



The effect of public subsidies on firms' investment–cash flow sensitivity: Transient or persistent?



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ABSTRACT

This work analyses the effect of public subsidies on firms' investments and investment–cash flow sensitivity in a longitudinal sample of 288 Italian unlisted non-venture capital backed owner-managed new-technology-based firms (NTBFs), observed over a 15-year period from 1994 to 2008. Seventy five of these firms received one or more public subsidies in the observation period. We use an error correction model (ECM) specification and system generalised method of moment (GMM) techniques that take into account the endogeneity of public subsidies. First, we find that the investments of small NTBFs are sensitive to internal cash flows, while those of large NTBFs are not. Receipt of public subsidies by small NTBFs results in an increased investment rate and a reduced investment–cash flow sensitivity, in the immediately following year. We interpret these results as an indication of the relaxation of financial constraints. Moreover, while the increase in the investment rate does not persist in the long run, the dependence of investments on cash flow remains negligible after receipt of the first public subsidy. These results support the view that public subsidies can help small NTBFs in persistently removing the financial constraints that bind their investment activity.

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1. Introduction

Scholars agree that young high-tech firms (NTBFs, new technology-based firms) play a crucial role in modern economies (Audretsch, 1995). It is also argued that capital market imperfections arising from information asymmetries (i.e., hidden information and hidden action) make it difficult for these firms, especially smaller ones, to obtain external financing (Carpenter and Petersen, 2002a; Hall, 2002). In turn, financial constraints negatively influence firms' investments and performance, with obvious negative implications for social welfare. The available empirical evidence that will be surveyed in Section 2 largely supports this view. It is important to highlight that investments in tangible assets, R&D investments and innovation are strongly interrelated for NTBFs (see e.g., Chiao, 2002). The business model, products and processes of these high-tech firms rely on the development of new knowledge. This new knowledge is embodied in the production process through investments in new plant and equipment (Himmelberg and Petersen, 1994). Hence, given the relevance of

financial constraints for this kind of firms, it is interesting to investigate how to stimulate NTBFs' investment activity, which significantly affects their ability to innovate.

Accordingly, NTBFs have attracted considerable attention from policy makers at local, national and supranational levels (see e.g., SEC, 2008, 2010), with the presumption that public subsidies can help these firms to overcome the above-mentioned financial constraints. However, whether public subsidies are beneficial to NTBFs is questionable (Holtz-Eakin, 2000). Indeed, public support may simply result in the replacement of market failures with governmental failures. For instance, politicians may use public subsidies to reward constituents, rather than to correct market failures (Cohen and Noll, 1991; Becker, 1983). Public subsidies may also prevent the emergence of active venture capital (VC) markets by “crowding-out” private funds (Leleux and Surlemont, 2003; Cumming and MacIntosh, 2007).

In this paper, we empirically investigate whether public subsidies in fact relax the financial constraints of NTBFs, a research question that has received limited attention in the extant literature (for exceptions see Hyytinen and Toivanen, 2005; Czarnitzki, 2006; Czarnitzki et al., 2011). More precisely, we aim to detect the “treatment” effect of public subsidies on the investment rate and investment–cash flow sensitivity of NTBFs. Following the approach originally proposed by Fazzari et al. (1988), we interpret a large investment–cash flow sensitivity as an indication that a firm is

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financially constrained. Accordingly, the removal of financial constraints after receipt of a public subsidy should result in an *increase* of the investment rate and a *reduction* of the investment–cash flow sensitivity. Moreover, we assess whether these allegedly beneficial effects of public subsidies are transient or persist over time.

For this purpose, we analyse the investments in tangible and intangible assets within a hand-collected dataset consisting of 288 Italian owner-managed privately held NTBFs, observed between 1994 and 2008. To isolate the effect of public subsidies on financial constraints, we build our sample by excluding firms that either received VC or went through an IPO. The sample is extracted from the RITA 2004 (Research on Entrepreneurship in Advanced Technologies) database, developed at Politecnico di Milano. This database is the most comprehensive source of data presently available on Italian NTBFs. In particular, it contains information on all public subsidies received by sample firms from national governmental institutions during the observation period. Previous studies have used the same dataset to investigate recourse to debt financing (Colombo and Grilli, 2007), VC (Bertoni et al., 2010, 2011) and public subsidies (Colombo et al., 2011, 2012, 2013), and their impact on firm performance. Nevertheless, none of the abovementioned works have analysed whether receipt of public subsidies engenders a *positive* and *persistent* effect on the removal of NTBF's financial constraints.

To detect financial constraints, we estimate an error correction model (ECM) specification in the spirit of Guariglia (2008). To take into account the potentially endogenous nature of public subsidies, we resort to a system generalised method of moments (GMM-SYS) estimator for dynamic panel data models. Moreover, we enlarge the usual set of internal instruments through the addition of variables that are a source of exogenous variation for receipt of public subsidies across firms, in order to better control for selection based on unobservables.

Our results highlight that small Italian NTBFs are financially constrained, while large NTBFs are not. Receipt of public subsidies by small NTBFs results in an increase of the investment rate and in a reduction of the investment–cash flow sensitivity in the immediately following year. These effects are both statistically significant and of large economic magnitude. Conversely, the effect of public subsidies on large NTBFs is negligible. Moreover, we find that for small NTBFs, the dependence of investments on cash flows remains negligible from receipt of the first public subsidy onward, while the increase in investment rate does not significantly persist in the long term.

The paper is structured as follows. In the next section, we briefly survey the literature on firms' financial constraints, and we discuss the expected effect of public subsidies on the investment rate and investment–cash flow sensitivity of NTBFs. Section 3 describes the data and briefly illustrates the industrial policy measures in support of Italian NTBFs. In Section 4, we describe the econometric methodology. In Section 5, we present the results of the econometric analysis. Section 6 concludes and discusses the policy implications of the study.

2. Literature review and theoretical background

2.1. The empirical literature on firms' financial constraints: Lessons for NTBFs

If capital markets were perfect, every privately profitable investment would be financed in equilibrium and under the additional assumption of tax neutrality between debt and equity, the source of financing would be irrelevant (Modigliani and Miller, 1958). As a corollary, internal liquidity (i.e., current cash flows) would not affect firms' investments (Jorgenson, 1963; Hall and

Jorgenson, 1967). Conversely, if investors are less informed than entrepreneurs, firms adhere to a “pecking order” when financing their investments (Myers and Majluf, 1984). First, they rely on internal sources of funds; then, when internal capital is exhausted, they turn to the external capital source with the lowest cost, which usually is debt (at least for firms with low leverage). Fazzari et al. (1988) argue that while the marginal opportunity cost of internal capital is constant, the debt supply curve is upward-sloping, and greater capital market imperfections result in a steeper slope. Under these circumstances, one would expect that the investments of firms that are more financially constrained (i.e., they face a steeper debt supply curve) are more sensitive to cash flows. The authors also show that investment–cash flow sensitivity is higher for firms with low dividend payouts, which allegedly have more binding financial constraints. Several studies replicated the above analysis by grouping firms according to different proxies of information costs (see Hubbard, 1998; Hall, 2002, for comprehensive surveys) and considering samples of small firms operating in high-tech industries (e.g. Himmelberg and Petersen, 1994; Carpenter and Petersen, 2002b). Based on these previous works, in what follows we will interpret a positive investment–cash flow sensitivity as a sign of binding financial constraints that negatively affect the investment activity of NTBFs.

We are aware that the approach proposed by Fazzari et al. (1988) presents some weaknesses. First, Kaplan and Zingales (1997) theoretically demonstrate that the relationship between financial constraints and the sensitivity of firms' investments to cash flows is not necessarily monotonic. Accordingly, for the 49 low-dividend firms included in the Fazzari et al.'s (1988) study, they use detailed information from the annual reports and financial statements to rank the extent to which these firms are financially constrained, finding that the investments of the least financially constrained firms are the most sensitive to the availability of cash flow.² However, Kaplan and Zingales (1997) focus their analysis only on a group of allegedly financially constrained firms, discussing whether differences in the investment–cash flow sensitivities are informative about differences in the extent of the financial constraints faced by these firms. It remains the case in Kaplan and Zingales's (1997) model that a firm facing no financial constraints would display no sensitivity of investments to cash flows.

Second, Jensen (1986) points out that opportunistic behaviour by managers who misuse firm's free cash flows to pursue personal objectives (e.g., empire building) could cause overinvestment and lead to a positive relationship between investment rate and level of cash flows in the absence of any financial constraint. In this vein, Pawlina and Renneboog (2005) using a sample of U.K. listed firms, find that the investment–cash flow sensitivity is higher when firm's managers have higher discretion. This applies when managerial ownership is low and in absence of effective monitoring of managerial decisions by blockholders. Even though overinvestment and underinvestment problems stem from different theoretical considerations, they generate similar empirical effects and are thus difficult to disentangle. Vogt (1994) reports evidence that both effects are at work and that overinvestment and underinvestment dominate for larger and smaller firms, respectively. In this paper, we focus attention on privately held owner-managed NTBFs that did not receive external equity by VC investors. As ownership and control generally are not separated in these firms, agency problems between owners and managers tend to be negligible.³ Therefore, in

² In the same vein, results that contradict Fazzari et al.'s (1988) hypothesis were found by Kadapakkam et al. (1998) and Cleary (1999, 2006), among others.

³ The presence of external individual investors like business angels might lead to horizontal agency costs (or principal–principal conflicts, see Young et al., 2008) between these external equity holders and the owner-managers. However, the

our sample, free cash flow abuses on the part of owner–managers leading to a positive correlation between cash flows and investments are implausible.

Third, positive investment–cash flow sensitivity may simply derive from lack of proper control for unobserved investment opportunities (see Hubbard, 1998). In empirical works these opportunities are generally captured using average Tobin's Q as a proxy for marginal q . Nevertheless, for privately held firms, it is not possible to estimate the Tobin's Q .⁴ An alternative approach is to estimate an Euler equation (Abel, 1980; Bond and Meghir, 1994), a structural model explicitly derived from a dynamic optimisation problem that captures the influence of current expectations of future profitability on current investment decisions. However, this model has several shortcomings. Notably, the interpretation of estimated coefficients from the Euler equation is controversial. The model yields to specific parameter restrictions that must hold under the null hypothesis of no financial constraints (see again Bond and Meghir, 1994, for details). If financial constraints do exist, these parameter restrictions should not be satisfied. Nevertheless, any deviation from the assumptions underlying the model may lead to deviations from the expected coefficients even in absence of any financial constraint (Harhoff, 1998). It is very difficult to assess whether parameter restrictions do not hold because of the presence of financial constraints or because of violations of the assumptions of the model (among other assumptions, the model assumes a symmetric, quadratic structure of adjustment costs that is very restrictive). In fact, the estimates of these structural models are often found to have the wrong sign on key explanatory variables or to imply implausibly slow speeds of adjustment (Bond et al., 2003). Recent works propose to use an error correction model (ECM) to estimate the investment dynamics (Bond et al., 2003; Bond and Lombardi, 2006; Bloom et al., 2007; Guariglia, 2008). The ECM is a reduced form model that allows a flexible specification for short-run investment dynamics and avoids a priori specification of adjustment costs. In fact, the long-term formulation for the level of the capital stock is drawn from a simple model of the firm's demand for capital, while the short-run investment dynamics is not grounded in any theoretical model (i.e., the specification is ad hoc). The main drawback of the ECM is that it does not allow to rigorously control for investment opportunities, as it mixes influences from the structural adjustment process and the expectations-formation process (Bond et al., 2003).⁵ Privately held NTBFs may look for alternative mechanisms to finance their investments, such as bootstrap finance (Van Auken, 2000). This mechanism, if successful, may engender a spurious correlation between current cash flows and investment opportunities. For example, biotech start-ups often engage in contract R&D with large pharmaceutical companies in order to finance internal R&D, thereby generating investment opportunities. However, bootstrap finance may be a source of conflict with the partner (see e.g., Lerner and Malmendier, 2010) and ultimately hamper the rapid development of firms' own products and technologies, with opposite implications for investment opportunities (see Harhoff, 2009). Moreover, the investment opportunities of NTBFs depend on factors such as the quality of their business ideas, the innovativeness of the technologies they are developing, or the entrepreneurial talent of their owner–managers. These factors are unlikely to be positively

correlated with current cash flows. In sum, whether the investment opportunities of NTBFs are correlated with current cash flows is a controversial issue. Even if the lack of a proper control for investment opportunities clearly is a weakness of the ECM model, in our view this weakness is relatively less severe than the ones of the Euler equation, making the ECM model our preferred option to study NTBFs' investment dynamics.

2.2. Are NTBFs financially constrained?

The entrepreneurial finance literature argues that privately held NTBFs are the firms most likely to be financially constrained. First, because of the technology-intensive nature of their activity and the lack of a track record, they face hidden information and hidden action problems (Carpenter and Petersen, 2002a; Hall, 2002). On the one hand, it is difficult for external investors to gauge ex-ante the quality of the investment projects of these firms. Moreover, these firms are reluctant to disclose relevant information to potential investors, as imitation of their innovative ideas by competitors can be very detrimental to their destiny (Anton and Yao, 2002). On the other hand, it is also difficult for external investors to monitor ex-post the decisions made by entrepreneurs and to discourage opportunism. Second, in spite of the above mentioned information asymmetries, NTBFs could obtain access to bank credit if they possessed assets that are acceptable to banks as collateral. The collateral pledged by NTBFs could indeed signal their quality to external investors and attenuate adverse selection problems (Bester, 1985; Berger and Udell, 1990, 2006). It would also provide a disincentive for borrowers to default, thus deterring opportunism (Stiglitz and Weiss, 1981). However, most of the assets of NTBFs are firm-specific or intangible and, hence, cannot be pledged as collateral (Berger and Udell, 1990). Third, the above mentioned financial constraints would be removed if NTBFs obtained access to external equity capital provided by VC investors. However, the diffusion of this mode of financing is fairly limited in most countries, except the USA and Israel (see e.g. OECD, 2011).

Previous empirical works support the view that privately held NTBFs are financially constrained. Bertoni et al. (2010) examine the investment–cash flow sensitivity in a sample of Italian NTBFs, and find that the investment activity of these firms reacts to internal cash flow shocks, but this sensitivity vanishes once firms obtain VC from independent investors. Colombo and Grilli (2007) examine debt financing in a similar sample. Their results conform to the “pecking order” hypothesis: NTBFs resort to bank debt only when the estimated amount of finance needed by firm's operations exceeds the amount available internally.

Furthermore, some NTBFs are more financially constrained than others. We argue here that *small NTBFs* are more likely to be financially constrained than their larger peers.⁶ First, small NTBFs are typically less well-known than larger ones. Indeed, they are less publicly visible and are often unable to provide audited financial statements. As a result, hidden information problems are more severe for small NTBFs than for larger ones (Berger and Udell, 1998). Second, large NTBFs possess more tangible assets (machinery, equipment) than small ones that may be pledged as collateral to secure debt. Accordingly, Harhoff and Körting (1998) using a dataset on German firms with no more than 500 employees, show that the propensity of banks to ask for collateral decreases

nature of these problems and so their likely effects on the investment–cash flow sensitivity, are very different from those examined by Jensen (1986).

⁴ Tobin's Q is defined as the market value of the firm over the replacement value of its capital stock, and cannot be calculated for unlisted firms.

⁵ In presence of convex adjustment costs, the current level of capital stock (and hence the current investment) would depend not only on current output and prices, but also on expectations of future output and prices. If these expectations depend on current cash flows, estimates of investment cash-flow sensitivity may be biased.

⁶ One may argue that younger NTBFs are also more likely to be financially constrained than their older peers. In a companion paper (Colombo et al., 2012) we find evidence that the investment–cash flow sensitivity of NTBFs decreases with both their size and the age. Similar results are obtained by Guariglia (2008). Note however that size and age of NTBFs are positively and significantly correlated in our sample. Hence we follow previous studies in focusing attention only on firm size.

with firm's size. Moreover, the collateral required by the bank is usually linked to the volume of the credit, so that the liquidation value of the collateral exceeds the credit exposure (Berger and Udell, 2006). Therefore, small NTBFs with few collateralisable assets are likely to incur in credit rationing with a higher probability, especially if they demand a large amount of credit. Finally, because of the fixed costs associated with screening, contracting, monitoring and servicing loans, banks capture scale economies in dealing with larger firms, which indeed tend to be larger borrowers (Avery et al., 1998).

Previous empirical studies support the contention that size matters in explaining firm's financial constraints. Studies that focus on small firms indeed detect the presence of financial constraints. Himmelberg and Petersen (1994) analyse a panel dataset composed of 179 U.S. small high-tech firms and find an economically large and statistically significant relationship between R&D investments and cash flows. Using a panel of more than 1600 U.S. small manufacturing firms, Carpenter and Petersen (2002b) document that the growth of firms' total assets closely depends on the amount of the available cash flow; a cash flow increase of \$1 results in a slightly larger increase of firms' total assets. Other studies explicitly compare the extent of financial constraints in small and large firms. Hao and Jaffe (1993) contrast the R&D investments of U.S. small and large firms; they show that the former firms are liquidity-constrained, while the latter are not (see Harhoff, 1998 for similar results on German firms). Guariglia (2008) studies the investment–cash flow sensitivity on a panel of UK firms and finds that the investment–cash flow sensitivity is monotonically decreasing with firm size.

2.3. The role of public support in alleviating NTBFs' financial constraints

Several previous studies analyse the effects of public support schemes on firms' R&D expenditures and various indicators of firm performance, such as growth and productivity (see e.g., Lerner, 1999; Wallsten, 2000; Lach, 2002; González et al., 2005. See David et al., 2000, Klette et al., 2000 for surveys of early studies, and Hussinger, 2008 for a review of more recent works). Conversely, studies that specifically examine whether public subsidies relax firms' financial constraints are quite rare. Hyttinen and Toivanen (2005) show that small Finnish firms operating in industries that are largely dependent on external finance invest more in R&D and are more growth-oriented if more public support is available locally. These results support the view that (i) capital market imperfections hold back innovation investments and growth in this type of firms and (ii) public support helps to alleviate the negative effects of these capital market imperfections. Czarnitzki (2006) analyses the effects of firms' internal financial resources, credit rating (interpreted as an inverse proxy of the difficulty of resorting to external finance), and public subsidies on R&D expenses in a large sample composed of small and medium firms located in West and East Germany. In the West Germany sample, internal financial resources and public subsidies are found to positively influence R&D, while bad credit rating has an opposite effect of large economic magnitude. Conversely, in East Germany where public subsidies are more widely available than in West Germany, the sensitivity of firms' R&D expenses to internal financial resources is considerably reduced, credit rating plays no role, and public subsidies are the driving force of R&D activity. Notably, receipt of public subsidies leads to a 60% increase in the probability of a firm located in East Germany being involved in R&D; the corresponding figure for West Germany is +24%. These findings again suggest that financial constraints indeed limit firms' R&D activity, and that public support alleviates these constraints. Finally, Czarnitzki et al. (2011) explore the effect of public subsidies

on the sensitivity of firms' R&D investments to internal financial resources, distinguishing between research and development investments. First, they show that firms rely more on internal funds for research investments than for experimental development activities. This may be due to the fact that the latter type of activity occurs later in the R&D process and is closer to yielding returns. Second, they find that public subsidies foster research activities and reduce the sensitivity of this type of investments to internal funds. Conversely, they did not find any significant impact of public subsidies on investments in development activities.

Let us assume that small NTBFs are financially constrained. If public subsidies relax these financial constraints, a greater amount of investments should be observed after receipt of the subsidies, accompanied by a reduction of the sensitivity of investments to cash flows. There are three non-competing explanations for these effects. First, the marginal cost of public subsidies is lower than for other external sources of finance. Hence, for financially constrained firms, receipt of a public subsidy renders profitable investment projects that would not be profitable in its absence. In particular, we expect an increase in the investment activity if the recipient firm has exhausted internal funds and the cost of external capital is high. In these circumstances, public support lowers the supply curve of external funds, allowing the subsidised NTBFs to increase their investment rates even if cash flows are negative. Conversely, if subsidised firms are not financially constrained, they will simply substitute the public subsidies for internal funds or debt and will not increase their spending (for a full development of the argument on R&D investments see Hall and Maffioli, 2008). We expect this substitution effect to be more likely for large NTBFs as these firms are less likely to be financially constrained than small NTBFs.

In addition to this direct effect, public subsidies may have two additional indirect positive effects on firms' investments. First, a financially constrained small NTBF receiving a public subsidy may use it, at least partially, to purchase tangible assets that can then be used as collateral. The possession of collateralisable assets alleviates information asymmetry problems, making it easier for the NTBF to obtain additional bank debt. Banks may be indeed reluctant to lend if the only asset that can be pledged as collateral is the one they are financing. In fact, the liquidation value of the collateral generally exceeds the credit exposure (Berger and Udell, 2006).

Second, if public subsidies are provided through a “selective”⁷ support scheme administered by a reputable governmental body and there is fierce competition among applicants, recipient firms will have a “certification effect”, signalling to uninformed external parties their good quality. In turn, this signal will alleviate the hidden information problems that make it difficult for these firms to obtain external finance. In accordance with this latter argument, Lerner (1999) shows that U.S. small high-technology firms receiving awards from the Small Business Innovation Research (SBIR) program exhibit greater growth over a decade than those included in a matched control sample,⁸ but only if they are located in a geographic area with high VC activity. This positive effect seems to be confined to the first award received; the effects of subsequent awards are minimal. In addition, SBIR awardees are found to be more likely to subsequently obtain VC, while VC investments did not predict SBIR awards. Colombo et al. (2011, 2013) document

⁷ An automatic scheme gives financial assistance to all applicants fulfilling the requirements specified in the law. In contrast, a selective scheme provides financial support to selected applicants; applicants compete for financial subsidies and their projects are judged by committees formed by experts who are appointed by the national authority.

⁸ Nonetheless, the finding that SBIR grants foster growth was not replicated by Wallsten (2000). After controlling for endogeneity of public support in a multi-equations framework, it was found that SBIR grants did not positively influence firms' employment growth, while crowding out firms' private R&D expenses.

that public subsidies obtained through selective support schemes had beneficial effects on total factor productivity and employment growth of Italian NTBFs, but only if they were obtained in the early years of the NTBFs' life, when adverse selection problems are thought to be more severe. If selective schemes channelled public subsidies to older NTBFs or if support was provided through automatic schemes, the effects were negligible.

If public subsidies relax the financial constraints from which small NTBFs suffer, the question arises as to whether this effect is transient or persistent. Persistence over time of the allegedly positive effects of public subsidies on the investments of small NTBFs would be an additional argument in favour of public support to this type of firm. However, in spite of its importance, this issue has been neglected by the extant literature. There are two reasons why public subsidies may have an enduring positive effect on the investment activity of small NTBFs. First, let us assume that public support have a short-term positive effect on investments. If subsidised firms leverage this positive effect to become larger, they may be able to reach a threshold size above which financial constraints are no longer binding. However, whether public subsidies lead to increased growth of recipient firms is questionable (see, e.g., Irwin and Klenow, 1996; Lerner, 1999; Wallsten, 2000; Colombo et al., 2013). More interestingly, we mentioned above that public subsidies may allow beneficiary firms to acquire collateralisable assets. In addition, award of a selective subsidy may signal a firm's good quality to uninformed third parties. To the extent that these indirect effects lead to the removal of the sources of financial constraints (i.e., hidden information and hidden action problems), we expect the associated benefits to persist over time.

3. The data

3.1. The sample

This work examines a sample of 288 Italian privately held non-VC backed NTBFs observed from 1994 (or since their founding) up to 2008. Sample firms were established in 1980 or later, were owner-managed at founding time and remained so up to 1/1/2008, and operate in the following high-tech sectors in manufacturing and services: computers, electronic components, telecommunications equipment, optical, medical and electronic instruments, biotechnology, pharmaceuticals, advanced materials, aerospace, robotics, process automation equipment, software, and internet and telecommunications services. The unbalanced panel dataset used in the empirical analysis includes 2329 firm-year observations; there are, on average, eight observations per firm.

The sample is extracted from the RITA 2004 directory, developed at Politecnico di Milano. This directory has been used in several prior studies. In the absence of reliable official statistics, it is the most complete source of data on NTBFs presently available in Italy and includes 1974 firms (see Appendix A.1 for a detailed description). It is important to emphasise that because of the procedure that was used to create this directory, "lifestyle" firms and firms that are created purely for tax-saving objectives are unlikely to be included. These firms are very unlikely to apply for public subsidies; their exclusion is an important strength of our dataset as it renders the estimates of the counterfactual (i.e., the investment choices that subsidised NTBFs would have made in absence of public support) more precise. The sample analysed in the present study includes all RITA directory firms (i) that participated in a survey administered in the first semester of 2004, (ii) for which accounting data are available for the entire observation period (sources: AIDA and CERVED databases) and (iii) that did not receive VC and that did not go through an IPO. This last restriction is motivated by the fact that we are interested in isolating the "treatment" effect of public

subsidies on firms' investments and investment-cash flow sensitivity.⁹ Since the RITA 2004 directory contains data up to 2004, for the firms of the sample used in this work we updated the information relating to accounting data and receipt of public subsidies contained in RITA 2004 up to 2008 (or up to the time of exit from the sample).¹⁰ The availability of a long panel allows us to correctly evaluate the investment dynamics of sample firms and obtain robust estimates of the "treatment effect" of public subsidies.

Table 1 reports the distribution of sample firms across industries, geographic areas and foundation dates (columns III and IV). It also shows the distribution of the RITA directory firms for comparison purposes (columns I and II). Two χ^2 tests show that there are no statistically significant differences between the distributions of the 288 sample firms across industries and geographic areas and the corresponding distributions of the 1974 RITA directory firms ($\chi^2(4) = 4.32$ and $\chi^2(3) = 6.00$, respectively). Conversely, sample firms are somewhat older than the population from which the sample is drawn ($\chi^2(3) = 41.13$), with the foundation dates being more (less) concentrated in 1992–1997 (1998–2003). The reason is probably that (i) in Italy, all limited liability companies are obliged by law to publish yearly accounting data, while for other firms, publication is not mandatory, and (ii) limited liability companies are relatively less common among very young NTBFs. Note, however, that to assess the effect of public subsidies on investments, firms need to be observed over time. Therefore, the observation of very young firms provides limited insights into the issues analysed in this paper.

Table 2 reports some interesting descriptive statistics on our sample. As shown in Panel A, on average, firms are 10 years old and have almost 18 employees. Average total assets and sales are 2.20 and 2.66 million €, respectively. Sample firms also exhibit quite rapid yearly growth of employment, total assets and sales during the observation period (equal to 8%, 13% and 10%, respectively). Indeed, as shown in Panel B of Table 2, the average values of total assets, sales and number of employees are considerably larger at survey date (2004) than at the beginning of the observation period (1994). Descriptive statistics in Panel A of Table 2 also distinguish between small and large NTBFs. A firm-year observation falls in the 'large firms' or 'small firms' category if in that particular year the focal firm has total assets above or below the overall median, that is equal to 0.59 million € (i.e., firms might move between the two sub-samples as their size changes over time). Large NTBFs have greater number of employees and sales than their smaller peers (28.74 versus 7.03 employees and 4.93 versus 0.39 million € of sales). They are also older (12.87 versus 7.90 years old). More interestingly, they exhibit a greater rate of growth in terms of total assets and sales (16% and 12%, for large firms, versus 9% and 7%, for small ones). All these differences are statistically significant at conventional confidence levels. Conversely, the employment growth rate is only marginally higher for large NTBFs and the difference is not significant. This evidence is in line with the view that small NTBFs face more severe capital markets imperfections and thus grow at slower rates while large NTBFs encounter less obstacles to finance their growth.

Our dataset provides a rich set of industry-, location-, firm- and founder-specific information on sample firms that can be used to build appropriate instruments for receipt of public subsidies.

⁹ Clearly VC and IPOs are not the only source of external equity for NTBFs. The presence of external individual investors like business angels might still affect our results. As far as we know, no previous study has examined the impact of this mode of financing on the investment-cash flow sensitivity of NTBFs. In Section 5.2, we offer (partial) evidence suggesting that our results are not driven by provision of external capital by individual investors.

¹⁰ As in 2008, 33 NTBFs have been acquired or have been liquidated.

Table 1
Distribution of total sample and subsidised firms across industries, geographic areas and foundation dates.

Industry	RITA directory firms		Sample firms		Subsidised firms		Subsidisation rate (%) ^b
	N	%	N	%	N	%	
ICT manufacturing ^a	427	21.63	58	20.14	17	22.67	29.31
Automation equipment and robotics	212	10.74	30	10.42	2	2.67	6.67
Biotechnology, pharmaceuticals and advanced materials	96	4.86	14	4.86	9	12.00	64.29
Software	539	27.30	94	32.64	27	36.00	28.72
Internet and telecommunications services	700	35.46	92	31.94	20	26.67	21.74
Total	1974	100.00	288	100.00	75	100.00	26.04
Geographic area							
Northwest	853	43.21	143	49.65	33	44.00	23.08
Northeast	447	22.64	64	22.22	12	16.00	18.75
Centre	366	18.54	42	14.58	9	12.00	21.43
South	308	15.60	39	13.54	21	28.00	53.85
Total	1974	100.00	288	100.00	75	100.00	26.04
Foundation date							
1980–1985	345	17.48	51	17.71	18	24.00	35.29
1986–1991	350	17.73	61	21.18	21	28.00	34.43
1992–1997	622	31.51	128	44.44	29	38.67	22.66
1998–2003	657	33.28	48	16.67	7	9.33	14.58
Total	1974	100.00	288	100.00	75	100.00	26.04

^a ICT manufacturing includes the following industries: computers, electronic components, telecommunications equipment, and electronic, optical and medical instruments.

^b Subsidisation rate: percentage of subsidised firms out of the total number of sample firms in the corresponding category.

However, only firms that survived up to the survey date could be included in the sample. Survivorship bias may clearly distort the estimates of the effect of public subsidies on firms' investments. For instance, in the absence of public support, low-quality firms are more likely to both exhibit low investment levels and cease operations than their better-quality counterparts. If the former firms receive a public subsidy and then manage to stay in business, a downward bias in the effect of public support on investments may follow. The same holds true if receipt of public subsidies by high-quality firms with high investment levels renders them more attractive as acquisition targets. Unfortunately, we are not able to properly control for survivorship bias, as it is common in studies that use survey-based data (for exceptions see [Delmar and Shane, 2006](#); [Eckhardt et al., 2006](#)). In Section 4.3 we describe a test that has been implemented in our estimates to check whether survivorship bias affects our results.

3.2. Public subsidies to NTBFs in Italy

During the observation period, there was no large-scale national public support scheme in Italy expressly targeted to NTBFs (like the SBIR program in the U.S. or the *Jeunes Entreprises Innovantes* scheme in France). The only partial exception is the Law 297/1999 that aimed at favouring the creation of academic start-ups. Indeed, the industrial policy of the Italian government relied on horizontal measures directed to all firms, or was aimed at supporting specific sectors (e.g., the Law 808/1985 in support of the aerospace sector, dominated by large enterprises like Finmeccanica), or focused attention on young or small enterprises independently of their sector of operations, with most beneficiaries being small low-tech firms that abound in Italy. As a result, in the period under observation here, sample NTBFs obtained direct financial support from 28 national policy schemes.

Table 2
Descriptive statistics on sample firms.

Panel A				
Variable	Total sample firms	Small firms	Large firms	Difference between small and large firms
$Age_{i,t}$	10.39 (5.71)	7.90 (4.75)	12.87 (5.50)	-4.97***
$Employees_{i,t}$	17.69 (24.59)	7.03 (5.49)	28.74 (31.00)	-21.71***
$Total Assets_{i,t}$	2.20 (9.29)	0.26 (0.16)	4.15 (12.85)	-3.89***
$Sales_{i,t}$	2.66 (13.09)	0.39 (0.31)	4.93 (18.23)	-4.54***
$Employment growth rate_{i,t}$	0.08 (0.31)	0.07 (0.34)	0.09 (0.28)	-0.02
$Total assets growth rate_{i,t}$	0.13 (0.01)	0.09 (0.01)	0.16 (0.01)	-0.07***
$Sales growth rate_{i,t}$	0.10 (0.55)	0.07 (0.62)	0.12 (0.47)	-0.04*
<i>N.obs</i>	2329	1165	1164	
Panel B				
Variable	1994	2004	Difference between 2004 and 1994	
<i>Employees</i>	10.11 (8.85)	19.09 (25.28)	8.98***	
<i>Total Assets</i>	0.85 (1.91)	2.00 (4.80)	1.15**	
<i>Sales</i>	1.03 (1.78)	2.47 (6.27)	1.44**	

Note: The Table reports sample means. Standard deviations are presented in parentheses. ***, ** and * indicate, respectively, significance levels of <1%, <5% and <10%. The subscript *i* indexes firms, and the subscript *t*, time, where *t* = 1994–2008. A firm *i* is considered small/large in year *t* if its size, measured by total assets is smaller/higher than median size (0.59 mil. €), measured pooling all the observations in the sample. $Age_{i,t}$ is the difference between the current and the foundation year. $Total Assets_{i,t}$, $Sales_{i,t}$ are expressed in mil. €. The variable $Employees_{i,t}$ indicates the number of full-time equivalent employees of firm *i*. It was available for 1548 observations. Growth rates has been calculated as logarithmic difference between *t* and *t* - 1.

The policy measures implemented by the Italian government¹¹ to provide direct support to private firms differ according to: (i) their objective, (ii) the evaluation method for applications, and (iii) the financial instrument through which subsidies are obtained by beneficiary firms. Regarding the latter two dimensions, some measures relied on automatic schemes, and others on selective ones. Moreover, financial instruments included tax credits, non-repayable grants, and low interest loans (i.e., repayable loans with below-market interest rates). As regards policy objectives, support to firms located in the depressed areas of the South, which suffer from an economic and social gap with respect to the other parts of the country, has traditionally been the most prominent one. Data provided by the Ministry of Industry for the period 2000–2003 clearly document the importance of this objective (see MAP, 2005).¹² In this period, policy measures inspired by this objective accounted for about 46% of the total amount of subsidies to private firms. The main schemes in this category, like the Law 64/1986 (“Intervento Straordinario nel Mezzogiorno”, *Extraordinary Intervention for the South of Italy*) and the Law 488/1992, provided firms located in this geographic area with grants and other forms of public support to their investments. Support to R&D and innovation was the second most important objective of Italian industrial policy, with a 22% share of the subsidies awarded to private firms in the 2000–2003 period. Most of the support was channelled through three instruments: the FAR fund (“Fondo Rotativo per le Agevolazioni alla Ricerca”, *Fund for Research Facilitations*), the FIT fund (“Fondo Rotativo per l’Innovazione Tecnologica”, *Fund for Technological Innovation*), both introduced by the Law 46/1982, and the Law 808/1985 targeting the aerospace industry. FAR supported pre-competitive R&D expenses, while FIT had broader scope and financed any type of innovation activity, including purchase of innovative machinery. FAR and FIT accounted for roughly half of the total amount of the R&D and innovation subsidies granted to Italian private firms in the 2000–2003 period and were widely used by NTBFs.¹³ The third most important objective (9% of subsidies in 2000–2003) was the support of investments in tangible and intangible assets. The remaining subsidies were channelled through schemes aimed at diverse objectives, including the promotion of entrepreneurship and of the internationalisation of firms’ activities.

One may presume that if NTBFs were financially constrained, receipt of a subsidy should have helped them to relax these constraints, thereby positively influencing their investments, independently of the specific objective of the policy measure through which the subsidy was obtained. In fact, most policy measures used by Italian NTBFs support investments in tangible or intangible (i.e.,

Table 3
Subsidies granted to firms by firm size at the time of receipt of the subsidy.

	No. of firm-year observations	Firm-year observations in which one or more subsidies were granted	
		N	%
Large firms	1164	65	5.58
Small firms	1165	31	2.66
Total sample firms	2329	96	4.12

Note: A firm i is considered small/large in year t if its size, measured by total assets is smaller/higher than median size, measured pooling all the observations in the sample.

R&D and innovation expenditures) assets.¹⁴ When this was not the case, the positive effect on investments may have been indirect. On the one hand, beneficiary NTBFs may have been able to finance investments through internal financial resources that would have been used for other purposes in absence of the subsidy. On the other hand, receipt of a selective subsidy may have made it easier to obtain external finance from other sources due to the quality certification effect associated with the award of the subsidy. For these reasons, in assessing the treatment effect of public subsidies on the investment activity of Italian NTBFs, we consider all national policy schemes from which NTBFs obtained support.

A total of 75 sample NTBFs received subsidies from the Italian government in the period 1994–2008. Most of these firms received only one subsidy (47 NTBFs). In the last three columns of Table 1, we illustrate the distributions of subsidised NTBFs by industry, geographic area and foundation date and the share accounted for by subsidised NTBFs out of the total number of sample firms in the corresponding category. From these figures, it is apparent that public subsidies were not ubiquitous among Italian NTBFs. Only 26% of sample firms received one or more subsidies during the observation period. Moreover, the “treatment” was not random. Results of χ^2 tests reject the null hypothesis that there are no differences between the distributions of subsidised and non-subsidised NTBFs by industry, geographical area and foundation date at conventional confidence levels ($\chi^2(4) = 13.34$, $\chi^2(3) = 13.71$ and $\chi^2(3) = 6.31$, respectively). In the light of the discussion above about the objectives of Italian industrial policy, the higher subsidisation rates for firms located in the South (53.85%) and for those in the biotechnology, pharmaceutical and advanced materials industries (64.29%), that are more R&D intensive than other firms, are hardly surprising. Looking at the foundation date, the low subsidisation rate among very young NTBFs (14.58%) may be attributed to the shorter observation period.

Table 3 reports the distribution of received subsidies across large and small NTBFs. Out of the 2329 observations in the dataset, there are 96 firm-year observations in which one or more public subsidies were granted to the focal NTBFs. This again indicates that the Italian government has not been overly generous with NTBFs. The “large firms” category accounted for 65 of these observations, while only 31 observations relate to “small firms”. Hence, the likelihood of obtaining public subsidies is twice as large for larger NTBFs than for their smaller counterparts (5.58% and 2.66%, respectively, with the difference being significant at 1%).¹⁵ Unfortunately, data on the amount of subsidies received by firms are not available. No systematic official publicly available records exist in Italy indicating the firms that benefited from public support and the amount

¹¹ In Italy, several governmental institutions were responsible for the administration of public subsidies. They include: the Ministry of Economics and Finance, the Ministry of Industry, the Ministry of University and Research, the Ministry of Labour and Welfare, the Ministry of Agricultural Food and Forest Policies, the Ministry of International Trade, and the Institute for Foreign Trade (ICE). Quite noteworthy is that in Italy, unlike other European countries, there is no public agency in charge of innovation policy measures.

¹² Measures in support of the South date back to the early 1950s, when the Italian Government created the “Cassa del Mezzogiorno” (*Fund for the South*), a public agency devoted to financing industrial development and public infrastructures in these regions. It ceased operations in 1992. Reliable data that distinguish policy schemes according to their objectives are not available for the period before 2000. However, the qualitative evidence provided by official documents confirms the prominence of this objective.

¹³ Law 808/1985 accounted for another 25%, but it mainly benefited large incumbent firms. The remaining 25% was dispersed among a plethora of schemes. Note that during the observation period there was no public support scheme explicitly targeting collaborative R&D (like the Framework Programs funded by the European Commission).

¹⁴ According to Italian fiscal law, firms may decide whether to treat R&D expenses as investments or to expense them when they are incurred. This latter option is more favourable for firms with positive net income.

¹⁵ We also estimated a probit model on the probability to obtain public subsidies. Firm size has a significant positive effect on such probability. See Section 4.3 for the description of the probit model and Appendix A.3 for the results.

of subsidies they received. Moreover, firms generally consider this information as confidential. This clearly is a limitation of our dataset that is quite common among micro-econometric evaluations of public support schemes (e.g., Czarnitzki et al., 2007; Girma et al., 2007, 2008).¹⁶ Hence, we cannot gauge whether the intensity of public support was stronger for large NTBFs than for their smaller peers. Actually, the higher subsidisation rate exhibited by large NTBFs may be considered as physiological, as these firms have more activities (i.e., a higher number of projects that may apply for public support). However, it may also indicate a pathology associated with the higher application costs that small and more resource constrained NTBFs encounter (see Takalo et al., 2013 for evidence on this issue relating to Finnish firms).

4. The econometric methodology

4.1. Specification of the econometric models

To analyse the investment–cash flow sensitivity, the literature proposes several econometric models (Hubbard, 1998; Bond and Van Reenen, 2007). As mentioned in Section 2.1, aiming to find the best combination in terms of accuracy of the model and validity of the hypotheses on which the model is based, we resort to an ECM specification (see Bond et al., 2003; Guariglia, 2008). This model specifies the long-term desired level of capital as a log-linear function of output and the user cost of capital. In particular, rather than to require assumptions on the adjustment costs function, it assumes a general autoregressive distributed lag dynamic model, that lets the data determine the relevant dynamics within the sample on which it is applied.

Following Guariglia (2008), to test differences in investment–cash flow sensitivity between small and large NTBFs we insert the variable $SMALL_{i,t}$, indicating that the firm i belongs to the “small firms” category at time t , and we interact the cash flow variable with $SMALL_{i,t}$ and $LARGE_{i,t} = (1 - SMALL_{i,t})$.¹⁷ This approach, as alternative to the estimation of the investment equation on the two separate sub-samples of firms, allow us to avoid problems of endogenous sample selection, to gain degrees of freedom and to take into account the fact that firms can transit between groups. The baseline equation is as follows.

$$\frac{I_{i,t}}{K_{i,t-1}} = \alpha_i + \tau_t + \beta_1 \left(\frac{I_{i,t-1}}{K_{i,t-2}} \right) + \beta_2 \Delta y_{i,t} + \beta_3 \Delta y_{i,t-1} + \beta_4 (k_{i,t-2} - y_{i,t-2}) + \beta_5 SMALL_{i,t} + \beta_6 \left(\frac{CF_{i,t}}{K_{i,t-1}} \right) \times SMALL_{i,t} + \beta_7 \left(\frac{CF_{i,t}}{K_{i,t-1}} \right) \times LARGE_{i,t} + \varepsilon_{i,t}; \quad (1)$$

where $I_{i,t}$ is the level of investments of firm i in period t , measured by the increase in the book value of tangible and intangible assets net of depreciation, $K_{i,t}$ is the end-of-period- t book value of firm i 's tangible and intangible assets, and $k_{i,t}$ its logarithm, $CF_{i,t}$ is firm i 's cash flow in period t after taxes but before dividends,¹⁸ and $y_{i,t}$ is the logarithm of firm i 's sales during period t . The coefficient β_5

captures differences between small and large NTBFs in the investment rate, while coefficients β_6 and β_7 reflect the investment–cash flow sensitivity of the two types of firms. In particular, if there are capital market imperfections and the external capital supply curve of small (large) NTBFs is upward-sloping, we expect β_6 (β_7) to be positive, indicating the presence of financial constraints.

To assess whether firms' investment rate and investment–cash flow sensitivity are affected by receipt of public subsidies, we modify the baseline Eq. (1) by inserting the dummy variable $PUB_{i,t-1}$, which captures the effect of receipt of public subsidies on firms' investment dynamics. More precisely, $PUB_{i,t}$ equals 0 if firms did not obtain public subsidies. It switches from 0 to 1 in the year in which the focal firm obtains the subsidy. Then it switches back to zero the year after the receipt of the subsidy and remains at zero thereafter.

$$\begin{aligned} \frac{I_{i,t}}{K_{i,t-1}} = & \alpha_i + \tau_t + \gamma_1 \left(\frac{I_{i,t-1}}{K_{i,t-2}} \right) + \gamma_2 \Delta y_{i,t} + \gamma_3 \Delta y_{i,t-1} + \gamma_4 (k_{i,t-2} - y_{i,t-2}) \\ & + \gamma_5 SMALL_{i,t} + \gamma_6 \left(\frac{CF_{i,t}}{K_{i,t-1}} \right) \times SMALL_{i,t} + \gamma_7 \left(\frac{CF_{i,t}}{K_{i,t-1}} \right) \times LARGE_{i,t} \\ & + \gamma_8 PUB_{i,t-1} \times SMALL_{i,t} + \gamma_9 PUB_{i,t-1} \times LARGE_{i,t} \\ & + \gamma_{10} PUB_{i,t-1} \times \left(\frac{CF_{i,t}}{K_{i,t-1}} \right) \times SMALL_{i,t} + \gamma_{11} PUB_{i,t-1} \times \left(\frac{CF_{i,t}}{K_{i,t-1}} \right) \times LARGE_{i,t} + \varepsilon_{i,t}. \end{aligned} \quad (2)$$

In Eq. (2), the coefficients γ_8 and γ_9 capture the (alleged) increase in the investment rate generated by receipt of a public subsidy in the immediately following year, for a small and a large NTBF, respectively. The coefficients γ_{10} and γ_{11} measure the effect of public subsidies on the investment–cash flow sensitivity of the two types of firms in the year following the receipt of a public subsidy.

So far, we have implicitly assumed that receipt of public subsidies has a lagged “impulse” effect (if any) on firms' investment rate and investment–cash flow sensitivity. In other words, receipt of public subsidies engenders an instantaneous shock that materialises in the following year but does not persist over time. This means that from year two after receipt of public subsidies onward, the investment choices of a subsidised firm do not differ from those of a firm that did not obtain a subsidy. To assess whether receipt of a subsidy *permanently* changes the investment dynamics of NTBFs, we extend Eq. (2) as follows:

$$\begin{aligned} \frac{I_{i,t}}{K_{i,t-1}} = & \alpha_i + \tau_t + \delta_1 \left(\frac{I_{i,t-1}}{K_{i,t-2}} \right) + \delta_2 \Delta y_{i,t} + \delta_3 \Delta y_{i,t-1} + \delta_4 (k_{i,t-2} - y_{i,t-2}) \\ & + \delta_5 SMALL_{i,t} + \delta_6 \left(\frac{CF_{i,t}}{K_{i,t-1}} \right) \times SMALL_{i,t} + \delta_7 \left(\frac{CF_{i,t}}{K_{i,t-1}} \right) \times LARGE_{i,t} \\ & + \delta_8 PUB_{i,t-1} \times SMALL_{i,t} + \delta_9 PUB_{i,t-1} \times LARGE_{i,t} \\ & + \delta_{10} PUB_{i,t-1} \times \left(\frac{CF_{i,t}}{K_{i,t-1}} \right) \times SMALL_{i,t} + \delta_{11} PUB_{i,t-1} \times \left(\frac{CF_{i,t}}{K_{i,t-1}} \right) \times LARGE_{i,t} \\ & + \delta_{12} PUB_pers_{i,t-1} \times SMALL_{i,t} + \delta_{13} PUB_pers_{i,t-1} \times LARGE_{i,t} \\ & + \delta_{14} PUB_pers_{i,t-1} \times \left(\frac{CF_{i,t}}{K_{i,t-1}} \right) \times SMALL_{i,t} + \delta_{15} PUB_pers_{i,t-1} \times \left(\frac{CF_{i,t}}{K_{i,t-1}} \right) \times LARGE_{i,t} + \varepsilon_{i,t}; \end{aligned} \quad (3)$$

In this specification, $PUB_pers_{i,t}$ equals 1 from the year that follows the one in which the focal firm receives a public subsidy up

¹⁶ In particular, without information on the amount of the subsidy, it is difficult to disentangle the mechanisms through which public subsidies relax NTBFs' financial constraints (i.e. through the direct, the collateral or the certification effect). Indeed, while the certification effect is expected to be independent from the financial amount of the subsidy (it depends on the mechanism through which subsidies are provided), the direct and the collateral effects are clearly related to the amount of the subsidy.

¹⁷ A firm i is considered small/large in year t if its size, measured by total assets, is smaller/larger than the median size, measured by pooling all sample observations. Results do not significantly change if we consider median size by year. For the sake of synthesis, these results are not presented here, but are available upon request from the authors.

¹⁸ Other authors have used ex-dividend cash flows (e.g. Manigart et al., 2003). We opt for cash flows before dividends because our sample is composed of unlisted firms. Managers of listed firms are more constrained than those of privately held firms to avoid a reduction in the amount of dividends paid to shareholders, as this

reduction may be perceived as a negative signal by investors. Conversely, in privately held firms, dividends have no signalling role and all cash flows can be reinvested if some profitable investment opportunity arises.

to the end of the observation period. If public subsidies have a persistent effect on the investment choices of small (large) NTBFs over and above the transitory effect captured by parameters δ_8 and δ_{10} (δ_9 and δ_{11}), this enduring impact is captured by parameters δ_{12} and δ_{14} (δ_{13} and δ_{15}), for investment rate and investment–cash flow sensitivity, respectively. In estimating Eq. (3), we exclude firms that, in the observation period, received more than one subsidy starting from the year in which they obtained the second subsidy. The aim here is to disentangle the persistent effect of public subsidies from their immediate (short-term) effect. Indeed, with the specification described by Eq. (3), the inclusion of firms that are “serial” beneficiaries of public support would make it impossible to separately detect these two different effects.¹⁹

Table 4 reports some descriptive statistics for the variables used in our models. Investment rate ($I_{i,t}/K_{i,t-1}$) and cash flow rate ($CF_{i,t}/K_{i,t-1}$) are normalised against the beginning-of-period- t stock of tangible and intangible assets. As firms in our sample are relatively young and small, this value is sometimes close to zero, producing extremely skewed and leptokurtic distributions of the variables. The presence of these outliers could severely bias our results. To avoid this problem, we winsorise all variables (e.g., Dixon, 1960) with a 2% cut-off for each tail. In other words, for each variable we calculate the values corresponding to the 2nd and 98th percentiles of its distribution and assign these values to all observations falling beyond them. This approach is useful because it reduces the impact of outliers and allows the use of a larger number of observations than would be possible if outliers were deleted. Furthermore, it has already been used in the investment literature (e.g., Baker and Stein, 2003), notably to assess investment–cash flow sensitivity (e.g., Cleary, 1999, 2006; Bertoni et al., 2010). Other cut-offs for winsorising were computed, i.e., 1% and 5%, but a 2% cut-off offered the best compromise between smoothing extreme values and maintaining sufficient variance.²⁰ Descriptive statistics for winsorised variables are also reported in Table 4.

4.2. Tests

The effect of public subsidies on investment–cash flow sensitivity can be gauged through a simple linear test on the parameters of the models. If an instantaneous change ΔCF in $CF_{i,t}$ produces a change in the investment rate, the coefficient of $CF_{i,t}/K_{i,t-1}$ should be positive and significant. We interpret this positive coefficient as an indication of financial constraints. As explained in Section 2.3, we expect small NTBFs to be financially constrained, and public subsidies to help them remove these constraints. Hence, after receiving a subsidy, internal cash flow should no longer have any positive effect on the investment rate of these firms (i.e., the coefficient of $CF_{i,t}/K_{i,t-1}$ should not be positive and significant). The relaxation of financial constraints engendered by public subsidies may be transitory or persistent. If it is transitory, the coefficient of the cash flow variable will not be positive (and significant) only in the year immediately following receipt of the public subsidy. Conversely, if the relaxation of financial constraints is persistent,

the coefficient of this variable will not be positive and significant also for the remaining observation period. Following this line of reasoning, we perform the following t -tests of the null hypothesis that a change in cash flow does not affect the investment rate:

In Eq. (2), $\gamma_6 = 0$ for small NTBFs that did not obtain public subsidies, $\gamma_6 + \gamma_{10} = 0$ for small NTBFs that obtained public subsidies, $\gamma_7 = 0$ for large NTBFs that did not obtain public subsidies, $\gamma_7 + \gamma_{11} = 0$ for large NTBFs that obtained public subsidies.

In Eq. (3), $\delta_6 = 0$ for small NTBFs that did not obtain public subsidies, $\delta_6 + \delta_{10} = 0$ for small NTBFs that obtained public subsidies (short-term effect), $\delta_6 + \delta_{14} = 0$ for small NTBFs that obtained public subsidies (persistent effect), $\delta_7 = 0$ for large NTBFs that did not obtain public subsidies, $\delta_7 + \delta_{11} = 0$ for large NTBFs that obtained public subsidies (short-term effect), $\delta_7 + \delta_{15} = 0$ for large NTBFs that obtained public subsidies (persistent effect).

The effect of public subsidies on the investment rate can be evaluated in a similar way by performing t -tests of the following null hypotheses:

In Eq. (2), $\gamma_8 = 0$ for small NTBFs and $\gamma_9 = 0$ for large ones.

In Eq. (3), $\delta_8 = 0$ for small NTBFs and $\delta_9 = 0$ for large ones (short-term effect), $\delta_{12} = 0$ for small NTBFs and $\delta_{13} = 0$ for large ones (persistent effect).

4.3. Estimation methodologies

In this work, we are interested in assessing the “treatment” effect of public subsidies on firm’s investment rate and investment–cash flow sensitivity. Therefore, we have to deal with the potentially endogenous nature of the public support variables (i.e., $PUB_{i,t-1}$ and $PUB_{pers,i,t-1}$). In fact, a firm that faces interesting investment opportunities is more likely to look for external finance, including public subsidies, thus leading to a correlation between the two variables caused by reverse causation (i.e., investments causing public finance). Moreover, the performance of an NTBF (including its investment rate) is related to unobservable characteristics such as a brilliant business idea, the development of a unique technology, or a team of smart owner–managers. If these unobservables also influence the ability of firms to obtain public subsidies (for example, because of the higher propensity of these firms to apply for public subsidies or the higher probability to be selected by public bodies that administer the support schemes), a spurious correlation between public subsidies and investment rate follows because of unobserved heterogeneity. An opposite bias in the estimated treatment effect of public support is also possible if public subsidies are channelled by governmental authorities to firms with poor investment opportunities, or if NTBFs with better investment opportunities self-select out of public support schemes because of high application costs.

Both pooled ordinary least squares (OLS) and fixed-effects within-groups (WG) estimates in these circumstances can lead to serious biases (Bond et al., 2001). We thus resort to the two-step system generalised method of moments estimation (GMM-SYS, Arellano and Bover, 1995; Blundell and Bond, 1998) with finite-sample correction (Windmeijer, 2005), which allows us to take into account the endogeneity of the covariates. In addition to lagged levels of the series as instruments for first differences equations, the GMM-SYS estimator employs additional moment conditions using first differences as instruments for variables in levels. We consider covariates in the ECM specification and all public support variables to be endogenous.

However, the GMM-SYS estimator also presents some weaknesses. First, the use of a large number of instruments results in significant finite sample bias, and measurement errors may cause potential distortions in estimates. To deal with these problems, we limit the instrument set with moment conditions in the interval between $t - 2$ and $t - 3$ (see Bond, 2002). Second, the moment

¹⁹ By excluding “serial” beneficiaries, the persistent effect of public subsidies should be attributable only to the purchase of collateralisable assets or to the certification effect in the case of selective public support schemes. However, this holds true if public subsidies are paid in a single round of financing. Conversely, if public subsidies are received in multiple rounds, the direct effect may be at work (i.e. NTBFs simply use the amount received at each round of financing to increase their investments). Unfortunately, our dataset does not allow to observe the precise schedule of payments of each subsidy. As to automatic subsidies, they are generally paid out in one single round (in the form of a tax credit). As to selective subsidies, some of them are actually paid in multiple rounds. Hence, the persistent effect of public subsidies is not entirely attributable to the collateral and certification effects.

²⁰ Estimates using these different cut-offs are very close to those described in the next sections. They are available from the authors upon request.

Table 4
Descriptive statistics on regression variables.

Variable	N	Mean	Median	Std. Dev.	Std. Dev. Between	Std. Dev. Within	Skewness	Kurtosis
Not winsorised								
$I_{i,t}/K_{i,t-1}$	2329	3.879	0.368	134.210	47.831	125.553	48.048	2315.211
$\Delta y_{i,t}$	2329	0.098	0.079	0.552	0.231	0.520	0.726	52.824
$(k_{i,t-2} - y_{i,t-2})$	2329	-2.077	-2.113	1.230	1.017	0.714	0.330	3.677
$CF_{i,t}/K_{i,t-1}$	2329	5.324	0.438	203.180	72.151	190.120	47.976	2310.238
Winsorised with a 2% cut-off for each tail								
$I_{i,t}/K_{i,t-1}$	2329	0.758	0.368	1.236	0.563	1.140	3.300	15.321
$\Delta y_{i,t}$	2329	0.108	0.079	0.378	0.162	0.350	0.906	6.619
$(k_{i,t-2} - y_{i,t-2})$	2329	-2.082	-2.113	1.180	0.985	0.672	0.227	2.845
$CF_{i,t}/K_{i,t-1}$	2329	0.802	0.438	1.466	1.043	1.099	2.891	13.566

Note: $I_{i,t}$ is the increase in a firm's book value of tangible and intangible assets net of depreciation between periods $t - 1$ and t . $K_{i,t-1}$ is the beginning-of-period- t book value of tangible and intangible assets, and $k_{i,t}$ its logarithm. $CF_{i,t}$ is firm i 's cash flows after taxes and before dividends in period t . $y_{i,t}$ is the logarithm of firm i 's sales during period t .

conditions of the GMM-SYS approach require that the instruments are uncorrelated with the error terms, meaning that deviations of dependent and independent endogenous variables from the long-run mean are not correlated with any unobservable and observable individual fixed effect. Results of the Hansen- J statistic reassure us about the validity of the moment conditions used in all the estimations. Moreover, pseudo-first stage regressions ensure the goodness of the GMM-SYS estimator with respect to the GMM-DIFF estimator (the specification of the pseudo-first stage regressions we use in this work is described in Appendix A.2). Third, and most important, the standard GMM-SYS estimator relies on the assumption of sequential exogeneity (see Wooldridge, 2000) in that it assumes that *future* shocks to the firm's investment opportunities are independent of receipt of public subsidies, while *past* shocks can affect it. Therefore, it might produce biased estimates of the "treatment" effect of public subsidies by mistakenly attributing a selection-derived effect to the influence of public subsidies on firm's investments (see Bertoni et al., 2011 for a detailed description of this problem in a similar context). To address this problem we add to the set of instruments of the GMM-SYS estimator two additional variables, which reflect the availability of public subsidies in the geographic area of the focal NTBF and in the industry in which it operates ($PUB.Area_i$ and $PUB.Sector_i$).²¹ Good instruments need to be related to public subsidies variables, but should be independent of the error terms of the ECM specification. Firms with great future investment opportunities may be located in geographic areas and operate in industries with abundance or scarcity of public subsidies. Independently of focal firm's future investment opportunities, the likelihood of obtaining public subsidies is higher if the firm operates in a sector and geographic area with an abundance of public subsidies. However, the effect of public subsidies on investment rate and investment-cash flow sensitivity is independent of these variables, and so they are a source of exogenous variation (in a similar vein, see Sørensen, 2007; Bottazzi et al., 2008; Chemmanur et al., 2011; Ivanov and Xie, 2010).²² As an additional robustness check, we replace these variables with the estimated likelihood of firm i obtaining public subsidies in year t (see Benfratello and Sembenelli, 2006 for a similar approach in a different context). This was estimated through a probit panel data model. Results of this model and

a description of the independent variables used in this regression are reported in Appendix A.3 (Tables A.3.1 and A.3.2).

Furthermore, a possible survivorship bias in data may intervene in the investigated relationship. We implement a test to check for such bias in the spirit of Wooldridge (1995) and Semykina and Wooldridge (2010). We estimate Eqs. (1)–(3) via GMM-SYS, inserting as a further control variable an inverse Mill's ratio type of control factor. To compute this time-varying control factor, we follow the procedure described by Bertoni et al. (2011) that estimated it on a similar sample. This time-varying ratio was then inserted in Eqs. (1)–(3) to test for possible survivorship bias.

Finally, to evaluate the relevance of all our econometric models, we also implement the Arellano and Bond test for first- and second-order serial autocorrelation of residuals [AR(1), AR(2)]. If ε_{it} is not serially correlated, the difference of residuals should be characterised by a negative first-order serial correlation and the absence of a second-order serial correlation. Moreover, the Hansen- J test is also implemented to verify that the null hypothesis of equality to zero of the specified orthogonality conditions is not rejected.

5. Econometric results

5.1. Main results

We illustrate in Panel A of Table 5 the estimates of Eqs. (2) and (3). In particular the first two columns (Model I) refer to the estimates of Eq. (2) on the total sample, while Model II, in the third and fourth columns, is run on the sub-sample of NTBFs that either did not receive any public subsidy or received it only once (these latter estimates are reported purely for comparison purposes). The remaining two columns (Model III) report the estimates of Eq. (3) on this last sub-sample. More specifically, in Models labelled with "a" (Models Ia, IIa, IIIa) we use, in addition to internal instruments, the exogenous instruments $PUB.Area_i$ and $PUB.Sector_i$. In Models labelled "b" (Models Ib, IIb, IIIb), these latter instruments are replaced by the likelihood of firm i obtaining public subsidies in year t . In all models, the null hypothesis of absence of a negative first-order serial correlation is rejected, while the null hypothesis of absence of a second-order serial correlation is not. The Hansen- J tests also indicate that the null hypothesis of equality to zero of the specified orthogonality conditions is not rejected (the p -values of the Hansen- J tests are reported at the bottom of Tables 5–8). Finally, in order to check whether our estimates are affected by a survivorship bias, we add to the model specification the inverse Mill's ratio type of control for survivorship bias described in Section 4.2. The coefficient of the survivorship bias control is never significant (for the sake of synthesis, we do not present these estimates in the text. The results are available from the authors upon request). Thus, unobserved factors that are positively or negatively associated with the

²¹ These indicators represent the share of RITA NTBFs that obtained public subsidies out of the total number of RITA NTBFs that are located in the same geographic area and operate in the same industry as firm i .

²² Note that in accordance with the studies mentioned above, we make the assumption that the clustering of public subsidies in specific industries or geographic markets is exogenous, that is it is not driven by the investment opportunities unobserved to third parties faced by the NTBFs that are in those markets and are potential candidates for receiving public subsidies. Therefore, it is uncorrelated with the error term of our model.

Table 5

Panel A. short-term and persistent effects of public subsidies on the investment rate and investment–cash flow sensitivity of sample firms.

	Short-term effect only (Eq. (2))				Short-term and persistent effects (Eq. (3))	
	Model Ia	Model Ib	Model IIa	Model IIb	Model IIIa	Model IIIb
$I_{i,t-1}/K_{i,t-2}$	−0.0592 (0.036)	−0.0639 (0.038)*	−0.0675 (0.038)*	−0.0654 (0.037)*	−0.0659 (0.037)*	−0.0612 (0.037)*
$\Delta y_{i,t}$	0.4494 (0.217)**	0.4932 (0.224)**	0.3468 (0.215)	0.3730 (0.218)*	0.3180 (0.190)*	0.3234 (0.183)*
$\Delta y_{i,t-1}$	0.4818 (0.125)***	0.5174 (0.133)***	0.4927 (0.110)***	0.5039 (0.120)***	0.4686 (0.105)***	0.4650 (0.109)***
$(k_{i,t-2}-y_{i,t-2})$	−0.2027 (0.081)**	−0.2179 (0.088)**	−0.1900 (0.067)***	−0.187 (0.071)***	−0.1996 (0.068)***	−0.1854 (0.065)***
$CF_{i,t}/K_{i,t-1} \times SMALL_{i,t}$	0.3495 (0.106)***	0.3593 (0.109)***	0.3025 (0.109)***	0.3097 (0.107)***	0.3768 (0.108)***	0.3887 (0.109)***
$CF_{i,t}/K_{i,t-1} \times LARGE_{i,t}$	0.0994 (0.106)	0.0863 (0.103)	0.1247 (0.101)	0.1345 (0.100)	0.1113 (0.111)	0.1184 (0.109)
$SMALL_{i,t}$	0.0987 (0.201)	−0.0236 (0.185)	0.1763 (0.228)	0.0575 (0.187)	0.2785 (0.245)	0.1706 (0.220)
$PUB_{i,t-1} \times SMALL_{i,t}$	1.1586 (0.540)**	1.2361 (0.544)**	1.4841 (0.438)***	1.5263 (0.447)***	1.2597 (0.518)**	1.2702 (0.492)***
$PUB_{i,t-1} \times LARGE_{i,t}$	−0.0780 (0.182)	−0.0923 (0.175)	−0.1279 (0.152)	−0.1843 (0.159)	−0.0271 (0.202)	−0.0708 (0.202)
$PUB_{pers_{i,t-1}} \times SMALL_{i,t}$					0.0517 (0.386)	0.0456 (0.321)
$PUB_{pers_{i,t-1}} \times LARGE_{i,t}$					0.2693 (0.238)	0.2887 (0.260)
$PUB_{i,t-1} \times CF_{i,t}/K_{i,t-1} \times SMALL_{i,t}$	−1.0580 (0.455)**	−1.1116 (0.452)**	−1.6307 (0.449)***	−1.664 (0.442)***	−1.7377 (0.454)***	−1.7693 (0.450)***
$PUB_{i,t-1} \times CF_{i,t}/K_{i,t-1} \times LARGE_{i,t}$	−0.0262 (0.168)	−0.0363 (0.165)	−0.1415 (0.145)	−0.1415 (0.137)	−0.1166 (0.167)	−0.1113 (0.166)
$PUB_{pers_{i,t-1}} \times CF_{i,t}/K_{i,t-1} \times SMALL_{i,t}$					−0.4311 (0.160)***	−0.4326 (0.156)***
$PUB_{pers_{i,t-1}} \times CF_{i,t}/K_{i,t-1} \times LARGE_{i,t}$					−0.0156 (0.181)	−0.0186 (0.200)
Constant	0.3973 (0.328)	0.4392 (0.415)	−0.0284 (0.177)	0.0199 (0.168)	−0.1533 (0.205)	−0.0948 (0.178)
No. of observations	2329	2329	2186	2186	2186	2186
Hansen-J (statistic)	170.19	169.49	174.40	173.93	165.81	165.06
Hansen-J (degrees of freedom)	[186]	[186]	[177]	[177]	[173]	[173]
Hansen-J (p-value)	0.7908	0.8017	0.5412	0.5513	0.6391	0.6545
AR(1)	−6.441***	−6.4121***	−6.0652***	−6.1127***	−6.0809***	−6.1009***
AR(2)	0.5996	0.5707	0.5004	0.4853	0.4212	0.3917

Panel B. test results on the short-term and persistent effects of public subsidies on the investment–cash flow sensitivity of sample firms

	Short-term effect only (Eq. (2))				Short-term and persistent effects (Eq. (3))	
	Model Ia	Model Ib	Model IIa	Model IIb	Model IIIa	Model IIIb
Investment–cash flow sensitivity of subsidised firms						
In the short-term for small subsidised firms	−0.7085 (0.440)	−0.7523 (0.434)*	−1.3282 (0.444)***	−1.3544 (0.437)***	−1.361 (0.428)***	−1.3806 (0.424)***
In the short-term for large subsidised firms	0.0732 (0.154)	0.0500 (0.148)	−0.0168 (0.100)	−0.0070 (0.098)	−0.0052 (0.117)	0.0070 (0.117)
In the long-term for small subsidised firms					−0.0543 (0.113)	−0.0439 (0.107)
In the long-term for large subsidised firms					0.0957 (0.172)	0.0998 (0.194)

Note: standard errors in parentheses; degrees of freedom in square brackets. ***, ** and * indicate, respectively, significance levels of <1%, <5% and <10%. All estimates include year dummies (coefficients are omitted from the table). Estimates are derived from the two-step system GMM with finite sample correction (Windmeijer, 2005). AR(1) and AR(2) are tests of the null hypothesis of, respectively, no first- and second-order serial correlation. The Hansen-J is a test of the validity of the overidentifying restrictions based on the efficient two-step GMM estimator. $I_{i,t}$ is firm i 's increase in book value of tangible and intangible assets net of depreciation between periods $t-1$ and t . $K_{i,t-1}$ is the beginning-of-period- t book value of tangible and intangible assets, and $k_{i,t}$ its logarithm. $CF_{i,t}$ is firm i 's cash flows after taxes and before dividends in period t . $y_{i,t}$ is the logarithm of firm i 's sales during period t . $PUB_{i,t}$ is a time-varying dummy variable equal to 1 if firm i received a public subsidy in year t . $PUB_{pers_{i,t}}$ equals 1 from the year after receipt of the public subsidy up to the end of the observation period. The dependent variable is the ratio between period t investments in tangible and intangible assets and the book value of total assets at the beginning of period t . $I_{i,t}/K_{i,t-1}$, $\Delta y_{i,t}$, $CF_{i,t}/K_{i,t-1}$, $(k_{i,t}-y_{i,t})$, $PUB_{FIN_{i,t}}$, $PUB_{FIN_{pers_{i,t}}}$ and size variables are treated as endogenous. Instruments start from $t-2$ and are limited to $t-3$. Additional exogenous instruments are the availability of public finance in the geographical area and in the industry in which the firm operates (PUB_{Area_i} , PUB_{Sector_i} in Models a) and the estimated likelihood of firm i obtaining public subsidies in year t (in Models b). Small and large firms are, respectively, below and above sample median for total assets. All ratios are winsorized with a 2% cut-off for each tail.

Table 6
Investment–cash flow sensitivity and firm size.

	Model 0	Model A	Model B	Model C	Model D	Model E
$I_{i,t-1}/K_{i,t-2}$	−0.0688 (0.040)*	−0.1000 (0.035)***			−0.0950 (0.034)***	−0.0666 (0.035)*
$I_{i,t-1}/K_{i,t-2} \times LARGE_{i,t}$			−0.1069 (0.063)*	−0.1193 (0.071)*		
$I_{i,t-1}/K_{i,t-2} \times SMALL_{i,t}$			−0.0888 (0.044)**	−0.0820 (0.055)		
$\Delta y_{i,t}$	0.4397 (0.241)*	0.6667 (0.196)***	0.6279 (0.203)***		0.5076 (0.17)***	0.6172 (0.195)***
$\Delta y_{i,t} \times LARGE_{i,t}$				0.7943 (0.351)**		
$\Delta y_{i,t} \times SMALL_{i,t}$				0.5337 (0.255)**		
$\Delta y_{i,t-1}$	0.4573 (0.1390)***	0.572 ***	0.5411 (0.148)***		0.5620 (0.139)***	0.4123 (0.130)***
$\Delta y_{i,t-1} \times LARGE_{i,t}$				0.5717 (0.313)*		
$\Delta y_{i,t-1} \times SMALL_{i,t}$				0.5073 (0.246)**		
$(k_{i,t-2} - y_{i,t-2})$	−0.1579 (0.093)*	−0.2548 (0.087)***			−0.2315 (0.081)***	−0.1679 (0.089)*
$(k_{i,t-2} - y_{i,t-2}) \times LARGE_{i,t}$			−0.3231 (0.138)**	−0.3408 (0.132)***		
$(k_{i,t-2} - y_{i,t-2}) \times SMALL_{i,t}$			−0.2032 (0.106)*	−0.1812 (0.140)		
$CF_{i,t}/K_{i,t-1}$	0.2437 (0.077)***					0.8524 (0.228)***
$CF_{i,t}/K_{i,t-1} \times LARGE_{i,t}$		0.0588 (0.097)	0.0492 (0.095)	0.0301 (0.110)		
$CF_{i,t}/K_{i,t-1} \times SMALL_{i,t}$		0.3928 (0.108)***	0.3996 (0.104)***	0.4048 (0.119)***		
$CF_{i,t}/K_{i,t-1} \times SMALL25_{i,t}$					0.4051 (0.146)***	
$CF_{i,t}/K_{i,t-1} \times MEDIUM-SMALL_{i,t}$					0.2925 (0.150)*	
$CF_{i,t}/K_{i,t-1} \times MEDIUM-LARGE_{i,t}$					0.0673 (0.146)	
$CF_{i,t}/K_{i,t-1} \times LARGE75_{i,t}$					0.0960 (0.097)	
$CF_{i,t}/K_{i,t-1} \times size_{i,t}$						−0.0853 (0.033)***
$SMALL_{i,t}$		−0.1560 (0.170)	0.0897 (0.397)	0.1852 (0.422)		
$SMALL25_{i,t}$					0.1010 (0.262)	
$MEDIUM-SMALL_{i,t}$					0.0486 (0.266)	
$MEDIUM-LARGE_{i,t}$					0.2215 (0.191)	
Constant	0.0493 (0.207)	−0.0402 (0.234)	−0.1676 (0.317)	−0.2143 (0.300)	−0.1113 (0.214)	0.0428 (0.242)
No. of observations	1841	1841	1841	1841	1841	1841
Hansen-J (statistic)	150.134	169.74	166.76	166.16	218.87	174.24
Hansen-J (degrees of freedom)	[130]	[161]	[159]	[157]	[224]	[160]
Hansen-J (p-value)	0.1090	0.3031	0.3208	0.2929	0.5842	0.2088
AR(1)	−5.5796***	−5.7141***	−5.6274***	−5.586***	−5.6069***	−5.4596***
AR(2)	0.3717	0.273	0.4126	0.3192	0.2997	0.1139

Note: standard errors in parentheses; degrees of freedom in square brackets. ***, ** and * indicate, respectively, significance levels of <1%, <5% and <10%. All estimates include year dummies (coefficients are omitted from the table). Estimates are derived from two-step system GMM with finite sample correction (Windmeijer, 2005). AR(1) and AR(2) are tests of the null hypothesis of, respectively, no first- and second-order serial correlation. The Hansen-J is a test of the validity of the overidentifying restrictions based on the efficient two-step GMM estimator. $I_{i,t}$ is firm i 's increase in book value of tangible and intangible assets net of depreciation between periods $t-1$ and t . $K_{i,t-1}$ is the beginning-of-period- t book value of tangible and intangible assets, and $k_{i,t}$ its logarithm. $CF_{i,t}$ is firm i 's cash flows after taxes and before dividends in period t . $y_{i,t}$ is the logarithm of firm i 's sales during period t . The dependent variable is the ratio between period t investments in tangible and intangible assets and the book value of total assets at the beginning of period t . $I_{i,t}/K_{i,t-1}$, $\Delta y_{i,t}$, $CF_{i,t}/K_{i,t-1}$, $(k_{i,t} - y_{i,t})$ and size variables are treated as endogenous. Instruments start from $t-2$ and are limited to $t-3$. All ratios are winsorised with a 2% cut-off for each tail.

Table 7

Panel A. short-term and persistent effects of public subsidies on the investment rate and investment–cash flow sensitivity of sample firms that did not receive external finance by individual investors at foundation.

	Model F	Model G
$I_{i,t-1}/K_{i,t-2}$	−0.0932 (0.050)*	−0.0917 (0.053)*
$\Delta y_{i,t}$	0.5512 (0.247)**	0.4047 (0.241)*
$\Delta y_{i,t-1}$	0.6447 (0.145)***	0.5898 (0.15)***
$(k_{i,t-2}-y_{i,t-2})$	−0.2913 (0.092)***	−0.2795 (0.093)***
$CF_{i,t}/K_{i,t-1} \times LARGE_{i,t}$	0.0284 (0.087)	−0.0551 (0.095)
$CF_{i,t}/K_{i,t-1} \times SMALL_{i,t}$	0.3526 (0.107)***	0.4163 (0.117)***
$SMALL_{i,t}$	0.0654 (0.185)	0.0517 (0.283)
$PUB_{i,t-1} \times SMALL_{i,t}$	1.1063 (0.442)**	1.5193 (0.453)***
$PUB_{i,t-1} \times LARGE_{i,t}$	−0.1276 (0.173)	−0.2446 (0.253)
$PUB.pers_{i,t-1} \times SMALL_{i,t}$		0.3205 (0.346)
$PUB.pers_{i,t-1} \times LARGE_{i,t}$		0.3034 (0.283)
$PUB_{i,t-1} \times CF_{i,t}/K_{i,t-1} \times SMALL_{i,t}$	−1.2089 (0.393)***	−2.0597 (0.375)***
$PUB_{i,t-1} \times CF_{i,t}/K_{i,t-1} \times LARGE_{i,t}$	0.0231 (0.135)	−0.0125 (0.124)
$PUB.pers_{i,t-1} \times CF_{i,t}/K_{i,t-1} \times SMALL_{i,t}$		−0.4688 (0.155)***
$PUB.pers_{i,t-1} \times CF_{i,t}/K_{i,t-1} \times LARGE_{i,t}$		−0.0988 (0.156)
Constant	0.5927 (1.617)	−0.1399 (0.250)
No. of observations	1736	1597
Hansen-J (statistic)	171.71	156.62
Hansen-J (degrees of freedom)	184	170
Hansen-J (p-value)	0.7326	0.7610
AR(1)	−5.1341***	−4.9172***
AR(2)	−0.0538	−0.1301

Panel B. test results on the short-term and persistent effects of public subsidies on the investment–cash flow sensitivity of sample firms that did not receive external finance by individual investors at foundation.

	Model F	Model G
<i>Investment–cash flow sensitivity of subsidised firms</i>		
<i>In the short-term for small subsidised firms</i>	−0.8563 (0.381)**	−1.6435 (0.359)***
<i>In the short-term for large subsidised firms</i>	0.0515 (0.133)	0.0426 (0.096)
<i>In the long-term for small subsidised firms</i>		−0.0525 (0.100)
<i>In the long-term for large subsidised firms</i>		−0.0436 (0.143)

Note: standard errors in parentheses; degrees of freedom in square brackets. ***, ** and * indicate, respectively, significance levels of <1%, <5% and <10%. All estimates include year dummies (coefficients are omitted from the table). Estimates are derived from two-step system GMM with finite sample correction (Windmeijer, 2005). AR(1) and AR(2) are tests of the null hypothesis of, respectively, no first- and second-order serial correlation. The Hansen-J is a test of the validity of the overidentifying restrictions based on the efficient two-step GMM estimator. $I_{i,t}$ is firm i 's increase in book value of tangible and intangible assets net of depreciation between periods $t-1$ and t . $K_{i,t-1}$ is the beginning-of-period- t book value of tangible and intangible assets, and $k_{i,t}$ its logarithm. $CF_{i,t}$ is firm i 's cash flows after taxes and before dividends in period t . $y_{i,t}$ is the logarithm of firm i 's sales during period t . $PUB_{i,t}$ is a time-varying dummy variable equal to 1 if firm i received a public subsidy in year t . $PUB.pers_{i,t}$ equals 1 from the year after receipt of the public subsidy up to the end of the observation period. The dependent variable is the ratio between period t investments in tangible and intangible assets and the book value of total assets at the beginning of period t . $I_{i,t}/K_{i,t-1}$, $\Delta y_{i,t}$, $CF_{i,t}/K_{i,t-1}$, $(k_{i,t}-y_{i,t})$, $PUB.FIN_{i,t}$, $PUB.FIN.pers_{i,t}$, and size variables are treated as endogenous. Instruments start from $t-2$ and are limited to $t-3$. As additional exogenous instrument, we include the estimated likelihood of firm i obtaining public subsidies in year t . Small and large firms are, respectively, below and above sample median for total assets. All ratios are winsorised with a 2% cut-off for each tail.

likelihood of exit of sample firms seem not to be correlated with a firms' investment rate.

It is important to emphasise that the ECM results are correctly specified in all models. Indeed, coefficients γ_4 and δ_4 (in Eqs. (2) and (3), respectively), which represent the error-correction term (i.e., the capital–output ratio), are both negative and significant. This is consistent with the “error correcting” behaviour: A capital stock above its desired level is associated with lower future investments. Moreover, the speed of adjustment is similar to the one estimated by previous similar studies (see e.g. Bond et al., 2003; Guariglia, 2008). Regarding sales growth terms (γ_2 , γ_3 and δ_2 , δ_3 in Eqs. (2) and (3), respectively), they are, as required, both positive and statistically significant.

Let us consider the results of Eq. (2). Results of the estimates of both Model I and Model II suggest that large NTBFs are not financially constrained, as the coefficient of $CF_{i,t}/K_{i,t-1} \times LARGE_{i,t}$, though positive, is not significant. On the contrary, coefficients capturing the investment–cash flow sensitivity of small NTBFs are positive and significant (at 1%). This result is in line with the argument that small NTBFs are financially constrained.

Let us now turn attention to the effect of public subsidies. When small NTBFs receive public subsidies, they are able to remove the financial constraints that would otherwise inhibit investments. Accordingly, their investment rate increases and investments are no longer positively related to internal cash flows. In fact, in

Models I and II, the coefficient of $PUB_{i,t-1} \times SMALL_{i,t}$ (i.e., γ_8) is positive, significant at conventional confidence levels and of large economic magnitude. The coefficient of the cash flow variable becomes negative (i.e., $\gamma_6 + \gamma_{10} < 0$) and significant at conventional confidence levels (except in Model Ia), as documented by the value of the test reported in the Panel B of Table 5. We interpret the negative coefficient of cash flow in small subsidised NTBFs as indicating that receipt of public subsidies indeed removes the financial constraints of these firms. Before receiving the subsidy, small NTBFs, since they are financially constrained, invest only if internal capital is available. Indeed, when internal financial resources are limited, they are obliged to postpone their investments as they cannot easily have access to external capital. With all else equal, the smaller the cash flow, the greater the amount of the investments they are forced to postpone. Once these firms receive public subsidies, they are able to finance the investments that were previously postponed. Hence, the negative relation between cash flow and investments. Conversely, the effect of public subsidies on large NTBFs is definitely less important. Indeed, receipt of public subsidies does not significantly affect the investment rate: the coefficient of $PUB_{i,t-1} \times LARGE_{i,t}$ is not significant. Moreover, the investment–cash flow sensitivity of subsidised large NTBFs is again not significant, as indicated by the test reported in the Panel B of Table 5 (i.e., the null hypothesis $\gamma_7 + \gamma_{11} = 0$ is not rejected). Finally it is interesting to observe that, according to the results

Table 8
Panel A. alternative specifications for the persistent effect of public subsidies on the investment rate and investment–cash flow sensitivity of sample firms.

	Model IV	Model V
$I_{i,t-1}/K_{i,t-2}$	−0.0625 (0.036)*	−0.0586 (0.038)
$\Delta y_{i,t}$	0.3684 (0.219)*	0.4713 (0.226)**
$\Delta y_{i,t-1}$	0.5042 (0.119)***	0.4844 (0.129)***
$(k_{i,t-2} - y_{i,t-2})$	−0.1868 (0.071)***	−0.2178 (0.085)**
$CF_{i,t}/K_{i,t-1} \times SMALL_{i,t}$	0.3138 (0.111)***	0.4241 (0.103)***
$CF_{i,t}/K_{i,t-1} \times LARGE_{i,t}$	0.1564 (0.106)	0.0914 (0.105)
$SMALL_{i,t}$	0.0645 (0.190)	−0.0177 (0.204)
$PUB_{i,t-1} \times SMALL_{i,t}$	1.4587 (0.469)***	0.9619 (0.478)**
$PUB_{i,t-1} \times LARGE_{i,t}$	−0.1825 (0.151)	−0.1821 (0.174)
$PUB_{i,t-2} \times SMALL_{i,t}$	−0.1829 (0.324)	
$PUB_{i,t-2} \times LARGE_{i,t}$	0.1233 (0.193)	
$PUB_step_{i,t-1} \times SMALL_{i,t}$		0.2211 (0.409)
$PUB_step_{i,t-1} \times LARGE_{i,t}$		0.1348 (0.203)
$PUB_{i,t-1} \times CF_{i,t}/K_{i,t-1} \times SMALL_{i,t}$	−1.6991 (0.438)***	−0.7755 (0.423)*
$PUB_{i,t-1} \times CF_{i,t}/K_{i,t-1} \times LARGE_{i,t}$	−0.1437 (0.178)	−0.0032 (0.192)
$PUB_{i,t-2} \times CF_{i,t}/K_{i,t-1} \times SMALL_{i,t}$	−0.0457 (0.241)	
$PUB_{i,t-2} \times CF_{i,t}/K_{i,t-1} \times LARGE_{i,t}$	−0.1612 (0.226)	
$PUB_step_{i,t-1} \times CF_{i,t}/K_{i,t-1} \times SMALL_{i,t}$		−0.3562 (0.214)
$PUB_step_{i,t-1} \times CF_{i,t}/K_{i,t-1} \times LARGE_{i,t}$		−0.0036 (0.205)
Constant	0.0005 (0.177)	−0.0247 (0.262)
No. of observations	2186	2329
Hansen-J (statistic)	173.60	168.35
Hansen-J (degrees of freedom)	[173]	[182]
Hansen-J (p-value)	0.4728	0.7578
AR(1)	−6.1444***	−6.4350***
AR(2)	0.5149	0.5292

Panel B. test results on the short-term and persistent effects of public subsidies on the investment–cash flow sensitivity of sample firms in alternative specifications.

	Model IV	Model V
<i>Investment–cash flow sensitivity of subsidised firms</i>		
<i>In the short-term (1 year) for small firms</i>	−1.3853 (0.431)***	−0.7076 (0.439)
<i>In the short-term (1 year) for large firms</i>	0.0127 (0.132)	0.0845 (0.195)
<i>In the short-term (2 years) for small firms</i>	0.2681 (0.240)	
<i>In the short-term (2 years) for large firms</i>	−0.0048 (0.203)	
<i>In the long-term for small firms</i>		0.0845 (0.195)
<i>In the long-term for large firms</i>		0.0877 (0.203)

Note: standard errors in parentheses; degrees of freedom in square brackets. ***, ** and * indicate, respectively, significance levels of <1%, <5% and <10%. All estimates include year dummies (coefficients are omitted from the table). Estimates are derived from two-step system GMM with finite sample correction (Windmeijer, 2005). AR(1) and AR(2) are tests of the null hypothesis of, respectively, no first- and second-order serial correlation. The Hansen-J is a test of the validity of the overidentifying restrictions based on the efficient two-step GMM estimator. $I_{i,t}$ is firm i 's increase in book value of tangible and intangible assets net of depreciation between periods $t-1$ and t . $K_{i,t-1}$ is the beginning-of-period- t book value of tangible and intangible assets, and $k_{i,t}$ its logarithm. $CF_{i,t}$ is firm i 's cash flows after taxes and before dividends in period t . $y_{i,t}$ is the logarithm of firm i 's sales during period t . $PUB_{i,t}$ is a time-varying dummy variable equal to 1 if firm i received a public subsidy in year t . $PUB_step_{i,t}$ equals 1 from the year in which the firm received the public subsidy up to the end of the observation period. The dependent variable is the ratio between period t investments in tangible and intangible assets and the book value of total assets at the beginning of period t . $I_{i,t}/K_{i,t-1}$, $\Delta y_{i,t}$, $CF_{i,t}/K_{i,t-1}$, $(k_{i,t} - y_{i,t})$, $PUB_{i,t}$, $PUB_step_{i,t}$ and size variables are treated as endogenous. Instruments start from $t-2$ and are limited to $t-3$. As additional exogenous instrument, we include the estimated likelihood of firm i obtaining public subsidies in year t . Small and large firms are, respectively, below and above sample median for total assets. All ratios are winsorised with a 2% cut-off for each tail.

of Model II, the first public subsidy received by small NTBFs has a larger “treatment” effect on both the investment rate and the investment–cash flow sensitivity than the effect estimated in Model I, in which we do not distinguish the first subsidy from the subsequent ones. These findings seem to suggest that the impact of the first public subsidy received by NTBFs is definitely more important than subsequent ones.

Let us now examine whether the effect of public subsidies on the investments of NTBFs is transitory or persistent. For this purpose, we turn attention to the results of the GMM-SYS estimates of Eq. (3) reported in Model III. Again, it is worth pointing out that small NTBFs show positive and significant investment–cash flow sensitivity while large NTBFs do not. Moreover, the estimated one-year ahead effects of public subsidies on the investment rate and the investment–cash flow sensitivity, captured respectively by $\delta_8(\delta_9)$ and $\delta_{10}(\delta_{11})$ for small (large) NTBFs, are remarkably similar to those obtained from the estimates of Eq. (2). We are interested here in assessing whether the effects of public subsidies persist over time. Regarding investment–cash flow sensitivity, the results of the tests reported in the Panel B of Table 5 indicate that for small subsidised NTBFs, the null hypothesis of no persistent positive dependence of investments on cash flow shocks after receipt

of a public subsidy cannot be rejected at conventional confidence levels (the coefficient $\delta_6 + \delta_{12}$ is negative and not significant). Thus, our results suggest that receipt of a public subsidy leads to a permanent relaxation of the financial constraints that small NTBFs have in absence of public support.²³ As to the investment–cash flow sensitivity of large NTBFs, receipt of public subsidies again has no effect even in the long run. Finally, the coefficients representing the long-run “treatment” effect of public subsidies on the investment rate (δ_{12} and δ_{13} for small and large NTBFs, respectively) are not significant, indicating that there is no difference in the log-run investment rate between subsidised and non-subsidised NTBFs, independently of NTBFs' size. In other words, the effect of public subsidies on the investment rate of NTBFs is not persistent over time.

²³ The fact that, for small subsidised NTBFs, the coefficient of the cash flow variable in Model III is negative but not significant, starting from the second year after receipt of the subsidy, indicates that the positive shock of the investment rate exhibited by these firms (that because of small cash flows were previously forced to postpone investments) is mainly concentrated in the year that immediately follows the receipt of the subsidy.

5.2. Robustness checks

First of all, we are aware that the threshold size which distinguishes between small and large NTBFs is quite arbitrary. Since in this work we argue that financial constraints depend on size, it is interesting to check whether our threshold effectively distinguishes between financially constrained and non-financially constrained NTBFs. For this purpose, we estimate Eq. (1), aiming to investigate the dependence of investment–cash flow sensitivity on firm size, with different size thresholds. Moreover, we check whether NTBF size affects the investment dynamics not only as regards to the investment rate and investment–cash flow sensitivity, but also by moderating the effect of other variables of the ECM specification. Table 6 reports the estimates of Eq. (1) on the subsample of NTBFs which did not receive any public subsidy. In the first column (Model O), we report the estimates using the ECM specification without interactions with the size variables $SMALL_{i,t}$ and $LARGE_{i,t}$. In the second column, we report the classification we used in this study, as it is described by Eq. (1), based on the median value of total assets (Model A). In the third column (Model B) we test a different specification of Eq. (1), in which we interact the size variables not only with the cash flow term, but also with the lagged investment ratio and the error correction term. In the fourth column (Model C) we add the interactions of the size variables with the current and the lagged sales growth. In both Model B and Model C no significant differences appear in the parameters of the ECM specification between small and large NTBFs, with the exception of the cash flow term. This ensures us in using Model A as the baseline specification of our study. In the fifth column (Model D) we consider a finer classification of NTBF size. Instead of simply distinguishing between small and large firms, here we consider small, medium-small, medium-large and large NTBFs. More specifically, $SMALL25_{i,t}$ equals 1 if the NTBF size is below the 25th percentile of total assets, $MEDIUM-SMALL_{i,t}$ equals 1 if the size is between the 25th and 50th percentile, $MEDIUM-LARGE_{i,t}$ equals 1 if the size is between the 50th and the 75th percentile and $LARGE75_{i,t}$ equals 1 if the size is above the 75th percentile. Results suggest that NTBFs whose size is under the 25th percentile are the most likely to be financially constrained. Medium–small NTBFs presents still a significant and positive investment–cash flow sensitivity. On the contrary, the coefficients of $CF_{i,t}/K_{i,t-1} \times MEDIUM - LARGE_{i,t}$ and $CF_{i,t}/K_{i,t-1} \times LARGE_{i,t}$ are not significant. In addition, in Model E, reported in the last column of Table 6, we consider another specification in which the cash flow rate, $CF_{i,t}/K_{i,t-1}$, is interacted with the logarithm of total assets ($size_{i,t}$). This interaction term turns out to be negative and significant, again indicating that as firm size increases, the dependence of investment decisions on internal cash flows progressively disappears.²⁴

Second, we run additional estimates of Eq. (1) by adding further controls (for the sake of synthesis these results are not reported in the text. They are available from the authors upon request). First, statistics shown in Table 1 indicate that sample firms are somewhat older than the RITA population from which the sample was drawn. We thus control for selection issues that might affect our results by adding NTBF age as an additional control in our multivariate setting. Results are qualitatively similar to those presented in the previous section. The coefficient of age is negative and significant indicating, as expected, that the investment rate decreases with firm age. This effect can be related to both a reduction in investments and an

increase in the total capital as firms become older. Second, some authors include in the ECM specification also a lagged cash-flow term (e.g. Bond et al., 2003). Therefore, we run the specification (1) also including lagged cash flow terms for both small and large NTBFs. The coefficients of these additional terms are not significant. Finally, in order to check whether cash flows may be correlated with investment opportunities, following the procedure described in Bond et al. (2005), we test if current and lagged cash flows are predictor of future sales (used as a proxy for future investment opportunities), using a VAR(2) model. We find that the cash flow terms are not significant. This result provides an additional indication that for the sample of NTBFs analysed in this study, a positive investment–cash flow sensitivity can be considered as a reliable indicator of the presence of financial constraints.

Third, even though we excluded from our analysis NTBFs that received VC, one may wonder whether our results are driven by the fact that we do not control for the provision of external equity capital from individual investors, like business angels. To deal with this issue, we collected data on the presence of external individual investors (i.e., investors with no operating role in firm's management) in the NTBF's equity capital at foundation. Unfortunately, we were unable to collect longitudinal data on the provision of this type of finance to sample firms. We do have data on the presence of external individual investors for 262 firms out of 288. Out of these 262 NTBFs, 67 obtained external finance from individuals at foundation (23% of the sample). Twelve of these firms received public subsidies during their life (16% of subsidised firms). Thus, there seems to be no positive correlation between the presence of this type of investor at foundation and receipt of public subsidies. We then re-run Eq. (2) while considering only those NTBFs that did not receive external finance by individual investors at foundation (i.e., NTBFs that did obtain external finance from individual investors at foundation were eliminated from the sample). Results are reported in the first column of Table 7 (Model F) and confirm the findings illustrated in the previous section. Finally, we re-run Eq. (3) only on the subsample of firms that did not receive external finance by individual investors at foundation. Results, shown in the second column of Table 7 (Model G), again remain unchanged. Hence, we are quite confident that the findings related to the effect of public subsidies on the relaxation of the financial constraints of small NTBFs that were illustrated in the previous section are not driven by external finance provided by individual investors (at foundation).

The last set of robustness check aims to gain further insights into the persistency of the effect of public subsidies. In Table 8 we show two alternative specifications of Eq. (3). In the first one (Model IV reported in the first column of Table 8) we resort to a distributed lags formulation obtained by adding, in Eq. (2), a variable capturing the effect of public subsidies after two years from receipt of the subsidy. We thus include the interactions of $PUB_{i,t-2}$ with both cash flow and size dummy variables. Results (reported in Panel A) are in line with the argument that the increase on the investment rate for small NTBFs generated by public subsidies is not persistent. Indeed, the coefficient of $PUB_{i,t-2} \times SMALL_{i,t}$ is not significant. This implies that small subsidised NTBFs increase their investment rate exclusively in the year following receipt of public subsidies. However, as expected, small subsidised NTBFs are not financially constrained both in the first and second year after receipt of the subsidy, as reported by the tests in Panel B of Table 8. The effect of public subsidies on large NTBFs is again not significant. Finally, in the last column of Table 8 (Model V) we evaluate the persistent effect in Eq. (3) on the whole sample (i.e., without eliminating firms which received more than one subsidy). The inclusion of firms that received more than one subsidy forces us to modify the specification of the model. In fact, in this sample, we need to isolate the persistent effect of public subsidies from the instantaneous effect generated by

²⁴ Finally, we run estimates on Eq. (1) while defining as “small firms” the NTBFs that have total assets lower than the value corresponding to the 40th, 45th, 55th and 60th percentiles. Results are in line with those we obtain when the threshold is the median value of total assets (these results are not reported in this study but are available from the authors upon request).

every subsidy that a serial subsidised NTBF receives during the observation period. To this aim, we replace the variable $PUB_pers_{i,t}$, (that equals 1 one year after receipt of public subsidies onward), with the dummy variable $PUB_step_{i,t}$, that equals 1 from the year in which the NTBF received the first subsidy onward. Thus, in this alternative specification, the coefficient of the variable $PUB_step_{i,t-1} \times SMALL_{i,t}$, represents the average treatment effect of public subsidies on the investment rate of a small NTBF from the first subsidy onward, net of any instantaneous effect generated by public subsidies. The instantaneous effect of public subsidies on the investment rate of small NTBFs, one year after receipt of every subsidy, is given by the sum of the coefficients of the variables $PUB_{i,t-1} \times SMALL_{i,t}$ and $PUB_step_{i,t-1} \times SMALL_{i,t}$. Similarly, we estimate the investment–cash flow sensitivity of a small subsidised NTBF, one year after receipt of the subsidy, by the sum of the coefficients of the variables $CF_{i,t}/K_{i,t-1} \times SMALL_{i,t}$, $PUB_{i,t-1} \times CF_{i,t}/K_{i,t-1} \times SMALL_{i,t}$ and $PUB_step_{i,t-1} \times CF_{i,t}/K_{i,t-1} \times SMALL_{i,t}$. Finally, the average investment–cash flow sensitivity of a small subsidised NTBF from the first subsidy onward, controlling for any instantaneous effect generated by public subsidies is given by the sum of the coefficients of the variables $CF_{i,t}/K_{i,t-1} \times SMALL_{i,t}$ and $PUB_step_{i,t-1} \times CF_{i,t}/K_{i,t-1} \times SMALL_{i,t}$. In Panel B of Table 8 we report the corresponding tests, under the null hypothesis that the investments cash–flow sensitivity of subsidised NTBFs equals zero. Again, results are in line with those reported in Table 5. For small NTBFs, which are financially constrained, receipt of a public subsidy leads to a permanent relaxation of the financial constraints. For large NTBFs, the investment–cash flow sensitivity is never significant, both before and after receipt of every subsidy, and public subsidies do not significantly affect the investment rate. Conversely, the effect of public subsidies on the investment rate of small subsidised NTBFs turns out not to be persistent over time.

6. Conclusions

The aim of this paper was to empirically analyse whether public subsidies help financially constrained NTBFs to relax the financial constraints that bind their investment activity. Moreover, we were interested in assessing whether the effects of public subsidies are transient or persist over time. For this purpose, we considered a unique hand-collected longitudinal dataset that includes 288 Italian privately held non-VC backed NTBFs observed from 1994 to 2008. Out of these firms, 75 obtained one or more public subsidies. The longitudinal dimension of the dataset and the availability of a rich set of variables allowed us to estimate an ECM specification using GMM-SYS estimation techniques with an enriched set of external instruments, so as to better take into account the endogenous nature of public subsidies.

Our results can be synthesised as follows. First, our estimates indicate that small NTBFs indeed are financially constrained. In fact, these firms exhibit a positive and significant investment–cash flow sensitivity. Conversely, large NTBFs seem not to be financially constrained. These findings are in the spirit of several previous studies that claimed that size matters in explaining financial constraints (Hao and Jaffe, 1993; Himmelberg and Petersen, 1994; Carpenter and Petersen, 2002b; Guariglia, 2008).

Second, we show that, for small NTBFs, receipt of public subsidies results in an increase, both statistically significant and of large economic magnitude, of the investment rate and a reduction of the investment–cash flow sensitivity in the immediately following year. In the absence of subsidies, small NTBFs are financially constrained and they have to postpone some investments because of lack of finance. Once these firms receive public subsidies, they are able to finance the investment projects which were previously

postponed. This explains the negative relationship between cash flow and investments in the year that immediately follows the one in which public subsidies are obtained by small NTBFs. Conversely, for large NTBFs, that are not financially constrained, the treatment effects of public subsidies on their investment rates and investment–cash flow sensitivity are negligible.

Third, we analyse the dynamics of firms' investments after receipt of a public subsidy. This is the main element of novelty of our study. For this purpose, we focus attention on NTBFs that, in the observation period, received public subsidies only once. We find that the increased investment rate detected for small NTBFs in the short term does not significantly persist in the long term. However, the sensitivity of investments to cash flow turned out not only to vanish immediately after receipt of the public subsidy, but also to remain negligible in the long term. We interpret this result as suggesting that after receipt of a public subsidy, the financial constraints that bind the investment activity of small NTBFs are permanently removed.

This work complements the findings by Bertoni et al. (2010) on a similar sample of Italian NTBFs regarding the impact of VC on NTBFs' investment–cash flow sensitivity. Bertoni and colleagues find that the investment activity of these firms reacts to internal cash flow shocks, but this sensitivity vanishes once firms obtain VC from independent investors (but not from corporate VC investors). Our analysis goes a step beyond Bertoni et al.'s (2010) study. First, the diffusion of VC is limited in Italy and also in most other countries except the US and Israel. Therefore, it is interesting to analyse the effect of public subsidies on NTBFs' investment dynamics, since they represent an important source of external finance for NTBFs in most countries. Second, we find that only small NTBFs are financially constrained and that public subsidies may play a role similar to that of VC in fostering the investment activity of these firms. Finally, and more interestingly, we add to the previous evidence by performing an analysis on the dynamics of firms' investments and we find that the financial constraints of small NTBFs are *persistently* removed after receipt of public subsidies.

This work suffers from some limitations, which, however, offer interesting directions for future research. First, our sample is composed of Italian NTBFs: One may wonder whether the results we obtained can be extended to other countries. In this perspective, the creation of a cross-country dataset, similar to the one used in this work, would be a fundamental step forward in providing a micro-econometric assessment of the effects of public policy measures in support of NTBFs. Second, we focus attention on subsidies provided by the Italian national government. Other forms of public support were not considered in the present work. For example, local and supranational (e.g., the EC) public institutions are increasingly important sources of public support to NTBFs. Moreover, other indirect forms of public support, such as public VC programs, can play an important role in sustaining the investments of NTBFs. Whether the results presented here depend on the type of public support is an interesting research issue. Third, in the same vein, while we excluded from the analysis firms that obtained VC, we did not have longitudinal data on the receipt by sample firms of external equity capital from individual investors. The checks we did, using information on the provision of this type of finance at firms' foundation, reassure us of the robustness of our findings relating to the effect of public subsidies on NTBFs' investment dynamics. Nevertheless, if longitudinal data were available, one would be able to examine in greater detail the interactions and potential complementarities between these two modes of finance. Finally, because of data limitations, we were not able to control for the amount of public subsidies received by sample NTBFs nor to discriminate between selective and automatic schemes. The availability of these data could allow us to distinguish between two different means through which

public subsidies can effectively and *persistently* alleviate the negative effects of the capital market imperfections faced by small NTBFs. On the one hand, the quality “certification” effect of public subsidies is confined to selective schemes administered by reputable governmental bodies and does not depend on the financial amount of the subsidy. On the other hand, public subsidies, independently of their nature (i.e., either selective or automatic), may allow beneficiary firms to increase the amount of tangible assets; in turn, these assets can be pledged as collateral to raise additional capital. In this latter case the amount of the subsidy plays a crucial role.

In spite of these limitations, our work originally contributes to the debate on innovation policy in support of NTBFs. The European 2020 agenda (SEC, 2010) has identified in the access to finance one of the most important bottlenecks for the development of these firms. Our results confirm this view and indicate to policy makers that public subsidies can help *small* NTBFs in *persistently* removing the financial constraints that bind their investment activity.

Appendix A.

A.1. The RITA directory

In this paper we use a sample drawn from the 2004 release of the RITA (Research on Entrepreneurship in Advanced Technologies) directory. In principle, one would like to draw a representative sample from the population of Italian NTBFs that are potential candidates for public finance. Unfortunately, this is not possible for several reasons. First, in this domain, representativeness is a slippery notion because NTBFs may be defined in different ways (e.g., Gimeno et al., 1997). Second, national official statistics do not provide a reliable description of the population of Italian NTBFs. On the one hand, in Italy most individuals who are defined as self-employed by official statistics (i.e. “independent employees”) actually are salaried workers with atypical employment contracts. Unfortunately, on the basis of official data such individuals cannot be distinguished from owner-managers of a new firm. As a consequence, the official number of NTBFs is enormously inflated, especially in sectors like software, where atypical employment contracts are very popular. Moreover, official data do not distinguish firms that were established by one or more entrepreneurs (i.e. independent owner-managed firms) from firms that were created as subsidiaries of other firms. This again inflates the number of NTBFs. Lastly, there are no official statistics about M&As: Therefore one cannot distinguish firms that were acquired by another firm and lost independence while keeping their legal status, from independent NTBFs.

In absence of reliable official statistics, the RITA directory developed at Politecnico di Milano, presently is the most complete source of information on Italian NTBFs. The directory was created in 2000 and it was updated in 2002 and 2004. For its construction several sources were used. These included: (i) the lists of the firms that are members of the national entrepreneurial associations of the focal industries; (ii) the lists of the members of the regional sections of the Italian entrepreneurial association (Confindustria); (iii) the lists of the members of the local Chambers of Commerce; (iv) the lists of companies that participated in the most important industry trades and expositions; and (v) the lists of companies that purchased advertising services in popular off-line (e.g. Kompass) and on-line (e.g. Infoimprese.it) directories. Moreover, the RITA directory includes: (vi) the population of young firms that were granted by the Italian communication authority (AGCOM) a license to provide telecommunication services (including Internet access services), (vii) the population of NTBFs that were incubated in a science park or a business innovation center (BIC) affiliated with the

respective national associations, and viii) the population of NTBFs that obtained equity financing from VC investors that adhere to the Italian financial investor association (AIFI), and (ix) the population of VC-backed NTBFs that were include in VentureXpert. Lastly, information provided by the national financial press, specialised magazines, and other sectorial studies was also used in the compilation of the directory. Altogether, the 2004 release of the RITA directory comprises 1974 firms that complied with the criteria relating to industry of operations, age and independence mentioned in Section 3.1. For each firm, the name of a contact person (i.e. one of the owner-managers) is also provided. While the RITA directory obviously is not exhaustive of the population of Italian NTBFs, it provides the most extensive and accurate available coverage of this population.

In the first semester of 2004, a questionnaire was sent to the contact person of the RITA directory firms either by fax or by mail. The first section of the questionnaire poses detailed questions relating to the human capital characteristics of firm’s founders. The second section comprises further questions concerning the characteristics of the firms including access to external equity financing, the identity of external investors, receipt of public subsidies, and the evolution over time of firm’s employees. Answers to the questionnaire were checked for internal coherence by educated personnel and were compared with information obtained from public sources (i.e., firm’s website and annual reports). In several cases, phone or face-to-face follow-up interviews were made with firm’s owner-managers. This final step was crucial in order to obtain missing data and ensure that data were reliable. In addition, financial and economic data including the evolution over time of firm’s sales from 1994 onwards, and data on patent activity during firm’s entire life were obtained from public sources (i.e., the AIDA and CERVED databases and the databases of patent offices, respectively).

A.2. Pseudo first-stage regressions

The orthogonality conditions requested in the GMM-SYS estimator determine that lagged levels are used as instruments for difference equations and that lagged differences are used as instruments for level equations. The validity of these instruments has been verified by means of the Hansen-J test. However for these instruments to be good we have to verify that they are correlated with the endogenous variables. In order to check such correlation, we run the following pseudo-first-stage regressions:

$$\begin{aligned} \text{Difference : } \Delta \text{endogenous}_{i,t} &= \sum_{\tau=0}^{t-2} \alpha_{\tau} \text{endogenous}_{i,\tau-2} + \beta \Delta(\text{age})_{i,t} \\ &\quad + \gamma \Delta(\text{PUB.FIN.sec tor})_{i,t} \\ &\quad + \eta \Delta(\text{PUB.FIN.area})_{i,t} + \Delta \omega_{i,t} \\ \text{Levels : } \text{endogenous}_{i,t} &= \sum_{\tau=0}^{t-2} \alpha_{\tau} \Delta(\text{endogenous}_{i,\tau-2}) \\ &\quad + \beta \text{age}_{i,t} + \gamma \text{PUB.FIN.sec tor}_{i,t} \\ &\quad + \eta \text{PUB.FIN.area}_{i,t} + \eta_{i,t} \end{aligned}$$

where *endogeneous* are all the covariates included in the ECM equation, the public subsidies variables and their interaction terms with cash-flows. We then perform a Wald test on the null hypothesis that all the coefficients in difference and all coefficients in levels are jointly zero.

Lagged instruments in first differences are strongly correlated with the endogenous variables, whereas oppositely, lagged instruments in levels are poorly correlated with the endogenous variable

Table A.3.1
Probit estimates on the probability to obtain public subsidies.

	Public financing
$Size_{i,t}$	0.2074 (0.065)***
$Age_{i,t}$	-0.1741 (0.143)
BIC_i	-0.2486 (0.309)
$Eco-education_i$	0.1086 (0.118)
$Tech-education_i$	0.0658 (0.037)*
$Tech-experience_i$	0.0066 (0.017)
$Comm-experience_i$	-0.0850 (0.041)**
$Manager_i$	-0.2366 (0.191)
$Founders_i$	-0.0190 (0.051)
ASU_i	0.1684 (0.258)
PUB_Area_i	0.6436 (0.170)***
PUB_Sector_i	0.6273 (0.390)*
Constant	-5.1079 (0.795)***
Time dummies	Yes
No. of observations	2443
Wald χ^2 test	58.82(26)***

Table A.3.2
Variables description.

Variable	Description
$Size_{i,t}$	Total assets of firm i at time t (log)
$Age_{i,t}$	Age of firm i at time t (log)
BIC_i	One for NTBFs located in a technology incubator when founded
$Eco-education_i$	Average number of years of economic and/or managerial university level education of founders
$Tech-education_i$	Average number of years of scientific and/or technical university level education of founders
$Tech-experience_i$	Average number of years of work experience in the same sector that founders gained before NTBF's founding in technical fields
$Comm-experience_i$	Average number of years of work experience that founders gained before NTBF's founding in commercial fields
$Manager_i$	One for NTBFs with one or more founders with a prior management position
$Founders_i$	Number of founders
ASU_i	One for NTBFs created by one or more individuals with experience in academic research
PUB_Area_i	Share of RITA NTBFs that obtained public funds out of the total number of RITA NTBFs that are located in the same geographical area as firm i
PUB_Sector_i	Share of RITA NTBFs that obtained public funds out of the total number of RITA NTBFs that operate in the same industry as firm i

in difference, pointing to the strength other than the validity of the additional instruments used in the GMM-SYS estimates.²⁵

A.3. Probit estimates on the probability to obtain public subsidies

Table A.3.1 reports the results of a probit model on the probability that the NTBF obtains a public subsidy. The dependent variable is $PUB_{i,t}$. Regressors include firm-specific characteristics (i.e., firm's size and age, as well as a dummy variable indicating firms that were located in a technology incubator when founded); founder-specific characteristics capturing human capital (i.e., years of university education in management and economics and in technical and scientific fields, years of technical and commercial work experience, management experience, and a dummy indicating firms created by one or more individuals with experience in academic research); the size of the founding team; and the instruments previously

mentioned ($PUB_FIN_Area_i$ and $PUB_FIN_Sector_i$). Detail on the independent variables are provided in Table A.3.2.

Estimates shown in Table A.3.1 suggest that the higher is the size of the firm, the higher is the probability to receive public subsidies. Moreover, human capital influences the ability of a firm to receive public financing: In particular, the technical education and commercial work experience of founders seem to have a significantly (positive and negative, respectively) effect on the probability to be selected for the subsidy. Finally, geographic- and industry-specific factors are likely to play a significant role in explaining the receipt of public subsidies by Italian NTBFs.

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²⁵ Results of pseudo-first stage regressions can be shown upon request from the authors.

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