The impact of public support on firms' R&D investment: Evidence from Slovenia

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Abstract: Private R&D investment in the business sector is often subject to the market failures, asymmetric information and risk, which makes their level lower than socially desirable level. This constitutes the main reason why many modern governments around the world provide different R&D public policy instruments for stimulating firms' R&D investment. Accordingly, the main aim of this paper is to establish the impact of public support on firm' R&D investment in Slovenia. The research will take into the account R&D subsidies as a way of direct funding and R&D tax incentives as a way of indirect funding. The paper therefore takes advantages of the unique database of Slovenian companies for the period 2012-2016. The empirical results of the multiple linear regression models on a sample of 3,113 company-year observations show that public support for R&D investment plays an important role in terms of firms' R&D expenditures. For R&D subsidies, the empirical results show that they are in general not effective since they displace firms' R&D expenditures. However, they are effective when they are used in a combination with R&D tax incentives and when growing companies receive them. Moreover, the empirical results reveal that R&D tax incentives are effective in any case, when companies have sufficient tax base. The findings are beneficial especially for policymakers in terms of designing R&D public support policies for R&D investment in the future.

Key words: R&D subsidies, R&D tax incentives, R&D investment, Slovenia, Multiple regression analysis

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1 Introduction

The global economy is currently facing new challenges associated with the globalisation, the emergence of new technologies and the transition towards the knowledge-based economy. This has resulted in fast growing market with increasingly harsh global competition, which forces companies to provide value-added products, processes and services. This has affected also companies' investment structure and the importance of certain types of investment (Ahuja, 2011). This constitutes a reason why the role of R&D investment is becoming increasingly important, since it is often considered as the key driver of generating innovation outcomes and keeping competitive position in the market. Consequently, R&D investment constitutes an important factor for long-term viability of contemporary companies, especially in the conditions of ever-changing business environment. Accordingly, companies should be motivated for R&D investment in order to develop their competitive advantages.

However, private R&D investment in the business sector is often subject to the market failures, asymmetric information and risk, which makes their level lower than socially desirable level (Arrow, 1962). This constitutes the main reason why many modern governments around the world provide different R&D public policy instruments for stimulating firms' R&D investment, which is widely recognised to be the main driver of competitiveness on a company as well as on a national level (Ravšelj & Aristovnik, 2017, 2018). The main purpose of these R&D public policy instruments is to overcome market failures and encourage companies to increase their R&D investment. There is an ongoing debate in the literature on what is more effective for stimulating firms' R&D investment: R&D subsidies or R&D tax incentives. However, there is no agreement on this issue since different results suggest different R&D public policies and different solutions (Becker, 2015; Dimos & Pugh, 2016; IMF, 2016). In general, there appears to be broad consensus that direct support through R&D subsidies is more suitable for supporting long-term, high-risk R&D activities and for targeting specific areas that generate public goods or that have particularly high potential for spillovers. In contrast, indirect support through R&D tax incentives is more suited for encouraging R&D activities oriented to developing applications with the potential to be brought to market within a reasonable timeframe (OECD, 2016).

Accordingly, the main aim of this paper is to determine the impact of public support for R&D investment on firms' R&D expenditures in Slovenia. Namely, Slovenia represents a natural environment for evaluating the aforementioned relationship, since both of the R&D public policy instruments are currently available for Slovenian companies. This paper therefore contributes to the existing empirical literature, which consider only a single R&D public policy instrument i.e. R&D subsidies or R&D tax incentives. Since governments in many modern economies provide both, direct and indirect public support for R&D investment, estimates that do not consider the simultaneous impact of both R&D public policy instruments could be biased. Moreover, the existing empirical studies are mostly focused on the advanced or large economies, while the smaller ones have been predominantly neglected. Therefore, this paper contributes to the existing empirical literature also by providing the empirical evidence for small open economy of Slovenia. The remaining sections of this paper are organized as follows. In the next section, theoretical considerations and hypotheses development is presented. The following section describes the data and methodology. In the next section, the empirical results are presented. The paper ends with conclusions in which the main findings are summarized.

2 Theoretical considerations and hypotheses development

The theory provides several justifications for the government promotion of private R&D investment. The first reason refers to the existence of market failures leading to a situation that the level of private R&D investment is lower than socially desirable level (Arrow, 1962). The second reason is the existence of asymmetric information about the expected outcome of R&D investments and sunk costs (Negassi & Sattin, 2014). Finally, compared to the investment in physical assets, R&D investment is considered to be more risky and uncertain (Czarnitzki, 2006). The aforementioned reasons represent the main rationale why should governments encourage firms' R&D expenditures. This can be achieved by the implementation of adequate R&D public policy instruments, which can contribute to reducing the cost of riskier but socially valuable R&D investment. Accordingly, many modern governments provide different R&D public policy instruments for stimulating private R&D expenditures in the business sector, whereby the major public R&D policies are R&D subsidies and R&D tax incentives. However, the public financial pressures, which resulted from the combination of high debt and low growth in the recent financial crisis and economic austerity, put forward a debate on the effectiveness of different forms of public support for R&D investment.

This can be also recognised in the existing literature, since there are many empirical studies that deal with effectiveness of different forms of public support for R&D investment. However, the vast majority of them deal

only with R&D subsidies (see Czarnitzki & Delanote, 2015; Hud and Hussinger, 2015; Kaiser, 2006) or R&D tax incentives (see Czarnitzki et al., 2011; Chen & Gupta, 2017; Kobayashi, 2014) at a time. Nevertheless, some empirical studies can be found in the literature that address both R&D public policy instruments at the same time. They are mostly focused on evaluating the impact of public support for R&D investment on firms' R&D expenditures (Carboni, 2011), their innovative or corporate performance (Bérubé & Mohnen, 2009; Radas et al., 2015) or on examining the determinants affecting the choice to use a certain instrument of public support for R&D investment (Busom et al., 2014).

The empirical results for Italy suggest that public support for R&D investment has a positive impact on firms' R&D expenditures meaning that companies using R&D public support instruments devote more own resources then in absence of public support. Moreover, the results reveal that R&D tax incentives are more effective than R&D subsidies. Finally, there is also some evidence in this study revealing the positive effects of public support on credit financing for R&D (Carboni, 2011). Further, Bérubé and Mohnen (2009) examine the effectiveness of R&D subsidies and R&D tax incentives in Canada by comparing innovation performance of companies that benefited from R&D tax incentives only with their counterparts that benefited from both, namely R&D tax incentives and R&D subsidies. They establish that concomitant use of both instruments of public support for R&D investment is more effective than using R&D tax incentives only. Put it differently, companies that benefited from both instruments of public support for R&D investment introduced more products, made more world-first product innovations and were more successful in commercializing their innovations than their counterparts that benefited only from R&D tax incentives. Moreover, Radas et al. (2015) investigate the effects of R&D subsidies and R&D tax incentives on SMEs in Croatia. They establish that R&D subsidies, used alone or with R&D tax incentives, enhance the R&D orientation, innovation output and absorptive capacity of SMEs. The effects of instruments of public support for R&D investment are obvious especially when comparing companies to the ones that did not benefited from any of the two instruments. Namely, when comparing beneficiaries of R&D subsidies with the companies using both instruments of public support not much difference is found. The aforementioned results suggest that in the case of SMEs, R&D subsidies take precedence over R&D tax incentives.

Finally, in the context of Spain, Busom et al. (2014) investigate the use of R&D subsidies and R&D tax incentives in addressing financing constraints and appropriability difficulties, which represent two sources of market failure. They also examine whether both instruments of public support for R&D investment act as substitutes. Their findings reveal that SMEs facing financing constraints (whether internal or external) are more likely to use R&D subsidies than R&D tax incentives. In the case of SMEs, they also establish that SMEs utilizing legal intellectual protection mechanisms are more likely to use R&D tax incentives even if financing constraints increase. The findings for large companies reveal that large companies facing external financing constraints prefer R&D subsidies rather than R&D tax incentives. In the case of large companies, they do not establish relationship between utilizing intellectual protection mechanisms and using of exclusively one of the instruments of public support. The authors end up with a common point for SMEs and large companies. They claim that both prefer R&D tax incentives (either alone or in combination with R&D subsidies) in the case of having past R&D experience. Moreover, they establish that young companies operating in knowledge intensive industries prefer R&D subsidies rather than R&D tax incentives. The authors make a conclusion that R&D subsidies and R&D tax incentives possess distinct abilities, especially in addressing causes of market failures. From the policy point of view, these two instruments of public support may therefore be adopted as complements. A summary of the key literature addressing the joint effect of R&D subsidies and R&D tax incentives is systematically presented in Table 1.

Table 1: A summary of the key literature addressing the joint effect of R&D subsidies and R&D tax incentives

Authors	Countries	Findings
Carboni (2011)	Italy	Companies using instruments of public support devote more own resources then in absence of public support. Moreover, R&D tax incentives are more effective than R&D subsidies.
Bérubé and Mohnen (2009)	Canada	Concomitant use of both instruments of public support is more effective than using R&D tax incentives only.
Radas et al. (2015)	Croatia	R&D subsidies, used alone or with R&D tax incentives, enhance the R&D orientation, innovation output and absorptive capacity of SMEs. Moreover, in the case of SMEs, R&D subsidies take precedence over R&D tax incentives.
Busom et al. (2014)	Spain	SMEs facing financing constraints (whether internal or external) are more likely to use R&D subsidies than R&D tax incentives. Moreover, large companies facing external financing constraints

		prefer R&D subsidies rather than R&D tax incentives.

Source: Authors' elaboration.

The review of the key literature addressing joint effect of R&D subsidies and R&D tax incentives reveals that in general to a greater or a lesser extent both instruments enhance firms' R&D expenditures, improve their innovation performance and correct market failures. Despite the beneficial effect of R&D subsidies and R&D tax incentives, the way how these two instruments of public support influence companies may be different, especially due to the existence of some differential features related to the eligibility, magnitude and certainty as well as timing of public support (Busom et al., 2014).

As regards eligibility of public support for R&D investment, all R&D projects are qualified for R&D tax credits if they meet all the conditions for classifying them as R&D activity. This is not the case for R&D subsidies, where only R&D projects demonstrating high degree of novelty, risk or spillover capacity may be qualified for R&D subsidies. In terms of magnitude of public support for R&D investment, R&D subsidies provide companies a higher level of certainty on the extent of R&D cost reduction. For example, beneficiaries of R&D subsidies know the exact amount of R&D subsidies in advance before the start of the R&D project, whereby the benefits of R&D tax incentives depend mostly on the companies' tax position at the end of fiscal year. Namely, the amount of tax liability at the end of fiscal year can be smaller than the benefits of the potential R&D tax incentives. The aforementioned often occurs in the case of SMEs and young companies. In this sense, in the case of companies facing financing constraints (whether internal or external), R&D subsidies are more beneficial than R&D tax incentives, since financially constrained companies cannot generate sufficient R&D expenditures qualifying for R&D tax incentives. With respect to the timing of public support for R&D investment, R&D subsidies are obtained ex ante before the R&D project starts, while R&D tax incentives are obtained ex post at the end of fiscal year. Thus, companies can benefit from R&D tax incentives only if they have enough own internal or external financial resources to fund the R&D project in advance. Since SMEs and young companies may often face financing constraints, they are less likely to benefit from R&D tax incentives. Furthermore, R&D subsidies may also serve as an indicator of the quality of an R&D project allowing companies to signal their success to potential investors. This means that due to the certification effect, receiving R&D subsidies may result in easier access to external finance (Meuleman & De Maeseneire, 2012; Wu, 2017). However, this is not the case for R&D tax incentives. The summary and comparison of characteristics between R&D subsidies and R&D tax incentives is presented in Table 2.

Table 2: Comparison between R&D subsidies and R&D tax incentives by individual characteristics

Characteristics	R&D subsidies	R&D tax incentives
Eligibility	Only R&D projects accomplishing funding agency requirements.	All R&D project funded by companies' own internal or external finances.
Magnitude and certainty	Depends on the amount of R&D subsidies, which companies know in advance (higher certainty).	Depends on the companies' tax position at the end of fiscal year (lower certainty).
Timing	Obtained *ex ante* before the R&D project starts.	Obtained *ex post* at the end of fiscal year.

Source: Busom et al., 2014.

The extensive literature review reveals predominantly positive effects of both forms of public support for R&D investment. However, the vast majority of the existing empirical studies are mostly focused only on a single public policy instrument i.e. R&D subsidies or R&D tax incentives. Moreover, many empirical studies are focused on the advanced or large economies, while the smaller ones have been predominantly neglected. Therefore, the Slovenian context represents a great opportunity to examine the impact of different forms of public support for R&D investment on firms' R&D expenditures. Therefore, the following research hypotheses are proposed:

- **Hypothesis 1.1:** *Direct public support for R&D investment in the form of R&D subsidies stimulates R&D expenditures at the firm level.*

- **Hypothesis 1.2:** *Indirect public support for R&D investment in the form of R&D tax incentives stimulates R&D expenditures at the firm level.*

3 Data and research methods

A comprehensive empirical analysis is performed on a unique dataset of Slovenian companies. The data is obtained from three man different sources provided by the Statistical Office of the Republic of Slovenia (SORS). The first source refers to database including the data on R&D activity of Slovenian companies. It covers all companies that are: 1) registered for performing R&D activity (NACE 72 classification) and have more than two employees; 2) not registered for performing R&D activity but are recipients of R&D subsidies; 3) liable to general and regional R&D tax incentives and 4) reporting about R&D investments in the survey on innovation activity (SORS, 2018a). The aforementioned database represents the leading source of the data meaning that it dictates the number of companies included in the empirical analysis. It provides crucial and comprehensive data regarding R&D activity in a certain company. The second source refers to the data from corporation tax forms. It covers all the relevant data on company's tax status including the use of R&D tax incentives. The third source provides data from the financial statements of companies including the data from balance sheet and income statement. All the aforementioned data sources are merged in to a unique and comprehensive database of Slovenian companies.

The final sample consists of Slovenian non-financial private companies operating whether in manufacturing (NACE 10-33) or service sectors (NACE 35-99) and having a legal organizational form of private or public limited company. Namely, such companies represent a good reflection of the Slovenian small open economy. Moreover, company-year observations with incomplete data, negative equity or less than one employee are excluded from the empirical analysis. Finally, in order to mitigate small deflator problem, company-year observations with less than 100,000 EUR of total assets and net sales are excluded from the empirical analysis. The final unbalanced panel dataset of Slovenian companies consists of 3,113 company-year observations. The distribution of the final sample of Slovenian companies by years is shown in Table 3. It reveals that the company-year observations vary from the minimum value of 541 in 2012 to the maximum value of 675 in 2014.

Table 3: Sample distribution of Slovenian companies by years

Year	Number	Share (in %)
2012	541	17.38
2013	615	19.76
2014	675	21.68
2015	667	21.43
2016	615	19.76
Total	**3,113**	**100**

Source: SORS, 2018b; authors' elaboration.

This paper is focused on the impact of different forms of public support for R&D investment on firms' R&D expenditures. Therefore, the dependent variable is net R&D intensity (NRDI), which is defined as firms' R&D expenditures (excluding R&D subsidies) divided by total assets. This measure represents a comparable basis for companies of different size and it is widely used in the existing empirical studies (Curtis et al., 2016; Ryan Jr, 2002).

Moreover, there are two main variables of interest in this paper. These are R&D subsidy intensity (SUB) and R&D tax incentive intensity (TAX). They are defined as the amount of received R&D subsidies or claimed R&D tax incentives divided by the amount of net sales. Such measures have been also used in the existing empirical studies (Jin et al., 2018). In order to obtain additional and comprehensive insights regarding the impact of public support for R&D investment on firms' R&D expenditures, the following interaction effects are considered in the empirical analysis. The first interaction term between R&D subsidy intensity and R&D tax incentive intensity (SUBxTAX) tries to capture the simultaneous use of both R&D public policy instruments. The second interaction term between R&D subsidy intensity and net sales growth (SUBxNSG) is considered in order to examine how R&D subsidies influence firms' R&D expenditures according to the company growth. Similarly, the third interaction term between R&D tax incentive intensity and net sales growth (TAXxNSG) is considered for the purposes of establishing how R&D tax incentives affect firms' R&D expenditures according to the company growth. According to the proposed research hypotheses, it is expected that both forms of public support for R&D investment as well as their interaction terms have a positive impact on firms' R&D expenditures.

Finally, according to the existing empirical studies, which can have an impact on firms' R&D expenditures. Therefore, all of the relevant determinants of firms' R&D expenditures are included and considered as control variable in the empirical analysis. The first control variable is financial leverage (LEV), which is measured as total (short-term and long-tern) liabilities divided by total assets. According to the previous empirical studies, it is expected that financial leverage has a negative impact on firms' R&D expenditures (Min & Smyth, 2016). The

second control variable is net sales growth (NSG), which is measured as a simple one-year growth of net sales. According to the previous empirical studies, it is expected that net sales growth has a positive impact on firms' R&D expenditures (Coad & Rao, 2010). The third control variable is company size (SIZE), which is defined as the natural logarithm of employees. According to the previous empirical studies, it is expected that company size has a positive impact on firms' R&D expenditures (Jin et al., 2018). Finally, year dummy variables (YEAR) are also included in the empirical analysis for the purposes of controlling for time effects. Based on 2012, there are four dummy variables, which take the value of 1 if a company-year observation is from a year studied (from 2013 to 2016) and 0 otherwise. A summary of all variables employed in the empirical analysis is systematically presented in Table 4.

Table 4: Summary of variables employed in the empirical analysis

Abbreviation	Variable	Definition	Source
Dependent variable			
NRDI	Net R&D intensity	The ratio between firms' R&D expenditures and total assets.	SORS
Independent variables			
SUB	R&D subsidy intensity	The ratio between received R&D subsidies and total assets.	SORS
TAX	R&D tax incentive intensity	The ratio between claimed R&D tax incentives and total assets.	FURS
SUBxTAX	Interaction between R&D subsidy intensity and R&D tax incentive intensity	The interaction between R&D subsidy intensity and R&D tax incentive intensity.	SORS/FURS
SUBxNSG	Interaction term between R&D subsidy intensity and net sales growth	The interaction between R&D subsidy intensity and company net sales growth.	SORS/AJPES
TAXxNSG	Interaction term between R&D tax incentive intensity and net sales growth	The interaction between R&D tax incentive intensity and company net sales growth.	FURS/AJPES
Control variables			
LEV	Financial leverage	The ratio between total liabilities and total assets.	AJPES
NSG	Net sales growth	A simple one-year growth of net sales.	AJPES
SIZE	Company size	The natural logarithm of employees.	AJPES
YEAR	Year dummy variable	Dummy variable that takes 1 for year studied, 0 otherwise.	AJPES

Note: SORS - Statistical office of the Republic of Slovenia; FURS - Financial Administration of the Republic of Slovenia; AJPES - Agency of the Republic of Slovenia for Public Legal Records and Related Services.
Source: Authors' elaboration.

This empirical study involves a comprehensive empirical analysis regarding the impact of different forms of public support for R&D investment on firms' R&D expenditures. The first step covers estimating the impact of different R&D public policy instruments, namely R&D subsidies and R&D tax incentives as well as their interaction term on firms' R&D expenditures. Accordingly, net R&D intensity (NRDI) is regressed against the main independent variables, namely R&D subsidy intensity (SUB), R&D tax incentive intensity (TAX) and the interaction term between R&D subsidy intensity and R&D tax incentive intensity (SUBxTAX) as a measures of public support for R&D investment (SUP). They are estimated in separate models as well as simultaneously. In addition, some control variables are further included in the multiple regression models, namely, financial leverage (LEV), net sales growth (NSG) and company size (SIZE). In order to control for year effects, also time dummy variables (YEAR) are taken into consideration. The multiple regression model is presented in the Equation (1.1).

$$NRDI_{i,t} = \alpha_0 + \beta_1 SUP_{i,t} + \beta_2 LEV_{i,t} + \beta_3 NSG_{i,t} + \beta_4 SIZE_{i,t} + \sum YEAR_{i,t} + \varepsilon_{i,t} \quad (1)$$

Where NRDI is a dependent variable measuring net R&D intensity. Furthermore, independent variables are identified as a vector of independent variables for public support for R&D investment (SUP), such as: R&D subsidy intensity (SUB), R&D tax incentive intensity (TAX) and the interaction term between R&D subsidy intensity and R&D tax incentive intensity (SUBxTAX). Furthermore, some control variables are included, which represent possible determinants of net R&D intensity such as: financial leverage (LEV), net sales growth (NSG) and company size (SIZE). Finally, also the control variables for time effects are considered (YEAR).

In order to obtain additional insights, the second step covers the impact of different R&D public policy instruments, namely R&D subsidies and R&D tax incentives by considering their interaction with net sales growth. Accordingly, net R&D intensity (NRDI) is regressed against the main independent variables, namely R&D subsidy intensity (SUB), R&D tax incentive intensity (TAX) as well as their interaction terms with net sales growth (SUBxNSG and TAXxNSG) denoted by (INT). They are estimated in separate models as well as simultaneously. Similar to the first step, financial leverage (LEV), net sales growth (NSG) and company size (SIZE) are considered as control variables. In order to control for year effects, also time dummy variables (YEAR) are taken into consideration. The multiple regression model is presented in the Equation (1.2).

$$NRDI_{i,t} = \alpha_0 + \beta_1 SUB_{i,t} + \beta_2 TAX_{i,t} + \beta_3 INT_{i,t} + \beta_4 LEV_{i,t} + \beta_5 NSG_{i,t} + \beta_6 SIZE_{i,t} + \sum YEAR_{i,t} + \varepsilon_{i,t} \quad (2)$$

Where NRDI is a dependent variable measuring net R&D intensity. Furthermore, independent variables are identified as R&D subsidy intensity (SUB) and R&D tax incentive intensity (TAX). Moreover, a vector of interaction variables (INT) is considered such as the interaction term between R&D subsidy intensity and net sales growth (SUBxNSG) and interaction term between R&D tax incentive intensity and net sales growth (TAXxNSG). Furthermore, some control variables are included, which represent possible determinants of net R&D intensity such as: financial leverage (LEV), net sales growth (NSG) and company size (SIZE). Finally, also the control variables for time effects are considered (YEAR).

4 Empirical results

Descriptive statistics of variables (except year and interaction effects) for the period 2012-2016 is presented in Table 5. It shows mean and standard deviation values for variables, which are included in the empirical analysis. Since companies represent a very heterogeneous group of units, there may be some outliers in the data. In order to eliminate the effect of possibly spurious outliers all of the continuous variables are winsorised at 1% and 99% level by each year. Furthermore, the procedure of Winsorisation is often considered also as robust statistics (Reifman & Keyton, 2010). Descriptive statistics reveals that Slovenian companies for R&D activity devote funds in a proportion of more than 11% of their total assets. Moreover, the mean values of R&D subsidy intensity (SUB) and R&D tax incentive intensity (TAX) suggest that the latter are more popular among Slovenian companies than R&D subsidies. The mean value of financial leverage (LEV) indicate that it is at relatively high level compared to the net R&D intensity (NRDI). Finally, the descriptive statistics reveals that Slovenian companies on average grow with an 11.20% rate.

Table 5: Descriptive statistics of variables

Variable	Mean	SD
NRDI	0.111	0.216
SUB	0.021	0.070
TAX	0.031	0.055
LEV	0.427	0.223
NSG	0.112	0.439
SIZE	3.624	1.605

Note: Data is strictly confidential; therefore, the minimum and maximum values are not presented.
Source: SORS, 2018b; authors' elaboration.

Table 6 shows the Pearson correlation between variables (except year and interaction effects). The simple correlation shows a positive and significant correlation between different forms of public support for R&D investment and firms' R&D expenditures. The Pearson correlation matrix also reveals that financial leverage (LEV) and company size (SIZE) are negatively correlated with firms' R&D expenditures. Finally, the correlation between net sales growth (NSG) and firms' R&D expenditures seem to be positive. These results are largely (except for company size) in line with the expectations. Nevertheless, the simple correlation between the explanatory variables does not indicate any strong linear relationship suggesting that there is no issue of multicollinearity in the data of Slovenian companies.

Table 6: Pearson correlation matrix of variables for Slovenian companies

	NRDI	SUB	TAX	LEV	NSG	SIZE
NRDI	1					

SUB	0.293***	1				
TAX	0.265***	0.088***	1			
LEV	-0.78***	0.001	-0.232***	1		
NSG	0.137***	0.152***	0,189***	0.048**	1	
SIZE	-0.316***	-0.206***	-0.277***	0.054**	-0.144***	1

Note: Levels of significance: *p<0.05; **p<0.01; ***p<0.001.
Source: SORS, 2018b; authors' elaboration.

The impact of public support on firms' R&D investment is estimated by multiple regression analysis with panel data. In order to determine statistically, which econometric specification is the most suitable for the data used in the empirical analysis, a three-step procedure is applied. First, LM test is used in order to decide between random effects and pooled regression model. Second, F test is applied in order to compare between pooled regression and fixed effects model. Third, the Hausman test is conducted in order to choose between a random effects and a fixed effects model (Hausman, 1978). The results of these tests suggest that the fixed effects model is the most preferable model for all of the proposed multiple regression models. Moreover, in order to check the presence of heteroscedasticity, a modified Wald test for groupwise heteroscedasticity is performed (Baum, 2001). Since the results of a modified Wald test show a positive result for all multiple regression models ($P < 0.001$), the heteroscedasticity-robust (White) standard errors are employed in the multiple regression models in order to alleviate the problem of heteroscedasticity.

The empirical results for the relationship between public support for R&D investment and firms' R&D expenditures are presented in Table 7. As regards the impact of two different forms of public support, the empirical results show the following. The regression coefficients of R&D subsidy intensity (SUB) reveal that it has a negative impact on net R&D intensity (NRDI), while the regression coefficient of R&D tax incentive intensity (TAX) show that it has a positive impact on net R&D intensity (NRDI). These results are evident from Model 1.1 (a) and Model 1.1 (b), which estimate only a single R&D public policy instrument i.e. R&D subsidies or R&D tax incentives. Since these results can be biased due to the inclusion only a single instrument of public support in the estimation, the Model 1.1 (c) extends previous models by the consideration of the simultaneous impact of both R&D public policy instruments. In this case, the empirical results remain similar. Since Slovenian companies are allowed to benefit from both forms of public support for R&D investment, it is therefore necessary to include the interaction between R&D subsidy intensity and R&D tax incentive intensity (SUBxTAX). The empirical results of Model 1.1 (d) reveal that concomitant use of both R&D subsidies and R&D tax incentives stimulates firms' R&D expenditures. As regards the control variables, the results show the following. First, the regression coefficient of financial leverage (LEV) is negative and significant, suggesting that companies with higher debt devote less funds for R&D activity (Min & Smyth, 2016). Second, the regression coefficient of net sales growth (NSG) is positive and significant, suggesting that growing companies devote more funds for R&D activity (Coad & Rao, 2010). Finally, the regression coefficient of company size (SIZE) is positive and significant (except for Model 1.1 (b)), indicating that larger companies devote more funds for R&D activity (Jin et al., 2018).

Table 7: Multiple regression results for the relationship between public support for R&D investment and firms' R&D expenditures

Variable	**Predicted Sign**	**Model 1 (a)**	**Model 1 (b)**	**Model 1 (c)**	**Model 1 (d)**
SUB	+	-0.342*** 0.045)		-0.347*** (0.045)	-0.477*** (0.051)
TAX	+		0.233*** (0.064)	0.245*** (0.063)	0.091 (0.069)
SUBxTAX	+				2.174*** (0.388)
LEV	-	-0.060** (0.023)	-0.061** (0.023)	-0.050* (0.023)	-0.054* (0.023)
NSG	+	0.027*** (0.005)	0.019*** (0.005)	0.024*** (0.005)	0.025*** (0.005)
SIZE	+	0.023** (0.010)	0.015 (0.010)	0.024* (0.010)	0.025* (0.010)
Constant	?	0.081** (0.037)	0.093* (0.038)	0.066 (0.037)	0.069 (0.037)
Year	?	Yes	Yes	Yes	Yes
R^2		0.1038	0.0032	0.0716	0.0830

Observations	3,113	3,113	3,113	3,113
LM test	1872.16***	2223.95***	1830.23***	1795.46***
F test	156.00***	27.66***	168.21***	192.29***
Hausman test	168.69***	44.90***	185.98***	207.92***

Note: 1) Levels of significance: *p<0.05; **p<0.01; ***p<0.001. 2) Heteroscedasticity-robust standard errors are in parentheses.
Source: SORS, 2018b; authors' elaboration.

The empirical results for the relationship between public support for R&D investment and firms' R&D expenditures according to their growth are presented in Table 8. The main variables of interest in this step of the empirical analysis represent interactions between R&D subsidy intensity, R&D tax incentive intensity and net sales growth (SUBxNSG and TAXxNSG). These interactions are estimated separately (see Model 1.2 (a) and Model 1.2 (b)) and jointly (see Model 1.2 (c)). Regardless of the empirical results for other relevant variables, which remain similar to those presented in the first step of the empirical analysis, the results for interaction terms provide the following insights. The regression coefficients of both interaction terms are positive and significant, suggesting that both forms of public support for R&D investment have a positive impact on firms' R&D expenditures for growing companies. The empirical results remain similar regardless of the model estimated. With respect to the control variables, the empirical results portray the following. The impact on net R&D intensity (NRD) is negative for financial leverage (LEV) and positive for net sales growth (NSG) and company size (SIZE), whereby the regression coefficients are not necessarily everywhere significant. Nevertheless, the results are similar to those presented above and in line with the initial expectations (Coad & Rao, 2010; Jin et al., 2018; Min & Smyth, 2016).

Table 8: Multiple regression results for the relationship between public support for R&D investment and firms' R&D expenditures according to their growth

Variable	**Predicted Sign**	**Model 2 (a)**	**Model 2 (b)**	**Model 2 (c)**
SUB	+	-0.395*** (0.049)	-0.339*** (0.045)	-0.393*** (0.049)
TAX	+	0.262*** (0.064)	0.126 (0.068)	0.141* (0.068)
SUBxNSG	+	0.087* (0.035)		0.097** (0.035)
TAXxNSG	+		0.273*** (0.059)	0.282*** (0.059)
LEV	-	-0.051* (0.023)	-0.049* (0.023)	-0.051* (0.023)
NSG	+	0.016** (0.006)	0.008 (0.006)	-0.001 (0.007)
SIZE	+	0.024* (0.010)	0.027** (0.010)	0.028** (0.010)
Constant	?	0.066 (0.037)	0.056 (0.037)	0.055 (0.037)
Year	?	Yes	Yes	Yes
R^2		0.0736	0.0799	0.0822
Observations		3,113	3,113	3,113
LM test		1814.32***	1832.77***	1816.54***
F test		169.13***	173.48***	174.83***
Hausman test		191.03***	195.30***	288.87***

Note: 1) Levels of significance: *p<0.05; **p<0.01; ***p<0.001. 2) Heteroscedasticity-robust standard errors are in parentheses.
Source: SORS, 2018b; authors' elaboration.

The empirical results provide the evidence that both forms of R&D public policy instruments play an important role in stimulating R&D expenditures at the firm level. This is in line with the findings of Carboni (2011) who established that companies benefiting from government support for R&D investment devote more funds for R&D activities then in the absence of public support. However, the results are not straightforward. As regards the impact of R&D subsidies on firms' R&D expenditures, it seems that they have a negative impact on firms' R&D expenditures, which is not in line with the initial expectations and some of the previous studies. However,

there are some cases, when the impact of R&D subsidies on firms' R&D expenditures becomes positive. The first situation when the positive impact occurs is when companies use R&D subsidies in a combination with R&D tax incentives. This suggests that concomitant use of both R&D public policy instruments is more effective than using only one instrument as it is established in the previous research studies (Bérubé and Mohnen, 2009). The aforementioned holds especially for the companies, which benefit only from R&D subsidies. The second situation when the impact of R&D subsidies on firms' R&D expenditures is positive is when the companies are in growing phase. Based on the discussion above, the first research hypothesis (Hypothesis 1) that direct public support for R&D investment in the form of R&D subsidies stimulates R&D expenditures at the firm level can be confirmed only for those companies, which use R&D subsidies with a combination with R&D tax incentives and for growing companies.

As regards the impact of R&D tax incentives on firms' R&D expenditures, the empirical analysis reveals positive effects regardless of the model estimated. Moreover, further examination shows that the impact of R&D tax incentives on firms' R&D expenditures becomes more prominent for growing companies. This result seems to be reasonable, since growing companies often exhibit a positive and large tax base, which is a prerequisite for claiming R&D tax incentives in Slovenia. Therefore, the second research hypothesis (Hypothesis 2) that indirect public support for R&D investment in the form of R&D tax incentives stimulates R&D expenditures at the firm level can be confirmed.

5 Conclusions

The empirical results of this paper explain that public support for R&D investment play an important role in terms of firms' R&D expenditures. They suggest that R&D subsidies in general displace firms' R&D expenditures in Slovenia. However, the results show that R&D subsidies become effective when they are used in a combination with R&D tax incentives and when growing companies receive them. Contrary, the empirical results show that R&D tax incentives are effective in any case, when companies have sufficient tax base. This implies that Slovenian companies do not exploit the potential of R&D subsidies. This is partly related to the fact, that Slovenian companies are not so familiar with R&D subsidies. On the other hand, it seems that the R&D tax incentives represent a good and effective R&D public policy instrument, which is successfully exploited by Slovenian companies.

The reasons for different findings regarding the impact of public support for R&D investment on firms' R&D expenditures stems from the differences in the characteristics of R&D subsidies and R&D tax incentives. As regards the eligibility of public support, for R&D subsidies are eligible only R&D projects with high degree of novelty, risk or spillover capacity and accomplish funding agency requirements. Contrary, for R&D tax incentives are eligible all R&D projects. Further, the magnitude of R&D subsidies depends on their amount, which companies know in advance, while the magnitude of R&D tax incentives depends on the companies' tax position at the end of fiscal year. Therefore, R&D subsidies are considered to be more certain than R&D tax incentives. Finally, as regards the timing of public support, R&D subsidies are obtained ex ante before the R&D project starts, while R&D tax incentives are obtained ex post at the end of fiscal year. Due to the presented characteristics of R&D subsidies, they do not stimulate companies to their natural growth, which would ultimately lead to an increase in their R&D expenditures. This implies that the effects of R&D subsidies are more in maintaining the companies' business operations rather than in stimulating their growth and their funds for R&D activity. Contrary, the presented characteristics of R&D tax incentives suggest that they are more growth-oriented, since they largely depend on their tax position at the end of fiscal year. The overall conclusion is that R&D subsidies are more used to help less-growing companies in maintaining employment and replacing older products, processes and services (this is not the case for companies using both R&D public policy instruments and growing companies), while R&D tax incentives are used in companies with sufficient tax base.

The results of this study provide additional empirical support to the main theoretical foundations, which are commonly used for explaining why public support for R&D investment is needed in a certain economy. The results reveal that public support for R&D investment contributes to reducing market failures, asymmetric information and risk through the reduction of costs needed to perform R&D activities, which allows companies to invest more in R&D activities. In the case of R&D subsidies, this can be confirmed for companies using R&D subsidies and R&D tax incentives at the same time and for growing companies. On the other hand, in the case of R&D tax incentives this can be confirmed in general sense.

The findings of this study provide also several important practical or policy implications. The overall findings suggest that R&D tax incentives are more effective than R&D subsidies in Slovenia. The reasons for that are the following. First, the overall system in Slovenia is relatively small, fragmented (the abundance and variety of

R&D tenders and non-homogeneous population of companies) and two-tiered (especially from 2012 when R&D tax allowance rate of 100% was introduced). This implies that companies, with sufficient tax base are more inclined towards R&D tax incentives, since all R&D projects funded by companies' own internal or external finances can be eligible for this form of public support for R&D investment. On the other hand, R&D subsidies may be still attractive especially for smaller companies without sufficient tax base. It is therefore important to consider both R&D public policy instruments as two parallel ways of supporting firms' R&D expenditures. For policymakers is crucial that they exploit the advantages and reduce the weaknesses of each instrument in order to provide public support for R&D investment in the efficient way.

Although this paper provides some new and interesting findings, some limitations are recognised and future research avenues are presented. First, the research period is limited on the period 2012-2016 due to the need to provide a research period with stable operating conditions for companies as well as to assure the period, when both instruments of public support for R&D investment are available to Slovenian companies. Accordingly, the direction for future research can be in the extension of the research period. This can provide additional empirical evidence regarding the impact of public support for R&D investment on firms' R&D expenditures, especially in the time of the recent economic crisis. The limited research period also makes difficult to use sophisticated econometric approaches, as they often require longer research period in order to get the credible empirical results. Finally, since this study is based solely on database, which besides some basic company characteristics includes only financial items of individual companies, some important information can be neglected. It would be therefore beneficial to conduct surveys or interviews in order to obtain some further insights, which cannot be obtained only through financial data.

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