Small Firm Investment and Financing Decisions: An Option Value Approach

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ABSTRACT. This paper reviews and discusses recent developments undergone by investment theory, and tries to address both financial and real decisions within an uncertain environment, here, the Italian economy. According to the recent "option value" approach to investment, if differing degrees of reversibility characterize the accumulation process by groups of firms (small and larger firms), we should expect their investment decisions to differ under uncertainty. On the other hand, asset reversibility has an influence on firm financing policy, given the observed relationship between asset and liability composition. Assuming a different degree of investment reversibility for small and larger firms, we explore how they react to interest rate uncertainty using the Italian experience during the 1980s as a benchmark. The main result of this paper is that interest rate uncertainty exerts a negative influence on firms' investment demand. The relationship is stronger for large firms than for small firms. Another result is that firm leverage also shows a negative relationship with interest rate uncertainty.

1. Introduction

The aim of this paper is threefold. It reviews and discusses recent developments undergone by investment theory which seem to represent a new viewpoint from which to analyze small firm as opposed to larger firm investment decisions; it tries to address both financial and real decisions within an uncertain environment; it presents some evidence with respect to the Italian economy.

According to the recent "option value" approach to investment, if differing degrees of irreversibility characterize the accumulation process by two groups of firms (small and larger firms), we should expect their investment decisions to differ under uncertainty: the more irreversible a project is, the more it will be negatively influenced by uncertainty. This result has been recently and more clearly demonstrated by a line of research that underlines the analogy between a financial option and the decision to invest (Dixit and Pindyck, 1994; Ingersoll and Ross, 1992; Pindyck, 1991). On the other hand, asset reversibility has an influence on firm financing policy: as has been already noted (Myers, 1977; Shleifer and Vishny, 1992) there is a positive relationship between the degree of asset reversibility and leverage. Uncertainty is also expected to play a role in the level of debt and in its maturity structure: an increase in uncertainty should have a negative influence on leverage while it should favor short-term over long-term debt (Morris, 1976; Houston and Venkataraman, 1994).

The option value approach to investment recognizes that financial options and *most* investment expenditures share three main characteristics:

(i) investment expenditures are largely irreversible as well as exercising an option. In other terms, they are mostly sunk costs that cannot be recovered. Indeed, capital is firm or industry specific, but irreversibility is partly due to the well known "lemons" problem;
(ii) investment outcomes are uncertain. Uncertainty may occur because either output or capital prices are uncertain, or future interest rates are uncertain;
(iii) the decision to invest can be delayed, giving the firm an opportunity to wait for new information on the formerly uncertain variables.

Conversely, the traditional view towards invest-

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ment, based on capital reversibility and labor flexibility, pointed out the existence of convex returns which implies, given the well-known Jensen's inequality, a positive relationship between investment demand and uncertainty.

In this paper we will discuss, and try to empirically test, these two approaches with respect to investment demand by small firms and larger firms, assuming that the degree of irreversibility is lower for the former. In particular, we will explore how small firms and large firms react to changes in interest rates, using as a benchmark the Italian experience during the 1980s. This line of research will give us two advantages. First, the Italian economy is largely based on small firms; secondly, the '80s were characterized by a period of positive and increasing real interest rates, as opposed to the '70s. Moreover, mainly focusing our attention on interest rates will allow us to relate, at the same time, uncertainty to both firm assets and liabilities more than to other types of uncertainty (price uncertainty, for instance). Of course we believe that interest rate uncertainty is not the only source of uncertainty relevant for investment decisions. We motivate our decision with respect to interest rate uncertainty by first noting that during the period of 1982–1992, to which our data set refers, the Italian economy experienced its longest and most stable growth since the 1950s. Therefore, we think aggregate demand uncertainty (as opposed to its growth) should have played a minor role, if any, in affecting investments. Secondly, during the same period, inflation was relatively low and stable under increasing competitive pressures produced by the European Monetary System, an agreement among European countries to avoid recurrent exchange rate devaluations, in place since the end of 1979.[1] Thirdly, interest rate uncertainty should already incorporate price uncertainty since we focus on the real interest rate and the latter is defined as the difference between the nominal interest rate and inflation. Finally, our approach will also allow us to draw policy conclusions and, in particular, to highlight the role of (interest rate) stabilization policies in favoring capital accumulation.

The main result of the paper is that interest rate uncertainty seems to exert a generally negative influence on large as well as on small firms' investment demand. Some evidence, though not robust, shows that smaller firms (likely those with fewer than 19 employees) could bear no significant relationship with interest rate uncertainty. Therefore, these results argue in favor of theories in which irreversibility causes the marginal revenue product of capital to be a concave function. Another important result is that firm leverage, and in particular short-term debt, shows a negative relationship with interest rate uncertainty as well. These two results are closely related. Indeed, since short-term debt is a main source of financing, especially for small firms, an increase in interest rate uncertainty, limiting firms' access to credit markets, also reduces their incentive to invest. However, the main shortcoming of this paper is that we work with a limited data set and still at a high level of aggregation. Notwithstanding this, empirical results are encouraging for future research.

The rest of the paper is organized as follows: in Section II we will review investment theory pointing out differences between the traditional (or neoclassical) view and the most updated *option value* approach. Section III presents some stylized facts on investment and uncertainty with respect to the Italian economy. In Section IV we will explore relationships between assets and liabilities induced by and related to interest rate uncertainty. Finally, Section V features a summary and conclusions.

2. Investment theory under uncertainty: A quick review

Over the last three decades, investment literature has underlined the unsatisfactory results obtained by empirically implementing investment models derived from Jorgenson's neoclassical approach. According to this approach, a firm should invest up to the point at which the marginal product of capital is equated to the user cost of capital.[2] Two main hypotheses on which the neoclassical investment theory relies are that (a) invested capital can be easily sold to other users, or that capital is reversible, and (b) each project is a once-and-for-all opportunity. Departure from this "traditional view" has mainly meant focusing on two types of frictions: adjustment costs and irreversibility. In particular, the irreversibility hypothesis also

recognizes the existence of a possibility to delay a project, giving rise to a call option: the firm has the right, though not the obligation, to buy an asset (the project) at some future time at its discretion. In other words, given investment irreversibility and uncertainty, it is worth waiting for more information.

One of the first attempts to model investment, taking into account irreversibility and the option to delay the project, dates back to Bernanke (1983). More recently, a growing body of related literature has stemmed from work by Pindyck and Dixit.[3] However, most of this literature focuses on output or capital price uncertainty. On the other hand, interest rate uncertainty was discussed in a paper by Ingersoll and Ross (1992). There they examine the role of interest rate uncertainty on a single and indivisible project of maturity equal to T. Instead, in a more recent paper this approach has been discussed and developed in the context of incremental investment decisions (Saltari and Calcagnini, 1995). We will now show the main results obtained in that paper.

We start from the traditional assumptions regarding a representative firm, according to which a single good (Y) is produced by a production function of the type $F(K)$, with $F' > 0$ and $F'' < 0$, and where K is a non depreciable single capital good. Moreover, we assume that output and capital prices are constant and respectively equal to 1 and q, while the interest rate is assumed to follow a Brownian stochastic process of the type:

$$dr = \sigma r^{3/2} dz \tag{II.1}$$

where z is a Wiener process, and σ is a constant measuring the interest rate variability, which we assume to be less than 1.[4]

Assuming a risk neutral firm and irreversible investments, the optimal level of capital should satisfy the following Bellman equation:

$$r_t V(K_t, r_t)dt = \max_{\{dK_t\}} [F(K_t)dt - q dK_t + E_t(dV(K_t, r_t))] \tag{II.2}$$

Equation (II.2) has a standard economic meaning: when capital stock is at its optimum level, the expected return (given by firm cash-flow plus capital losses or gains) must be equal to the market return at the current interest rate. It is worth noting that in equation (II.2) capital stock is a state variable as opposed to the more traditional model with investment reversibility.

It can be shown that the following relationship between the critical level of interest rates in the two models (with, respectively, investment irreversibility and reversibility) holds:

$$\begin{aligned} r_t^* &= \frac{F_K}{q(1-\sigma^2)}\left(1 + \frac{1}{n_1}\right) \\ &= \rho_t \left(1 + \frac{1}{n_1}\right) < \rho_t \end{aligned} \tag{II.3}$$

where ρ_t is the critical level of interest rates when investments are reversible. Since $n_1 < 0$, but $|n_1| > 1$, $\rho_t > (1 + 1/n_1)\rho_t$.[5] Equation (II.3) shows that, for a given capital stock, interest rates must be lower when investment is irreversible than they are when investments are reversible; the difference being an option value measure. Moreover it shows the standard negative relationship between capital stock and interest rate levels. In contrast, when we consider interest rate uncertainty (measured by changes in σ^2), it can be shown that an increase in σ^2 produces two effects: the first effect increases firm fundamentals (see Equation (II.3)) and therefore induces higher investment demand; the second effect increases the option value so that it depresses investment. Generally, the final effect is indeterminate. However, given the stochastic process (Equation (II.1)), the depressive effect is dominant. This is a quite intuitive result that shows how an increase in interest rate uncertainty tends to delay investment projects.[6] In other words, this also means that the marginal revenue product of capital is concave. Concavity has a simple and intuitive economic explanation: if interest rates turn out to be lower than expected, then actual capital stock is too low and the incentive is to invest more, thereby limiting the rise in the marginal revenue product of capital. If, on the other hand, interest rates turn out to be higher than expected, firms are left with too much capital (given the assumption of irreversibility) and, therefore, with low returns.

We can sum up results obtained by theoretical models, pivoting on the relationship between interest rate uncertainty and irreversible investment demand (Ingersoll and Ross, 1992; Saltari and Calcagnini, 1995), pointing out that this relationship is negative, as economic intuition

suggests, at least under given conditions. This is a quite general result since it applies both to single projects and to incremental investments. The generality of this result is such that it can be applied to a breakdown of investment demand by firm size. In other words, we assume that incremental capacity models are more suitable in describing large firm investment decisions, while the single project approach applies to smaller firms. Indeed, high entry and exit rates are observed in industries characterized by the presence of small firms. An entry or exit decision can be thought of as a single project decision: high entry and exit rates are typically the result of low entry and exit barriers which, in turn, depend on sunk costs. The latter are just a measure of the irreversibility of each investment expenditure. Therefore, we make the strong assumption that small firm investment decisions are reversible, while large firm investment decisions are not. Results from recent surveys seem to support this assumption and clearly suggest that Italian small firms' investment decisions are seen as largely reversible.[7] This is especially true for small firms from traditional industries organized into industrial districts, as they can take advantage of well developed second-hand markets for capital goods. However, we should also note that the degree of reversibility at the firm level may be different from the degree of reversibility at the industry level. In particular, the former is generally higher than the latter. This difference can be a main source of over-investment in small firm industries which, in turn, can be associated with their high entry and exit rates.

Our previous discussion left us with a nice and simple apparatus with which some empirical work on the relationship between interest rate uncertainty and investments may be done. Indeed, we said that (a) it may be expected that an increase in interest rate uncertainty will depress irreversible projects or large firms' investment demand, and (b) since small firm investment expenditures are expected to be largely reversible, they should be positively influenced by uncertainty.

3. Some stylized facts on investment and uncertainty

This section extends the empirical analysis carried out in Saltari and Calcagnini (1995) by making use of panel data and breaking down classes of firms by size. This approach allows us to directly test the hypothesis discussed in the previous section, according to which interest rate uncertainty should have a different influence on small firms as opposed to larger firms.

Interest rate uncertainty is measured, as in Saltari and Calcagnini (1995), by a transformation of residuals obtained by the following dividend-stock price VAR model:

$$\Delta d_t = \alpha_0 \Delta p_{t-1} + \alpha_1 \Delta d_{t-1} + \alpha_2 (d_{t-1} - p_{t-1}) + \varepsilon_t \qquad \text{(III.1)}$$

$$\Delta p_t = \beta_0 \Delta p_{t-1} + \beta_1 \Delta d_{t-1} + \beta_2 (d_{t-1} - p_{t-1}) + \eta_t \qquad \text{(III.2)}$$

where d stands for dividends and p for stock prices, while $(d_{t-1} - p_{t-1})$ is the error correction term.[8] In general, it will be true that $\text{cov}(\varepsilon_t, \eta_t) \neq 0$, but by means of Cholesky decomposition the two error terms can be made orthogonal: ε_t^* and η_t^*.

Since stock prices can be written as:

$$P_t = E_t \left[\sum_{j=1}^{\infty} \left(\prod_{i=1}^{j} \frac{1}{1 + \rho_{t+i}} \right) D_{t+j} \right] \qquad \text{(III.3)}$$

where the discount rate, ρ_t, is the sum of the interest rate, r_t, plus a constant risk premium[9] s_t, the term η_t^* only represents stock price innovations due to interest rate innovations. The absolute value of η_t^* is our measure of interest rate uncertainty $\sigma(r)$.

The advantage of using this measure of interest rate uncertainty, as opposed to the more traditional standard deviation of interest rate levels, is that it is already corrected for capital profitability innovations, or fundamentals, (represented by ε_t^*).[10]

We realize that this uncertainty measure has some disadvantages as well. First, it is still too general, while most shocks are idiosyncratic to the firm or to each class of firms. We will try to mitigate this problem by scaling our uncertainty measure according to the debt-sales of each class of firms, and the interest rate payment-gross

operating income ratio. Second, $\sigma(r)$ is an *ex post* interest rate innovation measure, while uncertainty relates to expectations.

Our strategy is to estimate the reduced form relationship between investment and interest rate uncertainty in the context of an accelerative model. Our entire sample consists of nine observations (from 1984 to 1992) for seven dimensional classes of firms by number of employees.[11]

We preferred the accelerative model since it captures liquidity effects, i.e., asymmetric information problems, better than other models. Moreover, we skipped the task of specifying a more structural model since the type of problems it involves have not yet been clearly set.[12] The final specification we used is:

$$\left(\frac{I_t}{Y_{t-1}}\right)_i = c + \gamma\left(\frac{\Delta Y_t}{Y_{t-1}}\right)_i + \omega\sigma(r)_{ti} + \lambda r_{ti} + \varepsilon_{ti} \qquad \text{(III.4)}$$

for $i = 1, \ldots 7$ and $t = 1984, \ldots 1992$.

Panel results are shown in Table I where under (a) we report estimates using our base interest rate uncertainty, while under (b) and (c) uncertainty is scaled by each firm class' debt-sales ratio and interest rate payment-gross operating income ratio, respectively. We also report *Beta* coefficients in order to make statements about the relative importance of each independent variable.

First of all, we note that all the coefficients are statistically significant and have their expected sign. Secondly, real interest rates result as being the most important explanatory variable for investment rate dynamics, its coefficient being respectively more than two or three times production growth and interest rate uncertainty coefficients. Moreover, as far as interest rate uncertainty is concerned, our results show that it is negatively correlated with investment demand and no significant differences are observable among firms of different size. Finally, different interest rate uncertainty specifications do not change this result in any significant way. Changes in the estimated coefficient show an increase in the explanatory power of interest rate uncertainty when we take into account firm leverage, and a less significant decrease when the interest rate payment-gross operating income ratio is used as a scaling factor.

These results are favorable towards models with investment irreversibility and highlight the role of interest rate uncertainty, besides interest rate levels, in influencing investment demand. However, most of the Italian economic literature that underlines small firm investment reversibility really has small businesses in mind: manufacturing

TABLE I
Panel data estimation: Random Effects Model (breakdown by firm size (nobs = 63))

		c	γ	ω	λ
(a)	Estimated "Beta" coefficients	6.188	0.196	–0.084	–0.243
	t-statistic	(15.57)	(4.98)	(–2.25)	(–6.50)
	R-squared	0.54	Std. error	0.27	
	test for [A,B = A_i,B_i]	F(24,35) = 21.63	P-value = 0.00		
	test for [A_i,B = A_i,B_i]	F(18,35) = 0.76	P-value = 0.73		
	Hausman test	$\aleph^2(3) = 2.58$	P-value = 0.46	$\theta = 0.012$	
(b)	Estimated "Beta" coefficients	6.132	0.180	–0.101	–0.234
	t-statistic	(15.57)	(4.54)	(–2.52)	(–6.26)
	R-squared	0.52	Std. error	0.29	
	test for [A,B = A_i,B_i]	F(24,35) = 18.93	P-value = 0.00		
	test for [A_i,B = A_i,B_i]	F(18,35) = 0.80	P-value = 0.68		
	Hausman test	$\aleph^2(3) = 6.53$	P-value = 0.09	$\theta = 0.014$	
(c)	Estimated "Beta" coefficients	6.208	0.191	–0.071	–0.248
	t-statistic	(15.33)	(4.78)	(–1.87)	(–6.50)
	R-squared	0.50	Std. error	0.29	
	test for [A,B = A_i,B_i]	F(24,35) = 21.18	P-value = 0.00		
	test for [A_i,B = A_i,B_i]	F(18,35) = 0.76	P-value = 0.73		
	Hausman test	$\aleph^2(3) = 5.24$	P-value = 0.15	$\theta = 0.012$	

average firm size was around 6 employees in 1991. On the contrary, our data set's average firm size is 185 employees. Therefore, in order to check previous results we decided to re-estimate model (III.4), extracting a subsample of manufacturing industries which traditionally characterize Italian small firms. In particular, we consider the following industries: leather goods, footwear and clothing, textiles, metalworking, timber and furniture, and other industries.[13]

Overall results, shown in Table II, are disappointing. Only real interest rates are highly significant, while the production growth coefficient and interest rate uncertainty coefficient are poorly estimated. From our point of view, the latter result may be interpreted as an indication of a looser relationship between investment demand from these industries and interest rate uncertainty.[14] However, we do realize that this is a far from conclusive result.

4. Investment and financing decisions

As for the relationship between investment and financing decisions, we concentrate our attention on two aspects which could explain small firm financial structure: (a) the importance of collateralized debt, and hence of asset composition, and (b) the influence of uncertainty on leverage and debt maturity.

As reversibility is one of the most important features for an asset to be accepted as collateral, we expect that the investment policy followed by small firms will favor their ability to raise debt. Asset composition by firm class roughly confirms this hypothesis: collaterizable assets (technical assets + working capital) represent more than 80% of capital employed by small firms, while they decline steadily to 61% in firms with more than 1000 employees (Table III).[15] At the same time the leverage ratio (short-term + long-term debt on total assets) spans from 33.2% in smaller firms to 26.2% in larger firms (Table IV).

As argued by Ang (1992), the relationship between size and leverage is rather complex and enough reasons can be found to justify both lower or higher leverage in (privately held) small firms compared with larger firms.[16] Indeed, empirical evidence does not demonstrate a clear and monotone relationship between size and leverage, although small firms generally show higher leverage ratios and make greater use of short-term financing then larger firms[17] (which is confirmed by our data-set, as shown in Table IV). Higher leverage ratios are generally justified by ownership concentration, while the preference for short-

TABLE II
Panel data estimation: Random Effects Model (breakdown by industry (nobs = 45))

		c	γ	ω	λ
(a)	Estimated "Beta" coefficients	6.357	0.091	–0.085	–0.236
	t-statistic	(8.50)	(1.59)	(–1.54)	(–4.19)
	R-squared	0.33	Std. error	0.49	
	test for [A,B = A_i,B_i]	F(16,25) = 21.87	P-value = 0.00		
	test for [A_i,B = A_i,B_i]	F(12,25) = 1.56	P-value = 0.16		
	Hausman test	$\aleph^2(3)$ = 0.025	P-value = 0.99	θ = 0.016	
(b)	Estimated "Beta" coefficients	6.300	0.080	–0.101	–0.228
	t-statistic	(8.53)	(1.38)	(–1.72)	(–4.07)
	R-squared	0.34	Std. error	0.49	
	test for [A,B = A_i,B_i]	F(16,25) = 20.52	P-value = 0.00		
	test for [A_i,B = A_i,B_i]	F(12,25) = 1.31	P-value = 0.27		
	Hausman test	$\aleph^2(3)$ = 0.046	P-value = 0.99	θ = 0.016	
(c)	Estimated "Beta" coefficients	6.445	0.087	–0.084	–0.244
	t-statistic	(8.46)	(1.52)	(–1.47)	(–4.30)
	R-squared	0.33	Std. error	0.49	
	test for [A,B = A_i,B_i]	F(16,25) = 20.97	P-value = 0.00		
	test for [A_i,B = A_i,B_i]	F(12,25) = 1.44	P-value = 0.21		
	Hausman test	$\aleph^2(3)$ = 3.45	P-value = 0.33	θ = 0.016	

TABLE III
Asset composition by firm class: average values 1983–1992 (percentage values)

Firm class – number of employees	1–19	20–49	50–99	100–199	200–499	500–999	≥ 1000
Technical assets	49.7	51.4	52.6	51.7	46.8	48.8	47.5
Intangible assets	2.4	2.2	2.1	2.2	2.0	2.7	3.6
Equity holdings	3.5	4.6	5.7	7.2	11.2	15.4	27.2
Net working capital	38.3	34.0	31.3	30.5	30.9	24.2	13.6
Liquidity	6.2	7.9	8.2	8.4	9.0	8.9	8.1

Source: Calculations based on Centrale dei Bilanci (1994).

TABLE IV
Firm sample characteristics: average values 1983–1992

Class of employees	No. of firms	Short-term debt/ Total assets (%)	Long-term debt/ Total assets (%)	Retained earning/ Total assets (%)	Net operat. income/ Sales (%)
1–19	1325	22.6	10.6	2.8	4.2
20–49	1756	20.6	10.9	5.1	5.3
50–99	2390	19.6	10.9	5.7	5.5
100–199	1027	19.3	11.8	6.0	5.3
200–499	592	18.7	12.0	6.4	6.1
500–999	443	18.4	11.5	7.2	5.9
≥ 1000	92	13.1	13.1	7.6	5.3
Total	7714	18.9	11.5	5.8	5.3

Source: Calculations based on Centrale dei Bilanci (1994).

term debt is explained by the existence of flotation costs and the access problems to capital markets associated with long-term debt.

Banks tend to collateralize their loans to small firms for two main reasons: (a) small firms have a higher probability of bankruptcy than larger ones, and (b) debt collateralization helps reduce transaction costs associated with information asymmetries between firms and lenders (Smith and Warner, 1979). For this reason, the use of debt by small firms (both quantitatively and qualitatively) is strictly related to the assets available for use as collateral (Constand et al., 1991). Specifically, short-term debt is for the most part collateralized on accounts receivable and inventories and its amount fluctuates continuously under a fixed contractual arrangement.[18] Long-term debt is generally collateralized on technical assets and, in small firms, it normally takes the form of loans or notes, while bond issues are less frequent.[19]

As for leverage and uncertainty, we expect a negative relationship between the two variables. Theoretical justification for this can be drawn from the trade-off theory (the more the uncertainty, the more the probability of bankruptcy) and from the under investment problem in the presence of growth options. The value of which increases with uncertainty (Myers, 1977). The former is expected to be stronger in the case of small firms, while the latter is more representative in the case of larger firms. Uncertainty should also favor short-term debt over long-term debt. Specifically, interest rate uncertainty should favor short-term debt when there is a positive correlation between interest rates and net operating income (NOI); in this case the use of a short maturity policy reduces the variability of net income and thus the risk to the stockholders associated with the use of debt (Morris, 1976).[20]

Other reasons explain small firm preference for short-term debt. First, the type of long-term debt normally used by small firms has a fixed repayment plan and does not allow firms to retire them without a cost.[21] In that case firms prefer short-term debt as it gives them the possibility of easily adjusting the amount of debt. Secondly, when investments are reversible (with a high liquidation value) the use of short-term debt guaranties that

the firms follow an optimal liquidation policy, while the use of long-term debt creates an incentive for equityholders to continue operating the firm even though liquidation is optimal.[22]

To summarize, we can expect that uncertainty will favor short-term debt while reducing the incentive to increase long-term debt, other things being equal.

Following our previous discussion, we tested three reduced form equations in order to explain total leverage, short-term and long-term debt. As opposed to other empirical studies on firms' financial structure,[23] we limited the number of explaining variables. Specifically, we omit variables that capture the importance of non-debt tax shields and the idiosyncratic risk, because we work with aggregate data which do not allow us to capture firm-level effects. Instead, we include a variable to take into account the internal generation of funds. We expect this variable to show a negative relationship with leverage since we assume the existence of a hierarchy in the use of funds, with internal sources being preferred to external sources (Myers, 1984). Although developed to explain the financing policy of large and managerial firms, the hierarchy hypothesis is also useful in describing small firms' financing policies. Indeed, preference for internal financing and debt to new equity issue can be justified by private ownership and by the difficulties present in raising funds through the stock and bond market.

We used the following specification for total leverage, short-term and long-term debt:

$$LEV_{ti} = c + \beta COL_{ti} + \gamma RE_{ti} + \omega\sigma(r) \quad \text{with } \beta > 0;\ \gamma < 0;\ \omega < 0 \qquad \text{(IV.1)}$$

$$STD_{ti} = c + \beta NWC_{ti} + \gamma RE_{ti} + \omega\sigma(r) \quad \text{with } \beta > 0;\ \gamma < 0;\ \omega < 0 \qquad \text{(IV.2)}$$

$$LTD_{ti} = c + \beta TA_{ti} + \gamma RE_{ti} + \omega\sigma(r) \quad \text{with } \beta > 0;\ \gamma < 0;\ \omega < 0 \qquad \text{(IV.3)}$$

where: LEV stands for total leverage; STD for short-term debt; LTD for long-term debt; NWC for net working capital; TA for technical assets; COL (NWC+TA) for assets available as collateral; RE for retained earnings; $\sigma(r)$ for uncertainty. All variables are in real terms and, except uncertainty, are scaled on total assets.

We test the three equations with a panel procedure, using the same data set as in Section III. As the estimates on levels show the presence of significant fixed effects, we take the first differences of variables in Equations (IV.1–IV.3) and run the panel procedure again. Results for the overall data set using the variance component (random effects) estimates are shown in Table V.

The coefficient associated with retained earnings shows the expected sign and is significant in all the models. This offers support to the hierarchy hypothesis, which is certainly justified if we consider Italian capital market imperfections.[24]

Assets available as collateral play an important role in explaining short-term debt, while they are not significant in the long-term debt equation. Coefficients in the long-term debt equation are significantly different between small and larger firms (Table VI): TA (technical assets) is the only significant variable in the long-term debt equation for small firms. This result demonstrates the strong dependence of small firms on collateralizable assets for the raising of long-term debt. In contrast, larger firms seem able to adjust long-term debt to their financial needs, independently of collateraz-ible assets.

Uncertainty is shown to have a significantly negative role on total leverage in small and larger firms, as our F tests seem to suggest (see Table V). What is not confirmed by the estimates is the influence of uncertainty on switching from long to short-term debt. Instead, uncertainty does show a significant negative influence on short-term debt, while it is never significant in long-term debt equations. This could be due to the specific measure of uncertainty we use, as it is a measure of realized uncertainty, while at the same time decisions about the duration of debt are based on expected (future) uncertainty.

Results obtained in this Section seem to suggest a financial explanation for the negative relationship between interest rate uncertainty and investments discussed in Sections II and III. Indeed, in the presence of higher interest rate uncertainty and capital market imperfections, firms may find it more difficult to expand their debt due to credit rationing by banks. The latter may be especially true when uncertainty concerns periods of increasing real interest rates, as in the case of the period we considered in this study. Therefore, as far as investments depend on bank loans, we may

TABLE V
Panel data estimation: Random Effects Model (breakdown by firm size (nobs = 63))

		c	β	γ	ω
(a)	*Dependent variable: LEV*				
	Estimated "Beta" coefficients	0.007	0.156	–0.294	–0.340
	t-statistic	(3.46)	(1.40)	(–2.33)	(–2.34)
	R-squared	0.36	Std. error	0.011	
	test for [A,B = A_i,B_i]	F(24,35) = 1.08	P-value = 0.41		
	test for [A_i,B = A_i,B_i]	F(18,35) = 1.05	P-value = 0.43		
	Hausman test	$\aleph^2(3)$ = 3.44	P-value = 0.33	θ = 0.89	
(b)	*Dependent variable: STD*				
	Estimated "Beta" coefficients	0.007	0.352	–0.301	–0.384
	t-statistic	(5.43)	(3.46)	(–2.63)	(–3.47)
	R-squared	0.40	Std. error	0.009	
	test for [A,B = A_i,B_i]	F(24,35) = 0.58	P-value = 0.92		
	test for [A_i,B = A_i,B_i]	F(18,35) = 0.67	P-value = 0.27		
	Hausman test	$\aleph^2(3)$ = 0.020	P-value = 0.99	θ = 0.74	
(c)	*Dependent variable: LTD*				
	Estimated "Beta" coefficients	0.002	–0.004	–0.304	0.004
	t-statistic	(–1.36)	(–0.02)	(–2.51)	(0.28)
	R-squared	0.16	Std. error	0.006	
	test for [A,B = A_i,B_i]	F(24,35) = 1.38	P-value = 0.19		
	test for [A_i,B = A_i,B_i]	F(18,35) = 1.50	P-value = 0.15		
	Hausman test	$\aleph^2(3)$ = 0.55	P-value = 0.99	θ = 0.53	

TABLE VI
Panel data estimation: Random Effects Model

		c	β	γ	ω
(a)	*Dependent variable: LTD – small firms (breakdown by firm size (nobs = 27))*				
	Estimated "Beta" coefficients	0.002	0.801	0.382	–0.168
	t-statistic	(1.98)	(3.47)	(1.49)	(–0.94)
	R-squared	0.35	Std. error	0.035	
	test for [A,B = A_i,B_i]	F(8,15) = 0.66	P-value = 0.71		
	test for [A_i,B = A_i,B_i]	F(6,15) = 0.72	P-value = 0.64		
	Hausman test	$\aleph^2(3)$ = 0.52	P-value = 0.99	θ = 0.69	
(b)	*Dependent variable: LTD – larger firms (breakdown by firm size (nobs = 36))*				
	Estimated "Beta" coefficients	–0.003	–0.157	–0.579	0.085
	t-statistic	(–1.91)	(–0.84)	(–2.66)	(0.46)
	R-squared	0.22	Std. error	0.0072	
	test for [A,B = A_i,B_i]	F(12,20) = 1.35	P-value = 0.27		
	test for [A_i,B = A_i,B_i]	F(9,20) = 1.39	P-value = 0.25		
	Hausman test	$\aleph^2(3)$ = 2.47	P-value = 0.48	θ = 0.94	

expect projects to be cut or delayed, even in the presence of investment reversibility.[25]

5. Conclusions

In this paper we have studied the relationship between interest rate uncertainty, firm investment demand and financial decisions. The first result obtained is that interest rate uncertainty seems to negatively influence investment demand, as in models in which irreversibility plays an important role. Moreover, we did not find significant differences between small firms and larger firms, as we would have expected. This result also shows

that from a policy point of view, not only interest rate levels are important, but their variability is important as well.

The second result is that the same type of relationship can be found between interest rate uncertainty and leverage, especially short-term debt. Since short-term debt is an important financing source for small firms, we interpret the latter result as evidence of the relationship between capital market imperfections and firm investment decisions.

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Notes

[1] Demand and price uncertainty effects on investment decisions are discussed and analyzed in Saltari and Calcagnini (1990) and Calcagnini (1990).

[2] A variant of this rule is that a firm should undertake investment projects with positive net present value (see Hubbard, 1994). It is also worth noting that the neoclassical theory determines the optimal stock of capital and not investment.

[3] See Pindyck (1991), Dixit (1992), Dixit and Pindyck (1994).

[4] The most important characteristic of the stochastic process (II.1) is that negative interest rates are excluded: 0 is an absorbing barrier.

[5] n_1 is one of the two roots of the characteristic equation associated with model (II.1)–(II.2).

[6] However, this conclusion suffers from the same type of criticism addressed to the neoclassical investment theory: this model determines the optimal stock of capital and not investment. It is well-known that this problem has been overcome by adjustment cost models. Abel and Eberly (1994) developed an adjustment cost model which takes into account investment irreversibility.

[7] See Contini and Revelli (1986), Garofoli (1992), Balloni (1994), Vivarelli (1994).

[8] A similar model has been estimated by Cochrane (1994).

[9] Instead, we can assume a variable risk premium, positively correlated with interest rate variability.

[10] Moreover, we noticed that the standard deviation of the yearly interest rate levels shows a strong negative correlation with the interest rate level.

[11] Our data set comes from Centrale dei Bilanci (1994). Data set characteristics and variable definitions are given in Appendix I.

[12] Examples of structural models of irreversible investments are Favero et al. (1994). Our approach is similar to that of Leahy and Whited (1995).

[13] These industries are also among those with the smallest capital-labor ratio.

[14] Similar results are obtained by Guiso and Parigi (1995). Indeed, they find that (demand) uncertainty plays a minor role in investment decisions of firms for which a secondary capital goods market exists (i.e., the investment decisions of which are reversible).

[15] The importance of equity holdings in the larger firms reflects the typical organization of manufacturing firms in Italy, based on groups rather than divisionalized firms.

[16] Evidence of this complex relationship is reported by Ferri and Jones (1979).

[17] See Marsh (1982), Titman and Wessels (1988), Chan and Chen (1991), Shleifer and Vishny (1992).

[18] This normally specifies the duration of single operations under the contract but not the duration of the contract.

[19] The use of a particular form of notes written on equipment is widespread among small firms in Italy, as it is subject to a State contribution which reduces the cost of the loan (the so-called Legge Sabatini). The duration of the notes is five years.

[20] In the case of our data set, we observe a weak but positive correlation between interest rates and NOI, which is stronger in small firms than in larger firms.

[21] While bond issues can be designed to better meet the financial flexibility needed by the firm.

[22] See Houston and Venkataraman (1994). They show that in presence of high liquidation value (which is associated to the degree or asset reversibility) the value of the firm financed with short-term debt increases as interest rate uncertainty increases.

[23] See Ferri and Jones (1979), Bradley et al. (1984), Titman and Wessels (1988).

[24] The same conclusion is reached by Buttignon and De Leo (1994) using a different data set of Italian manufacturing firms.

[25] The importance of liquidity constraints for small firm investment is also stressed by Audretsch and Elston (1994) and Gertler and Gilchrist (1994).

Data sources and variables

1. *Data sources*

Firm data are taken from Centrale dei Bilanci, the largest balance sheets and income statements data-base available in Italy. Data have been collected from joint-stock companies (Srl or Spa) by a consortium of banks since 1982.

TABLE AI
Firm sample characteristics for manufacturing firms – 1992

Class of employees	No. of firms	No. of employees	Average dimension	% of firms	% of employees
1–19	1051	13391	12	13.6	1.1
20–49	2501	81998	32	32.4	6.7
50–99	1874	133043	70	24.3	10.9
100–199	1201	164739	137	15.6	13.5
200–499	644	193195	299	8.3	15.8
500–999	200	137526	687	2.6	11.3
≥ 1000	154	496753	3225	2.0	40.7
Total	7714	1220645	158	100.0	100.0

Source: Calculations based on Centrale dei Bilanci (1994).

Data regarding a large panel of manufacturing and service firms are published annually by Centrale dei Bilanci in the volume "Economia e finanza delle imprese italiane". We used data regarding the manufacturing sector contained in the seventh report (published in 1994), covering the period 1982–1992. The balance-sheet data are in real terms and aggregated by class of employees. The main characteristics of the data-set are summarized in Table AI.

In 1992, the 7,714 manufacturing firms in the sample covered, 37.7% of the value added and 35.7% of manufacturing employment.

In our analysis we consider small and medium-sized firms with less than 200 employees and large firms with more than 200 employees (the European Union considers small and medium-sized firms to be those with not more than 250 employees).

The Centrale dei Bilanci sample is biased towards large firms which in 1992 accounted for 67.8% of the sample employment. Instead, according to the 1981 census data, firms with not more than 200 employees represented 69.2% of manufacturing employment; a percentage which increased to 76.8% in 1991. Indeed, the average size of manufacturing firms declined from 9.4 employees in 1981 to 8.8 in 1991 (see Table AII).

TABLE AII
Employees in Italian manufacturing firms

Class of employees	No. of employees		% of employees	
	1981	1991	1981	1991
1–9	1328922	1366845	22.8	26.1
10–19	724553	800899	12.4	15.3
20–99	1390905	1372329	23.8	26.2
100–199	590730	478440	10.1	9.1
≥ 200	1796746	1209036	30.8	23.1
Total	5833837	5229540	100.0	100.0

Source: ISTAT (1995).

Data on bank-loan interest rates, dividends and stock prices are taken from the Banca d'Italia (1995) and Mediobanca (1993a,b), respectively.

2. *Variables*

All balance-sheets data are in real terms at 1992 prices.

Investment. Total fixed investment in equipment and non-residential structures.

Output. Production value.

Technical assets. Equipment and non-residential structures.

Net working capital. Inventories, accounts receivable and other current assets (with the exclusion of liquidity) minus accounts payable and other current liabilities (with the exclusion of financial liabilities).

Intangible assets. R&D expenses, patents, trademarks, licenses and capitalized expenses.

Equity holdings. Majority and minority stakes in other firms.

Liquidity. Cash, securities and government bonds.

Short-term debt. Bank loans and other short-term loans.

Long-term debt. Bonds, long-term bank loans and other long-term loans.

Retained earnings. Cash-flow minus dividends.

Net operating income. Value added minus labor costs and depreciation.

Interest rate. Real bank-loan interest rate (bank-loan interest rate minus inflation rate).

Interest rate uncertainty. See definition in Section III.

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