Technology policy evaluation: The interaction between the financial constraint of firms and level of financial additionality

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3 June 2022

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Preliminary draft

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ABSTRACT

This study analyses the differentiated effects of the public support for private R&D and innovation considering the financial situation of the firm. Two main questions are analyzed. Firstly, do the firms that have less access to funds for RDI –and therefore could depend more on the public support- get more frequently support? And, secondly, do such firms show a higher level of financial additionality than the firms with less financial restrictions?

Despite of the fact that market failures imply basically that firms underinvest in R&D and often lack access to financial markets, only a few papers were detected that analyze the above-mentioned questions and present contradictory non-conclusive results. All of them used only one or two –often dummy- variables as indicator to measure the financial restrictions. Moreover, only four studies analyzed the intermediating role of the financial restriction on the policy impact in terms of the financial additionality and five measures its effect on the degree of participation.

The main novelty of this paper is the simultaneous use of a broad set 17 different indicators (reflecting quantitative data on the firm's liabilities or indebtedness, assets, and liquidity) directly derived from the firms' balance sheet. These were clustered by a factor analysis in 7 synthetic indicators, which are used in an innovation policy evaluation framework based on the Propensity Score Matching Method.

The main findings show that in Spain financial constraints negatively affect the access to public funds. There are significant differences between the level and cost of debt for both probability and financial additionality. Solvency indicators report that solvent firms are negatively discriminated for the likelihood of participation, however we find different effects for the impact depending on the public support that firms receive and their size.

Keywords: Public policy, innovation, financial constraints, evaluation, financial additionality.

JEL classification: G32, O38, H25

1.-INTRODUCTION

Following the theory on economics of innovation several market failures exist, which implies that innovation is a risky activity, causing underinvestment in R&D (Nelson, 1959; Arrow, 1962; Bloom et al., 2010) and makes the access to external private financial markets to finance R&D more problematic (Hall and Lerner, 2010). It could be expected that firms with financial constraints would be supported more frequently. Moreover, the impact in terms of additionality should also be greater for companies that cannot finance their innovative activities with internal funds or other external funds. For these companies, the obtained support implies access to external sources of innovation that they would not have been able to access on their own and the possibility of access to external funds because of certification effect of the support.

This fact would justify public intervention and, therefore, the relationship between the financial constraints of the firm and the policy impact can be considered an important research question though surprisingly its relevance in the policy evaluations is still underdeveloped. Although several studies have already analyzed the effect of financial restrictions on the impact of the policy considering their influence on participation (7 studies), only some of them (4) have analyzed their role in terms of the level of financial additionality. Moreover, all of them used only one or two qualitative indicators about the financial restrictions often based on a binary indicator. In addition, this empirical evidence is based on a set of very heterogeneous indicators of the financial constraints which makes it difficult to compare -or offer a global view- of the observed findings.

The novelty of this paper is the simultaneous use of broad set 17 different indicators (reflecting quantitative data on liabilities or indebtedness, assets, and liquidity) directly derived from the firms' balance sheet. We apply a factor analysis to integrate these measures in 7 synthetic indicators that are used in an innovation policy evaluation framework based on the Propensity Score Matching Method. In fact, two types of policy effects are evaluated and condensed in two research questions. First, are the firms that have less access to internal or external funds for RDI –and therefore could depend more on the public support- more frequently supported? Second, do such firms show a higher level of financial additionality than the firms with less financial restrictions?

Research of this kind confront the issue of selection bias, which arises because public support is not randomly assigned. To overcome this problem, the Propensity Score Matching (PSM) approach is used. According to the research question, we consider two different analyses. In the first stage, we

estimate the probability of being awarded and based in this propensity score (PS), we match each treated firm with an untreated one to obtain the effect at firm level. In the second stage, we regress these individual treatment effects on our synthetic. To this end, we use data from the the Spanish Survey of Business Strategies (ESEE) available as a panel data set for the period 2004-2018 with over 13.000 observations of innovative firms.

This study is structured as follows. The next section a review of the policy evaluations that consider the financial constraints. Sections 3 and 4 describe the methodology the used data set and indicators, with emphasis on the definition of the variables related to the financial area of the company. Finally, section 5 reflects the central part of this study reflecting the profile of firms with a higher/lower probability of participation and level of financial additionality with special attention to the financial aspects. Followed by a section with the main conclusions

2.- EMPIRICAL EVIDENCE OF THE INTERMEDIATING ROLE OF THE FINANCIAL RESTRICTIONS ON THE POLICY IMPACT

The proposed analysis of this paper may be important because since various decades the theoretical and empirical literature underpin the financial situation and constrains are crucial to assure investments in R&D and Innovation (RDI) (Hall, 2002; Oprel and Titman, 1994; Mohnen et al., 2007).

There are various theoretical arguments and practical reasons that make innovation a high-risk activity, which greatly complicates its financing with external funds or make such funds more expensive. Following the theory several obstacles or market failures exist, like the problem of the imperfect appropriation of the results of innovations due to the often non-tacit character of knowledge (Arrow, 1962). Moreover, the problem of asymmetric and/or imperfect information about the future costs of the technologies in development and the real size of the future markets makes innovation an uncertain and risk full technical and commercial activity holding the firm back to invest in such activities (Dosi, 1988). The failures impede the optimum assignment of financial resources for innovation and also implies an obstacle for the firms to obtain external funds on the financial markets (Hall and Lerner 2010, Hall et al, 2016). These obstacles are more remarkable among others for small and medium sized firms (Savignac, 2006 and 2008; Teirlinck, 2017) and for firms doing long-term basic R&D activities with a higher level of technological and commercial risks being activities still far from the momentum

of the market introduction, (Nelson, 1959; Hall and Lerner 2010; Brown et al., 2011). Therefore, firms finance most of their R&D expenditures with internal own funds (Hall,1992 and 2002; Hottenrott and Peters, 2012).

In the context of such market imperfections and given the important social returns of innovations –that would be higher than the private ones– would exist underinvestment on a level below the socially desirable since the access of firms to external private financial markets –and even to use internal funds– to finance R&D activities is difficult (Hall and Lerner, 2010). Firms' owners (including stockholders) and financial institutions often opt to channel their funds to more conservative investment options in less risky markets despite the fact that they generate a lower level of profitability.

On the other side, not all R&D policy programs that subsidize firms are designed to overcome the market failures, though the design of the policies can often be based on more direct practical needs, especially the promotion of competitiveness of the firms on the domestic and export markets or the development or diffusion of more specific key technologies (Blanes and Busom, 2004).

Since the 1980ties a large number of studies evaluated the impact of public support for business innovation and initially most of them only measure the average impact level in terms of financial additionality (see among others Meyer-Krahmer, 1988). In the last decade several studies underpin the differentiated level of impact by types of firms in terms of its structural characteristics and innovative behavior or by the specific features of the policy mix[1]. More recently several studies evaluated the intermediating effect of financial constraints on the impact of the R&D and innovation policies, although the results are not conclusive.

As can be observed in table 1, the empirical evidence on the intermediating role of financial constraints on the policy impact is small and the used indicators are very diverse. Twelve studies were identified[2]. In fact, six studies analyse the relationship of the financial restrictions with the probability of getting support, four do analyse the intermediating effect of such constraints on impact in terms of financial additionality and studies the additionality effect on the introduction of new innovations (output additionality). Six studies used PSM models and five used methods based on instrumental variables,

[1] See among others Czarnitzki et al., 2014 and 2015; Busom et al., 2014; Carboni, 2017; Huergo y Moreno, 2017; Heijs and Buesa et al., 2020.

[2] Though two of them used the firm's size as an explicit indicator for the financial constraint. In our opinion this character of the firm explains much more than only the firm's financial restriction and therefore and are excluded from the following description except mentioned explicitly.

using as depended variable the level of R&D expenditures or innovative results and include an interaction term between the public support and the indicator of financial restrictions.

The studies used a wide variety of indicators in order to capture the financial restrictions. We identified twelve studies that analyses relate the financial constraints and with the policy effects. Despite of the fact that each of them uses one or two variables at the time we still detected 17 different indicators[3] to approximate the firm's financial constraints. In fact, only two indicators were used by more than one studies being the self-assessment of the access to internal or external funds used in two studies[4]. Only 6 of the used indicators had a continuous set of values and 11 are binary ones. Looking to the type of indicators mentioned in the table 1, the following synthesis can be offered[5].

- Four studies included quantitative variables based on the balance sheet of the firms (cash flow, level of assets and of the liabilities)
- Four studies used indicators based on self-assessments of the difficulties to access internal and or external funds (4 studies)
- Four studies are based on external valuation of the credit worthiness of the firm. Some of them based on the a priori stick yards provided by banks or financial institutions and others based on the real assignment or refusal of the application for a credit of the firms.
- Two use different "ad hoc indicators" of the "dependency on external funds"

A last aspect of this short review is on the findings of each of the studies. As can be observed the studies show contradictory results, not even between countries though even the three studies for Spain show some incongruities in their findings (Busom et al., 2011: Acebo et al., 2020; Heijs et al., 2020).

Regarding to the empirical evidence of the effects of the financial restrictions on the degree of participation is not conclusive. Nine models[6] showed a positive effect, six a negative and two a non-significant one. In the case of the additionality effect a similar panorama was observed, six models show a positive relationship -firms with more financial restrictions have a higher additionality effect-

[3] The numbers of indicators for financial constraints mentioned in this paragraph and the rest of the text only refer to the variables used explicitly to analyses its intermediating effects with the policy effects. Those "financial variables" used only as control variables are not taken into account. It would raise the number of different indicators till 26.
[4] Even in this there are small differences in how they operationalized the indicator.
[5] Several studies estimated more than one model or used two indicators in the same model, so the number of models is higher than the number of studies
[6] In fact, 15 of the 19 used variables were binary and the vast majority of them are transformations of initially continuous quantitative or qualitative variables (see table 1)

though two studies obtained the opposite effect and nine found a non-significant relationship. Due to the diversity of the type of indicators used in each of the studies it's difficult to explain why certain differences can exist.

Curiously the ad-hoc interpretation of the results within the policy decision making system can defend each of the found results. The lower level of participation of firms with financial restrictions implies apparently that the public administrations do not attend to the financing problems of companies (Barajas et al., 2017; Carboni, 2011). While the fact that the administrations more frequently finance companies without restrictions in the financial market could be due to the fact that they support, above all, the more financially solid companies with an accumulation of innovative experience that ensures somehow success of the supported projects with good results introduced in the market, the so called "picking up the winner" strategy.

Focusing on the role of financial constraints as mediating/moderating variable we find that previous works find mixed effects. Mateut (2018) find that firms more financially constrained show higher levels of impact from public support. In contrast, Wang et al. (2021) estimate a negative influence of the R&D subsidies in combination with financial constraints. Although, it is remarkable that their results point out that the effect turn positive when a subsample for State owned firms is considered. Similarly, Acebo et al. (2020) carry out the analysis for Spanish firms concluding that financial constraints negatively affect the positive influence of subsidies on private R&D effort. As we mentioned above, the heterogeneity in the indicators used to proxy financial restrictions can lead to contradictory results, for this reason, the need to incorporate a greater number of financial indicators becomes more important to consider the joint effect of these variables.

[TABLE 1 ABOUT HERE]

3.- METHODOLOGICAL APPROACH

We are interested in the causal effect of public support on the private R&D expenditures (RDE). To overcome problems associated with selection bias, we consider the potential outcomes framework. Each firm has a potential outcome under each treatment status: $Y_i(1)$ denote the value of the RDE for individual *i* if it belonged to the treatment group ($D = 1$), and $Y_i(0)$ is the value of RDE for individual *i* if it belonged to the control group ($D = 0$). We wish to estimate the average difference in these

outcomes among treated individuals, the so-called Average Treatment Effect on the Treated (ATET) can be write as:

$$E[Y_i(1) - Y_i(0) \mid D_i = 1] \quad (1)$$

However, the individual treatment effect is unknown, as only one of these two states is observable, because we cannot observe what the subsidized firm would have spent on R&D without the subsidy. Therefore, to estimate the ATET a counterfactual approach is necessary. The unobservable potential outcome of the treatment group $[Y_i(0) \mid D_i = 1]$ can be substituted by the observed outcome of the control group $[Y_i(0) \mid D_i = 0]$. This analysis relies on the Conditional Independence Assumption (CIA). This assumption states that the mean counterfactual outcomes are independent of treatment status given a vector of covariates X_i.

$$Y_i(0), Y_i(1) \perp D_i, \mid X_i \quad (2)$$

This CIA assumptions means that the outcome under the control setting Y (0) is randomly assigned within groups defined by X_i, namely, the receipt of subsidies and potential outcome are independent for firms with the same set of exogenous characteristics (Rubin, 1977). This implies that:

$$E[Y_i(0) \mid D_i = 1, X_i] = E[Y_i(0) \mid D_i = 0, X_i] \quad (3)$$

Another feature the matching procedure relies on, is the overlap assumption. This assumption implies that each individual firm has a positive probability of receiving each treatment level and, moreover, the presence of comparable observations are available for both groups.

$$0 < \Pr(D_i = 1 \mid X_i) < 1 \quad (4)$$

If these assumptions are correct, then we can use the outcome for these matched untreated firms as a proxy for the outcome that would have been observed for the treated firms had they not participated in the programme. Since X_i is high-dimensional and is it impractical to compare with exact strata defined by X_i, a common approach is the Propensity Score Matching (PSM), which match firms on the conditional probability of treatment ($p(x) = \Pr(D = 1 \mid X)$. Rosenbaum and Rubin (1983) shown that if $Y(0)$ is independent of treatment given X_i, it will be also independent of treatment given $p(x)$. Therefore, the dimensionality problem can be addressed matching firms with a similar propensity score. Consequently, we can estimate the ATET averaging the simple deviation of the interest outcome between treated firms and their control matched ones:

$$ATET = E[Y_i(1) \mid D_i = 1, X_i] - E[Y_i(0) \mid D_i = 0, X_i] \quad (5)$$

where $[Y_i(1) \mid D_i = 1,\ X_i]$ represents the outcome of treated firms (Y_i^T) and $E[Y_i(0) \mid D_i = 0,\ X_i]$ is the counterfactual situation ($\hat{Y}_i^C$). The individual treatment effect (α_i) is estimated as the difference in the outcome variable between a treated firm and his contrafactual.

$$\alpha_i = Y_i^T - \hat{Y}_i^C \tag{6}$$

Since the presence of financial constraints, as well as, differences in the characteristics of the firms as their absorptive capacity, path dependency or technological opportunity, could lead to different effects over the individual effort we estimate a model to identify the determinants of the intensity of the financial additionality effect at the level of the individual treatment effect (α_i) as a dependent variable following Chapman et al. (2018); Czarnitzki and Delanote (2015); Czarnitzki and Lopes-Bento (2014), and Heijs and Buesa et al. (2020), in order to capture the heterogeneity of the effects.

$$\begin{aligned}\hat{\alpha}_i = {} & \beta_1 ExternalDebt + \beta_2 DebtCost + \beta_3 Liquidity + \beta_4 OwnFunds + \beta_5 FixedCapital + \\ & + \beta_6 TurnoverRatios + \beta_7 GrowthProspect + \boldsymbol{X}_{i,t-1}\boldsymbol{\gamma} + \varepsilon_i\end{aligned} \tag{7}$$

4. DATA AND VARIABLES

4.1.- Data source, dependent and Treatment Variables

The data used for this paper comes from the Survey of Business Strategies (ESEE) available as a panel data set for the period 2004-2018 being representative for the Spanish industrial firms with more than 10 employees. As usual the evaluation of policy effects of the support for R&D and innovation only the innovative firms are used.

The variable of interest of this paper –the one on which we measure the policy impact in terms of financial additionality or crowding-out effect- consist of the expenditures in R&D and innovation (ERDI) by sales, being the most common indicator used in the existing literature. Using this variable allows us to prevent for the size effect, which may lead to higher effects. In addition, we avoid the effect of prices since, both expenditures and sales, are measured in euros.

An advantage of this database is that the information on the participation in the support programs distinguishes between tax deductions and subsidies for R&D and innovation, thus we can estimate the impact accounting for differences in the nature of the support. Firms are classified in four mutual excluding groups: firms with: “only” tax deductions; “only” subventions; receiving both types of

support; and those without support. In order to estimate correctly the level of impact a PSM model should be applied for each of these combinations, as done by Czarnitzki and Delanote (2015). In synthesis, for each combination of the policy mix we estimate the Average (ATET) and Individual (ITE) Treatment Effect on the Treated on the R&D intensity. Although the OLS regression on the ITE will be done for the whole sample of firms that received support.

4.2.- Measuring the "financial structure" of the firm: a factor analysis approach

The previous studies on this topic used only one or two variables that reflect the firm's financial situation and mostly simplified by binary variable (financially restricted versus non restricted firms). The novelty of this paper is that it uses simultaneously 17 variables that reflect the quantitative information obtained directly from the firm's balance sheet, including its level of assets, liabilities and some indicators of the confidence in the firm's future

A first set reflect the firms' level of short-term liabilities and its non-current long-term debts, representing somehow their creditworthiness or debt. The obtained ratios reflect the ability of a company to meet its short or long-term financial obligations for the foreseeable future. The relative size of the liabilities is relevant because if firms have already a high level of indebtedness probably their access to external financial funds will be more restricted, moreover also their disposal to own or internal funds is not guaranteed. Such restrictions are especially problematic for long term and high-risk full R&D investments. In fact, Lartz and Schut (2005) and Teirlinck (2017) argue that R&D investment cannot be carried out through short-term investments. Another variable that reflects the firm's potential to pay back its credits would be the firms' liquidity in terms of the "debt turnover rates" (sales divided by debts).

A second set of indicators is based on the firm´s solvency distinguishes between the non-current or fixed assets and the current assets in form own financial resources. This last aspect is relevant because, as mentioned, the firms use mainly their own funds to finance R&D.

A third set of variables of this paper measures the level of confidence that investors and other financial institutions could have in the firm's survival. The company's image for future success can be measured by the dynamics or growth in terms of sales (Brown et al., 2011; Delen et al., 2013; Yang et al., 2014) or its level of added value (Delen et al., 2013) or by the ratio of the total amount of own funds divided by the volume of total funds which would reflect the level of self-finance (Hernandez, 2001; Savignac,

2006; Teirlinck, 2017). Other studies use also the change of its liabilities as an indicator of confidence (Sasidharan et al., 2015).

Most of the above mentioned indicators are the typical ones used by banks and investors or by earlier empirical work that study the finance of R&D in enterprises[7]. However, special comments can be made on specific definition of the "cash-flow". This indicator reflects somehow the availability of internal funds for R&D and innovation. The concept of "cash-flow" can be measured in several ways though in this paper –following the work of Hall (1992), Harhoff (1998), and Marra (2007)– it is defined as the difference between the value added of the company minus its personnel costs, adding the sum of internal R&D expenses, being that part of the added value reinvested in internal R&D activities. The cash flow on itself would indicate not only the self-financing capacity, but also the generation of liquidity by a company in a given period.

Although several of these indicators offer different and interesting complementary information of the firm's financial situation, several of them show a high level of correlation. Therefore, its simultaneous inclusion in an econometric model would generate multicollinearity problems, distorting or biasing the results. To overcome this problem without the loss of such a rich information a factor analysis was applied. As can be observed in Table 2, seven factors were extracted and represent 82.61% of the initial variance of the variables[8]. One of the advantages of the factor analysis –compared to other forms of creating combined or synthetic indicators- is that its fusion is based on the correlation between the variables, in other words, all the variables of a factor show a high correlation between them.

It can be highlighted that our factors are the result of one solely factor analysis model. In other words, the authors do not predefine the groups of theoretically similar variables carrying out individual factor analysis for each group. The advantage is that the Varimax adjustment can be applied assuring that all factors are highly orthogonal between each other (Kaiser, 1958), which make the use of econometric models easier. A disadvantage could have been that certain variables entered in an unexpected group, but this was not the case.

[TABLE 2 ABOUT HERE]

[7] Therefore, their relevance and appropriateness are not further discussed in this paper.
[8] The analysis accomplishes with all the statistical requirements for methodological details see Appendix A.

The obtained factors can be classified in three categories: (i) the level and costs of debts (factor 1, 4 and 7); (ii) the level of solvency (factors 3, 5, and 6); (iii) the level of confidence in the firms' future or market success (factor 2). Two of the three factors about the debts of the firm (F1 and F4) offer information on the level of indebtedness or leverage ratios in terms of their assets. One factor measures the amount of debts as a percentage of the firm's own funds (F4) and the other in relation to its total assets (F1). A higher factor score implies higher leverage ratios indicating that a larger part of the company's assets is financed with borrowed money. Moreover, factor 7 include two variables that shows the costs of the debts, being the average cost of long-term debts and the current cost of long-term debt with credit institutions.

Other three factors reflect in different manners the financial solvency of the firm measured as the amount of assets or cash of the firm (F3, F5 and F6). Factor 3 reflects the short-term liquidity level of the firms by two variables that reveals in which ways the cash flows generated by the firm cover the existing debts. Being a kind of turnover rate representing the firm's capacity to payback the short and/or long-term debts with its current liquidity –cash flows- generated by its regular business. Factor 5 has a similar interpretation using the turnover rates in terms of its volume of sales. The sixth factor reflects the long-term solvency of the firm based on the capacity of the firm's non-current assets to back up its debts.

A last factor (F2) reflects somehow the confidence that lenders –investors, banks and other financial institutions- could have in the future success firms in the markets and therefore could be more prone to obtain external funds or credits. Factor 2, therefore, represents the dynamics of the firms by the growth rates of its sales and added value, and by the annual variation of the absolute amount of liabilities or debts. In other words, a higher the factor score would reflect a better potential for the future of the firm.

4.3.- Other independent variables

Propensity Score Matching approach rely on the inclusion of all relevant variables to determine the allocation process (Caliendo and Kopeinig, 2008), with this regard to guarantee the correct application of the methodology the higher number of variables must be included. In addition, in the central part of this paper –the OLS regression of the ITES- the inclusion of the control variables is required to assure

that the observed effect is without any doubt attributable to the financial restriction and is not an apparent causal relationship caused by other relevant variables.

Although, the theoretical framework of R&D and innovation policy evaluation admit the selection problem it does not offer clear set of argument of which variables should be include. Most of previous evaluation studies include a common set of variables and for this paper we introduced a similar set[9]. These studies highlight the need to include variables related with firm's characteristics, both their innovative behaviour and successful innovations, as well as financial constraints. One group reflect the structural characteristics of the firm, especially the size of the firm, its age, and the property structure (individual firms, foreign affiliates, national groups, or public enterprises). A second set of variables collect information on the context in which companies carry out their economic activity. In particular, we control for the technological level of the sector to which firms belong including a set of dummies based on Pavitt's classification; the market's characteristics in which they operate considering their presence in international markets besides the dynamic of its main market and the evolution of its market share. Finally, last set of variables reflect the firm's innovative level in terms of previous successful innovations proxied by the number of patents and of product innovations. Moreover, a set of time dummies is included to correct for the overall macro-economic dynamics, especially for the possible bias generated by the "credit-crunch" during the crisis originated in 2008. For an exact definition and their descriptive statistics of each variable see Appendix B.

5. RESULTS

5.1.- Overall results

Like mentioned above, our models analyze two main questions. Firstly, the relationship between firms' financial constraints and their probability of being supported. Second, the role of these restrictions as key determinant of the financial additionality. Implicitly we also analyze a third aspect based on the simultaneous interpretation of the two basic questions. Is the positive discrimination of firms with certain characteristics (for example, more financial restrictions) justified by a higher level of financial

[9] For a broader discussion on the arguments mentioned to justify the inclusion of these variables see Heijs et al., (2019). A very broad review –although in Spanish- is developed in Heijs and Buesa et al. (2020) and Vergara et al. (2021).

additionality? Or, otherwise, the negative discrimination could be justified due to a lower additionality effect.

In a first step, we use a Probit model to obtain the firm's probability of participate in a public program, then this Probit model is used to determine to what extent firms with the same characteristics are positively or negatively discriminated against by the public administration and also depending on the type of aid received[10] (see Table 3). In this table column (1) offer the results for firm that only receive tax credits; in the column (2) can be seen the estimates for firms that receive direct support, while column (3) reveals the profile of participation for firms with policy mix. In the second stage the PSM calculate the "Individual Treatment effects (ITE)" by subtracting from the value of ERDI by sales of each firm with aid the value of the non-supported firms with the same propensity score and can be used to answer research question two of the paper. Finally, the PSM method calculate the "average treatment effect on the treated" (ATET) for the firms that got subsidies and/or tax advantages calculated as an unweighted average of before mentioned ITE values.

[TABLE 3 ABOUT HERE]

Paying attention to the effect of the policies on private R&D effort, we find that all policies have a positive effect on the R&D intensity (see Table 4[11]) confirming the results found by most policy evaluation on R&D and innovation for Spain (Herrera and Heijs, 2007; Gonzalez and Pazó, 2008; Herrera and Bravo, 2010, Huergo et al., 2016; Huergo and Moreno, 2017). On average, firms with policy mix show a higher estimated effect with expenditures around 1.6 percentage points higher than non-supported ones, although there is not statistical difference between the effects from firms that receive subsidies only and policy mix. This fact is also confirmed by the results of Instrumental Variable (IV) approach, which show that firms with policy mix and subsidies only tend to show similar levels of financial additionality (see Table D1 in Appendix D).

[10] Remember that there are three types of public aid or "treatments" and that these are mutually exclusive

[11] Since PSM is based on observable variables to control for potential selection bias on non-observable variables, we apply a Instrumental Variable (IV) regression to test the robustness of the results. These results are shown in Appendix D.

With regard to the main objective of this paper, the results presented in Table 5 allows us to explore if the existence of financial restrictions has an intermediating role on financial additionality effect. In order to interpret correctly the signs of the regression coefficients it can be highlighted that a negative sign does not imply that the firms with such characteristics lacks financial additionality, though, that the level of financial additionality of firms with such characteristics is below the average level of impact. Moreover, the explanatory power based on the value of coefficient of the different factors can be compared directly using the corresponding statistical tests- because each factor has the same range of values[12].

[TABLE 4 AND 5 ABOUT HERE]

5.2. The Financial constraints of the firms versus the policy impact

The level of indebtedness and its costs

Like mentioned three factors reflect the level of indebtedness. Two of them (F1 & F4) reflect that the relative level of indebtedness has –in global terms- a negative relationship with the probability of getting support. Two reasons could explain this lower degree of participation of the more indebted firms. First, because a substantial number of the more indebted firms cannot apply for tax advantages because probably, they have a low level of benefits or including losses. While in the case of the subsidies, the public agencies could have a conservative selection process avoiding the support companies with a higher level of indebtedness. As for factor 7 regarding the cost of debt, a positive effect is seen, this is due to the fact that they have received support from credit institutions, creating a positive signaling effect for policy makers, which makes them trust companies that have previously been supported to carry out innovative projects or investments.

For the impact (additionality or crowding-out), we see that factors four and seven have a negative sign, following the literature mentioned in section two, the explanation for these coefficients can be found in two reasons, firstly for F4 companies that have to finance their innovative projects with their own

[12] With a theoretical minimum and maximum of -4 and +4 and the average and standard deviation is 0 and 1 respectively

funds are more financially constrained and suffer more than those that can finance their R&D by other means such as bank credit or debt issuance. As for F7, companies that have received support from financial institutions but at a very high cost are more likely to abandon their innovative projects and/or not be able to maintain the initial investment in R&D, so there is a clear substitution of funds in this factor.

The solvency and level of confidence in the future attainment of the firm

In terms of solvency, the model includes three factors that reflect if the firms can accomplish their future obligations and pay back their credits obtained from private or public institutions. In order for the correct interpretation, it should be to take in mind that where a high factor score of the first set of factors implies a worse financial situation in the case of solvency the higher factor values reflect financial better situated firms.

The factors that reflect the short-term turnover rates of the debts by sales and the factor that reflect cash flows (F3 and F5) show –in global terms[13]- that less solvent firms in terms have a higher probability to participate. Consequently, the companies with a low solvency and/or liquidity holdings -that could really need public support in order to finance R&D activities- do get more frequently additional support. In other words, the public agencies cover somehow the needs of the companies with a less comfortable financial situation in terms of short-term solvency. On the contrary the factor (F6) that reflect the long-term solvency of the firm (based on fixed or non-current assets) show a positive relationship with the degree of participation for the case of subventions. E.g. the most solvent firms get less frequently support or self-exclude of participate.

In terms of the effect we find differences between the factors within the solvency group, firstly, we find a positive effect for companies that have large cash-flow holdings (F3), this in turn creates a paradox, since, according to the literature, companies (especially SMEs) need to finance their R&D with this type of internal funds, but we have seen that they effectively suffer a negative discrimination by policy makers because they understand that they do not need this aid, despite the fact that these companies need to accumulate their own funds. However, firms with high non-current asset (F6) clearly generate a crowding-out effect by substituting private for public funds, meaning that these firms

[13] At least in the case of the firms with only tax advantages and those simultaneously tax credits and subsidies

do not really need this public aid because of their financial slack, which allows them to carry out their R&D without public funds.

The model also included a factor that represents somehow the level of confidence in the future success of the firms (F2). This factor, based on the growth of the firm's sales and added value and its rhythm of paying back its debts- show a negative relationship with the level of additionality and a statistically non-significant relationship with the participation probability. In fact, the firms with a higher level of growth in terms of sales and the added value and that paid back their debts more rapidly have a slightly below level of financial additionality though on average level of probability of participation.

5.3- Profiles by some selected structural characteristics of the firms.

This section reflects the results of the established profiles for some of the structural characteristics of the firms. The first one is the size used by some studies as a proxy for the existence of financial constrains (Ugur et al., 2015; Ali Yrkkö, 2005) although it reflects much more aspects of the firm like its critical mass in terms of R&D and sales, its market power and access to complementary assets necessary to commercialize successfully new products (Teece, 1986). With respect participation in the programs, the size reflects a non-linear relationship where especially larger companies participate more. Although most empirical studies (like Herrera and Bravo, 2010; Guerzoni and Raitieri, 2015; Neicu, 2019) detect a higher participation of larger firms, some studies point out not significant relationship (Carboni, 2011; Hottenrott et al., 2017). This maybe because they take not into account the non-linearity. The higher level of participation of large companies is not justified by having a higher level of financial additionality.

The age of the firms -as a variable reflecting the entrepreneurial experience – does not affects the level of participation though older firms show a higher level of crowding-out.

Another outstanding result that emerges from the group of structural variables is that foreign multinational companies are negatively discriminated compared to Spanish multinationals. Such discrimination is observed in a large number of studies (Aerts and Schmidt, 2008; Czarnitzki and Lopes-Bento, 2014; Aristei et al., 2015; Heijs and Buesa et al., 2020). It seems that public agencies try to protect the competitive level of domestic firms to the detriment of international firms. Although we have not found significance in the effect of these variables MNEs have shown to play a fundamental

role in the development of companies and regions through the presence of spillovers effects (Elekes et al., 2019; Barge-Gil et al., 2020)

Regarding the block of variables reflecting the innovative behavior of firms, it is observed that more innovative firms more frequently receive state aid, being a conclusion very similar to the results in previous studies for Spain (see among others Busom et al., 2014; Herrera and Heijs, 2007; Heijs and Buesa et al., 2020) and other countries (Czarnitzki and Licht, 2006; Hud and Hussinger, 2015; Hottenrott et al., 2017.). Moreover, the most innovative firms –in terms of patents- show also a higher financial additionality effect.

6.- CONCLUSIONS AND FINAL COMMENTS

The theoretically framework of economics of innovation underpin that a free-market situation leads to under-investments in R&D and the correction of this problem would justify the public support. Moreover, as mentioned by (Czarnitzki and Lopes-Bento, 2014; p.14) the *"potential lenders may be less willing to finance R&D when compared to investments into fixed assets because of the higher uncertainty of returns and lower inside collateral values as R&D is immediately sunk when expensed (see e.g. Hall and Lerner, 2010, or Czarnitzki and Hottenrott, 2010).* The market imperfections based on the lack of appropriability of the results and of the commercial and technical risks withhold both, the firms to invest in RDI with internal funds and even more important withhold the banks and other financial institutions provide credits or other external funds for such type of activities. In fact, banks prefer to finance investments in project that are based on tangible and/ or fixed assets that can back up the credits. This means that the public support for investments R&D and innovation would be crucial for firms that lack access to internal or external funds, and it could be expected that the support of firms with higher financial obstacles would generate a higher level of additionality than the ones with a better financial situation.

Curiously, policy evaluations have not paid much attention to the relationship between financial constraints and the impact of policies. The few studies that offer empirical evidence are all based on one or two variables that reflect the financial restrictions and the majority used only a binary indicator. The main novelty of this paper is the more comprehensive approach to measure the financial constraints of a firm. It used a broad set of 17 complementary quantitative continuous indicators with data coming directly from the balance sheets of the firms, reflecting the company's level of assets, its

liabilities and some indicators of confidence or image of the firm. These 17 variables were combined by a factor analysis in seven synthetic variables or factors that were used to estimate each of the models. Concluding, the most novel aspect of this study is the in-depth analysis of the relationship between the firm's financial situation and the impact of public policies to promote private R&D in terms of their participation in the programs and the level of additionality effect. Therefore, we offered some interesting fresh empirical facts. At the same time new questions may arise after the completion of this study, we believe that it is necessary to further develop this field, for example there are still pending financial estimates from other countries so that the results can be compared at a global level, another pending question to develop would be to find new estimation methodologies that can reliably demonstrate the implication of financial variables in this type of studies.

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TABLES

Table 1.- Synthesis of the empirical evidence

	Composition of the indicators (Definition and background of indicator)		**Specific use of the indicator** For what is it used and how (transformation)			**Type of model, specific dependent variables and empirical result** Main result of the Intermediating role of the financial constraints on the financial additionality (FC) and the Prob. of participation (PP)		
Study (1)	Short definition (2)	Type (3)	Used for (4)	How is it used (5)	Type of variable (6)	Type of model (7)	Definition dependent variable (8)	A positive effect means that constraint firms participate more or have a higher additionality (9)
Busom et al. (2011)	• Dummy: At least one of 2 barriers for innovation is valued as important (lack of internal or external funds)	• Opinion	PP effect	Qual-SAS	Binary	Probit	PP. subsidies, tax credits or both	• PP effects for only tax: Negative for large and SMEs • PP effects for only subsidies: Positive for large and SMEs • PP effects for getting both: negative for SMEs and N.S. for large ones
Carboni (2017)	• Absolute amount of total debt • Credits are restricted (did the firm require extra credits?. If yes financial constraints exist)	• Debt • Opinion	PP effect PP effect	Quant. Qual-SAS	Contin Binary	Probit PSM	PP. Grant or subsidies	• PP effects – Negative for the debts • PP effect - positive for firms with financial constraints • The subsidies improved the firms access to credits on the financial market
Czarnitzki and Lopes-Bento (2014)	• Capital intensity: Total fixed assets/employment • Price cost margin: indicator for the availability internal funds (sales – staff cost – material costs) / sales)	• Assets • Profits	PP effect PP effect	Quant. Quant.	Contin Contin	PSM Probit	PP. in EU or National aids	• PP effects – Positive (for capital intensity for EU support (not for national support) • PP effects – Negative for the Cost Price Margin for geographic areas
Aristei et al. (2015)	• Firms whose applications for credits were denied • Firms relying on bank loans to finance R&D their activity	• Cre-worth • DEP-EX-F	PP effect PP effect	Qualit. Qualit.	Binary Binary	Probit PSM OLS	PP Gran or subsidies	• PP effects – non-significant for firms who´s request for credits was denied • PP Positive: For Spain, France, Italy and the UK the firms relying heavily on bank loans participate more in subsidies (e.g. have a higher probability to get funds) while for Germany a non significant relationship was found.
Jaffe and Le (2015)	• Easy/difficult to access to capital	• Cre-worth	PP effect	Qualit.	Binary	Probit PSM	PP. National programs	• PP effects – Higher difficulties for access leads to a higher probability of suppor
Ugur e.a. (2015)	• Turnover (size of the firm) as a proxy for "cash flows"	• Size-Sales	PP effect AF Control	Quant.	Contin	Probit Other	PP. EU or UK (national) aid AF. ERD-Int (Log)	• PP effect – Positive (size by sales) • A structural model with selection or the endogenous binary selection model
Heijs et al. (2020)	• Binary Var, (=1) if at least one 3 barriers is valued as important (lack of internal or external funds; high innovation costs.	• Opinion	FA & PP effect	Qualit.	Binary	Probit PSM	PP effect FA intensity (net ERD-S) FA Probability of the firm	• PP effects – Negative • FA effect on the probability of a firm showing FA – Not significant • FA effect on the intensity of the FA effect – Not significant
Ali-Yrkkö (2005)	• Employment (size) as proxy for financial restrictions • A firm is considered indebted if its interest rate expenditure exceeds its operating profit. • Absolute sales • Absolute long term profits • Absolute debts	• Size-labour • Debt • Sales • Profits • Debts	AF effect AF effect Control Control Control	Quant. Quant. Quant. Quant. Quant.	Bin Bin Contin Contin Contin	OLS with IV	FA. RD-Absolute	• FA effects – Negative (a smaller AF in smaller -e.g. financially constrained- firms) • • FA effects – NS (indebted vs non-indebted firms) • Using a sample of high tech firms (electronics and electro-technical, mechanical engineering and metals industries).
Acebo et al. (2020)	• Credit rating of a renowned financial institution • Cash flows/Total assets • Financial effort/ Total assets	• Cre-worth • Solvency • Solvency	FA effect Control Control	Quant. Quant. Quant.	Bin Contin Contin	OLS-VI (GMM)	FA. Growth of ERD by total assets	• FA effect – Positive Negative (sign mentioned in the text and the table with results is not equal, the finding of the table is used).

Wang et al. (2021)	• "New" Index Kaplan-Zingales of financial constraints • Return on assets (ROA) • Sales growth • Cash holdings Ratio to total assets • long-term debt Ratio to total assets (LT leverage)	• Cre-worth • Solvency • growth • Solvency • Debts	FA effect Control Control Control Control	Quant. Quant. Quant.	Contin Contin Contin	OSL-IV OLS - FE	FA. Net ERD intensity (On PSM based samples)	• FA. Effect positive for the whole sample • FA. Effect positive for state-owned Chinese firms • FA. Effect non-significant for private-owned Chinese firms
Hyytinen & Toivanen (2005)	*The study use of* ***industry level indicators*** *for:* • Dependency on external funds: fraction of total debt and equity that is attributable to corporate outsiders • Did external funds enable "Excess" growth (yes/no) • Profits (positive vs negative) • Change profits in last 3 years (higher vs lower)	• DEP-EX-F • Growth • Profits • Profits	AF & PP effect	Quant. Quant. Quant. Quant.	Contin Binary Binary Binary	Tobit model	FA. ERD OA. Sales growth	• FA effect Positive • OA effect: Positive • Government funding disproportionately impact in firms in industries that are more dependent on external finance. Firms in such sectors that get subsidies invest more in R&D and are more growth-oriented than the ones without support)
Cecere et al.. 2020	• lack of internal or funds; • lack of external financing;	• Opinion • Opinion	OA effect PP effect	Qualit Qualit	Binary Binary	Logistic regres.	OA. Intro. "eco-innova-tions" in SME (yaes/no)	• OA effect – Positive (The interaction term between public support and the lack of "external funds" reflect a higher positive output additionality for firms lacking funds than the financially less constrained ones. A fact confirmed for the whole sample and the small firms and not for the medium sized ones. • OA effect – non significant (The lack of internal funds is not related)

.- Column 1 indicates the review paper
.- Column 2 offers a short description of each variable
.- Column 3 classifies the indicator in the following categories; Debt, Assets, Profits, (solvency (Liquidity), Growth, Dependence on external funds (DEP-EX-F) or the opinion or self-assessment of the firms about its financial constrain
.- Column 4 show which indicators are used to analyse the intermediating effects and for which form of impact: the financial additionality (FC) and the Prob. of participation (PP)
.- Column 5 explain the inherent characteristic of the variable before its final transformation differentiating quantitative (Quan) versus qualitative (Qual) ones
.- Column 6 explain the inherent characteristic of the variable once its values were transformed for its used in the estimated models
.- Column 7 indicates the used methods or models like the generalised method of moments-system GMM-SYS; Instrumental variables (IV) and fixed effect (FE) and the PSM
.- Column 8 describes the depended variable used as an indicator of the policy effect (variable of interest)
.- Column 9 offers a short review of the found results in terms of the Probability of Participation (PP), the level of Financial additionality (FA) or Output Additionality (OA).

Table 2.- Description of the factors

Factors	Variables included in the factor
F1. Debt (1): as percentage of total funds	Short-term debt divided by total funds
	Total debt divided by own funds
	Total amount of own funds divided by total funds
F4. Debt (2): as percentage of own funds	Short-term debt divided by own funds
	Long-term debt divided by own funds
	Cash flow* divided by own funds
F7. Debt (2): Costs in "interest rates"	Average cost of long-term debt with credit institutions
	Current cost of long-term debt with credit institutions
F3. Solvency (1): Liquidity in terms of cash flows	Cash flow* divided by short-term external debt
	Cash flow* divided by total external debt
F5. Solvency (1): Liquidity in terms of turnover ratios or sales	Sales divided by total liabilities
	Sales divided by total external debt
F6. Solvency (3): Liquidity in term of non-current assets	Fixed capital divided by total liabilities
	Fixed capital divided by own funds
F2. Firms' future potential (Growth rates)	Change in liabilities between two periods
	Change in sales between two periods
	Change in value added between two periods

Table 3.- Determinants of the participation. Probit model

	(1)		(2)		(3)	
VARIABLES	**Tax credits only**		**Subsidies only**		**Policy Mix**	
	dy/dx	S.E	dy/dx	S.E	dy/dx	S.E
F1. Debt (1): as percentage of total funds	-0.027***	0.008	0.006	0.007	-0.024***	0.007
F4. Debt (2): As percentage of own funds	-0.002	0.007	-0.017***	0.006	-0.004	0.006
F7. Debt (3): Costs in "interest rates"	0.006*	0.006	-0.001	0.005	0.002**	0.001
F3. Solvency (1): Liquidity in terms of cash flows	-0.017	0.014	-0.022	0.016	-0.063***	0.017
F5. Solvency (2): Liquidity in terms sales or turnover ratios	-0.018**	0.008	0.004	0.004	-0.019***	0.007
F6. Solvency (3) : Liquidity in term of non-current assets	0.004	0.007	0.020***	0.005	0.022***	0.006
F2. Firms' future potential (Growth rates)	0.002	0.003	-0.002	0.007	0.006	0.007
S. traditional consumer goods	-0.014	0.023	-0.022	0.019	-0.064***	0.022
S. intermediate goods suppliers	0.015	0.030	0.027	0.023	-0.017	0.026
Sector of specialised suppliers	0.027	0.027	0.057***	0.022	0.012	0.024
Sector of scale-intensive and assembly-intensive goods.	0.114***	0.031	0.015	0.030	0.058**	0.027
National MNE	-0.014	0.021	0.032*	0.019	0.055***	0.018
Foreign MNE	-0.066***	0.019	-0.052***	0.018	-0.070***	0.019
Age (log)	0.016	0.013	-0.006	0.011	0.003	0.011
Size (log.) t-1	0.182***	0.040	0.070***	0.025	0.092***	0.030
Size squared (log.) t-1	-0.011***	0.004	-0.002	0.002	-0.003	0.003
Productivity (log.) t-1	0.062***	0.014	0.015	0.011	0.053***	0.014
Market share: recessive	-0.054***	0.018	-0.026*	0.014	-0.011	0.015
Market share. expansive	-0.007	0.015	-0.038***	0.014	0.007	0.012
Dynamism market recessive	0.006	0.015	0.036***	0.013	-0.007	0.014
Dynamism market expansive	-0.020	0.016	0.020	0.015	0.009	0.014
Low exporter	-0.034*	0.019	-0.016	0.016	-0.028*	0.017
High exporter	0.016	0.017	0.027*	0.015	0.023	0.015
Patents t-1	0.035**	0.014	0.029**	0.012	0.040***	0.012
Technological effort t-1	0.011***	0.003	0.016***	0.003	0.017***	0.003
Innovations t-1	0.041***	0.013	0.027**	0.011	0.060***	0.011
Observations	5,598		5,393		5,548	
Wald test dummies						
Sectoral (chi2(4))	30.61***		38.54***		62.50***	
Years (chi2(8))	35.97***		33.47***		13.02***	
LR (chi2(33))	347.6		316.9		453.8	
Log of likelihood	-2,185.1		-1,885.0		-1,858.0	
Pseudo R2	0.165		0.160		0.266	

Notes: ***: p-value<0.01, **: p-value<0.05, *: p-value<0.1. Marginal effects (*dy/dx*) are calculated at sample means. S.E. = Clustered standard errors at firm level. LR-test: Likelihood-ratio test of the joint significance of all regressors. The model includes the constant and sectoral and time dummies.

Table 4.- Average effect on the treated sample ("ATT") on gross R&D intensity

Treatment	ATET	S.E
Tax credits only	0.003**	0.001
Subsidies only	0.013***	0.002
Policy mix	0.016***	0.002

Notes: ***: p-value<0.01, **: p-value<0.05, *: p-value<0.1. Average treatment effect on the treated calculated with a matching procedure using a technique “nearest neighbor” with matching 1:1 and band wide at 5%. Exact matching is required on year and sector dummies.

Table 5.- Determinants of financial additionality: OLS regression on the ITEs

Dependent variable: Pooled ITEs for R&D intensity						
VARIABLES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Subsidies only	0.007***	0.007***	0.007***	0.005**	0.006***	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Policy Mix	0.013***	0.013***	0.012***	0.012***	0.012***	0.012***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Sector traditional consumer goods	-0.003*	-0.002	-0.003	-0.003	-0.004**	-0.004*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Sector intermediate goods suppliers	-0.002	-0.003	-0.004	-0.003	-0.004	-0.003
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Sector of specialised suppliers	0.006*	0.005*	0.004	0.005	0.003	0.003
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Sector of scale-intensive and assembly-intensive goods.	-0.004	-0.005	-0.006**	-0.005*	-0.006**	-0.005*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
National MNE	0.005**	0.004*	0.002	-0.000	0.000	0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Foreign MNE	-0.000	-0.000	-0.000	0.001	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Age (log)	-0.003*	-0.003*	-0.003**	-0.003**	-0.002	-0.003*
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
Size (log) t-1	-0.037***	-0.038***	-0.038***	-0.042***	-0.041***	-0.041***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Size squared (log) t-1	0.003***	0.003***	0.003***	0.003***	0.003***	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Productivity (log) t-1	-0.004**	-0.005**	-0.005**	-0.005**	-0.009***	-0.009***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Market share recessive		0.001	0.002	0.001	0.001	0.001
		(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Market share expansive		0.002	0.001	0.001	0.001	0.001
		(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Dynamism market recessive		-0.007***	-0.008***	-0.009***	-0.009***	-0.009***
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Dynamism market expansive		-0.004	-0.004	-0.005*	-0.005*	-0.005*
		(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Low exporter		-0.003	-0.003	-0.003	-0.003	-0.003
		(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
High exporter		0.001	0.001	0.001	0.001	0.001
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Patents t-1			0.010***	0.010***	0.009***	0.009***
			(0.002)	(0.002)	(0.002)	(0.002)
Innovations t-1			0.001	0.002	0.002	0.002
			(0.002)	(0.002)	(0.002)	(0.002)
F1. Debt (1): as percentage of total funds				0.001	0.001	0.001
				(0.001)	(0.001)	(0.001)
F4. Debt (2): As percentage of own funds				-0.008***	-0.008***	-0.008***
				(0.001)	(0.001)	(0.001)
F7. Debt (3): Costs in “interest rates”				-0.005**	-0.005**	-0.005**
				(0.002)	(0.002)	(0.002)

F3. Solvency (1): Liquidity in terms of cash flows					0.013***	0.013***
					(0.003)	(0.003)
F5. Solvency (2): Liquidity in terms sales or turnover ratio					-0.001	-0.001
					(0.001)	(0.001)
F6. Solvency (3): Liquidity in term of non-current assets					-0.001*	-0.002*
					(0.001)	(0.001)
F2. Firms' future potential (Growth rates)						-0.003**
						(0.001)
Constant	0.182***	0.190***	0.191***	0.198***	0.241***	0.243***
	(0.028)	(0.028)	(0.027)	(0.027)	(0.031)	(0.031)
Observations	2,659	2,659	2,659	2,659	2,659	2,659
R-squared	0.083	0.088	0.105	0.136	0.145	0.146
Sectoral dummies	2.587**	2.093*	2.335*	2.350*	2.234*	2.022*
Time dummies	0.585	0.911	0.998	0.797	0.730	0.741
Test: Subidy only=Policy Mix	5.995**	4.964**	5.024**	6.583**	7.321***	7.009***

Notes: ***: p-value<0.01, **: p-value<0.05, *: p-value<0.1. Robust standard errors in parenthesis. The model includes the constant and sectoral and time dummies

APPENDIX

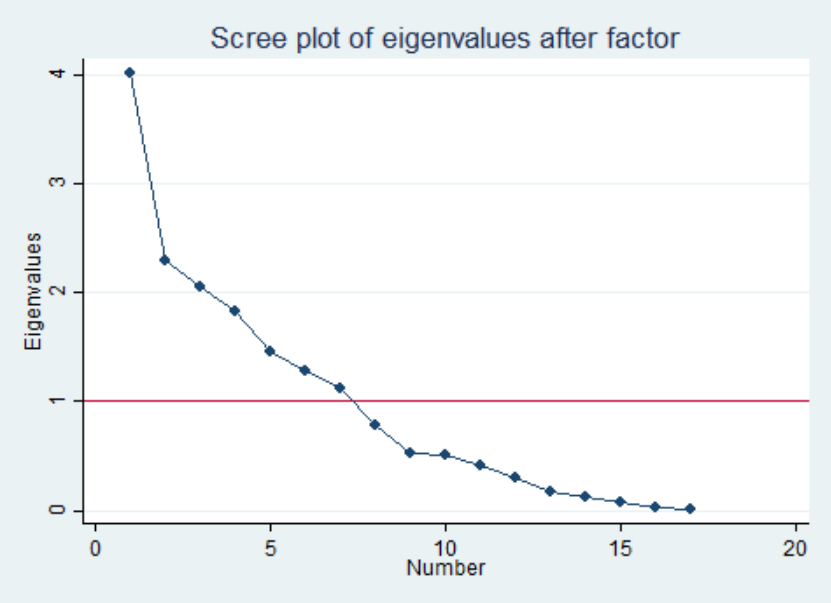
Appendix A: Characteristics and results of the factor analysis

Methodological Box 1: The application of factor analysis: a methodological approach

With regard to the factor analysis carried out in this study, information on the methodological decisions adopted and the tests that justify the reliability of the model are included in this annex.

Firstly, it was necessary to decide the number of factors to extract from the sample of variables, for which it was decided to use the latent root criteria, the base of this criterion is that each factor to be considered statistically significant must exceed unity, this is due to the fact that within each factor the variables initially contribute an absolute value of 1 in their variance, Therefore, if a factor does not manage to exceed unity, it is because it does not explain a sufficient level of variance of the variables. This may be due to the fact that from a certain number of factors, a sufficient number of variables are no longer "grouped" or that although they do manage to "group" a sufficient number, this is small and therefore not statistically significant (Hair et al., 2009).

Graph A1: Eigenvalues



As can be seen in the graph and with the above, the total number of factors that we will use in this analysis is 7 (the same that have exceeded unity and therefore are considered statistically significant), these represent exactly 82.61% of the total accumulated variance of all the financial variables that we had at the beginning, being these 17.

Having obtained the optimal number of factors and having decided on the most appropriate factor analysis technique for our model, it is time to perform the rotation of factor loadings. The rotation of factors or factor loadings is necessary to simplify and clarify the results obtained from this technique. (Osborne et al. 2014). What we ultimately seek with rotation is to redistribute the variance of the factors

we have extracted (which are unrotated) and to achieve a clearer and more statistically significant factor pattern.

Two main rotation techniques can be distinguished, oblique and orthogonal factor rotation. In our work we will use orthogonal rotation, as this is the most commonly used technique in most studies, due to the fact that it has a number of advantages over oblique rotation. Therefore, we will use a VARIMAX rotation (Kaiser, 1958), in which the variances of the variables that make up the factors are maximised. The advantage of VARIMAX is that, despite seeking to maximise the variances, it also seeks to simplify the factor loadings as much as possible through simplification in the columns of the factor matrix; normally the factor loadings resulting from this method obtain values of between -1 and +1, which indicates a clear positive or negative association between the variable and the factor. And we will only consider significant the variables of each factor whose loadings are greater than 0.40 in absolute terms. (Hair et al. 2009; Farrell and Rudd 2009).
Concluding, the initial financial variables are synthesised into 7 factors, which reflect various financial domains, among them, there are two factors reflecting indebtedness at the firm level (measured through debt structure and credit debt, corresponding to the first and seventh factor respectively), three factors correspond to financial solvency (reflected through various types of internal funds and resources of the company), one factor measures confidence or business success (through various ratios of financial growth of the company), finally, one factor refers to turnover ratios.

Table A1: Factor loadings

Variables	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Uniqueness
Short-term debt divided by total funds	0,557							0,033
Total debt divided by own funds	0,982							0,071
Total amount of own funds divided by total funds	-0,891							0,109
Change in liabilities between two periods		0,795						0,357
Change in sales between two periods		0,845						0,283
Change in value added between two periods		0,813						0,293
Cash flow* divided by short-term external debt			0,901					0,145
Cash flow* divided by total external debt			0,881					0,124
Short-term debt divided by own funds				0,701				0,242
Long-term debt divided by own funds				0,956				0,073
Cash flow* divided by own funds				-0,642				0,329
Sales divided by total liabilities					0,943			0,058
Sales divided by total external debt					0,734			0,082
Fixed capital divided by total liabilities						0,925		0,048

Fixed capital divided by own funds						0,776		0,033
Average cost of long-term debt with credit institutions							0,825	0,278
Current cost of long-term debt with credit institutions							0,871	0,238

Appendix B. Descriptive statistics of the variables[14]

Variable	Type	Definition	Min	Max	Average	S.D
Sector traditional consumer goods	Discrete	=1 if the activity falls under "traditional producers of consumer goods". CNAE-93 151 to 223; 261-268; 361-372.	0	1	0.520	0.499
Sector supplier dominated	Discrete	=1 if the activity is encompassed in intermediate goods suppliers. CNAE-93 271-287.	0	1	0.159	0.366
Sector intermediate goods suppliers	Discrete	=1 if the activity is covered by specialised suppliers. CNAE-93 251-252; 291-297; 300-335.	0	1	0.117	0.322
Sector of specialised suppliers	Discrete	=1 if the activity is encompassed in scale-intensive and assembly-intensive goods. CNAE-93 311-343.	0	1	0.134	0.341
Sector of scale-intensive and assembly-intensive goods.	Discrete	=1 if the activity is encompassed in science-based goods. CNAE-93 241-247; 351-355.	0	1	0.067	0.251
Size (log)	Continue	Number of total employed in the firm	0.693	9.616	4.216	1.441
Size squared (log)	Continue	The square of the variable “Size”	0.480	92.468	19.859	13.445
Age (log)	Continue	Number of ages of the firms	0.693	5.198	3.201	0.655
Foreign MNE	Discrete	=1 if the company's external capital is greater than 10% of total capital and not is a family firm	0	1	0.124	0.204
National MNE	Discrete	=1 if the company's external capital is minor than 10% of total capital and have inversions in firms that are not spaniards	0	1	0.216	0.198
Productivity (log)	Continue	Defined as the company's value added by the total number of employees	1.698	15.129	10.351	0.951
Market share recessive	Discrete	= 1 if the market share of the firm it’s recessive	0	1	0.534	0.498
Market share expansive	Discrete	= 1 if the market share of the firm it’s expansive	0	1	0.11	0.313
Dynamism market recessive	Discrete	= 1 if the industry market of the firm it’s considered like recessive	0	1	0.613	0.486
Dynamism market expansive	Discrete	= 1 if the industry market of the firm it’s considered like expansive	0	1	0.103	0.304
Low exporter	Discrete	=1 if the company exports less than 33% or none of its total sales.	0	1	0.730	0.443
High exporter	Discrete	=1 if the company exports more than 66% of its total sales.	0	1	0.112	0.315
Patents	Continue	Total number of patents registered both in Spain and abroad	0	1051	12.37	19.99
Technological effort	Continue	Defined how the total expenditure in R&D and technological import divided by the sales	1	3266.3	1.052	21.648
Innovations	Continue	Total number of innovations in products and process	0	489	46	32.31

[14] Remember that the factor scores have theoretically a value range from -4 to +4 with an average of zero and a standard deviation of 1

Appendix C: Matching procedure and validity tests

Table C1. Quality of the matching procedure: Comparing the average values for the variables before and after matching for the treatment "only subsidised"

Subsidies only	Before Matching				After Matching		
Variables	Treated	Control	p-value		Treated	Control	p-value
F1. Debt (1): As percentage of total funds	0,134	0,018	0,003		0,110	0,065	0,394
F4. Debt (2): As percentage of own funds	-0,229	0,048	0,000		-0,182	-0,258	0.121
F7. Debt (3): Costs in "interest rates"	0,005	-0,005	0,784		0.136	0.085	0.271
F3. Solvency (1): Liquidity in terms of cash flows	-0,041	0,003	0,290		-0,052	-0,067	0.387
F5. Solvency (2): Liquidity in terms sales or turnover ratio	-0,058	0,024	0,032		-0,012	0,031	0.434
F6. Solvency (3): Liquidity in term of non-current assets	0,116	0,002	0,003		0,085	0,079	0,915
F2. Firms' future potential (Growth rates)	0,009	0,007	0,971		0,019	-0,047	0.157
National MNE	0,232	0,091	0,000		0,186	0,209	0,281
Foreign MNE	0,219	0,179	0,007		0,223	0,224	0,949
Age (log)	3,432	3,343	0,000		3,408	3,437	0,387
Size (log.) t-1	5,412	4,415	0,000		5,204	5,241	0,566
Size squared (log.) t-1	31,091	21,146	0,000		28,563	28,953	0,581
Production (log.) t-1	10,858	10,726	0,000		10,842	10,775	0,116
Market share: recessive	0,199	0,227	0,081		0,206	0,210	0,843
Market share. expansive	0,175	0,205	0,052		0,178	0,193	0,491
Dynamism market recessive	0,414	0,362	0,005		0,422	0,390	0,230
Dynamism market expansive	0,209	0,198	0,456		0,200	0,196	0,840
Low exporter	0,163	0,281	0,000		0,186	0,206	0,344
High exporter	0,417	0,222	0,000		0,378	0,386	0,783
Patents t-1	0,273	0,078	0,000		0,117	0,110	0,752
Innovations t-1	0,697	0,556	0,000		0,676	0,639	0,142

Notes: Results obtained using a matching procedure using a technique "nearest neighbor" with matching 1:1 and band wide at 5%. Exact matching is required on year and sector dummies.

Table C2. Quality of the matching procedure: Comparing the average values for the variables before and after matching for the treatment "only tax credits"

Tax credits only	Before Matching				After Matching		
Variables	Treated	Control	p-value		Treated	Control	p-value
F1. Debt (1): As percentage of total funds	-0,189	0,018	0,000		-0,161	-0,153	0,839
F4. Debt (2): As percentage of own funds	-0,040	0,048	0,014		-0,038	-0,029	0,831
F7. Debt (3): Costs in "interest rates"	0,021	-0,005	0,433		0,020	0,057	0,483
F3. Solvency (1): Liquidity in terms of cash flows	0,020	0,003	0,637		0,014	0,036	0,328
F5. Solvency (2): Liquidity in terms sales or turnover ratio	-0,067	0,024	0,009		-0,040	-0,076	0,438
F6. Solvency (3): Liquidity in term of non-current assets	-0,100	0,002	0,004		-0,105	-0,157	0,256
F2. Firms' future potential (Growth rates)	-0,041	0,007	0,187		-0,047	-0,069	0,131
National MNE	0,171	0,091	0,000		0,155	0,159	0,800
Foreign MNE	0,265	0,179	0,000		0,268	0,244	0,223
Age (log)	3,536	3,343	0,000		3,508	3,483	0,368
Size (log.) t-1	5,347	4,415	0,000		5,290	5,271	0,716
Size squared (log.) t-1	29,897	21,146	0,000		29,283	29,100	0,752
Production (log.) t-1	11,073	10,726	0,000		11,046	11,057	0,663
Market share: recessive	0,134	0,227	0,000		0,140	0,130	0,543
Market share. expansive	0,218	0,205	0,341		0,215	0,206	0,650
Dynamism market recessive	0,332	0,362	0,077		0,341	0,333	0,732
Dynamism market expansive	0,189	0,198	0,540		0,190	0,167	0,184
Low exporter	0,168	0,281	0,000		0,175	0,188	0,472
High exporter	0,355	0,222	0,000		0,348	0,353	0,846
Patents t-1	0,177	0,078	0,000		0,132	0,123	0,656
Innovations t-1	0,683	0,556	0,000		0,667	0,643	0,285

Notes: Results obtained using a matching procedure using a technique "nearest neighbor" with matching 1:1 and band wide at 5%. Exact matching is required on year and sector dummies

Table C3. Quality of the matching procedure: Comparing the average values for the variables before and after matching for the treatment "policy mix"

Policy mix	Before Matching				After Matching		
Variables	Treated	Control	p-value		Treated	Control	p-value
F1. Debt (1): As percentage of total funds	-0,107	0,018	0,000		-0,081	-0,055	0,535
F4. Debt (2): As percentage of own funds	-0,159	0,048	0,000		-0,109	-0,053	0,239
F7. Debt (3): Costs in "interest rates"	0,230	-0,005	0,017		0,018	0,011	0,847
F3. Solvency (1): Liquidity in terms of cash flows	-0,023	0,003	0,489		-0,031	-0,048	0,231
F5. Solvency (2): Liquidity in terms sales or turnover ratio	-0,239	0,024	0,000		-0,169	-0,147	0,633
F6. Solvency (3): Liquidity in term of non-current assets	0,089	0,002	0,014		0,063	0,119	0,272
F2. Firms' future potential (Growth rates)	-0,058	0,007	0,078		-0,069	-0,075	0,642
National MNE	0,338	0,091	0,000		0,265	0,287	0,319
Foreign MNE	0,215	0,179	0,009		0,230	0,219	0,593
Age (log)	3,533	3,343	0,000		3,484	3,498	0,619
Size (log.) t-1	5,625	4,415	0,000		5,472	5,475	0,962
Size squared (log.) t-1	33,321	21,146	0,000		31,503	31,502	0,999
Production (log.) t-1	11,066	10,726	0,000		11,023	11,029	0,820
Market share: recessive	0,157	0,227	0,000		0,160	0,152	0,682
Market share. expansive	0,269	0,205	0,000		0,256	0,247	0,689
Dynamism market recessive	0,307	0,362	0,001		0,312	0,314	0,915
Dynamism market expansive	0,252	0,198	0,000		0,237	0,233	0,861
Low exporter	0,127	0,281	0,000		0,143	0,152	0,576
High exporter	0,430	0,222	0,000		0,429	0,431	0,920
Patents t-1	0,340	0,078	0,000		0,189	0,158	0,217
Innovations t-1	0,776	0,556	0,000		0,770	0,752	0,384

Notes: Results obtained using a matching procedure using a technique "nearest neighbor" with matching 1:1 and band wide at 5%. Exact matching is required on year and sector dummies

Appendix D: Robustness check: Instrumental Variables estimations

For the estimates made above to be considered valid we have to consider that there are no problems that could bias our results, one of the main problems that can affect our results is endogeneity, where the assumption of independence between the correlation of the variable of interest and the random disturbance is not accepted. This can be due to several factors, such as the omission of relevant variables in the estimation of the model, errors in the measurement of the dependent variable or the presence of self-selection.

For this reason, we must ensure that our estimates are robust to these types of problems, therefore, we decided to use one of the most widely used econometric techniques in the literature, instrumental variables, which consists of proposing additional information by means of variables known as instruments, an instrument must have the property of explaining the endogenous regressor, but without being directly correlated with the dependent variable or omitted variables, in our case valid instruments should be correlated with the pool of aid (only subsidy, only tax credits and both simultaneously) but uncorrelated with the gross R&D intensity.

We instrument each endogenous variable by two exogenous variables, these variables following the previous literature are, firstly the average amount of subsidies/tax incentives/both by year, size class, and industry sector, secondly, we use the number of firms across the sample that have been granted these aids. These instruments are provided because the selection of funds by public agencies is most likely to be driven by observable characteristics, thus capturing the variation over time in the overall budgets of the granting agencies, the variation in budgets depending on size and also the availability of subsidies for different industries.

First of all, the instruments used in this regression are valid, as they comfortably pass the test of relevance of the regressors (Anderson's test), over-identification test (Hansen's J test) and the p-value of first stage, this allows us to affirm that the regressions carried out throughout the work are indeed robust, proof of which is that the results obtained with the instrumental variables offer very similar results with respect to the coefficient and sign of the variables estimated using OLS, with all this we can rule out the hypothesis of the presence of endogeneity and/or problems of omitted variables in the estimations of this work.

Table D1. Instrumental Variable results. Second Stage

	Gross R&D intensity	
VARIABLES	Coef.	S.E
Subsidy amount (log.)	0.0017***	0.0001
Tax credits amount (log.)	0.0010***	0.0001
Policy mix amount (log.)	0.0017***	0.0001
S. traditional consumer goods	-0.0099***	0.0011
S. intermediate goods suppliers	-0.0075***	0.0012
Sector of specialised suppliers	-0.0011	0.0014
Sector of scale-intensive and assembly-intensive goods.	0.0080***	0.0016
National MNE	0.0011	0.0011
Foreign MNE	-0.0026***	0.0008
Age (log)	-0.0007	0.0005
Size (log) t-1	-0.0048***	0.0016
Size squared (log) t-1	0.0003*	0.0002
Productivity (log) t-1	-0.0031***	0.0008
Market share recessive	0.0022**	0.0010
Market share expansive	-0.0001	0.0010
Dynamism market recessive	-0.0020**	0.0009
Dynamism market expansive	-0.0015	0.0010
Low exporter	0.0003	0.0010
High exporter	0.0006	0.0008
Patents t-1	0.0075***	0.0010
Innovations t-1	0.0030***	0.0007
F1. Debt (1): As percentage of total funds	-0.0003	0.0003
F4. Debt (2):As percentage of own funds	-0.0041***	0.0004
F7. Debt (3): Costs in “interest rates”	-0.0003***	0.0001
F3. Solvency (1): Liquidity in terms of cash flows	0.0008	0.0008
F5. Solvency (2): Liquidity in terms sales or turnover ratio	-0.0019***	0.0003
F6. Solvency (3): Liquidity in term of non-current assets	-0.0009***	0.0003

F2. Firms' future potential (Growth rates)	0.0003	0.0004
Constant	0.0636***	0.0093
Observations	7,311	
R-squared	0.218	
Wald test dummies		
Sectoral	297.9***	
Year	15.5**	
Pvalue- Anderson's test	0.016	
Pvalue- Hansen's J test	0.118	
Pvalue- First stage	0.000	

*** p<0.01, ** p<0.05, * p<0.1. S.E=Robust standard errors