R&D tax incentives

Do R&D tax incentives stimulate innovations and economic growth? Evidence of OECD countries.

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Abstract:

This study investigates the impact of tax incentives on the firms’ innovative activity and economic growth by using sample of 28 OECD countries. The study using panel data analysis and applies fixed effect OLS models. The results of the econometric investigation indicate that tax incentives have significant and positive effect on the R&D expenditure. Regression analysis also shows a positive significant impact of R&D tax incentives in combination with direct funding for business R&D. The paper finds no evidence of significant relationship between tax incentives and economic growth. The research also finds a positive significant impact of direct R&D support, R&D expenditure and tax incentives on registered patents. We suggest to apply public support policy including both types of support since previous studies showed that tax incentives and direct funding are not perfect substitutes.

**Key words:** R&D tax incentives, direct funding for business R&D, market failure, spillover effect, patent, public support, innovation, innovative activity.
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1. INTRODUCTION

“... we may read a lesson from the young trees of the forest as they struggle upwards through the benumbing shade of their older rivals. Many succumb on the way, and only a few survive... And as with the growth of trees, so it was with the growth of businesses...”

Alfred Marshall

The potential of creativity exists in everyone. And like any creativity it is needed to be encouraged to appear. It is well known by providing jobs, creating infrastructures and new possibilities, we make new inventions easier to come out. Therefore, the more ideas tried and tested, the more chances to develop innovations. The field of research and development refers to innovative activities undertaken by corporations or government in developing new services or products, or improving existing services or products. Research and development (R&D) is a key driving force of technical progress and thus of sustainable economic growth (Aghion & Howitt, 1992; Romer, 1990). However, the market alone often fails to provide needed quantities of R&D from a socially desirable perspective, as the private rate of return to R&D is lower than its social rate of return. Thus, one of the policy tool of correcting such market failures is government’s support for business R&D. Tax incentives have been used all over the world to motivate firms R&D and nowadays tax incentives for innovative activity are important direction of economy regulation. The economic purpose behind tax incentive is that they fix market failures.

Basically R&D tax incentive is a support from government and these kinds of tax incentives are associated with the market failures, consequently state’s intervention needed. The major R&D’s features make the returns on investment in R&D difficult. Among these characteristics economists distinguish: non-rival and non-excludable public good, market uncertainty, asymmetry information, knowledge spill over. The level of R&D in the economy without government interference is below the efficient level (Chang, 2015). Realising such consequences, firms invest reluctantly. To encourage and motivate companies to spend more on R&D activities R&D tax credits can be offered. Lowering prices of doing R&D activities stimulate business to take the risk anyway.

Defining the impact of the R&D tax incentive can be an issue for government. The main problem of evaluating impact of R&D tax incentives is to analyse the impact of the externalities, and that is a major determinant of the effectiveness of R&D tax incentives.
Usually, econometric studies look at measures of the elasticity of R&D expenditure with respect to the R&D tax incentives, it is the response in a firm’s R&D expenditure to changes in the R&D tax incentives (Hall and Reenen, 2000). Such way of estimation tax incentives effectiveness is used in this paper.

This study aims to investigate the impact of R&D tax incentives on the firms’ innovative activity and economic growth by using sample of 28 OECD countries and OLS models including years and country fixed effects. Thus, this paper presents empirical investigation whether R&D tax incentives leads OECD economies towards economic growth. We carry out a literature review and go through the previous papers that study the impact of R&D tax incentives. The important questions that are included to the research: what is the effect of R&D expenditure and tax incentives on patents, tax incentives on R&D expenditure, tax incentives on economic growth, the reason of R&D tax support, externalities, R&D tax incentives as a tool to adjust market failures. Patents and R&D expenditure are included as an indicators of innovative activity and used separately in different regression models.

The empirical results show positive and significant effect of tax incentives and direct R&D support on R&D expenditure. The investigation shows also positive significant relationship of patents with R&D expenditures and with direct R&D support. Since it takes a certain time for investment in R&D to turn it into an actual patent, the paper finds a positive and significant relationships of patents with R&D expenditures in one, two and three years after introducing. The relationship between patents and tax incentives is significant and positive after 3 years of introducing the policy tool. The paper does not find any significant relationships of economic growth with tax incentives or direct R&D support but finds a positive and significant impact of openness and FDI on economic growth in OECD countries.
2. R&D tax incentives and direct funding as a policy tools

2.1 Market failures and need in R&D support

The First Fundamental Theorem of Welfare economics states that markets are the most efficient allocators of resources under three specific conditions (Ledyard, 2008):

- all supplied/demanded goods and services are traded at publicly known prices;
- all consumers and producers behave competitively (all agents are price takers);
- an equilibrium exists.

Under these three conditions, the allocation of resources by markets is “Pareto-optimal”; that is, no other allocation will make a consumer or producer better off without making someone else worse off. “Market failures” are said to occur when any of those conditions are violated; resource allocation by markets are in these situations inefficient. If markets are not Pareto efficient, then at least someone could be made better off through public policies.

There are many market failures can be defined but we examine only those that connected to innovative activity. Positive and negative externalities are being a major market failure in the R&D sector. For example, positive externalities arising from public goods (which are non-rivalrous and non-excludable) are characterized by under-investment by the private sector and will therefore require public intervention. This is the case for basic research, which has high spillovers that create difficulties in appropriating private returns; consequently, basic research is characterized by too little private investment. Negative externalities, such as those created by pollution, require public measures that cause the private sector to internalize external costs, such as through a carbon tax. (Mazzucato, 2016)

In effective terms, a tax incentive would be a special tax provision granted to qualified investment projects that has the effect of lowering the effective tax burden—measured in some way—on those projects, relative to the effective tax burden that would be borne by the investors in the absence of the special tax provision. Under this definition, all tax incentives are necessarily effective and such stimulus still used worldwide (Zee et al., 2002).

The main reasons that define R&D as a burden, are certain costs such as distortions between those who receive incentives and those who are deprived such opportunity;
administrative resources that needed to carry on the incentives and finally social costs of rent-seeking activity or corruption due to abuse of tax incentives provisions. Even though such costs can be effective sometimes, the benefits from tax incentives are much less clear and barely can be estimated. Consequently, economic efficiency of R&D tax incentives cause doubts.

It is also complicated procedure to calculate correction for externalities. All granted R&D tax incentives can never be equal to costs of externalities involved, because it is extremely difficult to measure such externalities. Also, such costs will be created in case if tax incentives will be given to a project that has no any social benefits (Zee et al., 2002). So, why R&D tax incentives are widespread yet? Why they are so needed?

The empirical evidence and economic theory show that innovations are an important indicator of long term economic development. Often R&D investors do not take into account the fact that innovations generate an effect of knowledge spillovers that is why the consequences can be underinvestment. A general equilibrium model explains that R&D tax credit leads to a large increase in research effort and welfare.

Knowledge spillovers are the major social benefits from R&D and an important investors’ concern that is why we will emphasize our attention on this externality. Hosein and Fallah (2004) explore the effect of knowledge spillovers within technological clusters on innovation, within the existing body of literature. Thus, the impact of spillover and knowledge transfer, has to be investigated at the individual level and the mechanisms of such a process should be grasped. Spillovers are considered an important location externality affecting innovative capacity of companies (Hosein and Fallah, 2004). However, little is known on the mechanisms that influence creativity and contribute to the increased innovative output of technological clusters.

P. Aghion and X.Jaravel (2015) investigate spillover effect as a positive phenomenon and demonstrated that knowledge spillovers can induce complementarities in R&D efforts. One of the objects that been examined in this paper was openness in the knowledge production process. Our paper will contain openness (trade) as one of independent variable as it is tightly connected with innovations as it is discussed in chapter “Previous literature”. Openness can encourage basic research and in fact lead to an increase in the flow of
discoveries (Aghion et al. 2008). The effect of tax incentives and externalities is shown on the figure 2.1.

Without any subsidy, private investors equate their expected private return to their required rate of return (the rate that covers the cost of investment funds) and the result is a level of investment of $R_0$. The socially optimal level of R&D investment is where the social return is equated to the opportunity cost of funds. The social return is higher due to the positive externalities of R&D. With a subsidy to R&D the government effectively raises the private return to equal the social return and so private investors now choose the socially preferred higher level of investment.

**Figure 2.1. The role of R&D subsidies in correcting market failure.**

Another important factor that makes direct impact on R&D investments and being one of the market failures is information asymmetry. Because of that fact that managers of the companies can observe changes in investment productivity during long period and outside investors have such information only during short period, such corporate investments create information asymmetry (Aboody & Lev, 2000). Thus, this feature of R&D investments
makes it complicated for outsiders to know about the productivity and value of a given firm's R&D from the performance and production of other firms in the industry, thereby creating favourable conditions for information asymmetry. The absence of organized R&D market makes the information asymmetry even more severe. It is much easier to get information about prices of assets concerning their value, but there is no information about prices on firms’ changes in the values and productivity of R&D (Aboody & Lev, 2000).

2.2 Policy tools for R&D support. Tax incentives or direct funding?

Tax incentives and direct funding through grants and loans are two policy instruments currently used in many countries to stimulate business R&D. While direct public funding of private R&D has a long tradition, tax incentives have spread gradually across countries. OECD estimates of the relative weight of each instrument as a share of GDP in 2009 show that Canada, The Netherlands and Japan rely mostly on tax incentives. France, Denmark, Spain, the United Kingdom and the United States use both instruments simultaneously, while exclusive reliance on direct funding is still preferred in Sweden, Finland or Germany (OECD 2011). Direct funding for R&D implies a programme directed into inducing an “additionality” effect in firms, with the result that they end up investing more of their own resources in R&D than originally planned. Tax incentives for business R&D implies a programme that directed on boosting R&D investment and productivity an economic growth. R&D tax incentives should be considered complementary to other measures of public support to business R&D (Ognyanova, 2017). R&D tax incentive is an instrument of public support to business R&D, it is most often associated with market failures related to credit constraints and positive externalities.

According to OECD reports tax incentives as a policy tool can include few different tax instruments:

- Tax credit and allowances. Tax relief can take the form of an allowance, exemption, deduction or credit. Tax allowances, exemptions and deductions efficiently subtract from the tax base before the tax liability is computed, reducing the taxable amount
before assessing the tax. A tax credit is an amount subtracted directly from the tax liability due from the beneficiary unit after the liability has been computed.

- **Tax base.** Tax relief measures can also be distinguished according to whether they are redeemable against corporate income with regard to payroll (e.g. withholding) taxes or social security contributions. Most countries provide corporate income tax offsets, payroll withholding tax credits and social security exemptions being offered in only seven OECD countries and the Russian Federation as of 2016. Some countries target tax credits (e.g. United States, Mexico as of 2017) to R&D expenditures over and above of a pre-defined baseline amount. The latter type of incentive is commonly described as “incremental”. Some countries offer a hybrid system comprising both a volume and an incremental tax credit (Korea, Portugal and Spain) or allowance (Czech Republic, Slovak Republic).

- **Temporary or permanent schemes.** The use of and impact of tax incentives can be influenced by the temporary or permanent schemes of these programmes. Most R&D tax support schemes initially came into being as temporary measures. Finland, introduced a scheme on a temporary basis over the 2013-14 biennium. The United States introduced the federal research and experimentation (R&E) credit as a temporary measure in 1986, which after 17 extensions became permanent with effect from 2016 (H.R.2029 - Consolidated Appropriations Act, 2016).

- **Taxability of tax relief.** Tax credits represent taxable income in Canada and the United Kingdom (R&D tax credit for large companies) or are effectively taxable (Australia, Chile and the United States) because in order to claim the headline credit rates the taxpayer has to renounce to the deductibility of the R&D expenses that are claimed.

Advantages and disadvantages are often discussed in the economic literature. A recent OECD study concludes that government should balance indirect support for business R&D through tax incentives with the use of direct support measures to encourage innovation where the market is less likely to deliver it on its own (Criscuolo et al. 2016). European Commission (2017) compares advantages and disadvantages tax incentives to a direct support for business R&D.

- **Tax incentives. Advantages:**
  - Less burdens for businesses
• Generally less distortive, especially if not focused on certain areas of specialization, and therefore more easily in line with EU State aid rules. The private sector can decide what is the most productive way to invest
• Lower administrative costs of planning, management and allocation
• Technology neutral: non-discriminatory nature in terms of research, technology fields or industrial sectors
• Less risk of governmental failure in ‘picking winners’ (choosing the wrong R&D projects)
• Encourage companies to report their R&D activities more accurately
• Avoid misappropriation of funds and rent-seeking activities by government’s civil servants
• Avoid an up-front budget since support is by means of forgone tax revenues

Disadvantages:
• Poor budget control
• Greater risk of dead weight loss (supporting projects which would have been performed anyway)
• Private firms will choose R&D projects with the highest private rates of return (not taking into account spillovers)
• Less additionality in the case of very large companies
• Risk of firms relabeling other activities as R&D
• Limited incentives for technology transfer
• Risk of tax competition and rent-seeking by companies

➢ Direct support to business R&D. Advantages:
• Better suited to encourage high risk projects and to meet specific policy goals and societal challenges. Can be used to target specific technologies or scientific areas to overcome sectoral slowdowns
• Adequate to target R&D activities with the highest discrepancy between social and private returns, i.e. highest spillovers
- Competition among firms ensures that public resources are directed to the best R&D projects
- Encourage cooperation and technology transfer
- Better budget control

Disadvantages:
- Higher administrative burden for companies
- Administratively difficult to process a high number of applications
- Firms may not undertake R&D projects not approved for public funding
- Risk of rewarding lobbyists

Depending on the way countries shape tax incentives, there are four types of tax incentives:

- Tax credits: it decreases the corporate income tax rate a firm has to pay. Rate can be applied to either corporate tax, payroll tax paid for R&D workers or personal income in case the incentive is targeted to self-employed.
- Enhanced allowances: An enhanced allowance effectively decreases the base amount that is taxed by allowing to 'inflate' the R&D expenditure base.
- Accelerated depreciation: this scheme permits to depreciate the purchased fixed assets at higher rates in the first years of the asset's life. This allows, to decrease the overall taxable income in the specific periods.
- Reduced corporate tax rate on intellectual property income ("Patent Box") are an outcome related incentive. It reduces the corporate income that firms pay on commercialization of innovative products that are protected by intellectual property (IP) rights (Straathof, 2014).

This paper includes both ways of R&D stimulation. R&D tax incentives and direct funding for R&D is included into the regression analysis and also their interaction term. Direct funding and tax credits are not perfect substitutes in terms of their ability to reach firms experiencing barriers associated to market failures; one size may not fit all in innovation policy when the type or intensity of market failure differs across firm size, and subsidies may
be better suited than tax credits to encourage firms, especially young knowledge-based firms, to start doing R&D (Busom, Corchuelo and Martínez-Ros, 2014).

2.3 Empirical observations

The support for business R&D is defined as a means of overcoming market failures that overwhelm the level of R&D and innovation activity in an economy. R&D tax incentives aim to motivate firms, which are the major investors in R&D by lowering their effective expenditures. Compared to most types of direct subsidies, R&D tax incentives let companies to decide the nature and orientation of their R&D activities, on the assumption that the businesses are best placed to define research areas that can be brought to the market. R&D tax incentives are more market-friendly and neutral than direct support instruments. Moreover, direct funding under international trade and competition rules are subject to conditions that are less stringent or do not apply in the case of indirect forms of tax support, provided the relief remains non-discretionary and different types of firms and sectors are not automatically excluded (OECD, 2010).

As a response to a difficult economic environment in order to help business R&D investments, many countries – members of EU increased their tax incentives (fig. 2.2). Consequently, the amount of foregone tax revenues due to tax incentives, significantly increased in most of EU members. Estimations based on OECD data show that for every euro invested in business R&D in the EU, Member States give on average an R&D tax subsidy of 12 cents (European Commission 2016). Tax incentives for R&D as % of GDP during 2006-2014 is represented on the figure 2.2.

European strategy of growth that was set out by European Commission, puts investments into R&D as one of five major priorities that should make Europe more competitive. The aim of the strategy is that the investment into R&D should reach 3% of GDP growth. But financial crisis made an impact on the way of reaching the goals.
First of all, the crisis forced many governments set strict fiscal consolidations, paying more attention to other issues related to R&D. Thus, in 2012 share of R&D expenditure in total government spending was lower than in 2007. Secondly, decreasing economic activity even more needed to find new sources of growth. Recent evidence showed that European firms have much lower rates of return in R&D than American firms (Cencera and Veugelers, 2014).

The differences in innovative activity between European countries is not big. However, there are still tangible gaps. Usually, the most innovative countries - Sweden, Denmark, Germany and Finland - are performing around three times better than the less innovative states (European Commission, 2014). These countries also have the highest gross domestic expenditure on R&D relative to GDP (Figure 2.3).

Most of tax incentives based on corporate income tax while other countries have incentives that apply to social contribution and wage taxes. Tax benefits applying to income from innovation (patent boxes) are increasing. By the end of 2014, eleven EU member states suggested corporate tax reduction for income resulting firm to intellectual property.

In the past decade countries have changed from tax incentives that only apply to increments in a firm’s R&D expenditure towards incentives that apply to total R&D expenditure. Currently, only seven European countries have incremental tax incentives,
usually in combination with a volume-based scheme, and for two of them - Ireland and United States - this design element is phasing out (European Commission, 2014).

Fig. 2.3 Gross Domestic expenditure on R&D (% of GDP).

![Diagram of Gross Domestic expenditure on R&D (% of GDP)]

Source: Eurostat, Gross domestic expenditure on R&D, 2014

2.4 Why R&D expenditures are not enough in measuring innovative activity?

Measuring innovation is a challenging task due to various inputs and those activities that drive innovation. An innovative process consists of the input and final output. There are two stages of measuring the innovative activity: evaluating an input into the process such as R&D expenditures and measuring an output such as the number of inventions patented (Seeni, 2015).

During 1950s and 1960s, R&D expenditures were used as an indicator of innovative activity, but expenditures do not necessarily mean successful implementation of innovations. The method has drawbacks measuring only the budget resources allocated towards trying to producing the innovative outputs and could not adequately form a reliable measure. Later in
1970s advanced method was used to measure innovative activity: using patent data (Acs et al., 2002). Thus, there are used both indicators in this paper, R&D expenditures in one model and patents in another model.

Moreover, patents are results of inventions, they represent the result of innovative process particularly those that can contribute to economic growth. First of all innovations point at science and technologies that create new opportunities. Patented inventions have significant economic meaning when they lead to an improved products or processes or/and in completely new fields. That is why patents has close connection with innovative products (Seeni, 2015). Even though, patents do not represent full measurement of innovations and not all inventions are patented, some of them cannot be patented (example: software is non-patentable), patents are still useful indicator of innovations (Tidd and Bessant, 2009).

2.5 R&D tax incentives and economic growth

An economic growth analysis related more to the terms of quantitative changes (increase in real GDP). However, some authors emphasise that analysis of economic growth is highlighted by the concept of economic development that includes quantitative and qualitative elements of the economy. The main determinants of economic growth are not only production factors, labour, land and available capital, natural resources, scientific and technical information, but also human capital, technological innovation, research and development investments and knowledge from various fields, social and cultural dimensions (Surugiu, 2015).

There are papers that have evidence of positive and negative impact of tax incentives on economic growth. Domazet and Marjanovic (2014) claim that a successful business environment correlated with a long-term economic growth. It is necessary to offer investors a wider range of tax incentives which would lead to the improvement of the business environment and economic growth A fiscal policies of the countries should be focused on stimulating such a healthy business environment, but some studies show that tax rates has a negative correlation with economic growth, since business and economy stimulating forces government to decrease taxes (Prillaman and Meier 2014, Dackehag and Hansson 2012).
Thus negative relationship is explained by the distortions that raising tax revenues cause on economic growth. Prillaman and Meier (2014) examine an impact of tax incentives on economic growth in Unites States, they find that the business tax cuts have little to no positive impact on gross state product. Anyway, we do not know how business taxation effects countries’ economies but we include such question in our study to find an answer.

We could suppose that since innovation is one of the main remedy for economic development, then increasing innovations by giving R&D tax support could lead to economic growth, however, some previous literatures shows that innovation by itself does not bring always success, and that is why marketers, economists and innovators must cooperate for favourable outcomes to occur (Surugiu, 2015). In general some other economists suggest that the government should not focus on the revenue that may be lost at this point because in the long-run the benefit surpasses what is lost at the initial time (Uwaoma and Ordu 2016).

2.6 An effect of R&D expenditures on patents.

Patent is major strategic indicator for a firm's success in the innovative field. R&D spending is a key to develop a new knowledge, improving a firm's capacity to create, invent and innovate. Patenting is considered the strongest legal form of protection of R&D outcomes, helps firms to keep their competitive advantage derived from invention, limits others’ opportunity to copy and carry out duplicative inventions (Ramos, 2017). By investing into research and development, companies create new knowledge that helps new inventions and increase their chances for creating patentable inventions. In general, the creation of knowledge inputs, that can be later recombined, is not only positively associated with increased creativity and invention, but also with the creation of value by means of patents (Ramos, 2017). On the other hand, R&D expenditures can make negative impact on the patenting (Hagedoorn and Duysters, 2002). The reason of such effect can be that fact that patents are costly and disclose information about innovations. One more factor to pay attention at is that different tendencies seem to apply in different geographical environment. For example, firms in Spain invest actively in R&D but submit only few patents. (Fig. 2.4)
Figure 2.4(a)

Gross domestic expenditure on R&D (GERD) in 2017

% of GDP

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Figure 2.4(b) Patent applications to the European patent office (EPO) in 2017 (The total European patent applications refer to requests for protection of an invention)
From the graphs it is shown that some OECD countries perform differently in terms of R&D inputs compared to its outputs (patents). It means that some countries invest more than other but end up with less patents than those whose R&D expenditure were much lower and vice versa. Thus, Austria invested more than 3% of GDP into research and development meanwhile its output is only two thousand patents. At the same period the investment of Italy for R&D is only about 1.3% but outcome is over 4 thousand patents which is more than in Austria. The R&D decision depends mostly on the ability of the firm to transform R&D inputs into economically useful output (opportunities), its capital investment decision depends mostly on the possibility to extract monetary benefits from such output. Another reason of such situation could be also that the number of patent applications always increases with company size (Piergiovanni and Santarelli, 2013).

3. PREVIOUS LITERATURE

The literature review is divided into two sections. First part consists of the literature examining the R&D tax incentives. Second part contains literature in general that examines variables potentially influencing R&D investment.

3.1 Literature examining the R&D tax incentives on firms’ innovations.

Even though we are aiming to investigate if tax incentives make any impact on innovations and economic growth generally, previous papers that had the same purposes are quite differentiated in their studies. That means that there are many ways and approaches that can be used to research the impact of tax incentives on innovations. Significant part of authors emphasize their studies on researching whether tax incentives affect innovations among SME (small and medium-sized enterprises). Most of researches directed towards investigation whether tax support makes impact on R&D expenditures within one country on
the micro–economic level, learning SME and the featured of their functioning. On the contrary, I am aiming to investigate the influence of tax incentives on the macro-economic level, using macroeconomic indicators embracing 28 countries from different continents of the world.

There is a number of authors that found positive impact of R&D tax incentives on the firms’ innovative activity: Dechezleprêtre (2016) studies an effect of tax incentives on firms’ innovation using a change in the asset-based size thresholds for eligibility for R&D tax subsidies. This study shows the policy causes an economically and statistically significant increase in R&D and patenting. R&D tax policies do seem effective in increasing innovation. Chiang (2014) investigates the effect of R&D tax credit on innovations using a life cycle analysis. The paper examines Taiwan’s economy (2002-2007) and finds that depending on the firm’s life cycle stage, R&D tax credits had a negligible impact on R&D spending. Thus, the most effective time in the company’s life cycle for the R&D tax credit to be effective is the stagnant stage. The paper of Junxue and Guangrong (2017) indicates whether tax incentives work on the firm-level in China. By using a panel dataset of Chinese listed companies covering 2007 to 2013, the authors find that tax incentives significantly stimulate R&D in private firms but have little influence on state-owned enterprises’ R&D expenditures. Also, the effects of tax incentives are more pronounced for private firms without political connections. A study of Macedo and Azevedo (2018) comprises a comparative examination of the effects of innovation support programmes’ spend on innovative activities in small, medium and large Brazilian firms. By using a PSM technique (propensity score matching) authors conclude that the support programmes for innovation are effective as they are able to stimulate increased spending on the innovative activities of small, medium and large Brazilian firms. Soares et. al (2014) use a panel data of 1127 firms belonging to 35 different industries from 21 OECD countries, during the period between 2003 and 2012, the research finds a positive effect on firms’ investment in R&D of tax policies directed on increasing R&D expenditures. Czarnitzki et. al. (2011) measures the impact of tax credits for R&D in Canadian manufacturing. Examining the sample of the cross-section of 4,644 manufacturing firms and using a non-parametric matching approach in order to control for a possible selection bias, the authors define that R&D tax credits indeed have a positive impact on innovation output of the recipient firms. Hui’e Fu et al. (2012) measures the incentive effect
of the tax on the scientific and technological innovation of the private enterprise. Using statistical analysis and exponential model, the research shows that appropriately designed system makes a positive and significant effect on R&D investment that could sufficiently reduce the firm’s development expenditures and risks. Svoboda (2017) analyses the effect of tax incentives on R&D expenditure and compares its effectiveness to direct government support of R&D. The author of the paper uses a regression analysis of 28 OECD countries in 2013 and evaluates the impact of tax incentives on effectiveness of innovative activity, measured by number of registered patents. The results showes that tax incentives make bigger positive impact on innovations than direct government funding.

The total number of patents produced by a country (or the number of patents produced per capita) is often used as an indicator for innovation. Though, there are authors that did not confirm the effectiveness of patents in their studies: Levin et al., 1987; Cohen et al., 2000; Sakakibara and Branstetter, 2001; Arundel, 2001, Penin and Neicu, 2018. These views are based on claiming: patents are not the most effective instrument to protect an invention, except for the pharmaceutical branch, patents are not needed to increase incentives to innovate (most firms would invest the same amount in R&D without having the patent system).

3.2 Literature that examines variables potentially influencing R&D investment.

The reason of including certain variables.

The reason of including certain variables into this paper is based on the previous studies and theory that undermines importance and impact of different economic indicators on the dependent variables. In this part of the thesis there are explanations of the reason of importance including chosen variables and their impact on both innovations and economic growth.

The dependent variable in this study is innovative activity that expressed by R&D expenditures. Philip Berger (1993) points out that the companies that have more innovation opportunities are expected to spend more on R&D than the firms that are less innovative. The
other regression analysis will contain GDP growth per capita as dependent variable and as the main economic growth indicator.

**Tax incentives.** First of all, the object of this study concentrates around tax incentives and its impact on R&D investment, economic growth and patents. To quantitatively evaluate the influence of R&D tax incentives, econometric studies pay attention to measures such as the elasticity of R&D expenditure with respect to the user cost of R&D capital, i.e. the response in a firm’s R&D expenditure to changes in the user cost of R&D capital. The user cost of capital is defined as the ‘actual costs’ of R&D faced by firm, where the R&D tax incentive is one of the determinants, next to the wage rate of researchers and the price of equipment (Hall & Van Reenen 2000). Another widely used measure is the input additionality, which is defined as the firm’s R&D expenditure that can be attributed to the policy intervention relative to the size of the tax incentive itself (CPB 2014). If a firm spends every euro it saves on taxes on R&D, then input additionality is equal to one; if the firm spends ten percent more than it receives from the tax incentive, input additionality is 1.1 (Ognyanova, 2017).

**Openness** can affect innovation effort of domestic firms through import competition, export and technology import. Import competition encourages R&D investment only in those industries, where the domestic market structure is highly concentrated. When the domestic market is less concentrated, import competition has a negative effect on R&D (Parameswaran, 2010). Trade expansion may increase long-run growth by allowing the economy to specialize in sectors with economies of scale that arise from research, development, and human capital accumulation. Increased competition provides incentives for technological progress and better management and this affects spill over into the non-export sectors. Increased exports enable import of goods, especially intermediate and capital goods. Exports have a positive impact on productivity due to better allocation of resources through specialization based on comparative advantage (Alhahoj, 2007). International trade can have both positive and negative effects. During the period of economic transformation in such countries like Czech and Slovak economies it was a crucial factor of the economic growth (Fitzová, Žídek, 2015). Liu et al. (2014) studies whether liberalization is good or bad for the firms’ R&D in China. The authors compare firms in industries experiencing more liberalization with those in industries experiencing less liberalization. The paper investigates whether trade influences innovation as an important factor determining a country’s economic
growth and long-term competitiveness. The results shows that liberalization reduces a companies’ overall innovation, and this conclusion was robust to a series of checks. Thus, the previous papers grow the interest to include such variable in my thesis and study whether there is any correlation between free trade and R&D expenditures.

*Foreign direct investment.* FDI, providing substantial financial capital, technological know-how and managerial expertise to the recipient economies, play a crucial role. FDI is one of the most important factors behind high economic growth (Erdala and Göçer, 2015). Extant theoretical arguments predict contrasting effects of FDI on firms’ innovative activity. One line of research highlights the benefits to host country firms. Another line of research highlights the deleterious consequences to host country firms. Loukil (2016) finds that FDI has a significant positive impact on innovation in 54 developing countries during period of 1980-2009. A large number of countries have enacted laws aimed at making it easier for firms to invest in their country, while many countries offer various monetary incentives and tax incentives to encourage inward Foreign Direct Investment (FDI). The desire to attract FDI is due not only to the fact that FDI brings in new investment boosting national income and employment, but also due to the expectation that inward FDI would also provide additional spillover benefits to the local economy that can result in higher productivity growth and increased export growth (Loukil, 2016). García, Jin and Salomon (2013) find that FDI inflows into Spain are negatively associated with the ex post innovation of local firms, inward FDI blunts domestic innovation. Among papers that examine impact of FDI on economic growth, the results of researches are also various. Investment is the engine of economic growth and it may be either domestic or foreign direct investment. The foreign direct investment acts as the force of economic growth. More specifically, FDI inflows contribute to economic growth through an increase in productivity by providing new investment, better technologies and managerial skills to the host countries. FDI tends to be directed at those manufacturing sectors and key infrastructures that enjoy actual and potential comparative advantage (Pegkas, 2015). There is also found inconclusive evidence of FDI impact on economic development (Bairagi, 2017). All these evidences from FDI impact on economic growth and innovations rises interest towards the indicator.

*Human capital.* Human capital is the stock of knowledge that people have learned and maintained. The more human capital one economy has the more creative its labour force can
be, thus the more prospects for productivity the economy will have. Higher education is the major source of R&D human capital supply and university knowledge spillovers (Wu, 2005). There are many economists who find strong empirical correlation between schooling and R&D and economic growth. Accordingly, it could be stated that education gives people skills that enable them to be more productive and creative. (Shukarov & Marić, 2016). Having clearly defines rules and regulations, meaning having institutionalized societies, the country can experience prospects for future economic growth. The human capital can have an impact on economic growth only if there is a creation of new job vacancies and higher absorption power for employment. By having high enrolment rate in the graduate schools, and having high investments in the R&D and higher degree of attraction of FDIs, the country can experience high economic growth. More institutionalized countries have lower unemployment rate, higher investments in the R&D but lower FDIs. They seem to manage to follow their created industrial policies, unlike the case of developing countries (Shukarov & Marić, 2016). Iorio et al. (2017) studies if the human capital has a relation with innovative capacity on a sample of European firm. The authors express the variable of human capital as the average number of years of schooling. The results show a statistically significant and positive relationship between the ratio of graduated employees and the percentage of R&D expenditure. Le (2016) argues in his paper that economies need both to accumulate human capital and do research in order to obtain long run balanced growth and there always exists a growth maximizing income tax/R&D subsidy rate. The paper highlights that education and training and R&D activities are both important for growth. Government intervention, through having a good fiscal policy, is also necessary for promoting growth. Sjögren (1998) finds that individuals accumulate human capital and invest in R&D which is carried out by entrepreneurs, the author finds that the long run growth rate of an economy is determined by the capacity of the economy to accumulate human capital. The paper explains that if an economy is poor in output per capita terms compared to its stock of human capital, it will grow quickly if the reason of the low output per capita is that the people are spending their time accumulating human capital instead of working. In this a case, the country has a stable output growth potential which is realized once people change time from school to work. All these facts create a reasonable background for including higher education into our research.
4 DATA. VARIABLES.

For the research there are taken 28 OECD countries and panel data analysis is used. 28 OECD countries that is included into this research are shown in the table 4.1.

**Table 4.1. OECD countries that is included into the research**

<table>
<thead>
<tr>
<th>Australia</th>
<th>Denmark</th>
<th>Japan</th>
<th>Romania</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>France</td>
<td>Lithuania</td>
<td>Portugal</td>
</tr>
<tr>
<td>Brazil</td>
<td>Iceland</td>
<td>Latvia</td>
<td>Slovenia</td>
</tr>
<tr>
<td>Belgium</td>
<td>Ireland</td>
<td>Mexico</td>
<td>Slovak Republic</td>
</tr>
<tr>
<td>Canada</td>
<td>Hungary</td>
<td>Netherlands</td>
<td>Spain</td>
</tr>
<tr>
<td>Chile</td>
<td>Italy</td>
<td>New Zealand</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>Korea</td>
<td>Norway</td>
<td>United States</td>
</tr>
</tbody>
</table>

The data is available for the research on OECD database during 2000-2015. Tax incentive support can be represented as *tax allowance*: the amount of money which a taxpayer is allowed to earn and not pay tax on (taxable income), as a result of carrying out activities defined as eligible R&D, or as *tax credit*: an amount of money that a taxpayer is able to subtract from the amount of tax that they owe to the government (payable tax) as a result of carrying out R&D activities. This thesis includes both tax allowance and tax credits data. It is typically based on a percentage of eligible R&D expenditures. *Direct funding for R&D* covers a variable proportion of the costs of an R&D project, requiring co-financing by beneficiary firms. A key objective of direct funding programs is to induce an “additionality” effect in firms, with the result that they end up investing more of their own resources in R&D than originally planned.

**Empirical model.** An econometric method is used to examine the effect of various dimensions of tax incentives and other explanatory variables on firms’ R&D investment. R&D expenditures is regressed on a set of explanatory variables.

This study examines the impact of R&D tax incentives on innovations and economic growth in OECD countries (Organization for Economic Cooperation and Development). The organization includes 34 countries. The reason of choosing particularly these countries is the availability of data and its reliability. The data is taken from The World Bank Database and
OECD database. During our study we will use panel data analysis and carry out sensitivity analysis of the effect of R&D tax credits on R&D investments and on GDP growth per capita. Thus, depending on the access to reliable data, our research will include 28 OECD countries out of 34 members of OECD during period of 2000-2015.

The paper contains four fixed effects OLS models to investigate an impact of R&D tax support on R&D expenditure, then on GDP growth and third model will consist patents as a dependent variable to investigate if there is any influence on innovations itself. Since it takes a certain period to see a change in dependent variables we are going to add three lags to our models. Also we will add variable country-fixed effect and years-fixed effects.

Scatter diagram with linear fit that shows the relationship between R&D expenditures (R&D exp.) and Tax Incentives (TI) is shown on the figure 4.1(a), R&D expenditures and patents – on the graph 4.1(b) and GDP growth per capita with Tax incentives – on the graph 4.1(c).

**Figure 4.1(a). The relationship between R&D expenditures (R&D exp.) and Tax Incentives (TI)**
Figure 4.1(b). The relationship between R&D expenditures and patents

![Figure 4.1(b)](image)

Figure 4.1(c). The relationship between GDP growth per capita and Tax incentives

![Figure 4.1(c)](image)

Table 4.2 Variables’ interpretations, measurements and source.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Interpretation</th>
<th>Measurement</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D exp.</td>
<td>R&amp;D expenditure</td>
<td>% of GDP</td>
<td>The World Bank database</td>
</tr>
<tr>
<td>GDPg.</td>
<td>GDP growth per capita</td>
<td>Annual %</td>
<td>The World Bank database</td>
</tr>
<tr>
<td>Variable</td>
<td>Observations</td>
<td>Mean</td>
<td>St. Dev.</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------</td>
<td>-------</td>
<td>----------</td>
</tr>
<tr>
<td>Years</td>
<td>464</td>
<td>2007.5</td>
<td>4.614</td>
</tr>
<tr>
<td>R&amp;D exp.</td>
<td>464</td>
<td>1.5975</td>
<td>0.8371</td>
</tr>
<tr>
<td>GDPg</td>
<td>464</td>
<td>2.186</td>
<td>3.563</td>
</tr>
<tr>
<td>Openness</td>
<td>464</td>
<td>84.569</td>
<td>42.3248</td>
</tr>
<tr>
<td>HC</td>
<td>464</td>
<td>60.752</td>
<td>18.5973</td>
</tr>
<tr>
<td>TI</td>
<td>464</td>
<td>0.0612</td>
<td>0.0479</td>
</tr>
<tr>
<td>DF</td>
<td>464</td>
<td>1.2108</td>
<td>2.8295</td>
</tr>
<tr>
<td>Pat</td>
<td>464</td>
<td>53.29</td>
<td>85.35</td>
</tr>
<tr>
<td>FDI</td>
<td>464</td>
<td>5.13</td>
<td>8.89</td>
</tr>
</tbody>
</table>

Table 4.3 Summary statistics is represented in the table below:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Observations</th>
<th>Mean</th>
<th>St. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years</td>
<td>464</td>
<td>2007.5</td>
<td>4.614</td>
<td>2000</td>
<td>2015</td>
</tr>
<tr>
<td>R&amp;D exp.</td>
<td>464</td>
<td>1.5975</td>
<td>0.8371</td>
<td>0.3106</td>
<td>4.2774</td>
</tr>
<tr>
<td>GDPg</td>
<td>464</td>
<td>2.186</td>
<td>3.563</td>
<td>-13.863</td>
<td>24.3765</td>
</tr>
<tr>
<td>Openness</td>
<td>464</td>
<td>84.569</td>
<td>42.3248</td>
<td>19.7981</td>
<td>216.18</td>
</tr>
<tr>
<td>HC</td>
<td>464</td>
<td>60.752</td>
<td>18.5973</td>
<td>7.62</td>
<td>40.69</td>
</tr>
<tr>
<td>TI</td>
<td>464</td>
<td>0.0612</td>
<td>0.0479</td>
<td>0.00095</td>
<td>0.2705</td>
</tr>
<tr>
<td>DF</td>
<td>464</td>
<td>1.2108</td>
<td>2.8295</td>
<td>0</td>
<td>20.3991</td>
</tr>
<tr>
<td>Pat</td>
<td>464</td>
<td>53.29</td>
<td>85.35</td>
<td>0</td>
<td>418.88</td>
</tr>
<tr>
<td>FDI</td>
<td>464</td>
<td>5.13</td>
<td>8.89</td>
<td>-15.98</td>
<td>87.44</td>
</tr>
</tbody>
</table>

Table 4.4 Correlation matrix:

<table>
<thead>
<tr>
<th></th>
<th>R&amp;D exp.</th>
<th>GDPg</th>
<th>Openness</th>
<th>HC</th>
<th>TI</th>
<th>Pat.</th>
<th>DF</th>
<th>FDI</th>
<th>DF*TI</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D exp.</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDPg</td>
<td>-0.2064</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Openness</td>
<td>-0.0733</td>
<td>0.0973</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HC</td>
<td>0.3872</td>
<td>-0.1909</td>
<td>0.2570</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TI</td>
<td>0.4570</td>
<td>-0.1431</td>
<td>0.0500</td>
<td>0.2767</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pat</td>
<td>0.6266</td>
<td>-0.0086</td>
<td>-0.2641</td>
<td>0.2498</td>
<td>0.1846</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DF</td>
<td>0.0935</td>
<td>-0.0034</td>
<td>-0.3489</td>
<td>-0.2847</td>
<td>0.3270</td>
<td>-0.1455</td>
<td>1.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FDI</td>
<td>-0.0855</td>
<td>0.1859</td>
<td>0.3598</td>
<td>0.0058</td>
<td>-0.1269</td>
<td>-0.1477</td>
<td>-0.0781</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>DF*TI</td>
<td>0.1376</td>
<td>-0.0638</td>
<td>-0.2597</td>
<td>-0.1323</td>
<td>-0.3872</td>
<td>-0.1030</td>
<td>0.9422</td>
<td>-0.0799</td>
<td>1.000</td>
</tr>
</tbody>
</table>
5 EMPIRICAL ANALYSIS

We include four models into our study. Three models study an impact of government support on innovative activity. Innovative activity is represented by R&D expenditures as one of indicators and by numbers of registered patents per capita as another indicator of innovations. Last fourth model reflect an impact of government support of R&D on economic growth. GDP growth per capita is used as an indicator of economic growth.

The regression models are presented below in equations 6.1, 6.2, 6.3 and 6.4:

\[ RD_{exp} = \alpha_0 + \alpha_1 TI + \alpha_2 TI_{t-1} + \alpha_3 TI_{t-2} + \alpha_4 TI_{t-3} + \alpha_5 HC + \alpha_6 DF + \alpha_7 DF * TI + \alpha_8 Open + \alpha_9 FDI + \alpha_{10} DF_{t-1} + \alpha_{11} DF_{t-2} + \alpha_{12} DF_{t-3} + \varepsilon \] (5.1)

\[ Pat = \beta_0 + \beta_1 TI + \beta_2 TI_{t-1} + \beta_3 TI_{t-2} + \beta_4 TI_{t-3} + \beta_5 HC + \beta_6 DF + \beta_7 DF * TI + \beta_8 Open + \beta_9 FDI + \beta_{10} DF_{t-1} + \beta_{11} DF_{t-2} + \beta_{12} DF_{t-3} + \varepsilon \] (5.2)

\[ Pat = \lambda_0 + \lambda_1 RD_{exp} + \lambda_2 RD_{exp,t-1} + \lambda_3 RD_{exp,t-2} + \lambda_4 RD_{exp,t-3} + \lambda_5 DF + \lambda_6 DF_{t-1} + \lambda_7 DF_{t-2} + \lambda_8 DF_{t-3} + \lambda_9 HC + \varepsilon \] (5.3)

\[ GDP_g = \gamma_0 + \gamma_1 TI + \gamma_2 HC + \gamma_3 DF + \gamma_4 DF * TI + \gamma_5 Open + \gamma_6 FDI + \gamma_7 DF_{t-1} + \gamma_8 DF_{t-2} + \gamma_9 DF_{t-3} + \gamma_{10} TI_{t-1} + \gamma_{11} TI_{t-2} + \gamma_{12} TI_{t-3} + \varepsilon \] (5.4)

By using the framework described above, we run our models and present the estimation results in the table 5.2. Robust standard errors are represented in the parentheses. Significance level are represented by symbols *, **, *** and correspond to 1%, 5% and 10% significance level respectively.

Due to the dissimilarity of the investigated countries all models suffer from heteroskedasticity. Wald test modified to check for heteroskedasticity. Wald test for heteroskedasticity presented in the table 5.1.
Table 5.1 Test for heteroskedasticity

<table>
<thead>
<tr>
<th>Model</th>
<th>Chi2</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>6.2e+31</td>
</tr>
<tr>
<td>5.2</td>
<td>4.9e+05</td>
</tr>
<tr>
<td>5.3</td>
<td>5676.88</td>
</tr>
<tr>
<td>5.4</td>
<td>1063.47</td>
</tr>
</tbody>
</table>

We find severe heteroskedasticity that is why in the table 5.2 robust standard errors. Summary table gives us some general information about our data. Sample size is varying between 390 and 470 observation and that is enough amount of observations to reduce uncertainty of the empirical results. The correlation matrix did not indicated severe correlation more than 51% between variables, it decreases probability having multicollinearity. R-squared or the coefficient of determination in the first model is equal to 30% and the closer it to 100% the better the model and vice versa. So 30% of the variation R&D expenditures is explained by all of the explanatory independent variable, and it means that 70% is still not explained or error in the model.

Model 5.1. P-values show significance level of our coefficients. In the model there are four significant values that are variables tax incentives, interaction term tax incentives with direct funding, foreign direct investments and openness. These coefficients are significant at 1%, 10%, 10% and 1% significant level respectively. That means we can rejects null hypothesis that R&D expenditures has no relationships with the mentioned variables. Thus, tax incentives, direct funding, FDI and openness have significant effect on R&D expenditures and we are confident 99%, 90%, 90% and 99% level respectively that these coefficients do not equal zero and have a significant effect on R&D expenditures.
Table 5.2a. Estimation Results: The Impact of R&D public support on R&D expenditure (model 5.1) and patents (model 5.2)

<table>
<thead>
<tr>
<th>Dependent: R&amp;D exp.</th>
<th>Model 5.1</th>
<th>Dependent: Pat.</th>
<th>Model 5.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>TI</td>
<td>3.5415*** (0.7341)</td>
<td>TI</td>
<td>-54.07 (86.50)</td>
</tr>
<tr>
<td>DF</td>
<td>-0.102 (0.1155)</td>
<td>DF</td>
<td>15.20** (0.008)</td>
</tr>
<tr>
<td>DF*TI</td>
<td>0.89* (0.513)</td>
<td>DF*TI</td>
<td>86.59* (0.56)</td>
</tr>
<tr>
<td>TI_L1</td>
<td>-0.282 (0.074)</td>
<td>TI_L1</td>
<td>22.10 (101.22)</td>
</tr>
<tr>
<td>TI_L2</td>
<td>0.763 (0.038)</td>
<td>TI_L2</td>
<td>77.70 (100.80)</td>
</tr>
<tr>
<td>TI_L3</td>
<td>-0.134 (0.032)</td>
<td>TI_L3</td>
<td>138.41** (0.041)</td>
</tr>
<tr>
<td>DF_L1</td>
<td>-0.004 (0.035)</td>
<td>DF_L1</td>
<td>-0.66 (0.0034)</td>
</tr>
<tr>
<td>DF_L2</td>
<td>-0.018 (0.036)</td>
<td>DF_L2</td>
<td>-0.12 (0.0033)</td>
</tr>
<tr>
<td>DF_L3</td>
<td>0.0063 (0.028)</td>
<td>DF_L3</td>
<td>0.12 (0.0026)</td>
</tr>
<tr>
<td>Open</td>
<td>0.00347* (0.0018)</td>
<td>Open</td>
<td>-0.763 (0.021)</td>
</tr>
<tr>
<td>HC</td>
<td>-0.00018 (0.003)</td>
<td>HC</td>
<td>-2.03 (0.064)</td>
</tr>
<tr>
<td>FDI</td>
<td>-0.0051*** (0.0023)</td>
<td>FDI</td>
<td>-1.79 (0.0050)</td>
</tr>
<tr>
<td>Number of observations</td>
<td>464</td>
<td>464</td>
<td></td>
</tr>
<tr>
<td>Time fixed effect</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Country fixed effect</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Robust SE in parenthesis</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.2b. Estimation Results: The Impact of R&D expenditure on R&D patents (model 5.3) and R&D support on economic growth (model 5.4)

<table>
<thead>
<tr>
<th>Dependent: Pat.</th>
<th>Model 5.3</th>
<th>Dependent: GDPg</th>
<th>Model 5.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;Dexp.</td>
<td>0.00544 (0.07)</td>
<td>TI</td>
<td>-3.314 (6.92)</td>
</tr>
<tr>
<td>R&amp;Dexp _L1</td>
<td>70.093** (0.03)</td>
<td>DF</td>
<td>0.039 (0.566)</td>
</tr>
<tr>
<td>R&amp;Dexp _L2</td>
<td>41.055** (0.05)</td>
<td>DF*TI</td>
<td>-0.254 (3.84)</td>
</tr>
<tr>
<td>R&amp;Dexp _L3</td>
<td>11.021** (0.06)</td>
<td>TI_L1</td>
<td>5.81 (8.16)</td>
</tr>
<tr>
<td>DF</td>
<td>5.77** (0.028)</td>
<td>TI_L2</td>
<td>2.06 (8.14)</td>
</tr>
<tr>
<td>DF_L1</td>
<td>1.95** (0.09)</td>
<td>TI_L3</td>
<td>-2.94 (6.33)</td>
</tr>
<tr>
<td>Variable</td>
<td>Coefficient</td>
<td>Standard Error</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>--------------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>DF_L2</td>
<td>0.915**</td>
<td>(0.09)</td>
<td></td>
</tr>
<tr>
<td>DF_L3</td>
<td>4.107***</td>
<td>(0.04)</td>
<td></td>
</tr>
<tr>
<td>HC</td>
<td>-1.48</td>
<td>(3.78)</td>
<td></td>
</tr>
<tr>
<td>Open</td>
<td>0.0434***</td>
<td>(0.013)</td>
<td></td>
</tr>
<tr>
<td>HC</td>
<td>0.0029</td>
<td>(0.023)</td>
<td></td>
</tr>
<tr>
<td>FDI</td>
<td>0.0827***</td>
<td>(0.0178)</td>
<td></td>
</tr>
</tbody>
</table>

| Table 5.2 shows the relationship between registered patents and independent variables.

We are allowed to interpret significant coefficients. The coefficient of tax incentives is 3.54, and it is positive. So we can say R&D expenditure has a positive significant relationship with tax incentives and an increase by one percentage point in tax incentives will lead to 3.54 percentage point increase in R&D expenditure. Therefore, an increase by one percentage point in foreign direct investments will lead to 0.0051 percentage point decrease in R&D expenditures. This goes in contrast with previous papers that showed evidence of negative relationship between innovative activity and FDI in developing countries during 1998-2009 (Loukil, 2016) and positive relationship in developed countries but negative in developing (Dhrifi, 2015).

The variables that reflects openness has positive and significant impact on R&D expenditure. Thus, a percentage point increase in openness can lead to 0.0034 percentage point increase in R&D expenditure. The increase in tax incentives in combination with direct R&D support could lead to increase in R&D expenditure by 0.89 percentage points.

Model 5.2 defines if there is any relationship between registered patents and studied independent variables. The coefficient of determination equals to 38% consequently, 38% in variation of amount of registered patents is explained by independent variables. Tax incentives (three years lag), direct funding per capita and interaction
term of tax incentives with direct funding have significant impact on our dependent variable. Thus, coefficient of DF*TI is significant at the 10% significance level. If a combination of such state support like tax incentives and direct funding would result in a growth of one percentage point, we could expect approximately 86 new registered patents. Meanwhile separately increase in direct funding support could lead to 15 new registered patents.

To see an effect of tax incentives and direct funding over time, we added three lags to each coefficient. Thus, empirical results show that the tax incentives can give a positive and significant effect on patents in three year after introducing. Thus, we expect that 138 new patents per 100 000 inhabitants are expected to be registered when tax incentives increase by one percentage point on the third year of introducing. Direct funding turned up significant at 5% significance level compared to tax incentives and one percentage point increase in direct funding would cause increase in patents by 15 approximately. Though, together with tax incentives the effect could be much bigger. So, increase in tax incentives together with direct funding could lead to increase in registered patents by 86. The major concern of the model 5.3 is to show the efficiency of R&D expenditure measures by patents. Thus, R&D research takes times to show results and effect of R&D expenditures on patents is significant and positive with lag of 1, 2 and 3 years. The results show that increase in R&D expenditure will lead to increase in patents by 70, 41 and 11 after one, two and three years since introducing respectively. Direct funding for R&D also make positive significant effect on patents. Thus, an increase in the direct funding support leads to increase in registered patents by 5 directly and each next year by 1.95, 0.9 and 4 respectively.

In the model 5.4 where was defined relationship between GDP growth per capita and explanatory variables, R-squared is 51% and this means that 51% of variations in GDP per capita is explained by independent variables and 49% is error term. P-values show that variables openness and foreign direct investment have significant effect on GDP growth. Both coefficients are significant at 1% significance level and they are positive. Thus, there is an evidence of positive and significant relationship between openness and GDP growth, and also FDI and GDP growth. One percentage point
increase in openness could lead to increase in GDP growth by 0.043 percentage point. An increase in foreign direct investment could lead to increase in GDP growth by 0.082 percentage point. The same as examined previous papers we did not find an evidence of significant correlation between economic growth and tax incentives.

6 CONCLUSIONS

In this final section, we summarize the major findings of regression analysis and estimation results and interpret them. We discuss the possible implications of these major findings and conclude the study.

The study’s major findings reveal that: tax incentives have a positive significant effect on R&D expenditure in OECD countries during 2000-2015, direct funding for business R&D makes positive significant effect on patents. Tax incentives, though, start to make positive effect on patents on the third year after they are introduced.

Another finding in the study is positive significant effect of openness on the R&D expenditures. Ruiz (2013) claims that the OECD countries have relatively higher percentage of openness in GDP, consequently our imperial results can be explained by previous findings: firms that are located in industries with a greater exposure to foreign openness, invest a greater amount in R&D contributing to industry productivity growth (Ruiz, 2013).

Our study finds positive and significant impact of direct funding for R&D on patents in OECD countries. Such results can be related to the fact that sample of chosen countries has a large number of small firms and regional subsidy programs. Previous studies in European countries showed that the smaller firm the greater the impact of the policy on the intensity and probability of patenting. Another policy implication says that the regional program seemed to be more effective than national programs (Bronzini and Piselli, 2016). The model also shows positive significant effect of interaction term tax incentives and direct funding.
Taking into account other indicators of economic growth, the study shows that openness and foreign direct investment have significant positive impact on economic growth in OECD countries. Our regression model, that estimates impact on economic growth, shows no clear evidence of significant effect of R&D tax incentives on GDP growth.

Thus, the empirical results show a significant and positive effect either tax incentives on R&D expenditure in the model 5.1, or direct R&D funding on patents in the models 5.2 and 5.3. There is no evidence of significant effect of both policy tools in one model. Meanwhile combination of these two policies (interaction term) makes a positive and significant effect on both R&D expenditure and patents. It means that if the aim would be increase not only R&D expenditures but also amount of registered patents, it would require applying both types of R&D support. Direct funding and tax incentives are not perfect substitutes in terms of their ability to reach firms experiencing barriers associated to market failures; one size may not fit all in innovation policy when the type or intensity of market failure differs across firm size, and subsidies may be better suited than tax credits to encourage firms, especially young knowledge-based firms, to start doing R&D. It means that policy should include all three directions that motivate innovative activity: patent protection, direct funding for business R&D and tax incentives for business R&D. Thus, we suggest applying the policy of R&D support by including both types of support: tax incentives and direct funding for business R&D since it allows to use fully all the levers of government public support for innovations (for instance if France, Denmark, Spain, the United Kingdom and the United States use both instruments simultaneously, while exclusive reliance on direct funding is still preferred in Sweden, Finland or Germany (OECD 2011).

This study has left some questions unanswered, and hopefully this will give inspiration to further research on R&D support. Size of firms, connections with government, patent protection could be added to the study. There are still uncovered questions in terms of bureaucrats and how to decide who will get a support for R&D.
For the future research it would be useful studying knowledge spillovers more in
details, this would show social aspect of the policy and not only private benefits. We
also did not take into account localisation of the R&D tax incentives, impact of tax
incentives on innovations depending on the regions where R&D support can be
introduced.

The government still cannot know, what research and development project will be in
the future successful and therefore should be financed by public budgets. These
conclusions still make the field of R&D support very ambiguous and complicated that
requires improvement and hard work at it.
REFERENCES


