation Survey which is not provided on a longitudinal basis and thus cannot be used within a panel approach. Conversely, by using a cross-sectional approach, we can plausibly consider some firm-specific variables which were collected with the CIS3 survey as additional determinants of a firm's leverage[10]. More specifically, we here estimate an OLS specification for a firm's leverage which takes into consideration alternative measures of its innovation. Thus, the following variables are in turn tested for:

- *inn_1996:* this is the usual dichotomous innovation variable referring to the beginning of our time span. It is intended to capture the effect of early successful innovation on the average debt_ratio.
- *prev_inn:* this is a new dummy variable which assumes value one when the firm introduced at least one technological innovation in the four years of the entire period and zero otherwise. It is designed to capture the effect of 'frequent' successful innovation.
- R&D_*cis3:* this is a dummy variable derived from the CIS3 survey. It is an input indicator of innovation and assumes value one if the firm performed systematic R&D activities during the period 1998-2000 and zero otherwise. It is intended to capture the effect of non-occasional R&D activities on a firm's debt-ratio.
- *innsales_cis3:* this is a continuous measure of output innovation. It is given by the share of total turnover due to products introduced during the period 1998-2000 which are new to the reference market.

A firm's group membership (*gp_cis3*) is also added to the list of regressors, as it is reasonable to suppose that being part of an industrial group may generate synergies, both financial and operative, within the group, thus reducing the need for external financing. In addition, the role of financial constraints to innovation in shaping a firm's financial structure is another interesting aspect we want to test for. This information derives from the CIS3 questionnaire and is intended to capture the firm's subjective perception of the presence of financial constraints to innovation. A dichotomous variable *(fin_const_cis3)* is derived from CIS3 responses, assuming value one when the firm considers relevant the presence of at least one economic obstacle to technological innovation[11] and zero otherwise.

[10] In fact, it is worth recalling that information collected with the CIS3 survey refers to the three-year period 1998-2000, which falls in the middle of our panel. The implicit hypothesis is that this additional information at the firm level can reasonably be assumed to be time invariant during our time span.

[11] The list of obstacles to innovation includes: 'excessive perceived economic risks', 'innovation costs too high' and 'lack of source of finance'.

(Table 4.3 about here)

The first relevant result is that a negative relationship between innovation and leverage is confirmed when using both the *inn_1996* and the *prev_inn* variables: in general firms which introduced a technological innovation at the beginning of the period or on a frequent basis tend, on average, to use more internal finance. Results by size class confirm that innovation is mainly financed with internal resources by small firms, whereas this relationship is not found significant for the groups of medium and large firms. Unfortunately, variable *R&D_cis3,* indicating whether the firm has undertaken systematic R&D activity, does not give any useful indication; in fact it is highly insignificant. This result is however in part as expected, due to the well-known scarcity of Italian firms conducting R&D activity in structural laboratories (less than one quarter of our sample).

Another interesting result linking a firm's innovation and leverage is the positive impact of the variable *innsales_cis3*, measuring the share of a firm's total sales due to innovative products. This is a measure of the economic return following the introduction of a product innovation, as a firm is expected to show a positive value of this variable when an innovative product has been successfully introduced for the first time on the reference market. In addition, this could also be considered an indirect measure of the innovative effort connected with the commercialisation of a product innovation, as the higher the share of total sales which can be related to new products, the more strategic a firm's innovation activity should be and, in the same way, the higher the need for financial resources required to develop an innovative project should also be. According to this interpretation, it is not surprising to note that the relationship with our leverage indicator is positive, indicating that a higher impact in terms of revenues generated from the development and introduction of a new product is likely to be associated with the need for a higher level of external finance. This positive relationship holds both for small and large firms, although the coefficient size is higher for large firms, the latter also revealing a higher share of total turnover due to innovative products. Unfortunately, the significance of the relationship is uncertain for the group of medium firms.

The positive association of *innsales_cis3* with a firm's leverage reminds us of the positive association emerging when the innovative effort is measured by using the share of intangible assets to total assets, which is a measure of input. This evidence, together with the confirmed negative relationship between a firm's profitability and its debt ratio, represent quite a strong confirmation of

the possible non-linear relationship linking innovation to the external finance requirement and a further proof of the pecking order hypothesis governing access to financial resources.

The inclusion of the dummy variable indicating whether a firm belongs to an industrial group, as an additional leverage determinant based on the CIS3 survey, confirms our expectations, as the coefficient is negative, indicating that firms forming part of an industrial group use more internal resources, probably due to the positive synergies within the group generating greater availability of self-financing. OLS regressions by firm size indicate that the negative relationship between group membership and a firm's debt ratio is statistically significant for the group of medium firms, whereas it is not verified for small and large firms.

Finally, CIS3 information allows us to investigate the effect of financial constraints on innovation, as proxied by the *fin_const_cis3* dummy. The observed positive relationship with a firm's leverage is somewhat counterintuitive: one would expect that in the presence of financial constraints a firm is likely to use more internal resources, thus suggesting a possible negative relationship. In fact, our dummy variable refers to the firm's subjective perception of its particular financial position, so a positive coefficient indicates that perceiving one's firm to be financially constrained is a consequence of being highly leveraged and, thus, reflects a fragile financial structure as proxied by a high debt ratio. One should also note that the coefficient of the financial constraints dummy is significantly positive for the medium and large firms, thus indicating that for them a high level of indebtedness may represent an obstacle to financing future innovative projects with external funds, whereas it is not significant for small firms, which are more likely to rely on internal resources to finance innovation, as our analysis has quite clearly demonstrated, by using both our longitudinal and our cross-sectional model specifications.

5. Conclusions

We have investigated the determinants of a firm's capital structure, paying particular attention to the role played by the firm's innovation and profitability.

The role of a firm's adoption of innovation has been examined by using both a qualitative indicator, an output measure derived from the Community Innovation Survey indicating whether a firm introduced or did not introduce technological innovation during our relevant time span, and an input measure, given by the book value of intangible assets as a proportion of a firm's total asset value. As the dynamic relationships between our focus variables may be crucially affected by simultaneity

patterns, we first performed a causality analysis based on the Granger-Causality approach. Results support the view that a firm's leverage is caused by both innovation and profitability, while no causal effect is registered as running on the long run from a firm's leverage to either profitability or to our measure of innovation output.

We then concentrated on the analysis of an econometric model of a firm's leverage. Different specifications, both static and dynamic, have been tested for, in order to estimate short- and long-run effects. The most interesting results are summarised below.

a *Capital structure is highly persistent over time* as suggested by stylized facts at the industry level and by the econometric investigation at the firm level. Results based on our dynamic specification show that lagged leverage captures a consistent part of the model variability with a large and significant coefficient in our preferred consistent specification (GMM sys_adj).

b *More profitable firms tend to use internal finance more* as implied by the negative relationship linking a firm's debt ratio and return on sales. The role of a firm's profitability in reducing the need for external finance characterises all firms regardless of size as measured by employment, although large firms show a lower sensitivity of leverage to profit variations. This relationship is robust to different model specifications: coefficients associated with the *ros* variable are large and significant even when lagged leverage is taken into account in our dynamic specification, and this is also confirmed in the long run, as suggested by our OLS specification based on time averages.

c *The need for external finance increases with the innovative effort* as shown by the fact that in all the econometric specifications, both static and dynamic, a positive relationship is found between alternative proxies for innovation intensity based on measures of both innovative input (the share of intangible assets to total assets) and innovative output (the share of a firm's sales due to the introduction of a product innovation). This relationship holds regardless of a firm's size.

d *Small innovative firms are more likely to rely on internal funds rather than debt*, whereas having introduced a successful innovation does not significantly affect the leverage level of medium and large firms. This relationship has been tested for by using alternative proxies capturing different timings of innovation.

e External conditions such as credit accessibility and financial obstacles to innovation have different impacts on capital structure, depending on a firm's size as shown by the fact that our indicator of credit availability based on the real growth rate of bank lending (*lending_gr*) is not significant in the groups of small and large firms, for opposite reasons. In the group of small firms, where innovation is highly sensitive to the availability of internal resources, this result is evidence of possible credit rationing, as short-run changes in bank credit accessibility do not play a role in determining their debt structure. This interpretation is reinforced if one considers the role played by financial factors perceived as constraints to innovation investments (*fin_const_cis3)*. Although economic obstacles to innovation turn out to be more important in smaller firms[12], these do not seem to affect their financial structure (see the results of our OLS specification), thus suggesting that small firms are the most likely to rely on internal resources instead of debt to finance innovative projects. Unfortunately, we do not have any elements to determine whether and to what extent the presence of credit rationing may actually constrain the size of the innovative effort in small firms. For large firms the fact that credit accessibility does not play a role in determining financial structure could be interpreted as indirect evidence of possibly preferential access to bank loans due to higher reputation. Large innovative efforts are more likely to be undertaken by larger firms (as is implied by point *c*). In addition, as we have stressed in point *b*, capital structure in large firms is less sensitive to increases in operating profitability, so a preferential relationship, unaffected by cyclical conditions, with the banking system is a crucial requisite for success.

A different story seems to be true of medium-sized firms. Short-term conditions of credit accessibility do matter in determining leverage in this group of firms, as suggested by the positive and significant coefficient associated with the *lending_gr* variable. In addition, a firm's perception of financial constraints to innovation is able to affect its capital structure significantly. These results suggest that for medium-sized firms, whose R&D intensity is generally much higher with respect to smaller-sized ones, the availability of external financing sources may have a crucial role in determining both capital structure and decisions taken regarding innovation funding (internal-external). It is not surprising that being part of an industrial group is found to be an important determinant only of medium-sized firms' leverage (and not other size classes), as suggested by results based on the OLS specification. In fact, the generation of possible synergies within the group may give access to additional financial resources, thus reducing the need for external (costly) funding.

[12] The number of small firms in our panel which indicated economic factors as being an important obstacle to innovation corresponds to 24% of the size class according to the CIS3 survey. This share declines to 22% and 18% respectively, for the groups of medium and large firms.

f The relationship between alternative measures of a firm's reputation and leverage is negative given the characteristics of our credit market, mainly dominated by the traditional banking system (limited venture capital); we suspect that this relationship actually captures the role of short-term borrowing, which is less costly with respect to long-term debt or equity and is thus more likely to be used by smaller and younger firms with respect to more established firms. This evidence, which is robust to different model specifications, also seems to hold in the long run, as suggested by the results based on our cross sectional specification.

e a firm's localisation significantly affects its leverage in that firms located in the northern regions show a debt ratio which is higher, on average, with respect to those in the centre and south. In addition, positive differentials characterise the leverage of firms located in the northeast compared to the northwest.

Overall these results may indicate that Myers and Majluf's *pecking order* mechanism dominates access to financial resources, as firms with a higher profitability tend to use less debt and more internal resources. We have also shown that debt financing increases with the intensity of innovative efforts, thus indicating that when internal resources are not sufficient to cover large innovative projects, debt financing is required. Problems of credit rationing do not seem to prevail in association with innovation *per se*. However, credit constraints could represent a serious problem for small innovative firms, which tend to use more internal resources. This view is reinforced by the consideration that in small firms external factors such as credit availability and financial obstacles to innovation do not represent significant determinants of small firms' leverage.

Medium-sized innovative firms, like larger firms, do not seem to face credit rationing. However, unlike large firms, they show a leverage ratio which is significantly affected by short-run changes in credit accessibility, is more sensitive to changes in operating profitability, and may be negatively affected by synergies possibly generated within an industrial group. Finally, structural factors such as a firm's location and sectoral characteristics are proven to be important determinants, significantly affecting a firm's leverage.

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Table 1: Leverage and Innovation

Table 1a: Does Innovation cause Leverage?

Test 1 - Innovation variable=INN

GMM-sys estimations

n. of lags	*1*	*2*	*3*
n. of instruments	*30*	*30*	*30*
Sargan test	16.91(22)	18.50(21)	20.33(20)
p value	*0.76*	*0.61*	*0.43*
m1	-17.31	-19.59	-6.02
p value	*0.00*	*0.00*	*0.00*
m2	-0.15	-0.31	0.87
p value	*0.87*	*0.18*	*0.38*
Wald test	3.36(1)	10.24(2)	10.63(3)
p value	*0.066*	*0.006*	*0.013*
INN variable: estimated coefficients			
L1	-0.493* (0.269)	-0-.451*** (0.147)	-0.49*** (0.150)
L2		-0.101 (0.140)	0.036 (0.817)
L3			0.080 (0.611)
Result	*YES**	*YES****	*YES ****

Note - Instruments for the difference equation: selected lags of the variables Debt ratio, Total Debt and Total Assets, depending on the lag structure. Instruments for the level equation: lagged differences of the Debt ratio and lagged values of the innovation variable, depending on the lag structure. In the model with 1 lag we used the differences of lagged values instead of the lagged levels of the innovation variable.

Test 2 - Innovation variable=Intangible Assets (log value)

GMM-sys estimations

n. of lags	*1*	*2*	*3*
n. of instruments	*29*	*32*	*30*
Sargan test	16.28(21)	19.53(23)	19.46(20)
p value	*0.75*	*0.66*	*0.49*
m1	-14.88	-19.78	-6.25
p value	*0.00*	*0.00*	*0.00*
m2	-0.08	-0.48	0.72
p value	*0.93*	*0.63*	*0.46*
Wald test	19.44(1)	23.68(2)	11.38(3)
p value	*0.000*	*0.000*	*0.009*
INT_ASS variable: estimated coefficients			
L1	-0.232*** (0.052)	-0.261*** (0.056)	-0.223*** (0.069)
L2		0.035 (0.051)	0.072 (0.058)
L3			0.151 (0.073)
Result	*YES****	*YES****	*YES****

Note - Instruments for the difference equation: selected lags of the variables Debt ratio, Total Debt and Total Assets and lagged differences of the innovation variable, depending on the lag structure. Instruments for the level equation: the lagged difference of the Debt ratio.

Table 1b: Does Leverage cause Innovation?

Test 1 - Innovation variable=INN

Logistic Random Effect estimations

n. of lags	*1*	*2*	*3*
Wald test	0.02(1)	1.91(2)	1.41(3)
p value	*0.893*	*0.385*	*0.703*
LEVERAGE variable: estimated coefficients			
L1	-0.000 (0.002)	0.003 (0.003)	0.002 (0.003)
L2		-0.004 (0.003)	0.000 (0.005)
L3			-0.003 (0.003)
Result	*NO*	*NO*	*NO*

Test 2 - Innovation variable=Intangible Assets (log value)

GMM-sys estimations

n. of lags	*1*	*2*	*3*
n. of instruments	*20*	*21*	*21*
Sargan test	11.42(12)	11.08(12)	11.04(11)
p value	*0.49*	*0.52*	*0.43*
m1	-9.97	-13.47	-3.64
p value	*0.00*	*0.00*	*0.00*
m2	0.20	-0.01	-0.19
p value	*0.83*	*0.98*	*0.84*
Wald test	8.19(1)	5.07(2)	8.76(3)
p value	*0.004*	*0.079*	*0.032*
LEVERAGE variable: estimated coefficients			
L1	-0.014*** (0.005)	-0.010** (0.005)	-0.009** (0.004)
L2		0.0006 (0.004)	-0.005 (0.006)
L3			0.003 (0.005)
Result	*YES****	*YES**	*YES***

Note - Instruments for the difference equation: selected lags of the variables Intangible Assets, Intangible Assets to Fixed Assets ratio, Intangible Assets per employee and lagged differences of the Debt ratio, depending on the lag structure. Instruments for the level equation: the lagged difference of the innovation variable.

(***) significant at 99%; (**) significant at 95%; (*) significant at least at 90% .
Standard errors (Robust s.e. in the GMM specifications) in parenteses
In the GMM specifications: m1 and *m2* is are, respectively, asymptotically N(0,1) tests for first and second-order serial correlation of the residuals. H_0: no
Sargan test is an asymptotically chi-square test for the validity of overidentifying restrictions. H0: overidentifying restrictions are valid

Table 2: Leverage and Profitability

Table 2a: Does Profitability cause Leverage ?

GMM-sys estimations

n. of lags	*1*	*2*	*3*
n. of instruments	*31*	*32*	*30*
Sargan test	19.94(23)	18.44(23)	19.79(20)
p value	*0.64*	*0.73*	*0.47*
m1	-17.87	-19.18	-8.17
p value	*0.00*	*0.00*	*0.00*
m2	-0.41	-0.65	-0.06
p value	*0.67*	*0.51*	*0.94*
Wald test	59.29(1)	51.21(2)	52.10(3)
p value	*0.000*	*0.000*	*0.000*
	ROS variable: estimated coefficients		
L1	-0.201*** (0.026)	-0.179*** (0.025)	-0.149*** (0.021)
L2		-0-087*** (0.034)	-0.073*** (0.043)
L3			-0.051 (0.034)
Result	*YES****	*YES****	*YES****

Note - Instruments for the difference equation: selected lags of variables Debt-ratio, Total Debts and Total Assets, depending on the lag structure. Instruments for the level equation: lagged differences of variables Debt ratio, Total Debt and Total Assets and lagged values of variable ROS, depending on the lag structure.

Table 2b: Does Leverage cause Profitability?

GMM-sys estimations

n. of lags	*1*	*2*	*3*
n. of instruments	*11*	*22*	*22*
Sargan test	0.57(3)	14.00(13)	11.10(12)
p value	*0.90*	*0.37*	*0.51*
m1	-1.31	-2.56	-13.9
p value	*0.18*	*0.01*	*0.00*
m2	-0.57	-0.16	-0.93
p value	*0.56*	*0.87*	*0.35*
Wald test	12.53(1)	2.71(2)	5.09(3)
p value	*0.000*	*0.258*	*0.165*
	LEVERAGE variable: estimated coefficients		
L1	-0.040*** (0.011)	-0.011 (0.002)	-0.012 (0.033)
L2		-0.003 (0.011)	0.009 (0.534)
L3			-0.036 (0.033)
Result	*YES****	*NO*	*NO*

Note - Instruments for the difference equation: selected lags of variables ROS, Sales and Operating Margins, depending on the lag structure. Instruments for the level equation: lagged difference of variable ROS and lagged values of the Debt Ratio, depending on the lag structure.

(***) significant at 99%.
Robust standard errors in parenteses
m1 and *m2* is are, respectively, asymptotically N(0,1) tests for first and second-order serial correlation of the residuals. H_0: no autocorrelation
Sargan test is an asymptotically chi-square test for the validity of overidentifying restrictions. H0: overidentifying restrictions are valid

Table 4.1 - Leverage equation: dynamic model

VARIABLES	OLS (1)	FE (2)	RE_gls (3)	RE_ml (4)	2SLS (5)	Abond (6)	SYS (7)	SYS_adj (8)
L.leverage	0.909***	0.541***	0.909***	0.908***	0.870***	0.694***	0.833***	0.825***
	[0.00407]	[0.0117]	[0.00407]	[0.00368]	[0.0175]	[0.0485]	[0.0255]	[0.0357]
L.inn	0.0219	-0.262**	0.0219	0.0217	0.0337	-0.199	-0.224	-0.249
	[0.0939]	[0.132]	[0.0939]	[0.0958]	[0.112]	[0.155]	[0.167]	[0.160]
L.intang_ta	0.0560***	0.0885***	0.0560***	0.0565***	0.0878***	0.127**	0.126**	0.0899*
	[0.0170]	[0.0301]	[0.0170]	[0.0148]	[0.0212]	[0.0498]	[0.0546]	[0.0528]
ros	-0.208***	-0.241***	-0.208***	-0.210***	-0.242***	-0.250***	-0.262***	-0.285***
	[0.0103]	[0.0177]	[0.0103]	[0.00709]	[0.0175]	[0.0235]	[0.0249]	[0.0277]
size	0.0000339	-0.000792	0.0000339	0.0000329	-0.0000503	-0.00148	-0.00184**	0.000615**
	[6.51e-05]	[0.000504]	[6.51e-05]	[8.58e-05]	[6.92e-05]	[0.00107]	[0.000853]	[0.000265]
age	-0.00977***	-0.251***	-0.00977***	-0.0102***	-0.0205***	-0.299***	0.449***	-0.248***
	[0.00349]	[0.0303]	[0.00349]	[0.00364]	[0.00621]	[0.0344]	[0.132]	[0.0377]
IR	0.531***	1.068***	0.531***	0.538***	0.757***	0.222*	0.0617	0.212*
	[0.0389]	[0.0786]	[0.0389]	[0.0319]	[0.0899]	[0.123]	[0.116]	[0.123]
Constant	6.185***	35.02***	7.266***	7.397***	8.734***	28.77***	3.948*	19.48***
	[0.350]	[1.068]	[0.312]	[0.304]	[1.169]	[3.285]	[2.062]	[2.341]
Observations	18,137	18,137	18,137	18,137	15,546	15,546	18,137	18,137
Number of firms	2,591	2,591	2,591	2,591	2,591	2,591	2,591	2,591
R-squared	0.897	0.832	0.897	0.228(*)	0.895	.	.	
within		0.375	0.359					
beetween		0.900	0.985					
rho			0.000	0.005				
m1						0.000	0.000	0.000
m2						0.149	0.230	0.231
Sargan						67.64 (20)	83.16 (25)	29.41(23)

Robust standard errors in brackets if not otherwise specified.
*** p<0.01, ** p<0.05, * p<0.1
(5) Performed with the STATA IVREG2 procedure. This allows for the computation of robust standard errors in presence of clustering. Instruments used for the lagged endogenous variable: l2.dedts and l2.assets
In equations (3) and (4) rho is the fraction of variance due to the individual component

(4) Standard errors based on the Observed Information Matrix (OIM)

(6) Instruments for the difference equation: l2.leverage and further lags; first differences of all the exogenous variables

(7) In addition to the same instruments for the difference equation in (6), the lagged difference of the laverage variable in the level equation

(8) Instruments for the difference equation: l2.debt and l2.assets and first differences of all the exogenous variables; instruments for the level equation: the lagged first differences of variables debt and assets
(*) McFadden R-squared

M1 and m2 is are, respectively, asymptotically N(0,1) tests for first and second-order serial correlation of the residuals. H0: no autocorrelation

Sargan test is an asymptotically chi-square test for the validity of overidentifying restrictions. H0: overidentifying restrictions are valid

Table 4.2 - Leverage equation: static model

	(1)	(2)	(2a) small firms	(2b) medium firms	(2c) large firms
VARIABLES					
L.inn	-0.257	-0.394**	-0.688**	-0.017	-0.0717
	[0.159]	[0.161]	[0.274]	[0.208]	[1.159]
L.intang_ta	0.219***	0.218***	0.211***	0.199***	0.283**
	[0.0346]	[0.0346]	[0.0484]	[0.0533]	[0.116]
ros	-0.282***	-0.286***	-0.275***	-0.304***	-0.162**
	[0.0168]	[0.0169]	[0.0268]	[0.0226]	[0.0671]
size	-0.0006	-0.000733*			
	[0.000415]	[0.000407]			
age	-0.246***	-0.265***	-0.355***	-0.218***	-0.0857
	[0.0205]	[0.0205]	[0.0373]	[0.0269]	[0.0810]
IR	2.426***	2.477***	2.569***	2.462***	2.050***
	[0.0771]	[0.0771]	[0.131]	[0.0972]	[0.258]
landing_gr		0.0279***	0.0102	0.0387***	0.033
		[0.00759]	[0.0130]	[0.00977]	[0.0336]
northwest		-1.739***	-2.167**	-1.371*	-4.607
		[0.612]	[1.049]	[0.769]	[3.442]
centre		-3.319***	-2.956***	-4.288***	-6.138
		[0.752]	[1.143]	[1.042]	[5.307]
south		-10.85***	-13.10***	-8.537***	-1.593
		[1.130]	[1.491]	[1.739]	[11.80]
Constant	65.70***	76.10***	76.09***	79.03***	59.35***
	[0.649]	[3.847]	[4.518]	[6.149]	[14.32]
industry dummies	*NO*	*YES*	*YES*	*YES*	*YES*
Observations	18,137	18,137	7,427	9,870	840
Number of firms	2,591	2,591	1,061	1,410	120
R-squared	0.296	0.324	0.331	0.339	0.348
within	0.116	0.116	0.110	0.125	0.103
beetween	0.338	0.365	0.371	0.385	0.383
Chow test			F(38,18061)=8.58***	F(37, 18063)=9.43***	F(35, 18067)=8.62***

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1
Estimations based on a random effect model specification
Time dummies included

Chow test is a F test for the equality of two sets of coefficients in linear regression models. H0: the set coefficients are equal. The test has been performed by comparing each sub-group with the pooled sample

Table 4.3 - Leverage equation: OLS estimations

VARIABLES	(1)	(2)	(2a) small firms	(2b) medium firms	(2c) large firms	(3)	(4)	(4a) small firms	(4b) medium firms	(4c) large firms
inn_1996	-1.307**									
	[0.604]									
inn		-1.370**	-2.197*	-0.374	-3.814					
		[0.655]	[1.193]	[1.110]	[5.991]					
R&D_cis3						-0.486				
						[0.604]				
innsales_cis3							2.621*	4.598*	1.842	12.82*
							[1.481]	[2.581]	[1.926]	[6.428]
gp_cis3	-1.383**	-1.321**	0.739	-1.280*	-1.048	-1.521***	-2.068***	-1.613	-1.592*	-0.0646
	[0.584]	[0.588]	[1.349]	[0.699]	[3.384]	[0.587]	[0.791]	[2.087]	[0.950]	[5.014]
mintang_ta	0.461***	0.466***	0.421***	0.497***	0.726	0.467***	0.404***	0.259	0.517**	1.126
	[0.0977]	[0.0977]	[0.143]	[0.139]	[0.602]	[0.0983]	[0.151]	[0.233]	[0.232]	[0.731]
mros	-1.178***	-1.169***	-1.296***	-1.116***	-0.916***	-1.176***	-1.152***	-1.201***	-1.170***	-0.656**
	[0.0493]	[0.0493]	[0.0832]	[0.0630]	[0.264]	[0.0494]	[0.0723]	[0.128]	[0.0919]	[0.312]
msize	-0.000393	-0.000371				-0.000422	-0.000537			
	[0.000470]	[0.000473]				[0.000470]	[0.000475]			
mage	-0.250***	-0.250***	-0.324***	-0.224***	-0.0788	-0.254***	-0.231***	-0.355***	-0.200***	-0.168**
	[0.0219]	[0.0220]	[0.0428]	[0.0267]	[0.0720]	[0.0218]	[0.0314]	[0.0707]	[0.0394]	[0.0789]
mIR	5.602***	5.590***	5.300***	5.940***	4.181***	5.577***	5.410***	5.399***	5.597***	1.39
	[0.192]	[0.193]	[0.307]	[0.252]	[1.021]	[0.193]	[0.285]	[0.519]	[0.352]	[1.356]
northwest	-1.678***	-1.619***	-2.329**	-1.016	-3.777	-1.505***	-0.45	-1.53	0.935	-7.152**
	[0.578]	[0.577]	[0.983]	[0.736]	[3.045]	[0.576]	[0.812]	[1.552]	[1.013]	[3.370]
centre	-3.579***	-3.581***	-3.936***	-3.865***	-4.954	-3.262***	-2.366**	-0.94	-3.415**	-12.85***
	[0.741]	[0.743]	[1.193]	[1.002]	[5.271]	[0.734]	[1.037]	[1.721]	[1.350]	[4.691]
south	-14.10***	-14.12***	-16.69***	-11.07***	-4.16	-13.49***	-15.43***	-17.51***	-12.20***	0
	[1.119]	[1.117]	[1.511]	[1.713]	[4.574]	[1.082]	[1.741]	[2.481]	[2.392]	[0]
fin_const_cis3	1.670***	1.680***	0.718	1.648**	10.72***	1.695***	2.311***	0.841	2.089**	13.98***
	[0.578]	[0.578]	[0.931]	[0.727]	[3.104]	[0.578]	[0.763]	[1.319]	[0.951]	[3.033]
Constant	76.88***	76.75***	78.06***	72.10***	60.83***	76.91***	80.29***	83.87***	50.42***	26.89***
	[5.006]	[4.994]	[3.624]	[2.694]	[6.702]	[5.057]	[10.70]	[10.40]	[3.345]	[8.335]
Observations	2591	2591	1061	1410	120	2591	1233	422	730	81
R-squared	0.488	0.488	0.503	0.503	0.536	0.487	0.491	0.525	0.521	0.618

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1
Industry dummies included

Appendix 1

Sectoral and geographical distribution of the industrial firms: panel of 2,591 firms vs. CIS3 sample of respondents - Year 2000

	panel			*CIS3 sample*		
Ateco 2 digit	n. of firms	of which, innovative (%)	mean size (n. of employees) *	n. of firms	of which, innovative (%)	mean size (n. of employees)*
15+16 Food products and beverages; Tobaccos	155	44.5%	179	627	47.7%	152
17 Textiles	176	44.3%	197	489	37.5%	117
18 Wearing apparel; dressing and dyeing of fur	95	29.5%	152	631	27.7%	65
19 Leather; luggage, handbags, saddlery, harness and footwear	76	32.9%	86	373	28.4%	55
20 Wood and products of wood and cork, except furniture	114	39.5%	65	422	44.1%	39
21 Pulp, paper and paper products	138	34.8%	81	353	47.4%	76
22 Publishing, printing and reproduction of recorded media	100	50.0%	76	420	39.3%	70
23 Coke, refined petroleum products and nuclear fuel	24	37.5%	90	94	42.8%	85
24 Chemicals and chemical products	163	54.0%	135	523	56.5%	173
25 Rubber and plastic products	208	51.9%	150	498	72.3%	94
26 Other non-metallic mineral products	190	51.6%	152	573	54.9%	98
27 Basic metals	131	48.1%	250	347	50.5%	183
28 Fabricated metal products, except machinery and equipment	197	56.3%	122	712	49.2%	76
29 Machinery and equipment n.e.c.	248	70.2%	266	697	49.9%	174
30 Office machinery and computers	10	100.0%	126	85	89.8%	65
31 Electrical machinery and apparatus n.e.c.	134	66.4%	144	466	48.4%	104
32 Radio, television and communication equipment and apparatus	47	78.7%	142	250	68.6%	128
33 Medical, precision and optical instruments, watches and clocks	84	79.8%	153	323	82.8%	96
34 Motor vehicles, trailers and semi-trailers	94	68.1%	329	289	51.6%	219
35 Other transport equipment	38	55.3%	149	238	44.0%	190
36 Furniture; manufacturing n.e.c.	151	49.7%	99	523	47.7%	56
37 Recycling	13	23.1%	45	101	30.5%	23
40 Electricity, gas and water supply	5	40.0%	25	133	17.8%	246
geographical area						
North West	983	54.9%	213	2,933	46.0%	159
North East	907	57.9%	141	2,834	45.0%	101
Centre	486	49.8%	117	2,049	37.2%	95
South	215	36.3%	69	1,351	27.3%	52
TOTAL	**2,591**	**52.6%**	**157**	**9,167**	**47.7%**	**111**

Appendix 2
Variables' definition and Summary Statistics

variable definition		Total sample (20,728 obs.)			Innovative firms: 11,893 obs.			Non innovative firms: 8,835 obs.		
		Mean	std. Dev.	median	Mean	std. Dev.	median	Mean	std. Dev.	median
LEVERAGE	Debt to assets ratio (%)	62.2	18.7	64.8	61.8	18.2	64.7	62.6	19.2	65.0
ROS	Return on sales (%). The ratio between gross operating profits and sales. An index of operating profitability.	10.6	7.2	9.8	11.2	7.3	10.4	9.8	7.1	9.1
AGE	Firm's age in years	24.7	13.3	24.0	26.3	13.9	25.0	22.6	12.2	22.0
SIZE	Number of employees	154.9	538.7	61.0	221.1	688.5	93.0	66.0	169.8	34.4
IR	Interest payment to sales (%). A variable reflecting the position of the firm with respect to external financing resources.	1.7	3.1	0.6	1.8	3.2	0.7	1.6	3.1	0.4
INTANG_TA	Intangible assets to total assets (%)	2.2	1.8	1.8	2.2	1.7	1.8	2.2	1.8	1.8