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THE EFFECTS OF TAX RELIEFS ON THE R&D ACTIVITY IN SLOVENIA

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Abstract

The paper investigates the effect of tax incentives on R&D expenditure in Slovenian firms, differentiating the impact by firm size and age. As there is a lack of empirical research on the effectiveness of these reliefs in Slovenia, and the research uses administrative firm-level data and an innovative approach, this study makes an important contribution to the literature. The effectiveness of the R&D tax incentives is based on the direct approach. The effect is identified by applying a quasi-experimental approach and the use of the difference-in-differences method. To rule out the effect of concurrent factors that could influence the level of R&D expenditure at the firm level, the paper uses the variation in regional tax relief rates. The paper finds that a one percentage point increase in the R&D tax relief was associated with a 0.571 percentage point increase in firms' R&D expenditure. The impact was larger for smaller and younger firms.

Keywords: R&D, tax reliefs, tax incentives, policy evaluation, Slovenia

1. INTRODUCTION

Investment in research and development (R&D) is one of the key factors driving innovation, productivity, and firm competitiveness with favorable effects on economic growth and general welfare. To promote R&D, governments adopt various instruments either in the form of grants (direct support) or fiscal incentives (see Appelt et al., 2016). The R&D tax incentives have become one of the most used policy tools to stimulate R&D – according to the OECD (2023), 33 of the 38 OECD countries offered tax relief for R&D expenditure in 2022, which is 50% more than in the year 2000. One of the reasons for this increase is the nature of the tax reliefs as such. Compared to direct supports, tax reliefs reduce the administrative burden and the risk of adverse selection (Dechezleprêtre et al., 2023), and they transfer the decision on the distribution of R&D investments to the markets, not the governments. Further advantages of tax reliefs are that (i) by reducing the costs of R&D projects, they increase the net present value of projects; (i) they encourage R&D in small and medium-sized enterprises, which have more difficulty accessing direct R&D incentives; and (iii) they can serve as a general incentive for R&D by lowering R&D costs for a large population of firms. On the other hand, the disadvantages of tax incentives are that (i) they do not allow governments to directly direct funds to R&D in areas with high social benefits (e.g., technological areas with spillover effects or basic research), and (ii) they may encourage short-term rather than long-term R&D projects (OECD, 2003).

An important question in existing literature is whether fiscal incentives contribute to R&D investment. The empirical findings mostly show that R&D tax reliefs encourage R&D activity of firms, but findings on the scope of the effect vary. According to empirical studies and meta-analysis, a 10% reduction in the firm's cost of capital for R&D at the expense of a tax relief increases R&D expenditures by between 1 and 10.9% on average (CPB et al., 2015; Castellacci & Lie, 2015; Ladinska et al., 2015; Parsons & Philips, 2007). The impacts of R&D tax reliefs vary also according to firm characteristics, with most empirical studies showing higher effects in smaller firms.

Slovenia introduced R&D tax reliefs in 2006. Initially, the tax relief amounted to 20% or up to 40% for firms operating in less developed regions of the country. The amount of tax relief for R&D has increased over the years and since 2012 amounts to 100% of the invested amount for R&D activities. The incentive is intended for successful firms that operate profitably and serves as an incentive to reduce income tax payments due to the risky and unpredictable nature of R&D activities (Ministry of Economic Development and Technology of the Republic of Slovenia, 2019). Despite the increase in the use of R&D tax reliefs among firms (in 2018, firms claimed a total of 239.4 million euros in R&D tax reliefs which is five times more compared to 2009 (FURS, 2021)), they represented only 0.08% of the GDP in 2020 which places Slovenia below the OECD (0.12%) and the EU-27 average (0.098%) (OECD, 2023).

This paper aims to study whether R&D tax incentives promoted R&D activity in Slovenian private firms and whether this effect differs with the firms' size and age. By applying a quasi-experimental approach, the study confirms the positive effect of tax incentives, as a one percentage point increase in the R&D tax relief was associated with a 0.571 percentage point increase in firms' R&D expenditure. The effect was even higher among smaller and younger firms. Similar findings were reported also by some other studies. Among recent studies in the region, Ravšelj and Aristovnik (2020) for Slovenia and Taş and Erdil (2023) for Turkey also report of positive effect of tax reliefs on R&D expenditures and activity. Similarly, Amendola (2023) shows for the OECD countries that the input additionality of R&D tax reliefs is approximately 1.3, indicating that R&D tax reliefs are effective in stimulating R&D and are likely to be cost-effective.

This paper contributes to the literature in several important ways. First, it is one of the few studies to evaluate the impact of R&D tax incentives in Slovenia, a country largely absent from international analyses of innovation policy. The only comparable study, by Ravšelj and Aristovnik (2020), used a different methodological approach. Second, the analysis is based on rich administrative firm-level data, including financial records, tax relief claims, and official R&D survey data, allowing for a more comprehensive assessment of policy effects than is typically available. Third, the study applies a quasi-experimental difference-in-differences approach, exploiting regional variation in tax relief rates to identify causal impacts. This methodological design is novel in the context of post-transition economies. Finally, the study highlights firm-level differences in responsiveness, showing that small and younger firms benefit most from R&D tax reliefs. These findings provide valuable insights for designing more effective and better-targeted innovation policies, both in Slovenia and in similar Central and Eastern European countries.

The structure of the paper is as follows. The next section gives a literature review on the impact of R&D tax reliefs on R&D activity, followed by a description of the data and methodology in Section 3. Section 4 presents empirical findings and Section 5 provides discussion and concluding remarks.

2. LITERATURE REVIEW

Studies on the effects of tax incentives for R&D on firms' R&D activities can be divided into two groups. The first group of studies deals with the evaluation of the effects of tax incentives on firm investments in R&D – so-called input additionality. The second group of studies assesses the effect of tax incentives on the outcomes and results of funded R&D – so-called output additionality, evaluating innovation outcomes such as publications, patents, licenses, or new products, services, and processes. Our research is focused on the first group – the impact of tax reliefs on R&D activity.

Empirical studies evaluating the effects of tax incentives on R&D investments use two approaches, which differ in how the information about the tax incentive is introduced into the empirical model (CPB et al., 2015; Appelt et al., 2016; Petrin, 2018; Blandinières & Steinbrenner, 2021):

- Estimation based on the price elasticity of R&D investments in relation to the user cost of capital,[1] which can be defined as the "actual cost" of R&D at the firm level. These estimates are based on a structural model, where R&D investments are a function of various firm explanatory variables and the price index of R&D inputs or user cost of capital.[2]
- Incrementality ratio estimation, which measures the change in R&D investments per unit of forgone tax revenue spent as a fiscal incentive for R&D. These estimates use a direct approach, meaning that R&D investments are a function of a variable indicating the presence or strength of the R&D tax incentive, and the identification of the effect is based on a quasi-experimental approach using matching methods and difference-in-differences.

A detailed review of both approaches and the studies that use them, along with their methodological limitations, can be found in the European Commission's report A Study on R&D Tax Incentives (CPB et al., 2015).[3]

CPB et al. (2015) report that elasticity estimates in literature, using the structural approach range between –4.4 and –0.03, while more methodologically sound studies report elasticities between –0.6 and –0.1. The latter means that a 10% reduction in the firm's cost of capital for R&D at the expense of tax relief increases R&D expenditures by between 1 and 6% on average. Similarly, studies that use a direct approach show comparable results, though comparing the estimated effects between these studies is more difficult. A comparison of tax sensitivity rates, or BFTB (bang-for-the-buck), indicates that the estimated effects range from 0.15 to 3.5. This means that 1 euro of R&D tax incentives results in between 0.15 to 3.5 euros of additional investment in R&D.

Further meta-analyses also reflect these conclusions.[4] For instance, Parsons and Phillips (2007), based on research conducted between 1990 and 2006 in the US, Canada, and other OECD countries, estimate that a 10% reduction in R&D capital costs leads to a 10.9% increase in R&D investments. Castellacci and Lie (2015), through a meta-regression analysis of 34 studies published between 1993 and 2012, show that a 10% reduction in the cost of capital for R&D increases R&D investments by 2.3%, with input additionality at 0.03 (i.e., 1 euro of tax

[1] Price elasticity of R&D investments is defined as the percentage change in the volume of R&D investments due to a tax incentive for each percentage change in the user's cost of capital for R&D (Appelt et al., 2016).
[2] In addition to these estimates, some authors also provide an assessment of the degree of tax sensitivity or BFTB (bang-for-the-buck), which is defined as the firm's R&D expenditure attributable to the tax incentive policy relative to the amount of the tax incentive itself (Mohnen & Lokshin, 2010).
[3] A review of studies is also available in Appelt et al. (2016) and Petrin (2018).
[4] See also Cerulli and Potì (2012) and Hall and Van Reenen (2000).

incentive leads to 0.03 additional euros of R&D investments). Higher input additionality is reported by Köhler et al. (2012), who, based on a review of 20 econometric studies from 12 countries between 1970 and 2000, find that it ranges between 0.3 and 3. Ladinska et al. (2019) highlight that study estimates are often overinflated due to publication bias. After correcting this bias, they find that the effect of R&D tax incentives remains positive but smaller. Based on an analysis of 25 empirical studies (conducted up to 2014), the authors show that a 10% reduction in the user's cost of capital increases the capital stock for R&D by 1.3%, the flow of R&D expenditures by 2.1%, and the mere presence of the tax incentive boosts R&D spending by 7%.

The findings of empirical studies on the effects of tax incentives on R&D investments suggest that, while there is no consensus on the magnitude of the effect, those studies that better control econometric issues such as endogeneity and selection effects show that the input additionality estimate is generally below one. This means that one euro of lost tax revenue leads to slightly less than one euro of additional private investment in R&D (see, for example, Lokshin & Mohnen, 2012; Mulkay & Mairesse, 2013). As a result, a country aiming to increase total R&D spending by 1% of gross domestic product (GDP) must spend at least an equivalent amount on tax incentives (Gaillard & Straathof, 2015; CPB et al., 2015).

Empirical studies show that the effects of R&D tax incentives are larger in the long run than in the short run. This can be attributed to adjustment costs, such as hiring new scientists and engineers (CPB et al., 2015).

R&D tax incentives also act as a stimulus for firms to initiate R&D activities. Ernst and Spengel (2011), using a sample of European firms from 1998–2007, demonstrated that the presence of R&D tax incentives increases the likelihood that firms will start investing in R&D, with this probability being higher for smaller firms. Similar findings were reported by Bozio et al. (2015) for France. Caiumi (2011) showed that the presence of tax incentives increased the likelihood of R&D investments in medium-sized firms, start-ups, and indebted firms in Italy.

The effects of R&D tax incentives vary depending on firm characteristics. Most empirical studies indicate that smaller firms benefit more from these incentives. Lokshin and Mohnen (2012), analysing Dutch firms, found that, on average, a 10% reduction in the cost of capital for R&D through tax incentives increases short-term R&D investments by 5.7% in small firms (up to 200 employees) but only by 1.5% in large firms. In the long term, these elasticities increase to 11% for small firms and 2.5% for large firms. The greater sensitivity of small firms to tax incentives can be attributed to their higher likelihood of debt, whereas large firms view tax relief as a bonus and do not let differences in tax incentives significantly affect their R&D investments. Similar findings are reported by Bloom et al. (2002) for OECD countries, Dumont (2019) for Belgium, Baghana and Mohnen (2009) and Agrawal et al. (2020) for Canada, and Kasahara et al. (2014) and Yohei (2011) for Japan. However, contrary results are reported by Busom et al. (2014) for Spain and Cerulli and Potì (2012) for Italy. These opposing

findings may partly be explained by the fact that small firms in Spain and Italy are less likely to claim tax incentives (CPB et al., 2015).

Tax incentives particularly encourage R&D in young firms. Cornet and Vroomen (2005) show that the introduction of more generous tax treatment for start-up firms in the Netherlands led to additional labour costs of between 50-to-80-euro cents, which was significantly higher than in medium-sized and large firms (10-to-20-euro cents). Similarly, Dechezleprêtre et al. (2023) find in the UK that R&D expenditures due to tax incentives increased by a factor of 2.4 in young firms, compared to 1.9 in older firms.

The effects of tax incentives for R&D vary across industries. Castellacci and Lie (2015), based on a meta-regression analysis, shows that the effects of tax incentives are smaller in high-tech industries, but this result should be interpreted with caution as it is based on a small number of observations. Freitas et al. (2017) analyse how the effects of tax incentives for R&D differ among industries with different investment orientations and competitive conditions. The results of their analysis, based on firm-level data collected from the Innovation Surveys of 2004, 2006, and 2008 in Norway, Italy, and France, indicate that firms in industries with high R&D intensity generally experience stronger effects of tax incentives on R&D investments compared to firms in industries with lower R&D intensity. Furthermore, the authors find that firms operating in more concentrated markets tend to be more inclined to claim R&D tax incentives and experience stronger effects on additional input. These findings were statistically significant only for France.

There is a lack of empirical evidence on the effectiveness of tax incentives for R&D in Slovenia. Ravšelj and Aristovnik (2020) showed that public support for R&D investment plays an important role in firms' R&D expenditures. R&D subsidies are generally ineffective when are not used in combination with R&D tax incentives and received by firms that are growing. But R&D tax incentives are always effective when firms have a sufficient tax base.

3. METHODOLOGY AND DATA

3.1. Data

The paper uses administrative firm-level data for all registered legal entities in Slovenia for the period 2007 – 2017. The following databases were used:

- Firms' financial statements, including detailed data from the balance sheets and income statements. The source of the data is the Agency of the Republic of Slovenia for Public Legal Records and Related Services (hereinafter AJPES).
- Business Register of Slovenia: the database contains data on the date of establishment, changes, and termination of firms, as well as information on the characteristics of firms, such as legal-organizational structure, ownership structure, region, activity, etc. The source of the data is AJPES.

Firm-level data on R&D tax reliefs, obtained from firms' income tax returns. The source of the data is the Financial Administration of the Republic of Slovenia.

To the above data, we have added firm-level survey data collected by the Slovenian Statistical Office, which include data on staff in the R&D and on financial resources for the R&D.

All the above datasets were merged into a single database via a hidden identification number. Due to statistical confidentiality issues, microdata access, preparation and empirical analyses took place in the secure room at the Slovenia Statistical Office, by which all information to be exported from the room were subjected to a thorough review.

3.2. Methodology

The empirical analysis was divided in two parts. First, using the datasets of firms' accounting and financial data and data on R&D tax relief, we analyse the dynamics and state of claiming tax relief for R&D, with a focus not only on the scope of tax relief but also on the characteristics of firms claiming the tax relief. These characteristics include legal form, capital origin, ownership, activity, firm size, and their business performance. The analysis was performed on the entire population of firms that were eligible for R&D tax reliefs throughout the studied period, ranging to 740 firms in 2015 (only legal entities included).

Second, we study the effect of R&D tax relief on R&D activity in Slovenian firms. The assessment of tax relief impacts on R&D is based on the assessment of the incremental rate, which measures the change in the R&D expenditures per monetary unit of the loss of tax revenues that are used as a fiscal stimulus for the R&D. We therefore use a direct approach, where R&D investments are a function of a variable indicating the amount of the R&D tax relief. The identification of the effect is based on a quasi-experimental approach and the use of the difference-in-differences method.

In order to be able to exclude the effect of concurrent factors that could influence the amount of the R&D investments – especially those related to economic growth – we use the fact that the amount of tax relief for the R&D in Slovenia in the period from 2006 to 2011 varied depending on the region, and we identify the effect based on differences in the R&D investment rates between regions. In the most developed regions of the country, the tax relief for R&D was 20% from 2006 to 2010, 40% in 2010 and 2011, and 100% from 2012 onwards. In regions that had a gross domestic product per capita lower than the national average by up to 15%, the tax relief for R&D was 30% from 2006 to 2010, 50% in 2010 and 2011, and 100% from 2012 onwards. In all other statistical regions, the tax relief for R&D was 40% from 2006 to 2010, 60% in 2010 and 2011, and 100% from 2012 onwards. The total number of firms included in the analysis was 1,114.

We estimate the following regression equation:

$$\ln(RD_{i,t}) = \alpha_0 + \alpha_1 \ln(k_{i,t}) + \alpha_2 \ln(l_{i,t}) + \alpha_3 \ln(y_{i,t}) + \sum_{t=2006}^{2012} \alpha_t I_t + \boldsymbol{\tau}^{+}_{r,t-1} \mathrm{T}^{+}_{r,t-1} + \boldsymbol{\tau}_{r,t-1} \mathrm{T}_{r,t-1} + u_{i,t} \quad (1)$$

where $RD_{i,t}$ denotes the total R&D expenditure of firm i in year t; $k_{i,t}$ the firm's capital; $l_{i,t}$ the number of employees; $y_{i,t}$ the firm's revenue; αt the annual binary variables; $T_{r,t-1}$ the applicable tax relief rate in the most developed regions (in percentage points) in the previous year; and $T_{r,t-1}$ the additional tax relief in the other regions in the previous year. The previous year is used to account for the possible delay in the planning of R&D expenditures in individual firms. We therefore assume that firms cannot respond to a higher tax relief immediately.

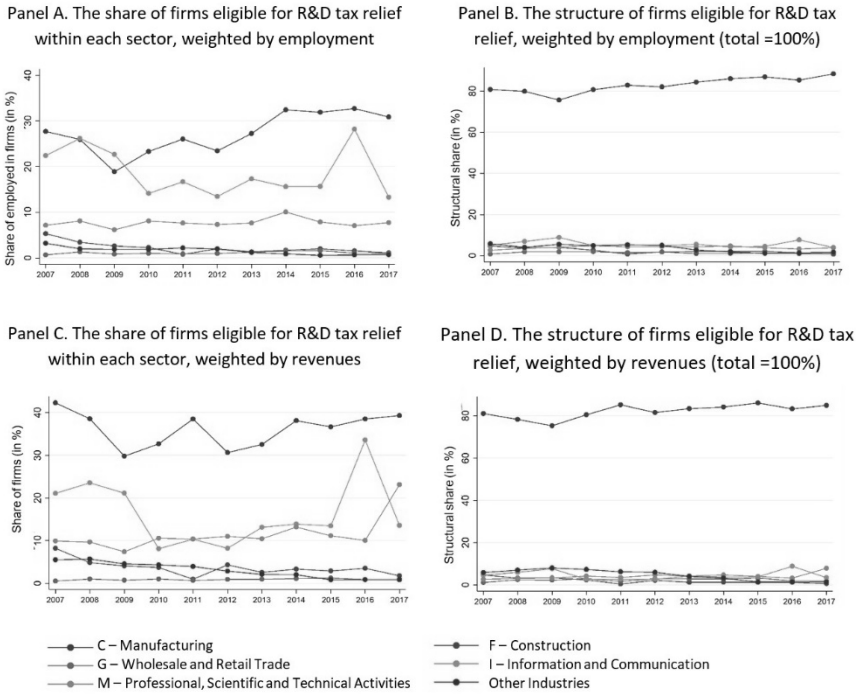
4. RESULTS

4.1. Overview of Tax Reliefs for R&D in Slovenia

Slovenia introduced R&D tax incentives in 2006. Initially, the tax relief amounted to 20%, or up to 40% for firms operating in less developed regions of the country (see Section 3.2). The rate has increased over the years, reaching 100% of the amount invested in R&D activities in 2012. It has remained the same since then. In 2009, R&D tax relief was claimed by 518 firms for a total of 58 million euro. This amount doubled by 2012 and increased steadily until 2015, when the total R&D tax relief amounted to 271 million euro, claimed by 757 firms. In the following three years, the total amount of tax relief slowly decreased, reaching 239 million euro in 2018 (FURS, 2021). In 2020, tax reliefs for R&D represented only 0.08% of Slovenian GDP, which is far below the OECD average (0.12%) and the EU-27 average (0.098%) (OECD, 2023).

An analysis of the characteristics of the firms claiming the R&D tax relief shows that the tax relief was mainly used by domestic firms, although there has been a trend in recent years towards an increasing structural share of foreign-owned firms. In addition, privately owned, large and predominantly export-oriented firms dominate among those claiming R&D tax reliefs. In the overall structure of firms claiming tax relief by industry, nearly 90% belong to the manufacturing (C) sector (Figure 1, panels B and D). Within this sector, almost one-third of all employees work in firms claiming tax relief (Figure 1, panel A), and these firms generate around 40% of all revenues within the sector (Figure 1, panel C). A high share of employees in firms claiming tax relief (Figure 1, panel A) is also recorded within the information and communication (I) sector (13.3% in 2017) and in the professional, scientific, and technical activities (M) sector (7.7% in 2017). From the perspective of sales revenue (Figure 1, panel C), firms that claimed tax relief in 2017 generated 13.6% of all sales revenue within the information and communication sector and 23.1% of all sales revenue within the professional, scientific, and technical activities sector.

Figure 1 Firms entitled to R&D tax relief by industry, 2007–2017



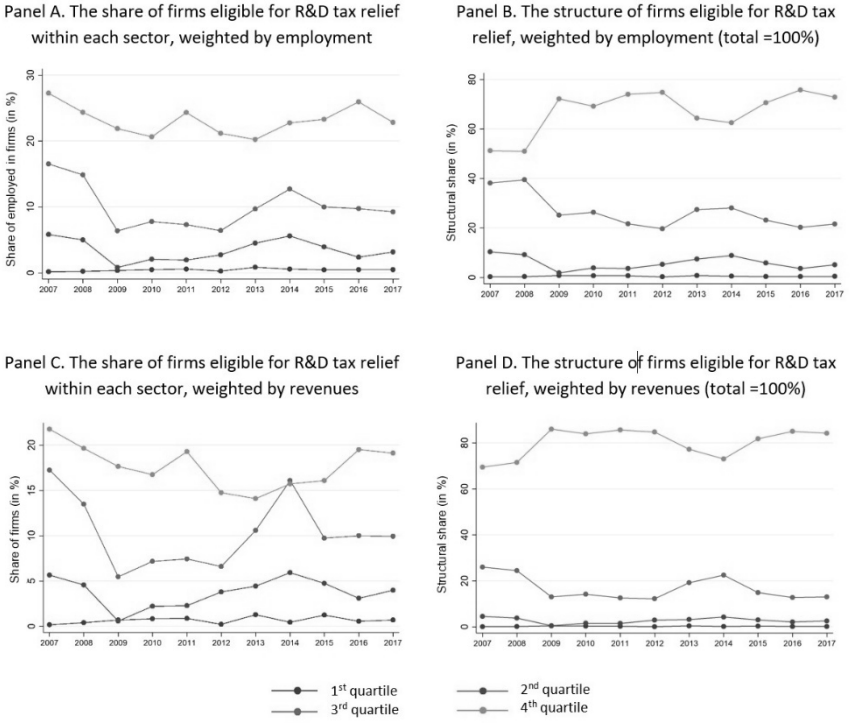
Source: own calculations based on microdata.

Tax relief is more often claimed by firms that, based on profitability indicators, rank in the upper half and by highly productive firms. Figure 2 illustrates the distribution of firms into quartiles based on real added value per employee during the studied period, weighted by the number of employees. More productive firms are more likely to claim R&D tax relief. As shown in panel A of Figure 2, in 2017, firms that utilized tax relief employed 27.2% of all employees in firms within the 4th quartile (this share exceeded 20% throughout the entire observed period). In the next, 3rd quartile, the share of employees in firms claiming tax relief was nearly half as much. In firms classified in the lowest, 1st quartile, based on real added value per employee, the share of employees in firms claiming tax relief was less than 1%.

Similar trends are observed when the share of firms is weighted by sales revenue (panel C of Figure 2). Highly productive firms also hold the majority share in the overall structure of tax relief recipients. In 2017, firms in the 4th quartile based on added value per employee accounted for a 72.8% share (weighted by the number of employees) of the total structure of firms claiming tax relief that year (panel B of Figure 2). This share is even higher when weighted by sales revenue, reaching 84.3% in 2017 (panel D). Firms in the 3rd quartile follow, with a share of 21.6% (weighted by the number of employees) or 13% (weighted by sales revenue) in the total structure in 2017.

Compared to 2007, their share decreased by 16.6 percentage points (weighted by the number of employees) or by 13 percentage points (weighted by sales revenue).

Figure 2 Value added per employee in firms entitled to R&D tax relief, 2007 – 2017



Note: The quartiles are determined based on the distribution of real added value per employee during the studied period, weighted by the number of employees. The first quartile includes companies with an added value of less than 16.9 thousand EUR per employee; the second quartile includes companies with an added value between 16.9 and 25.2 thousand EUR per employee; the third quartile includes companies with an added value between 25.2 and 37.5 thousand EUR per employee; and the fourth quartile includes companies with more than 37.5 thousand EUR per employee.

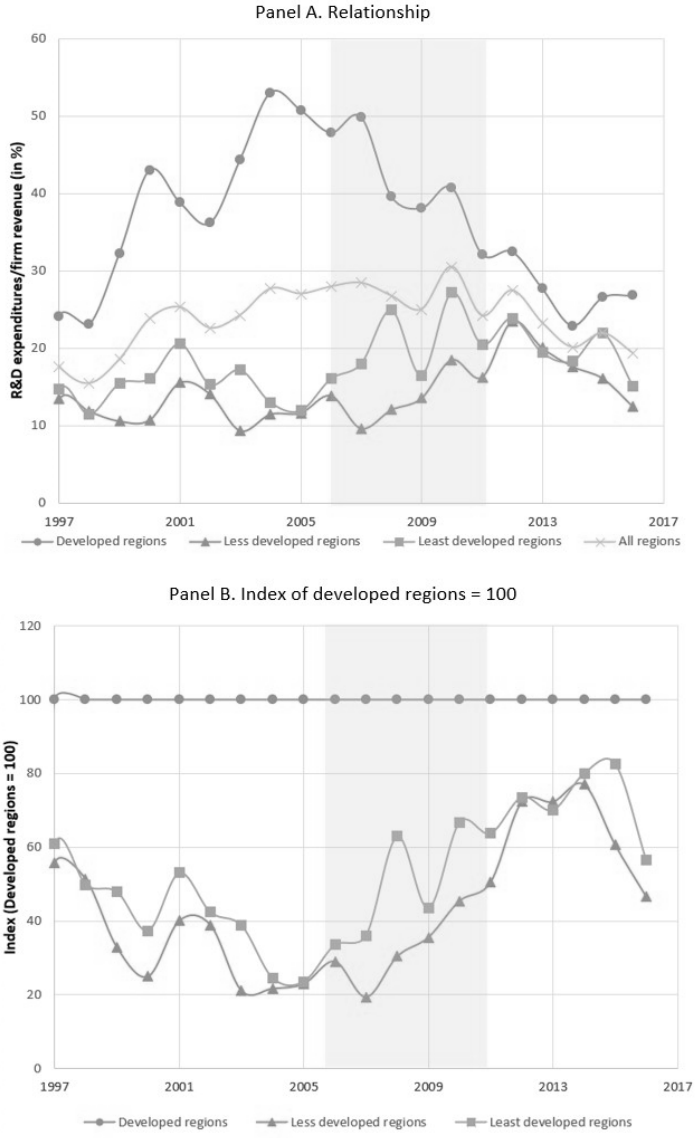
Source: own calculations based on microdata.

4.2. REGRESSION RESULTS

Figure 3 shows the development of R&D expenditure expressed as a share of firm's revenue. In the most developed regions, this share reached its peak in 2004 and then declined. In the remaining regions, in the middle of the studied period, expenditures lagged significantly behind the most developed regions, but the difference decreased significantly in the period following the introduction of regional tax reliefs. The relative decrease in less developed regions can be seen more clearly in panel B, which shows that towards the end of the period,

expenditure in less developed regions was up to 83% of the average in developed regions. To what extent can reduction of this gap be attributed to tax relief?

Figure 3 Value added per employee in firms entitled to R&D tax relief, 2007 – 2017



Note: The shaded areas of the graph indicate the period when special regional reliefs were in force.

Source: own calculations based on microdata.

As Table 1 shows, in the basic specification, we find that raising the tax relief for R&D by one percentage point increases investments in R&D by 0.571 percentage points (coefficient τ^{+}_{t-1} in the first column of Table 1). The estimated elasticity is statistically significant and implies that 1 euro of tax relief corresponds to almost 0.60 euro of additional R&D spending. Results in this specification, are based on data for all firms for which data on investments in R&D is available in the period from 2006-2013 (that is, in the period in which it is possible to use the difference-in-differences method, considering the investment deferral).

In the remaining specifications (columns [2] to [5] of Table 1), firms are divided based on age and the average number of employees in the studied period. It turns out that R&D tax reliefs have an impact mainly in younger and smaller firms. In both groups, the estimated elasticity of R&D investment with respect to the tax relief equals 1.0, indicating a one-to-one relationship. Both coefficients are statistically significant, at 10% significance level in the case of the coefficient for younger firms, and at 5% significance level in the case of the coefficient for smaller firms. On the other hand, elasticities are statistically insignificant for older and larger firms.

Table 1 Impact of tax reliefs on R&D expenditure in Slovenian firms

Dependent variable: *ln(total R&D expenditure*)	**Basic specification**	**Firm's age**		**Average number of employees**	
		≤10 years	**>10years**	**<50**	**≥50**
	[1]	**[2]**	**[3]**	**[4]**	**[5]**
Tax relief					
τ_{t-1}	-0.0174	-0.107	-0.0363	-0.146*	0.021
	(0.052)	(0.145)	(0.0587)	(0.0866)	(0.0665)
τ^{+}_{t-1}	0.571**	1.00*	0.333	1.00**	0.127
	(0.288)	(0.588)	(0.337)	(0.429)	(0.401)
Control variables					
ln(revenues)	0.273***	0.313***	0.266***	0.204***	0.453***
	(0.034)	(0.0554)	(0.0437)	(0.0409)	(0.0673)
ln(number of employees)	0.246***	0.236***	0.238***	0.350***	0.149**
	(0.0415)	(0.0711)	(0.0531)	(0.06)	(0.0603)
ln(capital)	0.116***	0.0385	0.163***	0.125***	0.075
	(0.0223)	(0.0343)	(0.0304)	(0.0257)	(0.0506)
Annual binary variables					
2006	0.0226	0.0307	0.0257	-0.0245	0.0387
	(0.0552)	(0.13)	(0.0613)	(0.0958)	(0.0661)
2007	-0.081	0.0751	-0.111*	-0.0914	-0.0674
	(0.0549)	(0.125)	(0.0618)	(0.0881)	(0.0715)
2008	0.0369	0.0999	0.0298	0.0159	0.0364
	(0.052)	(0.121)	(0.0592)	(0.0805)	(0.0698)
2009	0.157***	0.194	0.156***	0.104	0.203***
	(0.051)	(0.122)	(0.0574)	(0.0797)	(0.0676)
2010	0.170***	0.137	0.186***	0.0351	0.262***
	(0.0512)	(0.123)	(0.058)	(0.0792)	(0.0688)
2011	0.108**	0.1	0.110**	0.0142	0.160**
	(0.045)	(0.103)	(0.0517)	(0.0664)	(0.0639)
2012	-0.000297	-0.0539	0.00672	-0.0997	0.0564
	(0.0448)	(0.105)	(0.0513)	(0.0661)	(0.0641)
Constant	5.559***	6.580***	4.829***	6.746***	3.127***
	(0.497)	(0.761)	(0.666)	(0.537)	(1.125)
Number of observations	3,953	1,035	2,918	2,060	1,893
Number of firms	1,114	431	755	717	397
R^2	0.106	0.152	0.093	0.134	0.093

Note: τ_{t-1} reflects the applicable tax relief for firms in developed regions in the previous year, expressed in percentage points. τ^{+}_{t-1} reflects the additional tax relief for firms outside the developed regions in the previous year, expressed in percentage points (it takes the value of 0 for firms in developed regions). The value of tangible fixed assets is used for the capital amount; the number of employees is calculated based on the total annual number of working hours. The calculations use the period from 2006 to 2013. All regressions use the firm-level fixed effects method. Standard error in parentheses.

***p<0.01, ** p<0.05, * p<0.1

Source: own calculation based on the microdata.

The results imply that R&D tax incentives are effective in promoting R&D activity, especially among smaller and younger firms. This finding is consistent with Ravšelj and Aristovnik (2020) for Slovenia and by other cross-country studies (Lokshin & Mohnen 2012; Hall & Reenen 2000; Appelt at al., 2016; Sterlacchini & Venturini, 2019). The comparison of the size of the effect between the studies is however not straightforward, as studies largely differ in methodological approach and often rely on cross-country analysis.

5. DISCUSSION

R&D tax incentives have been recognized in literature and in policymaking as an effective tool to stimulate R&D activity. Governments around the world use these incentives to encourage businesses to invest in R&D which brings several economic and societal benefits. It is proved that tax incentives are linked to increased productivity through the development of new products, processes and technologies (see Petrin 2018 for an overview of studies). Higher productive firms contribute more to overall economic growth, competitiveness, welfare and sustainability (Appelt et al., 2016; European Commission, 2024). R&D tax incentives are important for fostering innovation, also in the fields or with ideas that might otherwise be seen as too risky (OECD, 2019) and have important spillover effects also to other sector of economy (European Commission, 2020). Relatedly, R&D tax reliefs stimulate the creation of jobs. For example, Hallépée and Garcia (2012) establish that the introduction of a tax relief for R&D in France increased employment in the examined companies by 8.4 percentage points and contributed to higher wages. Importantly, R&D tax reliefs indirectly also improve well-being and foster societal welfare, as they bring several advancements that improve quality of life and address societal challenges (Castellacci, 2022).

This study confirms the effectiveness of R&D on promoting R&D activity in Slovenia. The difference-in-differences estimate of the tax price elasticity is 0.57. In other words, in the short run a one euro of tax reliefs results in 57 cents of additional tax expenditure. With this estimate, Slovenia place roughly in the middle compared to the estimates for other countries, which – despite the large ranges in the estimates – largely find the elasticity to be somewhere below 1 (see Petrin 2018 for an overview of studies).

The results also suggest that tax reliefs encourage R&D especially in small or young firms. In both cases, the estimated elasticity of the effect of tax reliefs was one, indicating that one euro of tax reliefs results in equal amount of additional tax expenditure. In the remaining firms, i.e., older and larger firms, this relationship is much weaker – according to our calculations, although it is positive, it is statistically insignificant. These findings are in line with other research that indicates that tax incentives often produce relatively larger additional R&D in smaller or younger companies, whereas large, R&D-intensive firms tend to exhibit a much weaker incremental response (Mitchell et al., 2020: Appelt et al., 2025). This pattern suggests potential gains from better targeting tax incentives toward

small and young firms, who are more likely to be financially constrained in their innovation activities (Jusufi et al., 2022). Based on these findings, policymakers should consider more precisely targeting R&D tax incentives toward small and younger firms, which appear most responsive to such support. By refining the design of tax reliefs to better reach these firms, Slovenia could improve the efficiency of public spending, ensuring that forgone tax revenues translate into higher additionality. This approach would not only enhance the return on fiscal investment but also foster innovation-driven growth and long-term competitiveness in the Slovenian economy.

It is important to acknowledge that the results are context-specific, reflecting Slovenia's institutional setting, tax relief design, broader innovation ecosystem, and economic conditions. Given cross-country differences, the complete generalizability of the quantitative estimates to other countries is limited (Mršić Radas and Petković, 2021). Even within Slovenia, unobserved regional factors could be influencing the effectiveness of R&D incentives. For instance, differences in local innovation capacity (for example, the presence of technology clusters or universities) and regional economic conditions might cause firms in some regions to respond more vigorously to tax incentives than others, an effect not fully captured in our analysis. Evidence from Croatia underscores the importance of such spatial heterogeneity: in Croatia, smaller cities significantly lag behind larger ones in "smart economy" indicators – including the density of ICT and R&D activity – which correlates with weaker innovation performance in those cities (Babić et al., 2022). Regional disparities suggest that the effectiveness of R&D policy may vary within countries. While our analysis controls for observable differences, we acknowledge the possibility of unobserved regional factors that could influence R&D investment trends. Although unlikely to substantially bias the results, these factors may contribute to variation in firm responses, underscoring the context-specific nature of our findings.

6. CONCLUDING REMARKS AND POLICY CONSIDERATIONS

This paper examined the impact of R&D tax incentives on firm-level R&D investment in Slovenia, with a focus on differences by firm size and age. Using a quasi-experimental design and administrative microdata, the analysis provides new evidence on the effectiveness of these incentives in a post-transition context.

The findings indicate a positive effect of R&D tax reliefs on R&D expenditures, with particularly strong impacts observed among small and younger firms. This suggest that by tailoring R&D tax reliefs to the needs of young SMEs, policymakers could enhance the additionality of private R&D investment. This recommendation aligns with remaining evidence that generic R&D tax incentives have at least as strong an effect on young firms as on established ones and that large firms, despite claiming the bulk of tax benefits, generate comparatively less new

R&D per tax euro (Mitchell et al., 2020; Appelt et al., 2016, 2025, European Commission, 2024). Encouraging R&D in smaller, high-growth-potential companies can thus yield substantial innovation outcomes.

Despite nearly two decades of implementation, the uptake of R&D tax reliefs in Slovenia remains relatively limited, with only 757 legal entities claiming the relief in 2015. A key barrier appears to be the complex and demanding administrative procedures, which require firms to provide extensive documentation and prove that their R&D activities meet strict eligibility and innovation criteria. These burdens may particularly discourage smaller and younger firms, which often lack the capacity or resources to navigate such requirements. Given the strong responsiveness of these firms to R&D incentives, as shown in this study, streamlining the application process and reducing administrative hurdles could significantly increase participation and policy effectiveness. A targeted review and simplification of the current procedures would not only improve access but also enhance the overall efficiency and impact of the R&D tax relief system.

This study provides new empirical evidence on the effectiveness of R&D tax incentives in a post-transition economy, using comprehensive administrative firm-level data that covers the entire population of firms engaged in R&D activities in Slovenia. By applying a quasi-experimental difference-in-differences approach, the paper offers a robust causal estimate of the policy's impact. Its contribution is threefold. First, it addresses a notable gap in the literature by focusing on Slovenia – a country rarely examined in comparative analyses of innovation policy – while offering insights that are relevant to other Central and Eastern European countries with similar trajectories in R&D policy development. Second, the estimated effect suggests substantial input additionality, supporting the view that R&D tax incentives can serve as a cost-effective instrument for fostering innovation-driven growth in transition economies. Third, the analysis reveals considerable firm-level heterogeneity, showing that small and younger firms are particularly responsive to fiscal incentives. These findings are especially salient in light of recent studies highlighting the importance of more targeted, evidence-based innovation support in smaller economies and for SMEs (e.g., Kacprzyk & Doryń, 2017; Mršić Radas & Petković, 2021). By identifying which firms benefit most from tax incentives, the study contributes valuable insights for designing more inclusive and effective innovation policies aimed at strengthening private sector R&D and addressing structural productivity gaps.

Finally, while this study focuses on input additionality, an important open question remains the extent to which R&D tax incentives generate output additionality. Future research should therefore explore whether the additional R&D investment induced by tax relief translates into tangible innovation outcomes such as new patents, products, or measurable productivity gains. Although existing studies suggest that generic R&D tax incentives often have limited direct effects on specific innovation outputs, they may nonetheless contribute to broader performance improvements, including increases in turnover, labour productivity, and employment (Mitchell et al., 2020). A deeper understanding of output additionality would complement the present findings on R&D expenditure and

enable a more comprehensive assessment of the long-term impact of R&D tax incentives on innovation performance and economic growth.

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UČINCI POREZNIH OLAKŠICA NA ISTRAŽIVANJE I RAZVOJ U SLOVENIJI

Sažetak

Ovaj rad analizira učinak poreznih poticaja na izdatke za istraživanje i razvoj (I&R) u slovenskim poduzećima, s naglaskom na razlike u učinku s obzirom na veličinu i starost poduzeća. S obzirom na nedostatak empirijskih istraživanja o učinkovitosti tih poticaja u Sloveniji te korištenje administrativnim podacima na razini poduzeća i inovativnog pristupa, ovo istraživanje predstavlja važan doprinos znanstvenoj literaturi. Učinkovitost poreznih poticaja za I&R ocjenjuje se primjenom izravnog pristupa. Učinak se identificira korištenjem kvazieksperimentalnom metodom, konkretno, metodom razlika-u-razlikama. Kako bi se isključio utjecaj istodobnih čimbenika koji bi mogli utjecati na razinu izdataka za I&R na razini poduzeća, rad se koristi varijacijama u regionalnim stopama poreznih olakšica. Rezultati pokazuju da je povećanje porezne olakšice za jedan postotni bod povezano s povećanjem izdataka za I&R od 0,571 postotnog boda. Učinak je bio izraženiji kod manjih i mlađih poduzeća.

Ključne riječi: istraživanje i razvoj, porezne olakšice, porezni poticaji, procjena politike, Slovenija.

JEL klasifikacija: H25, O32, O38.