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# THE IMPACT OF TAX INCENTIVES ON RESEARCH AND DEVELOPMENT

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## Abstract

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The goal of this article is to analyze the impact of tax incentives on research and development and compare its effectiveness to direct government support of research and development. The analysis is based on regression analysis, which compares effect of tax incentives for research and development and direct government support (as percentage of GDP) in 28 countries of OECD in 2013 on innovative effectiveness of these countries measured by number of registered triadic patent families per billion GDP in the same year. Results suggest that tax incentives are more effective form of research and development support than direct government funding. Research also revealed interesting case of Switzerland's research and development performance backed by almost none government support, which should be subject to future study.

Keywords: Tax incentives, research and development, government funding, triadic patent families

## INTRODUCTION

Research and development is today very important in modern knowledge-based economies. Advanced knowledges across many fields of industry can significantly contribute to competitive advantage of one economy over another. Already in the past, economists have identified innovation process of business as one of key element of economic growth (Schumpeter, 1939) (Kuznetz, 1966) (Kirzner, 1973) (Mises, 2006). Corporate research and development expenditures are a main component of inventive activity (Bhagat, Welch, 1994). It is no wonder that sooner or later governments all around the world realized this connection between research and development of business and increased wellbeing of country's society. With this realization they started their efforts to stimulate research and development process. Nowadays, all 34 member states of OECD use some kind of government support of research and development. This support recorded significant increase in time of beginning of economic crisis in 2008–2009 as result of major drop in business research and development financing. In 2010 business research and development recovered and government support has declined. Yet since 2013 we can see increase of government support of research and development again. Governments can adopt various ways how to promote research and development. One of the support tools are tax incentives for research and development. The trend in the period 2000–2013 was increase of percentage of tax support as share of total government support of research and development in advanced knowledge-based economies like France, Japan, the Netherlands or the United Kingdom and remaining of fairly stable tax support in the United States and Canada.

The goal of this article is to analyze the impact of tax incentives on research and development and compare its effectiveness to direct government support of research and development. As the method of research was selected regression analysis, which compares amount of tax incentives for research and development and direct government support (as percentage of GDP) in 28 countries of OECD in 2013 on innovative effectiveness of these countries measured by number of registered triadic patent families per billion GDP in the same year

## Background research

There are many ways how government can support research and development and there has always been the conflict between liberal and etatist economists, whether actually state should support research and development and if so, what is the best way to do it. First, let's look on the very famous example from history described by Becker as "Miracle from Silicon Valley" (Becker, 2000). Silicon Valley, home to many of the world's largest high-tech corporations and thousands of startup companies, started in 1950's as humble project of Stanford's Engineering School dean, to create an industrial park on unused Stanford land. Over few decades, the region has become world's main base for IT hi-tech leading companies like Apple, Intel, IBM or Cisco Systems. In 1999, Silicon Valley already employed over a million persons with 40 % of them having university degree of some kind. Same year, over 6 billion dollars were invested into local companies in form of venture capital. Two nearby universities, Stanford and University of California, with strong science and engineering departments cooperate with Silicon Valley. With all these characteristics Silicon Valley is the shining example of successful research and development project. The most interesting point is that miracle from Silicon Valley happened without government help of any kind, no direct or indirect support. The essence of success was flexible capital and labor market and liberal conditions for company startup. Conversely, major attempt from government to help Silicon Valley in 1986 in form of antidumping restrictions on import of semiconductors from Japan actually backfired terribly and slowed innovation progress in the region. Meanwhile other countries tried to build their own Silicon Valley with the help of strong government subsidy programs like Germany for example, but failed. According to Becker's opinion problem of subsidies is that state bureaucracy supports only safe projects, not risky ones, but very risky projects are proving to be most successful on the field on innovation in hi-tech industries.

On the field of scientific research, there are already many studies about effects of government support for research and development and these studies are often in contradiction giving no clear answer together. There are a few ways how to measure effects of government support of research and development. Researches mostly focus on changes in spending on research and development induced by government support with some exceptions. Cordes in his study (Cordes, 1989) measured effect of research and development tax credits in the United States on business research and development spending. He concludes that tax credits demonstrably had some effect on research and development spending but it is difficult to estimate the magnitude. The estimate is that incremental twenty-five percent research and development tax credit could stimulate between $0.35 and $0.93 of additional business research and development spending per each one dollar of tax revenue forgone. Hall and Reenen made similar study (Hall and Reenen, 2000), exploring the effects of tax systems in OECD countries on the user cost of research and development. They conclude one dollar in tax credits for research and development stimulates dollar of additional research and development. In more specific study McCutchen (McCuthen, 1993) explored impact of research and development tax credits on spending of strategic groups in pharmaceutical industry in the United States after Economic Recovery and Tax Act of 1981, which provided a 25 percent tax credit for increases in research and experimentation expenditures. The conclusion is that tax incentives caused an increase in research and development expenditures in the industry. Also tax incentives contributed to increase competitive spending among the pharmaceutical companies in research and development. Leyden and Link made study (Leyden and Link, 1993), which compared effects of tax policies on research and development spending in the United States, Canada, Japan and Sweden in 1980's period. The empirical evidence on the effectiveness of research and development tax credits is mixed. Even thou research and development spending in explored era raised, there is disagreement whether it was induced by tax credits or not. González and Pazó (González and Pazó, 2005) also explored impact of government support, this time in form of public subsidies for Spanish manufacturing companies in 1990's, for research and development spending. They conclude that public subsidies for research and development have no effect on private research and development spending, however there is no crowd out effect of these subsidies and total spending on research and development is increased. With different conclusion comes Clausen in his paper about effects of subsidies on research and development (Clausen, 2007). Results of his research shows that research subsidies stimulate private activity, mainly by increasing research expenditures, and has positive impact upon quality of research and development done at the firm level, while development subsidies decreases private development expenditures because of substitution effect. Study made by Busom, Corchuelo and Ros (Busom, Corchuelo and Ros, 2012) focused on question what kind of government support for research and development do companies use and why using firm-level data from Spanish Community Innovation Survey (CIS). They found out that use of type of government support depends on company size as well as other conditions. Large companies that care about knowledge protection, companies facing financial constraints and newly created firms are more likely to use direct government support. Small and medium enterprises are more likely to use tax incentives. Interesting study was made by Bloom, Griffith and Reenen (Bloom, Griffith and Reenen, 2007). In this study authors examined impact of research and development tax incentives on the level of research and development investments in nine OECD countries over period 1979–1997. They conclude that tax incentives are effective in increasing research and development intensity. They estimate a ten percent drop in cost of research and development will bring in the future one percent increase in level of research and development in short term and almost ten percent increase in long term. Russo in his study (Russo, 2014) made cost-benefit analysis of research and development tax incentives. He finds mixed evidences of effectiveness of tax incentives on research and development. He states incremental and comprehensive research tax credits create relatively large increase in research efforts measured as the proportion of skilled labor employed in the innovative sector. Lower corporate income tax rate and investment tax credits are less effective in research efforts for downstream users of innovative inputs and ineffective for upstream producers of innovative goods.

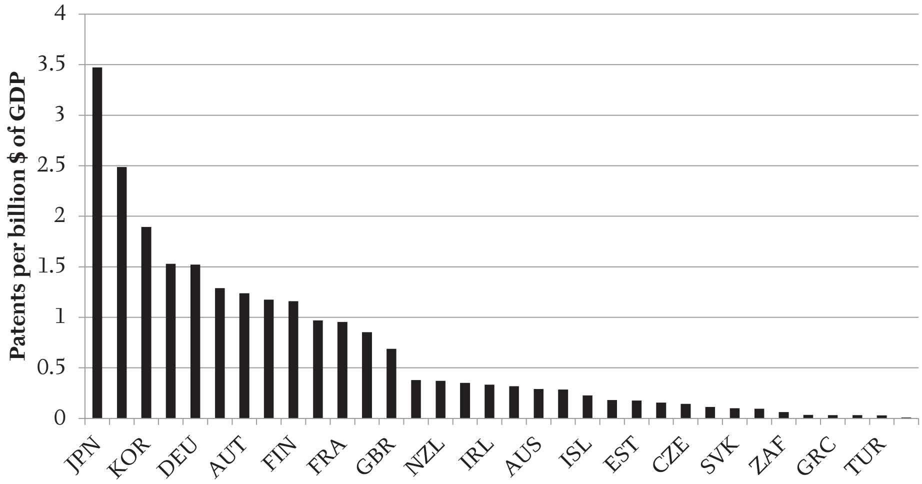
The most valid approach in our opinion, as discussed in next chapter, is used in study made by Cappelen, Raknerud and Rybalka (Cappelen, Raknerud and Rybalka, 2008). They measured effects of tax credits on patenting activity of companies in Norway after introduction of SkatteFUN, Norwegian tax-based incentive in 2002. They come to conclusion that projects receiving tax credits result in the production of new production processes and products for the firm, however the scheme does not have impact on innovation in form of new products for the market or patenting.

## MATERIALS AND METHODS

In our opinion the problem of all above mentioned studies, with exception of one made by Cappelen, Raknerud and Rybalka, is that they measure the impact of government support mostly by changes in spending and investment on research and development or changes in research effort. But society does not support research and development by its sources just to report increased expenditures or investments; it expects increase of real results of research and development in form of new knowledge, technology or something that can increase wellbeing of its members. Increased spending on research and development or investments alone do not guarantee increase of useful results of research and development. Because of this logic, we think that impact of government support should be measured by changes in patent activity, which represents real results.

In contrast with Norwegian study, which was closely focused on research and development in Norway and one tax incentive program SkatteFUN, our study tries to bring much broader perspective on tax incentives and patenting activity. We compare tax incentives of 28 OECD members and their patenting activity in 2013 trying to find link between the data. As the suitable method for analysis was selected regression analysis, because of need to include other variables, which can possibly influence patenting activity of countries.

As stated above, we think that impact of government support should be measured by real results of research and development in form of new patents. For this reason we use number of triadic patent families per one billion dollars of GDP as dependent variable in regression model. Triadic patent family is set of patents registered at three major patent offices to protect same invention. These offices are European Patent Office, the Japan Patent Office and the United States Patent and Trademark Office. Triadic patent family counts are contributed to the inventor's country of residence (OECD, 2016). Fig. 1 bellow shows number of triadic



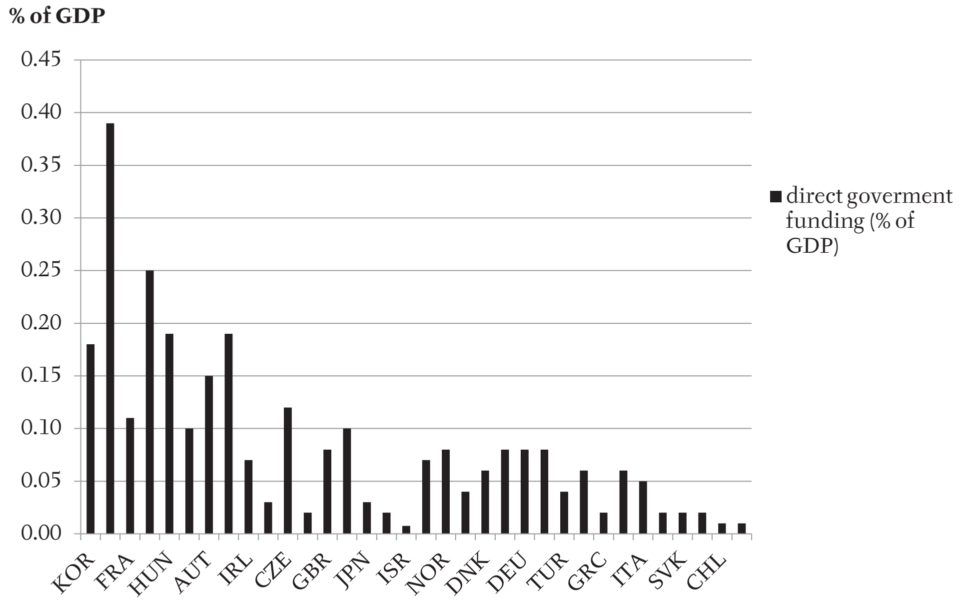

1: *Number of triadic patent families per billion dollars of GDP in 2013*
Source: OECD, triadic patent families 2016

patent families per billion dollars of GDP scored by examined countries in 2013.

Two main independent variables in the regression model were selected tax incentives and direct funding of research and development measured by OECD as the percentage of GDP. Data of analyzed countries was taken from OECD's Science, Technology and Industry Scoreboard 2015 (OECD, 2015). Values of these variables for examined countries in 2013 shows Fig. 2 bellow. Apart from these two variables the regression model was expanded by four additional independent variables to capture other possible influences on patenting performance of the countries. Data for these variables were collected from World Bank database (World Bank, 2016). These variables are gross domestic product per capita; industry share on creation of gross domestic product; effective corporate tax rate and starting the business ease score. Gross domestic product per capita and share of industry on creating of gross domestic product captures economic development of the countries which can affect research performance. Effective corporate tax rate and starting the business ease score captures attractiveness of the country for new investors and entrepreneurs. Starting a business ease score is based on number of procedures needed to create a new business, time needed for creation a new business measured in days, cost of creating a new business and minimum capital needed.

In the Tab. I are descriptive statistics of all variables in regression model. As the appropriate regression model was chosen semi-logarithmic model, where variables GDP per capita and Patents per GDP were transformed to logarithmic values because of wider range of its values.

The expected outcome of regression analysis is that tax incentives will be statistically more significant than direct government funding and there will be positive correlation between tax incentives and patents per GDP. We assume these results because tax incentives seems to be better tool for support of research and development based on previous researches mentioned in previous chapter, historical experience from Silicon Valley industrial complex described by Becker and also




2: *Direct government funding and tax incentives for research and development in 2013*
Source: OECD, Science, Technology and Industry Scoreboard 2015

I: *Descriptive statistics of variables*

| Variable | Mean | Median | Minimum | Maximum | Std. deviation |
|---|---|---|---|---|---|
| **Patents per GDP** | 0.675 | 0.325 | 0.009 | 3.473 | 0.796 |
| **Tax incentives as % of GDP** | 0.0769 | 0.06 | 0.001 | 0.26 | 0.073 |
| **Direct government funding as % of GDP** | 0.0834 | 0.065 | 0.007 | 0.39 | 0.08 |
| **GDP per capita** | 35790.3 | 36077.5 | 12200 | 66812 | 12744.7 |
| **Industry share on GDP** | 0.280 | 0.269 | 0.163 | 0.436 | 0.062 |
| **Effective corporate tax rate** | 0.429 | 0.43 | 0.199 | 0.687 | 0.127 |
| **Doing the business ease score** | 0.890 | 0.896 | 0.685 | 0.999 | 0.041 |

Source: authorial computation

II: *Results of regression analysis, statistically significant independent variables*

| Indp. variable | Coefficient | Std. error | t-ratio | p-value |
|---|---|---|---|---|
| **Const.** | –25.644 | 6.272 | –4.072 | 0.0004*** |
| **Tax incentives** | 6.429 | 2.602 | 2.471 | 0.0201** |
| **l_GDP per capita** | 2.563 | 0.506 | 5.058 | <0.0001*** |
| **Adjusted R square = 0.524**<br>**P value (F) = 0.00013** | | | | |
| **White's test: $H_0$: there is no heteroscedasticity**<br>**p-value = 0.58** | | | | |
| **Test for normality of residuals: $H_0$: residuals have normal distribution**<br>**p-value = 0.392** | | | | |

Source: authorial computation

logical reasoning. We think the reason for higher effectiveness of tax incentives on patenting activity is because its flat use in business. Wide variety of business can reach for tax incentives, but only limited number of companies can access direct government funding. Tax incentives can support creation of real innovative and sometimes risky ideas. On the other hand direct government funding goes to companies which are best in persuading bureaucrats outside of business that they can make best use of these subsidies, but in the end they come up with no real innovation and money are wasted.

## RESULTS AND DISCUSSION

Results of the regression analysis are shown in Tab. II. Only statistically significant independent variables are displayed. Dependent variable is number of triadic patent families per one billion dollars of GDP.

Results of the regression analysis show that there is positive link between tax incentives and research and development performance measured by number of triadic patent families. Countries with higher amount of tax incentives for research and development tend to produce higher number of triadic patent families. However the same does not apply for direct government support of research and development. This independent variable was statistically insignificant (p-value = 0.6198) in the regression analysis. Not surprisingly, also economic development represented by variable GDP per capita is important for better research and development performance of the country. However, in this case it is not entirely clear if GDP per capita affects research and development performance or vice versa.

Results of this study confirm previous studies which conclude that tax incentives have positive effects on research and development. Also our results are consistent with Becker's opinion described in his "Miracle from Silicon Valley". Countries focusing on supporting research and development in form of tax incentives are more successful in obtaining palpable results in form of patents because tax incentives is more blanket tool that can reach more companies with more risky innovative ideas. On the other hand, bureaucrats are deciding, who will get direct government support and which research and development will be financed. But no bureaucrat can naturally know, what technology or innovation will be successful or even revolutionary in next five or ten years. Nobody actually knows that. For example before World Wide Web was invented, who could knew it will be so revolutionary invention that will change the whole world? Definitely not bureaucrats, who decide what research will be financed. Direct government support is therefore sort of gamble with public money. Because of this, bureaucrats tend to not support risky or even crazy innovative ideas, but history shows us that the risky ideas are the ones with highest potential and most successful (Becker, 2000).

It is interesting to look at some countries in the analysis individually. Russia has second largest public support of research and development in 2013 (0.41 % of GDP). Almost all of this support is in form of direct government funding (0.39 % of GDP) and negligible part in form of tax incentives (0.02 % of GDP). Despite this large support, Russia scored in 2013 only 0.03 triadic patent families per billion dollars of GDP, that is third lowest from all tracked countries. That is almost one hundred times lower than Japan had (3.47). But Japanese distribution of research and development support is 0.13 % of GDP in form of tax incentives and only 0.03 % of GDP in direct support. But not all countries with higher share of tax incentives in their research and development support score high number of triadic patent families per billion dollars of GDP. Canada's distribution was 0.18 % of GDP in form of tax incentives and only 0.03 % of GDP in form of direct support in 2013. Its number of triadic patent families per billion dollars of GDP was only 0.38. Still this is more than ten times higher than Russia had with Canada giving only 0.21 % of GDP total into research and development support (almost half of support of Russia in total). The most curious cases are Germany and especially Switzerland. These two countries scored very high number of triadic patent families per billion dollars of GDP despite low total support of research and development in 2013. Germany had total support of 0.08 % of GDP, all in form of direct government funding and scored 1.52 triadic patent families per billion dollars of GDP. Switzerland had just only 0.02 % of GDP total support of research and development, also all in form of direct government funding and scored incredible 2.48 triadic patent families per billion dollars of GDP, second highest of all tracked countries. Putting this to contrast with Russia and other countries (Slovenia, Hungary) with high total support of research and development but low research and development results, this shows that it clearly does not depend only on support of research and development but also other factors, like GDP per capita for example and others. The extraordinary case of Switzerland should be examined in the future research for new interesting findings about factors of successful research and development.

## CONCLUSION

This article analyzed the impact of tax incentives on research and development and compared its effectiveness to direct government support of research and development. Analysis showed that tax incentives are more effective form of research and development support than direct government funding. Effectiveness was measured by number of triadic patent families per billions of dollars of GDP produced by tracked countries in 2013, because in our opinion it is better indicator of effectiveness of research and development support than changes in research and development expenditures or investments that was examined in most previous studies. We think the reason for higher effectiveness of tax incentives on patenting activity is because its flat use in business. On the other hand, bureaucrats are deciding, who will get direct government support and which research and development will be financed so this tool is much more individual. But bureaucrats do not (and even can't) know, what research and development project will be in future successful and therefore should be financed by public budgets. Logically, money from direct government support will not obtain companies with best innovative ideas, but companies which can persuade bureaucrats that they can produce best innovative ideas and that is significant difference that can decrease patenting performance of the state. As the logical conclusion, policy recommendation for government is to focus on tax incentives and minimize direct government support. Tax incentives can reach more companies, especially new companies with very innovative and also risky ideas, which do not have resources necessary to succeed in tough competition for direct government subsidies. This may lead to better research and development performance of the country measured by number of triadic patent families per GDP.

However closer look at individual countries in the analysis and their patenting performance revealed interesting information. This information suggests that other factors than support of research and development play also important role in patenting performance of the country. Most curious is case of Switzerland, which has close to zero support of research and development yet its patenting performance is second highest from all tracked countries in the analysis. Further analysis of Switzerland's research and development should be made in future for new interesting findings about factors of successful research and development. Also another future research in this area should focus on comparing real values of number of triadic patent families in selected countries and corresponding values from the regression equation. Explaining the difference between these values could bring new ideas what are other important factors in research and development performance.

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