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R&D SPENDING AND INVESTMENT DECISION: EVIDENCE FROM EUROPEAN FIRMS

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WORKING PAPERS

2015/15

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Title: R&D SPENDING AND INVESTMENT DECISION: EVIDENCE FROM EUROPEAN FIRMS

ISBN: 978 88 8467 955 0

First Edition: November 2015

Via Is Mirrionis, 1
09123 Cagliari
Tel./Fax 070 291201
www.cuec.it

R&D Spending and Investment Decision: Evidence from European Firms

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Abstract

This paper investigates the role of research activity and other micro determinants, on firms' investment behaviour. The empirical analysis is based on a large representative and cross-country comparative sample of manufacturing firms across seven European countries. Given the potential simultaneity between investment decision and R&D spending, we used an instrumental variable procedure to overcome the problem of endogeneity and an instrument was constructed to cope with this issue. We find that R&D positively affects investment decisions. The analysis highlights the importance of financial factors, particularly with respect to firms' internal resources, and also sensible cross-country effects, in determining the investment level.

Keywords: R&D; investment; firm behavior; IV model
Jel classification: O32, C31, C36, D22.

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Introduction

The relationship between investments and R&D emerges in macroeconomic models where growth is the result of the interaction between physical capital accumulation and technological progress.

Innovations and the accumulation of physical capital are recognized as the main sources of economic growth in neoclassical growth theories. In late 1980s and 1990s new growth theories reinforced this idea. Making use of the concept of spillovers, models of growth were built with no diminishing returns for the accumulation of capital (Romer, 1986; Lucas, 1988), leading to indefinitely growth. In this setting, investment in physical capital are the main factors promoting economic growth, and the returns at the aggregate level exceed the private returns of private firms. Investment (as a share of GDP) is the most robust explanatory variable of a country's growth in empirical studies using international panel data, such as Sala-i-Martin (1997).

Other endogenous models have focused on the importance of technological change in the process of growth, on one hand addressing the role of deliberate actions, such as R&D done by agents (primarily the firms) in search of innovations or, more generally, new ideas (Romer, 1990; Aghion and Howitt, 1992). On the other hand, technological progress is viewed as a process induced by capital accumulation itself, through channels such as learning by investing, or capital embodiment of technology.

The concept of absorptive capacity, developed by Abramowitz (1986) and employed at firm level by Cohen and Levinthal (1990), states that human capital and R&D have significant benefits, in that they create a knowledge base within a country or a firm. Such knowledge permits one to identify, assimilate, and exploit information and ideas from the environment, not only in technology, but also in a more general framework, ranging from organizational theories to financial markets, and marketing advances.

Micro-level studies have demonstrated that R&D enhances a firm's productivity, and so higher returns may be extracted from investment in physical capital. Furthermore, innovative activities may require additional facilities and equipment to be created, thus inducing physical investment by the firm. In other words, these studies argue that R&D may be a stimulus for firms to invest in physical capital.

While there is a significant literature on the financial factors which influence a firm's investment behaviour (Mairesse, Hall, Mulkay, 1999), and on the sources and effects of R&D activities (Medda and Piga, 2014), there is limited information at the micro level on the interaction between R&D and investments in physical capital.

In this paper we attempt to assess the relationship between the intensity of a firm's investment and research activities. Given their ability to manage risk, firms which spend on R&D expect higher returns on investment than do traditional firms, and are more likely to bear high capital costs, and hence invest more, especially when there is a shortage of available credit. The analysis uses a data-set from 2007-2009, when there was a financial squeeze in all European countries.

Our empirical analysis is based on a large and representative sample of European manufacturing firms, namely the Efige dataset This provides information about investment and R&D expenditure by the firms, along with other survey and balance-sheet data, for the 2007-2009 period. Data are cross-country comparative and are collected for seven countries: Germany, France, Italy, Spain, the UK, Austria and Hungary.

The econometric methodology takes into account that in a group of firms, those that invest in R&D do not arise randomly. This may potentially introduce an endogeneity issue. Successful firms which conduct innovative activities are more likely to invest in physical capital. Hence, in order to identify the impact of micro and macroeconomic factors on the propensity to invest in equipment, any comparison between innovative and traditional firms should take into account this type of endogeneity. Hence, the IV variable specification is employed as well as the simple OLS model. Given that a substantial number of firms in the sample did not invest at all, we also estimate a multilevel Tobit model.

Among the factors which influence a firm's decision to carry out R&D, the analysis places particular emphasis on public financial support for R&D. Considerable effort has been devoted to evaluating the efficiency of public support for R&D, on the grounds that there may be underinvestment in R&D. Since innovative firms operate in a field where there is high technical uncertainty even when they succeed they are not able to gain the full return associated with their innovations (Jones and Williams, 2000). In our view, public R&D grants influence a firm's investment behaviour, but solely through their impact on a firm's decision about whether or not to carry out R&D, and how much to spend on it.

The analysis reveals that R&D spending is positively correlated with the level of investment intensity. This strongly suggests the existence of a potential complementarity relationship between intangible and tangible investment.

The additional investment intensity is estimated to be in a range of from 14.4% to 16.8% for R&D firms that received R&D grants. Elasticities of investment intensity with respect to R&D intensity are found to be about 13% in the standard OLS specification, and 14% in the Tobit model. Estimates of elasticity of investments with respect to R&D cluster around 4% - 5% when IV models are used to take into account potential endogeneity in R&D .

The results also suggest that lack of external sources of credit is a factor constraining investment, especially for highly innovative firms. For the firms in the sample, which refers to data during the international financial crisis of 2008-2009, exposure to international markets had a negative impact on the propensity to invest in both R&D and tangible capital. Finally the results highlight significant differences across countries.

The remainder of the paper is organized as follows: Section 1 begins with a brief review of the literature, focusing on the general findings on investment behaviour by the firms, their propensity to carry out R&D activities, and the relationship between the traditional-tangible investment propensity and innovative activities. Section 2 describes the data set and section 3 the variables employed in the econometric analysis. Section 4 describes the estimation equation and the econometric technique. Section 5 contains the estimates of the effect of R&D on investment behaviour. The conclusions are reported in section 6.

1 Firms' investment decision and R&D

Previous studies aimed at investigating a firm's investment decision used different specifications of the investment function (accelerator specifications, formulations based on Tobin’s Q, Euler's equation), testing primarily whether financial constraints significantly enter the equation and whether they affect groups of firms with particular common characteristics differently (Mairesse, Hall, Mulkay, 1999).

Investment in fixed capital is costly, especially when investment is not easily reversed. As a result, uncertainty causes firms to reduce or delay investment. In real option theory a generally negative relationship between investment and uncertainty is predicted, because high uncertainty is associated with high risk, and thus uncertainty causes investors to diminish investment in fixed capital (Pindyck, 1991). During recessions, firms may decide to cut investment to reduce costs. However, Aghion and Saint-Paul (1998) argue that macroeconomic recession can reduce the opportunity costs of restructuring businesses, thus promoting innovative activities in the search for productivity growth and increased profits. Moreover, using a thirty-year panel of U.S. manufacturing firms, Hall (2007) observed that R&D spending does not vary much over time within firms, which tend to smooth out their R&D expenditures over time, as a possible consequence of high adjustment costs.

Hence, innovative activities play a crucial role in the dynamics of a firm's investments. As stated by Mairesse and Siu (1984),while there is no necessary influence of physical investment on R&D, R&D programs may lead to product or process innovations, which may result in new investment programs. However, they find little evidence of such a causal relationship between R&D and investment in their empirical analysis,.

The literature has shown that R&D has positive private returns, in that it increases productivity by improving the quality or reducing the average production costs of existing goods or by creating new final products or intermediate inputs. Micro-level studies, surveyed by Medda and Piga (2014), show that there is a strong positive marginal return to R&D spending. This ranges between 24% and 39%.

Chan et al. (2001) and Penman and (2002) also provide evidence of a positive association between firms’ R&D outlays and both share prices and returns. Investors view R&D outlays as investments that are expected to produce future benefits, and they take such benefits into consideration when pricing shares, as such outlays lead to them earning excess (risk-adjusted) returns. Alternatively, excess returns from R&D-intensive firms are viewed as compensation for risk-bearing associated with R&D activities.

There is a significant amount of work available in the literature on the factors affecting R&D investments and on which kind of firms are more likely to carry out R&D activities. A number of the factors driving R&D have been identified. These include size, internal financing, market competition and belonging to a group (see Hall, 2002, for a survey).

Limited research is available on the interrelationships between physical and R&D investment. Bernstein and Nadiri (1988) pointed out that “there is a substantial difference between the rate of return on physical capital and R&D”, with the latter being higher than the former. This implies that the spread between the marginal value of R&D and the cost of capital, measured by the interest rate, is greater than the spread between the marginal value of physical capital and the interest rate.

Lach and Rob (1996) argue that innovative activities may require additional facilities and equipment to be created and involves physical investment by the firm. Lin (2012) identifies another channel through which R&D (mainly R&D aimed at process innovation) affects physical investments. He argues that because physical capital embodies current technological progress, R&D increases the productivity of physical capital and reduces production costs, so that a firm's expected returns on physical investment are increased when it invests in R&D. Conversely, assuming diminishing marginal returns on physical capital, a firm's expected returns on physical investment decreases in the case of physical investment.

Several studies have focused on the differences between the sources of financing of physical investments and R&D. Mairesse, Hall and Mulkay (1999) argue that the riskiness of innovative projects and the hidden-information nature of these projects induces firms to finance R&D internally. This is different from what happens with physical investments. However, they do not find any significant differences in the financing of physical investment and R&D. Chiao (2002) employs a simultaneous approach to study the relationship between long-term debt, R&D and physical investments. Comparing firms belonging to science-based and to non-science-based industries he finds that the former use long-term debt to finance physical investment but not R&D, while the latter use long-term debt to finance both kinds of investment.

Bond, Harhoff and Van Reenen (2010), in a sample of UK and German companies, assessed the relationship between physical investment and cash flow for R&D performing and non-R&D firms separately. They found that cash flow had a greater impact on the physical investment for non-R&D investing than R&D investing British companies.

Several studies argue that there may be underinvestment in R&D, because of the high technical uncertainty that innovative firms face, and even when they succeed, they are not able to gain the entire return associated with their innovations (Jones and Williams, 2000). From a policy perspective, these arguments justify the social desirability of public schemes which are designed to reduce the costs involved in a firm investing in R&D.

Hyytinen and Toivanen (2005) provide evidence that government funding helps firms in industries that are dependent on external financing. Czarnitzki and Toole (2007) find that R&D subsidies mitigate the effects of market uncertainty for the products on R&D investment and suggest ways in which public policies can increase R&D investment. Finally, Carboni (2011, 2012, 2013) found that public programs support marginal R&D projects which are expected to be low in profit and which would be not pursued without a subsidy.

As part of this strand of literature, this work attempts to shed some light by adding empirical evidence on the relationship between a firm's investments behaviour and its R&D spending.

2 Data and descriptive statistics

Data used in this study are taken from the EFIGE dataset, a representative (at the country level for the manufacturing industry) and cross-country comparable sample of 14,911 manufacturing firms across seven European countries: about 3,000 firms from each of France, Germany, Italy and Spain, 2,000 from the UK, and 500 each from Austria and Hungary. The EFIGE questionnaire provides information on the structure and the behaviour of firms. It is complemented with their balance sheets, taken from Amadeus, a database of comparable financial information for public and private European companies collected by the Bureau van Dijk.

The database, for the first time in Europe, contains qualitative and quantitative data on the characteristics and activities of firms. This results in a total of around 150 different variables, split into six different sections (proprietary structure of the firm; structure of the workforce; investment, technological innovation and R&D; internationalization; finance; market and pricing).

The survey provides consistent cross-country data on all the international activities of firms, combined with many other characteristics of the firms. This wide span of information was not available in earlier data sets (Navaretti et al 2014).

The firms included in the dataset were selected using a sampling design that stratifies them by sector and firm size. Three elements were used in the sample stratification: industries (11-NACE classification), regions (NUTS-1 level of aggregation) and size class (10-19; 20-49; 50-250; more than 250 employees). The reference population consists of firms with more than 10 employees.

All the questions were for the year 2008, with some questions asking information about 2009 and the balance sheet data from previous years. After some necessary cleaning, the final dataset includes 14,010 European firms (see Table 1). About 21.4% are from Italy, 3.2% from Austria, 20.7% each from France and from Germany, 3.3% from Hungary, about 16% from Spain, and 15% from the UK (see Altomonte and Aquilante, 2012 for more information). Most firms are small: 73% of the firms have less than 50 employees; only 6.9% of firms are large, with 250 employees or more.

Admittedly one limit of the dataset is that it is only a cross-section. This clearly prevents the analysis from addressing long-term considerations and makes it more difficult to address issues of causality.

Our dependent variable, which characterize a firm's investment behaviour, is a measure of investment intensity. We employ the (log of) ratio of investment over sales (*INV_intensity*). The intensity of R&D expenditure is our main explanatory variable (*RD_intensity*). This provides an indication of a firm’s engagement in technological activity and a raw proxy of human capital intensity (direct measurement of such a variable would dramatically reduce the data set by about one half). According to neo-Schumpeterian literature and the resource based view, knowledge capital is a crucial intangible asset in innovation activity. Human capital is considered to reflect a firm’s capacity to absorb, assimilate and develop new knowledge and technology (Bartel and Lichtenberg, 1987,). The more there is of such new knowledge and technology, the higher the innovation propensity of the firms (Hall and Mairesse, 2006, Barbosa et al. 2014).

The model comprises country dummies, in order to account for unobserved country specific effects, and industry dummies (manufacturing sectors, defined by two digit NACE Rev. 1 codes) are employed to check for potential sectoral systematic differences in investment decisions. This is because there may be various factors, such as technological opportunities, dynamic aspects and accumulation, whose characteristics differ across sectors.

Table 1 describes the composition of the industries. It is worth noting that the sector of manufacturing basic metals and fabricated metal products is the most common industry class among the firms in the sample (3,230 cases). The manufacturing of leather and leather products + manufacturing of other non-metallic mineral products (2,247) is the second most important group. The Manufacturing of textiles and textile products + manufacturing of wood pulp, paper and paper products, publishing and printing (1,909) is next.

Table 1
about here

About a half of firms in the sample carried out R&D with only small differences depending on size, but great differences in different industries: 33.2% of firms in the wood and wood products industry performed R&D, while over 75% of firms in the chemical industry did. The reported statistics for R&D intensity, measured as R&D over sales, show that firms which carried out R&D, i.e. firms with R&D spending > 0 have a mean value of R&D intensity of 6.9, with large companies spending more (7.13). Across countries, German and Spanish firms invested more in R&D, 7.85 and 7.55, respectively, while Hungarian and French companies spent less on average.

Of the firms, 87.6% have positive investments with a mean value for investment intensity (measured as a ratio of investments over sales) of 11.59. Cross country comparisons show that Spanish firms are those with the greatest investment intensity, over 14.6, while Germany is the country with the largest percentage of firms which invest in R&D: 97.3%. In Italy, only 81.4% of companies have positive investments, with a mean value for investment intensity of 10.95.

Table 2 provides cross-tabulations of the firms R&D and investments activity. It can be seen that R&D is not necessarily considered as an investment, as 567 firms out of 1,744 which declare no investments have positive R&D spending. Furthermore, over half of the firms with positive investments also carried out R&D. Note that 5,764 companies with positive investments did not carry out R&D (about 47% of firms with positive investments).

All firms which received R&D subsidies exhibit positive R&D spending, as it was a necessary condition for receiving the grant. However, two-third of firms which spent on R&D did so regardless of public R&D grants. Ruling out the possibility of so-called "defiers", i.e. agents whose behaviour is the opposite of the group they are assigned to[1], using the taxonomy reported in Angrist and Pischke (2009), such firms are "always takers": firms which do R&D irrespective of public funding.

[1] In this framework, "defiers" would be those firms which do R&D despite not receiving R&D grants, and firms which do not perform R&D even though they received R&D grants.

Overall, among firms which received public R&D funding the proportion of those with positive investments is larger (92.7%), than among firms with no R&D grants (84.4%).

Table 2
about here

Table 3 describes the main variables employed. These are investment intensity and R&D intensity, with breakdown of firms by investments and R&D behaviour, and dividing firms which benefited from public R&D funding from those that do not receive the R&D grant. Average investment intensity is greater for firms which did not carry out R&D, as well as for those which did not receive R&D grants. R&D intensity is greater for firms with positive investments and less for those which received R&D grants. This supports the argument that those firms which undertake R&D after having received R&D grants are mainly so called “compliers”, i.e. firms which would not have carried out R&D in the absence of R&D grants. By contrast the firms which spend on R&D without any grants are the so called “always takers”.

Table 3
about here

3 Variables affecting innovation activity and background

In this section we describe the variables used in the empirical analysis. The statistics of such variables are reported in Table 4.

Given its potential importance in investment decisions, a size variable, expressed as the logarithm of the number of employees (*EMPL*) is considered in the model. The relationship between a firm's size and investments is an area of special interest and has attracted the attention of many scholars. The literature on industrial organization has highlighted several key facts about size distributions. Given the considerable amount of heterogeneity in the production system, size may be important for understanding the differences in the average behaviour of firms (Hubbard, 1998), and as a factor impacting financial constraints.

Constraints are of several types: information asymmetry between insiders and outsiders; transaction and agency costs and uncertainty. For example, if small firms face high transaction costs, they will be more likely to use more internal sources. Moreover, in industries dominated by small firms, the increased uncertainty about future profits reduces investment activity (Schiantarelli, 1996). This may result in higher interest rates for loans to small businesses, because of the greater uncertainty of repayment (Petersen and Rajan; 1994). Furthermore, firm size is supposed to reflects a firm's ability to absorb new technology, its organizational capacity, economies of scale and scope, access to markets and acquirement of resource. A firm's size is also a crucial factor in determining whether or not to conduct R&D activities, and how much to invest in it (Cohen and Klepper, 1996).

The sources of investments may vary considerably across firms. Innovative firms may be reluctant to reveal details of their R&D projects to investors. Hall (2002) argues that external financing of innovation may be more costly than other investments. Internal sources of finance are preferred by innovative firms for implementing changes. Even when internal funds, such as cash flow, are limited, raising new equity may be costly and often undesirable. As a result a variable indicating the amount of internal financing (*INV_internal-finan*) and its squared term (*INV^2_internal-finan*) are included in the model.

A measure of the financial constraints, captured by some variables indicating a firm's willingness to apply for more credit, is also considered (*RATION*). Such constraints are, in general, good at explaining under-investment in technology and in R&D expenditure. The measure of financial constraints also provides an approximate proxy of the efficiency of the credit market.

A great deal of the theoretical and empirical literature on firm-level investment has focused on the role that financial factors and liquidity play in investment decision (Schiantarelli, 1996; Hubbard, 1998; Mairesse, Hall, Mulkay, 1999). It is still an open question whether or not the presence of financial factors in the investment equation indicates that firms are subject to liquidity constraints or this is the the result of their inability to finance all their desired investments (Kaplan and Zingales, 1997; Fazzari et al., 2000). A positive, significant coefficient for the internal cash flow variable may indicate the presence of constraints on external financing. Cleary (2006), for example, finds that cash flow-investment sensitivity is higher in financially constrained firms while firms without financial constraints have lower cash flow-investment sensitivity.

One question of interest is thus whether firms facing a decrease in available funds will reduce their investment spending and whether firms’ behaviour in this respect differs across countries. The argument is that having access to internal resources facilitates investment, by limiting the risks that arise when firms use external sources of finance, particularly when undertaking potentially unproductive and unprofitable investments. Internal funds are typically characterized by low information costs (Devereux and Schiantarelli, 1990), which in turn influences a firm’s investment activity.

An export dummy (*EXPORT*) is included in the analysis because a relationship between export performance and investment behaviour at firm level is expected . Firms are required to invest in equipment and technology, in order to push production and quality up to international standards of competition. At the same time profits from good export performance can be used for investment, particularly if firms depend greatly on internal funds. In most cases, competing in international markets stimulates investment and R&D (Harris and Li, 2009). It can be a source of diversification, but, at the same time, in times of international financial crisis (as the period covered in this study) it may leave firms severely exposed (Altomonte, Aquilante, and Ottaviano, 2012).

The age of the firms, measured in years since their foundation, is also included in the model (*AGE*). The age of a firm is supposed to affect its decision to invest. If a learning-by-doing process occurs (Arrow, 1962), the stock of intangible assets, which is cumulative in nature, is likely to grow with the age of the firm. Older, firms may also have accumulated valuable production and business experience that gives them a possible market advantage. If this is the case, young firms may be less efficient and grow more slowly than older ones. Nevertheless, the empirical evidence across many different countries and industries mostly suggests that young firms grow more than older ones (Navaretti et al., 2014).

We also distinguish between firms which received public R&D grants and those which did not. A dummy indicates if firms belong to the former group or the latter (*DU_fiscal_grant*).

Belonging to a group may alleviate financial constraints, both for innovative and traditional firms. Schiantarelli and Sembenelli (2000) found that firms belonging to large and medium-sized business groups are less sensitive to cash flow constraints. Firms in a group can also internalize externalities from R&D activities. Two dummy variables which are equal to one if the firm is part of a foreign group (*GROUP_foreign*) and if the firm is part of a domestic group (*GROUP_national*) are also considered in the model. A binary variable controlling for large firms (250 or more employees, *SIZE_large*) and an interaction term controlling for mainly self-financed firms (>50% of sales) and able to access more credit (*INT_FIN_high_RATION*) are also included among the regressors.

Industry dummies are used to pick-up sector heterogeneity. There might be significant cross-sectional differences in technological opportunity, appropriate conditions, which may also have effects on the innovation behaviour of individual establishments, and competence. In some industries, fixed costs may also be lower than in others. Controls for intercept effects may be desirable in such cases, so that some of these unobservable effects can be captured. For similar reasons, country dummies are also included in the analysis.

According to the micro-related literature, more explanatory variables should have been included, as proxies for the relative costs of labour and capital and the financial structure of the firms. However, the dataset severely limits this possibility, and the use of this and other desirable information would have meant the loss of up to five thousand observations, depending on the variable considered. Thus we preferred to improve the robustness of the estimates by including the largest possible number of firms with reliable information in the sample. Furthermore, as noted by Mairesse and Siu (1984) it is plausible that the cost of these factors and the financial structure tend to vary in a roughly parallel way with other variables within countries and industries, and these can be captured by the dummy variables included in the model.

Table 4
about here

4 The analytical setting

The purpose of this paper is to investigate what determines a firm's investment decisions, with particular emphasis on the role of research activity. It is assumed that firms determine whether or not to invest in R&D rationally, and thus the sub-sample of firms performing R&D is not random, which may potentially introduce an endogeneity issue. Secondly, we address the issue that firms may decide to spend money on R&D and investment in physical capital simultaneously.

The questions of both endogeneity and simultaneity are dealt with by employing a two-step solution. This allows us to explore whether firms consider different investment options simultaneously when attempting to maximize results. This model uses a system estimation method to estimate how the characteristics that influence a firm’s decision affect the likelihood that they will opt for a particular strategy. The analysis also combines the decision to carry out R&D with the intensity of R&D spending, in order to assess its relationship with the general investment intensity of the firms.

In order to compare the investment behaviour of R&D firms and non-R&D firms, we develop an investment equation which consists of firm-specific characteristics (vector X^1) and macroeconomic factors (vector Z). This is to account for country-specific and industry effects. The analysis includes firms sizes, source of financing and measures of cash flow and credit constraints, propensity to export and R&D among the firm-specific characteristics. Investment is expressed in intensive form, i.e. investment over sales, as is the R&D measurement:

$$INV/SALES_i = f\,(X_i^1, Z_i, R\&D/SALES_i) \qquad (1)$$

Note that, in the simplest case, the R&D variable can be a simple dichotomous variable equal to zero if no R&D spending is carried out, or equal to one if a positive ratio *R&D/SALES* is observed for the firm. Simultaneously with the decision about how much to invest in physical capital, or prior to this decision, firms decide on their innovative strategies and whether or not to carry out R&D activities or not. Hence the R&D equation is as follows:

$$R\&D/SALES_i = f\,(X_i^2, Z_i) \qquad (2)$$

where X^2 represents a vector of the firm specific characteristics which affect the decision about conducting innovative activities and how much to invest in R&D. As above, a vector Z of country-specific and industry variables is included.

The R&D equation can be seen as a function which attempts to account for the propensity of firms to invest in their desired R&D. It seems plausible, however, that these expectations might also depend on other variables besides the ones included in the equation. However, since the purpose of this paper is not to study what determines R&D spending by the firm, eq. (2) accounts for the endogeneity of R&D by allowing for an endogenous selection of firms in R&D activities.

In practice, the investment equation can be written as:

$$Y = \beta_0+\beta_1 R+\beta_2 X^1+\beta_3 Z+u \qquad (3)$$

where Y is the (log of) investment intensity for each firm and R is a measure of a firm's R&D. This latter can be dichotomous when one studies the effect of the decision about whether or not to carry out R&D, otherwise R is a measure of R&D intensity when one addresses the relationship between the amount of R&D spending for each firm and its investment intensity. X^1 is a vector of the specific characteristic of a firm which affect investment behaviour, chosen according to the guidelines laid out in section 4, and Z is a vector of country and industry dummies.

In our framework, unobservable characteristics differentiate the behaviour of R&D performing firms from non-R&D performing firms and, as a consequence, the OLS method produces biased and inconsistent estimators for the parameters in the model. Following Wooldridge (2002), we use a 2SLS approach, where as a first step we estimate an R&D equation, compute predicted values and use them as an instrument for R&D in equation (3):

$$R = \alpha_0+\alpha_1 X^1+\alpha_2 X^2+\alpha_3 Z+v \quad (4)$$

where R is either the binary variable representing the decision to invest in R&D or the actual amount of R&D spending (in intensive form). As above, X^1 is a vector of the specific variables which affect a firm's investment behaviour, X^2 is a vector of the specific variables which affect a firm's R&D behaviour, and Z, again, is a vector of country and industry dummies.

Vectors X^1 and X^2 are partially overlapping. X^2 contains as an excluded variable from X^1 the binary variable which indicates whether a firm has received a public R&D grant which influences the R&D behaviour of the firm (namely the decision of whether or not to engage in innovative activities), but it does not impact investment behavior directly. Since public subsidies or other public incentives aimed at stimulating R&D activities by the firm cannot be used for purposes other than R&D, it is assumed that public incentives affect investment behaviour solely through their impact on R&D decisions.

Note that (4) does not assume the form of a probit/logit model when R is represented by a binary variable decision. A simple OLS model is, instead, employed for this purpose. As Angrist and Krueger (2001) argue, using a non-linear first stage to generate fitted values for the second stage is not necessary and may even result in inconsistent estimates unless the first stage model is exactly correct. We use both OLS and a tobit model specification to estimate the effect of R&D intensity for the first stage equation.

Angrist and Krueger (2001) provide similar arguments for second-stage equation too. They argue that if the second-stage relationship is non-linear, then a correctly specified functional form is required for an easy interpretation of the results, while linear 2SLS captures the average causal effect of R&D on investments for those firms whose behaviour would be changed by the instrument if it were assigned in a randomized trial. In some cases both results (instrumental variable with censored and non-censored dependent variable) are provided.

Estimations of eq. (4) are run in order to build instruments for the R&D variables included in (second stage) eq. 3. The results from the first stage equations are reported in Table 5.

Table 5
about here

5 Econometric results

Not all firms in the sample are engaged in investment activity, so some observations are left censored. The presence of ''zero'' observations makes the relationship between the investment variable and the independent variables more complex than it is assumed to be by traditional regression models. The standard Tobit model (Wooldridge, 2001) has typically been employed to estimate censored models by assuming that an unobservable latent framework generates the data (i.e. the censored data have the same distribution of errors as the uncensored data). Fig (1) shows the Kernel density distribution of the investment variable under investigation, which is skewed by the zero values. Our main area of interest is whether R&D investing firms invest more in terms of total investment.

Fig 1
about here

The model includes controls for the structural characteristics of the firms, as follows:

INV_intensity = f(RD_intensity, EMPL, INV_internal-finan, INV²interal-finan, AGE, RATION, EXPORT, INT_FIN_high_RATION, SIZE_large, GROUP_foreign, GROUP_national, COUNTRIES, INDUSTRIES) (5)

Firstly, the investment intensity variable on dummy R&D is regressed, along with exogenous covariates and controls. Table 6 presents the simple OLS regression in column (1), which is displayed as a benchmark. Column (2) reports the results of the tobit model, where investment intensity is considered as a left-censored variable.

Columns (3) and (4) show the IV variable estimate of the investment equation, where the dependent variable is treated either as a continuous variable, in which case we perform a standard 2SLS model, or as a left-censored variable, in which case we perform an instrumental variable tobit model. Both the IV estimations, seen as an instrument for the R&D dummy, use OLS fitted values from estimation of eq. (4), where *R* is a dummy R&D variable.

Simple OLS estimate of parameter in terms of eq. (3) shows a significant coefficient of 15.9%, which could be interpreted as 15.9% higher investment intensity on average for those firms which engage in R&D activities. Tobit estimates are reported in column (2): a larger impact of R&D decisions on investment intensity is estimated, of the magnitude of 19.2% (which implies a marginal effect equal to 16.6%[2]).

These estimates would partly reflect unobserved characteristics for R&D-firms which alter their investment behaviour (e.g. during a macroeconomic crisis). Instrumental variable estimates (columns 3–4) consider the effect of R&D-fiscal incentives on investment behaviour solely through a firm's decision on whether or not to carry out R&D activities.

Instrumental variable estimations exhibit similar coefficients for the R&D dummy. When investment intensity is treated as a continuous variable (column 3), the regression results in a coefficient for the R&D dummy of 14.4%, slightly less than that of the standard OLS estimate. When the dependent variable is treated as a left-censored variable (IVTOBIT, column 4), the estimated coefficient for the R&D dummy is 19.5% (with a marginal effect of 16.8%), slightly greater than the equivalent coefficient from the simple tobit estimate. These results can be interpreted as meaning that there is an average increase in investment intensity for those firms which decide to engage in R&D activities, having received a financial incentive, in a range from 14.4% to 16.8%. This results can be generalized for all R&D-performing firms, assuming that the beneficial effect of R&D is common for all innovative firms.

Table 6
about here

[2] To allow for a comparison between the tobit estimates and OLS coefficient, the marginal effects are computed , multiplying tobit coefficients by an adjustment factor, as a function of the inverse Mill's ratio, at the mean values of the variable of interest (Wooldridge, 2001, ch. 16).

The analysis show the strong significance of the variables which indicate the share of internal financing in spending on investment. While the age of the firms has a negative impact on the willingness to invest, size seems to have no significant effect on investment intensity. Exposure to international markets has a negative impact on investment behaviour. Both dummies indicating whether the firms have exported and dummies indicating whether the firms belong to a group show negative and significant coefficients. This result contrasts somewhat with theoretical predictions, which state that foreign market oriented firms should be more competitive. However the sample covers the period from 2007 to 2009 which witnessed an international collapse in trade that was greater than the decline in global GDP (Alfaro and Chen, 2012).

Credit rationing, captured by variables indicating willingness to obtain more credit, and the interaction term checking for highly self-financed firms willing to obtain more credit, negatively affects the investment behaviour of firms. Once again, the sample period may have accentuated this effect.

We then estimated the relationship between a firm's R&D intensity and investments. Table 7 (column 1) shows the results from a simple OLS regression of investment intensity on R&D intensity with covariates and controls. The same table in columns (2) – (3) shows the results when R&D is allowed to be endogenous, through the use of instrumental variable methods. Two different instrumental variables are employed. They are constructed as predicted values from the first-stage regressions, the tobit model and a OLS of R&D intensity on fiscal incentives respectively (all first-stage regressions contain covariates and controls).

The coefficient of R&D intensity from the simple OLS estimate is significant and equal to 0.138. However, when checking for endogeneity, the marginal effect of R&D on investments falls, although it still remains positive and significant. This coefficient is 0.043 when tobit-generated predicted values for R&D intensity are used (column 2),, while its value is 0.051 when the instrument is built using OLS predicted values of R&D intensity. In both cases, estimated coefficients are significant at 5% level.

We also test for the endogeneity of the R&D variable. The IV approach assumes that R&D is endogenous (if this is not the case, standard techniques are more efficient). The Wald test of exogeneity strongly rejects the null hypothesis of independence between the error terms of the two equations. Indeed, the results suggest a positive and strongly significant correlation between the errors in equation (3) and (4) (χ^2 =25.2; Prob>χ^2=0.000), meaning there is not sufficient information in the sample to reject the null hypothesis of no endogeneity. Hence the point estimates from the instrumental regression are consistent, although those from tobit have similar standard errors.

The hypothesis that the estimated slope coefficients of the industry dummies are jointly zero can be safely rejected at one percent significance ($\chi^2(10)$= 17.68*** for the OLS; over 120 for the IV regressions), confirming that there are differences in the investment intensity across industries.

Table 7
about here

Table 8 reports the results of the censored dependent variable tobit model of investment intensity on R&D intensity (column 1) and the instrumental variable method, using as instruments, as above, the predicted values of R&D intensity generated from tobit and OLS first-stage equations (IVTOBIT, columns 2-3).

The effects of R&D intensity on investment intensity estimated from tobit is not sensibly different from that from the OLS. The coefficient estimate is 0.150 and this implies a marginal effect of 0.130. The coefficients still remain significant when taking into account R&D endogeneity. However, as in the previous case, their values fall to marginal effects values of 0.054 when the predicted values for R&D are generated from the tobit procedure, and to 0.060 when the predicted values for R&D derive from the OLS first-stage model. Note that the effect of R&D on investment is found to be slightly larger when investment intensity is considered left-censored, regardless of which instrument is included, than when investment intensity is treated as a continuous variable.

Tests for IVTOBIT models support the hypothesis that R&D intensity is endogenous and hence the use of instrumental variable techniques is appropriate. We found endogeneity for R&D intensity, while the tests did not permit us to reject exogeneity for decisions about whether or not to do R&D (table 6). This finding is supported by the view that R&D is a long-term investment decision. While a firm may decide to change its investment plans, depending on the macroeconomic framework, the incidental costs of changing its planned R&D activities is too high, even during huge international crises. While it is difficult for a firm to abandon an R&D project or to begin a new one during a crisis, planned spending in R&D, smoothed out over years, can be delayed or reduced, depending on other exogenous factors.

Given the cross sectional nature of the data set, the analysis does not allow us to test the long-term innovative activities behaviour of firms. However the results show that, even in a period of huge international crisis, innovative activities sustain firms' investments. The analysis also supports the view that decisions on R&D spending and traditional investments are taken at the same time by the firms.

Interestingly, the estimates reveal that there are substantial cross-country differences in the sample. To be more precise, the analysis shows that in Germany, Austria and Spain, larger average coefficient values are estimated than in the case of the UK, which is used here as benchmark, and those of France, Hungary (both non-significant) and Italy (coefficient very small though statistically significant). This suggests that, after checking for a firm's characteristics, all the other countries in the sample are less likely to invest than Germany. This is confirmed by all the models run for the empirical analysis.

Table 8
about here

Conclusion

The relationship between investments and R&D is a crucial issue for a firm's growth, given the strong interaction between physical capital accumulation and technological progress. It is widely recognized that R&D enhances a firm's productivity, and that research activities may require additional physical investment by the firms.

While there is a significant literature on the characteristics of a firm that influence investment behavior and on the sources and effects of R&D activities, there is limited evidence at the micro level on the interaction between R&D and investments in physical capital. This work tries to shed some light on this very issue.

The analysis uses a large and representative sample of European manufacturing firms in Germany, France, Italy, Spain, the UK, Austria and Hungary. The period under consideration is from 2007 to 2009, when there was a monetary tightening in all European countries.

The analysis accounts for the fact that firms performing R&D may not arise randomly in the population set, giving rise to a potential endogeneity issue. The econometric strategy also takes into consideration that a substantial number of firms in the sample do not invest at all. Hence a multilevel tobit model is used to study what factors trigger investment.

We find that R&D spending is positively correlated to the level of investment intensity, which suggests that there is a potentially complementarity relationship between intangible investment and tangible investment. This is confirmed in all the specifications used.

Firms that carry out R&D activities and that received R&D grants are those with greater investment intensity. For such firms an increase in investment intensity is estimated as being within the range 14.4% - 16.8%. Elasticities of investment intensity with respect to R&D intensity are found to be in the range from 13% to 14% in the standard OLS and tobit models. Taking into account the potential endogeneity of R&D when using IV models, the estimates of elasticity of investments with respect to R&D cluster around 4% - 5%.

Internal financing was found to have a significant non-linear relationship with investment. The shortage of external sources of financing was found to be significantly positive. Exposure to international trade appears to be negatively correlated to investments. This result may be due to the international financial crisis which occurred during the period covered by the data set. If a firm exports, this has on average a negative effect on investment intensity, possibly because such firms were particularly affected by the international crisis at the time. Similarly, belonging to an international group was found to be negatively correlated with investment, although not significantly, while belonging to a national group fostered investment by the firms.

The analysis shows that in Germany, Austria and Spain there were larger average coefficient values for the impact of R&D on investments than in the UK, France, and Hungary. The analysis also confirms that there are significant differences in the investment intensity across industries.

From a policy point of view, the results suggest that given that a significant number of firms suffer from financial constraints, particularly firms with high innovative capabilities, government policies should stimulate the provision of risk-taking external capital and provide public funding for R&D activities. For example, if innovation is a common characteristic of firms suffering from financial constraints, this ought to be considered as an important criterion for supporting private physical or R&D investment.

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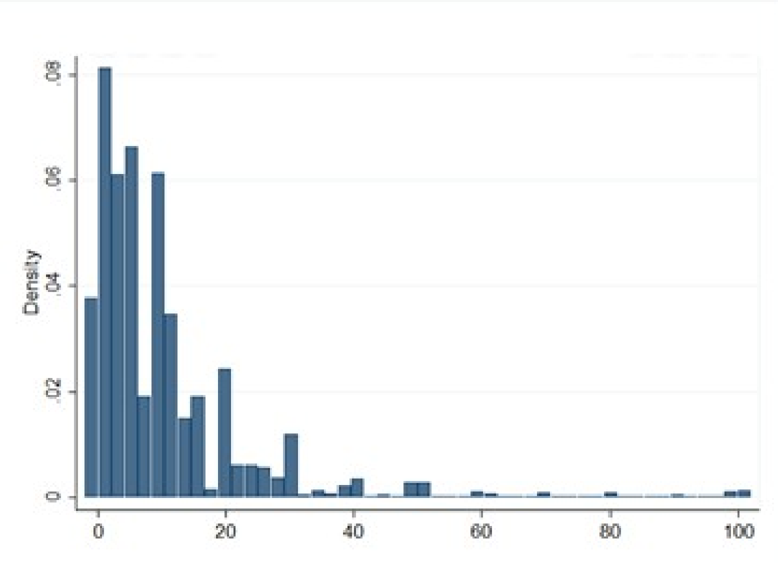

Fig. 1 - Kernel distribution: Investment intensity

Table 1 - Dataset: country and industry composition

	FIRMS WITH R&D OVER SALES > 0						FIRMS WITH INVESTMENTS OVER SALES > 0						FIRMS WHICH RECEIVED R&D GRANT		TOT.
			R&D / SALES						INVESTMENT / SALES						
	N	%	mean	sd	min	max	N	%	mean	sd	min	max	N	%	N
Austria	231	51.0	6.02	7.51	1.0	70.0	430	94.9	11.78	13.50	1.0	100	106	23.4	453
France	1,464	50.4	5.79	7.20	1.0	80.0	2,426	83.5	9.91	13.24	0.5	100	587	20.2	2,907
Germany	1,538	53.0	7.85	8.84	1.0	95.0	2,824	97.3	12.09	13.17	1.0	100	279	9.6	2,902
Hungary	109	23.3	5.67	7.59	1.0	50.0	399	85.3	12.15	14.86	1.0	100	33	7.1	468
Italy	1,651	55.2	7.15	8.31	1.0	70.0	2,436	81.4	10.95	11.65	0.5	100	578	19.3	2,993
Spain	964	44.0	7.58	9.22	1.0	80.0	1,969	89.9	14.63	16.07	0.5	100	433	19.8	2,189
U.K.	1,112	53.0	6.42	8.59	1.0	80.0	1,782	84.9	10.44	13.05	0.5	100	314	15.0	2,098
food product, beverage and tobacco	580	40.5	4.78	6.45	1.0	60.0	1,295	90.4	12.78	15.37	1.0	100	172	12.0	1,433
textiles and textile products	821	43.0	6.52	7.76	1.0	52.0	1,614	84.5	12.27	15.04	1.0	100	210	11.0	1,909
leather and leather products + manufacture of other non metallic	1,334	59.4	8.75	10.07	1.0	95.0	1,947	86.6	10.59	13.07	0.5	100	532	23.7	2,247
wood and wood products	220	33.2	6.29	7.55	1.0	50.0	571	86.3	12.56	13.86	0.5	100	57	8.6	662
coke; refined petroleum products and nuclear fue	6	30.0	6.83	4.92	1.0	15.0	20	100.0	11.83	10.09	1.0	40.0	0	0.0	20
chemicals, chemical products and man-made fibres	389	75.5	7.67	9.68	1.0	80.0	469	91.1	10.91	14.29	1.0	100	153	29.7	515
rubber and plastic products	511	56.8	5.38	5.44	1.0	40.0	800	88.9	10.85	12.35	1.0	100	158	17.6	900
basic metals and fabricated metal products	1,359	42.1	6.27	7.02	1.0	58.0	2,839	87.9	12.59	13.21	0.5	100	398	12.3	3,230
machine and equipment n.e.c.	1,105	64.3	7.15	8.15	1.0	80.0	1,520	88.4	10.19	12.08	0.5	100	411	23.9	1,719
transport equipment	233	58.3	8.84	12.48	1.0	90.0	351	87.8	10.37	12.51	1.0	100	101	25.3	400
manufacturing n.e.c	502	51.5	6.58	8.58	1.0	80.0	840	86.2	10.84	12.73	0.5	100	138	14.2	975
small	5,211	51.0	6.89	8.42	1.0	90.0	8,966	87.7	11.41	13.27	0.5	100	1,732	16.9	10,225
medium	1,384	49.2	6.87	8.01	1.0	80.0	2,451	87.1	12.17	14.17	0.5	100	452	16.1	2,813
large	474	48.8	7.13	9.11	1.0	95.0	849	87.3	11.83	14.59	1.0	100	146	15.0	972
total	7,069	50.5	6.90	8.39	1.0	95.0	12,266	87.6	11.59	13.55	0.5	100	2,330	16.6	14,010

Table 2 - Cross-tabulations of firms by propensity to invest and R&D

		INVESTMENTS OVER SALES %					R&D OVER SALES %				
		mean	min	max	sd	n	mean	min	max	sd	n
DID UNDERTAKE INVESTMENTS?	No	0	0	0	0	1,744	6.44	1	70	8.68	567
	Yes	11.59	0.5	100	13.55	12,266	6.94	1	95	8.36	6,502
DID UNDERTAKE R&D?	No	12.11	0.5	100	14.09	5,764	0	0	0	0	6,941
	Yes	11.13	0.5	100	13.04	6,502	6.90	1	95	8.39	7,069
RECEIVED R&D GRANT?	No	11.75	0.5	100	13.63	10,105	6.27	1	95	7.70	4,739
	Yes	10.85	0.5	100	13.15	2,161	6.17	1	80	9.51	2,330

Table 3 - Investment and R&D intensities

		DID UNDERTAKE R&D?			
		No	Yes	Total	
DID UNDERTAKE INVESTMENTS?	No	1,177	567	1,744	(12.4%)
	Yes	5,764	6,502	12,266	(87.6%)
	Total	6,941	7,069	14,010	
		(49.5%)	(50.5%)		

		RECEIVED R&D GRANT?			
		No	Yes	Total	
DID UNDERTAKE R&D?	No	6,941	0	6,941	(49.5%)
	Yes	4,739	2,330	7,069	(50.5%)
	Total	11,680	2,330	14,010	
		(83.4%)	(16.6%)		

		RECEIVED R&D GRANT?			
		No	Yes	Total	
DID UNDERTAKE INVESTMENTS?	No	1,575	169	1,744	(12.4%)
	Yes	10,105	2,161	12,266	(87.6%)
	Total	11,680	2,330	14,010	
		(83.4%)	(16.6%)		

Table 4 – Descriptive statistics for control variables

	INVESTMENTS = 0		INVESTMENTS > 0		R&D = 0		R&D > 0	
	1,744 obs		12,266 obs		6,941 obs		7,069 obs	
	mean / std. dev.	min / max	mean / std. dev.	min / max	mean / std. dev.	min / max	mean / std. dev.	min / max
EMPL	3.59	2.30	3.58	2.30	3.60	2.30	3.56	2.30
	1.02	8.61	1.03	9.62	1.03	9.39	1.02	9.62
EXPORT	0.59	0	0.66	0	0.50	0	0.79	0
	0.49	1	0.48	1	0.50	1	0.41	1
INV_internal-finan	1.05	1	3.43	0	2.95	0	3.31	0
	0.40	4.61	1.39	4.61	1.59	4.61	1.44	4.61
INV^2_internal-finan	1.26	1	13.70	0	11.23	0	13.06	0
	2.20	21.21	7.96	21.21	8.82	21.21	8.16	21.21
RATION	0.14	0	0.17	0	0.15	0	0.18	0
	0.35	1	0.37	1	0.35	1	0.39	1
SIZE_large	0.07	0	0.07	0	0.07	0	0.07	0
	0.26	1	0.25	1	0.26	1	0.25	1
INT_FIN_high_RATION	0.01	0	0.20	0	0.14	0	0.21	0
	0.19	4.61	0.93	4.61	0.79	4.61	0.95	4.61
GROUP_foreign	0.18	0	0.13	0	0.13	0	0.14	0
	0.39	1	0.33	1	0.34	1	0.34	1
GROUP_national	0.12	0	0.08	0	0.09	0	0.08	0
	0.33	1	0.28	1	0.29	1	0.28	1
AGE	3.11	0	3.23	0	3.16	0	3.26	0
	0.83	5.07	0.87	5.24	0.86	5.21	0.87	5.24

Table 5 – R&D propensity / intensity regressions

	(1)			(2)			(3)		
Model	OLS			TOBIT			OLS		
DEPENDENT VARIABLE	DUMMY R&D			R&D intensity			R&D intensity		
obs	14010			14010			14010		
left-censored obs				6941					
LR chi2(18)				3977.76		***			
F(18, 13991)	286.40		***				260.81		***
R2	0.2693						0.2512		
Adj R2	0.2683						0.2503		
	Coeff.	S.E.	Sig.	Coeff.	S.E.		Sig.	S.E.	Sig.
DU_fiscal_grant	0.5065	0.0100	***	2.2412	0.0509	***	1.4122	0.0286	***
EMPL	-0.0038	0.0035		-0.0150	0.0193		-0.0050	0.0100	
INV_internal-finan	0.1529	0.0167	***	0.8677	0.0909	***	0.4054	0.0474	***
INV²_internal-finan	-0.0233	0.0030	***	-0.1303	0.0162	***	-0.0607	0.0085	***
AGE	0.0172	0.0042	***	0.0402	0.0231		0.0061	0.0120	
RATION	0.0167	0.0100		0.1301	0.0538	**	0.0711	0.0284	**
EXPORT	0.2094	0.0079	***	1.1102	0.0456	***	0.4795	0.0226	***
Country dummies	YES			YES			YES		
(Wald test for jointly = 0)	46.90		***	52.55		***	52.16		***
Industry dummies	YES			YES			YES		
(Wald test for jointly = 0)	23.57		***	28.48		***	32.15		***
constant term	0.0883	0.0288	***	-2.8385	0.1600	***	-0.8325	0.0820	***
SIGMA				2.0868	0.0197				

Table 6 - Investment intensity and the decision about carrying out R&D

	(1)			(2)			(3)			(4)		
Model	OLS			TOBIT			IVREGRESS			IVTOBIT		
DEPENDENT VARIABLE	Log of Investments over sales			Log of Investments over sales			Log of Investments over sales			Log of Investments over sales		
R&D variable	DUMMY R&D			DUMMY R&D			DUMMY R&D			DUMMY R&D		
INSTR FOR R&D							Predicted dummy R&D			Predicted dummy R&D		
obs	14010			14010			14010			14010		
left-censored obs				1744						1744		
Wald chi2							3487,63		***	3727,19		***
F	130,56		***	102.54		***						
Wald test of ex							0,09			0,00		
R2	0,201						0,201					
Adj R2	0,200											
	Coeff.	S.E.	Sig.	Coeff.	S.E.	Sig.	Coeff.	S.E.	Sig.	Coeff.	S.E.	Sig.
DU_RD	0.1592	0.0224	***	0.1920	0.0252	***	0.1438	0.0567	**	0.1948	0.0642	***
EMPL	0.0151	0.0141		0.0181	0.0161		0.0150	0.0141		0.0181	0.0160	
INV_internal-finan	1.7499	0.0490	***	2.0017	0.0572	***	1.7533	0.0503	***	2.0011	0.0568	***
INV²_internal-finan	-0.2710	0.0088	***	-0.3021	0.0096	***	-0.2715	0.0090	***	-0.3020	0.0101	***
AGE	-0.0569	0.0123	***	-0.0564	0.0137	***	-0.0568	0.0123	***	-0.0564	0.0140	***
RATION	0.2178	0.0336	***	0.2756	0.0423	***	0.2187	0.0337	***	0.2754	0.0383	***
EXPORT	-0.1830	0.0233	***	-0.1906	0.0272	***	-0.1787	0.0273	***	-0.1914	0.0310	***
INT_FIN_high_RATION	-0.0585	0.0140	***	-0.0700	0.0134	***	-0.0585	0.0140	***	-0.0700	0.0158	***
SIZE_large	-0.0916	0.0571		-0.1131	0.0640		-0.0916	0.0570		-0.1131	0.0648	
GROUP_foreign	-0.0666	0.0368		-0.0950	0.0474	**	-0.0668	0.0367		-0.0950	0.0419	**
GROUP_national	-0.2842	0.0306	***	-0.3207	0.0367	***	-0.2841	0.0305	***	-0.3207	0.0349	***
Germany	0.4917	0.0355	***	0.5639	0.0377	***	0.4915	0.0355	***	0.5640	0.0402	***
Austria	0.3927	0.0638	***	0.4478	0.0636	***	0.3920	0.0638	***	0.4479	0.0721	***
Spain	0.2842	0.0383	***	0.3064	0.0430	***	0.2826	0.0386	***	0.3067	0.0439	***
Italy	0.0924	0.0353	***	0.1097	0.0419	***	0.0926	0.0353	***	0.1097	0.0403	***
Hungary	0.0643	0.0635		0.0602	0.0747		0.0596	0.0653		0.0610	0.0744	
France	-0.0418	0.0359		-0.0124	0.0423		-0.0416	0.0359		-0.0124	0.0409	
Industry dummies	YES			YES			YES			YES		
(Wald test for jointly = 0)	13.63		***	13.90		***	128.22		***	125.36		***
constant term	-0.7015	0.0900	***	-1.2598	0.1125	***	-0.7007	0.0899	***	-1.2600	0.1027	***

Table 7 - Investment intensity and R&D intensity (1)

	(1)			(2)			(3)		
Model	OLS			IVREGRESS			IVREGRESS		
DEPENDENT VARIABLE	Log of Investments over sales			Log of Investments over sales			Log of Investments over sales		
R&D variable	R&D intensity			R&D intensity			R&D intensity		
INSTR FOR R&D				Predicted from TOBIT			Predicted from OLS		
obs	14010			14010			14010		
left-censored obs									
Wald chi2				3513.98		***	3521.56		***
F	142.73		***						
Wald test of exogeneity				25.1972		***	22.9376		***
R2	0.2161			0.2078			0.2090		
Adj R2	0.2146								
	Coeff.	S.E.	Sig.	Coeff.	S.E.	Sig.	Coeff.	S.E.	Sig.
RD_intensity	0.1385	0.0078	***	0.0434	0.0206	**	0.0509	0.0200	**
EMPL	0.0155	0.0140		0.0148	0.0140		0.0148	0.0140	
INV_internal-finan	1.7085	0.0485	***	1.7609	0.0498	***	1.7567	0.0497	***
INV²_internal-finan	-0.2648	0.0087	***	-0.2727	0.0089	***	-0.2721	0.0089	***
AGE	-0.0531	0.0122	***	-0.0548	0.0122	***	-0.0546	0.0122	***
RATION	0.2031	0.0333	***	0.2196	0.0336	***	0.2184	0.0335	***
EXPORT	-0.2312	0.0228	***	-0.1680	0.0262	***	-0.1730	0.0260	***
INT_FIN_high_RATION	-0.0581	0.0139	***	-0.0587	0.0139	***	-0.0586	0.0139	***
SIZE_large	-0.0946	0.0565		-0.0919	0.0568		-0.0921	0.0567	
GROUP_foreign	-0.0619	0.0364		-0.0667	0.0366		-0.0664	0.0366	
GROUP_national	-0.2848	0.0303	***	-0.2836	0.0304	***	-0.2837	0.0304	***
Germany	0.4685	0.0352	***	0.4827	0.0355	***	0.4816	0.0355	***
Austria	0.3967	0.0632	***	0.3892	0.0635	***	0.3898	0.0635	***
Spain	0.2863	0.0379	***	0.2742	0.0382	***	0.2751	0.0381	***
Italy	0.0779	0.0350	**	0.0891	0.0352	**	0.0882	0.0352	**
Hungary	0.1185	0.0628		0.0483	0.0646		0.0538	0.0645	
France	-0.0438	0.0356		-0.0412	0.0357		-0.0414	0.0357	
Industry dummies	YES			YES			YES		
(Wald test for jointly = 0)	17.68		***	122.99		***	126.24		***
constant term	-0.5643	0.0894	***	-0.6528	0.0916	***	-0.6458	0.0914	***

Table 8 - Investment intensity and R&D intensity (2)

	(1)			(2)			(3)		
Model	TOBIT			IVTOBIT			IVTOBIT		
DEPENDENT VARIABLE	Log of Investments over sales			Log of Investments over sales			Log of Investments over sales		
R&D variable	R&D intensity			R&D intensity			R&D intensity		
INSTR FOR R&D				Predicted from TOBIT			Predicted from OLS		
obs	14010			14010			14010		
left-censored obs	1744			1744			1744		
Wald chi2				3758.29		***	3764.49		***
F	115.18		***						
Wald test of exogeneity				16.99		***	15.40		***
R2									
Adj R2									
	Coeff.	S.E.	Sig.	Coeff.	S.E.		Sig.	S.E.	Sig.
RD_intensity	0.1504	0.0086	***	0.0619	0.0232	***	0.0690	0.0226	***
EMPL	0.0186	0.0159		0.0179	0.0159		0.0179	0.0159	
INV_internal-finan	1.9587	0.0568	***	2.0069	0.0561	***	2.0030	0.0560	***
INV²_internal-finan	-0.2957	0.0095	***	-0.3030	0.0100	***	-0.3024	0.0100	***
AGE	-0.0521	0.0136	***	-0.0536	0.0139	***	-0.0535	0.0139	***
RATION	0.2606	0.0419	***	0.2760	0.0381	***	0.2747	0.0381	***
EXPORT	-0.2381	0.0266	***	-0.1789	0.0297	***	-0.1839	0.0295	***
INT_FIN_high_RATION	-0.0696	0.0132	***	-0.0701	0.0157	***	-0.0700	0.0157	***
SIZE_large	-0.1160	0.0635		-0.1136	0.0644		-0.1137	0.0644	
GROUP_foreign	-0.0897	0.0470		-0.0941	0.0416	**	-0.0937	0.0416	**
GROUP_national	-0.3208	0.0363	***	-0.3195	0.0346	***	-0.3196	0.0346	***
Germany	0.5378	0.0374	***	0.5509	0.0401	***	0.5499	0.0401	***
Austria	0.4508	0.0632	***	0.4439	0.0716	***	0.4445	0.0716	***
Spain	0.3067	0.0425	***	0.2955	0.0433	***	0.2964	0.0432	***
Italy	0.0939	0.0415	**	0.1044	0.0401	***	0.1036	0.0401	***
Hungary	0.1140	0.0744		0.0486	0.0734		0.0539	0.0732	
France	-0.0142	0.0420		-0.0116	0.0406		-0.0118	0.0406	
Industry dummies	YES			YES			YES		
(Wald test for jointly = 0)	17.68		***	133.17		***	128.40		***
constant term	-1.1049	0.1117	***	-1.1868	0.1042	***	-1.1801	0.1041	***

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Finito di stampare nel mese di Dicembre 2015
Presso Centro Stampa dell'Università degli Studi di Cagliari
Via Università 40
09125 Cagliari

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