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The impact of subsidies and fiscal incentives on corporate R&D expenditures in Belgium (2001-2009)

January 2013

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Abstract - This paper presents the results of an initial evaluation of federal fiscal incentives in support of Research and Development (R&D) by companies in Belgium. The impact of regional subsidies and the partial exemption from advance payment for R&D personnel is estimated for the period 2001-2009. The results show that the existing measures of public support have stimulated companies to carry out additional R&D activities.

Jel Classification - H32, O32, O38

Keywords – R&D, public support

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1. Introduction

At the 2002 European Summit in Barcelona, EU Member States agreed to raise R&D expenditures in the European Union to 3% of GDP by 2010. This objective was not met but it was reassumed in the framework of the Europe 2020 strategy and included by Belgium in its National Reform Programme. As a result of state reforms in the 1980s and the 1990s, most competencies in science and technology in Belgium now reside at the level of the three regions: Brussels-Capital Region, Flanders and the Walloon Region. The regions provide substantial direct support for R&D and innovation by private companies. In order to achieve the 3% objective, the Belgian federal government - in addition to the direct support provided by the regions - introduced a number of fiscal incentives to foster R&D activities. The most popular measure is the partial exemption from advance payment for R&D personnel. There are currently four possibilities for companies to obtain such a partial exemption:

– for R&D personnel in companies that cooperate in research with a university, a higher education institution in the European Economic Area or a scientific institution registered by the Council of Ministers (as of 1 October 2005);

– for Young Innovative Companies (YIC)[1] (as of 1 July 2006);

– for R&D personnel with a PhD degree in exact or applied sciences, doctor degree in (veterinary) medicine or a civil engineering degree (as of 1 January 2006: List 1);

– For R&D personnel with a master's degree, with the exception of masters in social and human sciences (as of 1 January 2007: List 2).

For the first two measures the exemption originally amounted to 50% and for the last two to 25%. The exemption, for all four measures, was raised to 65% in July 2008 and as of January 2009 the exemption amounts to 75%.

Many studies already assessed the extent to which subsidies or fiscal incentives succeed in fostering additional R&D activities by companies. The majority of these studies tend to confirm that public support does indeed result in additional R&D (see for example, reviews by David, Hall and Toole, 2000; Hall and van Reenen, 2000). A meta-analysis performed by García-Quevedo (2004) established that the results of empirical studies do not depend on the specific setup (for example, estimation procedure or the data that are used) although studies in which firm-level data are used, more frequently provide indications of crowding out. Busom, Corchuelo and Martínez-Ros (2011) have recently pointed out that in most empirical studies the impact of a specific measure of public support for R&D is estimated individually, whereas only in a very limited number of studies the interaction between direct support and tax benefits is considered. For example, Corchuelo and Martínez-Ros (2009) concluded

[1] A Young Innovative Company is defined (see Belgian Science Policy, 2006) as a company which:
- carries out research projects;
- has been set up for less than 10 years before January 1 of the year during which the advance payment exemption is granted;
- is not set up within the framework of concentration, a restructuration, an extension of a pre-existing activity or resumption of such activities;
- has made expenditures on R&D representing at least 15% of the total costs in the foregoing taxable period.

that the probability that a company in Spain uses a tax incentive for R&D depends on whether it has received a grant or not, a result they attribute to the complementarity between tax benefits and subsidies. In this paper, the effects of the direct support provided by the regions and of the more recent federal fiscal incentives on the R&D expenditures of Belgian companies are estimated. The possible substitution or complementarity between direct support and indirect support is also assessed. Section 2 describes the data that are used, which cover the period 2001-2009. In section 3 the estimation procedure is discussed and the estimation results are reported. Conclusions are provided in section 4.

2. Data

To evaluate the fiscal incentives of the Belgian federal government and the subsidies provided by the regions, a database was created by the Federal Public Service Finance. Data from the biennial R&D survey, carried out by the Federal Science Policy Office, were linked to data on the direct support by the regions (Innoviris for Brussels-Capital Region, IWT for Flanders and DG06 for the Walloon Region) and data on the partial exemption from advance payment for R&D personnel (four specific measures as enlisted in the introduction)[2]. The database currently covers the period 2001-2009. As the partial exemption from advance payment only started in 2005 at the earliest, the database only contains observations on federal support for three up to five years.

Table 1 **Number of R&D active companies having received a regional subsidy or fiscal incentive** *(2001-2009)*

		Partial exemption from advance payment for R&D personnel:				
	Regional subsidy	Research cooperation	Young Innovative Company	List 1	List 2	Total R&D Survey
2001	484					2,432
2002	583					1,704
2003	674					1,728
2004	777					1,836
2005	809	51				1,850
2006	884	152	76	287		2,574
2007	790	174	138	376	177	2,585
2008	648	155	119	393	274	3,258
2009	558	147	134	501	451	3,294

Note: The table shows, for each year in the period 2001-2009, the number of companies that received a subsidy (Brussels-Capital Region; Flanders or the Walloon Region) or a partial exemption from advance payment for R&D personnel (four measures as listed in the introduction) insofar as the company is enlisted in the repertory of R&D active companies which the Federal Science Policy Office uses for the biennial R&D survey. The last column shows the number of companies that reported their R&D expenditures in the R&D survey.

Table 1 shows, for each given year in the period 2001-2009, the number of companies that benefitted from direct support provided by one of the three regions or from one of the four measures of partial exemption from advance payment for R&D personnel. The last column shows the total number of companies that reported their R&D expenditures in the R&D survey. The largest number of companies received a regional subsidy. The partial exemption from advance payment for R&D personnel with a degree in List 1 or List 2 is becoming increasingly popular, which is probably explained by the percentage of exemption that has been raised and the rising acquaintance with the tax benefits. The partial exemption for Young Innovative Companies and for companies that cooperate in research with a university, higher education institution or a scientific institution has also witnessed a strong increase, but given the specific nature of these measures, the number of beneficiary companies remains relatively small.

[2] The database also contains information on other fiscal incentives such as tax credits for investment in R&D and patents, but given the small number of observations these were not considered in the analysis.

For those companies that reported their R&D expenditures in the 2010 R&D survey, Table 2 shows the total amount of public support for each measure as well as the average benefit received by companies (median reported in parentheses).

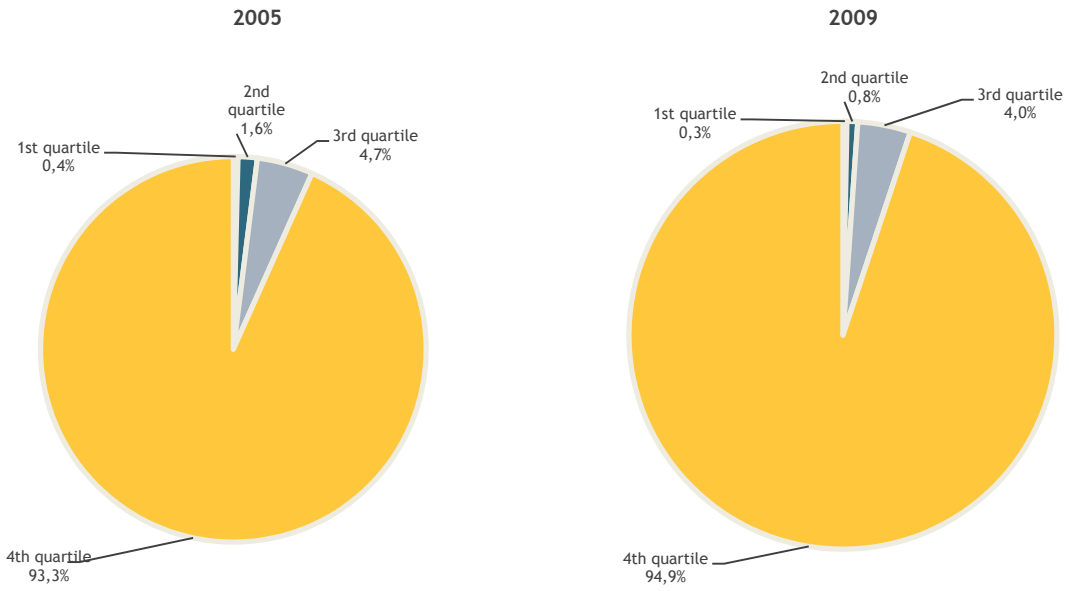
Table 2 **Total amount and average (median) of public support for R&D in 2009**
in euro

	Total amount of public support (number of companies benefiting)	Average (median)
Regional subsidy	160,000,000 (558)	286,587 (86,312)
Research cooperation	14,400,000 (147)	97,969 (25,135)
Young Innovative Company	9,873,727 (134)	73,685 (44,025)
List 1	120,000,000 (501)	239,053 (52,115)
List 2	95,200,000 (451)	211,151 (46,112)

Note: The second column shows the total amount of public support for companies that reported their R&D expenditures (2010 R&D survey) with the number of companies benefitting given in parentheses. The average amount of support received by companies is reported in the third column (median in parentheses).

As Graph 1 clearly shows, R&D expenditures of companies in Belgium are extremely concentrated at a fairly small group of companies.

Graph 1 **Share in total R&D expenditures by quartile**



The fourth quartile[3] had a share in total R&D expenditures of 93% in 2005 and 95% in 2009. The combined share in total R&D expenditures of the lowest half of the R&D active companies (first and second quartile) was only 2% in 2005, dropping to hardly 1% in 2009. Due to the skewed distribution of R&D expenditures, there is a substantial difference between the average and the median benefit received by companies. The average amount of public support is highest for regional subsidies, followed by the average amount for the partial exemption from advance payment for R&D personnel with a degree on List 1 and List 2. The latter two have the largest relative gap between average and median support.

[3] The first quartile contains the 25% of companies with the lowest R&D expenditures and so up to the fourth quartile representing the 25% of companies with the highest R&D expenditures.

To assess the impact of the regional subsidies and the fiscal incentives, data on R&D expenditures are required. Unfortunately, this information is not available for a rather large number of companies. Table 3 shows, for companies that received a regional subsidy or a partial exemption from advance payment in 2009, whether they responded to the 2010 R&D survey or not and whether they reported any R&D activities in the year they received public support.

Table 3 Responses in 2010 R&D survey of companies that received public support for R&D in 2009

	R&D	No R&D	No response	Not in repertory	Total
Regional subsidy	255	41	262	370	928
Partial exemption from advance payment:					
Research cooperation	76	8	63	40	187
Young Innovative Company	69	4	61	70	204
List 1	287	30	184	132	633
List 2	246	42	163	125	576

Note: The table shows, for companies which received a regional subsidy or a partial exemption from advance payment in 2009, the response with regard to 2009 (2010 R&D survey). The second column shows the number of companies that replied having performed R&D activities, the third column the number of companies that replied that they did not have any internal R&D activities in 2008 or in 2009, the fourth column the number of companies that did not respond to the R&D survey and the fifth column the number of companies that are not listed in the repertory used for the R&D survey. The last column reports the total number of companies that benefitted from the given measure of public support for R&D in 2009.

As the third column shows, a number of companies that received public support for R&D in 2009 actually replied in the R&D survey that they did not carry out any internal R&D activities in that year. For regional subsidies, this answer could be explained by the fact that some of the direct support by the regions is provided for innovation activities, which do not necessarily imply formal R&D activities. For the partial exemption from advance payment for R&D personnel, however, internal R&D activities are required. The answers for these measures may perhaps be due to the department (person) within a company answering the R&D survey differing from the department responsible for the application and administration of the tax benefits. The fourth column shows the number of companies that did not respond to the 2010 R&D survey, whereas the fifth column reports the number of companies that do not appear in the repertory used for the R&D survey. The last column shows the total number of companies that received a subsidy or a fiscal incentive in 2009.

Companies with high R&D expenditures are likely to be more appreciative of subsidies or tax benefits. This is confirmed in Table 4 which for each quartile of the distribution of R&D expenditures shows the percentage of companies with reported R&D activities in 2009 (2010 R&D survey) that received a regional subsidy or a partial exemption from advance payment for R&D personnel. For subsidies as well as the partial exemption, the highest percentage is found in the fourth quartile. Companies in the first quartile are relatively best represented for regional subsidies. This can be easily explained as some regional subsidies specifically aim at SMEs. Despite the fact that - unlike for the other measures - there is no selection criterion for the partial exemption from advance payment for R&D personnel with a degree in List 1 or List 2, the differences between the quartiles are most pronounced for these two incentives. Given the fairly easy procedure to obtain a partial exemption from advance payment, it is noteworthy that even in 2009 less than half of the largest R&D companies claimed this benefit.

Table 4 Percentage of R&D companies that received public support for R&D in 2009, by quartile (R&D expenditures)

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Regional subsidy	7	13	17	31
Partial exemption from advance payment tax:				
Research cooperation	2	2	3	11
Young Innovative Company	2	3	5	7
List 1	3	4	11	42
List 2	2	6	11	35

Note: The table shows, for companies with reported R&D activities in 2009 (2010 R&D survey), the percentage that received a regional subsidy or a partial exemption from advance payment. The data are broken down by quartile of R&D expenditures. The first quartile includes the companies in the bottom 25% of the distribution, up to the fourth quartile including the companies in the top 25% of the distribution of R&D expenditures.

The highly skewed distribution of R&D expenditures, as shown in Graph 1, and hence also of public support for R&D, is also reflected in Table 5 which shows for 2009, for each quartile of the R&D expenditures distribution, average R&D expenditures (excluding the amount of public support that was received), the average amount of regional subsidies and the partial exemption from advance payment.

Table 5 Average R&D expenditures, public support and generosity in 2009, by quartile (R&D expenditures)

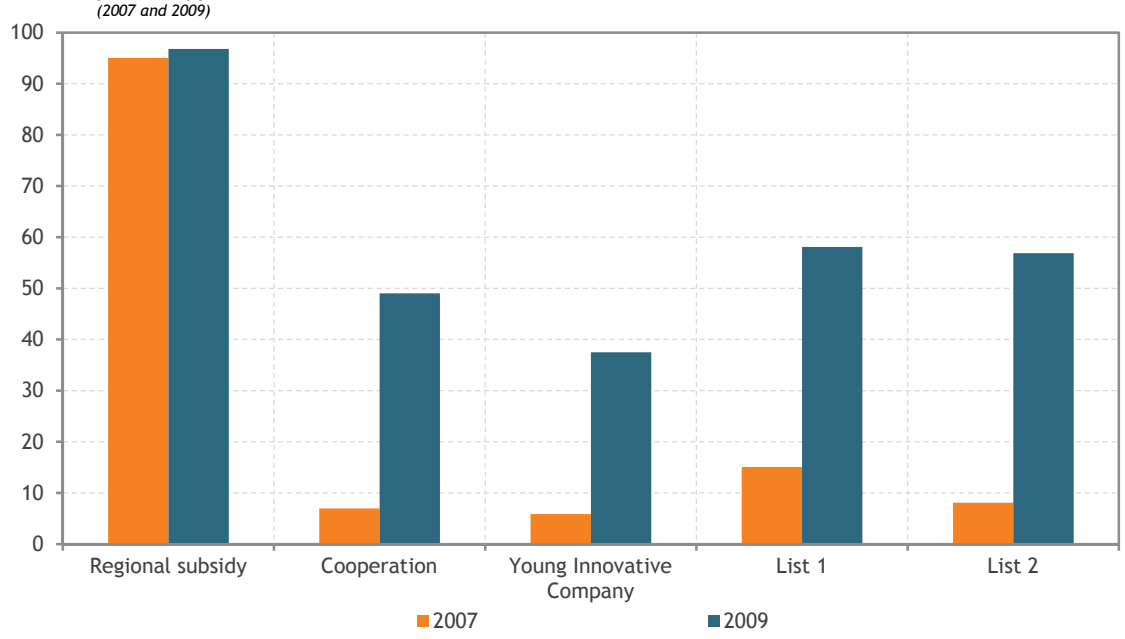
	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
R&D expenditures (public support excluded)	13,272	44,226	193,973	4,603,206
Regional subsidy	37,297	49,265	120,238	474,466
Partial exemption from advance payment tax:				
Research cooperation	8,946	15,560	34,420	164,494
Young Innovative Company	17,474	34,941	44,257	139,037
List 1	14,294	33,667	35,661	366,790
List 2	10,748	24,900	37,736	340,693
Generosity	0.60	0.36	0.22	0.12

Note: The table shows, for companies with reported R&D activities in 2009 (2010 R&D survey), the average R&D expenditures (excluding public support), the average amount of the subsidy or the partial exemption from advance payment and average generosity (public support/R&D expenditures). The data are broken down by quartile of R&D expenditures. The first quartile includes the companies in the bottom 25% of the distribution, up to the fourth quartile including the companies in the top 25% of the distribution of R&D expenditures.

The last line reports the average generosity of the public support that was received with generosity defined as the ratio of public support to R&D expenditures. The generosity of public support is clearly higher the smaller companies are.

In the biennial R&D survey, companies are asked whether part of their internal R&D expenditures is financed by a regional, national or international authority. Graph 2 provides some indication whether companies actually consider a subsidy granted by one of the regions or the partial exemption from advance payment for R&D personnel credited by the federal government, as part of the financing of their R&D expenditures, for 2007 (2008 R&D survey) and 2009 (2010 R&D survey). Apparently, most companies consider a regional subsidy as public support for their R&D activities, but the partial exemption from advance payment is far less perceived as federal support despite a substantial increase in the percentage of companies that do indeed report the exemption as public support.

Graph 2 **Percentage of companies that report regional subsidy or partial exemption from advance payment as public support for R&D**
(2007 and 2009)



Note: The graph shows for companies that obtained a subsidy or partial exemption from advance payment in 2007 or 2009 the percentage that reported having received public support for their R&D activities from a regional authority or from the federal government.

Table 6 shows, for the period 2006-2009, the extent to which companies combine the three main measures of public support for R&D.

Table 6 **Percentage of companies that combine subsidies with a partial exemption from advance payment**
(2006-2009)

	2006	2007	2008	2009
Percentage of companies having obtained a subsidy which also received partial exemption for R&D personnel with a degree in List 1	13	16	22	31
Percentage of companies having obtained a subsidy which also received partial exemption for R&D personnel with a degree in List 2		7	15	24
Percentage of companies with partial exemption for R&D personnel with a degree in List 1 that also obtained a subsidy	41	33	37	34
Percentage of companies with partial exemption for R&D personnel with a degree in List 2 that also obtained a subsidy		31	35	30
Percentage of companies with partial exemption for R&D personnel with a degree in List 1 that also obtained exemption for List 2		29	44	46

Although companies can apply for a partial exemption from advance payment for R&D personnel with a degree in List 1 as well as for R&D personnel with a degree in List 2, in 2009 still less than half of the companies that received partial exemption for their R&D personnel with a degree in list 1 also received partial exemption for their R&D personnel with a degree in List 2. The finding that only 30 to 40% of companies that received a partial exemption from advance payment in a given year in the period 2006-2009 were also granted a regional subsidy in the same year can be explained by the application procedure for regional subsidies. The latter does, however, not explain even an even smaller share of companies that received a subsidy also applied for the partial exemption of advance payment for their R&D personnel.

3. Estimation

In section 3.1, the econometric procedure used to estimate the impact of regional subsidies and the partial exemption from advance payment is discussed. The estimation results are reported in section 3.2.

3.1. Estimation procedure

If the R&D expenditures of companies are regressed on the amount of public support they received, the estimated coefficients directly provide the so-called Bang for the Buck (see for example Brouwer et al. 2002; Hægeland and Møen 2007 a; Lokshin and Mohnen 2007). The Bang for the Buck (BFTB) indicates how much one euro in public support fosters in additional R&D expenditures by companies. Ordinary Least Squares (OLS) estimation of such a linear specification however provides extremely unreliable estimates, probably due to the distribution of R&D expenditures which - as already shown in Graph 1 - deviates dramatically from the normal distribution which underpins the interpretation of OLS estimation. The logarithm of R&D expenditures on the other hand appears to be fairly normally distributed which argues for the use of a specification in which variables (except for dummies) are expressed in logarithms:

$$\begin{aligned}\ln(RD_{it}) = \alpha_0 &+ \beta^{reg}\ln(X_{it}^{reg}) + \beta^{coop}\ln(X_{it}^{coop}) + \beta^{YIC}\ln(X_{it}^{YIC}) + \beta^{List\ 1}\ln(X_{it}^{List\ 1}) \\ &+ \beta^{List\ 2}\ln(X_{it}^{List\ 2}) + \beta^{VA}\ln(VA_{it}) + \beta^{E}\ln(Employees_{it}) \\ &+ \sum_{s=2}^{S}\alpha_s D_{i,s} + \sum_{r=2}^{3}\alpha_r D_{i,r} + \sum_{t=2}^{T}\alpha_t D_t + \beta^{\lambda}\lambda_{it} + \varepsilon_{it}\end{aligned}$$

RD_{it} denotes the internal R&D expenditures (excluding the amount of public support) of company *i* in year *t*, the X variables indicate the amount of the regional subsidy (reg) or the amount of one of the four measures of partial exemption from advance payment: coop (research cooperation with a university, college or a scientific institution; YIC (Young Innovative Company); List 1 (PhD degree in exact or applied sciences, doctor degree in (veterinary) medicine or a civil engineering degree) and List 2 (master's degree with the exception of master in social or human sciences). For about 15% of the observations, the amount of public support granted in a given year to a company exceeds the total R&D expenditures reported by the company in the R&D survey. As a result, R&D expenditures excluding public support are negative and as a logarithmic specification is considered for estimation, these observations are not included.

In previous empirical studies, size and industry classification were found to be important determinants of the R&D expenditures of a company. Therefore, value added (VA), the number of employees and industry (NACE 2-digit industry dummy $D_{i,s}$) are included as control variables. A dummy denoting in which region the company operates ($D_{i,r}$) as well as year dummies (D_t) are included in the estimation, as is the usual residual term, ε_{it}. Finally, λ_{it} denotes the inverse Mills ratio which is included to account for the potential bias due to self-selection by companies.

The econometric specification could be estimated using Ordinary Least Squares (OLS). However, as can be seen from Table 5, there are substantial differences between companies in the extent to which they receive public support for their R&D activities. Regional subsidies are granted following an application procedure. The regional authorities evaluate the applications, submitted by companies, based on a number of criteria such as the quality of the proposal and the expected valorisation of the project. The regions also have programmes targeting specific technological domains or SMEs. Companies with much experience in R&D activities are, on average, likely to present application forms of a higher quality and therefore have a higher probability to receive a subsidy. Although the partial exemption from advance payment for R&D personnel with a degree in List 1 or List 2 is not subject to any company-specific criterion, Table 5 shows that the use of these tax benefits is even more disproportionally concentrated in the largest R&D companies. The results of an OLS estimation could be substantially biased if the fact that the probability to obtain public support differs between companies is not taken into account. There are a number of ways to accommodate the potential bias due to the self-selection by companies. In some studies on the impact of R&D subsidies, matching procedures are used (for example, Czarnitzki and Fier, 2002; Almus and Czarnitzki, 2003; Duguet, 2004). Given our interest in assessing the interaction between different measures of public support, a two-step Heckman procedure seems more appropriate. In the first (probit) step of this procedure, the probability of a company to receive a regional subsidy or a partial exemption from advance payment is estimated using possible determinants such as company size, industry classification and R&D intensity. The estimation of the selection equation provides the inverse Mills ratio λ_{it} which decreases monotonically as the probability that a company is selected (in effect, receives a subsidy or tax benefit) rises. The ratio is then included as a variable in the second-step estimation of the structural equation. If the coefficient of the ratio is found to differ significantly from zero, Ordinary Least Squares results are likely to be biased by failing to take into account self-selection by companies. Heckman (1979) noted that although the coefficients in the second step estimation are consistent, standard errors will be underestimated and, therefore, statistical significance overestimated. Maximum Likelihood (ML) estimation is needed to obtain correct standard errors. This requires a specification of the joint density function of the errors in the first-step selection equation and the second-step equation. As ML is an iterative process, it does not always converge. Especially in large samples, the two-step Heckman procedure is often preferred to the ML estimation (for example, Hussinger 2008).

3.2. Estimation results

The results of a regression of the R&D expenditures (excluding the amount of public support) on the amount of regional subsidies or partial exemption from advance payment received by the company in that year, are reported in Table 7. Both the results of a two-step Heckman procedure and a Maximum Likelihood estimation are reported. The results of the estimation of a selection equation (first step of the Heckman procedure) are discussed in annex. As all variables are expressed in logarithms, the reported coefficients can be interpreted as measures of elasticity (for example, the coefficient of 0.75 for the number of employees in the second column implies that an increase in the number of employees by 10% concurs, on average, with an increase in R&D expenditures by 7.5%).

Table 7 Estimation of the impact of subsidies and the partial exemption from advance payment *(2001-2009)*

	Heckman	Maximum Likelihood
Regional subsidy	0.03(4.03)***	0.03(4.11)***
Research cooperation	0.02(2.51)**	0.02(2.68)***
Young Innovative Company	0.06(3.91)***	0.06(3.26)***
List 1	0.07(8.19)***	0.07(7.85)***
List 2	0.02(2.64)***	0.02(2.84)**
Value added	0.24(4.14)***	0.24(1.57)
Number of emmployees	0.75(30.18)***	0.75(17.96)***
Test selection bias	Mills lambda: -0.54 (-10.23)***	χ^2: (52.06)***
Number of observations	11,639 (uncensored: 1,860)	11,639 (uncensored: 1,860)

Note: The table shows the results of a regression of R&D expenditures (excluding public support) of companies on the amount of regional subsidies and the partial exemption from advance payment for R&D personnel they received. Dummies for industry (NACE two-digit), region and year were included in the estimation but not reported. Rejection of the null hypothesis of the selection bias indicates, both for the two-step Heckman procedure and the Maximum Likelihood estimation, that results of Ordinary Least Squares estimation would be biased. The t-values are reported in parentheses and *, **, *** denotes statistical significance at 10%, 5% and 1% respectively. The "uncensored" observations denote the number of observations of companies that received a regional subsidy or a partial exemption from advance payment.

Both in the Heckman procedure and the Maximum Likelihood estimation, the test on the selection bias clearly indicates that the results of a simple OLS estimation are likely to be biased as they do not take into account the apparent self-selection by companies in applying for and receiving public support.

The coefficients of all measures of public support are positive and statistically significant. There are minor differences in the significance between the Heckman procedure and the Maximum Likelihood estimation. The coefficients for regional subsidies, Young Innovative Companies and the partial exemption from advance payment for R&D personnel with a degree in List 1 are significant at 1% in both estimations. The coefficient for the partial exemption from advance payment for researchers in companies that cooperate in research is significant at 5% in the Heckman estimation but at 1% in the Maximum Likelihood estimation. For the coefficient of the partial exemption for R&D personnel with a degree in List 2, it is the other way around, in effect significant at 1% in Heckman and at 5% in the Maximum Likelihood estimation. The most substantial difference in standard errors is for the coefficient of value added which in the Heckman procedure is significant at 1%, but not even significant at 10% in the Maximum Likelihood estimation. A number of industry dummies, included in the estimation but not reported, are statistically significant, indicating the well-known heterogeneity between industries in terms of R&D activities.

The Bang for the Buck (BFTB), which in many empirical studies is considered as a measure of the additionality of public support, cannot be derived directly from Table 7. The BFTB depends on the level of the regional subsidy or partial exemption. Table 8 shows the BFTB for each of the five measures of public support for R&D, computed with the estimated elasticity from Table 7, the average amount of support received by companies and average R&D expenditures. As the dependent variable is R&D expenditures excluding the amount of public support received, a BFTB greater than 0 implies that one euro in public support results in more than one euro of additional R&D expenditures by companies.

Table 8 **Bang for the Buck of regional subsidies and the partial exemption from advance payment for R&D personnel** *(2001-2009)*

	Heckman	Maximum Likelihood
Regional subsidy	0.58	0.58
Research cooperation	2.13	2.31
Young Innovative Company	0.77	0.81
List 1	3.46	3.53
List 2	0.81	0.82

Note: The table shows the Bang for the Buck, computed on the basis of the elasticity coefficients reported in Table 7, the average R&D expenditures (excluding public support) and the average amount in regional subsidy or partial exemption received by companies. A Bang for the Buck greater than 0 implies that 1 euro in public support results in more than 1 euro additional R&D expenditures by companies.

All measures of public support apparently foster additional R&D expenditures. The highest additionality is found for the partial exemption from advance payment for R&D personnel with a degree in List 1 and the partial exemption for companies that cooperate in research with a university, higher education institution or a scientific institution. For the other measures, additionality is somewhat lower but in line with the results in previous studies.

Companies are probably more inclined to apply for public support if support is generous. González, Jaumandreu and Pazo (2005) found, based on a panel of 2,214 Spanish companies in the period 1990-1999, that the impact of subsidies on the R&D expenditures of companies increased with the generosity of the grants but the effect appeared to be rather limited. Görg and Strobl (2007) considered, for R&D subsidies in Ireland, three equal groups according to the level of the grant: 12,500 euro, between 12,500 and 55,000 euro and more than 55,000 euro. Estimates suggested that only the lowest subsidies resulted in additional R&D expenditures (for foreign companies there were no indications of additionality at all). In a recent study of R&D subsidies granted by the Catalan Government in 2005 and 2006, Duch-Brown, Garcia-Quevedo and Montolio (2011) found indications of a non-linear relationship between the generosity of subsidies and the R&D efforts of companies.

Table 9 shows the results of a Heckman estimation in which R&D expenditures of companies are not regressed on the amount of subsidies or tax benefits but on the generosity, which is defined as the ratio of public support to internal R&D expenditures. To allow for possible non-linearity, square terms of generosity are also included. Only for Young Innovative Companies generosity appears to have a positive impact on R&D expenditures. For regional subsidies and the partial exemption for companies that cooperate in research with a university or higher education institution, the estimation actually suggests a negative effect of generosity. The percentage of partial exemption from advance payment has been raised twice since 2006 and currently amounts to 75%. To assess whether this may have resulted in different effects, Table 10 shows the Bang for the Buck for each year separately. The BFTB is computed based on estimated elasticity (results not reported), average R&D expenditures and the average level of public support. Additionality varies considerably over the years. This is most striking for the partial exemption from advance payment for R&D personnel in List 1. Although, for this specific measure, the percentage of exemption only amounted to 25% in 2006 and 2007, 65% in 2008 and 75% as of January 2009, the BFTB is lower for 2008 and 2009 than for the first two years.

Table 9 Estimation of the impact of the generosity of public support on R&D expenditures *(2001-2009)*

Regional subsidy	-0.20(-12.11)***
Regional subsidy ^{2}	-0.01(-10.01)**
Research cooperation	-0.06(-2.22)**
Research cooperation ^{2}	-0.00(-0.96)
Young Innovative Company	0.89(32.06)***
Young Innovative Company ^{2}	0.06(39.56)***
Partial exemption List 1	-0.00(-0.19)
Partial exemption List 1^2	0.00(0.88)
Partial exemption List 2	-0.03(-0.93)
Partial exemption List 2^2	-0.00(-0.22)
Value added	-0.08(-2.72)***
Number of employees	0.14(8.71)***
Test selection bias	Mills lambda: -0.31(-9.07)***
Number of observations	11,638 (uncensored: 1,859)

Note: The table shows the results of a regression of R&D expenditures of companies (excluding public support) on the generosity (public support/R&D expenditures) of regional subsidies and the partial exemption from advance payment for R&D personnel. Dummies for industry (NACE two-digit), region and year were included in the estimation but not reported. The t-values are reported in parentheses and *, **, *** denotes statistical significance at 10%, 5% and 1% respectively. The "uncensored" observations denote the number of observations of companies that received a regional subsidy or a partial exemption from advance payment.

Table 10 Bang for the Buck of partial exemption from advance payment for R&D personnel, by year

	2006	2007	2008	2009
Research cooperation	6.73	/	/	/
Young Innovative Company	-2.81	1.16	0.68	0.60
List 1	13.77	8.92	2.82	1.41
List 2	n.a.	/	/	0.97

Note: The table shows the Bang for the Buck, computed on the basis of elasticity estimated by year (results not reported); average R&D expenditures and the average amount of the partial exemption. A Bang for the Buck greater than 0 implies that 1 euro in public support results in more than 1 euro additional R&D expenditures by companies. (n.a.: not applicable as the measure only started in 2007, /: the estimated elasticity was not statistically significant).

However, the BFTB in 2006 and 2007 for List 1 is extremely high compared to what is found in previous empirical studies. This may be explained by relabeling of activities by companies, for example attribute personnel to the R&D department, in order to apply for a partial exemption from advance payment for R&D personnel with the appropriate degree. Another possible explanation could be that in the year before the partial exemption was introduced some companies kept planned R&D projects on hold in prospect of the public support in the next year. These effects likely play a less important role in the last years of the period considered, for which the BFTB appears more reliable, in effect in line with previous estimates. The somewhat surprisingly negative BFTB for Young Innovative Companies in 2006 may be due to the rather low number of observations for this measure (76 Young Innovative Companies in 2006).

As pointed out in the introduction, only a small number of studies have tried to assess whether there are complementarities or substitution effects between different forms of public support for R&D. To evaluate the effects of the combination of measures of public support in Belgium, Table 11 shows the BFTB computed for companies that received only one of the five incentives considered (first five lines) and the BFTB for companies that combined a regional subsidy with a partial exemption from advance payment for R&D personnel with a degree in List 1 or in List 2 and companies that combined the latter

two measures (List 1 and List 2).[4] The BFTB was computed on the estimated elasticity (results not reported); average R&D expenditures and the average amount of public support (specific to each group considered).

Table 11 Bang for the Buck computed for single use of measures and for the combination of a regional subsidy and partial exemption from advance payment for R&D personnel with a degree in List 1 or List 2 *(2001-2009)*

Regional subsidy	0.41 (5,563)
Research cooperation	1.46 (679)
Young Innovative Company	0.68 (467)
Exemption List 1	3.78 (687)
Exemption List 2	0.55 (304)
Regional subsidy and exemption List 1	4.01 (558)
Regional subsidy and exemption List 1	- (286)
Exemption List 1 and List 2	2.20 (512)

Note: The table shows the Bang for the Buck, computed on the basis of elasticity estimated by year (results not reported); average R&D expenditures and the average amount of the partial exemption (all considered for each specific group). The BFTB in the first five lines concerns those companies that used only one of the five measures considered. The three last lines show the BFTB for companies that combined two specific measures. The number of observations to which the BFTB relates is shown in parentheses. A Bang for the Buck greater than 0 implies that 1 euro in public support results in more than 1 euro additional R&D expenditures by companies.

The highest additionality is again found for the partial exemption from advance payment for R&D personnel with a degree in List 1, whether companies only used this specific benefit or whether it was combined with a regional subsidy. There appear to be significant differences in the probability to obtain public support between companies that use only one specific measure and companies that combine different measures.[5] The results in Table 11 may therefore partly be explained by the self-selection of companies. An alternative way to assess the complementarities or substitution is to estimate the BFTB for each measure using all companies that have received a given benefit and estimate the additional impact for companies that have combined different measures. The BFTB computed on the basis of such an estimation (results not reported) are shown in Table 12. The results in Table 12 suggest the highest additionality for the use of individual measures, whereas there are indications that the additionality of public support decreases substantially when a regional subsidy is combined with a partial exemption for R&D personnel with a degree in List 1 or a partial exemption for R&D personnel with a degree in List 1 is combined with a partial exemption for R&D personnel with a degree in List 2. For example, the BFTB in Table 12 suggest that for each euro that companies received in partial exemption from advance payment for R&D personnel with a degree in List 1, they spent 7.29 euro additionally on R&D, whereas for each euro that companies received in partial exemption from advance payment for R&D personnel with a degree in List 2 they spent 3.66 euro additionally.

[4] Given the rather low number of observations for the partial exemption from withholding tax for companies that cooperate in research and for Young Innovative Companies, no interaction with other forms of public support is considered for these two measures.

[5] This is suggested by a number of probit estimations of the probability that companies either use one measure or combine different measures. The results of these estimations are not reported but available upon request.

Table 12 Bang for the Buck computed for each specific measure and for the additional impact of combining a subsidy and a partial exemption for R&D personnel with a degree in List 1 or List 2
(2001-2009)

Regional subsidy	1.57 (6,207)
Research cooperation	3.01 (679)
Young Innovative Company	0.99 (467)
Exemption List 1	7.29 (1,557)
Exemption List 2	3.66 (902)
Regional subsidy and exemption List 1	-3.22 (558)
Regional subsidy and exemption List 1	- (286)
Exemption List 1 and List 2	-4.00 (512)

Note: The table shows the Bang for the Buck, computed on the basis of elasticity estimated by year (results not reported); average R&D expenditures and the average amount of the partial exemption (all considered for each specific group).
The BFTB in the first five lines concerns all companies which, in a given year, have benefited from that measure. The three last lines show the BFTB for the additional impact for companies that combined two specific measures. The number of observations to which the BFTB relates is shown in brackets. A Bang for the Buck greater than 0 implies that 1 euro in public support results in more than 1 euro additional R&D expenditures by companies.

However, for each euro that companies received in combined partial exemption for R&D personnel in List 1 and in List 2 (for example, 50 cent for List 1 and 50 cent for List 2), they only spent 1.48 euro additionally (0.5*7.29 + 0.5*3.66 - 4.00). This result shows the need to coordinate between the regions and the federal government as to the entire amount of public support that is granted to companies for their R&D activities.

In a number of studies the additionality of public support for R&D is found to differ by company size. The results seem to depend on the country-specific characteristics of subsidies and tax benefits. Evaluating the effects of a wage tax benefit in the Netherlands, Lokshin and Mohnen (2007) established the highest BFTB for medium-large companies (between 50 and 250 employees), whereas for large companies estimates suggested no additionality. For Austria, estimates by Streicher, Schibany and Gretzmacher (2004) indicated that the additionality was higher for small and large companies than for medium-large companies, whereas Corchuelo and Martínez Ros (2009), for Spain, and Cerulli and Poti (2010), for Italy, concluded that the additionality of fiscal incentives was highest for large companies. Table 13 shows the BFTB computed for the sample of Belgian companies over the period 2001-2009, based on the estimation of a specification in which companies were grouped by quartile of the distribution of R&D expenditures. The BFTB is only computed for the elasticity estimates that are statistically significant[6]. In the first three quartiles, there appears to be no additionality and some BFTB are even negative. Additionality of regional subsidies as well as of the partial exemption from advance payment seems to be limited to the largest R&D companies. For Young Innovative Companies, no additionality is found in any of the four quartiles, as opposed to the results (reported in previous tables) for the total sample of companies. Given the rather small number of Young Innovative Companies and companies that cooperate in research, considering four separate groups may be slicing up the data too thin. An estimation in which companies are divided into two groups (lower and upper half of the distribution) provides indications of additionality in the upper half for all measures, including for Young Innovative Companies.

[6] The results of the Heckman regression are not reported but available upon request.

Table 13 Bang for the Buck based on estimates for companies grouped by quartile (R&D expenditures) *(2001-2009)*

1st quartile	
Regional subsidy	-0.05
Research cooperation	
Young Innovative Company	
Exemption List 1	-0.27
Exemption List 2	
2nd quartile	
Regional subsidy	-0.08
Research cooperation	
Young Innovative Company	-0.17
Exemption List 1	
Exemption List 2	-0.11
3rd quartile	
Regional subsidy	-0.09
Research cooperation	
Young Innovative Company	
Exemption List 1	
Exemption List 2	
4th quartile	
Regional subsidy	0.41
Research cooperation	2.42
Young Innovative Company	
Exemption List 1	1.66
Exemption List 2	0.68

Note: The table shows the Bang for the Buck, computed on the basis of elasticity estimates in a regression in which companies were grouped by quartile of the distribution of R&D expenditures and the average of R&D expenditures and public support (considered by quartile). Only statistically significant elasticity estimates are considered. A Bang for the Buck greater than 0 implies that 1 euro in public support results in more than 1 euro additional R&D expenditures by companies.

The results of additionality for large companies are in line with the findings of Corchuelo and Martínez-Ros (2009) and Cerulli and Poti (2010). The finding that there only appears to be additionality for large companies is not dramatic from a budgetary point of view as companies in the fourth quartile take up to 95% of corporate R&D expenditures in Belgium (see Graph 1).

If the supply of R&D personnel is inelastic, an increase in demand may result in upward pressure on wages. Part of the additionality of public support may therefore simply reflect an increase in wages rather than an increase in R&D activities. Estimations for a panel of 20 OECD countries by Jaumotte and Pain (2005) pointed out the difficulty in raising R&D intensity given the inelastic supply of researchers, especially in the short term. Estimates for the USA by Goolsbee (1998) suggest that an increase in R&D expenditures by 10% resulted in an immediate rise in the wages of researchers by 1% and by another 2% in the ensuing four years. He concluded that by ignoring this effect, the additionality of public support for R&D may be overestimated by 30 up to 50%. Rising wages will, moreover, also affect those companies that do not receive a subsidy or tax benefit. For the Netherlands, Marey and Borghans (2000) found that an increase in R&D expenditures by 1% resulted in a long-term increase of 0.5% in the supply of researchers and a rise in wages of 0.4%. In the short run, the wage increase was even more substantial. According to the estimates for Norway by Hægeland and Møen (2007 b), a tax

benefit of 100,000 Norwegian Krone was absorbed to the extent of 33,000 Krone (up to 55,000 for SMEs) in rising wages for researchers.

In the Belgian R&D survey, companies are asked to report the total wage sum of their R&D personnel and the total number of R&D employees. This permits to compute an average wage for R&D personnel. Regressing this average wage (in logarithm) on the amount of regional subsidies and partial exemption from advance payment, a two-step Heckman procedure suggests a statistically significant positive effect on the average wage for the Young Innovative Companies and the partial exemption from advance payment for R&D personnel with a degree in List 1. The results of a Maximum Likelihood estimation of the same specification provides different conclusions, suggesting that regional subsidies and the partial exemption for Young Innovative Companies and for R&D personnel with a master's degree (List 2) raise the average wage of R&D employees. The statistically significant elasticity estimates suggest that one euro in subsidy or partial exemption from advance payment tends to concur with a rise in wages of 15 up to 45 cents. However, the results do not appear very robust and do not account for changes in the skill composition of the R&D personnel, for example a rising share of researchers with a PhD. Moreover, Ientile and Mairesse (2009) argued that it should be kept in mind that rising wages may be due to increasing productivity or that governments provide support precisely to partly offset the wage increases of researchers.

4. Conclusions

In granting subsidies or tax benefits for R&D, governments have to strike a balance between the incentive for companies to apply for support – which depends on the administrative ease of the application and on the generosity of support – and the budgetary cost and effectiveness of public support. The rising popularity of the partial exemption from advance payment for R&D personnel attests to the sufficient incentive for companies. The estimates in this paper seem to show that the direct support provided by the regions as well as the federal tax benefits do indeed foster additional corporate R&D.

Highest additionality of public support for R&D in Belgium is found for the partial exemption from the advance payment for R&D personnel with a doctorate in (applied) science or (veterinary) medicine or with a civil engineering degree and for companies that cooperate in research with a university, higher education institution or scientific institution. The additionality is somewhat lower for the partial exemption for Young Innovative Companies or for the remuneration of R&D personnel with a master's degree and for regional subsidies. Additionality appears to decrease as companies combine different measures of support (for example subsidies and the partial exemption from advance payment). The indications that additionality of public support in Belgium is limited to the largest R&D companies should not be dramatized, knowing that companies in the fourth quartile take up to 95% of corporate R&D expenditures. As such, the partial exemption from advance payment can be an important instrument in view of the Europe 2020 objective to raise R&D expenditures to 3% of GDP.

Although there are a number of limitations to this study, the recent fiscal incentives introduced by the federal government appear to have improved the investment climate for R&D activities in Belgium. Relabeling of activities as R&D may have resulted in the overestimation of the impact of the fiscal incentives. On the other hand, the fact that companies may have continued R&D activities they would not have carried out in the absence of fiscal incentives could not be taken into account in the estimations. The latter effect of public support may have been substantial at the end of the period considered (2008 and 2009).

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Annex

Self-selection by companies in public support for R&D

In this paper, the possibility of self-selection by companies is taken into account through the use of a two-step Heckman estimation. The final results of the estimation are reported throughout the text. In this section, the results of the first step estimation are reported. In the first step, a probit estimation assesses the extent to which the probability that a company received a subsidy or partial exemption from advance payment for R&D personnel with a degree in List 1 or in List 2 can be explained by company-specific characteristics such as size, industry classification and R&D intensity, but also information on possible public support in the previous year.

Table A.1 indicates the strong impact of company size in explaining the R&D activities of companies. For regional subsidies, the number of employees has a significant impact on R&D expenditures, whereas for the partial exemption from advance payment, value added explains more than the number of employees.

Table A.1 The determinants of the probability to receive a subsidy or partial exemption *(2001-2009)*

	Regional subsidy	Exemption List 1	Exemption List 2
Regional subsidy	1.76 (52.83)***	0.62 (15.18)***	0.37 (7.82)***
Research cooperation	0.00 (4.15)***	0.00 (6.37)***	0.00 (4.50)***
Young Innovative Company	0.00 (2.95)***	-0.00 (-1.44)	0.00 (0.72)
Exemption List 1	0.00 (1.93)**	-	-
Exemption List 2	0.00 (1.49)	-	-
Value added	-0.02 (-1.30)	0.52 (17.71)***	0.55 (15.29)***
Number of employees	0.03 (2.70)***	0.11 (8.67)***	0.07 (4.42)***
R&D intensity	0.00 (1.91)*	0.00 (1.67)*	-0.00 (-0.17)
Number of observations	17,351	16,472	16,756
Pseudo R^2	0.33	0.21	0.17

Note: The table shows the results of a probit estimation in which the probability that a company received a subsidy or tax benefit in a given year is explained by company-specific characteristics such as size and industry classification but also the fact that the company received public support in the previous year. Industry (NACE two-digit); region and year dummies are included in the estimation but not reported. Missing coefficients for List 1 and List 2 point out the fact that when a company has applied for exemption in a given year, it almost certainly did this in the next year. The t-values are reported in parentheses and *, **, *** denotes statistical significance at 10%, 5% and 1% respectively. The pseudo R2 is similar to the R2 in Ordinary Least Squares estimation and indicates the extent (%) to which the variables included can explain the variance in the dependent variable.

The most striking result is the very high and statistically significant positive coefficient of regional subsidies in explaining the fact that a company received a partial exemption from advance payment. The fact that a company was granted a subsidy appears to have increased the awareness of tax benefits or to have incited companies with little experience in R&D activities to set up a R&D project which is then followed up in later years with support of tax benefits. This seems in line with the conclusions of Corchuelo and Martinez-Ros (2009) for Spain that obtaining a grant increases the probability of consequently using tax benefits.

Using data from the Community Innovation Survey (CIS), Busom, Corchuelo and Martínez-Ros (2011) established that companies with difficulties to attract funding for their innovation projects and young

companies were more inclined to apply for direct support than for a tax benefit. In the Belgian R&D survey, companies are asked what percentage of their internal R&D expenditures is financed with borrowed money. This variable can provide an indication of the extent to which companies have difficulties to borrow money for R&D activities. Table A.2 reports the results of an estimation similar to the one for which results are reported in Table A.1, except for the inclusion of this variable. As many companies that respond to the R&D survey do not answer the question regarding the financing of their R&D, the number of observations drops quite dramatically.

Table A.2 Impact of credit constraints on the probability to receive a subsidy or partial exemption *(2001-2009)*

	Regional subsidy	Exemption List 1	Exemption List 2
Regional subsidy	1.55(23.13)***	0.36(4.87)***	0.21(2.56)***
Research cooperation	0.00(2.28)**	0.00(3.11)***	0.00(2.69)***
Young Innovative Company	0.00(1.00)	0.00(-1.02)	0.00(0.92)
Exemption List 1	0.00(0.19)	-	0.00(0.34)
Exemption List 2	0.00(1.81)*	-	-
Value added	-0.08(-2.34)**	0.47(8.73)***	0.50(8.09)***
Number of employees	0.08(3.20)***	0.14(4.89)***	0.10(3.07)***
R&D intensity	0.00(0.77)	0.00(-0.50)	-0.00(-0.11)
% of R&D expenditures financed with borrowed money	0.00(1.15)	0.01(3.18)***	0.01(2.30)**
Number of observations	2,555	2,420	2,469
Pseudo R^2	0.31	0.19	0.16

Note: The table shows the results of a probit estimation in which the probability that a company received a subsidy or tax benefit in a given year is explained by company-specific characteristics such as size and industry classification but also the fact that the company received public support in the previous year. In addition the variables used in the estimation in Table A.1, the percentage of R&D expenditures that is financed with borrowed money is also included to assess the role of credit constraints. Industry (NACE two-digit); region and year dummies are included in the estimation but not reported. Missing coefficients for List 1 and List 2 point out the fact that when a company has applied for exemption in a given year, it almost certainly will do this the next year. The t-values are reported in parentheses and *, **, *** denotes statistical significance at 10%, 5% and 1% respectively. The pseudo R2 is similar to the R2 in Ordinary Least Squares estimation and indicates the extent (%) to which the variables included can explain the variance in the dependent variable.

The coefficient of the percentage of R&D expenditures financed with borrowed money is positive and statistically significant for the partial exemption from advance payment but not for regional subsidies. For regional subsidies, the coefficient of value added is negative (as in Table A.1) and statistically significant. These effects seem to point out - in line with Busom, Corchuelo and Martínez-Ros (2011) - that companies with sufficient own or external sources to finance R&D are more likely to apply for tax benefits, whereas companies that lack (own) sources tend to apply for direct support.