The effect of (Corporate) Venture Capital on firm's financial constraints

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Abstract: This work studies the different effect of two sources of Private Equity (PE), namely Venture Capital (VC) and Corporate Venture Capital (CVC), on firm's investment policy in a sample of Italian New Technology Based Firms (NTBFs). We show that, on average, NTBFs are severely affected by financial constraints and their investment rate is strongly correlated with their current cash-flows. We also find that, after receiving external financing by PE NTBFs increase their investment rate. However the impact of VC is more significant and makes firm's investment policy nearly independent by short-run liquidity.

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1. Introduction

Firm's investment decisions have been the object of study by several branches of economics including macro- and micro-economics, political economics, industrial economics, and corporate finance. This latter field of study focussed particularly on the effect that capital market imperfections, especially those deriving from information asymmetries, have on firm's ability to raise external financing for its investments.

Several empirical works found that investments are strongly related to firm's liquidity and that this relationship is stronger for those firms which are particularly affected by asymmetries in information (Hubbard, 1998). Young firms, especially those operating in high-tech sectors, are the ones which are more likely to be financially constrained (Carpenter and Petersen, 2002). This is particularly worrying since they are generally seen as fundamental for the static and dynamic efficiency of economies (Audretsch, 1995). Several authors point out that Private Equity (PE, hereafter) is the most natural candidate for ameliorating financial constraints for New Technology Based Firms (NTBFs, hereafter). PE investors are supposed to be more capable than others to deal with asymmetries in information both ex-ante (e.g. assessing the potential value of an investment opportunity) and ex-post (e.g. designing contracts that reduce moral-hazard). The ability to handle ex-ante asymmetries in information is known in the literature as *scouting*, while the ability of managing ex-post asymmetries in information is known as *monitoring*. There are some other ways by which PE supports invested firms such as *coaching* (e.g. professionalisation) and *signalling* (i.e. PE provides to invested firms a credible brand of quality)[1]. However PE comprises several typologies of investors which have considerably different characteristics both in their level and mix of support activity and on the objectives and time horizon of their investments. In this work we analyse the impact on the investment policy of firms that are backed by two particular typologies of PE: Venture Capital (VC) and Corporate Venture Capital (CVC).

We expect that a firm getting PE should be less financially constrained, this causing an increase in its investment rate and a lower or null correlation with firm's liquidity.

In this work we study the investments in fixed and intangible assets in a long longitudinal hand-collected dataset of 378 Italian NTBFs between 1994 and 2003. We first analyse the investment-cash flow sensitivity of all firms in the sample. Then we study whether the investment rate of firms that received PE, after financing, is higher and less correlated to current cash flows. Finally we distinguish PE according to the typology of investor, namely VC or CVC to study whether they

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[1] See Denis (2004) for an interesting survey on this topic.

have a different impact of firm's investment policy and, in particular, on its dependence on current cash-flows.

We find robust evidence that NTBFs rely significantly on internal capital to finance their investments, meaning that they face severe financial constraints. Firms that get PE financing have a higher investment rates but they still depend on internal capital. Different types of PE, however, have radically different effects on firm's investments. VC outperforms CVC both because of the increase in the investment rate and because of the long-run dependence on internal capital. VC-backed companies get closer to the first-best scenario in which investments are uncorrelated with current cash-flows while their CVC-backed counterparts still exhibit a positive investment-cash-flow sensitivity. We interpret this result as a consequence of the differences between VC and CVC. While the first is interested mainly in the making the firm grow in size and profitability in a relatively short period of time realising a sizeable capital gain from the investment, the latter has an investment objective that often entails a longer time horizon and industrial objectives (e.g. strategic or technological advantages).

The structure of the work is the following. Section 2 summarizes the related literature on this topic. Section 3 describes the sample of the analysis and reports some descriptive statistics. Section 4 describes the econometric models and reports the results. Section 5 concludes.

2 Related literature

Modigliani and Miller (1958) show that, under the hypothesis of perfect and frictionless financial markets, every investment with positive Net Present Value is financed in equilibrium and that the financing mix is irrelevant. Under the same hypotheses Jorgenson (1963) and Hall and Jorgenson (1967) developed a theory of firm's intertemporal optimal investments. In these models, developed under the assumption of perfect capital markets, the availability of internal capital (e.g. current cash flows) plays no role. Internal and external capital are perfect substitute whose (opportunity) cost is set by market equilibrium.

However, when market imperfections, such as information asymmetries, are taken into account inefficient equilibria arise. In particular external capital, both in the form of debt (Stiglitz and Weiss, 1981) and equity (Myers and Majluf, 1984), is rationed and some profitable investments are not financed. Fazzari et al. (1988) argued that, because of capital market imperfection, internal and external capital are no longer substitutes since the latter entails an additional (information) cost, this producing underinvestment in equilibrium. As a consequence, firms adhere to a "pecking order" in financing their investment relying on internal capital first. There also is a pecking order among different categories of external capital depending on their relative information cost with debt generally preferred to equity for firms with low leverage. Fazzari et al. (1988) support their theoretical predictions with an empirical analysis on investments in fixed assets in a sample of manufacturing listed firms between 1970 and 1984. They show that investments are significantly and positively correlated with the availability of internal capital, measured by firm's cash-flows.

Moreover they show that the investment-cash flow sensitivity is higher for firms with low dividend payouts, which allegedly have superior investment opportunities relative to current profits. The work by Whited (1992) further supports their findings showing that the investment-cash flow sensitivity is higher for highly leveraged firms. Himmelberg and Petersen (1994) investigate the relationship between investments in fixed assets and R&D expenses in a sample of 179 listed firms from 1983 to 1987. They show that cash flows are the main determinant of investments for firms in their sample. The work by Carpenter et al. (1998) proves that inventory investments are also significantly influenced by cash flows.

However, Jensen (1986) points out that underinvestment is not the only problem that might bias firm's investment choices and, more importantly, explain the empirical results. Opportunistic behaviour by managers misusing firm's free-cash flows could cause overinvestment. Even though both under- and over-investment, being deviations from first-best, entail economic inefficiencies they derive from fundamentally different information problems (respectively: insiders vs. outsiders and managers vs. insiders) and have extremely different policy implications. Policy measures trying to reduce underinvestment are mainly aimed at improving financial market efficiency (e.g. fostering Venture Capital). On the other hand, reducing over-investment claims for Corporate Governance interventions (e.g. increasing shareholder protection). Notably, even though over- and under-investment stem from extremely different theoretical considerations they generate similar empirical effects and are, thus, difficult to disentangle, especially because most of the empirical evidence refers to listed companies where overinvestment could potentially play a significant role. Vogt (1994) reports evidence that both effects are active and that overinvestment (underinvestment) dominates for larger (smaller) firms.

In this work we consider the investments in fixed and intangible assets in a sample of Italian unlisted NTBFs from 1994 to 2003. This sample has several interesting features. First, firms in the sample are likely to face severe financial constraints because they combine high information costs of external equity and debt (Bolton and Freixas, 2000) with substantial investment opportunities (i.e. need for external capital). Second, our results are less subject to the complex combination of under- and over-investment since our sample is made of private companies in which the latter is at minimum levels. Finally, we are able to assess the effect of (various forms of) PE financing on firm's investment-cash-flow sensitivity. PE and, in particular, VC are crucial for NTBFs whose growth is often deemed to be constrained by the availability of internal capital (Carpenter and Petersen, 2002). The existence itself of VC and, more generally, PE is due to its efficiency in dealing with moral hazard and adverse selection (Chan, 1983 and Amit et al., 1998). PE support to invested firms goes beyond the direct provision of financial resources. PE also exerts effort in direct non financial support (Hellman and Puri, 2002). Moreover PE indirectly supports invested firms through signalling (Megginson and Weiss, 1991): PE-backed firms are perceived as high-quality and thus face lower external capital cost.

A recent work by Manigart et al. (2002) analyses a sample of Belgian unlisted firms and studies whether VC reduces the cash flow sensitivity of investments in fixed assets. Surprisingly they find that investments of VC-backed firms are more sensitive to cash-flows than those of non-VC-backed firms, this calling into question the efficiency of the Belgian VC industry in reducing information asymmetries. Yet, Manigart et al. (2002) show that VC seems to play a positive role in financing intangible assets.

3 Sample and descriptive statistics

In this section we describe the sample and report some descriptive statistics (section 3.2). Section 3.1 describes the sampling procedure and sample characteristics. Section 3.2 reports geographic and industry distribution of sample firms.

3.1 Sampling and sample characteristics

This work is based on a sample of 374 Italian NTBFs observed from 1994 (or since their founding) to 2003, 55 of which (14.7%) obtained external PE funding. Sample firms were established in 1980 or later, were independent at founding time and have remained so at 1/1/2004 (i.e. they are not controlled by another business organisation even though other organisations may hold minority shareholdings), and operate in the following high-tech sectors in manufacturing and services: computers, electronic components, telecommunication equipment, optical, medical and electronic instruments, biotechnology, pharmaceuticals, advanced materials, aerospace, robotics and process automation equipment, multimedia content, software, Internet services (e-commerce, ISP, web-related services), and telecommunication services. The sample of NTBFs was extracted from the RITA (Research on Entrepreneurship in Advanced Technologies) database, developed at Politecnico di Milano. The development of the database went through a series of steps.

First, Italian firms that complied with the above mentioned criteria relating to age and sector of operations were identified. For the construction of the target population a number of sources were used. These included lists provided by national industry associations, on-line and off-line commercial firm directories, and lists of participants in industry trades and expositions. Information provided by the national financial press, specialized magazines, other sectoral studies, and regional Chambers of Commerce was also considered. Altogether, 1,974 firms were selected for inclusion in the database. For each firm, a contact person (i.e. one of the owner-managers) was also identified. Unfortunately, data provided by official national statistics do not allow to obtain a reliable description of the universe of Italian NTBFs. Second, a questionnaire was sent to the contact person of the target firms either by fax or by e-mail. The first section of the questionnaire provides detailed information on the human capital characteristics of firms' founders. The second section comprises further questions concerning the characteristics of the firms including their access to external PE-financing and their post-entry performances. Lastly, answers to the questionnaire were checked for internal coherence by educated personnel and were compared with published data (basically data provided by firms' annual reports and financial accounts) if they were available. In several cases, phone or face-to-face follow-up interviews were made with firms' owner-managers. This final step was crucial in order to obtain missing data and ensure that data were reliable.

The sample used in the present work consists of all RITA firms for which we were able to create a complete data set. For each firm in the sample we have hand-collected data about year and typology of outside equity financing (if any) as well as detailed financial statement information. It is worth noticing that only limited liability firms (namely S.r.l. and S.p.A.) are compelled to disclose financial statements[2].

Two χ^2 tests show that there are no statistically significant differences between the distributions of the sample firms across industries and regions and the corresponding distribution of the population of 1,974 of RITA firms from which the sample was obtained (respectively $\chi^2(4)= 2.17$ and $\chi^2(3)= 3.19$).

The sample is quite large and exhibits considerable heterogeneity as to the relevant explanatory variables. Note, however that there is no presumption here to have a random sample. First, in this domain representativeness is a slippery notion as new ventures may be defined in different ways (see, for instance, Birley 1984, Aldrich et al. 1989, Gimeno et al. 1997). Second, as was mentioned above, in absence of reliable official statistics it is very difficult to identify unambiguously the universe of Italian NTBFs. Therefore, one cannot check ex-post whether the sample used in this work is representative of the universe or not. Third, only firms having survived up to the survey date could be included in the sample. In principle, attrition may generate a sample selection bias that is difficult to control. Nonetheless, our sample has many interesting characteristics that lacked in those used by most of previous empirical studies investment-cash-flow sensitivity. First, since

[2] Some firms disclose their financial accounts even when not compulsory and are thus included in our sample.

firms in our sample are non-listed, hence less subject to overinvestment problems, significant investment-cash-flow sensitivity unambiguously indicates underinvestment. Second, we can study the effect of PE on firm's investments both in term of level and in terms of sensitivity to cash-flows. Third, we are able to distinguish, among PE-backed firms, those which are financed by VC and CVC and contrast their relative effect on level and cash-flow sensitivity of investments.

3.2 Geographic and Industry distribution of sample firms

We report in Table 1 some descriptive statistics about the geographical and industrial distribution of the firms in our sample.

[Table 1 about here]

The most numerous industry is Internet & TLC services representing 33.94% of firms in our sample. Of the 127 firms in this sector 24 (18.9%) obtained external PE financing. The second industry in terms of number of firms in the sample is Software (30.48%). Only 10 firms out of the 114 in this sector (8.77%) have been financed by PE: this is the lowest percentage among all industries. Nearly half (48.13%) of the firms in our sample are located in the North-West of the country, while only 13.4% are in Southern regions. Firms in the South are also less likely to get external PE financing (10.0%) relatively to firms in other Areas (between 14.4% to 16.7%).

Table 2 shows the industrial and geographic distribution of firms in our sample according to the typology of PE financing (namely, VC, CVC and Other).

[Table 2 about here]

Overall 23 firms in our sample (6.1%) received financing by VC, 33 by CVC (8.8%) and 6 (1.3%) by other PE investors (e.g. banks)[3]. VC and CVC focus approximately on the same industry with the notable exception of Software where CVC seems to be much more active than VC (9 vs. 2 investments). Both VC and CVC invest little in the South of the Country with 2 investments (4%) each. VC investments are more concentrated in the North-Western Regions (14 out of 23 investments) while the distribution of CVC is more equal across the rest of the country. Only 6 firms in our sample are financed by PE investors other than VC or CVC (e.g. direct equity investments from banks and other financial intermediaries). We will thus restrain from a further distinction of this residual category and on an in-depth analysis of its differences with VC and CVC.

[3] 7 firms in the sample received PE financing from more than one typology of investor.

4. Effect of VC and CVC investments on firm's investments

In this section we analyse the effect of PE investments on firm's investments. Section 4.1 describes the econometric models. Section 4.2 illustrates the variables and reports some descriptive statistics. Section 4.3 reports estimation results.

4.1 Econometric models

Several econometric models have been adopted in the literature to analyse the investment-cash-flow sensitivity (Hubbard, 1998). The main problem is that current cash-flows are used as a measure of the availability of internal capital but are, at the same time, possibly related to firms investment opportunities. It is thus important to include in the model some control for firm's investment opportunities. Theoretically this could be accomplished including in the model firm's marginal Tobin's *q* which is, however, difficult to estimate empirically. Under some hypotheses average Tobin's *q* can be used but, as pointed out by Hubbard (1998), these hypotheses are likely not to be met. An alternative approach[4], which we follow in our work, is to estimate a Euler Equation (Bond and Meghir, 1994):

$$\frac{I_{i,t}}{K_{i,t-1}} = \alpha_i + \beta_t + \gamma_1\left(\frac{I_{i,t-1}}{K_{i,t-2}}\right) + \gamma_2\left(\frac{I_{i,t-1}}{K_{i,t-2}}\right)^2 + \gamma_3\left(\frac{CF_{i,t}}{K_{i,t-1}}\right) + \gamma_4\left(\frac{CF_{i,t-1}}{K_{i,t-2}}\right) + \gamma_5\left(\frac{S_{i,t}}{K_{i,t-1}}\right) + \gamma_6\left(\frac{D_{i,t}}{K_{i,t}}\right) + \varepsilon_{i.t} \quad (1)$$

where: $I_{i,t}$ are investments of firm *i* at time *t*, $K_{i,t}$ is the end-of-period *t* net value of firm's *i* invested assets, $CF_{i,t}$ is firm's *i* cash flow at time *t*, $S_{i,t}$ are firm's *i* sales during year *t* and $D_{i,t}$ are firm's *i* total end-of-period *t* debts.

If financial markets were perfect and external capital a perfect substitute for internal capital, we would expect coefficients γ_3 and γ_4 in equation (1) not to be significantly different from zero. In presence of capital rationing, however, we expect that (at least one of) the two coefficients will be positive and statistically significant.

To understand whether the investment-cash-flow sensitivity is affected by the presence of a PE we estimate an augmented version of equation (1):

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[4] An alternative specification which is commonly found in the literature is the *sales accelerator model* (Abel and Blanchard, 1986) which is, however, less likely to correctly control for firm's investment opportunities (Fazzari et al., 1988).

$$\frac{I_{i,t}}{K_{i,t-1}} = \alpha_i + \beta_t + \gamma_1\left(\frac{I_{i,t-1}}{K_{i,t-2}}\right) + \gamma_2\left(\frac{I_{i,t-1}}{K_{i,t-2}}\right)^2 + \gamma_3\left(\frac{CF_{i,t}}{K_{i,t-1}}\right) + \gamma_4\left(\frac{CF_{i,t-1}}{K_{i,t-2}}\right) + \gamma_5\left(\frac{S_{i,t}}{K_{i,t-1}}\right) + \gamma_6\left(\frac{D_{i,t}}{K_{i,t}}\right) + \\ + \delta_1 PE_{i,t}\left(\frac{CF_{i,t}}{K_{i,t-1}}\right) + \delta_2 PE_{i,t}\left(\frac{CF_{i,t-1}}{K_{i,t-2}}\right) + \phi_1 PE_{i,t} + \varepsilon_{i.t} \qquad (2)$$

Where $PE_{i,t}$ is a dummy variable that equals 1 if firm *i* received external PE before or during period *t*. Coefficients δ_1 and δ_2 measure the effect of PE on firm's investment-cash-flow sensitivity while coefficient ϕ_1 captures whether investment's level increases after receiving PE. It is worth noticing that δ_i and ϕ_1 relate to two different and complementary aspects of the problem: the former deals with changes in the sensitivity of firm's investments to current and lagged cash flows but does not say anything about their level, while the latter measures the change in the investment level but not how it relates to the availability of internal capital.

Finally we further extend equation (2) to analyse whether different types of PE have different effects on firm's investments:

$$\frac{I_{i,t}}{K_{i,t-1}} = \alpha_i + \beta_t + \gamma_1\left(\frac{I_{i,t-1}}{K_{i,t-2}}\right) + \gamma_2\left(\frac{I_{i,t-1}}{K_{i,t-2}}\right)^2 + \gamma_3\left(\frac{CF_{i,t}}{K_{i,t-1}}\right) + \gamma_4\left(\frac{CF_{i,t-1}}{K_{i,t-2}}\right) + \gamma_5\left(\frac{S_{i,t}}{K_{i,t-1}}\right) + \gamma_6\left(\frac{D_{i,t}}{K_{i,t}}\right) + \\ + \delta_1 VC_{i,t}\left(\frac{CF_{i,t}}{K_{i,t-1}}\right) + \delta_2 VC_{i,t}\left(\frac{CF_{i,t-1}}{K_{i,t-2}}\right) + \phi_1 VC_{i,t} + \delta_3 CVC_{i,t}\left(\frac{CF_{i,t}}{K_{i,t-1}}\right) + \delta_4 CVC_{i,t}\left(\frac{CF_{i,t-1}}{K_{i,t-2}}\right) + \phi_2 CVC_{i,t} \qquad (3) \\ \delta_5 OTHERPE_{i,t}\left(\frac{CF_{i,t}}{K_{i,t-1}}\right) + \delta_6 OTHERPE_{i,t}\left(\frac{CF_{i,t-1}}{K_{i,t-2}}\right) + \phi_6 OTHERPE_{i,t} + \varepsilon_{i.t}$$

Where $VC_{i,t}$, $CVC_{i,t}$ and $OTHERPE_{i,t}$ are dummy variables that equal 1 if firm *i* received financing respectively from VC, CVC or Other PE, before or during period *t*. Again, δ_i and ϕ_i measure the effect of each type of PE on firm's investment-cash-flow sensitivity and on firm's investment level.

Models (1), (2) and (3) are autoregressive-distributed lag models on a panel with a large number of cross-section units, each observed for a relatively short time period. Within (i.e. Fixed) Effects estimation in these circumstances can lead to serious biases (Bond et al., 2001). We thus resort to a two-step system GMM estimation (Arellano and Bover, 1995; Blundell and Bond, 1998) with finite-sample correction (Windmeijer, 2005). The use of GMM estimation allows us to explicitly model endogeneity between covariates and investment rate. In particular, endogeneity of PE, VC and CVC are likely to be a problem in our model. We thus consider those variables (and the relative interaction terms) as endogenous or pre-determined. Hansen-Sargan tests are performed to control for over-identification.

4.2 Variables

The literature analysed the sensitivity of several typologies of firm's investments to the availability of internal capital, like fixed assets, intangible assets, R&D, and inventories. In this work we focus on investments in fixed and intangible assets. Hence the dependent variable, $I_{i,t}$, is computed as the increase in firm's book value of tangible and intangible assets net of depreciation. The investment rate $I_{i,t}/K_{i,t-1}$ is the ratio between total investments in year *t* and the beginning-of-period total book value of fixed and intangible assets.

Firm's cash flows, $CF_{i,t}$, are calculated after taxes but before dividends. Other authors use ex-dividend cash-flows (e.g. Manigart et al., 2002) but we opted for cash-flows before dividends as our sample is composed by unlisted firms in which dividends have no signalling role. In other words a reduction in dividends paid is perceived as a negative signal by investors in listed firms; in private firms shareholders are much more informed about firm performance and the signalling power of dividends is strongly reduced. This implies that private firms are less constrained than listed ones in their dividend policy and, theoretically, all cash flows can be reinvested if some profitable investment opportunity arises.

Variable $S_{i,t}$ is calculated as total sales of firm *i* in period *t*. Variable $D_{i,t}$ accounts for current and long-term debt of firm *i* in period.

Table 3 reports some statistics about the variables in equations (1)-(3).

[Table 3 about here]

All the variables in equations (1)-(3) are normalised to the beginning of period stock of fixed and intangible assets. However, since firms in our sample are relatively young and small, this value is sometimes close to zero producing extremely skewed and leptokurtic distributions of the parameters which would severely bias our results. We thus winsorise all the variables with a 2% cut-off for each tail. In other words we compute the 2nd and 98th percentile of each variable and assign this value to all observations falling beyond that value. This approach reduces the impact of extreme observations and allows for the use of a larger number of observations than would be possible if "tails" were deleted (a similar approach is followed by Cleary, 1999). Other cut-offs for winsorising where computed (namely 1%, 5% and 10%) but 2% exhibits the best compromise between smoothing extreme values and maintaining sufficient variance[5]. Descriptive statistics about winsorised variables are also reported in Table 3.

[5] Most of the results shown in the following section are quite robust to this respect and hold for all cut-offs.

4.3 Results

Equations (1)-(3) are estimated with a two-step "system GMM" model (Arellano and Bover, 1995; Blundell and Bond, 1998) with Windmeijer, (2005) finite-sample correction. Table 4 reports the results.

[Table 4 about here]

Focussing on the first column in Table 4 we notice that $CF_{i,t}/K_{i,t-1}$ is positive and statistically significant. This supports the hypothesis that firms in our sample are subject to significant financial constraints and rely on internal capital to finance their investments. It should be stressed, again, that firms in our sample are young, not listed and operate in high-tech sectors. If financial markets inefficiencies exist they are the most likely to suffer from that. Our result is thus not surprising to this extent. However it should also be kept in mind that managerial misbehaviour is at minimum levels in our sample since firms are private. This result is thus not driven by over-investment and is solely due to under-investment.

The second column in Table 4 reports the estimation of coefficients in equation (2). While $PE_{i,t}$ is positive and statistically significant, coefficients of current and lagged cash-flows ($CF_{i,t}/K_{i,t-1}$ and $CF_{i,-1t}/K_{i,t-2}$) are not significantly different from zero. In other words results in Table 4 show that, although firms invest more after receiving PE financing, their investment rate is still dependent on internally generated cash-flows. PE, when not distinguishing the typology of investor, therefore solves only partially firm's underinvestment. While the increase in the investment rate is significant on average, firms continue to invest more when they have more internal capital available.

Finally we turn to the analysis of the differences between different types of PE investors. Results are reported in the third column of Table 4. We observe that, for VC-backed firms, both the intercept $VC_{i,t}$ and the interaction terms ($CF_{i,t}/K_{i,t-1}$ and $CF_{i,-1t}/K_{i,t-2}$) are significantly different from zero while they are not for firms backed by other types of PE investors. This suggests that VC has a stronger impact on the firms being financed. However, given the dynamic structure of equation (3) it is unclear the extent to which VC outperforms other typologies of PE investors. To better understand VC's effect on firm's investments we analyse it from two complementary perspectives. First we analyse how firm's investment change because of a parallel shock in $CF_{.}/K$. To do so we perform some linear tests on the estimated coefficients of equation (3). Second we consider the effect of random disturbances on $CF_{.}/K$ running a simulation that builds on results in Table 4. Because of the small number of observations relative to other-PE investors we limit our analysis to a comparison between VC and CVC.

To investigate whether overall investment-cash-flow sensitivity is null for parallel changes in $CF_{.}/K$ for VC- and CVC-backed firms we perform the following linear tests:

VC test : $\gamma_3 + \gamma_4 + \delta_1 + \delta_2 = 0 \rightarrow \chi^2(1) = 0.00$ ($p-value$: 4.17%)
CVC test : $\gamma_3 + \gamma_4 + \delta_3 + \delta_4 = 0 \rightarrow \chi^2(1) = 3.66$ ($p-value$: 94.6%)

Wald tests indicate that we cannot exclude that overall investment-cash-flow sensitivity for parallel changes in *CF/K* for VC-backed firms is null while we can for CVC-backed firms. In other words, investments of VC-backed firms are nearly independent from parallel shocks in cash-flows while investments of CVC-backed firms are still positively correlated with availability of internal capital.

To understand the different behaviour of VC and CVC backed firms to random shocks in *CF/K* we run a simulation experiment. We set all dependent variables, with the exception of *CF/K* to their median value[6]. $(CF/K)_{t=1,\ldots10}$ is randomly generated from a AR(1) model with random noise having standard deviation equal to within standard error reported in Table 3[7]; $(CF/K)_{t=0}$ it's set to its median value (0.457). We compare three typologies of firms: non-PE-backed, VC-backed and CVC-backed; these two latter receiving PE at time $t=1$. Investment rate is estimated for each firm on a 10-year period and 500 simulation runs, building on coefficients estimates in Table 4. Results of simulation are reported in Table 5.

[Table 5 about here]

First we notice, obviously, that VC-backed firms invest on average at a higher rate (0.911) than CVC-backed (0.759) and non-PE-backed firms (0.560). Second, we notice that standard deviation of investments is 0.279 for non-PE-backed firms, 0.375 for VC-backed firms and 0.523 for CVC-backed firms. The coefficient of variation (i.e. the ratio between standard deviation and mean) is a measure of the relative volatility of the investment rate due to random shocks in *CF/K*. The lower coefficient of variation is that of VC-backed firms (0.378), followed by non-PE-backed firms (0.498); CVC-backed firms exhibit the highest coefficient of variation (0.689). This confirms that VC-backed firms not only invest more than non-PE-backed and CVC-backed but also that this type of PE investor smoothes random shocks in available internal capital.

These results confirm that different PE investor have dramatically different effects on firm's performance. This can be explained considering the different objectives and time horizons VC and CVC. The former is mainly interested in investments with a short- to mid-term time horizon with the goal of achieving substantial capital gains when eventually divesting its stake (e.g. at the IPO). On the other hand CVC is usually interested in long-term investments intended to achieve technological and strategic advantages. Exit from the investment is not considered as an

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[6] We opted for median instead of mean values because of the skewness that characterises the variables. Comparisons are obviously unaffected by this choice given the linearity of equation (3).

[7] Coefficients of the AR(1) model are estimated with a system GMM model with finite sample correction, omitted here for the sake of concision but available upon request to authors.

indispensable step of the investment process, nor capital gains deriving from it are the main goal of CVC. This might explain the boost in the investment rate (and its independence from firm's cash-flows) by VC-backed firms compared to their CVC-backed counterparts.

5 Concluding remarks

In this work we study the relationship between firm's investments and PE financing on a sample of 374 Italian NTBFs, 55 of which PE-backed. We analyse both whether PE-backed firms increase their investment rate and if their investment-cash-flow sensitivity decreases. Under the Modigliani and Miller (1958) hypotheses all profitable investments should be financed in equilibrium and firm's investment policy should be independent from their available internal capital. However financial market imperfections produce a pecking order among different forms of financing, with external capital being more costly than internal capital because of information asymmetries (Fazarri et al., 1988). This entails some that some correlation should be found between cash-flows (used as a measure of available internal capital) and investments, even when controlling for investment opportunities (possibly correlated with cash-flows). Several empirical works support the existence of a positive correlation between different types of investments (e.g. in fixed and intangible assets, in R&D, and in inventories) and cash-flows. However Jensen (1986) points out that these results could be driven, instead, by managerial misbehaviour, particularly in listed firms with dispersed shareholders.

Our sample is composed of private firms in which overinvestment should be absent or, at least, minimum. Since we find significant correlation between investment rate and cash flows we interpret this as a clear support of the pecking-order theory.

Moreover, 55 firms in our sample received external PE financing and this allows us to study whether investments by PE-backed firms differ from those of non-PE-backed firms both in terms of level and in terms of sensitivity to cash flow. We find that firms increase their investment rate after receiving PE financing but that their investment-cash-flow sensitivity is still significant.

Finally we distinguish between two categories of PE investors: namely VC and CVC[8]. We show that the increase in investment rate for VC-backed firms is positive and significant while it is not for CVC-backed firms. Moreover, investments by VC-backed firms are nearly independent from permanent shock in cash flows and less dependent on transitory shocks.

[8] We also have a third, residual, category but the small number of observations restrains us from considering it in-depth.

Our work confirms that different PE investor have dramatically different effects on firm's performance[9] Such differences can be understood considering that VC and CVC investments are characterised by different objectives and time horizon. VC is mainly interested in investments with a short- to mid-term time horizon with the goal of achieving a substantial capital gain from the exit. On the other hand CVC is usually interested in long-term investments intended to achieve technological and strategic advantages.

[9] In a paper on a closely related sample Bertoni and Grilli (2005) find similar differences regarding firm's growth.

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Tables and Figures

Table 1. Distribution of NTBFs and PE-backed firms by industry and geographic area

Industry	Number of firms	Number of PE-backed firms	% of PE-backed firms
Internet & TLC services	127	24	18.90%
Software	114	10	8.77%
ICT manufacturing	78	13	16.67%
Biotechnology & Pharmaceutics	19	4	21.05%
Automation & Robotics	36	4	11.11%
Total	374	55	14.71%

Area	Number of firms	Number of PE-backed firms	% of PE-backed firms
North-West	180	26	14.44%
North-East	84	14	16.67%
Centre	60	10	16.67%
South	50	5	10.00%
Total	374	55	14.71%

Table 2. Distribution of PE-backed firms by typology of investors, industry and geographic area

Industry	Number of firms	VC-backed firms		CVC-backed firms		Other PE	
		N°	%	N°	%	N°	%
Internet & TLC services	127	13	10.2	12	9.4	2	2
Software	114	2	1.8	9	7.9	1	0.6
ICT manufacturing	78	6	7.7	7	9.0	2	1
Biotechnology & Pharmaceutics	19	1	5.3	2	10.5	1	0.8
Automation & Robotics	36	1	2.8	3	8.3	0	0
Total	374	23	6.1	33	8.8	6	1.3

Area	Number of firms	VC-backed firms		CVC-backed firms		BNC-backed firms	
		N°	%	N°	%	N°	%
North-West	180	14	7.8	15	8.3	2	1.1
North-East	84	4	4.8	10	11.9	1	1.2
Centre	60	3	5.0	6	10.0	2	3.3
South	50	2	4.0	2	4.0	1	2.0
Total	374	23	6.1	33	8.8	6	1.6

Table 3: Descriptive statistics on regression variables

	Variable	N. obs.	Mean	Median	Std. Dev. Overall	Std. Dev. Between	Std. Dev. Within	Skweness	Kurtosis
Not wisnorised	$I_{i,t}/K_{i,t-1}$	2578	2.176	0.457	23.773	7.435	22.293	36.870	1573.367
	$CF_{i,t}/K_{i,t-1}$	2578	0.984	0.444	14.021	6.242	12.762	26.990	1062.486
	$S_{i,t}/K_{i,t-1}$	2578	57.650	9.942	1417.079	430.908	1325.315	46.171	2221.537
	$D_{i,t}/K_{i,-1t}$	2578	22.484	4.945	417.761	129.382	390.238	46.192	2234.156
Winsorised 2% each tail	$I_{i,t}/K_{i,t-1}$	2578	1.081	0.457	1.867	1.122	1.658	3.279	14.439
	$CF_{i,t}/K_{i,t-1}$	2578	0.742	0.444	1.756	1.328	1.364	1.656	10.262
	$S_{i,t}/K_{i,t-1}$	2578	19.181	9.942	25.574	20.640	16.878	2.604	10.375
	$D_{i,t}/K_{i,-1t}$	2578	10.093	4.945	14.105	11.097	9.830	3.145	14.028

Note: $I_{i,t}$ is the increase in firm's book value of tangible and intangible assets net of depreciation. $K_{i,t-1}$ is the beginning of period book value tangible and intangible assets. $CF_{i,t}$ is firm's *i* cash flows after taxes and before dividends. $S_{i,t}$ are firm's *i* sales in year *t*. $D_{i,t}$ is firm's *i* total current and long-term debt at year *t*.

Table 4: Investment-cash-flow sensitivity

Variable	Pooled		PE		PE by typology	
I/K lag	0.109196 (0.163)		0.058267 (0.392)		0.0858121 (0.245)	
I/K^2 lag	-0.00159 (0.829)		1.79E-05 (0.998)		-0.001399 (0.851)	
CF/K	0.199632 (0.025)	**	0.155651 (0.025)	**	0.18673973 (0.016)	**
CF/K lag	-0.10228 (0.255)		-0.01138 (0.877)		-0.052174 (0.551)	
Sales/K	0.005285 (0.763)		0.003018 (0.844)		0.00405821 (0.756)	
Debt/K	0.032717 (0.351)		0.033176 (0.290)		0.03148774 (0.236)	
PE			0.360435 (0.005)	***		
PE*(CF/K)			-0.08216 (0.627)			
PE*(CF/K lag)			0.071151 (0.533)			
VC					0.47004592 (0.004)	***
CVC					0.10613907 (0.544)	
Other PE					0.09585581 (0.758)	
VC*(CF/K)					-0.4094762 (0.001)	***
VC*(CF/K lag)					0.27928486 (0.001)	***
CVC*(CF/K)					0.32488803 (0.177)	
CVC*(CF/K lag)					-0.1043323 (0.329)	
Other PE*(CF/K lag)					0.30204071 (0.665)	
Other PE*(CF/K lag)					-0.02977082 (0.810)	
N. observations	2,109		2,109		2,109	
Sargan-Hansen	0.5057		0.7172		0.7979	
AR(1)	0.0000		0.0000		0.0000	
AR(2)	0.7519		0.8645		0.7816	

Note: System GMM estimates of equations (1)-(3) with finite sample correction (Windmeijer, 2005). p-values in parenthesis. ***, ** and * indicate respectively significance levels <1%, <5%, and <10%. Group and year coefficients are omitted. Sargan-Hansen and AR(.) p-values are reported. *I* measures firm's investments in fixed and intangible assets. *K* is the beginning of period book value tangible and intangible assets. *CF* is firm's cash flows after taxes and before dividends. *S* are firm's sales. $D_{i,t}$ is firm's *i* total current and long-term debt. PE, VC, CVC and OtherPE are dummy variables equal to one after firm receives financing respectively by PE, VC, CVC or another PE investor.

Table 5: Results of the simulation on investment rate

T	Non-PE-Backed			VC-backed			CVC-backed		
	Mean	Standard Deviation	Coefficient of variation	Mean	Standard Deviation	Coefficient of variation	Mean	Standard Deviation	Coefficient of variation
0	0.457	0.000	0.000	0.457	0.000	0.000	0.457	0.000	0.000
1	0.548	0.279	0.510	0.896	0.306	0.341	0.751	0.519	0.691
2	0.557	0.286	0.514	1.050	0.317	0.302	0.766	0.532	0.694
3	0.569	0.287	0.505	1.054	0.354	0.336	0.787	0.533	0.677
4	0.569	0.302	0.531	1.066	0.368	0.345	0.787	0.561	0.712
5	0.575	0.287	0.500	1.062	0.340	0.320	0.798	0.533	0.668
6	0.569	0.276	0.486	1.074	0.353	0.328	0.787	0.513	0.652
7	0.569	0.297	0.522	1.069	0.353	0.330	0.788	0.552	0.700
8	0.566	0.291	0.515	1.072	0.359	0.335	0.782	0.541	0.692
9	0.585	0.303	0.519	1.048	0.348	0.332	0.817	0.563	0.689
10	0.594	0.292	0.492	1.057	0.370	0.350	0.833	0.543	0.651
All periods	0.560	0.279	0.498	0.991	0.375	0.378	0.759	0.523	0.689

Note: median values are assumed for all covariates with the exception of $CF_{i,t}/K_{i,t-1}$ which is randomly generated with a AR(1) model. 500 runs of simulation have been performed. Estimation of the investment rate $I_{i,t}/K_{i,t-1}$ is made from results in Table 4 (third column).