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Determinants of corporate R&D expenditures: the role of taxes

Abstract

The paper aims to find the relationship between corporate expenditures on R&D and tax burdens comparing German with French R&D incentives. We use the OLS method for the financial and patent cross-sectional data retrieved from the Amadeus database. The results confirm that firms with higher tax spread (the difference between the nominal and effective tax rates) spend less on R&D. These are in line with findings of a positive relationship between corporate R&D investment and tax burdens. Thus, firms that invest in R&D more pay higher taxes. However, they are less profitable as the return on R&D investment is visible only in the long run. German corporate expenditures on R&D are significantly sensitive to internal funds (proxied by cash flow) and depend on debt, contrary to French. The results indicate that the French firm's age (a phase of life cycle) has a significant impact on spending on R&D compared to German. Whereas in both countries, corporate expenditures on R&D are sensitive to the number of obtained patents. The capability of reducing the level of tax burdens below the nominal tax rate in the case of older German firms stimulates them to increase their R&D expenditures. However, German firms can decrease tax due to the use of R&D grants (revenues without taxation) in the absence of other tax incentives related to R&D.

Keywords

R&D | tax incentives | patents | Germany | France

JEL Codes

O30, D22, H20

1 Introduction

This paper aims to find the relationship between corporate expenditures on R&D and tax burdens, comparing German with the French R&D incentive system. Both Germany and France have made significant efforts to encourage firms to increase corporate R&D expenditure by improving the conditions for R&D investment. These countries spend annually ca. 2–3% of the national gross domestic product on R&D activities, but using different incentives. France focuses on the R&D tax credit, tax benefits and reduced CIT tax rate applicable to revenues derived from patents. In contrast, Germany concentrates on non-refundable cash R&D grants available for R&D projects in specific thematic areas (EY, 2017).

Besides the usage of well-known determinants of corporate expenditures on R&D as control variables, we contribute to the existing literature (i.e. Shao & Xiao, 2019; Freitas et al., 2017; Jia & Ma, 2017; Chen & Gupta, 2017; Yang, Huang, & Hou, 2012) by a focus on their dependency on the level of income-tax burdens (lower due to reduced tax rates, tax benefits or untaxable revenue from R&D grants). In this study, we compare German with the French R&D incentives system to answer the research question, whether the support for corporate R&D activity, different in German and France, stimulates corporate spending on R&D at the expense of tax burden on a firm level. The topic undertaken in our study is of policymakers' and R&D project's managers' interests as the European Union (EU) bases innovation policy on fiscal incentives. R&D incentives are necessary to continuously enhance the innovation in the economy through increasing the R&D expenditures. Moreover, increasing R&D expenditures is one of the most important objectives of the Europe 2020 strategy. The EU aims to achieve R&D expenditures at the level of 3% of GDP. Private spending on R&D is a crucial factor for increasing innovation in the economy. Each member state, as well as the EU as a whole, needs to support

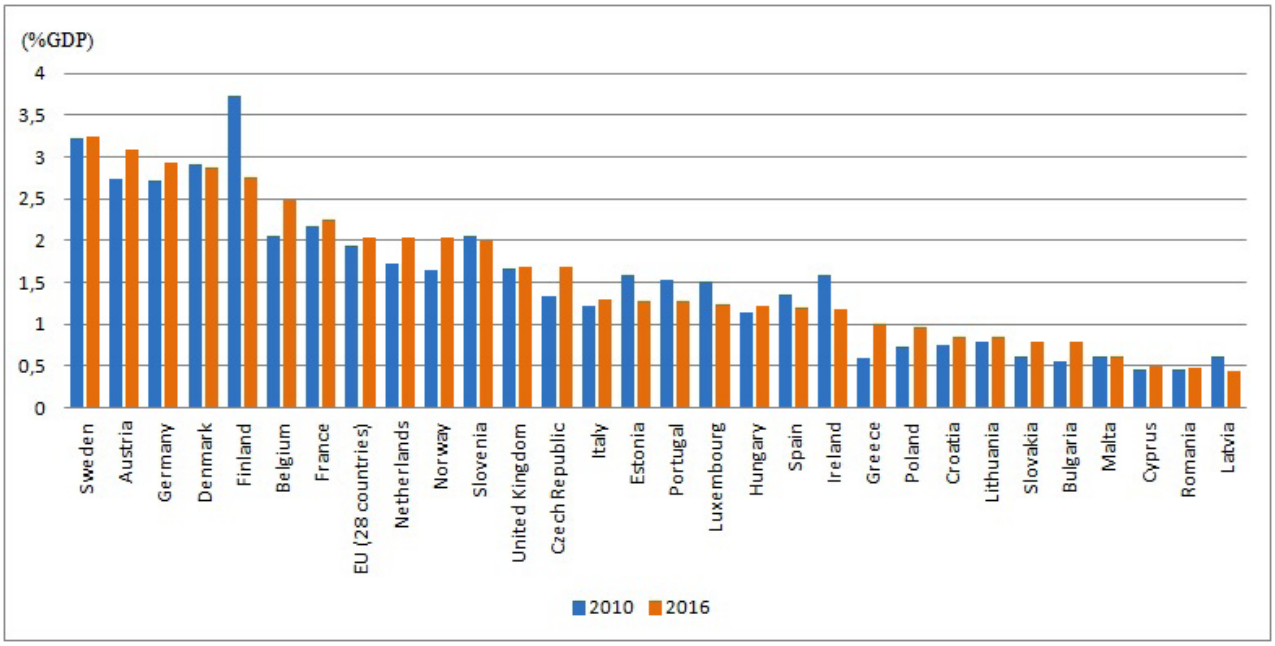

Fig. 1. R&D expenditure by country (% GDP). Source: own elaboration based on Eurostat data.

enterprises effectively in R&D activity to achieve this goal. Moreover, an appropriate choice of fiscal policy is of high importance for the effective stimulation of innovation and R&D expenditures.

Our study is conducted based on cross-sectional data on German and French enterprises from the Amadeus database, with the use of the ordinary least squares (OLS) method. The differences in their innovation policy dictated the choice of these particular countries. Germany and France are both highly ranked in terms of innovation progress. However, they achieve this differently: France by cutting the income taxes, whereas Germany via a focus on non-refundable grants and subsidies. The analysis consists of three models: the first model is estimated using the data on German companies; the second model bases on data of both German and French companies; and the third model contains observations from France. The logarithm of the size of corporate R&D expenditures is the dependent variable in all three models. The impact of tax spread (the difference between the nominal and effective tax rates), tax burdens (a share of paid, due and deferred taxes in total operating revenue), cash flow (internal funds), debt, profitability and company's age (a phase of life cycle) are among main determinants of the corporate R&D expenditures in our study.

This paper is structured as follows. In Section 2, we present the R&D incentive systems supporting innovation in the EU, followed by a comparison of both countries considered in the analysis, i.e., Germany and France, in Section 3. Section 4 reviews the literature and formulates the research hypotheses. Section 5 describes the research design, sample, followed by definitions of variables. In Section 6, we present and interpret our findings. Finally, we conclude in the last part.

2 R&D incentive systems supporting innovativeness of the EU

Without the appropriate engagement from the member states, the achievement of R&D expenditures at the level of 3% of the EU's GDP would not be possible. The Europe 2020 strategy, although it has not changed the priority in comparison with that of Lisbon, changed the way of its implementation. It is essential that, now, each country has its goal set to achieve. Moreover, member states are subject to stricter control, and they are obliged to present their National Reform Programmes and policies, which would enable the completion of particular tasks. However, actions aimed at increasing the private investment in R&D are the most important. Different tax incentives are implemented, such as the ones enabling the reduction

of tax, increase of tax-deductible costs (tax reliefs), or systems of direct government subsidies and cash non-refundable grants. In effect, R&D expenditures have risen to 2.03% of GDP in the EU since the implementation of the Europe 2020 strategy. However, it is still far from the achievement of the goal set in 2010. Belgium is the country with the highest growth (by 0.44 pp.) of R&D expenditures between 2010 and 2016. On the other hand, Finland had the most significant decline of almost 1 pp within that period. Sweden is the EU leader in terms of the size of R&D expenditures in 2016, despite only a slight increase since 2010 (KPMG, 2017). Germany is the closest to achieving the goal set by the EU (Figure 1).

R&D activity is an essential factor for the development of innovation, which leads to economic growth. Due to the enhanced change, e.g., through developing new inventions and implementing them to obtain financial benefits and satisfy social needs, enterprises boost their competitiveness (Schumpeter, 1960). They can generate considerable profits but in the long run. However, because R&D activity holds a substantial risk (Schumpeter, 1960), enterprises count on the support from the government. Public support encourages firms to start risky research and enables them to reduce the costs of current R&D projects, as well as future ones. Therefore countries should support private investments in R&D. For this purpose, they can use various instruments, including direct support in the form of cash grants and subsidies, or indirect support, such as tax reliefs enabling the reduction of tax burdens (Kargol-Wasiluk & Wyszkowski, 2016).

However, the innovation policy should be adapted to the actual economic situation in a particular country. Different solutions would produce the desired effect in different countries. The most popular tool in terms of enhancing innovation are systems of tax incentives (European Commission, 2014). Nevertheless, the direct instruments have a broad scope of application as well. Namely, grants enable direct financing in industries having a critical strategic role in the economy, such as defence or healthcare, and lead to achieve goals set by the government. One of the flaws in such a type of R&D financing is a way of selecting projects to fund by grants. But it takes time and often does not favour the best projects.

On the other hand, a broader scope of recipients can benefit from tax reliefs. Often, they enable a considerable reduction in enterprises' current liabilities and increase internal funds (cash flow). The downside of tax relief is often complex construction. Additionally, the government does not have full control regarding which industries would exhibit the highest growth due to this type of support. Therefore, the government cannot conduct R&D activity effectively in areas with the most extensive social benefits (OECD, 2014). The results from numerous studies indicate the positive impact of both types of mentioned instruments on the increase in R&D expenditures, both public and private. Often, both solutions complement each other within the policy of a given country. More and more countries develop the innovation policy in this regard, and the interest in fiscal instruments supporting R&D activity increases. Indirect expenditures are of vital importance within tax systems as well (Kargol-Wasiluk & Wyszkowski, 2016). Undoubtedly, it results from the fact that without incurring R&D expenditures, it is impossible to develop a strong and innovative economy.

3 R&D incentive systems applied in Germany and France

We choose German and French enterprises for the comparative study based on the following reasons. First, Germany has the highest GDP in Europe. Additionally, both Germany and France are considered as the most innovative countries in Europe. According to the *Summary Innovation Index*, Germany was placed sixth in 2016 in Europe with a score of 0.609, considerably higher than the EU average. Moreover, the German government is very effective in implementing the goal of 3% of GDP dedicated to innovation concerning the Europe 2020 strategy. Corporate expenditures on R&D have increased by 0.23 pp since the implementation of the Europe 2020 strategy. As a result, the goal has been almost achieved (Figure 1). It is necessary to mention the high level of the indicator concerning the private expenditures of companies on R&D (1.95% of GDP). This indicator reflects the high importance of private investment in innovation in the scope of the entire economy and the effectiveness of the government in encouraging companies to invest in R&D activity. Almost 38% of German small and medium-sized enterprises (SMEs) conduct innovative R&D activity, whereas 41.6% and 49.1% implement product and process innovation as well as marketing and organisational innovation, respectively. Indeed, the German economy is on high extent based on the innovative activity of SMEs. The support for the R&D activity in Germany is provided

through special programmes offering subsidies and grants. For that reason, it is possible to examine whether in the country using such a solution the size of tax burdens has a significant impact on the corporate expenditures on R&D.

France has been included in the group of strong innovators and placed 10th in Europe according to the *Summary Innovation Index*. This result is better than the EU average. The indicators describing human capital are especially worth mentioning. France is the country characterised by the high share of the population with higher education and a considerable percentage of doctoral students from outside the EU (40.1% of all postgraduate students), which reflects the strength of the scientific environment and education system of this country. The private corporate R&D expenditures equal to 1.45% of GDP.

Considering the scope of our comparative analysis, Table 1 compares the incentives for corporate R&D activity in Germany and France (EY, 2017). France is one of the countries which uses tax relief as a central instrument for supporting innovation. In contrast, Germany offers many generous funding programmes, but its tax law does not provide any specific system of tax incentives for R&D activity. Because French and German policies vary vastly, we aim to compare two different approaches of leading European innovators using data on a firm level.

Tab. 1: Instruments of innovation support.

R&D incentives	France	Germany
Tax credits	✓	
Cash grants	✓	✓
Loans	✓	✓
Reduced tax rates/preferable tax rates	✓	
Reduced social security contributions	✓	
Accelerated depreciation on R&D assets	✓	
Tax allowance		
Infrastructure/land preferential price		
Tax deduction		
Tax exemptions		
Income tax withholding incentives		
Patent-related incentives	✓	
Financial support		
Tax holiday	✓	
The expedited government approval process		
VAT reimbursement		
Qualifies for Horizon 2020 funding	✓	✓
Other		

Source: Based on EY Worldwide R&D Incentives Reference Guide 2018.

In Germany, national funding programmes cover the broad scope of industries, according to the binding 'high tech' strategy, notably including such sectors as climate and energy, ICT, mobility and infrastructure, security, as well as healthcare and nutrition. The regional funding programmes focus on supporting SMEs that implement vital, innovative technologies. The programmes offer support in the form of non-refundable cash grants and loans for R&D. The funding covers 25–75% of eligible costs of R&D activity, depending on the programme, the research category of the project, project cooperation with other companies or research institutes and the size of the company. More beneficial programmes are offered to SMEs, as they finance up to 75% of the costs, whereas large enterprises may only benefit from funding up to 50% of R&D costs (EY, 2017). Germany supports via these grants critical technologies such as innovation drivers which include ICT, materials technologies, biotechnology, nanotechnology, microsystems technology and innovative services. Authorities and the respective ministries fund the cross-sectional technology topics: Internet of Things, industry 4.0, digitalisation, and disruptive technologies. There is also support for the creation of new R&D centres (or production premises) in Germany. Large enterprises' capital expenditures can be funded up to 20%, depending on the region and under the condition of the creation of new permanent jobs.

France is one of the countries which implements the most generous incentives for R&D activity, including the R&D tax credit and a reduced CIT rate (15% instead of 34.43%-38%) applicable to revenues derived from patents. Since 2008, the French government has offered tax reliefs for scientific research (*Crédit d'Impôt Recherche*, RTC), which are considered as one of the most generous in the world (KPMG, 2017). Since 2011, these R&D tax credit beneficiaries have been a subject of tax audits, notably for significant tax benefits of €500,000 or more. Full deductibility of depreciation and amortisation allowances and financing costs

is available on the standard 33.33% CIT rate. Additionally, a 15% CIT rate applies to the income derived by a French corporation from the licencing or sale of patents or patentable rights, conditional upon a two-year holding period for acquired IP. These tax benefits exclude IP transactions between related parties (i.e., inside the business group).

A choice of the *Innovative New Company* legal status (*Jeune Enterprise Innovante*) provides tax benefits for firms engaged in R&D projects, including full exemptions from income tax for the first year with a profit and a 50% reduction for the second profitable year. These firms pay lower social security contributions (less of the employer part) for higher qualified employees (engineers, researchers) involved in R&D activity for eight years. Tax benefits increase by the exemption from property tax and the local economic contribution for seven years if approved by the relevant local authorities (EY, 2017).

Since 2013, the scope of the RTC tax relief, dedicated to firms that conduct research activity, has been extended. It covers SMEs' expenditures related to the construction of prototypes and the costs of pilot plants for new products. These tax-deductible costs equal to 20%, but not more than €400,000 (KPMG, 2017). Moreover, there is a possibility for reduction of CIT rate to 15% (standard rate amounts to 33.33%) in the case of the revenue resulting from the licencing, selling patents or patent rights (under particular conditions, e.g., two years of acquired assets maintenance) (EY, 2017).

4 Literature review and hypothesis development

4.1 Tax incentives for R&D

The difficulty of the analysis of tax reliefs' impact on the R&D expenditures is related to the fact that systems of tax incentives are complex and dependent on various factors, such as the level of income and the number of employed scientists or researchers. Often, to investigate the impact of tax burdens on corporate R&D activity, it is necessary to determine a way of measuring the level of taxation, which is a sophisticated task. Therefore, it is required to construct a variable that is a proxy for the entire tax system, where economic variables characterising a firm and taxation level of R&D expenditures are used. Jia and Ma (2017) claim that, very often, tax systems are so sophisticated that it is not easy for a firm to be eligible for exercising a relief. Only a part of expenditures is subject to the deduction, or specified limits of minimal investments are set. The type of ownership, i.e., either private or public, has an impact on whether the firm benefits from a tax incentive. In the case of private firms, the effects of tax incentives are more visible. Therefore Jia and Ma (2017) use the price flexibility model to study the impact of tax incentives on stimulation of corporate R&D expenditures based on panel data on Chinese companies listed on the Shanghai Stock Exchange. The dependent variable in their study is a natural logarithm of R&D expenditures. The estimated elasticity, by these researchers, indicates that 10% of cost reduction would motivate enterprises to increase their R&D expenditures by 3.97% on average in the short-term and by 62% in the long run. Their findings suggest that tax incentives are effective in stimulating R&D expenditures. Ownership concentration is negatively associated with corporate R&D expenditures. This indicates that the effects of tax incentives regarding the R&D activity are more visible in the case of private firms that do not have any political ties with the government.

Implementation of appropriately constructed tax incentives leads to a reduction of expenditures on research, due to, for instance, the possibility to deduct a part of the tax basis. If the cost of R&D work decreases by 10%, the increase of R&D expenditures by slightly more than 1% is possible in the short-term, whereas in the long-term, this growth may even amount to 10% (Bloom, Griffin, & Van Reenen, 2002). This analysis of corporate expenditures on R&D based on panel data concerns changes in taxation and R&D expenditures in nine OECD countries from 1979 till 1997. The variable approximating the tax system represents the cost of capital dedicated to R&D. It depends on tax rates, depreciation, tax relief and the size of the corporate income tax. Obtained results unambiguously indicate that tax incentives are effective in increasing the intensity of R&D activities.

The scope of the R&D activity differs among industries. The R&D activity in some sectors depends more on the implementation of innovation, and therefore their R&D intensity is higher. Among those industries are high-tech sectors, where enterprises use advanced technical solutions and base their activity on implementing novel technologies. Mainly firms operating in these sectors exercise tax reliefs (Wu, 2008). Additionally, tax incentives cause a much higher

increase in R&D expenditures of high-tech firms than others (Yang et al., 2012). The study was conducted based on data on Taiwanese manufacturing firms listed on the Taiwan Stock Exchange in the period 2001–2005, representing an emerging economy. The analysis indicated not only that the impact of tax reliefs on R&D differs among high-tech firms and non-high-tech ones but also that tax incentives do not crowd out private corporate R&D expenditures.

In the empirical literature, the R&D intensity is used as a dependent variable to compare the research activity among firms of different sizes and the effects of tax policy on small and large firms. Chen and Gupta (2017) measure the R&D intensity as total expenditure on R&D to turnover ratio. R&D intensity is substantially higher in high-tech industries and firms with more internal funds (cash flow). Considering the impact of tax relief on R&D expenditures, the study (also based on Taiwanese firms) indicates that the increase in the tax reliefs leads to an increase in the R&D intensity, but only in the case of the high-tech industry. Enterprises that benefit from tax reliefs have better opportunities for increasing their R&D expenditures in the future. Based on the literature review, which suggests that tax incentives stimulate corporate R&D expenditures, we state the following hypothesis**:**

> **H1:** *There is a positive association between tax spread (the difference between the nominal and the effective tax rate) and R&D expenditures.*

4.2 R&D grants

Reduction of tax burdens is possible due to the use of tax reliefs or obtaining revenues in the form of cash grants, which are exempt from tax. Due to the possibility to get funding from the government (grants or subsidies), enterprises can engage in new research projects, as government funding covers the cost of risk and improves the profitability of projects, which would not be profitable without such funding. Public financing enables firms to cover expenses of R&D activity, build an appropriate infrastructure or train professional staff. Thanks to that, the probability of successful implementation of R&D investment increases. Firms that have the opportunity to use public funding for R&D activity are likely to take advantage of it, which increases their current and future expenses on R&D (Ali-Yrkkö, 2004).

Grants certainly enable enterprises to obtain numerous benefits, as they open up opportunities for starting new R&D activities. Moreover, R&D grants allow the continuation of projects which were already started and give support to most innovative enterprises. All these factors may benefit the entire country. However, a question arises whether government grants result in a reduction of private corporate expenditures on R&D (crowding-out effect). The opportunity to obtain additional funds encourages enterprises to implement more research projects. Klette and Møen (2012) analyse data on Norwegian companies in the high-tech industry and provide evidence that the crowding-out effect does not exist, at least in this case.

Germany is the country that uses subsidies as the central tool for supporting R&D activity. In the eastern part of Germany, the government spent around €2.2 billion for the support of R&D activity in manufacturing companies. Almus and Czarnitzki (2003) study the average result of all public programmes dedicated to R&D in Germany in 1994, 1996 and 1998. They divide the research sample into two subsamples: enterprises that did not participate in funding programmes for R&D and the beneficiaries of such programmes. The R&D intensity is the dependent variable. The comparison of two distinguished groups indicates that entities who had been obtaining grants earlier exhibited higher R&D intensity. Their finding implies that government grants impact the increase in private expenditures on R&D. Companies that received cash grants tend to develop their research activity more intensively as a result of increasing their internal spending. Therefore, obtained results confirm that government subsidies stimulate private R&D expenditures and that the crowding-out effect does not occur. On the contrary, these results confirm the crowding-in effect. Thus we assume that cash grants out of income tax burdens allow firms to boost cash flow, and this way, firms can hoard invest more in R&D.

> **H2:** *There is a negative relationship between tax burdens (the income taxes to total operating revenues ratio) and R&D expenditures.*

4.3 Firm characteristics crucial for the R&D activity

The size of corporate R&D expenditures does not only depend on the support of the government. The fact that an enterprise would engage in the R&D activity to a great extent depends on the company's financial situation or its activity profile. There are many characteristics of an enterprise that play a considerable role in determining its R&D expenditures, such as those describing the firm's debt or the capability of internal financing (cash flow and cash holdings). Both factors determine a firm's financial flexibility that is crucial in R&D activity (Gryko, 2018).

R&D activity requires substantial financial resources. Besides, it also holds a significant risk of investment failure or default. Therefore, it is crucial for an enterprise, which conducts R&D activity, to have sufficient resources. Thus, the capability of internal financing (cash flow) is of great importance in terms of high risk. The problem of liquidity and financial constraints occurs in the case of young firms. However, they need to boost R&D expenditures to increase their competitiveness (Audretsch, Segarra, & Teruel, 2014). Small firms are more vulnerable, in terms of investment, to the accessibility of funds (including cash flow from operations) than larger entities. Investments of high-tech firms depend on internal resources as well.

On the other hand, large enterprises' investment should be less sensitive to their internal sources of finance due to better access to external funding, e.g., bank loans. Nevertheless, Ughetto (2008) finds a positive relationship between the R&D expenditures of large companies and their cash flow. However, most common in the literature is that this relationship is positive in the case of small firms. Based on these findings, we assume that:

> **H3:** *Corporate R&D expenditures are sensitive to internal funds (cash flow from operations).*

Enterprise's capability of financing its R&D activity with its own funds may also determine the level of its debt. Chen and Gupta (2017) find that more indebted enterprises may have problems with liquidity and may lack sufficient funding for expansion investment. They explain their findings by the fact that firms with high debt need to incur higher costs related to the debt payment, which often results in the necessity for the delay in their R&D expenditures.

More profitable companies may invest more in R&D due to retained profits. Furthermore, a company with higher profitability in the current year is more willing to save on taxes and spend on investments instead. Thus, it may suggest that the profitability in the current year is a vital determinant of the willingness to use tax reliefs for R&D or other tools for tax optimisation (Yang et al., 2012). Based on these findings, we state the following hypothesis:

> **H4:** *More profitable firms spend more on R&D.*

Determining the influence of the company's age (a phase of life cycle) on the R&D expenditures is not a trivial task because, based on the existing studies, this relationship is not clear, and it is either positive or negative. A positive correlation implies that older companies invest more in R&D. Higher R&D intensity may result from their experience and broader knowledge, which they require to boost competitiveness. Enterprises gain experience over the years, which enables them to improve the way of managing the company and utilise human and capital resources. Moreover, an opportunity for using research achievements made so far arises. The so-called 'learning by doing' effect occurs, causing the increase of R&D work effectiveness. However, Yang et al. (2012) confirm that young companies invest more intensively in their R&D activity. Due to further development, they can position themselves higher on the market. The innovation activity improves the competitiveness of enterprises and accelerates business development (Yang et al., 2012). It can also happen due to the higher flexibility and creativity of younger firms. However, believing more in the 'learning by doing' effect, we assume that

> **H5:** *Older firms (operating for a longer time on the market) invest more in R&D.*

R&D activity is a crucial factor in influencing innovation. For it to result in quantifiable benefits in the future, appropriate intellectual property protection is necessary, including patent protection. Obtaining a patent enables commercialisation of an invention and provides economic benefits. Moreover, an obtained patent is a confirmation of the effective conclusion of experimental development works. Enterprises operating in regions where property rights are executed sharply exhibit the higher intensity of R&D expenditures.

Tab. 2: Definitions of variables.

Variable	Definition
R&D	A continuous variable equals to the natural logarithm of the amount of the company's spending on R&D activity, recognised in the Profit & Loss Statement
tax	A variable equals to a relation of paid, due and deferred taxes to total operating revenue. In the case of items where the value was negative, we truncated the variable to 0. The indicator reflects the part of the revenue related to the operating activity, which constitutes taxes. It approximates tax burdens due to the income tax.
tax_spread	A variable equals the difference between the nominal and the effective tax rate; an effective tax rate is a ratio of taxes to gross income (before taxes). The difference reflects the use of tax reliefs available within the tax system of a country.
growth	A dynamic variable reflects the growth opportunities of a firm, defined as a sales growth rate, i.e., a relation of the net sales in a given year to the net sales in the previous year.
ROA	Rate of return on assets, informing about the profitability of the company's assets (relation of generated revenues to assets). It reflects how effectively each one EUR of the capital invested in the company creates new profits.
patent	Number of patents obtained by the firm from the beginning of its existence, defined as a natural logarithm of (1+ number of patents).
age	Number of months since the firm was established divided by the age of the oldest firm in the sample.
cash_flow	Indicator representing the cash flows from operating activities scaled by total sales. It reflects the part of the sale revenues, which the company obtained in the form of real money (cash).
debt	The debt ratio defined as the company's long-term liabilities to its total operating revenue ratio.
industry	Division of companies according to the industry they operate in, based on Statistical Classification of Economic Activities in the European Communities, Rev. 2 (NACE Rev. 2) 1 – high-tech, 2 – manufacturing and construction, 3 – water supply, sewerage, waste management and remediation activities; electricity, gas, steam and air conditioning supply, 4 – wholesale and retail trade, 5 – finance and insurance, 6 – ICT information and communication; real estate activities, 7 – professional, scientific and technical activities, 8 – administrative and support service, 9 – services (accommodation and catering services); arts, entertainment and recreation, and other services

Furthermore, adequate intellectual property protection allows for more extensive technology transfer to regions under patent law and reduces the risk of illegal use of someone else's achievements (Manap, Shapiee, Shariff, & Tehrani, 2016). Considering the intellectual property protection in different industries in the same country, it is of the highest importance for the high-tech industry. Reliable patent protection increases private R&D expenditures in those sectors (Brawn, Martinsson, & Pearson, 2017). Therefore, we expect a positive correlation between the number of patents and a firm's spending on R&D.

5 Research design

The conducted empirical analysis aims to find the relationship between corporate R&D expenditures and tax burdens, comparing German (based on non-refundable cash R&D grants) with the French R&D incentive system (focused on the R&D tax credit, tax incentives, reduced CIT tax rate applicable to revenues derived from patents). For this purpose, our research sample covers all 351 French and German enterprises that reported a positive value of R&D expenditures in the years 2014–2015 (available in the Amadeus database in November 2017). We use cross-sectional financial and patent data on German and French companies retrieved from the Amadeus database. Moreover, we examine the well-recognised in the literature determinants of corporate expenditure on R&D, including the debt, firm's profitability (return on assets (ROA) ratio), internal funds (cash flow from operations) and age (a phase of life cycle). The number of patents obtained by an enterprise is a control variable, similar to the industry dummies. Table 2 presents definitions of variables in detail.

Because Germany and France apply different innovation policy, our analysis enables us to evaluate two types of fiscal policy instruments used: grants and

Tab. 3: Descriptive statistics of variables.

Variable	Model	Number of observations	Mean	Standard deviation	Min	Max
R&D	1 Germany	209	9.9327	2.0846	6.0039	15.6684
	2 Total	351	9.7378	2.2718	2.4849	15.6684
	3 France	142	9.4088	2.4424	2.3979	15.3560
growth	1 Germany	209	1.0787	0.1732	0.1419	1.8622
	2 Total	351	1.0993	0.2916	0.1419	3.9503
	3 France	142	1.2765	1.4565	0	15.0511
tax	1 Germany	209	0.0209	0.0223	0	0.2249
	2 Total	351	0.0200	0.0226	0	0.2249
	3 France	142	0.0208	0.0213	0	0.0886
cash_flow	1 Germany	209	0.0536	0.4691	−6.6	0.2496
	2 Total	351	−0.1305	1.7295	−27.4894	1.8076
	3 France	142	−0.2092	1.6924	−18.4402	0.4985
ROA	1 Germany	209	5.3605	5.0256	0	25.23
	2 Total	351	4.5955	5.0288	0	37.88
	3 France	142	3.8730	5.8296	0	50.81
patent	1 Germany	209	3.3132	3.0014	0	12.1611
	2 Total	351	3.1978	2.8336	0	12.1611
	3 France	142	3.0408	2.5391	0	9.2757
debt	1 Germany	209	0.2060	0.3514	0	3.1568
	2 Total	351	0.2852	0.7245	0	8.7687
	3 France	142	0.3430	0.8987	0	7.5436
age	1 Germany	209	0.2172	0.2166	0.0124	1
	2 Total	351	0.2061	0.1786	0.0124	1
	3 France	142	0.3977	0.2121	0.0642	0.9931
tax_spread	1 Germany	209	0.1078	0.1285	0	0.33
	2 Total	351	0.1348	0.1362	0	0.33

R&D tax reliefs. The former is subject to exemption from income tax and lower tax burdens, whereas the latter results in a higher difference between the nominal and the effective tax rate. Table 3 presents the descriptive statistics of the variables used in our study.

We estimate three models using the OLS method to verify the research hypotheses. The results of diagnostics confirm the accuracy of using the OLS regression. They are available on request. Particularly, Table 4 delivers outcomes of tests for normality of errors, whereas Figure 2 explains the reason for using a logarithm measure of the dependent variable.

The logarithmic dependent variable is much more like normal distribution. The bias and kurtosis have values similar to those of normal distribution. This is confirmed by the test for normal distribution of the logarithm of the R&D variable, as follows (see Table 4).

Table 5 presents the results of the conducted analysis. Specifically, column (1) lists explanatory variables used; column (2) gives outcomes of the model estimation for data on German companies; column (3) shows results of the analysis of data on companies from both countries, Germany and France; and finally, last column (4) presents findings of the model estimation for French firms. The dependent variable in all three models is the natural logarithm

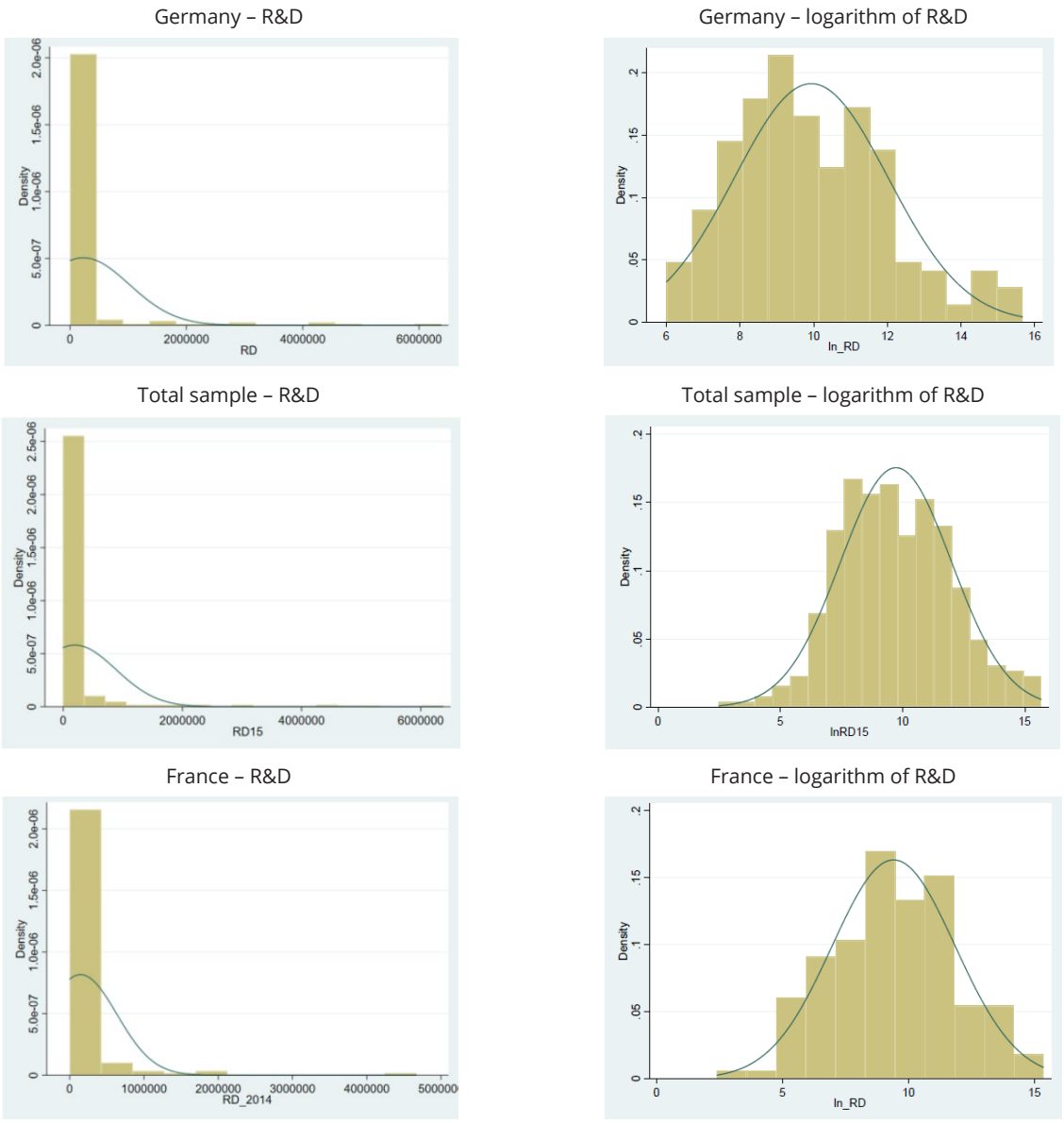

Fig. 2. Histogram of the dependent variable before and after logarithm.

Tab. 4. Jarque-Berra tests for normality of R&D logarithm.

Variable	Model	Number of observations	Pr(Skewness)	Pr(Kurtosis)	Test χ^2	*p*-value
R&D	1 Germany	209	0.0030	0.8850	8.11	0.0173
	2 Total	351	0.2515	0.8342	1.37	0.5049
	3 France	142	0.9119	0.4380	0.62	0.7329

of corporate R&D expenditures. Only enterprises that reported the positive value of R&D expenditures in their income statement were considered in the study. In the case of model 3 (column 4) on the data of French companies, we apply the robust variance-covariance matrix because we identified the heteroscedasticity problem. The correctness of the choice of functional form was confirmed based on the RESET (Regression Specification Error Test), which verifies the hypothesis on the linear structure of the model.

We identify neither the multicollinearity nor the strong correlation between independent variables (results from these tests are available on request). To

Tab. 5. Determinants of corporate R&D expenditures.

Variable	R&D	R&D	R&D
	(1) Germany	(2) Germany and France	(3) France
cash_flow	0.8328***	0.0416*	−0.0739
	(0.2988)	(0.0217)	(0.1051)
growth	2.3007***	−0.2544	−0.2017*
	(0.6937)	(0.3276)	(0.1154)
age	0.447	1.1234**	2.513***
	(0.7627)	(0.5207)	(0.8563)
debt	0.9604**	−0.1587	−0.6826***
	(0.4269)	(0.1069)	(0.2000)
ROA	−0.065**	−0.0509***	−0.0659**
	(0.0262)	(0.016)	(0.0301)
patent	0.4846***	0.4803***	0.4682***
	(0.0628)	(0.0446)	(0.065)
tax (*current and deferred*)	12.013*	15.45***	28.0578***
	(6.1376)	(3.3793)	(9.2165)
tax_spread	−2.8787**	−2.0161***	insignificant
	(1.2828)	(0.7495)	
industry	YES	YES	YES
manufactury	−1.555***	−1.2875***	
	(0.3749)	(0.2806)	
trade	−2.0148***	−1.8409***	
	(0.6158)	(0.4493)	
finance			1.5965***
			(0.4914)
ICT			1.6046**
			(0.5306)
prof&scien			1.6016***
			(0.3909)
const	6.8698***	9.2393***	6.1104***
	(0.7949)	(0.4394)	(0.4901)
N (number of observations)	209	351	142
R^2	0.4624	0.4012	0.4947
Test	**Test statistic (*p*-value)**		
RESET	0.77	2.28	1.73
	(0.5105)	(0.0791)	(0.1637)
Breusch–Pagan test	0.29		0.54
	(0.5888)		(0.4617)

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Standard errors are given in parentheses below coefficients.

verify formulated hypotheses, we use the following functional form:

$$R\&D_i=\beta_0+\beta_1 tax_i+\beta_2 growth_i+\beta_3 ROA_i+\beta_4 patent_i+\beta_5 age_i+\beta_6 cash\_flow_i+\beta_7 debt_i+\beta_8 industry_i+\varepsilon_i$$

where e_i is error term and b_i are parameters.

Table 2 presents detailed definitions of the variables used in our analysis.

6 Results

Table 5 presents the results of estimated models concerning the corporate R&D expenditure, separately for Germany, France and the total sample, containing both Germany and France. The conducted analysis enabled to verify formulated research hypotheses. Not all the obtained results are consistent between the models. Besides the verification of formulated hypotheses, additional information about the factors that have an impact on the studied R&D expenditures of private firms, including the industry of a given firm or the number of patents granted to the firm (the intellectual property protection), were obtained. The most important aspect of the conducted study was the analysis of the impact of the tax policy and programmes offering grants for R&D projects on the corporate expenditures on R&D.

Contrary to the H1 hypothesis, we provide evidence that an increase in the *tax spread* (the difference between the nominal and the effective tax rate) causes an average decrease in R&D expenditures by 2.84% for German companies and 1.67% decrease for both France and Germany (the entire sample). These findings indicate that companies with lower effective tax rates spend less on R&D. However, the negative effect of lower effective tax rates can be triggered by the endogeneity. For example, high innovation requires higher R&D costs, which can lower profits in the early stages of the life cycle. Perhaps it can be related to higher tax deduction due to tax credit. However, it results in a higher deferred income tax and a higher effective tax rate, which is equal to a ratio of tax (presented in the P&L statement) to gross income.

Estimates of the *tax* variable indicate a positive value of the coefficient in the case of all three models. These results imply that firms that pay lower taxes (measured as a ratio to total operating revenues) spend less on R&D, contrary to our expectations formulated in the H2 hypothesis. For French enterprises, a decrease of 1 pp causes an average reduction of R&D expenditures by 32.38%, whereas in Germany, such decrease leads to an average lower R&D expenditures by 12.74%, *ceteris paribus*.

These findings indicate that the reduction of tax burdens (current and deferred) decrease investment in R&D. Perhaps it results from a relatively more significant role of the enterprise's profitability in determining the decision on engagement in R&D activity rather than an opportunity to reduce tax burdens. However, it is worth noting that due to the cross-sectional character of the data, changes in time are not taken into consideration. Next, Table 6 delivers the results of the interaction analysis.

For German firms, the interaction between a firm's age and tax spread (the difference between nominal and effective tax rate) indicates that older firms, which pay lower taxes, invest more in R&D by 7.84%, on average. More mature German enterprises, which can reduce their tax burdens below the nominal tax rate (i.e., positive values of *tax_spread*), invest more in R&D. Therefore, the capability of reducing the level of tax burdens below the nominal tax rate (in German case due to the use of exemption of R&D grants from taxation) seems to stimulate enterprises to increase their R&D expenditures. We can explain this finding by the fact that older companies have more experience and better access to external sources of financing due to their credit history or bank account history, which enables them to increase their R&D expenditures. R&D grants are an opportunity for faster growth and improvement of competitiveness as they allow enterprises to increase their profitability due to cover costs by grants and generate additional income as a consequence. Thus, our results partially confirm the H1 hypothesis, only for older German firms, while rejecting the H2 hypothesis.

The conducted analysis confirms that corporate R&D expenditures are sensitive to internal funds (cash flow from operations), in the case of two presented models – model 1 for German firms and model 2 for the entire sample, covering both Germany and France. These results confirm the H3 hypothesis. Whereas in the case of model 3 estimated on French firms, the *cash flow* variable turned out insignificant. Obtained values of coefficients of variable *cash flow* indicate that an increase of cash flows from operations to net sales ratio by 1 pp results in an average rise of R&D

Tab. 6. Corporate R&D expenditures relationship with income tax.

Variable spread sensitive to age, and IP protection in different industries	R&D	R&D
	(1) Germany	(2) Germany and France
tax_spread # age	7.5442***	
	(4.5114)	
patent # prof&scien	−0.342***	−0.1403**
	(0.086)	(0.0586)
patent # high-tech	−0.2542**	
	(0.1264)	

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Standard errors are given in parentheses below coefficients.

expenditures by 0.83% in the case of German firms, and by 0.42% in the case of the entire sample. The indicator used for the analysis of cash flows reflects what percentage of revenues from sales an enterprise obtained in the form of cash. Therefore, the amount spent on R&D activity is sensitive to cash generated by a company from the core business.

Profitability reflects the capability of a company to generate income. In this context, the higher the ROA ratio, the better the financial situation of an enterprise. All three estimated models indicate a negative relationship between the company's profitability and R&D expenditures, which is against the hypothesis H4. These findings imply that increase in the company's profitability results in the reduction of R&D expenditures. Research projects are not only capital-intensive but also time-consuming, relate to high risk and uncertainty of profits, which can be achieved only in the long-term. Therefore, enterprises report lower profitability and even incur losses in the early stage of investment in R&D. Thus, the relationship between the profitability and R&D expenditures in a particular year may turn out to be negative, especially considering that just the costing of R&D expenditures (instead of capitalising allowed in some countries) reduces the financial result by default. In the case of other studies where the relationship between the company's profitability and its R&D expenditures is analysed, authors obtained different results (Jeny & Moldovan, 2020). These diverse outcomes may result from economic differences between analysed countries or the specificity of a particular market, industry or accounting approach to R&D expenditures: capitalisation or expensing.

Another variable considered in the model is the company's age. Our results of models 2 and 3 indicate that older firms (operating longer on the market) invest more in R&D activity. An increase of the company's age (related to the oldest one) by 1 pp causes an average increase of R&D expenditures by 2.54% in the case of French firms (model 3) and 1.12% in both countries (model 2), on average. These outcomes are in favour of the H5 hypothesis. Moreover, in the model with interactions estimated on the data on German firms (Table 6), an interaction between the company's age and tax burdens shows that older firms invest more in their R&D activity if they pay lower taxes. Thus, our findings suggest that older enterprises use their experience and potential to benefit from tax incentives and cash grants for R&D activity.

Besides the main variables describing tax burdens, we analyse other enterprises' characteristics that may have an impact on R&D expenditures. We use the debt ratio measured as long-term liabilities to the total operating revenue ratio. Obtained results do not imply a clear direction of a relationship between debt and R&D expenditures. In the case of German companies, the level of debt has a positive impact on R&D expenditures. An increase in the ratio of long-term liabilities to the total operating revenue by 1 pp causes an average increase of R&D expenditures by 0.97%. On the contrary, we observe a negative relationship between debt and R&D expenditures for French enterprises, where the rise in debt causes a decrease in R&D expenditures by 0.69%, on average.

R&D activity requires substantial funding and holds considerable risk. Often, enterprises do not have sufficient internal funds (cash flow) or do not want to risk their funds, and therefore they finance their R&D activity with external resources, such as loans. On the other hand, a high risk of R&D activity discourages banks from granting loans for R&D, since eventually, they do not benefit from extraordinary profits over interests. The success of the R&D project brings the opportunity for substantial rates of return and profits, which are usually sufficient for paying liabilities related to it. Prospects of future benefits encourage enterprises to take loans for current R&D activity. The result indicating a positive relationship between debt and expenditures on R&D supports this explanation. However, due to the high risk of R&D activity and related high costs, the capability of internal funding of such activity from cash flow is very often needed. An increase in debt reduces the internal funds, which results in the reduction of investment in R&D.

Next, we find a positive relationship between the growth opportunity and corporate spending on R&D in the case of German companies. However, in the case of French companies, a year-to-year growth of sales causes a decrease in R&D expenditures by 0.2%, on average. On the other hand, based on the positive relationship obtained in the analysis of German enterprises, it may be concluded that entities who engage in R&D activity and recognise related benefits would expand their business in this regard. In the case of the model estimated on the entire sample, the sales growth rate turned out not to be significant for an increase in R&D expenses.

Intellectual property protection (approximated with the number of obtained patents) is a control variable in our study. In line with our expectations, it positively correlates with R&D expenditures. Both Germany and France are highly developed countries, which provide appropriate legal protection for the enterprises operating in their country. Although patent protection is an essential step for benefitting from R&D activity, in particular for the high-tech industry (Brawn et al., 2017), we find that the number of obtained patents in the high-tech sector (a proxy for the importance of IP protection) negatively links with R&D expenditures (Table 6). An increase in the number of patents obtained by firms from the high-tech industry by 1 pp causes an average decrease in R&D expenditures of German companies by 0.25%, compared to all firms which obtained patents.

On the other hand, an increase in the number of patents obtained by companies from the professional, scientific and technical activity sector by 1 pp causes an average decrease of R&D expenditures of German companies by 0.34% and 0.14% decrease in the model on the total sample, compared to companies from all sectors which obtained patents (Table 6). These results are contrary to our expectations for the role of IP protection. However, lower motivation for increasing R&D expenditures may result from the institutional environment in analysed countries.

7 Conclusion

The conducted analysis does not confirm the negative relationship between the level of tax burdens and corporate R&D expenditures, in the case of neither France nor Germany, where tax reliefs or cash grants are the primary instruments of support for innovation. These relations may be due to various reasons. Our research sample is not limited to beneficiaries of R&D tax reliefs. The selection of cross-sectional data for the conducted analysis could also influence the obtained results. Therefore, we suggest considering panel data in future research.

Due to the limitation in data availability in the Amadeus database, the analysed research sample contains only companies that recognised a positive value of R&D expenditures in the profit and loss statement. We omit the companies that capitalise R&D expenditures in the balance sheet (Jeny & Moldovan, 2020) as the Amadeus database includes such an R&D in other intangible assets. Because the R&D activity is highly capital-intensive, R&D-intensive enterprises need sufficient funds (sources of finance). Often, these are enterprises that generate enough cash flow (financial surplus from operating activities) to cover the costs of their primary operation and their R&D investment. Perhaps, they pay higher taxes, and therefore the influence of tax reliefs for R&D activity on their tax burden is not visible in our research. The obtained result indicates that lower tax burdens and a reduction of the effective tax rate below the nominal rate negatively affects the size of enterprises' investment in R&D. The only exception is older German firms that invest more in R&D when paying lower taxes that result in higher tax spread between nominal and effective tax rates.

Engaging in R&D activity by enterprises is often a risky endeavour. Such action requires large amounts of financial outlay. Quantifiable benefits from R&D activity are very often achieved only after a few years since the implementation of particular research projects with success. Less profitable enterprises tend to invest more in R&D. Low profitability is indeed a result of the large investment in R&D, which may even lead to reporting a loss in the early stage of the investment. Therefore, successful implementation of the entire investment is determined by an appropriate funding capability of the company. Based on that, it may be stated that enterprises that conduct the R&D activity are generally large and have large enough revenues enabling them to take a risk which R&D activity holds. For such enterprises, the amount of tax burdens does not determine whether to start a particular R&D activity or not.

R&D activity does not always bring quantifiable financial benefits. Experience plays a vital role in this regard. Firms who operate longer on the market tend to invest more in innovative projects. In line with the 'learning by doing' effect, an enterprise uses its

experience, which enables the effective planning of future creative projects and successfully conclude a particular R&D activity.

The main aim of the article was gained by examining the effectiveness of the fiscal policy supporting innovation, with the use of econometric methods dedicated to cross-sectional data. Tax reliefs may serve as an instrument, which encourages enterprises to increase their investment in R&D. However, the effectiveness of this tool depends on the extent to which they allow a sufficient lowering of the level of tax burden perceived by a particular enterprise.

The conducted study indicates possible directions for further research for the Polish economy. However, it requires data on corporate R&D expenditures, which have not yet been separated from the costs of the operational activity, due to the Polish Accounting Act (Białek-Jaworska, 2016).

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