Financial constraints and the failure of innovation projects

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Abstract:
Theoretical and empirical approaches have stressed the existence of financial constraints in firms' innovative activities. Although a large number of innovation projects are abandoned before their completion, the empirical evidence has focused on the determinants of innovation while failed projects have received little attention. This paper analyses the role of financial obstacles on the likelihood of abandoning an innovation project by using panel data of potential innovative Spanish firms for the period 2005–2013. Our analysis differentiates between internal and external barriers on the probability of abandoning a project and we examine whether the effects are different depending on the stage of the innovation process. Controlling for potential endogeneity, we use a bivariate probit model to take into account the simultaneity of financial constraints and the decision to abandon an innovation project. Our results show that financial constraints most affect the probability of abandoning an innovation project during the concept stage.

Keywords: barriers to innovation, failure of innovation projects, financial constraints
JEL Classifications: O31, D21

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1. Introduction

Theoretical and empirical approaches have stressed the existence of financial constraints in the innovative activities of firms. However, only a scarce amount of empirical evidence has analysed the effect of financial constraints on the probability of abandoning an innovation project. Our data shows that 23.6% of Spanish potential innovators abandon an innovation project and that 41.8% of firms state to face medium-high financial constraints. Our evidence shows that this is a non-neglible phenomenon given the opportunity costs of abandoning a project. Furthermore, innovation projects show different characteristics in comparison with other projects. In particular, innovative firms encounter higher external financial difficulties to invest in new R&D projects, because their specific features increase risk and reinforce the informational problems with external investors (Hall, 2002). In fact, innovation is a complex process that frequently fails (Mazzucato, 2013). Hence, due to specific features of innovation in terms of risk and informational asymmetries, innovative firms usually find persistent barriers for accessing external financial support. Surprisingly, empirical evidence has usually focused on the determinants of innovation and the characteristics of innovative firms, while the failure of innovation projects has received very little attention.

The literature highlights access to financing as being a crucial determinant for innovative firms (D'Este et al., 2012; Hölzl and Janger, 2014; Segarra et al., 2008). Among the different types of barriers, financial constraints are highly important due to the possible macroeconomic consequences. In particular, where financial constraints affect innovating firms more intensely, this may cause a decrease in the new knowledge required for economic development. This may potentially inhibit economic growth (Mazzucato, 2013). For instance, Carpenter and Petersen (2002) indicate that firms in high-tech sectors may have been under-investing due to financial constraints. Furthermore, financial constraints are crucial since they may lead to the reinforcement of other innovation barriers. In consequence, it is by no means trivial to analyse the financial barriers on innovation projects.

In accordance with previous findings, Spain represents an interesting country in which to analyse the effect of financial barriers (Hölzl and Janger, 2014). Hence, this paper analyses the role of financial constraints on the likelihood of Spanish firms abandoning an innovation project during the period 2005–2013. In line with previous studies (D'Este et al., 2012; Mohnen et al., 2008; Savignac, 2008), we exclude those firms which are non-innovative and did not experience any barriers. Hence, our sample considers only 'potential innovative firms', in other words those firms who engaged in innovation activities or did not do so due to one or more obstacles. This procedure corrects the sample selection bias that can appear when asking all surveyed firms about barriers to innovation.

Our panel data is drawn from the Technological Innovation Panel (PITEC), which offers an extensive sample of Spanish firms from some waves of Community Innovation Survey (CIS). After the dataset treatment, our sample contains 4,600 potential innovative firms. From the total number of potential innovators, 302 firms did not innovate but felt barriers against

them engaging in innovation activities, while 4,298 firms innovated successfully between 2005 and 2013. We apply a recursive biprobit model to take into account financial constraints simultaneously with the decision to abandon an innovation project and controlling for potential endogeneity. The empirical model measures the probability that an innovative firm abandons an innovation project due to the existence of internal and external financial barriers[1]. Our results show that financial constraints have more effect on the probability of abandoning an innovation project during the concept stage.

This article makes several contributions. First, the access to sources of finance may restrict the capacity of potential innovative firms to carry out innovation projects. However**,** empirical literature is not as conclusive as one might expect concerning the existence of significant financial constraints[2]. We contribute to this line of empirical literature by differentiating the effect of internal and external financial barriers on the probability of abandoning a project. Second, we consider that the financial sources may have different effects depending on the stage of the innovation projects. Hence, we examine if financial constraints affect the probability of abandoning the innovation project prematurely or once it has started[3].

The remainder of the article is structured as follows. Section 2 analyses the literature related to financial constraints to innovation. Section 3 presents our main hypotheses. Section 4 describes the database and main statistics. The next section presents the econometric methodology. Section 6 shows our main empirical results. Finally, Section 7 presents the main conclusions.

2. Innovation projects and financial constraints

2.1. Financial constraints and innovation

Financial constraints of innovation projects are linked with the nature of knowledge (Hall and Lerner, 2009). Innovation shows a heterogeneous, asymmetrical and accumulative nature (Benedetti, 2009). First, innovation activities are heterogeneous in the sense that some firms do not innovate, some concentrate on specific types of innovation –product, process, organization or marketing– while others carry out various types of innovation. Second, innovation strategies are asymmetric; that is, the distribution of innovation and its impact on a firm's productivity and growth is asymmetric, with its distribution being more skewed

[1] Here, we decided not to include the barriers related to the excessive costs of innovation projects while we focus on financial obstacles.

[2] Some articles have strongly criticized the positive correlation between R&D and internal financial sources, in particular cash-flow, since it may also reflect that innovative firms anticipate high future profits that lead them to invest strongly (Savignac, 2008). The presence of financial constraints for innovative firms is frequently investigated via the sensitivity of R&D investment to financial factors (Himmelberg and Petersen, 1994; Harhoff, 1998; Mulkay, Hall and Mairesse, 2001; Tiwari et al., 2007). During recent years, a new line of research has focused on the analysis of the impact of financial constraints on R&D risk projects.

[3] CIS include as innovation activities the acquisition of machinery, equipment, software, and licenses; engineering and development work, training, marketing and R&D when they are specifically undertaken to develop and/or implement a product or process innovation.

towards the right. Third, innovations are accumulative since innovation increases when a firm has already introduced other innovations. Additionally, innovation projects present a high degree of uncertainty, in particular at the beginning of research programmes. This considerable uncertainty and risk reduces the capacity of innovative firms to find external sources of finance and, as an alternative, they have to generate internal funds.

In essence, innovative firms encounter financial obstacles for investment in innovative activities through the presence of externalities, problems of informational asymmetries and problems of appropriability with the return on R&D investment (Nelson, 1959; Arrow, 1962; Mina et al., 2013). Consequently, innovative firms experience high costs for R&D investments and induce underinvestment in innovation activities. Obstacles associated with asymmetric information or moral hazard problems can derive from a gap between external and internal costs that lead to R&D underinvestment or liquidity constraints.

From the point of view of financial markets, these may under-invest in innovation projects. Financial barriers to innovation projects are closely related to some of their inherent characteristics (Hall, 2002) such as the low return expectation due to an inability to secure profits from an innovation, the higher cost of innovation projects, the high sunk costs, the specific dimension of the physical capital, the presence of externalities and free-riders, among others. All these characteristics reduce the capacity of financial institutions and financial markets to increase sources to firms' innovation projects.

Furthermore, some innovation projects may not be started, have to be delayed or are abandoned because of lack of access to financial resources. Some of the factors that may increase barriers to external funds are the risk of bankruptcy and the low value of intangibles in case of liquidation. The empirical analysis remarks how financial barriers restrict the capacity of innovative firms to carry out innovation projects ("hampering barriers"), and how financial constraints reduce the capacity of potential innovative firms to become innovative firms ("deterring barriers").

Hence, financial constraints for innovation are an important constraint impeding firms from catching up and developing innovations to reduce the gap between themselves and the technological frontier.

The emergence of financial constraints is closely related to the two groups of market failures described by Arrow (1962) and Nelson (1982). On the one hand, some failures are due to the nature of knowledge (Arrow, 1962): appropriability, high sunk costs, high risk with a skewed distribution of outcomes, and spillovers. On the other hand, others are due to innovation systems (Nelson, 1982): lack of confidence to cooperate in R&D, the agents involved lack the scale to cope with the challenges of innovation and few linkages between the agents involved in the innovation process.

2.2. Empirical evidence

Since Fazzari et al. (1988) an increasing number of econometric studies have tried to observe the existence of financial constraints by analysing the sensitivity of investment to changes in available financial resources. In those works, the presence of financial restrictions is derived in an indirect way, given that when a firm's R&D investment is sensitive to cash flow, this is reflected indirectly by the firm's lack of access to external funds.

During recent years, the access to new datasets on firms' financial sources facilitates applying direct methods to observe the presence of financial restrictions at the firm level (Czarnitzki, 2006; Czarnitzki and Hottenrott, 2009; Piga and Atzeni, 2007). In addition, the increased access to datasets from some countries with harmonized surveys on innovation activities at the firm level has facilitated the identification of potentially financially constrained firms (Canepa and Stoneman, 2002; Savignac, 2008).

A strand of empirical literature remarks on the existence of financial constraints as a significant determinant for abandoning a project. For instance, Mohnen et al. (2008) analyse the impact of financial constraints on hampering innovation using the Dutch CIS survey. According to their results, financial constraints "have a significant and positive impact on the three probabilities of prematurely stopping, seriously slowing down and not starting a project, but not on that of abandoning a project". Similarly, for a sample of French firms, Savignac (2008) finds the probability of innovating diminishes due to the existence of financial barriers. In fact, this author finds that barriers exert a negative effect among non-innovative firms that try to innovate. More recently, Garcia-Vega and Lopez (2010) analyse a sample of more than 8,300 innovative Spanish firms for the period 2005–2007. Their results show the importance of the lack of funds on the probability of abandoning innovation projects. In particular, large firms are much more affected since they invest in innovation projects that involve a larger amount of funds. Finally, Efthyvoulou and Vahter (2015) show that financial constraints have negative effects on innovation performance but that these effects are heterogeneous. Their results point out that financial constraints have more negative effects in the manufactures than in service sectors and that they are particularly detrimental for innovative non-exporting firms. To carry out their empirical analysis they use the CIS for 11 countries for the period 2002–2004 and as in previous analysis they restrict the sample to potential innovative firms.

In spite of this evidence, another strand of empirical literature finds some mixed results. For instance, Galia and Legros (2004) show that financial constraints are not among the main obstacles to innovation (their database is composed of firms with 20 or more employees from French CIS2). Also Hölzl and Janger (2014) show ambiguous results with respect to the effect of financial barriers on the probability of hampering and deterring an innovation project. For a sample of firms from 18 countries and using CIS4 and CIS 2006, Hölzl and Janger (2014) highlight the differences between country groups. According to their results, in Southern European countries and emerging countries, R&D and non-technological

innovators are most hampered by financial barriers. However, they exert a less important effect on countries at the cutting edge of technology. Finally, using CIS 2 data for European countries, Canepa and Stoneman (2008) show ambiguous results for UK CIS. While they can accept for CIS 2 that high-tech firms are more financially constrained than low-tech firms, for CIS 3 the test statistics reject the null hypothesis.

Furthermore, some studies have highlighted the existence of higher financial barriers for firms in high-tech industries. Firms operating in technologically intensive sectors face higher risks since they usually have to invest in innovations which are less likely to have been undertaken elsewhere. As a consequence, they are going to suffer from higher information asymmetries (Canepa and Stoneman, 2008; Revest and Sapio, 2012)[4]. According to Guiso (1998, p. 40), higher financial barriers are due to the more severe informational frictions which affect high-tech firms[5].

3. Main hypotheses

As we have seen previously, economic theory and empirical evidence have stressed the existence of financial constraints in R&D and innovation activities (Hall, 2002; Canepa and Stoneman, 2008). Recent empirical analyses have shown that financial obstacles negatively affect the propensity of firms to innovate (Savignac, 2008; Blanchard et al., 2012).

In this paper we focus on the impact of financial obstacles in the failure of innovation projects. Although the conceptualization of failures of innovation projects has received less attention in literature and specific evidence on their determinants is scarce, empirical findings tend to point out that facing financial barriers increases the likelihood of failure of innovation projects (Mohnen et al., 2008). Financial obstacles may be internal, when firms' own resources are insufficient to develop innovation projects, or external when there is a lack of access to external funding, either public or private. Based on the literature on financial constraints and innovation, our first hypothesis is that firms that state they face lack of funds will be more likely to have innovation projects that fail.

Departing from this main hypothesis, two sources of heterogeneity may exist in the effects that financial obstacles have on the probability of abandoning an innovation project. First,

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[4] According to Carpenter and Petersen (2002, p.54), *"there are three reasons why high-tech investment is particularly likely to be affected by capital market imperfections. First, the returns to high-tech investment are skewed and highly uncertain, in part because R&D projects have a low probability of financial success. Second, substantial information asymmetries are likely to exist between firms and potential investors. Because high-tech investments are difficult to evaluate and frequently embody new knowledge, insiders will have much better information than outsiders about the prospects of the firm's investments. […] Third, high-tech investments often have limited collateral value R&D investment, which is predominantly salary payments, has little salvage value in the event of failure. Furthermore, physical investments designed to embody R&D results are likely to be firm specific and therefore have little collateral value."*

[5] This is due to the fact that innovation projects are much less well understood by outside observers, since past experience or observed past realisations can offer little guidance in assessing the prospects of truly new projects; rather it is likely that the entrepreneur undertaking the innovation project has, if not more knowledge, at least a better perception of its likelihood of success.

the effects may be different depending on the stage of the lifecycle of the innovation project. Second, facing internal or external barriers may affect the likelihood that an innovation project fails with a different degree or intensity.

Regarding the differences on the stage of the lifecycle of the innovation project, failure is inherent to innovation projects and there are different stages where firms may consider it convenient to abandon a project. The information available from PITEC allows us to distinguish two stages, those of abandoning during the conceptual phase or once the project has started.

Theoretical literature does not provide a clear prediction whether there are differences on the effects of financial obstacles on the probability that a firm abandons a project at one specific stage. Nevertheless, the characteristics of R&D and innovation projects suggest the existence of possible differences. Firstly, R&D projects are characterised by the existence of high sunk and fixed costs. Therefore, once firms have decided to begin an innovation project it is less likely that they abandon it because of financial obstacles. Secondly, the asymmetric information problem that affects obtaining external funds is more relevant in the concept stage when it is more difficult to give indications of the quality of the innovation project. Once the project has started, the returns are less uncertain and to obtain external funds will probably require a lower risk premium than in the concept stage. Thirdly, firms mostly apply for public subsidies for their R&D projects in the concept stage and, in the case of it not being granted, may cause the abandonment of the project. Finally, some empirical analyses have pointed out that financial constraints have a significant and positive impact on the probability of stopping prematurely, seriously slowing down and not starting a project, but not on the probability of abandoning a project (Mohnen et al., 2008). Departing from these arguments, our hypothesis is that financial obstacles will impact on the likelihood of abandoning a project in the concept stage but not once the project has started.

With respect to the effect of internal and external financial constraints, there may be differences. Although facing financial barriers, external or internal, should increase the probability of abandoning an innovation project, the effects of both types of financial barriers on the likelihood of abandoning an innovation project may be different. In a model of firm-level investment in R&D it is assumed that a firm faces a marginal cost of capital schedule with an upward slope (David et al., 2000). This upward slope shows that when the volume of R&D increases the firm will have to move from financing projects with internal funds to resort to external sources where the cost of capital is higher. The literature on the financing of R&D shows that the source of financing matters because of the specific characteristics of R&D investment, the existence of information asymmetries and other imperfections in capital markets (Mina et al., 2013).

This literature has also pointed out that the degree of credit constraints also depends on the characteristics of firms and R&D projects and they affect high-tech sectors in particular (Canepa and Stoneman, 2008). All these arguments suggest that to face external barriers may

have greater effects on the decision not to start or to abandon a project than the lack of internal funds and that these effects are probably greater for riskier projects. In addition, one of the sources of external funds is public subsidies that have their own criteria to select approved projects and currently they finance high impact and risky projects that the firms themselves would not have financed on their own (Takalo et al., 2013). Therefore, our hypothesis is that the lack of access to external funding will be more positively associated with the likelihood of abandoning an innovation project than when the main limitation is the lack of funds within the firm or the group.

4. Database

4.1. The database

The data used is from PITEC. PITEC is the result of the collaboration between the Spanish National Statistics Institute and COTEC foundation with the aim of providing data from the CIS. The main advantage of CIS data is that it contains detailed information on innovation behaviour at firm level. However, CIS data has several constraints. First, it does not offer information on firms' balance sheets, which would allow us to assess the effect of internal or external finance on the behaviour of R&D investment. Second, financial constraints and the innovation pattern at firm level present a dynamic nature where time may be a relevant dimension. Finally, CIS dataset offers a cross section. PITEC overcomes this drawback by offering panel data which covers the period 2003–2013.

Our dataset provides exhaustive information for a sample of Spanish firms over an eleven year period. The sample used in the econometric estimations only includes potential innovative firms in the manufacturing and service sectors. Furthermore, since 2010 PITEC provides the setup year so we may take into consideration the firm's age. Hence, PITEC is the best database for observing the innovation activities of Spanish firms over time (Barge-Gil, 2010). However, the primary data has two main drawbacks. First, 'potential innovators' might be underrepresented since CIS tends to have an overrepresentation of firms that carry out innovative activities. Second, our indicators for lack of finance have a qualitative dimension and are proxies of the existence of financial constraints[6].

The procedure for filtering our sample is the following. First, we restrict our sample to firms with at least 8 or 9 observations, hence, those that appear in 2005 or 2006 and remain active until 2013. Second, we drop firms that have suffered a process of mergers. Third, to avoid a problem of sample selection bias, we select firms that are potential innovators since they will perceive financial constraints more directly. Following Savignac (2008), D'Este et al. (2012) and Blanchard et al. (2012), we exclude firms that do not have the intention of innovating since they will not perceive any financial constraint in relation to R&D activities. Hence, we

[6] However, recent studies (Hadlock and Pierce, 2010) have cast doubts on the validity of the Kaplan and Zingales's (1997) index of constraints to proxy for financial constraints.

do not take into account firms that do not innovate and do not declare that they face any type of barriers. After empirical treatment, our sample contains 4,600 firms.

4.2 Dependent variables

We consider two groups of dependent variables. The first group captures whether potential innovative firms perceive financial constraints. *FCinternal* captures the lack of funds within a firm or group; *FCexternal* captures the lack of funds from sources outside a firm, and *FC* captures the lack of funds regardless of the source. The survey asks what degree of importance the financial funds had on the innovation activities and projects in the decision of not innovating. These three dummy variables are equal to 1 in the case that the firm states it perceives a high level of financial constraint and nil when the degree is medium, low or null[7].

The second group captures whether a firm abandons an innovation project. *AB_conc_proj* indicates those firms that abandon a project, while *AB_conc* and *AB_proc* indicate when the project is abandoned: during the initial period (*AB_conc*) or once the innovation project had started (*AB_proj*)[8]. To be more precise, the questionnaire asks if: i) during the last three years, any of the innovation activities or projects were abandoned during the initial period; ii) during the last three years, any of the innovation activities or projects were abandoned once the activity or project was initiated.

4.3 Explanatory variables

The explanatory variables are the following. *lnAge* measures the firm age (in natural logs) as the difference between the period of observation and the year of creation. *lnSize* measures the number of employees (in natural logs). *RD* is a dummy variable that captures whether the firm invests in R&D or 0 otherwise. *Group* is a dummy variable that takes a value equal to 1 if the firm belongs to a group. *Know* and *Market* are dummy variables that indicate whether the firm perceives a medium or high level of barriers related to knowledge or market factors. *lnPatents* is the number of patents generated by a firm a year plus 1 (in natural logs). *Coop* is a dummy variable controlling whether a firm cooperates with other agents. *InternatMarket* takes a value equal to 1 in the case that the firm participates in international markets. *lnRDintensity* is the R&D investment per employee in thousands of Euros (in natural logs). *lnKLsector* indicates the real stock capital per worker intensity (in natural logs). The source is the EUKLEMS database and we have information up to 2009. Between 2009 and

[7] There are certain limitations when measuring financial constraints and attempting to find the proper indicators for carrying out empirical research at the firm level (Czarnitzki and Hottenrott, 2010; Salies, 2010). In this paper, we adopt a direct approach based on the firms' own assessments from the information provided in the CIS in the same way as the rest of the potential barriers (knowledge, market) used in the empirical analysis. This is the only information regarding financial constraints provided by PITEC. Obtaining additional indicators, such as cash flow or dividends, would require merging PITEC with other databases which would present considerable difficulties because of the anonymity requirements.

[8] The Spanish CIS questionnaire considers other alternatives related to the serious delay in the innovation project, but it only appeared in 2004.

2012, we assume a growth rate of the stock of capital intensity equal to the last year (2008–2009). *FinLocReg*; *FinState*, and *FinEur* are dummy variables equal to 1 if the firm receives a financial support from a local/regional government, the State, or Europe. Finally, we also include industry and time dummies to control differences in the probability of abandoning a project and of suffering financial constraints across sectors and over time.

4.4. Descriptive analysis

Table 1 presents the distribution of observations according to whether firms abandon a project or not and according to whether they perceive financial constraints. We observe that 23.57% of potential innovative firms state that they abandon an innovation project during the concept and/or project stage. First, we must highlight that the percentage of firms perceiving financial constraints is larger among the group of firms that abandon an innovation project than those that do not abandon one. Second, differences appear when distinguishing according to the stage: 57.03% of firms that abandon the project once the project has started state they do not perceive any financial constraint, while this percentage diminishes to 48.57% for firms that abandon the project during the concept stage. Third, when comparing firms that abandon during the concept and project stage, the percentage of firms abandoning during the project stage and that perceive external financial barriers is significantly lower than the percentage of firms that abandon during the concept stage. Hence, this preliminary descriptive would indicate a positive association between the perception of financial barriers and the probability of abandoning a project, in particular during the concept stage.

---- Insert Table 1 ----

Additionally, following Canepa and Stoneman (2008), we estimate the Pearson's χ^2 and the likelihood-ratio (LR) test which compare that the rows and columns in the two-way tables are independent. The test statistics suggest that there are differences in the percentage of firms perceiving financial constraints according to whether they abandon or not an innovation project.

Table A-1 provides the overall means of the main variables used in our econometric analysis and compares four groups of firms: (i) firms that do not abandon a project; (ii) firms that abandon a project during any stage; (iii) firms that abandon a project during the concept stage; and (iv) firms that abandon a project once the project has started.

First, it is interesting to note that firms that abandon a project are, on average, older and larger than those that do not abandon a project. *RD* and *RDintensity* are significantly higher for those firms that abandon a project. In particular, firms that abandon during the project stage demonstrate a higher average of R&D intensity. Second, a large percentage of firms state that they perceive some type of knowledge or market barriers. However, this percentage increases up to more than 90% for firms that abandon a project. Third, significant differences

appear when considering the proportion of firms belonging to a group, cooperating with other firms and competing in international markets. In these categories, there are a larger proportion of firms that abandon a project than those that do not abandon. Fourth, the sectoral capital intensity per worker is larger for firms that do not abandon a project. Fifth, firms that do not abandon receive less public support to finance innovation and among those that abandon, firms that abandon during the concept stage receive more public funding. Finally, regarding the number of patents, firms that abandon an innovation project show a larger mean for patents.

---- Insert Table 3 ----

Table A-2 shows the correlations between our explanatory variables. All the correlations show a low level of significance.

5. Econometric methodology

Our aim is to examine the determinants of Spanish firms abandoning innovation projects between 2005 and 2013. In line with previous scholars (Savignac, 2008; Blanchard et al., 2012), we consider that financial obstacles affect the probability of deterring innovation projects. In others words, financial constraints significantly affect the likelihood that firms abandon innovative activities. However, there may be an endogeneity problem since the financial constraints and the abandoning of an innovation project may be affected by common elements of unobservable heterogeneity (for instance the quality of the project). Similar to Savignac (2008) and Blanchard et al. (2012), we employ a biprobit model composed of two equations.[9]

$$FC_{it} = X'_{i,t}\beta_1 + Y'_{i,t-1}\gamma_{11} + \varepsilon_{1i,t} \qquad \text{Eq. [1]}$$

$$ABANDON_{it} = X'_{i,t}\beta_2 + \gamma_{21}R\&Dintensity_{i,t-1} + \gamma_{22}FC_{i,t} + \varepsilon_{2i,t} \qquad \text{Eq. [2]}$$

and where

$$\left(\frac{\varepsilon_1}{\varepsilon_1}\right) \sim N\left\{\binom{0}{0}, \begin{bmatrix} 1 & \rho_{12} \\ \rho_{22} & 1 \end{bmatrix}\right\}$$

[9] According to Savignac (2008), the probability of deterring innovative activities and the presence of financial restrictions must be estimated simultaneously, since there is a strong endogeneity between innovative activities and financial constraints. In other words, financial constraints significantly reduce the likelihood that firms carry out innovative activities and, in counterpart, innovative firms enjoy a higher probability of generating ex-ante internal resources in order to reduce financial restrictions in investment decisions. The bivariate probit model takes the correlations between the likelihood of failure of an innovation project and the facing of financial barriers into account. The bivariate probit estimation, where we assume normality of the error terms, provides a correlation parameter that yields information about the co-variation of the error terms of the two estimations.

The first equation measures the probability that a potentially innovative firm perceives financial constraints. The second equation estimates the determinants of abandoning an innovation project where the estimated value of the financial constraints is introduced.

The first step estimates three different equations according to the type of financial constraints. *FC, FCinternal* and *FCexternal* are dummy variables which indicate that a firm perceives financial constraints, internal financial constraints and external financial constraints[10]. The set of explanatory variables are the following:

1. Firm size: we consider that large firms are in a better position to overcome financial obstacles. We expect that large firms face fewer obstacles than small firms.
2. Firm age: we consider young firms will suffer more financial constraints.
3. R&D: firms investing in R&D will often perceive more financial obstacles.
4. Group: we consider a firm belonging to a corporate group will overcome financial barriers more easily in comparison to an independent firm.
5. Sectoral capital intensity: the sectoral capital intensity per worker in the sector may affect to the financial need to invest and, in consequence, the perception of financial restrictions.
6. Public funding: access to public funding may alleviate financial constraints. We include three dummies identifying firms that have received local or regional, state, or European funding.
7. Sectoral dummies: we consider that firms in some sectors may suffer higher financial constraints due to higher sunk costs or competitiveness levels.
8. Time dummies: during expansion there are better facilities to gain access to financial resources, while during a crisis financial resources decrease.

The second step is to estimate the probability that a firm abandons an innovation project. We consider three dependent variables: i) a dummy variable when a firm abandons a project, regardless of the stage (*AB_conc_proj*); ii) a dummy variable which takes a value equal to 1 when the firm abandons a project during the concept stage (*AB_conc*); iii) and a dummy variable which takes a value equal to 1 when the project is abandoned once the project has started (*AB_proj*). Those three variables will depend on the following explanatory variables:

1. Financial constraints (internal, external or both): we consider that they will increase the likelihood of abandoning an innovation project.
2. Knowledge and Market barriers: given previous literature, we also introduce both barriers since they may also cause a firm to abandon a project.

[10] There is wide-ranging discussion in the literature regarding the determinants of the financial constraints. Recently, Hadlock and Pierce (2010) analyse different financial measures to explain financial constraints. Their results suggest that financial constraints may be reasonably better approximated based on firm age and firm size than with respect to other more complex financial indexes such as Kaplan and Zingales (1997) or Whited and Wu (2006). Their results deal with the fact that young and small firms suffer from "liability of newness" due to the fact that entrants who are characterised by small sizes suffer from lower survival likelihood. This results in them suffering larger financial market failures.

3. Firm age: we consider that young firms will have less experience and they may abandon a project before its completion.
4. Firm size: similarly, small firms may have more problems in continuing with innovation projects. However, large firms usually have a larger portfolio of innovations. Hence, large firms may state more often that they have abandoned a project.
5. Patents: This variable introduces the concept of innovative capability. In line with previous literature (Hottenrott and Peters, 2012), there may be an interaction between a firm's innovative capability and the sensitiveness to perceive financial barriers.[11]
6. Cooperation: firms participating in a project through cooperation may be doing so because the projects are riskier. Consequently, this variable is expected to affect positively the probability of abandoning an innovation project.
7. International markets: firms in international markets are engaged in more intense competition; hence, it is likely that they will carry out more innovation projects.
8. R&D intensity: Potentially innovative firms with higher R&D intensity will be more probable to engage in riskier projects and, consequently, their probability of abandonment may be higher.
9. Sectoral dummies: we consider that firms in some sectors may engage in riskier projects due to the nature of their activities.
10. Time dummies: we include time dummies to control the effect of expansions and crisis on the probability of abandoning innovation projects.

Additionally, we must mention that CIS datasets present a potential endogeneity. Firms may be more likely to indicate 'some' lack of finance the more innovation projects they conduct and thus the amount they invest in R&D. To solve this situation, the estimation methods usually use instrumental variables (Czarnitzki and Hottenrott, 2009). Similarly to Efthyvoloulou and Vahter (2015), we estimate a dynamic equation of the determinants of the R&D intensity depending on the firm age, firm size, group, R&D, cooperation, sectoral R&D intensity, sectoral and time dummies. With this procedure, first, the estimated error terms are introduced in Equations [1] and [2] and, second, the predicted value of the R&D intensity is introduced in Equation [2].

Finally, following Rabe-Hesketh and Skrondal (2013), we apply a refined version of Wooldridge's (2005) model to estimate all the equations. Hence, we add the lagged dependent variable and its initial value, and the within-means of the explanatory variables based on all periods but excluding the first. The time-average of the explanatory variables allow us control for a correlation between the individual specific effects and the time-varying variables

[11] A recursive drawback in these empirical studies is that information about the number of projects that a firm has is unavailable. We correct for this by introducing the number of patents that a firm has. Our results show that those firms with more patents have a greater probability of abandoning R&D projects. The effect of the number of patents is particularly high for firms in the low-tech manufacturing firms and non-KIS services.

6. Results

Table 2 presents the analysis of the effect of financial constraints and other control variables on the probability of abandoning a project.

With respect to the determinants affecting the probability of suffering financial constraints, the main results are the following. First, a clear persistence of financial constraints appears since the lagged value of the dependent variable shows a positive and significant impact. Also, its initial value shows a positive and significant impact. Hence, firms are persistently feeling financial constraints controlling for other variables. Second, some of our control variables, such as firm age, firm size, the R&D activity and the sectoral capital intensity, do not exhibit a significant impact on the probability of perceiving financial restrictions. Controlling for the potential endogeneity, our results do not confirm previous evidence. For instance, Savignac (2008) finds that the probability of financing constraints decreases with firm size and depends on the firms' ex-ante financing structure while Blanchard et al. (2012) assert that firms investing in R&D will be more likely to face obstacles. However, the time-average of belonging to a group affects diminishes the probability of perceiving external financial constraints. Our results would be consistent with Tiwari et al. (2008) and Galia et al. (2012). Their evidence indicates that firms belonging to a group may obtain financial support for their R&D activities more easily when they belong inside a group of firms. If we turn to the public financial variables, one interesting finding is that the sign of the access to State public funds is the opposite of the corresponding time-averaged variable. In particular, firms that have access to State public funds show a lower probability of perceiving external financial constraints. However, the time-average values of the access to State funds shows a positive and significant impact on the probability of perceiving financial constraints regardless of the financial source. The interpretation of this finding is that the access to previous State public funds decreases the perception of financial barriers; however, in the long-run, firms which are accessing more to State public funds have a larger probability to perceive financial constraints. Finally, the time-average of the access to the European funds also shows a positive impact on the probability of perceiving financial funds.

---- Insert Table 2 ----

Concerning the determinants affecting the probability of abandoning a project, our findings are the following. Table 2 presents the estimation of the determinants of abandoning an innovation project (Equations (1 to (3)), secondly the probability of abandoning a project during the concept stage (Equations (4) to (6)), and finally the probability of abandoning once the project has started (Equations (7) to (9)). Each equation will consider our three types of financial constraints, *FC*, *FCinternal* and *FCexternal*.

First, in line with Mohnen et al. (2008) financial constraints in general increase the probability of abandoning a project. However, the distinction with the stage of abandonment seems important given that financial constraints are only significant to abandoning the project during the concept stage, while only the external financial constraints shows a positive

significant impact on the probability of abandoning a project once it has started. One likely explanation may be related to the existence of the high sunk costs of R&D activities. Once a firm carries out R&D activities, other factors may be more important for abandoning a project. Finally, there seems that the effect of external financial restrictions is much more important on the probability of abandoning an R&D project.

Second, our results show that those firms that abandon an innovation project the previous year show a positive impact on the future. Hence, a certain persistence of abandoning a project appears among potential innovative firms.

Third, regarding other barriers related to knowledge and market, they increase the probability of abandoning a project. However, the results are only significant for firms that state the abandonment of a project during the concept stage. This result may indicate the fact that the probability of abandonment not only depends during the initial period on financial constraints but also on other barriers, where the viability and the technical difficulties may also be important.

Forth, with respect to firm age we observe that the impact is not significant. This result may be due to the fact that young firms assume more risks through lack of experience, while older firms will have more experience but also a larger number of R&D projects. Hence, firm age may not show a clear pattern.

Fifth, one interesting finding is that the sign of the lagged firm size is opposite to the corresponding time-averaged variable. The interpretation of this finding is that increasing the number of employees during the previous year may increase the probability of abandoning a project; however, in the long run, firms with larger firm size have a lower probability of abandoning an innovation project. According with Canepa and Stoneman (2008, p. 720) the positive relationship between firm size and the probability of abandoning an innovation project "may reflect the fact that larger firms on average have higher levels of R&D spending and broader production programmes, and thus may have a greater likelihood of engaging in risky projects; as a result they may be more likely to terminate projects".

However, the fact that average value of firm size shows a negative impact may also be related to the greater number of tools that large firms may have. The complex and uncertain nature of the innovation projects causes the need to screen them. There are many techniques to evaluate and choose project portfolios (Archer and Ghasemzadeh, 1999). The complexity of these tools may cause that some firms are not able to treat correctly the risk and uncertainty. Hence, small firms may show a larger propensity to fail innovation projects because they do not have access to these tools and, consequently, they have less capacity to screen those projects. For instance Love et al. (2005) point out for the case of the IT projects that "the lack of risk identification and management is a major contributing factor to project failure – especially for SMEs "frequently suffer from limited IT competencies and poor understanding of IT capabilities and the risks involved. Finally, the higher failure propensity

of small firms may be explained by the lower capacity of small and young firms to appropriate the investment in innovation projects. Our results may show both realities: larger firms have a larger portfolio of innovation projects, but also larger resources to be devoted to assess and screen innovation projects.

Furthermore, the lagged number of patents shows a non-significant impact. However, the time-averaged value shows a significant positive impact, with the exception of the abandonment once the project has started. Hence, those firms that show a larger capacity to formally protect their knowledge have a greater propensity to abandon a project. This suggests that these firms have a larger number of projects and, as a consequence, the probability of having abandoned at least one project is also larger.

With respect to the R&D cooperation, we observe also an opposite sign between the lagged variable and the time-average value. Our results indicate that the lagged cooperation in R&D shows a positive and significant impact on the likelihood of abandoning a project. However, the coefficient of the R&D cooperation is larger when we estimate the probability of abandoning during the concept stage than the probability of abandoning a project once it has started. This result must be interpreted carefully since this variable may indicate that firms that start risky projects will cooperate more frequently. Evidence along this line can be found in Lhuillery and Pfister (2009). Those authors observe that firms which are collaborating are more likely to delay or stop an innovation project because of difficulties encountered in their R&D partnerships. Furthermore, their results show that firms collaborating with their suppliers also face a higher risk of cooperation failures. However, the fact that the time-averaged value shows a significant negative impact on the probability of abandoning may point out that those firms that constantly cooperate are able to reduce the probability of abandoning. The reason may be that firms which are able to establish enduring R&D cooperation with other partners may mitigate the risks and enlarge their capacity to develop innovation projects.

With reference to international competition, the coefficient shows a positive impact on the probability of abandonment. One potential explanation of result is that international competition obliges firms to be more competitive by investing in R&D projects. While in the long-run R&D projects may increase price-cost margins, in the short-run firms have to survive the current international competition and, consequently, they may be more prone to abandon an innovation project. Another explanation may be the fact that internationalized firms may be more able to screen the viability of innovation projects and hence they will be more prone to abandoning. However, the impact is not significant when we distinguish by stage. Furthermore, its time-average value does not show a significant impact. Hence, this may indicate that this negative impact would only have an effect in the short-run.

Finally, the lagged investment in R&D has a positive and significant effect on the likelihood of abandoning a project only once the project has started, while its time-average shows a positive impact regardless the stage. Hence, those firms that show a larger average R&D

investment during the period show a larger probability of abandoning a project regardless the project. Hence, our results may be related to the fact that those firms with higher capacity to invest constantly in R&D activities may have more capacity to carry out new and different projects during the initial stage and, consequently, the probability that they will abandon any given project will also increase.

Robustness checks

As a robustness check, first we analyse the impact of including non-potential innovators in our estimations. In that sense, we are including firms that they did not declare they innovate and they did not face any innovation obstacle. Table 3 shows the results of our main variables which have been estimated similarly to those in Table 2. We observe that there are not significant differences regarding the impact of the financial constraints on the likelihood of abandoning an innovation project.

---- Insert Table 3 ----

Furthermore, previous literature has mentioned the possibility that their results suffer a "survivorship bias" (Mohnen et al., 2008; Landry et al., 2008), since they are not able to "control for firms that did not survive after the failure of an innovation project". In that sense, our results may suffer the same bias since we have all those firms that survived until 2013. However, a few firms are excluded because we are not able to observe them. According with our data, around 4% of firms are not observed at the end of the period.

---- Insert Table 4 ----

Table 4 shows the results for the whole database including non-potential firms regardless of how they are observed at the end of the period. Our results do not show significant differences on the behaviour of the impact of the financial constraints on both cases. Hence, we may confirm our results.

Hence, our robustness checks confirm the existence of a negative impact of the perception of financial constraints on the probability of abandoning.

7. Concluding remarks

The aim of this paper is to analyse the effects of financial barriers on the failure of innovation projects. Although the conceptualisation of failures of innovation projects has received less attention in literature and the specific evidence on their determinants is scarce, empirical findings tend to point out that facing financial barriers increases the likelihood of failure of innovation projects (Mohnen et al., 2008). Our interest is to contribute to the existing

literature by analysing the different effect of internal and external financial barriers on the probability of abandonment during the initial stage of concept and during its development.

The sensitivity of our proxies of financial constraints on the probability of abandonment indicates the necessity to increase the mechanisms that define firms in order to diminish information asymmetries. The existence of higher financial constraints in innovating firms justifies public intervention (Schneider and Veugelers, 2010). Governments should create new mechanisms to promote the access to external funds for R&D projects. We must take into account that banks usually do not have tools to properly measure the risk of innovation projects. However, other variables explain the probability of abandoning a project. In line with previous findings (see Hottenrott and Peters, 2012), money is not the only factor that affects abandoning a project; variables such as the innovative capacity of the firm are also crucial.

Our results may complement previous literature since we are disentangling whether different sources of funds may exert a significantly increased probability of abandoning a project taking into consideration the stage of the project.

We must mention two different drawbacks. First, our proxies for barriers are of subjective nature, being based on the personal appreciation of the respondents. However, we consider a firm suffering from barriers when the respondent states a medium-high level barrier. Second, we ignore the amount of projects that are abandoned. Hence, a firm that abandons one innovation project is considered identical to a firm that abandons three different projects. However, variables such as belonging to a group of firms, firm size and firm age may capture a firm's capacity to carry on innovation projects.

The difficulties for firms to accede to financial funds for their R&D projects are increased by market failures. Hence, governments enact a series of actions to reduce the financial restrictions. Some of these public actions (venture capital funds, loans and public grants) involve the provision of financial instruments and public aid to facilitate access to public resources, while others strengthen structures that facilitate R&D cooperation and knowledge transfer (technological transfer, R&D grants cooperation, universities). Public actions have different impacts on industries and firms. For instance, small firms and KIS services tend to benefit more from the actions related to the reinforcement of structures, such as the creation of scientific parks, which generates an innovative atmosphere and encourages R&D.

Finally, we should remark that the abandonment of an innovation project does not imply a failure. In fact, the lack of financial resources which negatively affect the probability to carry on an innovation project may have positive effects on the future firm's survival likelihood by guaranteeing its financial equilibrium and choosing more efficient projects. Furthermore, our results highlight the complexity of the innovation activity (Mazzucatto, 2013). The fact that other innovation obstacles may impact on the abandonment of a project during the concept stage may reinforce this idea. Hence, our results may cast some doubts in that not

only financial constraints may decrease the failure of innovation projects, while the access to technical knowledge and the market access may benefit the success of innovation projects.

Acknowledgements
Previous versions of this paper were presented at the ·35th DRUID Celebration Conference (Barcelona, Spain, 2013); at the EARIE 2013 Conference (Evora, Portugal); at the XVI Encuentro de Economía Aplicada (Granada, Spain, 2013) and at the XREAP 2013 Symposium (Barcelona, Spain). We would like to thank the participants at these meetings for their helpful comments. Agustí Segarra and Mercedes Teruel thank the financial support of the Ministry of Innovation and Science (project ECO2009-08735) and the Consolidated Group of Research 2009-SGR-907. José García-Quevedo gratefully acknowledges support from the Spanish Ministry of Science and Education (ECO2010-16934) and from the Government of Catalonia (2009SGR102). Agustí Segarra, José García-Quevedo and Mercedes Teruel acknowledge the support of the Xarxa de Referència en Economia Aplicada. We are grateful to Verònica Gombau for her research support. The usual disclaimer applies.

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Table 1.
Number of observations. Distribution of observations according with the FC and whether they abandon or not a project. 2005-2013.

Firms that…	Number of observations	%	Financial constraints (%) Internal	External	Internal and external	No financial constraints
Do not abandon	30,585	76.43%	9,28	7,73	23,03	59,96
Abandon only during the concept stage	3,381	8.44%	11,09	11,33	29,02	48,57
Abandon only during the project stage	2,360	5.90%	9,28	8,31	25,38	57,03
Abandon during concept & project	3,689	9.22%	12,01	10,44	24,97	52,59
Pearson χ^2	= 243.8	Pr = 0.000				
LR χ^2	= 238.3	Pr = 0.000				

Source: PITEC database.

Table 2.
Recursive bivariate probit of the probability of abandoning a project and the probability to suffer financial constraints

	During the concept and the project			During the concept			During the project		
	FC	**FCinternal**	**FCexternal**	**FC**	**FCinternal**	**FCexternal**	**FC**	**FCinternal**	**FCexternal**
AB_conc_proj $_{t-1}$	1.520***	1.521***	1.521***						
	(0.0213)	(0.0213)	(0.0213)						
L.AB_conc $_{t-1}$				1.685***	1.687***	1.687***			
				(0.0233)	(0.0233)	(0.0233)			
L.AB_proj $_{t-1}$							1.559***	1.558***	1.559***
							(0.0246)	(0.0246)	(0.0246)
FC	0.106***			0.130***			0.0512		
	(0.0335)			(0.0358)			(0.0367)		
FCinternal		0.0711**			0.106***			0.0139	
		(0.0347)			(0.0369)			(0.0375)	
FCexternal			0.0918***			0.0906**			0.0699*
			(0.0347)			(0.0368)			(0.0380)
Know $_{t-1}$	0.106**	0.114**	0.114**	0.226***	0.237***	0.237***	-0.0249	-0.0182	-0.0159
	(0.0534)	(0.0532)	(0.0533)	(0.0610)	(0.0609)	(0.0609)	(0.0595)	(0.0593)	(0.0594)
Market $_{t-1}$	0.158***	0.160***	0.163***	0.208***	0.211***	0.214***	0.0830	0.0842	0.0887
	(0.0515)	(0.0514)	(0.0515)	(0.0590)	(0.0589)	(0.0590)	(0.0573)	(0.0573)	(0.0574)
lnAge $_{t-1}$	0.0117	0.0120	0.0013	0.0321	0.0312	0.0241	0.0112	0.00987	0.00353
	(0.138)	(0.138)	(0.138)	(0.149)	(0.149)	(0.149)	(0.154)	(0.154)	(0.154)
lnSize $_{t-1}$	0.232***	0.232***	0.233***	0.148***	0.148***	0.149***	0.239***	0.238***	0.241***
	(0.0502)	(0.0502)	(0.0502)	(0.0549)	(0.0548)	(0.0549)	(0.0564)	(0.0564)	(0.0564)
lnPatents $_{t-1}$	0.0289	0.0283	0.0259	-0.00713	-0.00815	-0.00976	0.0482	0.0477	0.0445
	(0.0296)	(0.0296)	(0.0296)	(0.0324)	(0.0324)	(0.0324)	(0.0329)	(0.0328)	(0.0329)
Coop $_{t-1}$	0.143***	0.144***	0.144***	0.215***	0.216***	0.216***	0.0640*	0.0649*	0.0650*
	(0.0353)	(0.0353)	(0.0354)	(0.0378)	(0.0378)	(0.0378)	(0.0385)	(0.0385)	(0.0386)
InternatMarket $_{t-1}$	0.103*	0.101*	0.100*	0.0290	0.0270	0.0273	0.0880	0.0878	0.0854
	(0.0547)	(0.0547)	(0.0547)	(0.0610)	(0.0610)	(0.0610)	(0.0611)	(0.0611)	(0.0611)
lnRDintensity $_{t-1}$	-0.0024	-0.0024	-0.0024	-0.0010	-0.0010	-0.0010	0.0067**	0.0067**	0.0066**
	(0.0025)	(0.0025)	(0.0025)	(0.0029)	(0.0029)	(0.0029)	(0.0030)	(0.0030)	(0.0030)
Initial values									
AB_conc_proj_1	0.333***	0.334***	0.335***						
	(0.0211)	(0.0211)	(0.0211)						
AB_concept_1				0.364***	0.364***	0.365***			
				(0.0250)	(0.0250)	(0.0250)			
AB_project_1							0.406***	0.406***	0.408***
							(0.0255)	(0.0255)	(0.0255)
FC_1	-0.0054			0.0094			-0.0110		
	(0.0238)			(0.0259)			(0.0263)		
FC_internal_1		-0.0275			-0.00634			-0.0287	
		(0.0260)			(0.0282)			(0.0286)	
FC_external_1			0.0211			0.0297			0.0101
			(0.0246)			(0.0269)			(0.0271)
Time-average variables									
Know_RHS	0.0085	0.0179	0.0039	-0.141*	-0.134	-0.140*	0.222***	0.228***	0.213**
	(0.0758)	(0.0757)	(0.0755)	(0.0828)	(0.0827)	(0.0825)	(0.0861)	(0.0860)	(0.0859)
Market_RHS	0.0361	0.0359	0.0368	0.0560	0.0561	0.0568	0.0061	0.0066	0.0039
	(0.0730)	(0.0729)	(0.0730)	(0.0822)	(0.0821)	(0.0822)	(0.0804)	(0.0803)	(0.0805)
lnAge_RHS	0.0009	-0.0009	0.0122	-0.0132	-0.0135	-0.0049	-0.0197	-0.0197	-0.0108
	(0.135)	(0.134)	(0.135)	(0.146)	(0.146)	(0.146)	(0.150)	(0.150)	(0.150)
lnPatents_RHS	0.0967**	0.0960**	0.0985**	0.137***	0.137***	0.137***	0.0361	0.0351	0.0392
	(0.0383)	(0.0384)	(0.0383)	(0.0417)	(0.0417)	(0.0417)	(0.0417)	(0.0417)	(0.0418)
lnSize_RHS	-0.244***	-0.247***	-0.245***	-0.131**	-0.134**	-0.134**	-0.258***	-0.261***	-0.259***
	(0.0510)	(0.0510)	(0.0510)	(0.0558)	(0.0558)	(0.0558)	(0.0573)	(0.0573)	(0.0573)
Coop_RHS	-0.296***	-0.297***	-0.295***	-0.203***	-0.205***	-0.202***	-0.293***	-0.294***	-0.293***
	(0.0480)	(0.0479)	(0.0480)	(0.0517)	(0.0516)	(0.0517)	(0.0523)	(0.0522)	(0.0523)
InternatMarket _RHS	-0.0812	-0.0786	-0.0790	-0.0262	-0.0228	-0.0247	-0.0678	-0.0668	-0.0657
	(0.0642)	(0.0643)	(0.0642)	(0.0717)	(0.0717)	(0.0717)	(0.0714)	(0.0714)	(0.0714)
lnRDintensity _RHS	0.0726***	0.0727***	0.0722***	0.0517***	0.0518***	0.0513***	0.0657***	0.0657***	0.0654***
	(0.0037)	(0.0037)	(0.0037)	(0.0041)	(0.0041)	(0.0041)	(0.0042)	(0.0042)	(0.0042)
Constant	-1.918***	-1.883***	-1.921***	-2.289***	-2.262***	-2.274***	-2.093***	-2.062***	-2.119***
	(0.113)	(0.113)	(0.113)	(0.131)	(0.130)	(0.130)	(0.130)	(0.130)	(0.130)
	FC	FC_internal	FC_external	FC	FC_internal	FC_external	FC	FC_internal	FC_external
FC $_{t-1}$	1.798***			1.798***			1.798***		
	(0.0187)			(0.0187)			(0.0187)		
FC_internal $_{t-1}$		1.824***			1.824***			1.824***	
		(0.0194)			(0.0194)			(0.0194)	
FC_external $_{t-1}$			1.767***			1.767***			1.767***
			(0.0192)			(0.0192)			(0.0192)
lnAge $_{t-1}$	-0.0790	-0.115	0.0592	-0.0782	-0.114	0.0596	-0.0795	-0.115	0.0595
	(0.129)	(0.132)	(0.131)	(0.129)	(0.132)	(0.131)	(0.129)	(0.132)	(0.131)
lnSize $_{t-1}$	-0.0091	0.0034	-0.0411	-0.0097	0.0019	-0.0414	-0.0091	0.0033	-0.0414
	(0.0457)	(0.0463)	(0.0463)	(0.0457)	(0.0463)	(0.0462)	(0.0457)	(0.0463)	(0.0462)
RD $_{t-1}$	0.0024	0.0130	-0.0005	0.0074	0.0234	0.0019	-0.0013	0.0090	0.0008

	(0.0377)	(0.0385)	(0.0383)	(0.0366)	(0.0374)	(0.0372)	(0.0370)	(0.0378)	(0.0376)
$Group_{t-1}$	-0.0419	-0.0513	-0.0068	-0.0415	-0.0499	-0.0066	-0.0425	-0.0520	-0.0065
	(0.0595)	(0.0604)	(0.0605)	(0.0596)	(0.0605)	(0.0605)	(0.0595)	(0.0604)	(0.0605)
lnKLsector	-0.104	0.0199	-0.0463	-0.104	0.0207	-0.0462	-0.106	0.0179	-0.0464
	(0.105)	(0.108)	(0.108)	(0.105)	(0.108)	(0.107)	(0.105)	(0.108)	(0.108)
$FinLocReg_t$	0.0382	0.0359	-0.0066	0.0384	0.0368	-0.0065	0.0388	0.0367	-0.0063
	(0.0332)	(0.0338)	(0.0336)	(0.0332)	(0.0339)	(0.0337)	(0.0332)	(0.0338)	(0.0336)
$FinState_t$	-0.0463	-0.0214	-0.114***	-0.0460	-0.0211	-0.114***	-0.0462	-0.0211	-0.114***
	(0.0338)	(0.0342)	(0.0343)	(0.0338)	(0.0342)	(0.0343)	(0.0338)	(0.0341)	(0.0343)
$FinEur_t$	-0.0496	-0.0601	-0.0356	-0.0496	-0.0597	-0.0355	-0.0494	-0.0603	-0.0352
	(0.0690)	(0.0683)	(0.0687)	(0.0690)	(0.0682)	(0.0687)	(0.0689)	(0.0683)	(0.0687)
Initial values									
FC_1	0.364***			0.364***			0.364***		
	(0.0196)			(0.0196)			(0.0196)		
FC_internal_1		0.364***			0.364***			0.364***	
		(0.0213)			(0.0213)			(0.0213)	
FC_external_1			0.352***			0.352***			0.352***
			(0.0206)			(0.0206)			(0.0206)
Time-average variables									
lnAge_RHS	0.0894	0.117	-0.0560	0.0886	0.115	-0.0564	0.0897	0.117	-0.0563
	(0.125)	(0.128)	(0.127)	(0.125)	(0.128)	(0.127)	(0.126)	(0.128)	(0.127)
lnSize_RHS	-0.0354	-0.0491	-0.0163	-0.0347	-0.0475	-0.0160	-0.0354	-0.0491	-0.0160
	(0.0465)	(0.0472)	(0.0472)	(0.0465)	(0.0472)	(0.0471)	(0.0465)	(0.0472)	(0.0471)
RD_RHS	0.0611	-0.0192	0.0763	0.0559	-0.0297	0.0737	0.0650	-0.0154	0.0749
	(0.0531)	(0.0542)	(0.0542)	(0.0523)	(0.0533)	(0.0533)	(0.0527)	(0.0537)	(0.0536)
GROUP_RHS	-0.0905	-0.0889	-0.160**	-0.0908	-0.0899	-0.160**	-0.0904	-0.0888	-0.160**
	(0.0646)	(0.0655)	(0.0654)	(0.0646)	(0.0656)	(0.0654)	(0.0645)	(0.0655)	(0.0654)
lnKLsector_RHS	-0.0353	0.0124	-0.0569	-0.0347	0.0137	-0.0567	-0.0357	0.0126	-0.0567
	(0.0869)	(0.0864)	(0.0881)	(0.0869)	(0.0865)	(0.0881)	(0.0868)	(0.0865)	(0.0881)
FinLocReg _RHS	0.0252	0.0315	0.0426	0.0248	0.0297	0.0423	0.0250	0.0310	0.0422
	(0.0490)	(0.0501)	(0.0492)	(0.0490)	(0.0502)	(0.0492)	(0.0489)	(0.0501)	(0.0492)
FinState _RHS	0.121**	0.105**	0.199***	0.120**	0.103**	0.198***	0.122**	0.106**	0.198***
	(0.0509)	(0.0518)	(0.0511)	(0.0508)	(0.0518)	(0.0511)	(0.0508)	(0.0517)	(0.0511)
FinEur _RHS	0.172*	0.135	0.208**	0.173*	0.137	0.208**	0.173*	0.137	0.208**
	(0.0956)	(0.0942)	(0.0955)	(0.0956)	(0.0942)	(0.0955)	(0.0956)	(0.0942)	(0.0955)
Constant	-0.876***	-1.082***	-0.921***	-0.877***	-1.084***	-0.921***	-0.874***	-1.080***	-0.921***
	(0.152)	(0.156)	(0.156)	(0.153)	(0.156)	(0.156)	(0.152)	(0.156)	(0.156)
ρ	0.0249	0.0395	0.0114	0.0152	0.0105	0.0062	0.0551**	0.0768***	0.0103
	(0.0241)	(0.0245)	(0.0244)	(0.0258)	(0.0262)	(0.0257)	(0.0264)	(0.0268)	(0.0267)
χ^2	19567.10	19004.05	18264.58	19998.59	19358.98	18670.76	17885.19	17253.93	16640.23
Prob (χ^2)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations					30,480				

Estimations control for time and sector dummies
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3. Recursive bivariate probit of the probability of abandoning a project and the probability to suffer financial constraints for potential and non-potential firms.

	Probability of abandoning an innovation project								
	During the concept and the project			During the concept			During the project		
	FC	FCinternal	FCexternal	FC	FCinternal	FCexternal	FC	FCinternal	FCexternal
AB_conc_proj $_{t-1}$	1.522***	1.523***	1.523***						
	(0.0212)	(0.0212)	(0.0212)						
AB_concept $_{t-1}$				1.687***	1.688***	1.689***			
				(0.0232)	(0.0232)	(0.0232)			
AB_project $_{t-1}$							1.560***	1.559***	1.560***
							(0.0244)	(0.0244)	(0.0244)
FC $_t$	0.114***			0.137***			0.0559		
	(0.0332)			(0.0356)			(0.0363)		
FC_internal $_t$		0.0767**			0.112***			0.0192	
		(0.0344)			(0.0366)			(0.0371)	
FC_external $_t$			0.0935***			0.0916**			0.0655*
			(0.0345)			(0.0367)			(0.0378)
Initial values									
AB_conc_proj_1	0.326***	0.327***	0.327***						
	(0.0209)	(0.0209)	(0.0209)						
AB_concept_1				0.358***	0.358***	0.359***			
				(0.0249)	(0.0249)	(0.0249)			
AB_project_1							0.399***	0.399***	0.401***
							(0.0252)	(0.0252)	(0.0253)
FC_1	-0.0106			0.00602			-0.0137		
	(0.0236)			(0.0258)			(0.0260)		
FC_internal_1		-0.0321			-0.0103			-0.0336	
		(0.0258)			(0.0281)			(0.0284)	
FC_external_1			0.0178			0.0279			0.0108
			(0.0244)			(0.0267)			(0.0268)
ρ	0.0220	0.0393	0.0098	0.0149	0.0118	0.0066	0.0534	0.0763	0.0113
	(0.0238)	(0.0243)	(0.0242)	(0.0256)	(0.0260)	(0.0256)	(0.0261)* **	(0.0265)***	(0.0266)
χ^2	20026.34	19413.76	18667.54	20470.63	19779.91	19081.05	18258.40	17577.09	16961.08
Prob (χ^2)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations					31,260				

Estimations control for time and sector dummies
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4. Robustness checks.
Recursive bivariate probit of the probability of abandoning a project and the probability to suffer financial constraints for the whole database.

		Probability of abandoning an innovation project								
		During the concept and the project			During the concept			During the project		
		FC	FCinternal	FCexternal	FC	FCinternal	FCexternal	FC	FCinternal	FCexternal
	AB_conc_proj $_{t-1}$	1.519***	1.520***	1.520***						
		(0.0209)	(0.0209)	(0.0209)						
	AB_concept $_{t-1}$				1.682***	1.684***	1.684***			
					(0.0228)	(0.0228)	(0.0228)			
	AB_project $_{t-1}$							1.560***	1.560***	1.560***
								(0.0241)	(0.0241)	(0.0242)
	FC $_t$	0.101***			0.125***			0.0530		
		(0.0328)			(0.0350)			(0.0360)		
	FC_internal $_t$		0.0658*			0.0931***			0.0161	
			(0.0340)			(0.0361)			(0.0368)	
	FC_external $_t$			0.0920***			0.0946***			0.0760**
				(0.0338)			(0.0359)			(0.0370)
Initial values										
	AB_conc_proj_1	0.333***	0.334***	0.335***						
		(0.0207)	(0.0207)	(0.0207)						
	AB_concept_1				0.366***	0.366***	0.367***			
					(0.0245)	(0.0245)	(0.0245)			
	AB_project_1							0.403***	0.404***	0.405***
								(0.0251)	(0.0250)	(0.0251)
	FC_1	-0.0026			0.0105			-0.0099		
		(0.0233)			(0.0254)			(0.0258)		
	FC_internal_1		-0.0250			-0.0014			-0.0303	
			(0.0254)			(0.0275)			(0.0280)	
	FC_external_1			0.0225			0.0259			0.0127
				(0.0241)			(0.0263)			(0.0265)
ρ		0.0335	0.0461	0.0072	0.0238	0.0223	0.0033	0.0576	0.0773	0.0022
		(0.0236)	(0.0241)*	(0.0238)	(0.0253)	(0.0257)	(0.0251)	(0.0259)**	(0.0262)***	(0.0261)
χ^2		20428.93	19881.48	19039.34	20891.89	20257.53	19514.24	18684.59	18046.90	17318.05
Prob (χ^2)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations						31,859				

Estimations control for time and sector dummies
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A-1.
Statistical descriptive. Mean and Standard deviations between brackets. 2005-2013

	(A)	Firrms that abandon a project			
	Firms that do not abandon a project	(B) during any phase	(C) during the phase of concept	(D) during the phase of development	Wilks' lambda F (Prob>F) (A) vs. (B)
AB_conc_proj	-	1.00	1.00	1.00	-
		(0.00)	(0.00)	(0.00)	
AB_concept	-	0.75	1.00	0.61	91620.82
		(0.43)	(0.00)	(0.49)	(0.000)
AB_project	-	0.64	0.52	1.00	54717.37
		(0.48)	(0.50)	(0.00)	(0.000)
FC	0.40	0.48	0.49	0.46	176.30
	(0.49)	(0.50)	(0.50)	(0.50)	(0.000)
FC_internal	0.32	0.38	0.38	0.36	87.92
	(0.47)	(0.48)	(0.49)	(0.48)	(0.000)
FC_external	0.31	0.37	0.38	0.35	118.63
	(0.46)	(0.48)	(0.48)	(0.48)	(0.000)
Age	27.12	28.36	28.74	28.83	28.70
	(19.51)	(20.03)	(20.19)	(20.31)	(0.000)
Size	161.28	228.91	261.71	223.78	73.73
	(534.54)	(985.31)	(1,123.20)	(935.92)	(0.000)
RD	0.66	0.83	0.92	0.81	1061.42
	(0.47)	(0.37)	(0.27)	(0.39)	(0.000)
Group	0.34	0.42	0.44	0.43	210.89
	(0.47)	(0.49)	(0.50)	(0.49)	(0.000)
Know	0.82	0.92	0.94	0.91	598.65
	(0.39)	(0.27)	(0.23)	(0.28)	(0.000)
Market	0.82	0.92	0.94	0.91	590.10
	(0.39)	(0.27)	(0.23)	(0.28)	(0.000)
Coop	0.28	0.45	0.49	0.44	974.50
	(0.45)	(0.50)	(0.50)	(0.50)	(0.000)
InternatMarket	0.71	0.83	0.85	0.83	510.38
	(0.45)	(0.38)	(0.36)	(0.37)	(0.000)
RDintensity	7,196.94	10,805.42	12,007.25	11,189.39	72.63
	(30,359.48)	(49,940.24)	(55,728.57)	(60,638.87)	(0.000))
KLsect	11.73	10.33	10.05	10.57	11.15
	(37.95)	(26.30)	(23.08)	(27.96)	(0.000)
FinLocReg	0.21	0.28	0.30	0.26	186.62
	(0.41)	(0.45)	(0.46)	(0.44)	(0.000)
FinState	0.20	0.29	0.32	0.27	372.17
	(0.40)	(0.45)	(0.47)	(0.45)	(0.000)
FinEur	0.04	0.08	0.09	0.07	192.76
	(0.20)	(0.26)	(0.28)	(0.25)	(0.000)
Patents (+1)	1.44	2.18	2.40	2.29	87.71
	(6.17)	(8.29)	(9.46)	(9.78)	(0.000)
Observations	30,585	9,430	7,070	6,049	

Source: PITEC database.

Table A-2.
Spearman's rank correlation.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
(1) AB_conc_proj	1.000																			
(2) AB_concept	0.834*	1.000																		
(3) AB_project	0.760*	0.479*	1.000																	
(4) FC	0.066*	0.070*	0.033*	1.000																
(5) FC_internal	0.047*	0.048*	0.023*	0.837*	1.000															
(6) FC_external	0.054*	0.055*	0.023*	0.812*	0.592*	1.000														
(7) Age	0.027*	0.031*	0.031*	-0.090*	-0.086*	-0.076*	1.000													
(8) Size	0.043*	0.058*	0.029*	-0.068*	-0.062*	-0.072*	0.201*	1.000												
(9) RD	0.161*	0.222*	0.098*	0.022*	-0.016*	0.025*	0.018*	0.064*	1.000											
(10) Group	0.072*	0.080*	0.057*	-0.138*	-0.143*	-0.126*	0.123*	0.196*	0.127*	1.000										
(11) KLsector	-0.017*	-0.018*	-0.010*	-0.036*	-0.030*	-0.029*	-0.016*	0.001*	-0.063	0.040*	1.000									
(12) Know	0.121*	0.128*	0.082*	0.220*	0.183*	0.191*	-0.019*	-0.007*	0.228*	-0.020*	-0.064*	1.000								
(13) Market	0.121*	0.128*	0.080*	0.184*	0.157*	0.155*	-0.024*	-0.027*	0.201*	-0.019*	-0.063*	0.583*	1.000							
(14) Coop	0.154*	0.170*	0.107*	0.023*	0.006	0.017*	0.021	0.094*	0.290*	0.173*	-0.003*	0.125*	0.101*	1.000						
(15) InternatMarket	0.112*	0.113*	0.088*	-0.006	-0.028*	0.004	0.127*	0.017*	0.197*	0.129*	-0.083	0.111*	0.124*	0.091*	1.000					
(16) RDintensity	0.043*	0.051*	0.037*	0.017*	-0.006*	0.023*	-0.071*	-0.004	0.146*	0.027*	0.004*	0.034*	0.030*	0.129*	0.006*	1.000				
(17) FinLocReg	0.068*	0.084*	0.031*	0.039*	0.029*	0.025*	-0.071*	0.004*	0.301*	0.016	-0.043*	0.121*	0.094*	0.291*	0.070*	0.138*	1.000			
(18) FinState	0.096*	0.111*	0.054*	0.021*	0.012*	0.021*	-0.000*	0.081*	0.315*	0.124^*	-0.026*	0.111*	0.099*	0.324*	0.109*	0.169*	0.314*	1.000		
(19) FinEur	0.069*	0.083*	0.033*	0.040*	0.031*	0.039*	-0.036*	0.027*	0.135*	-0.001	-0.027*	0.056*	0.044*	0.212*	0.042*	0.174*	0.228*	0.280*	1.000	
(20) Patents	0.047*	0.054*	0.043*	-0.015	-0.019*	-0.009*	0.032*	0.076*	0.055*	0.052*	-0.004	0.009*	0.009*	0.062*	0.041*	0.055*	0.051*	0.080*	0.055*	1.000

** signficant at 5%.*
Source: PITEC database.