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The participation of new technology-based firms in EU funded R&D partnerships: The role of venture capital

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Abstract

This paper investigates the participation of new technology-based firms (NTBFs) in EU-funded R&D partnerships. We examine whether venture capital (VC)-backed firms are more likely to enter these partnerships than their non VC-backed peers and the role of the ownership and governance of the VC investor. We also explore whether VC backing makes NTBFs more prone to act as project coordinator. The empirical analysis takes advantage of a new longitudinal dataset on European NTBFs, the VICO dataset. We examine a sample composed of 8,346 NTBFs from seven European countries observed between 1995 and 2008, out of which 758 are VC-backed. 643 of these firms participated in one or more EU funded R&D partnerships; in 161 out of 1,398 partnerships the NTBF was the project coordinator. The econometric analysis shows that VC backing has a strong positive impact on project participation. The magnitude of this impact considerably differs depending on the type of investor, with bank and government VC exhibiting the strongest positive effects. Conditional on participation, VC backing does not positively influence the likelihood of the focal NTBF acting as the project coordinator, with the exception of bank VC.

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1. Introduction

R&D partnerships, defined as "innovation-based relationships that involve, at least partially, a significant effort in research and development (R&D)" (Hagedoorn et al. 2000), are commonly used by firms to explore new technologies. Therefore, several studies have focused attention on firm-specific and environment-specific factors that drive the formation of these partnerships (e.g. Kleinknecht and Reijnen, 1992; Sakakibara, 2002; Hernan et al., 2003; Marin and Siotis, 2008; Barajas and Huergo 2010).

Collaborative R&D projects funded by the European Union (EU) under the Framework Programmes (FPs) and other supporting schemes are a prominent example of this type of partnership. Indeed, the European Union research and innovation policy has been increasingly relying on these collaborative projects to foster knowledge exchange, sharing and re-combination between academic and industrial partners located in different EU countries and to overcome in this way its innovation gap compared to key competitors, Japan and the US in particular (Commission's mid-term review of the Lisbon Process, 2005). The fact that a considerable portion of the costs of these projects are reimbursed to participants constitutes an important peculiarity of this type of R&D partnership.

R&D partnerships are especially important for young high-tech entrepreneurial ventures (new technology-based firms, NTBFs). These firms typically possess distinctive technological competencies relating to a new product, process or service idea, that need to be used in conjunction with complementary specialized assets and capabilities, of technical and commercial nature, in order to generate economic returns. Building these complementary assets and capabilities internally require financial and managerial resources which generally NTBFs do not possess. R&D partnerships are a (potentially) effective alternative (Teece, 1986; Gans and Stern, 2002). Moreover, NTBFs are often financially constrained (Hall, 2002; Denis, 2004). Hence, the fact that EU funded R&D partnerships are subsidized makes them even more appealing to this type of firms.

However, NTBFs also encounter serious obstacles in forming these partnerships. These difficulties are clearly documented by the fact that small and medium enterprises, of which NTBFs are a sub-category, accounted for an amount of about 3 Billion Euros corresponding to only 16.3% of the FP 7 budget (EC, DG Research & Innovation, 2012). Indeed, ensuring an active involvement of NTBFs in EU funded R&D partnerships has been repeatedly declared as a top-priority by the European Commission (Small Business Act for Europe, European Commission, 2008). Therefore, the analysis of factors that favor or hinder the participation of NTBFs in these partnerships is an interesting, though under-researched issue, with self evident policy implications.

Previous studies on NTBFs have highlighted that when these firms are backed by *a venture capital (VC) investor* their propensity to form alliances is greater (see e.g. Gans et al., 2002; Hsu, 2006; Colombo et al., 2006; Lindsey, 2008; Olmez et al. 2013). One wonders whether VC backing may have a similarly positive effect on the propensity of NTBFs to participate in EU funded R&D partnerships. On the one hand, VC backing may remove some of the obstacles that make it difficult for NTBFs to find suitable partners. Indeed, receipt of VC sends a quality signal to uninformed third parties (Megginson and Weiss, 1991), thereby alleviating the information asymmetries that otherwise may prevent partnership formation. Moreover, VC investors generally have a wide network of business contacts which portfolio companies can leverage when looking for a partner (Hochberg et al. 2007). VC investors may also "coach" portfolio firms in filling an application. On the other hand, the cash infusion from a VC investor may reduce NTBFs' incentives to look for other sources of finance, thereby negatively affecting participation in EU funded R&D partnerships. In addition, whether VC backing favors or hinders participation in EU funded R&D partnerships may well depend on VC investors' characteristics, notably their *ownership* and *governance*. The entrepreneurial finance literature has acknowledged that the objectives and resources of VC investors differ depending on their ownership and governance (e.g. Dimov and Gedajlovic, 2010. See also Da Rin et al. 2011). However, the association between NTBFs' propensity to participate in EU funded R&D partnerships and the type of VC investors that back them has gone unremarked (with the partial exception of Colombo et al. 2006).

In sum, whether VC backing influences the propensity of NTBFs to participate in EU funded R&D partnerships and whether this effect is moderated by the type of VC investor, still are open issues which wait for more robust evidence. Moreover, to the best of our knowledge, the literature is silent about factors that make it easier for NTBFs to take responsibility for *project coordination*. This is an important issue as acting as project coordinator entails important advantages for NTBFs but also greater management and coordination costs.

The objective of the present paper is to fill the above mentioned gaps in the literature. In particular, we address the following research questions: does VC backing help NTBFs to enter into EU funded R&D partnerships? Conditional on participation in a EU funded R&D partnership, are VC-backed NTBFs more prone to act as project coordinator than their non-VC-backed counterparts? Do the ownership and governance of the VC investor moderate these effects?

For this purpose, we take advantage of a unique large-scale longitudinal dataset on European NTBFs: the VICO dataset. This dataset was created by the FP 7 VICO project, promoted by the European Commission (http://www.vicoproject.org/). It includes data on 8,346 NTBFs located in seven European countries (Belgium, Finland, France, Germany, Italy, Spain, and the United

Kingdom), which were less than 20 years old in 2010, were independent at their founding date (i.e., not controlled by other business organizations), operate in high-tech manufacturing and services industries, and are observed between 1995 and 2008. Out of these firms 758 are VC backed. As is well known, there is a low coverage by commercial databases (e.g., the Thomson One database) of VC investments in Europe, especially those conducted by non-independent VC investors (Ivanov and Xie, 2010: p. 135). The VICO dataset avoids the misreport of VC investment types which plagues the studies based on the above mentioned datasets (for more details, see Cumming et al., 2013). For all NTBFs included in the VICO database, we collected data on their participation in EU funded R&D partnerships from the CORDIS database. 643 of these firms participated in one or more EU funded projects; in 161 out of 1,398 projects the NTBF was the project coordinator.

The results of the econometric analysis show that VC backing has a strong positive impact on the participation of NTBFs in EU funded R&D partnerships. The magnitude of this impact decreases with NTBFs' previous experience of EU partnerships. It also considerably differs depending on the type of investor. Bank VC (BVC) and governmental VC (GVC) have the strongest positive impact, while the impact of corporate VC (CVC) is negligible, with independent VC (IVC) being in an intermediate position. Conditional on participation, VC backing does not positively influence the likelihood of the focal NTBF acting as the project coordinator, with the exception of BVC.

The paper proceeds as follows. In Section 2 we first survey the relevant literature and develop the theoretical hypotheses. Section 3 is devoted to the illustration of the sample. In section 4 we present the results of the econometric estimates. In the concluding section we highlight the contribution of the paper to the R&D partnership and VC literature, discuss limitations, and suggest directions for further research.

2. Literature review and theoretical hypotheses

2.1. Factors influencing the participation of NTBFs in EU funded R&D partnerships

For NTBFs the participation in EU funded R&D partnerships entails benefits, but also considerable costs. On the benefit side, these partnerships provide to NTBFs: i) benefits that are typical of technological alliances, including access to partners' complementary technological competencies and commercial assets, and R&D cost sharing (Teece, 1986; Pisano, 1991; Einsenhardt and Schoonhoven, 1996; Gans and Stern, 2003); ii) financial resources that are otherwise difficult to obtain due to the information asymmetries that make it difficult for these firms to obtain capital from private sources especially in the early period of their life (Hall, 2002; Denis, 2004); and iii) a valuable double 'quality certification effect' towards uninformed external parties that arises from

endorsement by other members of the partnership (Stuart et al. 1999) and the competitive nature of the support obtained from the EU (Lerner, 2002; Colombo et al. 2013). On the cost side, NTBFs participating in EU funded R&D partnerships incur four types of costs: (i) costs for the search and selection of suitable partners; (ii) project application and negotiation costs; (iii) project management and coordination costs, which are especially high if the focal NTBF is responsible for project coordination; and (iv) costs related to the appropriability hazards engendered by the partnership (Alvarez and Barney, 2001; Katila et al., 2008; Diestre and Rajagopalan, 2013).

Several previous studies have examined firm-specific factors that influence the likelihood of formation of R&D partnerships. Among them, prior experience of R&D partnerships has been unanimously recognized as the most influential variable increasing the likelihood of a firm engaging in subsequent R&D partnerships (Sakakibara, 2002; Hernan et al., 2003; Marin and Siotis, 2008). In particular, Barajas and Huergo (2010), while analyzing the submission of proposals for FP grants by Spanish firms, documented that the probability of firms applying for a grant increases with both firm's prior experience in preparing a FP proposal and the submission of a proposal in the previous year, independently of whether the proposal was successful or not. Moreover, conditional on making an application, the probability of being awarded a grant is greater for firms that submitted a proposal in the previous year. There are several arguments possibly explaining these results. First, if application costs are high due to the significant amount of paperwork needed, like in the case of EU funded R&D partnerships, firms that already submitted applications in the past have a clear advantage over inexperienced firms because of learning economies (Hernan et al., 2003; Röller et al., 2007). Second, firms with prior experience of R&D partnerships can leverage their network of previously established relationships to find suitable partners. Accordingly, Sakakibara (2002) showed that past participation matters especially when the firm participated in projects with a large number of participants. This effect is reinforced by the quality certification effect of participation in previous partnerships.

Two additional factors that have attracted scholars' attention are firms' R&D intensity and extent of slack resources. R&D intensity is generally regarded as a proxy of firms' absorptive capacity (Cohen and Levinthal, 1989). A firm with greater absorptive capacity is likely to benefit more from a R&D partnership as it can learn more from its partners. A firm with greater technological resources is also likely to be more attractive for partners, because of its greater R&D capabilities (Ahuya, 2000). In accordance with these arguments, the effect of this variable is generally found to be positive (Sakakibara, 2002; Barajas and Huergo, 2010). As to slack, Barajas and Huergo (2010) found that the liquidity ratio of applicants to EU FP projects is significantly lower than that of non-applicants, suggesting that the willingness to participate in R&D partnership

is higher if a firm is financially constrained, because of the greater importance of sharing R&D costs (see also Hayton et al., 2010) and obtaining EU subsidies.

Lastly, several previous studies examined the effect of firm size. On the one hand, the inducement to get access to partners' resources and capabilities is larger for smaller firms, that have a smaller internal resource base (Ahuja, 2000). On the other side, larger firms may combine their internal resources and capabilities with those of their partners, generating synergistic effects. Moreover, larger firms can spread the fixed application and management costs involved in project participation across a larger volume of sales. Hence they may be more willing to form a R&D partnerships than their smaller counterparts. Empirical evidence of a positive relation between firm size and the establishment of R&D partnerships generally support these latter arguments (Hernan et al., 2003; Marin and Siotis, 2008). An interesting exception is provided by Barajas and Huergo (2010) who found a non-linear U-shaped relationship between firm size and the probability to submit a proposal for a FP project. They detected a positive impact for large firms (i.e. firms with 200 employees or more) and a negative one for small firms. The authors explained this result with the special effort made by Spanish authorities to stimulate the participation of very small firms in FP projects.

As far as we know, no previous empirical study specifically examined factors that stimulate or hinder the participation of NTBFs in EU funded R&D partnerships, with the exception of Colombo et al. (2006).[1] This study considers a sample of Italian NTBFs and finds that the likelihood of participation in EU funded R&D partnerships increases with firm size, in accordance with the great application and management costs of these partnerships. In also increases with firms' past experience of participation in these partnerships, up to a number of partnerships equal to around 8, after which the marginal effect turns negative. Conversely, no relation is found with firms' patent stock. In sum, whether the results obtained while examining samples that are composed mostly of large established firms can be generalized to NTBFs, is questionable. Even more importantly, NTBFs have peculiar characteristics which are likely to influence participation in EU funded R&D partnerships. Among these characteristics, VC backing figures prominently. Indeed, the receipt of VC is a crucial event, that drastically modifies the strategy, resources and capabilities of NTBFs (e. g. Gompers and Lerner, 2001). Therefore, as we will argue in the next section, we expect VC backing to substantially influence the benefits and costs for NTBFs of

[1] Several studies examined the determinants of the alliances of NTBFs (see e.g. Shan, 1990; Shan et al., 1994; Eisenardt and Schoonhoven, 1996. See Okamuro et al., 2011 for a recent analysis of Japanese R&D oriented start-ups). However, due to the specificities of EU funded R&D partnerships, it is questionable whether the results of these studies can be generalized to this type of partnership.

participation in EU funded R&D partnerships. However, whether and how VC backing affects NTBFs' participation in these partnerships still is an open issue.

2.2. The impact of VC backing on NTBFs' participation in EU funded R&D partnerships

The fact that a NTBF is backed by a VC investor lowers the costs that the firm incurs in participating in EU funded R&D partnerships (see Hsu, 2006 for similar arguments relating to the establishment of alliances). First, the costs of the search for suitable partners are clearly lower for VC-backed NTBFs. On the one hand, VC-backed NTBFs can leverage the social capital of their VC investors to get in touch with potential partner firms, with the VC investor acting as an information intermediary. In accordance with this intermediary function, Lindsey (2008) found that the likelihood of alliance formation is greater among firms that share a common VC investor. On the other hand once a candidate partner has been located by a NTBF, it is generally difficult for the candidate partner to gauge the quality of the NTBF because of lack of a reliable track record. Endorsement by a VC investor, especially a prominent one, provides a signal to uninformed third parties of the good quality of the focal NTBF (Megginson and Weiss, 1991). This signal lowers the information asymmetries that otherwise may prevent the formation of the partnership. In line with a signaling argument, Ozmel et al. (2013) showed that affiliation with prominent VC investors has a positive impact on biotech entrepreneurial ventures' formation of future alliances, but this effect diminishes with ventures' prominence in the alliance network.

Second, several studies have argued that in addition to a capital infusion, VC investors provide portfolio firms with value added services in areas where these latter lack relevant expertise (e.g. Gorman and Sahlman, 1989; Sapienza, 1992; Gompers and Lerner, 1999). Typical areas in which valuable support is provided by VC investors include recruiting managers and other skilled personnel, designing portfolio firms' business model, improving financial, accounting, control and incentive systems, and legal matters (Hellmann and Puri, 2002; Kaplan and Strömberg, 2004). Preparing an application for a EU funded partnership and managing participation in the partnership are additional areas where coaching by a VC investor is likely to be extremely valuable to portfolio NTBFs.

Third, a serious obstacle to the participation of NTBFs in EU funded R&D partnerships is the fear of expropriation of their technological knowledge, which quite often is the only resource on which these firms can rely to create a sustainable competitive advantage (Alvarez and Barney, 2001). These appropriability hazards (Oxley, 1997) have been shown to influence the governance of the alliances established by NTBFs (Reuer et al. 2006; Arino et al. 2008; Colombo et al., 2014) and the selection of alliance partners (Diestre and Rajagopalan, 2012). VC investors may reduce the

appropriability hazards inherent in NTBFs' participation in EU funded R&D partnerships through different mechanisms. They can help portfolio firms select appropriate partners thereby avoiding the danger of "swimming with sharks" (Katila et al., 2008). They can also help them both to design better contractual provisions and to effectively monitor partners' behavior. Lastly, cooperation defection is likely to be more costly for partners if a NTBF is VC backed. On the one hand, VC-backed NTBFs possess the financial resources and legal expertise needed to engage in IPR infringement litigations, which are generally too costly for their non VC-backed counterparts. On the other hand, VC backing makes threat of retaliation in case of partners' misbehavior more credible, as this misbehavior can be broadcasted more rapidly and pervasively through the network of business contacts of the VC investor.

The above mentioned arguments would suggest that VC-backed NTBFs are more likely to participate in EU funded R&D partnerships than their non VC-backed counterparts. However, this positive association is not straightforward, as VC backing may also reduce the benefits that NTBFs reap from EU funded R&D partnerships. First of all, the cash infusion obtained from VC investors has been shown to relax the financial constraints which bind NTBFs' activity (Bertoni et al., 2010). Therefore it likely renders the EU subsidies less appealing to these firms. In line with this contention, Wang et al. (2012) showed that the number of alliances entered by VC-backed firms is negatively associated with the amount of VC they received. Second, in spite of the fact that the quality signaling effect engendered by receipt of VC facilitates the search for appropriate partners, it is also likely to reduce the benefits arising from the double quality signaling effect associated with participation in EU funded R&D partnerships. Accordingly, Ozmel et al. (2013) have provided evidence that signals associated with a NTBF's affiliation with VC investors who have prominent positions in syndicate networks and those associated with a NTBF's prominent position in alliance networks offer redundant benefits and substitute for each other in favoring formation of alliances between biotech start-ups and established pharmaceutical companies.

In sum, since opposed forces are likely to be at work, we develop competing hypotheses as to the impact of VC backing on the likelihood of NTBFs participating in EU funded R&D partnerships.[2]

H1a. VC-backed NTBFs are more likely to participate in EU funded R&D partnerships than their non VC-backed counterparts.

[2] Previous studies that have focused attention on the association between VC backing and the formation of alliances have generally found a positive association (see e.g. Gans et al., 2002; Hsu, 2006; Ozmel et al. 2013b). However, whether these results can be generalized to EU funded R&D partnerships again is questionable.

H1b. VC-backed NTBFs are less likely to participate in EU funded R&D partnerships than their non VC-backed counterparts.

We have argued in the previous section that the likelihood of entering a EU funded R&D partnership increases with the number of previous participations in this type of partnership. The number of previous EU funded R&D partnerships is also likely to moderate the effect of VC backing on the likelihood of participation in additional partnerships. First, the learning process associated with the experience of previous participations in these partnerships makes the value added provided by VC investors in preparing applications and managing projects less valuable. Second, in accordance with the evidence provided by Ozmel (2013b) on alliances, the signaling effect of VC backing in reducing information asymmetries about NTBFs' quality is likely to be weaker when firms have a track record of previous participations in EU funded R&D partnerships. Previous participation in EU funded partnerships also provides NTBFs with a valuable network of business contacts. Both these effects lower the cost of finding suitable partners. Hypothesis H2 follows

H2. The effect of VC backing on the likelihood of a NTBF participating in a EU funded R&D partnership is positively moderated by the number of past EU funded R&D partnerships in which the NTBF participated.

The VC literature has highlighted that VC investors are heterogeneous and differ along several dimensions. For the purpose of the present analysis, one of the most important dimensions is the type of *ownership and governance* (Da Rin et al., 2011). In its most familiar form, the independent VC (IVC) investor, a VC firms manages several pools of capital provided by institutional and individual investors. Each pool is organized as a legally separate limited partnership, with a management company serving as a general partner and the investors serving as limited partners (Sahlman, 1990). Non-independent, or captive, VC investors are structured as investment vehicles or business units of a parent company. The parent company may be a non-financial company, in the case of CVC, a bank, in the case of BVC, or a governmental body, in the case of governmental GVC. Regardless of its nature, the parent company of a captive VC provides capital and has substantial influence on the selection and management of investments (Gompers, 2002; Leleux & Surlemont, 2003; Hellmann, Lindsey & Puri, 2008; Dimov & Gedajlovic, 2010; Dushnitsky, 2012).

The ownership and governance of VC investors clearly influence the *strategic objectives* that shape their investment activity (e.g. Dimov and Gedajlovic, 2010. See also Da Rin et al. 2011).

In turn, we claim that depending on the objectives of the VC investor, portfolio NTBFs may be more or less prone to engage in EU funded R&D partnerships.[3]

In comparison with captive investors, for IVC investors financial objectives are clearly more important than strategic objectives. Therefore, one might argue that the objectives of this type of investor are aligned with those of their portfolio firms. However, as regards participation in EU funded R&D partnerships this may not be the case. The life of the funds raised by IVC investors generally has an agreed-upon termination date, which can be extended only for a limited period. At the end of a fund's legal existence, the general partners cash in their carried interest and all remaining cash and securities are distributed to the limited partners. In addition, typically well before a fund's termination date, a new fund is raised and invested in new ventures (see e.g. Sahlman, 1990). Therefore, timely exit is fundamental for IVC investors in order for general partners to realize their carried interest and be able to raise capital for a new fund. It follows that the typical duration of the investments made by IVC investors is quite short.[4] The short time horizon of IVC investments may well be at odds with the participation of IVC-backed NTBFs in EU funded R&D partnerships, that focus on pre-competitive research and generally have long term returns. Conversely, IVC investors are likely to be more interested in making portfolio firms focus effort and resources on the commercial exploitation of the promising technologies they have already developed. Accordingly, Colombo et al. (2006) documented that IVC backing had a positive effect on the likelihood of Italian NTBFs establishing exploitative commercial alliances, while the effect on explorative alliances, and notably on EU funded R&D partnerships, was negligible.

Let us now turn attention to captive VC investors. Among them, CVC is the category that has received the broadest coverage by scholars.[5] Previous studies have highlighted that in addition to financial objectives, CVC investors have crucial strategic objectives, as CVC reportedly is used by large incumbent firms for "technology window" purposes, i.e. for monitoring promising new technologies portfolio NTBFs may be developing (see e.g. Siegel *et al.* 1988, Ernst *et al.* 2005, Dushnitsky and Lenox 2006, Benson and Ziedonis, 2009). One may then argue that CVC investors will stimulate the participation of portfolio NTBFs in EU funded R&D partnerships, in which the CVC investor may or may not participate, with the aim of enlarging the technological capabilities

[3] The ownership and governance of VC investors also influence the resources they possess and the added value they can contribute to portfolio firms (see again Dimov and Gedajlovic, 2010; Da Rin et al., 2011). However, the influence on the costs and benefits for NTBFs of participation in EU funded R&D projects is ambiguous and quite unpredictable. Therefore, we make here the simplifying assumptions that these costs and benefits do not vary systematically depending on the type of VC investors, and focus attention on the effect of the different strategic objectives of these investors.

[4] Gompers (1996) showed that this reasoning applies especially to younger IVC firms that are prone to rapidly bring portfolio firms through an IPO in an effort to "grandstand" (i.e. build a reputation as a successful investor).

[5] In the last 15 years, CVC has played a crucial role in the overall VC market in the US. On average, from 1995 to 2011, CVC funds participated in 15.8% of total VC deals and accounted for more than 8% of the total amount of VC amount in the US (source: PricewaterhouseCoopers / National Venture Capital Association MoneyTree™ Report).

and resources of their portfolio firms. A positive association between CVC backing and the likelihood of NTBFs' participation in these partnerships may follow, in conformity with the evidence that CVC investments increase the likelihood of the CVC investor establishing a subsequent alliance with the portfolio NTBF (Van de Vrande and Vanhaverbeke, 2012). Nonetheless, if one carefully considers the specificity of EU funded R&D partnerships, one may also predict an opposite effect of CVC investments. Scholars have highlighted that CVC investments can serve the purpose of creating a real option, giving the corporate investor the time to learn about the technological feasibility and market potential of a new technology-based entrepreneurial idea. This option can be exercised later through a follow-on investment which may take the form of an alliance with or the acquisition of the portfolio firm (Tong and Li, 2011; Van de Vrande and Vanhaverbeke, 2012; Wadwha and Phelps, 2013). The participation of this latter firm in a EU funded R&D partnership may considerably reduce the option value of the CVC investment. First, we mentioned above that high appropriability hazards are inherent in EU funded R&D partnerships. If there are unintended leakages of portfolio firm's technological knowledge to other members of the partnership, the interest of the CVC investor in exercising its option may vanish. Second, participation of the portfolio NTBF in EU funded R&D partnerships offers this firm the opportunity to collaborate with other firms that are members of the partnership and may be interested in the new technologies the NTBF is developing. The focal NTBF may then hinge on these collaborative relations to reduce the bargaining power of the CVC investor in the subsequent negotiation of the exploitation rights over these technologies. This again reduces the option value of the CVC investment.

Conversely, we argue that BVC- and GVC-backed NTBFs[6] are more likely to participate in EU funded R&D partnerships than their IVC- and CVC-backed counterparts. BVC investment activity is driven by the strategic objective of building future customers for the lending side of the bank. Hellmann et al. (2008) finds that the creation of a VC link between a bank and a NTBF increases the bank's likelihood of providing a loan to the firm at a later stage. They also find that banks invest in later stage VC deals and in firms with potentially greater debt capacity. This evidence clearly supports the argument that banks use VC investments to build lending relationships. As to GVC investments, their main aim is to contribute to job creation and economic development. Accordingly, GVC investments have been used by national and local European governments as a mechanism to fill the VC gap left by private investors, and are concentrated in European young, small, early stage companies (Bertoni et al. 2014). For both BVC and GVC

[6] GVC and BVC investments are very popular in Europe, accounting for around 20% and 15% of the VC investments in the period 1994- 2004 (source: VICO dataset).

investors, participation of their portfolio NTBFs in EU funded R&D partnerships is likely to be considered as a complement of their VC investments. First, receipt of EU subsidies decreases the likelihood of the NTBF getting bankrupt, a situation which would be at odd with the strategic objectives of both these types of investor. Note also that due to the liability of newness (Stinchcombe, 1965), the likelihood of getting bankrupt is quite high for the young, small, early stage firms that attract GVC investments. Second, EU funded R&D partnerships offers portfolio NTBFs the opportunity to install further collaborations with other members of the partnership and get access in this way to the resources and competencies they need to scale up their business. Because of their strategic objectives, BVC and GVC investors are likely to favor these moves.

On the basis of the above arguments, we derive the following hypotheses.

H3a. BVC-backed NTBFs are more likely to participate in EU funded R&D partnerships than their IVC- and CVC backed counterparts.

H2a. GVC-backed NTBFs are more likely to participate in EU funded R&D partnerships than their IVC- and CVC backed counterparts.

2.3. The coordination of EU funded R&D partnerships by NTBFs

In this paper we are also interested in investigating factors that conditional on participation in EU funded R&D partnerships, make a focal NTBF more or less prone to act as the coordinator of the partnership.

There clearly are advantages and disadvantages associated with this role. Among the former, the coordinator of a EU funded R&D partnership generally is entitled to a larger share of EU subsidies than simple participants. Moreover, the quality signal conveyed to uninformed third party by coordination of the partnership is stronger than the one associated with being a member of the partnership without any coordination responsibility. However, coordination of EU funded R&D partnerships also entails considerable costs for NTBFs, relating to the opportunity cost of the time spent by managers in preparing the application and then in managing the collaborative project. These costs are large enough to discourage most NTBFs from acting as project coordinator, as will be documented later.

It is difficult to predict whether VC backing makes it more or less likely for NTBFs to act as the coordinator of a EU funded R&D partnership, as opposed forces are likely to be at work. As no previous study examined the antecedents of coordination, we prefer to abstain from developing theoretical hypotheses on the above issues, and to leave them to an explorative empirical analysis.

3. Sample and data

3.1. Sample

This work takes advantage of the merge of two data sources: the VICO and CORDIS databases. VICO is a new database developed within the 7th Framework Program VICO project funded by the European Commission. It contains longitudinal accounting, investment and performance data on European NTBFs. CORDIS is a database containing information about all the projects financed by the European Commission through different support schemes.

The VICO dataset[7] includes data on 8,367 NTBFs located in 7 European countries: Belgium, Finland, France, Germany, Italy, Spain, and the United Kingdom. Firms included in the dataset were less than 20 years old in 2010, were independent at their founding date (i.e., not controlled by other business organizations), and operate in the following high-tech manufacturing and services industries: nanotechnology, biotechnology, pharmaceuticals, computers, electronic components, telecommunications equipment, precision, optical and medical instruments, robotics, aerospace, software, telecommunications services, internet and multimedia services, web publishing, renewable energies, R&D and engineering services. 758 of these firms are VC-backed. All VC-backed firms received their first round of VC between 1994 and 2004 and were less than 10 years old at that time. Both surviving and non-surviving firms (i.e., firms that ceased operations or were acquired) are included in the dataset, and therefore, concerns with respect to survivorship bias are alleviated. Firms in the dataset were observed from 1994 (or the foundation date if posterior) up to 2010 (or the time they ceased operations or were acquired).

Data relating to VC-backed companies were collected via random extraction from commercial databases (i.e., Thomson One, VC-PRO, and Zephyr) and country-specific proprietary datasets, including the yearbooks of the Belgium Venture Capital Association and the Finnish Venture Capital Association, the ZEW Foundation Panel (Germany), the RITA directory and Private Equity Monitor (Italy), the José Martí Pellón Database (Spain), and the Library House - now Venture Source (the UK). Moreover, the data were cross-checked with those available from public sources (e.g., websites and annual reports of VC investors, press releases and press clippings, and initial public offering prospectuses). A central data collection unit ensured that the information was consistent and comparable across countries. This data collection process ensures that the VICO dataset offers a reliable representation of the European population of VC-backed companies (Cumming et al., 2013). The non-VC-backed companies were randomly extracted from all available

[7] For a comprehensive description of the VICO dataset, and detailed information on the procedures and sources used in the data gathering process, see Bertoni and Martí (2011).

vintage years of Bureau van Dijk's Amadeus database. Also in this case, country-specific proprietary sources were used (e.g., Creditreform in Germany) to complete the dataset.

We used the CORDIS database to collect data on the participation of VICO firms in R&D partnerships funded by the EU. 643 NTBFs included in the VICO database participated in one or more EU funded R&D partnerships. In total, these firms were involved in 1,398 partnerships. The data we extracted from CORDIS relate to the following characteristics of partnerships: project name, start and end date, type of support programme, cost and funding amount, coordinator identity, and number and characteristics of project partners. In 161 of these projects the NTBF acted as the project coordinator.

3.2 Data

In table 1 we provide the breakdown by industry of firm's operation, home country and foundation date of the sample NTBFs participating in EU funded R&D partnerships and of the ones acting as coordinator. Only 7.7% of the sample firms participated in one or more partnerships. This evidence confirms the view that small and young firms encounter serious obstacles in accessing EU support schemes. In addition, only 11% of these latter firms acted as coordinator in one or more projects. Quite interestingly, there are significant differences across industries, home countries and foundation dates in firms' participation rate, given by the ratio of the number of firms participating in EU funded R&D partnerships to the total number of sample NTBFs included in the focal category, as highlighted by the values of the Pearson χ^2 tests ($\chi^2(6)=141.68$, $\chi^2(6)=108.27$ and $\chi^2(3)=8.63$, respectively). Conversely, there is no evidence of statistically significant differences in the distributions of coordinating and non-coordinating firms by industry, home country and foundation date ($\chi^2(6)=9.54$, $\chi^2(6)=5.94$and $\chi^2(3)=7.35$, respectively).

Insert Tables 1 and 2 around here

Table 2 shows the distribution of VICO firms having participated in EU funded R&D partnerships by number of partnerships in which they participated. Almost half of participating firms took part in more than one partnership, and more than 30% of them participated in three or more partnerships. The quite high frequency of serial participants indirectly suggest that there are considerable learning effects and other advantages from participation in this type of partnership. These effects seem less important for project coordination. Only 15 firms coordinated more than one partnership, corresponding to only 28% of coordinating firms, and only five firms coordinated more than three partnerships.

In this paper we are interested in investigating whether receipt of VC makes NTBFs more or less prone to participating in and coordinating EU funded R&D partnerships. Table 3 provides some

preliminary evidence on this issue. More than 26% of the NTBFs that participated in these partnerships also received VC financing, while only 7.7% of the sample firms that did not participate in any partnership are VC-backed. Out of NTBFs that coordinated one or more EU projects, the share of VC-backed firms is even higher (32%). A χ^2 test documents a positive association, significant at x%, between participation in EU projects and receipt of VC ($\chi^2(1)=245.13$). On the contrary we do not find a similarly statistically significant association between coordination of EU funded R&D partnerships and VC backing, conditionally on participation ($\chi^2(1)=1.62$).

Insert Table 3 around here

It is also interesting to assess whether for the 758 NTBFs that received VC, the likelihood of participation in a EU funded R&D partnership increases after the first VC round. For this purpose, we performed a t-test on the difference in participation rate before and after receiving VC. After the first VC round the average yearly participation rate doubles from 2% to 4% ($p<0.001$). On the contrary, after receiving VC, there is no statistically significant increase in the likelihood of coordination, conditional on participation. Altogether, the descriptive evidence illustrated so far suggests the existence of a positive association between VC financing and NTBFs' participation in EU funded R&D partnerships.

Lastly, in Table 4 we illustrate the characteristics of the 1,398 EU funded R&D partnerships in which sample NTBFs participated. Partnerships lasts on average 35 months, involving 13 participants located in 6 different countries and receiving 3.6 Million € of EU funding.

Insert Table 4 around here

We also distinguished between partnerships in which sample NTBFs act as coordinators and the remaining partnerships and performed univariate t-tests on the differences in means of partnership characteristics. We found significant differences of substantial magnitude in length, number of participants, number of countries in which participants are located, cost of the project and amount of EU funding. The partnerships coordinated by a NTBF are significantly shorter and smaller. However, the average funding per participant is not statistically different across the two categories of partnership.

We also computed two inverse normalized Herfindahl indexes reflecting diversity of the participants in the partnerships under consideration in terms of home countries and nature of the participating organizations. As to the latter aspect, we considered five types of partners: education,

research, industry, consultancy and others.[8] The values of a t-test show that the geographical diversity of partnerships in which sample NTBFs act as coordinator is not statistically different from the one of the remaining partnerships. Conversely, when a NTBF is the project coordinator, partnerships tend to be significantly more heterogeneous in terms of types of organization involved.

4. Econometric analysis

4. 1 Dependent and independent variables

The dependent variable used to analyze the antecedents of the participation of sample NTBFs in EU funded R&D partnerships (*DEUproject*) is a time-varying dummy variable equal to one in the starting year of a EU project in which the NTBF is involved. Given the panel structure of our dataset, we used lagged explanatory variables as regressors in order to reduce potential endogeneity/reverse causality issues. We also performed several robustness checks to assure that reverse causality and/or unobserved heterogeneity do not drive our results (see Section 4.2.2).

In order to capture the effect of VC backing on the likelihood of participation in EU funded R&D partnerships we considered a set of step dummy variables that equal one from the year after the one in which the first VC investment round was received onwards. More specifically, *VC* indicates receipt of VC independently of the type of investor from which VC was received. The variables *IVC*, *CVC*, *BVC* and *GVC* specifies the type of lead investor in the first VC round. They equal 1 from the year that immediately follows the first VC round if the lead investor in this round was an Independent VC (*IVC*), was affiliated to a non-financial firm (i.e. it was a corporate CVC investor, *CVC*), was affiliated to a bank or another financial institution (*BVC*), or was affiliated to a governmental organization (*GVC*).

Let us now consider control variables. First of all, we considered the logarithms of firms' total assets and firm age (*lnTotal Assets* and *lnAge)*, and their squared terms (*lnTotal Assets2* and *lnAge2*). We used two proxies of experience of participation in and coordination of EU funded R&D partnerships, namely the (log of the) number of previous partnerships in which firms participated (*lnN. Past non-Coord. Projects*) and the (log of the) number of previous partnerships that firms coordinated (*lnN. Past Coord. Projects*). *Patent Stock* is the depreciated sum of the number of firms' patents,[9] interacted with a dummy indicating that the firms operates in manufacturing sector. *Cash flow/Sales* and *Financial Debt/Total Assets* are accounting ratios proxying the amount of internal finance available to the firm and its leverage. Statistics about explanatory variables are reported in the Table 5.

Insert Table 5 almost here

[8] The two indicators have been constructed using the inverse normalized Herfindahl.
[9] We considered a yearly depreciation rate of 0.15.

4.2 Econometric results

4.2.1 Participation in EU funded R&D parterships

In Table 6 we illustrate the results of the estimates of random effect panel data probit models aimed at analyzing the antecedents of the likelihood of a NTBF participating in one or more EU project in year t. Let us first consider the effect of control variables.

First of all, our estimates show that the likelihood of NTBFs' participation in EU projects is significantly related to both firms' total assets and age. Indeed, the null hypotheses that *lnTotal Assets* and *lnTotal Assets2,* and *lnAge* and *lnAge2* are jointly equal to zero can be rejected by a Wald χ^2 test at conventional confidence levels. With all other variables at their mean, we computed the marginal effects at different percentiles (from the 10^{th} to the 90^{th}, with steps of 10) of the underlying variable. Firm size as reflected by total assets always has a positive marginal effect on the probability of participation while age has a negative marginal effect. In particular, as regards firm size, in spite of an estimated inverse U shaped relation, the inflection point lies outside the observed range of the focal variable(i.e. the relation with the likelihood of project participation is upward sloped). Second, *lnN. Past Non-Coord. Project*, reflecting the experience a NTBF has accumulated in participating in EU projects, has a positive effect, significant at 1%. At the mean value of all other variables, for every project in which the focal NTBF has participated in the past, we estimated an increase in the likelihood of participating in a new project ranging between 0.09 and 0.014. This evidence is in line with the view that there are considerable learning effects relating to the formation of a consortium, the draft of a project proposal and other aspects of the application process. Moreover, our estimates suggest that there are no additional advantage in this respect from taking on the role of project coordinator. As to accounting variables, cash availability makes firms significantly less prone to participate in EU projects, thereby suggesting that the financial support provided by the EC makes EU projects especially attractive for cash constrained NTBFs. Conversely, the level of leverage does not have any significant effects. The discounted patent stock also turns out to have no significant effect. Lastly, the null hypotheses that industry dummies are jointly equal to null is rejected at conventional confidence levels. The same applies to country dummies. These results are in line with the descriptive evidence illustrated earlier and the results of previous studies which indicate that industry characteristics such as the tightness of the appropriability regime and the extent of technological opportunities, and institutional characteristics of countries generate noteworthy differences in the propensity of firms to enter into collaborative research projects.

Insert Table 6 around here

Let us now consider the impact of VC backing. Models I and II indicate that receipt of VC results in an increase of the likelihood of participation in EU projects. The effect is significant at 1% and of large economic magnitude (+0.007, corresponding to a 213% increase of the probability of participation from the value in absence of VC). As highlighted by the estimates of Model IV, there are notable differences contingent on the *type* of investor. While the effects of IVC and CVC are not significant at conventional confidence levels, those of GVC and BVC are large (in both cases the likelihood of participation is about three times as large as in absence of VC) and significant (at 5% and 10%, respectively).

Insert Figure 1 around here

In order to understand whether the effect of VC backing on the likelihood of a NTBF participating in a EU funded R&D partnership is moderated by the number of past EU funded R&D partnerships in which the NTBF participated, we depict marginal effect of VC as a function of the cumulative number of past participations as non-coordinator. Figure 1 documents that VC has a significant positive effect on participation only when the NTBF has no experience (the effect is only close to significance when the firm participated to only one project in the past). This confirming a some kind of substitution between VC receipt and past participations.

Insert Table 7 around here

In order to ascertain the robustness of our findings, we performed several checks. First, we highlighted above that NTBFs' participation in EU projects renders additional participations far more likely. Hence, one may wonder whether our results are influenced by the presence in the sample of a limited number of serial participants in EU projects. In order to better control for serial participation, we focused attention on the first participation of sample NTBFs in a EU project and modeled through Cox and Weibull survival data models firm's hazard rate of participating in the project in time t, conditional on having never participated in any other projects up to time t. The results of the Cox estimates are presented in Table 7 and are fully in line with those presented earlier. In particular, as is shown in Figg. 1a and 1b, with all else being equal, the hazard rate is substantially higher for VC-backed than for non-VC-backed firms, and this effect is mostly attributable to GVC- and BVC-backed firms.

Even more importantly, a serious concern in the estimates illustrated previously is endogeneity of the VC variables. In particular, the estimate positive effect of VC backing on the likelihood of firms participating in EU projects might be due to a selection effect rather than a treatment effect (see e.g. Bertoni et al., 2011). VC investors may be attracted by firms that are planning to participate in EU projects, generating a reverse causality problem. Alternatively, there

might be unobserved factors (e.g. the quality of a NTBF's technology or the smartness of its managers) that explain both attraction of VC and participation in EU projects. In order to deal with this endogeneity issue, we resorted to several addition estimations. First, we estimated all panel models including firm-specific averages of time-variant explanatory variables in Mundlak's style (see Mundlak 1978). The underlying assumption is that unobserved individual effects will depend upon the average of the other observable time-variant regressors, thus mimicking a fixed effect estimation with these averages within time. The results again available from the authors upon request, are similar to the ones reported in Table 6. Second, we resorted to a propensity score matching estimation strategy, as suggested by Rosenbaum and Rubin (1983).[10] In our matching procedure, for each VC-backed firm that received the first round of VC financing in year *t*, we selected the non-VC-backed firms that had the closest probability of receiving VC financing (i.e. the propensity score). The aim of this step is to get a sample composed of VC-backed and "twin" non-VC-backed firms thereby reducing the potential selection bias. For this purpose, we estimated a series of probit models on the sample of NTBFs drawn from the VICO dataset, whereby the dependent variable is a dummy indicating whether a NTBF is VC-backed or not. More specifically, we computed different propensity scores for each type of lead investor in the first investment round, namely IVC, CVC, BVC and GVC. In this way, we ended up with 4 matched samples: (1) IVC-backed and IVC control group firms, (2) CVC-backed and CVC control group firms, (3) BVC-backed and BVC control group firms and (4) GVC-backed and GVC control group firms. The independent variables of these probit models included firm size, measured by the logarithm of firms' total sales, the discounted patent stock and year, country and industry dummies. We performed a nearest neighbor propensity score 1-to-1 matching without replacement. We also required that a VC-backed firm and its matched non-VC-backed firm belong to the same country and industry, be founded in the same year and have the same age. The four matching procedures passed the balancing and reliability tests suggested by Dehejia and Wahba (2002).[11] Therefore, the treatment variable (i.e. the typology of lead VC investor) is closer to being independent of the background covariates and the potential for selection bias is greatly reduced compared to the parametric analysis based on raw data (Ho et al., 2007).We then repeated the estimates of the RE probit panel data models on the sample composed of VC-backed firms and their twin non-VC-

[10] Matching methods have been extensively used in previous studies that analyzed the impact of VC deals on investee firms' performance (see among others Megginson and Weiss, 1991; Chemmanur et al., 2011; Puri and Zarutskie, 2012; Tian, 2012; Croce et al., 2013;).

[11] More specifically, we refer to: i) the t-tests for equality of means before and after matching procedure for all covariates used in the matching procedures; ii) the comparison between the pseudo R^2 obtained by estimating the probit models on the matched samples and those obtained before matching; and iii) the comparison between the p-values of the LR test on the joint insignificance of covariates before and after matching.

backed firms. Results are reported in Table 7. The results relating to the effect of VC-backing are qualitatively similar to those presented in Table 6. They confirm the sizeable positive effect of bank and government affiliated VC on the likelihood of participation in EU projects. The computed marginal effects at means are actually bigger in this estimation than in the one relating to raw data. Moreover, in this estimate IVC also has a significant (at 10%) positive effect on participation in EU projects, although of smaller magnitude in comparison with the ones of BVCs and GVCs.

Insert Table 9 around here

4.2 Coordination of EU projects

In analyzing the probability that a NTBF coordinates an EU project, we restricted the sample to firms participating in these projects. The underlying assumption is that the decision to act as coordinator is made by a NTBF *only* conditional on participation. The unit of analysis is the individual project. The dependent variable *DCoordination* equals 1 if the NTBF takes the role of coordinator of the focal project. The estimates of a probit model are reported in Table 8.

In Table 9 we restrict the sample to the participating firms and look at the coordination probability. We find no robust evidence of industry or country that exhibit higher coordination propensity, neither an effect of the coordination or participating experience (number of project coordinated by the NTBF in the past). Also the presence and type of VC investors seem to be negligible.

Insert Table 9 almost here

Let us first consider project-specific variables. The results of the estimates confirm the qualitative evidence presented earlier in that the duration of the project and the number of countries in which participants are located negatively and significantly affect the likelihood of a NTBF acting as poject coordinator.

As to firm-level control variables, experience in the coordination of past projects turns out to be a powerful predictor of the likelihood of a NTBF acting as the project coordinator. The probability of coordination increase almost 3 times when number of coordinated project shifts from 0 to 1.

This result is a further confirmation of the importance of learning by doing in managing EU projects. As to the remaining firm-specific variables, only firm size has a significant positive effect on participation probability. An increase from the 10^{th} to the 90^{th} percentile of lnTotal Assets doubles the probability of coordination.

Lastly, as regards the VC variables, the only significant (at 5%) effect relates to BVC. A NTBF backed by a bank-affiliated venture capitalist is 4.35 times more likelihood of coordinating a EC project than a non-VC-backed NTBF. Conversely, the effect of IVC is not significant.[12]

5. Discussion and Conclusions

The present work aim at contributing to the existent literature by providing some original empirical evidences of NTBFs' participation (and coordination) to R&D collaborative projects funded by the European Union. This topic is particularly relevant nowadays. On the one side, NTBFs' participation to these projects is a primary objective of EU research and innovation policies (Small Business Act, 2008). On the other side, a weakness stressed by the existing RTD Framework Programmes is the difficulty in participation that NTBFs, and SMEs in general, face. In the Programmes established by EU for the period 2014-2020, Horizon 2020 and COSME (Programme for the Competitiveness of Enterprises and SMEs), 15% of the total 80 billion € budget is reserved to SMEs, moreover one of the aim is the simplification of the access to these Programmes and the design of specific financing schemes for innovative projects conducted by SMEs.

The empirical analysis, based on an extensive sample composed of 8346 European NTBFs, allow us to describe the characteristics of the NTBFs participating in EU projects. An original aspect of this work is the analysis of the decision to coordinate a project, a role that confers visibility and prestige but that requires additional efforts in managing the project and coordinating participants.

The average participation and coordination rate in the sample are 7.7% and 0.85% (11.0% of the participating firms) respectively and most of the firms operate in Software, ICT and Biotech & Pharmaceutical sectors. Country-wise, Italy, France, and Belgium have significantly higher participation rate in EU projects with respect to other countries.

Serial participation by a NTBF is a frequent phenomenon: 49% of the participating NTBFs take part in more than one project and the average number of projects for participating firms is 2.2. This evidence suggests the presence of learning economies in designing and executing a project. The NTBFs that "know the rules" and that have already developed a network, manage to get in projects and manage them with lower costs (most of those are sunk and related to the first participation). Therefore, some good quality NTBFs may decide to abstain from presenting an application because a lack of an adequate knowledge of these supporting schemes.

In Europe, coordinating firms are not different with respect to mere participants in term of sector and country. Looking at the year of the first project, coordinating NTBFs are bigger in terms of number of employees. Only NTBFs with an adequate organizational structure are likely to

[12] As NTBFs backed by CVC or GVC never acted as project coordinator, the corresponding variables are dropped from the estimates.

overcome administrative and partner coordination burden. We also analyze what are the average characteristics of a project involving a NTBF. We find that projects coordinated by a NTBF are significantly different: they are smaller in terms of the number of participants, number of countries involved, total cost of the project and total co-funding provided by the EU, suggesting that coordination costs arising from the management of large projects are difficult to sustain for a NTBF. It's likely that there is a dimensional threshold for projects coordinated by a NTBF, probably because of the high organizational costs that bigger projects entail.

Another interesting evidence is the relation between Venture Capital and project participation: VC-backed firms are about 3 times more likely to participate in FP projects and the yearly participation rate of a NTBF doubles after the entry of a VC investor. This evidence suggests the existence of some complementarities between the participation in the EU projects and the presence of VC investors. However, no statistically significant increase in the coordination probability was found after VC entry. Moreover, we find that the typology of investors do matters, with bank and governmental affiliated VC investors that positively affects the participation probability, while classical independent and corporate sponsored VC have no effect.

The econometric analyses, using non-participating NTBF ad control group, mostly confirm statistical evidence by using different models (and different underlying hypothesis).

A natural future development of this study is the analysis of post-participation performances of NTBFs, while taking into account the selection into these collaborations. This two-step analysis would clearly lead to a better understanding of the real benefits, at the firm level, engendered by the involvement of NTBFs in RTD projects. This would give more precise indication to policy makers.

Another attractive research direction is about the degree of complementarity or substitution between EU / national supporting schemes and venture capital funding. This would provide very interesting information for policy makers and would highlight the possible existence synergic benefits from combining public and private support for NTBFs.

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Tables and figures

Table 1: Sample NTBFs participating in and coordinating EU-funded projects: breakdown by industry, country and foundation period

	All firms		Participating firms			Coordinating firms		
	(a) No.	%	(b) No.	%	(b)/(a)	(c) No.	%	(c)/(b)
Industry								
ICT manufacturing[a]	1499	17.96	125	19.44	8.34	9	12.68	7.20
Biotech & Pharmaceuticals	865	10.36	145	22.55	16.76	22	30.99	15.17
Other high-tech manufacturing[b]	456	5.46	24	3.73	5.26	3	4.23	12.50
Internet	972	11.65	62	9.64	6.38	4	5.63	6.45
TLC	387	4.64	22	3.42	5.68	5	7.04	22.73
Software	3747	44.9	214	33.28	5.71	21	29.58	9.81
R&D and engineering services	420	5.03	51	7.93	12.14	7	9.86	13.73
Total	**8346**	**100**	**643**	**100.00**	**7.70**	**71**	**100**	**11.04**
Country								
Belgium	914	10.95	93	14.46	10.18	11	15.49	11.83
Finland	760	9.11	36	5.6	4.74	0	0	0.00
France	1726	20.68	191	29.7	11.07	25	35.21	13.09
Germany	1335	16	53	8.24	3.97	7	9.86	13.21
Italy	1052	12.6	123	19.13	11.69	12	16.9	9.76
Spain	877	10.51	49	7.62	5.59	6	8.45	12.24
UK	1682	20.15	98	15.24	5.83	10	14.08	10.20
Total	**8346**	**100**	**643**	**100**	**7.70**	**71**	**100**	**11.04**
Foundation date								
1984-1989	1016	12.17	96	14.93	9.45	14	19.72	14.58
1990-1994	1234	14.79	106	16.49	8.59	18	25.35	16.98
1995-1999	2937	35.19	223	34.68	7.59	21	29.58	9.42
2000-2004	3159	37.85	218	33.9	6.90	18	25.35	8.26
Total	**8346**	**100**	**643**	**100**	**7.70**	**71**	**100**	**11.04**

Legend: a) ICT manufacturing includes the following industries: manufacture of computers and office machineries, manufacture of radio and communication equipments, manufacture of precision and medical instruments.
b) Other high-tech manufacturing includes the following industries: aerospace, robotics, nanotech and cleantech

Table 2: Number of projects participated and coordinated by sample NTBFs

	Participating firms		Coordinating firms	
	No.	**%**	**No.**	**%**
N. projects participated / coordinated				
0	-	-	572	88.96
1	328	51.01	51	7.93
2	119	18.51	15	2.33
3 to 5	142	22.08	5	0.78
more than 5	54	8.4	0	0.00
Total	**643**	**100**	**643**	**100**

Table 3: The effect of Venture Capital on participation rate and coordination rate (given participation)

	All firms		**Firms that did not participate in EU projects**			**Firms that participated in EU projects firms**			**Firms that coordinated EU pojects**		
	No. (a)	**%**	**No.** (b)	**%**	**b/a (%)**	**No.** (c)	**%**	**c/a (%)**	**No.** (d)	**%**	**d/c (%)**
Non VC-backed	7588	90.92	7113	92.34	93.74	475	73.87	6.26	48	67.61	10.11
VC-backed	758	9.08	590	7.66	77.84	168	26.13	22.16	23	32.39	13.69
Total	**8346**	**100**	**7703**	**100**	**92.3**	**643**	**100**	**7.7**	**71**	**100**	**11.04**

Table 4: Characteristics of EU projects: projects coordinated by a NTBF vs. projects participated and non-coordinated by a NTBF

	Participated			**Participated and non-coordinated**	**Coordinated**	**t-test**
	Mean	**SD**	**Median**	**(a) Mean**	**(b) Mean**	**(a)-(b)**
Project length (months)	34.96	12.77	36.00	35.54	30.45	5.087***
Number of participants	13.37	12.88	9.00	13.90	9.29	4.613***
Number of home countries of participants	6.11	3.31	5.00	6.30	4.62	1.681***
Cost of the project (Million Euros)	6.053	11.484	3.094	6.288	4.161	2.126***
Amount of EU funding for the project (Million Euros)	3.659	5.966	1.950	3.809	2.486	1.323***
Average funding for participant (thousand Euros)	249.7	209.9	218.8	251.9	232.2	19.7
Geographical dispersion index	0.84	0.11	0.86	0.84	0.83	0.008
Organization dispersion index	0.49	0.23	0.54	0.49	0.55	-0.068**
Observations	**1398**			**1237**	**161**	**1398**

Table 5: Explanatory variables: Descriptive statistics

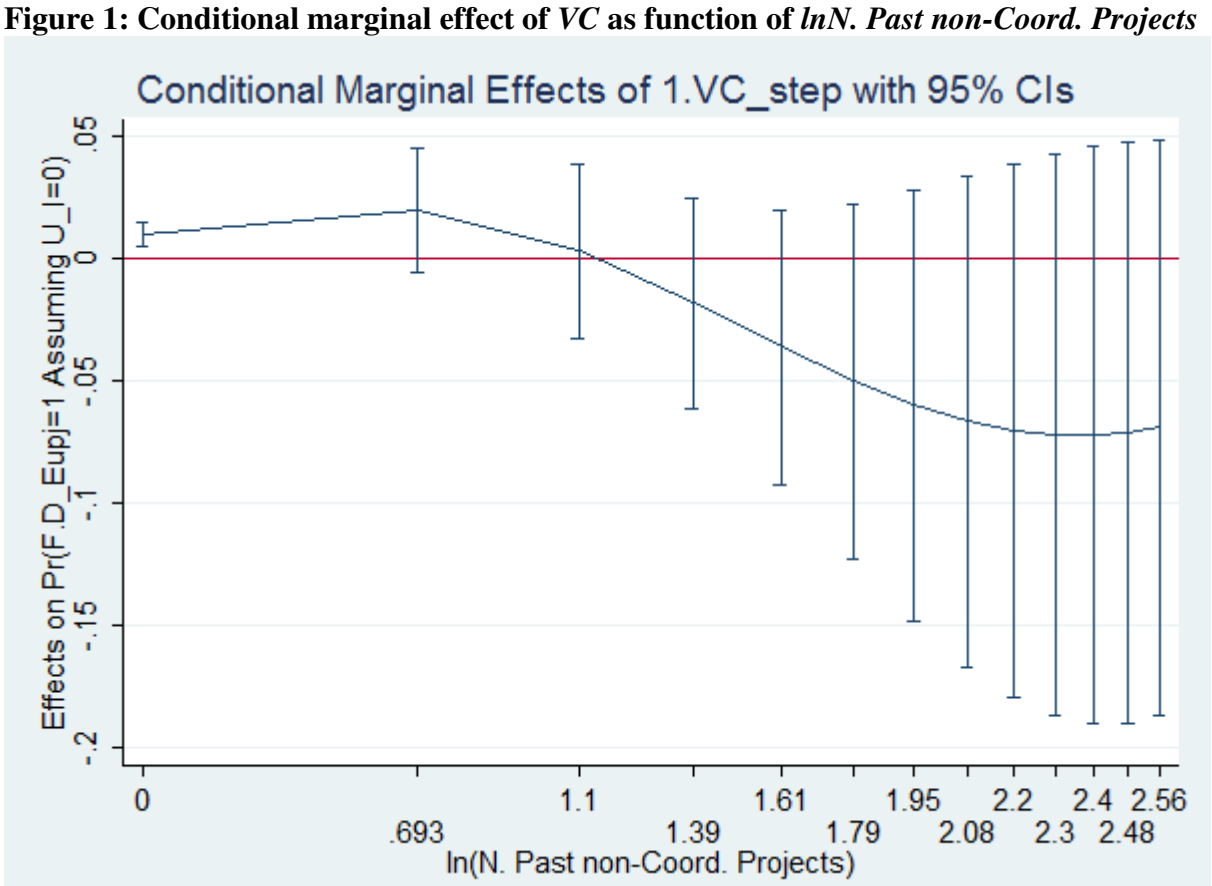
	N. Obs.	Mean	SD	Median	Min	Max
lnTotal Assets	62154	6.27	2.09	6.25	0.00	15.69
lnAge	62154	1.99	0.72	2.08	0.00	3.26
lnN. Past non-Coord. Projects	62154	0.06	0.25	0.00	0.00	2.56
lnN. Past Coord. Projects	62154	0.01	0.07	0.00	0.00	1.61
Patent Stock x Manufacturing sector	62154	0.08	1.48	0.00	0.00	133.31
Cash flow/Sales	47751	0.00	0.41	0.06	-1.39	0.99
Debt/Total Assets	42448	0.20	0.38	0.07	0.00	2.83
VC	62154	0.08	0.26	0.00	0.00	1.00
VC syndication	62154	0.02	0.14	0.00	0.00	1.00
IVC	62154	0.04	0.19	0.00	0.00	1.00
CVC	62154	0.01	0.07	0.00	0.00	1.00
BVC	62154	0.01	0.08	0.00	0.00	1.00
GVC	62154	0.02	0.12	0.00	0.00	1.00

Table 6: The determinants of NTBFs' participation in EU projects: RE panel data probit models

	Model I	Model II	Model III	Model IV	Model V
lnTotal Assets	0.131***	0.204***	0.200***	0.194***	0.208***
	(2.987)	(2.856)	(2.865)	(2.701)	(2.928)
lnTotal Assets2	-0.004	-0.008*	-0.008*	-0.007	-0.008*
	(-1.207)	(-1.756)	(-1.788)	(-1.613)	(-1.770)
lnAge	-0.139*	-0.161	-0.238**	-0.143	-0.138
	(-1.683)	(-1.340)	(-2.016)	(-1.180)	(-1.149)
lnAge2	-0.035	-0.033	-0.009	-0.038	-0.041
	(-1.422)	(-0.962)	(-0.260)	(-1.107)	(-1.205)
lnN. Past non-Coord. Projects	0.788***	0.877***	1.570***	0.946***	0.892***
	(13.120)	(17.994)	(13.764)	(18.197)	(18.533)
lnN. Past non-Coord. Projects2			-0.427***		
			(-6.402)		
lnN. Past Coord. Projects	0.259**	0.131	0.174	0.118	0.110
	(2.109)	(0.953)	(1.325)	(0.861)	(0.807)
Patent Stock x Manufacturing sector	0.009	0.011	0.011	0.011	0.011
	(1.325)	(1.237)	(1.235)	(1.256)	(1.202)
Cash flow / Sales		-0.145***	-0.140***	-0.141***	-0.160***
		(-3.335)	(-3.267)	(-3.236)	(-3.714)
Debt / Total Assets		-0.109	-0.102	-0.107	-0.108
		(-1.577)	(-1.499)	(-1.545)	(-1.565)
VC (d)	0.402***	0.331***	0.291***	0.442***	
	(7.579)	(5.309)	(4.769)	(6.303)	
lnN. Past non-Coord. Projects x VC				-0.303***	
				(-3.186)	
IVC (d)					0.187**
					(2.038)
CVC (d)					0.012
					(0.051)
BVC (d)					0.512***
					(3.478)
GVC (d)					0.440***
					(4.008)
Constant	-3.092***	-3.246***	-3.155***	-3.245***	-3.271***
	(-16.831)	(-10.828)	(-10.811)	(-10.791)	(-10.995)
Industry dummies	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes
lnTotal Assets=lnTotal Assets2=0 $\chi^2(2)$	59.242***	35.769***	34.780***	34.490***	39.389***
lnAge=lnAge2=0 $\chi^2(2)$	101.232***	60.953***	61.057***	60.436***	63.96***9
lnN. Past non-Coord. Projects=lnN. Past non-Coord. Projects2=0 $\chi^2(2)$			404.397***		
Number of observations	62154	33168	33168	33168	33168
Number of firms	6990	5187	5187	5187	5187

Reporting coefficients, *t* statistics in parentheses. (d) for discrete change of dummy variable from 0 to 1. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
In random effect probit models we omit year dummies to allow convergence, using pooled probit models with year dummies the results are unchanged.

Figure 1: Conditional marginal effect of *VC* as function of *lnN. Past non-Coord. Projects*



We computed the marginal effect on the means of VC (d) as function of *lnN. Past non-Coord. Projects* using model IV in Table 6

Table 7: The determinants of NTBFs' first participation in EU projects: Cox survival data models

	Model I	Model II	Model III
lnTotal Assets	0.455***	0.789***	0.808***
	(3.432)	(3.419)	(3.502)
lnTotal Assets2	-0.017*	-0.038**	-0.038***
	(-1.929)	(-2.570)	(-2.588)
Patent Stock x Manufacturing sector	0.013	0.020	0.018
	(1.072)	(1.188)	(1.063)
Cash flow/Sales		-0.300**	-0.372***
		(-2.567)	(-3.207)
Debt/Total Assets		-0.073	-0.077
		(-0.390)	(-0.411)
VC	1.119***	0.892***	
	(9.717)	(5.726)	
IVC			0.400*
			(1.659)
CVC			0.084
			(0.143)
BVC			1.400***
			(4.374)
GVC			1.091***
			(4.238)
Industry dummies	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes
Number of observations	57797	30659	30659

Reporting coefficients, *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: The determinants of NTBFs' participation in EU projects: RE panel data probit model with matching of VC-backed and non-VC-backed firms

	Model I	Model II	Model III	Model IV	Model V
lnTotal Assets	0.192	0.424*	0.524**	0.420*	0.421*
	(1.437)	(1.747)	(2.066)	(1.667)	(1.740)
lnTotal Assets2	-0.010	-0.026*	-0.032**	-0.026	-0.026*
	(-1.127)	(-1.741)	(-2.046)	(-1.645)	(-1.748)
lnAge	-0.354*	-0.298	-0.351	-0.318	-0.271
	(-1.842)	(-1.100)	(-1.288)	(-1.151)	(-0.992)
lnAge2	0.038	0.028	0.040	0.035	0.018
	(0.586)	(0.339)	(0.480)	(0.403)	(0.218)
lnN. Past non-Coord. Projects	0.774***	0.783***	1.825***	1.019***	0.785***
	(5.300)	(8.620)	(6.525)	(5.012)	(8.538)
lnN. Past non-Coord. Projects2			-0.689***		
			(-3.883)		
lnN. Past Coord. Projects	0.241	0.317	0.296	0.293	0.270
	(0.835)	(1.103)	(1.028)	(0.990)	(0.925)
Patent Stock x Manufacturing sector	0.064	0.059	0.072	0.065	0.067
	(1.631)	(1.167)	(1.419)	(1.250)	(1.361)
Cash flow / Sales		-0.086	-0.076	-0.089	-0.070
		(-0.882)	(-0.780)	(-0.891)	(-0.714)
Debt / Total Assets		-0.068	-0.019	-0.061	-0.072
		(-0.470)	(-0.133)	(-0.417)	(-0.497)
VC (d)	0.400***	0.372***	0.323**	0.460***	
	(3.922)	(2.870)	(2.446)	(3.038)	
lnN. Past non-Coord. Projects x VC				-0.318	
				(-1.257)	
IVC (d)					0.315**
					(2.157)
CVC (d)					0.078
					(0.246)
BVC (d)					0.572***
					(2.903)
GVC (d)					0.451***
					(2.837)
Constant	-3.475***	-4.297***	-4.743***	-4.419***	-4.189***
	(-5.306)	(-4.028)	(-4.233)	(-3.944)	(-3.926)
Industry dummies	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes
lnTotal Assets=lnTotal Assets2=0 $\chi^2(2)$	3.695	3.064	4.271	2.779	3.064
lnAge=lnAge2=0 $\chi^2(2)$	15.524***	5.949*	6.841**	5.742*	6.020**
lnN. Past non-Coord. Projects=lnN. Past non-Coord. Projects2=0 $\chi^2(2)$			87.011***		
Number of observations	4852	3018	3018	3018	3018
Number of firms	536	427	427	427	427

Reporting marginal effects at the means, *t* statistics in parentheses. (d) for discrete change of dummy variable from 0 to 1. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: The determinants of coordination of EU projects: probit models

	Model I	Model II
lnTotal Assets	-0.205	-0.249
	(-1.335)	(-1.620)
lnTotal Assets2	0.021**	0.025**
	(2.108)	(2.402)
lnAge	-0.295	-0.180
	(-0.674)	(-0.402)
lnAge2	0.146	0.107
	(1.084)	(0.793)
lnN. Past non-Coord. Projects	0.047	0.053
	(0.270)	(0.298)
lnN. Past Coord. Projects	0.771**	0.639*
	(2.314)	(1.856)
Patent Stock x Manufacturing sector	-0.024	-0.017
	(-0.678)	(-0.473)
VC (d)	0.083	
	(0.339)	
IVC (d)		-0.142
		(-0.393)
BVC (d)		1.001***
		(2.691)
Number of participants	-0.007	-0.012
	(-0.237)	(-0.458)
Number of countries involved	-0.243***	-0.244***
	(-3.197)	(-3.212)
Project length (months)	-0.033***	-0.031***
	(-3.021)	(-2.856)
Average funding (per months and participant)	-0.350	-3.922
	(-0.018)	(-0.199)
Organization dispersion	0.387	0.366
	(1.099)	(1.045)
	1.070	0.951
Industry dummies	(1.002)	(0.873)
Country dummies	Yes	Yes
Year dummies	Yes	Yes
Number of observations	682	651

Reporting marginal effects at the means, *t* statistics in parentheses. (d) for discrete change of dummy variable from 0 to 1. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
The unit of observation is the firm-project. Firm-level explanatory variables are measured in the year before the starting year of the project.

Figure 2a. Hazard rate of NTBFs' participation in EU projects: Effect of VC backing

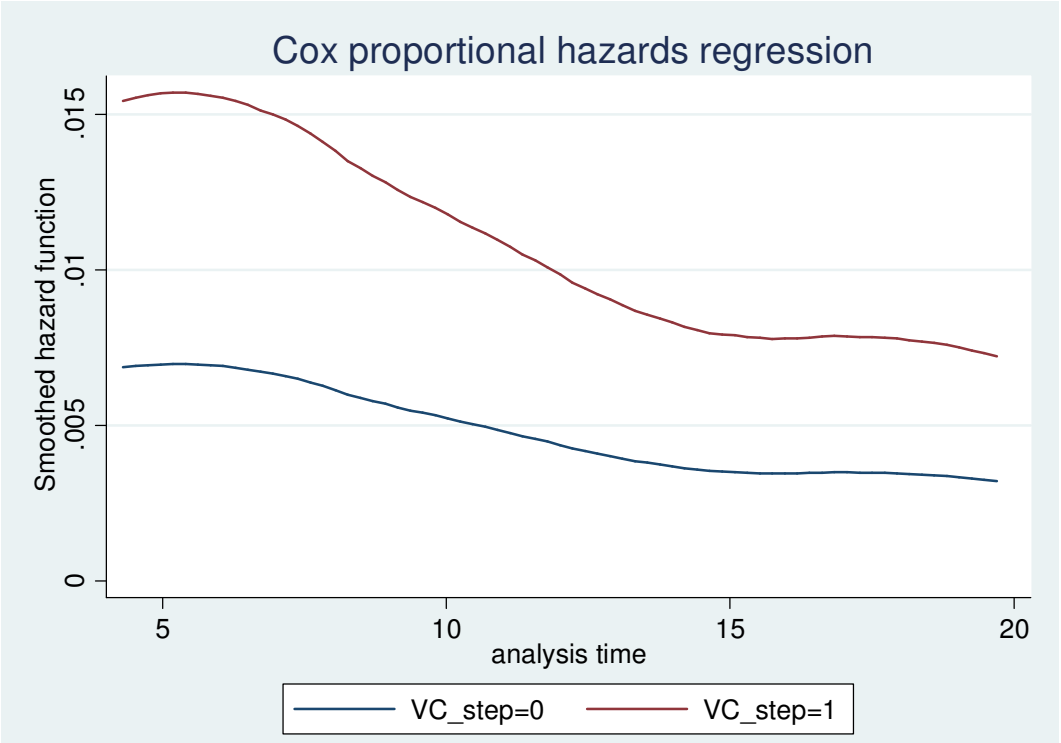


Figure 2b. Hazard rate of NTBFs' participation in EU projects: Effect of IVC- and BVC backing