THE DYNAMICS OF PUBLIC SUPPORT TO BUSINESS R&D

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Abstract

In this paper we investigate the dynamic interaction between R&D tax credits and R&D subsidies when both tools are available to firms, as is the case in most OECD countries. Using a sample of manufacturing firms in Spain, we find that (i) controlling for firms' observed attributes and unobserved heterogeneity, there is stronger persistence in the use of tax incentives than in the use of subsidies; (ii) firms are less likely to switch between each of these tools but if they use one at t they are likely to use both the next period; (iii) non-R&D performers are more likely to either use only subsidies or both instruments. Altogether these results suggest that tax credits and subsidies serve different types of firms and policy goals; in particular subsidies seem to be an appropriate tool to get more firms to perform R&D, while tax credits would not be suited to that end. Tax credits are more appealing for large firms already engaged in R&D, who then keep using them irrespective of most observed attributes. The budgetary cost of each policy will differ over time, as possibly will social benefits.

Keywords: R&D, innovation, public policy, R&D tax incentives, R&D subsidies, persistence

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I. Introduction

Many policy-makers aim at increasing a country's competitiveness and living standards by fostering innovation-based growth. R&D tax incentives and direct subsidies to private firms are among the most widely used specific policy tools to increase innovation. Both tools are often used at the same time in many countries, along with patenting systems and other types of support. A growing body of studies investigates how effective tax incentives are at increasing private sector R&D effort (R&D investment) or outcomes (innovation, patenting and productivity), and analogously for subsidies.

Most of these studies focus on the estimation of the additionality effect of each tool individually, testing for potential crowding out effects of each of these tools. While this is an essential part of a policy evaluation exercise, the interaction between both tools and their joint dynamics have basically not been studied. [1] To fully understand how these incentives operate, an analysis of the users of these tools, in particular what determines take up over time should be included. Two issues of policy interest are whether the use of a tool at time t predicts its future use (the extent of continuity or persistence in the use of each tool) and whether both tools interact dynamically, that is, whether using subsidies at time t increases the likelihood of using tax credits later on, and vice versa (cross-persistence). Are firms that claim tax credits more likely to obtain a subsidy in the future? That is, do firms that conduct commercially successful R&D eventually invest in projects that fit the agency's preferences? Does receiving a subsidy at time t increase the chances that a firm will use tax incentives in the future? How strong is interdependence across both tools? Is the magnitude of this effect larger than the magnitude of the own effect? Do firms that get subsidies generate an additional future cost in terms of tax deductions? Do firms that claim tax deductions engage in subsidized projects in subsequent periods? The answer to these questions would be provided by an analysis of cross-persistence.

[1] See surveys by Correa et al. (2013) on the effects of direct support, and Mairesse and Ientile (2009) on R&D tax incentives. For studies at the aggregate level, see Guellec and Pottelsberghe (2003) and Popp et al. (2007).

Thus, rather than focusing on the effects that these tools have on private R&D investment, the main goal and contribution of this paper is to explore the joint dynamics of R&D subsidies and fiscal incentives, a subject that to the best of our knowledge has not been previously explored.

To investigate these questions we use data from the Spanish Business Strategies Survey (*Encuesta sobre Estrategias Empresariales* –ESEE henceforth), an annual survey of a representative sample of Spanish manufacturing firms over the period 2001 to 2008. [2] These data allows us to control for individual heterogeneity and identify state dependence. We first estimate static and dynamic individual probit models to describe the likelihood that a firm will use subsidies or tax credits. We then estimate static and dynamic bivariate probit models that take into account the potential correlation between the use of both tools.

We find that R&D differences in own-persistence and cross-persistence R&D subsidies and tax credits. Own persistence is positive and much higher for tax credit users than for subsidy users. Cross persistence is found to be negative: firms that use exclusively tax credits are less likely to use only subsidies next period, while firms that are exclusive users of subsidies are less likely to rely on only tax credits the next period. At this stage, however, our results are still preliminary and largely descriptive, and point to correlations that are not conclusive regarding causation.

This paper is organized as follows. Section 2 gives a short description of the data, variable definitions and descriptive statistics. Section 3 outlines the hypothesis and econometric approach. Section 4 presents our empirical results and section 5 concludes.

II. Data and descriptive statistics

The ESEE contains questions on the firm's production, ownership, markets and R&D decisions as well as on the use of several types of public support to R&D activities. The usable sample in 2001-2008 consists of an unbalanced panel of about 12.000

[2] This survey collects information for manufacturing firms with more than 10 employees since 1990, but the questions relative to the use of tax incentives were first introduced in 2001. Firms with 10-200 employees (small and medium enterprises, SMEs henceforth) are randomly sampled by industry and size strata and firms with more than 200 employees are surveyed exhaustively. The response rate is high. See www.funep.es for a thorough description.

observations and 2000 firms.[3] About one third of firms invest in R&D, although as expected this rate is higher among large firms (about 70%) and much smaller among SMEs (about 21%). Regarding public support, we will focus on the use of R&D tax credits and R&D subsidies granted by the central administration. Subsidies may be offered as well by regional and European administrations, but the goals of support may differ across agencies, in which case aggregating all sources of public support may distort the analysis.

The proportion of firms using tax credits or subsidies from the central government is surprisingly small, even when comparing to those that invest in R&D. The use of tax credits is more frequent than the use of subsidies. Regarding employee education level, the median percentage of employees with higher education is 4%. It is surprising to find that about half of firms in the sample do not answer the question relative to the type of market they operate in and their position in their main market, meaning whether the market is atomized, and whether the firm is a market leader. Table 1 summarizes some of the main features of firms in the unbalanced panel. [4]

Table 1 Descriptive Statistics. Whole sample

	2008		All years	
	Percentage of firms or median	Num firms	% of firms or median	Num. firm-year Observations
Use Subsidies (%)	8%	2008	7%	12004
Use Tax Credits (%)	11%	2008	12%	12004
Use both	4%	2008	4%	12004
Use none	85%	2008	85%	12004
Use only TaxCred	7%	2008	8%	12004
Use only Subsidies	4%	2008	3%	12004
Invest in R&D	35%	2005	36%	12373
Num. Employees (median)	50	2009	51	12418
Firms with more than 200 employees	25%	2009	29%	12418
Age (median)	23	1845	21	12161
Human capital (med)	4%	2006	3%	12389
Exporter (%)	64%	2009	63%	12418
Foreign capital	15%	2009	16%	11992
Market leader	23%	960	23%	5654
Atomized market	42%	960	42%	5654
Private domestic firm	83%	2009	81%	11992
Foreign cap (+50%)	15%	2009	16%	11992

[3] The number of firms and observations will be smaller in the estimation sample, as some firms may not have answered all questions and firms not in the panel in 2001 are dropped.
[4] Variables are defined in Table A in the Appendix.

Evaluate tech change	25%	2009	28%	12418
Debt/Equity	0.48	1604	0.44	9963
Use legal IP tools	7%	2009	7%	11998
High tech (%)	8%	2009	8%	12418
Medium tech (%)	12%	2009	13%	12418

Notes:
Tax Credits includes only deductions for R&D, and not for technological innovation. Subsidies includes only direct support granted to firms by the Central Government.

Regarding the two sources of public support, we observe not only that the use of R&D tax incentives is more widespread than the use of subsidies, but that more firms use them for more than one year, suggesting higher persistence.

Table 2 Subsidies and Tax Incentives

Status duration over the sample period

% of firms

	R&D Subsidy	R&D Tax Incentives
Never have	88%	82%
Only one year	5.5%	7.4%
More than one year	6.5	10.6%
Whole period	0.5%	1.5%
Total	100	100

Finally, Table 3 shows the transition rates across policy status considering four possible situations. 96% of firm-years that do not use any type of support one period did not use any next period. The degree of persistence is lower for remaining status. When only one type of support is used (either a subsidy or a tax deduction), in most cases support is lost in the next period. When both types are used, the most frequent status the following year is using a tax credit. However, conditional probabilities may lead to wrong conclusions about true state dependence because both observable and non-observable heterogeneity are not taken into account.

Table 3 Transition matrix of R&D subsidy and tax credit status

% of firms

at t-1	at t (%)			
	No S, no TC	S, no TC	TC, no S	S and TC
No S, no TC	96%	1%	2%	0.5%
S, no TC	31%	51%	5%	13%
TC, no S	28%	2%	60%	9%
S and TC	8%	9%	21%	62%

Note: S stands for Subsidy, and TC for Tax Credit

III. Hypotheses and Econometric Specifications

R&D subsidies and tax incentives, although apparently similar in that they both reduce the cost of R&D investment for the firm, may work quite differently, especially in terms of the R&D projects involved. A subsidy reduces the cost of the project independently of its success and provides funds to carry it out. Tax incentives, which include tax allowances and tax credits, allow a firm to reduce its corporate tax liability, reducing in fact the user cost of capital; but unless tax credits are refundable, a firm must obtain positive profits to benefit from this type of support. Subsidies are allocated through public agencies that rank R&D projects submitted by firms according to some criteria. These might include indicators of the gap between social and private returns associated to the project. Borrowing constraints and knowledge spillovers may be at the origin of this gap. It is less likely that firms whose potential projects face financing constraints or appropriability difficulties will benefit from tax credits, simply because they are less likely to generate sufficient taxable income. [5] In that sense, subsidies respond to a cost-sharing scheme, while tax incentives become a reward for success or performance.[6] These different mechanisms are likely to have several implications. First, in terms of the features of the R&D projects undertaken, and second in terms of the persistence in the use of each tool, as well as their cross-persistence.

We expect that, in the case of tax incentives, the chances that a firm will claim a deduction at time t are likely to depend on whether it did at t-1. This is so because a firm whose R&D investment was commercially successful at time t-1 is likely to keep investing at time t therefore becoming eligible for further tax deductions (this is the hypothesis of "success-breeds-success" in innovation).[7] A less positive interpretation of persistence is that fiscal incentives might protect incumbents against innovative entrants (Bravo Biosca, Criscuolo and Menon (2012)).

[5] See Busom, Corchuelo and Martínez-Ros (2012) for a static study on the attributes of users of R&D subsidies and tax credits in the manufacturing industry.

[6] Berubé and Mohnen (2009) find differences in the innovation output of Canadian firms that received subsidies on top of tax credits. Firms that benefited from both policy measures introduced more new products than firms that only benefited from R&D tax incentives. They also made more world-first product innovations, suggesting that the nature of subsidized projects was quite different from purely privately funded projects.

[7] For recent research on the persistence of innovation, see Peters (2009), Martínez and Labeaga (2009), Raymond et al. (2013), and Arqué-Castells (2013).

In the case of subsidies, however, we expect persistence to be smaller for at least two reasons. One, because public agencies are selective, and the type of projects they fund is likely to differ from privately profitable projects. A firm may not be interested in continually undertaking this type of project, even if subsidized. In addition, agencies may have the goal of facilitating firm entry into RD, resulting in a high proportion of first-time awardees.

If it turns out that subsidies increase the likelihood of claiming tax credits in the future it would mean that subsidies have a permanent effect on the ability of the firm to conduct commercially successful innovations. It is conceivable that the knowledge generated trough a subsidized project will lead to further R&D projects which generate profits, so that the firm can use tax credits at some point. Evidence on a permanent effect of R&D subsidies on a firm's investment is found by Arqué (2013) and Arqué and Mohnen (2013). [8] We should expect this to be reflected at some point in the firm's claims for tax deductions. On the other hand, firms that have experience in performing R&D projects with high private returns might be interested in undertaking projects that would be eligible for a subsidy, so we would expect cross persistence in this direction as well.

Estimation Strategy and Econometric Specifications

Our basic aim is to estimate a dynamic model of the use of each policy tool in order to determine the extent of persistence and the importance of some firm attributes. We observe two binary indicator variables, y_{jit}, with j=1 referring to firm i' s status in regard to R&D tax credits in year t, and j=2 referring to status with respect to direct support. We assume that the underlying unobserved latent variables are a function of a vector of lagged observable variables x_{it-1}; the firm's status regarding the use of support the previous year, y_{jit-1}; an unobservable time-variant firm-specific random effect, η_{ji}, and a time-varying random error term u_{it}:

[8] Aschhoff (2010) also provides evidence of persistence of participation in R&D subsidy programs in Germany.

$$y^{*}_{jit} = \gamma_j y_{jit-1} + \beta x_{it-1} + \eta_{ji} + u_{jit}$$
$$y_{jit} = \begin{cases} 1 & y^{*}_{jit} > 0 \\ 0 & else \end{cases} \qquad [1]$$

where the importance of heterogeneity is measured by $\rho = \sigma_\mu^2 / \left(\sigma_\mu^2 + \sigma_u^2\right)$. We first estimate a set of univariate static (assuming no state dependence, $\gamma = 0$) and dynamic models, and we then jointly estimate both equations through a bivariate probit model, as both dependent variables are likely to be correlated and efficiency will increase with joint estimation. In addition, when the model contains an endogenous explanatory variable, the estimation obtained with a bivariate probit model will be consistent.[9]

The simplest specification is to estimate a static, pooled model assuming that there is no neglected heterogeneity and that u_{it} are independent over time. A static pooled probit model provides estimates of partial effects that are consistent and robust to clustering within individuals, provided that omitted heterogeneity is independent of vector x (Wooldridge, 2010). We next we estimate a static random effects model using Mundlak's procedure to allow for correlation between the individual effects and observed firm attributes. The third univariate model we estimate is a dynamic probit model to distinguish between *true state* dependence- the impact of the lagged dependent variable on the dependent variable-, and *spurious state* dependence caused by the presence of time-invariant unobserved heterogeneity.

When estimating the dynamic model(s), we need to take into account the *initial condition* problem, which arises from the fact that the lagged dependent variable may be correlated with unobserved heterogeneity. In the dynamic case, a pooled estimation method does not provide consistent estimates. We will use a modified Wooldridge's (2005) approach, based on conditional maximum likelihood estimator of a random effects probit model. A common specification of this approach usually includes, in addition to the independent variables and lagged dependent variable, the within means of the time-varying explanatory variables (Chamberlain-Mundlak Random Effects model). However, as Akay (2011), Rabe-Hesketh and Skrondal (2013) and others show, this model is overly constrained, and can lead to serious bias for short panels, which is

[9] See Wooldridge (2010), Chapter 15.

our case. Rabe-Hesketh and Skrondal show through a series of Monte Carlo experiments that when initial period explanatory variables are included the bias practically disappears. We will therefore assume that:

$$\eta_i = \alpha_0 + \alpha_1 y_{ji0} + \alpha_2 x_{i0} + \alpha_3 \bar{x}_i' + \varepsilon_i, \quad \varepsilon_i \sim idd\ N(0, \sigma_\varepsilon^2) \qquad [2]$$

where x_{i0} and $\bar{x}_i'$ are, respectively the initial values of independent variables, and the mean of each independent variable excluding the initial period. This model allows to test for true state dependence after controlling for unobserved heterogeneity. Finally, given that both policy statuses may interact, the error terms of the two equations may be correlated. To deal with this, we formulate the subsidies and tax credit decisions interpedently through a static bivariate probit model:

$$\begin{aligned} y_{1it}^* &= \beta_1 x_{t-1} + \eta_i + u_{1t} \\ y_{2it}^* &= \beta_2 x_{t-1} + \eta_i + u_{2t} \end{aligned} \qquad [3]$$

$$y_{ijt} = \begin{cases} 1 & y_{it}^* > 0 \\ 0 & else \end{cases}$$

and a dynamic bivariate probit model:

$$\begin{aligned} y_{1it}^* &= \gamma_{11} y_{1,it-1} + \gamma_{21} y_{2,it-1} + \beta_1 x_{it-1} + \eta_i + u_{1it} \\ y_{2it}^* &= \gamma_{21} y_{1,it-1} + \gamma_{22} y_{2,it-1} + \beta_2 x_{it-1} + \eta_i + u_{2it} \end{aligned} \qquad [4]$$

$$y_{jit} = \begin{cases} 1 & y_{jit}^* > 0 \\ 0 & else \end{cases} \quad \text{where j} = 1, 2$$

with $y_{1,t-1}$ being the indicator for "claiming a tax credit" and $y_{2,t-1}$ the indicator for "obtaining a subsidy".

Independent variables

The set of independent variables common to both equations are likely to be those related to the expected profitability of performing R&D conditional on obtaining a subsidy or using a tax credit. These are some firm-level characteristics such as firm size, age, indicators of financing constraints and use of legal intel·lectual property rights, human capital, export status and capital ownership, as regularly found in existing

empirical literature, along with industry and year dummies. To these we add some new variables. First, some interaction terms between firm size and financial standing, and between firm size and use of protection methods, because SMEs are often found to face larger barriers than large firms in both respects, and because in the case of subsidies the public agency have the goal of favoring SMEs. We also consider previous internal R&D investment, the firm's perceived market share evolution, and whether the firm's managers monitor the evolution of technology.

IV. Results

To estimate the models described above we use the subsample of firms that are in the sample since year 2001 and remain in it for at least four consecutive periods. Once observations with some missing value for a relevant variable are discarded, we are left with a sample of 650 firms and 3902 observations. The average number of years a firm remains in the panel is 6, and the minimum is 3.[10] 10% of the 650 firms received a subsidy during this period. About half of them had a subsidy for only one year, and the other half for more than one year. Regarding tax deductions, 28 % did claim them; one third of those did so only one year in the whole period, and 72% claimed deductions for more than one year.

Static and dynamic univariate probit models

Initial conditions of all relevant variables (dependent and independent) in 2001 are defined in order to control for endogeneity and heterogeneity. Estimation of model [1] is then performed with data from 2002 to 2008. We first report in Table 4A the estimated average marginal effects of each independent variable on the probability of using direct support to R&D. The dynamic specification (M1) shows that when controlling for initial conditions and heterogeneity, there is indeed support for own path-dependence in the use of subsidies, but no evidence of cross-persistence with respect to tax credit claims. While having obtained a subsidy in the past increases the likelihood of obtaining one in the future, whether the firm claimed R&D tax credits or not does not seem to affect the use of subsidies. That is, using tax credits does not increase nor decrease the chances of obtaining a subsidy.

[10] One year is lost when lagging variables.

An interesting finding is that firms that were R&D performers at the beginning of the period are less likely to enjoy a subsidy. This suggests that subsidies may facilitate entry into R&D by non-performers. In addition, foreign owned firms are less likely to obtain R&D subsidies, possibly responding to the public agency selecting domestic firms' projects. We finally find that estimated coefficients for initial values of variables in the x vector and coefficients for their means from t=1 onward differ; therefore, using the standard Mundlak means would bias the results.

If dynamics are ignored but heterogeneity is controlled for (M2), results for the remaining variables are very similar, except that the magnitude of significant coefficients increases. When we estimate the pooled static model with unobserved heterogeneity we find that lagged R&D investment becomes positive and significant, suggesting a positive bias, distorting the role of previous R&D investment.

Table 4 B reports estimated average marginal effects for R&D tax credits. We find, according to Model 1, that using tax credits in period t-1 increases the likelihood of using them in period t by 9 percentual points, which is reinforced by the significant and positive coefficient for the corresponding initial value. In comparison, the extent of persistence is stronger in this case than for direct support. Having obtained subsidies at t-1 does not affect the chances of using tax credits, but the initial value for subsidies is, suggesting that although subsidy recipients may not claim tax deductions immediately, they are likely to do so at some point in the future, relative to non-recipients. We also find that young firms are less likely to claim R&D tax credits, possibly because generally a low taxable income can be expected.

Heterogeneity has a small weight in the use of subsidies (estimated rho=0.28), but is not significant in the case of tax credits. All in all, from results shown on Table 4A and Table 4B we can conclude that we observe own-persistence in the use of both incentive mechanisms, although it is about three times stronger for tax credits than for direct support. As for cross-persistence, we only observe it from direct support towards tax credits, suggesting that direct support may be acting as a mechanism to select promising projects that might have not been undertaken otherwise.

Table 4 A: Direct Support, Univariate Probit Estimates

	Dynamic Probit Wooldridge Mundlak Rabe (M1)		Pooled Static Mundlak (M2)		Pooled Static (M3)	
	dy/dx	s.e.	dy/dx	s.e.	dy/dx	s.e.
dTC_{t-1}	0.004	0.006	-	-	-	-
dS_{t-1}	0.034***	0.008	-	-	-	-
$Approp_{t-1}$	-0.008	0.009	-0.003	0.010	0.023**	0.011
$Aprop*sme_{t-1}$	0.003	0.016	-0.002	0.019	-0.041**	0.020
$Financial_{t-1}$	0.001	0.001	0.001*	0.001	0.001	0.001
$Financial*sme_{t-1}$	-0.001	0.002	-0.002	0.002	-0.001	0.001
$No\ HEE_{t-1}$	0.005	0.010	0.004	0.016	-0.005	0.019
$EPCT_{t-1}$	-0.014**	0.006	-0.008	0.008	0.029***	0.008
$dIRD_{t-1}$	0.001	0.009	0.015	0.012	0.045***	0.009
$EXPORT_{t-1}$	0.011	0.009	0.022	0.016	0.023	0.016
$Foreign_{t-1}$	-0.012*	0.006	-0.018*	0.009	-0.021**	0.010
$Ev.\ Mkt\ share_{t-1}$	0.004	0.005	0.006	0.006	-0.003	0.006
Size 51-100	0.009	0.010	0.025	0.017	0.023	0.020
101-200	0.025***	0.009	0.026*	0.015	0.029*	0.015
201-400	0.013	0.009	0.024	0.016	0.029	0.019
401-700	0.009	0.011	0.015	0.019	0.028	0.022
+700	0.030***	0.011	0.061***	0.018	0.073***	0.018
High-tech	0.022	0.007	0.031***	0.011	0.038***	0.013
Med-tech	0.011**	0.007	0.025***	0.010	0.027***	0.009
dTC_{t0}	0.005	0.007	-	-		
dS_{t0}	0.029***	0.008	-	-		
$Approp_{t0}$	-0.020*	0.012	-0.011	0.016		
$Approp*sme_{t0}$	0.014	0.023	-0.010	0.027		
$Financial_{t0}$	-0.001	0.001	-0.001	0.001		
$Financial*sme_{t0}$	0.000	0.001	0.001	0.001		
$EPCT_{t0}$	0.003	0.006	-0.003	0.009		
$dIRD_{t0}$	-0.025***	0.010	-0.032**	0.016		
$Ev.\ Mkt\ share_{t0}$	0.006	0.006	0.012	0.011		
Rapprop	0.028**	0.014	0.041***	0.018		
Rapropsme	-0.037	0.031	-0.056	0.037		
Rfinancial	0.000	0.003	-0.001	0.003		
Rfinancial*sme	-0.001	0.006	0.001	0.005		
REPCT	0.044***	0.010	0.064***	0.014		
Rird	0.041***	0.014	0.066***	0.023		
Remktshare	-0.008	0.012	-0.040*	0.021		
Num. obs	3902		3902		3902	
Num firms	650		650		650	
Log Lik	-248.8		-343.83		-385.83	
Pseudo R2			0.45		0.38	
ρ	0.28***	0.11				

Note: year dummies have been included in the estimations; the variable "young firm" is dropped because there is no young firm obtaining a subsidy in this sample; last rows of variables starting with R denote Mundlak-Rabe means

Table 4 B: Tax credits, Univariate Probit Estimates

	Dynamic Wooldridge Mundlak-Rabe (M1)		Static Pooled Mundlak (M2)		Static Pooled (M3)	
	dy/dx	s.e.	dy/dx	s.e.	dy/dx	s.e.
dTC_{t-1}	0.087***	0.012	-	-	-	-
dS_{t-1}	-0.012	0.012	-	-	-	-
$Approp_{t-1}$	0.000	0.017	-0.002	0.015	0.048****	0.019
$Aprop*sme_{t-1}$	0.001	0.025	0.000	0.027	-0.031	0.028
$Financial_{t\_1}$	-0.002	0.002	-0.002	0.002	-0.001	0.001
$Financial*sme_{t\_1}$	0.002	0.002	0.002	0.002	-0.001	0.002
No HEE_{t_1}	-0.023	0.015	-0.036	0.023	-0.059**	0.025
$EPCT_{t\_1}$	-0.006	0.009	-0.005	0.009	0.038***	0.011
$dIRD_{t\_1}$	0.003	0.012	0.032**	0.017	0.128***	0.012
$EXPORT_{t\_1}$	0.001	0.011	0.007	0.015	0.023	0.018
$Foreign_{t\_1}$	-0.001	0.008	0.001	0.011	-0.011	0.013
Ev. Mkt share $_{t\_1}$	0.014*	0.008	0.022**	0.010	0.040***	0.011
$Young_{t\_1}$	-0.026*	0.014	-0.044***	0.016	-0.049***	0.017
Size 51-100	0.005	0.013	0.007	0.016	0.010	0.021
101-200	0.022**	0.011	0.018	0.016	0.026	0.018
201-400	0.017	0.012	0.019	0.016	0.043**	0.018
401-700	0.000	0.014	-0.002	0.020	0.020	0.023
+700	0.015	0.016	0.009	0.022	0.060***	0.023
High-tech	0.027**	0.011	0.038***	0.013	0.059***	0.017
Med-tech	-0.014	0.010	-0.019	0.014	-0.010	0.018
dTC_{t0}	0.026***	0.010	0.078	0.010		
dS_{t0}	0.024*	0.013	0.025***	0.020		
$Approp_{t0}$	-0.023	0.019	-0.031	0.029		
$Approp*sme_{t0}$	0.020	0.027	0.028	0.039		
$Financial_{t0}$	0.001	0.001	0.001	0.001		
$Financial*sme_{t0}$	-0.001	0.001	-0.002	0.001		
$EPCT_{t0}$	0.010	0.008	0.008	0.012		
$dIRD_{t0}$	0.002	0.011	-0.002	0.016		
Ev. Mkt $share_{t0}$	0.004	0.008	0.004	0.011		
Rapprop	0.036	0.024	0.062*	0.033		
Rapropsme	-0.012	0.040	-0.018	0.048		
Rfinancial	0.000	0.003	-0.002	0.005		
Rfinancial*sme	-0.003	0.007	-0.003	0.008		
REPCT	0.026**	0.013	0.044***	0.017		
Rird	0.065***	0.016	0.068***	0.023		
Remktshare	0.030*	0.016	0.038*	0.021		
N obs	3902		3902		3902	
N firms	650		650		650	
Log Lik	-478.4		-567.8		-684.53	
Pseudo R2			0.52		0.42	
ρ	0.10	0.08				

Static and dynamic bivariate probit models

The next step is to investigate the two-way dynamic relationship between the firm's status regarding R&D subsidies and tax credits taking into account the potential correlation between both incentives. We estimate model [4] using the same independent variables as above, so as to allow an explicit comparison across models. Table 5 reports the results; each column shows the average marginal effect of a change in variable x on the probability that a firm will be in each of the four possible situations regarding policy status.

While all four columns are informative, we focus first on columns (2) and (3), which respectively refer to status “use only tax credits” and “use only subsidies”. Regarding own-persistence, results are very close to those obtained with the dynamic univariate model: previous use of tax credits increases the likelihood of only using them by 9 pp., and previous use of subsidies increases the likelihood of only using them by 3 pp.

What is different is cross-persistence. We now find that firms that using subsidies in period t is negatively correlated with using only tax credits in t+1, but positively correlated to using both incentive systems in t+1. And firms that used tax credits in t are less likely to use only subsidies at t+1, but more likely to use both. This means that firms that have used one or the other at time t are more likely to use both in the future. Most individual firm attributes do not appear to be of relevance, except for firm age (young firms appear to be more likely to use only tax credits, in contrast with dynamic univariate results) and foreign ownership (foreign firms are less likely to use only subsidies, or both tools at the same time, coinciding with dynamic univariate results). We finally also observe that firms that were not R&D performers at the beginning of the period are more likely to use only subsidies, while it is initial R&D performers that are more likely to use only tax credits. Most other attributes, such as the firm’s financial standing, does not appear to be relevant on average. But foreign ownership, uncorrelated with the use of tax credits, seems in contrast to reduce the probability that a firm will use subsidies, either because it does not apply for one, or because it is rejected.

Table 5: Bivariate Dynamic Probit Estimates

Average Marginal Effects on joint probabilities

	TC, DS or P11 (1)	TC, 0 or P10 (2)	0, DS or P01 (3)	0, 0 or P00 (4)
	dy/dx	dy/dx	dy/dx	dy/dx
dTC_{t-1}	0.015***	0.090***	-0.012***	-0.092***
	0.003	0.006	0.003	0.009
dS_{t-1}	0.024***	-0.036***	0.030***	-0.021*
	0.003	0.011	0.004	0.013
$Approp_{t-1}$	-0.004	0.004	-0.001	-0.007
	0.006	0.011	0.006	0.015
$Aprop*sme_{t-1}$	-0.001	0.001	-0.001	-0.001
	0.010	0.022	0.011	0.029
$Financial_{t\_1}$	0.000	-0.002	0.000	0.002
	0.000	0.001	0.000	0.001
$Financial*sme_{t\_1}$	0.000	0.002	-0.001	-0.002
	0.001	0.001	0.001	0.002
$No\ HEE_{t\_1}$	-0.002	-0.020	0.004	0.018
	0.005	0.014	0.006	0.016
$EPCT_{t\_1}$	-0.007*	0.001	-0.006*	0.011
	0.003	0.009	0.003	0.009
$dIRD_{t\_1}$	-0.001	0.001	-0.001	0.001
	0.004	0.014	0.005	0.015
$EXPORT_{t\_1}$	0.005	-0.001	0.005	-0.010
	0.005	0.009	0.005	0.012
$Foreign_{t\_1}$	-0.008**	0.006	-0.008***	0.013
	0.003	0.007	0.003	0.008
Ev. Mkt share $_{t\_1}$	0.004	0.011	0.000	-0.015*
	0.003	0.008	0.003	0.009
$Young_{t\_1}$	-0.090***	0.062***	-0.089***	0.135***
	0.010	0.013	0.014	0.020
Size 51-100	0.005	-0.003	0.005	-0.007
	0.006	0.011	0.006	0.013
101-200	0.013**	0.011	0.008	-0.026**
	0.005	0.010	0.005	0.013
201-400	0.009**	0.005	0.007	-0.022*
	0.005	0.010	0.005	0.013
401-700	0.005	-0.009	0.005	0.001
	0.006	0.012	0.006	0.015
+700	0.017**	-0.014	0.018***	-0.021
	0.003	0.012	0.006	0.015
High-tech	0.013**	0.012	0.008***	-0.038
	0.003	0.007	0.004	0.009
Med-tech	0.003	-0.016*	0.008	0.002
	0.004	0.008	0.004	0.010

dTC_{t0}	0.005	0.014**	0.001	-0.022**
	0.004	0.007	0.003	0.009
dS_{t0}	0.013***	0.007	0.008**	-0.038***
	0.004	0.014	0.004	0.015
$Approp_{t0}$	-0.012**	-0.009	-0.007	0.027
	0.005	0.017	0.005	0.019
$Approp*sme_{t0}$	0.010	0.066**	-0.073***	0.071**
	0.010	0.029	0.014	0.032
$Financial_{t0}$	-0.000	0.001**	-0.001**	0.000
	0.000	0.000	0.000	0.001
$Financial*sme_{t0}$	0.000	-0.001	0.000	0.001
	0	0.001	0.000	0.001
$EPCT_{t0}$	0.003	0.008	0.000	-0.010
	0.003	0.008	0.003	0.008
$dIRD_{t0}$	-0.013**	0.018*	-0.014***	0.011
	0.005	0.011	0.005	0.013
Ev. Mkt $share_{t0}$	0.003	-0.002	0.004	-0.007
	0.003	0.007	0.003	0.008
Rapprop	0.019***	0.005	0.010*	-0.021
	0.007	0.023	0.006	0.024
Rapropsme	-0.016	0.008	-0.015	0.023
	0.015	0.035	0.016	0.038
Rfinancial	0	0.000	0.000	-0.001
	0.001	0.002	0.001	0.003
Rfinancial*sme	-0.002	-0.006	0.000	0.007
	0.002	0.005	0.002	0.005
REPCT	0.023***	0.003	0.017***	-0.043***
	0.005	0.012	0.005	0.014
Rird	0.031***	0.036**	0.016**	-0.084***
	0.007	0.015	0.008	0.020
Remktshare	-0.003	0.028*	-0.009	-0.015
	0.006	0.013	0.005	0.017
N Observat.	3902			
N Firms	650			
Loglikel.	-721.79			

Notes: 1,1: both; 1.0: only tax deductions; 0,1: only subsidies. Year dummies included but not shown. Estimated rho: 0.44 (chi2=24.15, p-value =0.000). 22% of observations correspond to large firms, and 78% to Smes.

V. Conclusions

In this paper we have investigated the existence and extent of persistence in the use of R&D subsidies and R&D tax incentives, as well as cross-persistence across both tools. We find that (i) controlling for firms' observed attributes and unobserved heterogeneity, there is stronger persistence in the use of tax incentives than in the use of subsidies; (ii)

firms are less likely to switch between each of these tools but if they use one at t they are likely to use both the next period; (iii) non-R&D performers are more likely to either use only subsidies or both instruments.

Altogether these results suggest that tax credits and subsidies serve different types of firms and purposes; in particular subsidies seem to be an appropriate tool to get more firms to perform R&D, while tax credits would not be quite suited to that end. Our findings on subsidies are consistent with Arqué and Arqué and Mohnen (2013). The extent of persistence in the use of tax credits, and their limited ability to induce the use of subsidies, would advise a closer look at the behavior of claimants in terms of the nature of their projects in order to rule out crowding out effects. At this stage, however, our results are still preliminary and further work is ongoing, in particular regarding sensitivity analysis.

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Appendix

Table A Variable definitions

Core variables of interest

R&D Tax deduction [dTC]: dummy variable equal to 1 if the firm has claimed the tax deduction at time t

R&D Subsidy [dS]: dummy variable equal to 1 if the firm has obtained an R&D subsidy from the central administration at time t

Firm size: a set of six dummy variables for six size intervals (up to 50 employees; 51-100; 101-200; 201-400; 400-700; more than 700)

Sme: binary indicator; 1 if size less than or equal 200 employees

Financial standing [Financial]: debt to equity ratio

Appropiability [Approp]: binary indicator of whether the firm has obtained patents or design models

Human capital [HEE]: binary indicator of whether the firm has employees with a higher education degree.

Technology monitoring[EPCT]: binary indicator of whether the firm monitors technology outlook

In-house R&D investment [dIRD]: binary indicator; equals 1 if firm invested at time t-1.

Young [Young]: indicator equals 1 if firm has 10 or less years of age

Main controls

Increasing market share [Ev Mkt share]: a binary indicator of whether the firm perceives its own market share to be increasing

Exporter [EXPORT]: binary indicator of being an exporter

Foreign capital [Foreign]: binary variable taking the value of 1 if the firm's foreign capital share is at least 50%

Industry dummy variables: set of 3 industry binary indicators of technological intensity according to the standard OECD definition (high tech, medium tech and low tech)

Time dummy variables: for years 2003 to 2008