Quaderni del Dipartimento di Scienze dell'Economia

Università del Salento

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Numero E/14
Aprile 2015

Dipartimento di Scienze dell'Economia
Facoltà di Economia
Università del Salento - Lecce
ISSN 2284-0818

Quaderni del Dipartimento di Scienze dell'Economia

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Editore:

Dipartimento di Scienze dell'Economia
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Ecotekne - via Monteroni
73100 Lecce

Codice ISSN: 2284-0818

The determinants of R&D: the role of fiscal incentives

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Abstract

This paper investigates the microeconomic effects of fiscal incentives aimed at supporting business R&D spending. Italian private R&D investment is low by OECD standards. In order to foster business R&D in 2006 the Italian government introduced a total tax credit system for R&D investment. This fiscal incentive was added to the full deductibility of R&D expenses, already present in Italian fiscal law. Using a panel data set of Italian companies, covering the years 2004-2010, I investigate if the possibility to benefit from marginal tax savings – due to both R&D deductibility and R&D tax credits – could affect the decision of companies to invest in R&D and how match to invest. The econometric analysis delivers strong evidence that fiscal incentives significantly affect business R&D, fostering companies to invest more in R&D.

Keywords: R&D expenditure, corporate taxation, fiscal incentives, tax credits

JEL classification: O32, O38, H25, H32

1 *Introduction*

The European commission has set the R&D spending target for the 2020 European Strategy at 3% of GDP. The rationale for this objective is the belief that business R&D is a key driver for the growth, innovation and competitiveness of national economies, as strongly supported by both economic theory and empirical evidence (Aghion and Howitt, 1998; Romer, 1990; Griliches, 1992; Grossman and Helpman, 1991). However, according to economic theory, companies under-invest in R&D and markets fails to provide the "socially" optimal quantity of R&D. Indeed, R&D outputs have some characteristics of public-good, so that a company that invest in R&D can not entirely internalize the benefits of R&D. Consequentially, public intervention is necessary to boost private R&D investment and to raise social welfare (Arrow, 1962).

In order to increase business R&D expenditure, governments can design policy interventions in two main ways. They can either offer public R&D resources directly, through grants or procurement, or they can provide support indirectly through fiscal incentives, such as the recognition of R&D tax credits (Berger, 1993; Hall, 2002a,b). The main difference among these different public policies is that direct grants/subsidies are offered to specific projects having high social potential returns, while fiscal incentives reduce the costs of R&D and, therefore, stimulate investment in innovation, allowing private companies to select which projects to fund. In general, direct R&D policies are aimed at stimulating long-term research, while fiscal incentives are used mostly to increase short-term R&D investments.

Countries differ significantly in their use of direct and indirect policies aimed at increasing R&D. The optimal balance of these different tools varies significantly from country to country, since each policy addresses different market failures and stimulates different types of investments. In 2008, for example, the United States and Spain provided more direct support, while Canada and Japan mostly use indirect support to increase industrial R&D activity (OECD, 2010).

The use of fiscal incentives to increase R&D expenditure has become very widespread over the preceding decades. Actually more than 20 OECD countries provide fiscal incentives to support business R&D, up from 12 and 18 in 1995 and in 2004 respectively. Moreover, not only advanced, but also developing countries, such as Brazil, China, India, Singapore and South Africa, provide generous fiscal incentives for companies investing in R&D (OECD, 2010 and 2013).

Growing empirical literature evaluates the capacity of direct and indirect support policies to increase R&D investment. Notwithstanding the fact that macroeconomic investigation into the effects of fiscal incentives would result in being very useful in many aspects (i.e. to analyse the global effect of R&D policies, to evaluate the optimal mix of incentive policies), not many studies have been conducted at the macroeconomic level (Bloom et al., 2002; Guellac et al., 2003; Griffith et al., 1996; Montmartin and Herrera, 2015). On the other hand, in the literature there is a wide range of microeconomic studies investigating the link between fiscal incentives and company's R&D expenditure. However, the results obtained are still mixed. While US companies have been the main focus of the earlier literature, over the last few years there has been a significant increase in micro-econometric studies focused on non-US countries (i.e. Baghana and Mohen, 2009; Clausen, 2009; Czarnitzki and Fier, 2002). This new focus of literature is partly due to the increasing adoption of R&D tax incentives, which, as already seen, have become a popular innovation policy instrument. Moreover, the growth of non-US micro-econometric literature has been partly fostered by the increasing diffusion of firm-level data in several countries in the OECD area, in particular in Europe (i.e. Bodas Freitas and von Tunzelmann, 2008; OECD, 2010).

The majority of the papers in this literature assess whether fiscal incentives could increase innovation inputs of companies, i.e. R&D expenditure, the value of tangible assets or employment level. Hall and Van Reenen (2000) present an accurate review of methods and results obtained in this field. They surveyed some US and international studies (covering Australia, Canada, France, Japan and Sweden) empirically analysing the effect of fiscal treatment of R&D on the investment choices made by companies. The authors concluded that there is substantial evidence that fiscal considerations have a role in affecting R&D expenditure. The most compelling evidence is provided by the studies using a quasi-experimental approach (i.e. Dagenais *et al.*, 1997; Hall, 1993), which computes a user cost of R&D and estimates the response of R&D to this price variable.

Mairesse and Mohen (2010) provide an updated survey of the main results in the literature using innovation surveys data for econometric analysis. The common finding reached by the major part of the studies reviewed is that public incentives increase private R&D expenditures (some examples include Almus and Czarnitzki, 2003; Berube and Mohnen, 2009; Busom, 2000; Gonzales *et al.*, 2005; Hall and Maffioli, 2008). Moreover, a common finding is that size and technological opportunities (generally captured by industry dummies) could be relevant factors explaining a company's propensity to innovate (i. e. Blundell *et al.*, 1990; Clausen, 2009).

The majority of the studies in the empirical literature investigates the effect of fiscal incentives estimating the link between the price of R&D and R&D expenditure. As underlined by Hall and Van Reenen (2000), the main limit of this approach is that the price variable does not contain a direct measure of the tax incentives (i.e. R&D tax credits) and that it does not take into account that the possibility of benefiting from R&D tax credits depends on a wide range of characteristics of companies, such as operating loss position, the R&D investment level and so on an so forth.

This paper tries to overcome this problem, by investigating whether the fiscal benefits derived from R&D investment affect the R&D activity of Italian companies. In particular I aim to analyse the presence of a fiscal effect affecting both the decision of companies to invest in R&D and the magnitude of such expenditure.

This paper contributes to existing literature in several respects. To the best of my knowledge, this is the first paper that provides direct evidence of fiscal effect on business R&D, using two very accurate proxies for the firm-specific tax benefits stemming from R&D investments. The first originates from R&D deductibility and is measured by the corporate marginal tax rate (*MTR*), defined as the present value of current and expected future taxes paid on an additional unit of income earned today. In order to compute the marginal tax rate I develop a model of microsimulation, following the Graham–Shevlin methodology (Graham, 1996a, 1996b, 1999; Shevlin, 1990). The second fiscal benefit achievable by a company investing in R&D originates from R&D tax credit and is measured by the marginal tax credit rate (*MTCR*). The *MTCR* is equal to the marginal increase in the amount of tax credit obtained by companies following a marginal increase in R&D expenditure.

In the literature there are very few studies focusing on Italy which analyse the relationship between R&D and fiscal incentives. One reason for this lack is the low diffusion of micro data on R&D of Italian companies. Bronzini and Iachini (2011) overcome this problem by using balance sheet data (provided by CERVED) and, in particular, proxing investment spending with those balance sheet items associated with R&D outlays. They build an analysis focused on a place-based program implemented in a region of northern Italy (Emilia Romagna) in 2003. Using a sharp regression discontinuity design they find no significant increases in investment spending of companies subsidized by the program. Bronzini and Piselli (2014), on the other hand, overcome the unavailability of R&D expenditure data, focusing their analysis on patent applications and investigating how fiscal incentives could affect the output of R&D activity. However, the use of patent application has some limitation: fiscal incentives could have an impact on R&D expenditure and no effect on the number of patent applications. Usually the achievement of a patent requires a long period of time and it is possible that a patent does not originate from R&D activity. I overcome the patents' limitation by investigating whether fiscal variables affect a company's R&D investment choices, using the data of R&D expenditure of Italian companies provided by ORBIS (a data base provided by Bureau van Dick). This paper could provide some significant policy implications, showing if and how much R&D polices adopted in Italy during the last decade have been effective in stimulating and increasing business R&D.

The remainder of this paper is organized as follows. Section 2 offers an outline of the Italian situation in the R&D field and its lag compared to other OECD and EU countries. Section 3 provides information briefly describing the fiscal and non-fiscal variables affecting R&D expenditure. Section 4 describes the data sources and presents summary statistics. The estimations and the results are discussed in section 5. The final section provides some concluding remarks.

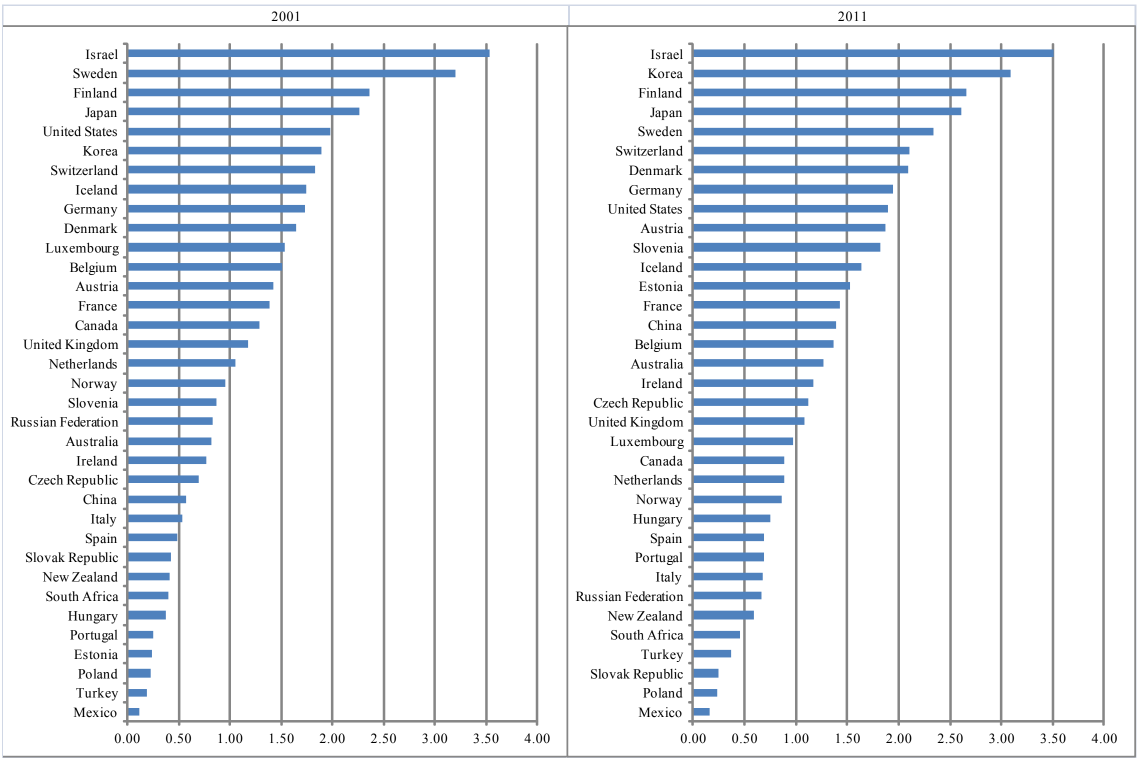
2 *The delay of R&D activity in Italy*

Business R&D expenditure is an important driver for innovation and economic growth. If I compare Italy to other OECD and European countries, I can highlight that over the last decade Italy has failed to improve its relative position with regard to business enterprise expenditure on R&D.

The OECD Science, Technology and Industry Scoreboard (OECD, 2013) provides internationally comparable data on business enterprise expenditure on R&D (BERD). It shows that during the years 2001-2011 Italian BERD grew from 0.53% of GDP to 0.68%. However, OECD ranking (figure 1) places Italy in 25th position out of a possible 35 in terms of BERD in 2001; in 2011, despite the increase in business R&D expenditure, Italy dropped to 28th place. Moreover, Italian business R&D expenditure in 2011 remained below the OECD and the European average (equal to 1.59% and 1.20% respectively) and far from Germany (1.94%) and from Scandinavian Countries (Sweden and Finland with 2.34% and 2.66% respectively).

This analysis shows that during the last decade the growth of business R&D expenditure was not sufficient to improve Italy's ranking with respect to other OECD and European countries. It has emerged that there is the necessity for Italy to strengthen or reshape, when opportune, public policies aimed at stimulating and increasing business R&D expenditure, in order to reach the R&D target established by Europe strategy 2020 (European Commission, 2010).

Figure 1. **Business enterprise expenditure on R&D (as percentage of GDP), 2001 and 2011**



Source: OECD Science, Technology and Industry Scoreboard 2013.

3 Determinants of companies' R&D expenditure

The main purpose of this paper is to investigate the effectiveness of R&D policies adopted in Italy to foster business R&D. The empirical analysis investigates the existence of a fiscal effect affecting both the decision of companies to invest in R&D and R&D expenditure.

In the first step I estimate a binary choice model which uses a dummy as dependent variable: it takes value of 1 for companies that record a positive value of R&D expenditure and value of 0 where this has not occurred. The multivariate analysis relies on a probit model. Subsequently, in the second step, I estimate the impact of fiscal benefits on R&D intensity, measured by the ratio between R&D expenditure and total assets (Almus and Czarnitzki, 2003). I implement this analysis by estimating a tobit model.

3.1 The role of taxation in R&D investments

R&D fiscal incentives are one of the major public policy instruments aimed at incentivising and increasing business investment in innovation.

The main fiscal incentive allowed to Italian companies is the possibility to fully deduct R&D expenses from the tax base of corporate income tax (*IRES*). The deduction has the effect of reducing the marginal cost of R&D investments faced by firms (Hall and Van Reenen, 2000). Italian fiscal rules establish that R&D expenditure can be fully deducted in the fiscal year when they have been incurred or in a constant rate in the fiscal year in which they have been incurred and in the following years, up to the fourth year (art. 108, section 1, TUIR[1]).

In addition to deductibility, in 2006, in order to promote R&D investments, the Italian Government introduced a total tax credit system for R&D expenditure, starting from the 2007 fiscal year. The financial law no. 296/2006 (article 1, sections 280-283) allowed a tax credit to any company involved in R&D. The tax credit amounted to 10% of R&D expenditure and to a maximum of 15 million euro[2] for each fiscal year. The tax

[1] The TUIR (*Testo unico delle imposte sul reddito*) represents Italy's income tax consolidated text.

[2] The financial law no. 244/2007 2006 (article 1, section 66) increased this limit, establishing that R&D tax credit cannot exceed 50 million euro.

credit could be used to pay corporate income tax (*IRES*) or the regional business tax (*IRAP – Imposta Regionale sulle Attivita' Produttive*).

Due to the deductibility a marginal increase in R&D expenditure implies a reduction in tax liabilities measured by the marginal tax rate (*MTR*), which is defined as the present value of current and expected future taxes paid on an additional unit of income earned today. Due to the tax credit a marginal increase in R&D expenditure implies a reduction in tax liabilities measured by the marginal tax credit rate (*MTCR*), which is equal to the marginal increase in the amount of tax credit received due to a marginal increase in R&D expenditure in a current year.

I suppose that an increase in the *MTR* will entail an increase in both the probability that companies will invest in R&D such as its expenditure. At the same time I suppose that an increase in *MTCR* will also positively affect a company's R&D activity. Hence, I formulate the following hypothesis:

H1: The probability to invest in R&D and R&D expenditure increases with an increase in both the marginal tax rate and the marginal tax credit rate .

3.1.1 Computation of the marginal tax rate

The marginal tax rate measures the present value of current and expected future taxes paid on an additional unit of income earned today. If a company has a positive taxable income (before R&D expenditure) the *MTR* is equal to the statutory tax rate. Otherwise, if a company has no taxable income today, an additional unit of income reduces the losses that can be carried forward and used to offset the taxable income in future years. In this case the *MTR* is equal to the discounted value of the taxes paid on the marginal unit of income in the first year when the firm is expected to have positive taxable income.

Italian companies are subject to the corporate income tax called *IRES* (*Imposta sul reddito delle persone fisiche*). The base for *IRES* was accounting income (as defined under the Italian Civil Code), subject to some adjustments. From 2004 to 2007 the tax rate on *IRES* was stable at 33%; it was reduced to 27.5% from 2008 onwards (Law 24 December 2007, n. 244). Companies with negative taxable income were allowed to carry forward losses to offset taxable income up to the following 5 years. Current-year losses could be added to any unused losses from previous years. No tax-loss carry-back existed under the *IRES* regime.

Therefore, the corporate taxation rules governing Italian companies entail that, in order to calculate the *MTR*, it is necessary to distinguish two different cases:

1. in year t a company has positive taxable income (before R&D expenditure) and it has no unused losses of previous years to carry forward. In such a situation, an additional unit of income pays the comprehensive tax rate. Hence, the *MTR* is equal to:

   $$MTR = \tau_{IRES}$$

   where τ_{IRES} represents the statutory *IRES* tax rate in force in year t;

2. in year t a company has negative taxable income or it has positive taxable income (before R&D expenditure) and a share of unused losses of previous years to carry forward. An additional unit of income earned in year t produces fiscal effects only if at least in one of the following 5 years the companies will have a positive taxable income and it will pay taxes. In this case the *MTR* is equal to the discounted value of the additional *IRES*. Assume that $t+n$ is the first year when the company has a positive taxable income and it will pay taxes. In this situation two different scenarios may take shape:

   a) $MTR_t = 0$ if $n > 5$

   b) $MTR_t = \dfrac{\tau_{IRES}}{(1+r)^n}$ if $n \leq 5$

In order to compute the true value of *MTR* three sets of information are required. The first one regards the corporate taxation rules, namely the level of the statutory tax rate and the tax code treatment of net operating losses. The second one is the value of losses in excess in the previous five years to carry forward. The third one is the expectations of managers on future income flows.

I proxy the expectations of managers using the methodology proposed by Graham (1996a, 1996b, 1999) and Shevlin (1990), based on the assumption that taxable income follows a pseudo-random walk with drift:

$$\Delta Y_{it} = \mu_i + \varepsilon_{it}$$

where ΔY_{it} is the difference in income before tax and R&D expenditure of company i in year t, μ_i is the sample mean of ΔY_{it} and ε_{it} is a normally distributed random variable with mean zero and variance equal to that of ΔY_{it} over the years 2004–2010.

When, in a given year, the *IRES* tax base is negative or there are unused losses of previous years to carry forward I run 100 simulations of income in the following 5 years using a different random normal realization of ε_{it} for each year. For each simulation I calculate first the present value of taxes to be paid taking into account loss carry-forward provisions.[3] Then I add a unit of income in the reference year and recalculate the present value of the tax bill. By taking the differences between these two present values, 100 simulations of the marginal tax rate are obtained. I use their average as the proxy for the "true" marginal tax rate. This procedure has been adopted for each company in the sample for every year.

Graham (1996b) argues that this proxy is the best predictor of the marginal tax rate calculated on actual income realizations. This claim has been questioned by Blouin *et al*. (2010). They show that the Shevlin/Graham *MTR* forecasting approach produces inaccurate estimates of mean future income (too high when the current income is high and too low when the current income is low) and underestimates the future volatility of income for all income groups, and propose a non-parametric procedure to estimate the marginal tax rate. The reasons are twofold. Firstly, income is better described by a mean-reverting process than a random walk, due to transitory components in accounting income and economic factors such as entry and exit. Secondly, when a firm's assets and

[3] In calculating the present value of taxes to be paid in the following 5 years, it would have been possible to use two different approaches: the first solution hypothesizes that managers in year *t* forecast exactly the statutory tax rate that will be in force in the following 5 years; the second solution, instead, hypothesizes that managers in year *t* conjecture that in the following 5 years the statutory tax rate will be exactly equal to that of the current year. Both the alternative results are too extreme, since it appears unrealistic to suppose on the one hand the possibility to forecast exactly the value of the statutory tax rate that will be in force in the following 5 years and on the other hand to suppose the impossibility for managers to know in year *t* at least what the statutory tax rate will be in force in year *t+1* . We follow a midway approach, supposing a mix of these two alternatives. We hypothesize that if in year *t* it a regulatory change is announced which will be in force from year *t+1* onwards, in calculating the present value of taxes to be paid in the following 5 years managers, in year *t*, will take this regulatory change into account and, if in year *t* it is not differently specified, they will presuppose that this regulatory change will be in force up to year *t+5*. Otherwise, if in year *t* no regulatory change is announced, we suppose that managers in year *t* would presuppose that in the following 5 years the statutory tax rate will be exactly equal to that of the current year.

income grow over time, the historical volatility measured since inception is likely to substantially understate future volatility. However, in my analysis the bias in the *MTR* calculated following the Shevlin/Graham methodology is limited by two factors. In the first place, my sample covers a significantly shorter period than the one analyzed by Blouin *et al*. (2010) (27 years - from 1980 to 2007); this should reduce the underestimation of income volatility for growing firms. In the second place, loss carry-forward is limited to 5 years in Italy compared with 22 years in the US. The shorter forecasting horizon should reduce the error in the simulated *MTR* . Moreover, Graham and Kim (2009) demonstrate the importance of using firm specific data when estimating marginal tax rates and show that the non-parametric approach proposed by Blouin *et al.* (2010) produces a distribution of *MTRs* characterized by too many observations clustered near the center.

The endogeneity of the tax status may produce a spurious correlation between the R&D expenditure and the marginal tax rate. By investing in R&D, which benefit from deductibility, a company reduces its taxable income and potentially lowers its *MTR*. This may result in a negative correlation between R&D expenditure and estimated *MTRs*, even if high taxes induce companies to increase their R&D expenditure so as to reduce their tax burden. In order to avoid this spurious correlation, following Graham *et al.* (1998), Alworth and Arachi (2001) and Arachi and Bucci (2010), I compute a measure of the marginal tax rate based on the income before taxes and before R&D deductions, which results not endogenously affected by R&D choices.

3.1.2 Computation of the marginal tax credit rate

The computation of the marginal tax credit rate requires knowledge of the statutory tax rate, R&D expenditure, taxable income and current taxes (*IRES* and *IRAP*). In year *t* an additional unit of R&D expenditure implies a marginal increase in tax credit (and hence a marginal reduction in a company's tax burden) equal to the sum of statutory tax rate *IRES* and IRAP, if all these conditions are met: the value of current tax is positive and higher than 10% of R&D expenses; the 10% of R&D expenses is not higher than the threshold, equal to 15 in 2007 and increased to 50 million euro from 2008 onwards. In any different scenario a marginal increase in R&D expenditure would not affect the tax burden, so the *MTCR* would be equal to zero.

The marginal tax credit rate is computed as:

a) $ETCR_t = \tau_{IRES} + \tau_{IRAP}$ if $(Current\ Tax)_t > 0$

$\& (Current\ Tax)_t > 0.1 \cdot (R \& D\ Expenditre)_t$

$\& 0.1 \cdot (R \& D\ Expenditre)_t < treshold$

b) $ETCR_t = 0$ if $(Current\ Tax)_t < 0$

c) $ETCR_t = 0$ if $(Current\ Tax)_t < 0.1 \cdot (R \& D\ Expenditre)_t$

d) $ETCR_t = 0$ if $0.1 \cdot (R \& D\ Expenditre)_t > treshold$

3.2 Non fiscal factors affecting R&D investments

In order to correctly identify the link between R&D expenditure of companies and fiscal incentives, I should control for other factors that may affect R&D investments. Prior research has found that several characteristics of companies (size, age, regional location), market competition and the sector's level of innovation affect R&D choices. These variables are discussed in turn below.

Size of companies is an important determinant of private R&D expenditure and innovation activity. Larger companies could benefit from economies of scale and scope, have a better organizational structure and are less exposed to capital market imperfections (Galbraith, 1952; Scherer, 1965; Schumpeter, 1942). So, in line with the results of previous literature, I expect to find that the larger the company's size is the higher both its probability to invest in R&D and R&D expenditure are. To check for this "size effect" I can use different variables. The first is the log of sales, as suggested by Clausen (2009). The second is a dummy variable based on the added value of a company. Following Bronzini and Iachini (2011) I compute the variable *LARGE*, which is equal to one if the added value of a company is above its median value, otherwise it results equal to zero. In addition, previous literature suggests using the log of the number of employees as a measure of a company's size (see for example Almus and Czarnitzki, 2003[4]; Berube and Mohen 2009; Clausen, 2009; Gorg and Strobl, 2007;

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[4] Almus and Czarnitzki (2003) underline that to use the number of employees as control variable could determine the potential problem of endogeneity: companies benefitting from fiscal incentives may hire R&D staff, and thus their employment increases. However, Italian R&D tax credit could increase the R&D staff indirectly and R&D staff represents only a small proportion of all employees of Italian

Hussinger, 2008; Takalo *et al.*, 2013). Due to the unavailability of such information for several companies in several years, the inclusion of these controls significantly decreases the number of observations. For this reasons I decided to insert these additional controls in the robustness analysis.

A company's age could also be a significant factor linked to its R&D choices. Most of the studies in previous literature (see for example Almus and Czarnitzki, 2003; Busom, 2000; Clausen, 2009; Gonzales *et al.*, 2005; Gorg and Strobl, 2007; Hussinger, 2008) have claimed that older firms are more reluctant to pursue innovation, while younger firms have an higher propensity towards R&D. I control for the age of companies using the log of the number of years since its foundation. In line with previous literature, I expect to find a negative correlation between a company's age and its attitude towards R&D.

Another important factor that might have an influence on business R&D is market competition. The relationship between market competition and innovation is widely discussed in the literature. The standard theoretical model predicts that innovation activity should decline with competition, since a higher competition lowers monopolistic profits of successful innovators[5]. However, several empirical works, such as Blundell *et. al* (1999) and Nickell (1996) find a positive correlation between market competition and innovation. In order to control for the impact of competition, following Almus and Czarnitzki (2003) and Hussinger (2008), I use the market share variable, which is computed as sales of a company in relation to those of the sector to which it belongs.

Geography could be an important element to take into account, as provincial R&D incentives could differ. To control for this aspect, I considered three regions in my analysis: North-East, North-West and Centre including Southern Regions (Berube and Mohen, 2009; Gonzales *et al.*, 2005; Takalo et al., 2013).

The R&D distribution of firms varies significantly by sectors. More innovative companies are typically concentrated in technologically advanced industries, whereas companies in more traditional sectors are less likely to invest in R&D (Almus and

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companies. Hence Italian R&D fiscal incentives could affect the number of R&D staff, but this change is not significant compared to the total number of all employees.

5 See for example, Schumpeter (1934), Dasgupta and Stiglitz (1980), Aghion and Howitt (1992).

Czarnitzki, 2003; Gonzales *et al.*, 2005; Takalo et al., 2013). To control for these differences I include several industry dummies in the empirical model, measured on the NACE two-digit level.

Empirical research (Aerts and Czarnitzki, 2004; Blanes and Busom, 2004; Czarnitzki and Hussinger, 2004; Hussinger, 2006; Wallsten, 2000) has shown that R&D choices are positively affected by past innovative practises, proxied by patents or the presence of R&D departments. Also a company's trade openness could affect R&D (Gonzales *et al.* 2005, Gorg and Strobl, 2007 and Takalo et al., 2013). Companies active in exportation usually face higher international competition and are more likely to strengthen their competitiveness through R&D. These are arguably the most important omitted variables not included in my analysis, due to data unavailability.

4 Sample composition and description

The empirical analysis uses an unbalanced panel data set composed of Italian companies observed over the years 2004-2010. Several reforms of Italian corporate income tax, together with the introduction of a tax credit for R&D expenditure in 2007, make this period particularly interesting and provide an ideal setting for testing the effect of fiscal variables on R&D choices of Italian companies.

The accounting data are gathered merging the AIDA and the ORBIS databases, both compiled by Bureau van Dijk Electronic Publishing, containing accounting information on Italian corporations. Initially I identified a balanced panel composed by 163 companies having a known value of R&D expenditure (for which the value of R&D expenditure is not a missing data in ORBIS) and having balance sheet data in every year between 1999 and 2010. I excluded 13 inconsistent data[6] from the sample. The result is a non-balanced panel data set, described in panel A of table 1.

Panel B of table 1 provides summary statistics on the fiscal status of the companies included in the sample, showing that the percentage of companies having positive income before tax and R&D expenditure (column 3) is almost stable from 2004 to 2007 (around a value of 82-84%), while it decreases from 2008 onwards, declining to

[6] We dropped observations with a negative value of some variables such as R&D expenditure or sales.

a value of 72.7% in 2010. This reduction in the number of profitable companies is basically due to the economic crisis.

Table 1. **Sample formation and composition**

Panel A: Sample formation

	Companies	Observations
Balance sheet data available in every years between 2004 and 2010	163	1,141
Inconsistent data		13
Final sample		**1,128**

Panel B: Sample composition and status of companies

Fiscal Year	Observations	Income before taxes and R&D expenditure	
		Positive	Null or negative
2004	159	134	25
2005	162	135	27
2006	162	133	29
2007	162	133	29
2008	161	112	49
2009	161	103	58
2010	161	117	44

Notes: Panel A shows the sample formation. Panel B shows the sample composition for every year during the period 2004-2010 and the status of companies.
Source: Authors' calculation on ORBIS data.

Figure 2 shows the distributions of the simulated *MTRs* for the companies in the sample. The marginal tax rates are aggregated for sub-groups of years having the same statutory tax rate. The time-series variation in the *MTRs* is primarily due to the change in statutory tax rate, which was stable at 33% from 2004 to 2007 and was reduced to 27.5% in 2008. The figure shows that the majority of the companies faced the maximum statutory tax rate (i.e. the majority of the companies had positive taxable income before R&D expenditure). In particular, the percentage of companies facing the maximum statutory tax rate is almost stable (equal to 80%) during the period considered (see table 1) and is consistent with the findings of previous studies (Alworth and Arachi, 2001; Arachi and Bucci, 2010) on Italy.

Figure 2.* The distribution of the simulated *MTRs

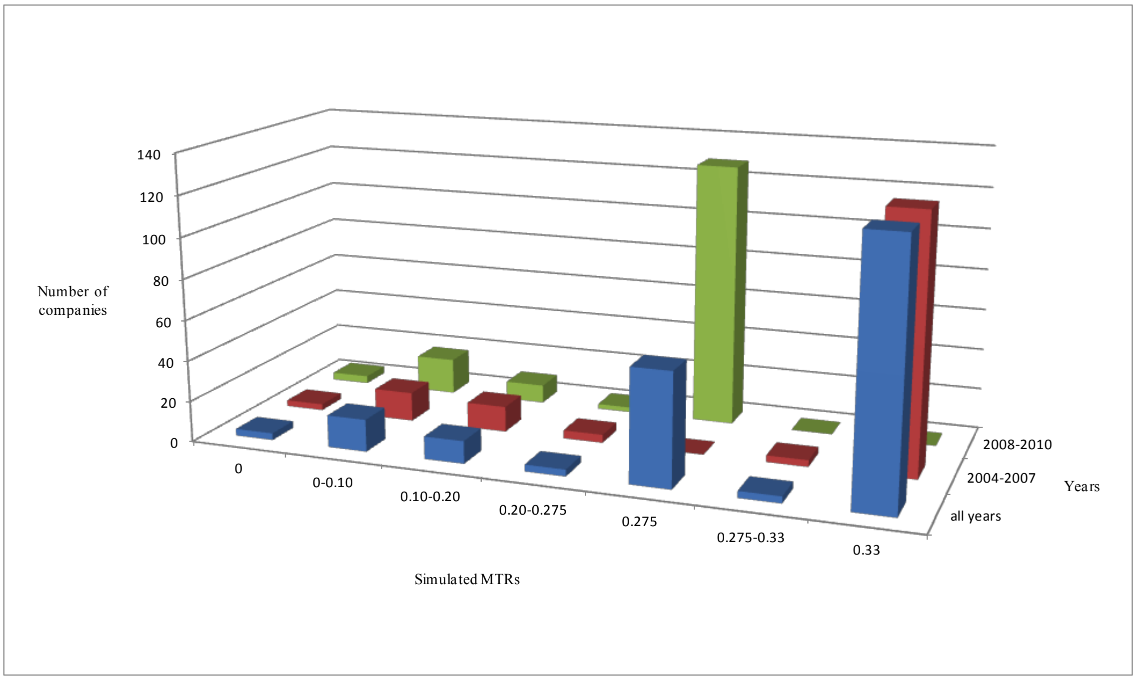

Table 2 reports summary statistics of all the variables included in the empirical model. The dummy variable *R&DC*, which assumes value 1 for companies investing in R&D, shows that on average 17.2% of sample observations record a positive value of R&D expenditure. The proxy for R&D intensity computed by the ratio between R&D expenditure and total assets (*R&DI*) ranges between a value of 0 and 0.362 (reaching a mean value of 0.006); the alternative proxy, measured by the ratio between R&D expenditure and total number of employees (*ALT_R&DI*), has a lower mean and a lower maximum value (equal to 0.001 and 0.032 respectively). Among the fiscal variables, the marginal tax rate reaches a mean value (0.262) higher than that of the effective tax credit rate (0.158), implying that on average the fiscal benefit due to the deductibility of R&D expenditure is higher than the one due to R&D tax credit.

Panel B of table 2 presents the correlation among the variables: the correlation between the dummy for R&D companies and both the proxies for R&D intensity (0.597 and 0.655 respectively) is high. Among the controls variables the highest correlation is between employees and the size of the company: the correlation between *EMP* and *S* is equal to 0.875, while that with *LARGE* is 0.641. Also the correlation between *EMP* and the dummy variable *R&DC* (0.446) results strong. There is no significant correlation between the remaining variables included in the empirical model.

***Table 2.* Descriptive statistics and correlation among variables**

Panel A: Descriptive statistics for all variables, pooled for years 2004-2010 (obs.1,128)

Definition	*Variable*	*Mean*	*SD*	*Min*	*Max*
Dummy variable for companies with a positive R&D expenditure	*R&DC*	0.172	0.378	0	1
R&D intensity (in % of total assets)	*R&DI*	0.006	0.021	0	0.362
R&D intensity (in % of employees)	*ALT_R&DI*	0.001	0.004	0	0.032
Marginal tax rate	*MTR*	0.262	0.096	0	0.33
Effective tax credit rate	*ETCR*	0.158	0.166	0	0.382
Natural log of sales	*S*	5.749	1.905	0.367	11.591
Dummy variable for large companies	*LARGE*	0.563	0.496	0	1
Natural log of company's age	*AGE*	3.474	0.985	0	5.063
Market competition	*MC*	0.080	0.209	0.001	1
Natural log of number of employees	*EMP*	7.149	1.903	1.792	12.206

Panel B:Correlation among variables

	R&DC	*R&DI*	*ALT_R&DI*	*MTR*	*ETCR*	*S*	*LARGE*	*AGE*	*MC*	*EMP*
R&DC	1									
R&DI	0.597	1								
ALT_R&DI	0.655	0.866	1							
MTR	0.174	0.078	0.110	1						
ETCR	0.062	0.018	-0.016	-0.006	1					
S	0.387	0.075	0.200	0.345	0.031	1				
LARGE	0.267	0.097	0.163	0.309	0.027	0.703	1			
AGE	-0.021	0.006	0.024	0.055	0.082	0.063	0.019	1		
MC	0.168	-0.075	0.001	0.158	-0.045	0.271	0.145	-0.038	1	
EMP	0.446	0.154	0.258	0.333	0.029	0.875	0.641	0.081	0.196	1

Notes: Panel A shows the descriptive statistics for all variables pooled for year 2004-2010. Panel B presents the cross-correlation among all variables included in the empirical model.

5 The micro-econometric analysis: estimation results

In line with empirical literature analyzing the effects of R&D fiscal incentives on firms' innovation, I estimate the following equation:

$$R\&D_{it} = \alpha_i + \beta MTR_{it} + \gamma MTCR_{it} + \theta X_{it} + \varepsilon_{it}$$

where $R\&D_{it}$ is the R&D expenditure of firm i in year t, MTR_{it} is a variable measuring the fiscal benefit due to the deductibility of R&D expenditure, $MTCR_{it}$ measures the tax credit received by the enterprise investing in R&D and X_{ij} is a vector of firm-specific characteristics affecting R&D behavior. In this specification, the parameters β and γ, expected to be positive, measure the average increase that, respectively, the fiscal benefits due to R&D deductibility and to R&D tax credit induce in companies' R&D activity.

The empirical analysis proceeds in two steps. In the first I test the presence of a fiscal effect affecting the decision of companies to invest in R&D. I use the dummy *R&DC* as dependent variable, which shows companies investing in R&D. The multivariate analysis relies on a probit model. Subsequently, in the second step, I estimate the impact of fiscal and non-fiscal controls on R&D expenditure. I implement this analysis by estimating a tobit model.

For the sake of comparison with prior literature, I start the empirical analysis investigating which effects size, age and market structure have on R&D, without inserting the fiscal variables among the controls.

The results of the probit regression (column 1.a of table 3) show that the variable *S* (the log of company's sales) is signed positive and is highly statistically significant. This finding, in line with previous literature (i.e. Clausen, 2009), confirms that the higher company's size is, the higher its probability to invest in R&D is. On the contrary, the variable *LARGE* results not statistically significant. The variable *AGE* is significantly and negatively linked to the probability to invest in R&D, confirming that older companies have a lower propensity to invest in R&D than younger ones (i.e. Clausen, 2009; Almus and Czarnitzki, 2003). Finally, market competition is not a significant factor affecting R&D investment choice.

The tobit analysis (column 1.b of table 3) confirms that size and age of a company are significant factors affecting also R&D expenditure: the bigger or the younger the company is, the higher the value of the investment in R&D is. Contrary to the probit analysis, it emerges that market competition significantly and negatively affects R&D expenditure. In line with the theoretical prediction (i.e. Shumpeter, 1934; Desgupta-Stiglitz, 1980, Aghion-Howitt, 1992) R&D expenditure decreases in the presence of higher market competition.

In the second column of table 3 I present the results obtained when the marginal tax rate is added to the control variables. In line with my expectation, I find a strong evidence of a fiscal effect affecting both the probability to invest in R&D and the magnitude of R&D expenditure. The positive and strongly significant coefficients associated to the marginal tax rate show that the higher the tax saving due to R&D deductibility is, the more likely companies are to invest in R&D and to increase R&D expenditure. The inclusion of the *MTR* changes neither the sign nor the significance level of non-fiscal factors.

Then I study the effect of tax credits for companies investing in R&D activity. The results (column 3 of table 3) show that the marginal tax credit rate positively and significantly affects both the probability to invest in R&D and R&D expenditure. This finding confirms my expectations that an increase in the tax credit due to R&D investment has positive effects on R&D choices of companies. By comparing the magnitude of the two different fiscal effects I can highlight that R&D behavior responds stronger to an increase in the marginal tax rate than in the marginal tax credit rate.

The results in the fourth and fifth columns are very similar in terms of signs and of significance level, showing that the inclusion of the regional and industrial dummies does not significantly affect the relationship between control variables and R&D activity. For expositional convenience, the table reports the estimated coefficients neither for regional nor for industry dummies. However, it should be pointed out that the regional dummies are not statistically linked to either the probability to invest in R&D and R&D expenditure, showing that the presence of different regional or provincial R&D incentives does not affect business R&D. As regard to industry dummies, it emerges that those companies operating in “*Electricity, gas, steam and air conditioning*”, “*Construction*” and “*Transportation and Storage*” are less likely to invest in R&D activity and have lower R&D expenditure than manufacturing companies.

Table 3. **Determinants of R&D investments**

Independent Variables		*Expected Signs*	1 (a)	1 (b)	2 (a)	2 (b)	3 (a)	3 (b)	4 (a)	4 (b)	5 (a)	5 (b)
Fiscal variable	*MTR*	+			0.547***	0.190***	0.618***	0.211***	0.611***	0.209***	0.615***	0.221***
					(0.122)	(0.046)	(0.133)	(0.051)	(0.135)	(0.052)	(0.131)	(0.053)
	ETCR	N.S.S.					0.193**	0.047**	0.190**	0.047**	0.213***	0.056**
							(0.060)	(0.019)	(0.060)	(0.019)	(0.058)	(0.019)
Other controls	*S*	+	0.063***	0.014***	0.057***	0.012***	0.054***	0.012***	0.055***	0.012***	0.055***	0.012***
			(0.008)	(0.003)	(0.008)	(0.002)	(0.008)	(0.002)	(0.008)	(0.002)	(0.008)	(0.002)
	LARGE	+	0.001	0.007	-0.010	0.003	-0.007	0.004	-0.009	0.005	0.003	0.009
			(0.032)	(0.009)	(0.031)	(0.009)	(0.031)	(0.009)	(0.031)	(0.009)	(0.029)	(0.009)
	AGE	-	-0.020**	-0.005*	-0.021**	-0.005*	-0.022**	-0.005**	-0.022**	-0.006**	-0.031***	-0.008**
			(0.009)	(0.003)	(0.009)	(0.003)	(0.009)	(0.003)	(0.009)	(0.003)	(0.009)	(0.003)
	MC	?	-0.018	-0.033**	-0.016	-0.031**	-0.008	-0.028**	-0.005	-0.026	0.002	-0.017
			(0.047)	(0.012)	(0.044)	(0.011)	(0.042)	(0.011)	(0.042)	(0.012)	(0.042)	(0.012)
Regional dummies			*No*		*No*		*No*		*Yes*		*Yes*	
Industry dummies			*No*		*No*		*No*		*No*		*Yes*	
Observations			1128		1128		1128		1128		1128	

Notes: column (a) provides the marginal effects (calculated at the means of the independent variables) of the impact of fiscal and non-fiscal factors on the probability to invest in R&D activity; column (b) provides the estimates of the impact of tax and non-tax factors on R&D expenditure. Regressions in columns (a) use as dependent variable *R&DC*, a dummy showing companies investing in R&D activity; regression in columns (b) use as dependent variable *R&DI*, which is the ratio between R&D investment and total assets. *MTR* is the marginal tax rate computed using the Graham-Shevlin methodology; *ETCR* is the marginal effective tax credit deriving from R&D investment; *S* is the log of sales; *LARGE* is a dummy variables showing companies having a value added above the median value; *AGE* is the log of the number of year since firm's foundation; *MC* is the ratio between firm's and industry's sales. Estimated regressions are:

1) $$\begin{cases} a)\ R\&DC_{it} \\ b)\ R\&DI_{it} \end{cases} = \alpha_0 + \alpha_1 S_{it} + \alpha_2 LARGE_{it} + \alpha_3 AGE_{it} + \alpha_4 MC_{it} + \varepsilon_{it}$$

2) $$\begin{cases} a)\ R\&DC_{it} \\ b)\ R\&DI_{it} \end{cases} = \alpha_0 + \alpha_1 MTR_{it} + \alpha_2 S_{it} + \alpha_3 LARGE_{it} + \alpha_4 AGE_{it} + \alpha_5 MC_{it} + \varepsilon_{it}$$

3) $$\begin{cases} a)\ R\&DC_{it} \\ b)\ R\&DI_{it} \end{cases} = \alpha_0 + \alpha_1 MTR_{it} + \alpha_2 ETCR_{it} + \alpha_3 S_{it} + \alpha_4 LARGE_{it} + \alpha_5 AGE_{it} + \alpha_6 MC_{it} + \varepsilon_{it}$$

4) $$\begin{cases} a)\ R\&DC_{it} \\ b)\ R\&DI_{it} \end{cases} = \alpha_0 + \alpha_1 MTR_{it} + \alpha_2 ETCR_{it} + \alpha_3 S_{it} + \alpha_4 LARGE_{it} + \alpha_5 AGE_{it} + \alpha_6 MC_{it} + regional\ dummies + \varepsilon_{it}$$

5) $$\begin{cases} a)\ R\&DC_{it} \\ b)\ R\&DI_{it} \end{cases} = \alpha_0 + \alpha_1 MTR_{it} + \alpha_2 ETCR_{it} + \alpha_3 S_{it} + \alpha_4 LARGE_{it} + \alpha_5 AGE_{it} + \alpha_6 MC_{it} + regional\ dummies + industry\ dummies + \varepsilon_{it}$$

Robust standard errors in parentheses. Superscript asterisks indicate statistical significance at 0.01 (***), 0.05 (**) and 0.10 (*).

Table 4 reports the results of several sensitivity and robustness checks.

First, I insert an alternative proxy for the marginal tax rate into the empirical model , the taxable income dummy (*TID*), which is a dichotomous variable based on the sign of the current period taxable income before R&D deductions (Graham, 1996b). *TID* takes a value equal to the top statutory tax rate for firms having positive income before taxes and before R&D expenditure, and otherwise zero. The results confirm that an increase in fiscal benefit due to R&D deductibility has a positive impact on both the decision of companies to invest in R&D and R&D expenditure, even if the marginal effects of *TID* is almost half of those estimated for *MTR* (columns 5 of table 3).

Supposing that bigger companies are more likely to invest in R&D, I replicate the main analysis on a sub-sample, which excludes small companies. Following the definition of Italian legislation, I consider as small those companies having less than 50 employees and satisfying one of the 2 following criteria: the total assets or the sales revenues at the end of the fiscal year do not exceed 10 million euro. The results (columns 2 of table 4) show that excluding small companies from the sample slightly increases the magnitude of the fiscal effect on the decision to invest in R&D activity: a mean-level unit increase in *MTR* raises the probability to invest in R&D by about 65% (almost 4 percentage points more than in the complete sample). Among the remaining control variables there are not significant differences regarding the signs and the significance level obtained by estimating the full sample.

In line with previous literature (Almus and Czarnitzki, 2003; Berube and Mohen, 2009; Clausen, 2009; Gorg and Strobl, 2007; Hussinger, 2008; Takalo *et al.*, 2013) I add another measure of size of the company to control variables: the log of the number of employees. The unavailability of such information for several companies over numerous years, implies a significant reduction in the number of observations. The results (columns 3 of table 4) confirm the presence of a fiscal effect affecting both the probability to invest and the magnitude of R&D activity and confirm that, in line with previous literature (i.e. Almus and Czarnitzki, 2003; Berube and Mohen 2009; Clausen, 2009; Hussinger, 2008; Gorg and Strobl, 2007; Takalo *et al.*, 2013), an increase in the number of employees has a positive impact on R&D choices.

Finally, I replicate the main analysis using an alternative proxy for R&D intensity, computed as the ratio between R&D expenditure and total number of employees. By comparing the results obtained (column 4 of table 4) with those estimated for the main model (column 5 of table 3) I can underline that there are no significant differences in terms of signs or significance levels. However, it emerges that an increase in both the marginal tax rate or the effective tax credit rate has a lower effect on R&D expenditure (the coefficients decrease from 0.221 to 0.03 and from 0.056 to 0.009, respectively).

6 Concluding remarks

In this paper I have investigated whether fiscal incentives affect R&D of companies, focusing the analysis on the effect of marginal tax saving due to R&D deductibility and to R&D tax credits. The results deliver strong evidence that fiscal variables significantly affect the decision of companies to invest in R&D such as R&D expenditure. The positive and strongly significant coefficients associated with the marginal tax rate show that the higher the tax saving due to R&D deductibility is, the more likely companies are to invest in R&D and to increase R&D expenditure. Also the marginal tax credit rate positively and significantly affects both the probability to invest in R&D and R&D expenditure. These findings show that R&D deductibility and the R&D tax credits are instruments which are able to foster business R&D. Nevertheless, over the last decade the growth of business R&D expenditure has not been suffice in improving the Italian ranking as regard to other OECD and European countries. A policy implication is that public policies should be strengthened so as to increase business R&D expenditure and reach the R&D target established by strategy Europe 2020 (European Commission, 2010).

The main limit of this study is that the empirical analysis is made on a sample composed of a small number of firms, which is not fully representative of the grand total of Italian companies. However, it would be interesting to replicate these analysis using different data (for example the Community Innovation Survey) and verifying whether my main results can be confirmed.

Table 5. **Robustness checks**

Independent Variables		***Expected Signs***	1 (a)	1 (b)	2 (a)	2 (b)	3 (a)	3 (b)	4 (a)	4 (b)
Fiscal variable	*MTR*	+			0.654***	0.221***	0.394**	0.128**	0.514**	0.030**
					(0.139)	(0.054)	(0.139)	(0.041)	(0.160)	(0.009)
	TID	+	0.370***	0.133***						
			(0.094)	(0.037)						
	ETCR	N.S.S.	0.209***	0.053**	0.225***	0.056**	0.247***	0.060**	0.222**	0.009**
			(0.059)	(0.019)	(0.061)	(0.019)	(0.066)	(0.020)	(0.078)	(0.004)
Other controls	*S*	+	0.058***	0.013***	0.056***	0.011***	-0.042**	-0.020***	0.077***	0.003***
			(0.008)	(0.003)	(0.009)	(0.003)	(0.017)	(0.006)	(0.010)	(0.001)
	LARGE	+	-0.002	0.008	0.004	0.010	-0.036	0.003	0.016	0.001
			(0.030)	(0.009)	(0.031)	(0.009)	(0.036)	(0.010)	(0.039)	(0.002)
	AGE	-	-0.028**	-0.007**	-0.033**	-0.008**	-0.039***	-0.010**	-0.036**	-0.002**
			(0.009)	(0.003)	(0.009)	(0.003)	(0.011)	(0.003)	(0.012)	(0.001)
	MC	?	0.001	-0.018	0.012	-0.013	0.044	-0.007	0.005	-0.003
			(0.044)	(0.012)	(0.048)	(0.012)	(0.048)	(0.011)	(0.055)	(0.003)
	EMP	+					0.131***	0.039***		
							(0.018)	(0.007)		
Regional dummies			*Yes*		*Yes*		*Yes*		*Yes*	
Industry dummies			*Yes*		*Yes*		*Yes*		*Yes*	
Observations			1,128		1,088		794		794	

Notes: column (a) provides the marginal effects (calculated at the means of the independent variables) of the impact of fiscal and non-fiscal factors on the probability to invest in R&D activity; column (b) provides the estimates of the impact of tax and non-tax factors on R&D expenditure. Regressions in columns (a) use as dependent variable *R&DC*, a dummy showing companies investing in R&D activity; regressions in columns (b) use as dependent variable *R&DI*, which is the ratio between R&D investment and total assets. *MTR* is the marginal tax rate computed using the Graham-Shevlin methodology; *ETCR* is the marginal effective tax credit deriving from R&D investment; *S* is the log of sales; *LARGE* is a dummy variables showing companies having a value added above the median value; *AGE* is the log of the number of year since firm's foundation; *MC* is the ratio between firm's and industry's sales; *EMP* is the log of total number of employees. In columns (1) I use an alternative proxy for marginal tax rate, *TID*, which is equal to the top statutory tax rate if a company in the fiscal year as a positive income before taxes and before R&D expenditure; in column (2) I uses a sample purged by small companies (I follow the definition of small companies adapted by the Italian legislation, based on the value of total assets, sales and total number of employees); in columns (3) I add to controls the log of the number of employees; in column 4 I use as dependent variable *ALT_R&DI*, which is the ratio between R&D investment and total number of employees. Estimated regressions are:

1) $$\begin{cases} a)\ R\&DC_{it} \\ b)\ R\&DI_{it} \end{cases} = \alpha_0 + \alpha_1 TID_{it} + \alpha_2 ETCR_{it} + \alpha_3 S_{it} + \alpha_4 LARGE_{it} + \alpha_5 AGE_{it} + \alpha_6 MC_{it} + regional\ dummies + industry\ dummies + \varepsilon_{it}$$

2) $$\begin{cases} a)\ R\&DC_{it} \\ b)\ R\&DI_{it} \end{cases} = \alpha_0 + \alpha_1 MTR_{it} + \alpha_2 ETCR_{it} + \alpha_3 S_{it} + \alpha_4 LARGE_{it} + \alpha_5 AGE_{it} + \alpha_6 MC_{it} + regional\ dummies + industry\ dummies + \varepsilon_{it}$$

3) $$\begin{cases} a)\ R\&DC_{it} \\ b)\ R\&DI_{it} \end{cases} = \alpha_0 + \alpha_1 MTR_{it} + \alpha_2 ETCR_{it} + \alpha_3 S_{it} + \alpha_4 LARGE_{it} + \alpha_5 AGE_{it} + \alpha_6 MC_{it} + \alpha_7 EMP_{it} + regional\ dummies + industry\ dummies + \varepsilon_{it}$$

4) $$\begin{cases} a)\ R\&DC_{it} \\ b)\ ALT\_R\&DI_{it} \end{cases} = \alpha_0 + \alpha_1 MTR_{it} + \alpha_2 ETCR_{it} + \alpha_3 S_{it} + \alpha_4 LARGE_{it} + \alpha_5 AGE_{it} + \alpha_6 MC_{it} + regional\ dummies + industry\ dummies + \varepsilon_{it}$$

Robust standard errors in parentheses. Superscript asterisks indicate statistical significance at 0.01 (***), 0.05 (**) and 0.10 (*).

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