MACROECONOMY CONDITIONS AND S&T DEVELOPMENT[117]

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Abstract

The paper is devoted to the issues of interconnectedness of S&T development and macroeconomic conditions. Despite of a bulk of studies on the impact of innovation and S&T expenditures on economic growth, there is a lack of studies which try to capture influence of economic development on innovation and S&T patterns. Thus in this paper we have tried to find statistical interrelations between a number of macroeconomic indicators and R&D intensity of GDP as the main indicator of S&T development. The scope of the study covers all countries which send their data to the World Bank database and UNESCO Institute of statistic during 2000-2011. Analysed period reflects one full business cycle from the end of the previous crisis (end of 90es) to the end of the last one (end of 2000-es). Number of quite interesting evidence were identified in the paper. First of all it concerns the fact that R&D policy does not heavily depend on some macroeconomic indicators such as cash balance, the level of industrialization but it rather depends on the level of natural recourses endowment, cost of capital, macroeconomic stability as well.

Keywords: macroeconomic indicators, R&D intensity.
JEL Classification: O1, O32, O33

Introduction

As innovation and S&T development are considered the one of the major engine for economic growth there a lot of studies to measure the impact of innovation as well as R&D on the growth. Well-known Solow model developed in 60s is one of the first studies regarding this issue. The comprehensive analysis of the most popular models of economic growth was done by *Aghion Ph. and Howit P.* (2009). In the last 10-15 years there were a lot of studies based on micro data, that allowed to demonstrate how innovation and R&D influence firm performance (see *Doraszelski U., Jaumandreu J.,* 2013). Efficiency of different policy measures is another popular issue of economic research on innovation. Government subsidies and tax credits are the most discussable of them. *Zuniga-Vicente J.A et all* (2012) has analyzed a bulk of studies regarding the impact of public subsidies and tax credit on R&D. They found that 60% of these studies showed positive impact of policy measures on R&D activity . *Mohnen P. and Lokshin B. (*2012) argued that effectiveness of policy measures, in particular tax credit, is highly depended on circumstances and conditions, where these measures were applied. We agree with this point and state that macroeconomic conditions are key factor of policy effectiveness.

Despite this the number of studies related to the influence of macroeconomic conditions on R&D and innovation is limited. Thomson N. *and Stam E.*(2010) have presented own research results on macroeconomic dynamics and innovation performance of SME in the Netherlands. They used Logit models to test following hypotheses:

- Consumption is positively correlated with product innovations;
- Unemployment is positively correlated with product innovations;
- Cost of capital is negatively correlated with product innovations;
- GDP growth and product innovation are not correlated;
- Real GDP growth is negatively correlated with product innovations.

Time period of the study covered 1999-2009 that is corresponded to the business cycle. Evidence that real GDP growth in the Netherlands is positively correlated with innovations is one of the most important results of this study. However, industries with traditionally high innovation activities are not sensitive to macroeconomic dynamics, they do innovate regardless the economic situation as

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innovation is an important part of their strategies. Usually these industries are capital intensive so termination or delaying innovation projects may lead them to damaging adjustment costs.

Also we found some papers, where the impact of specific issues on innovation development was studies. So, *Aghion P. et all (*2009) found that higher competition lead to more intensive innovation activity. This view is also confirmed by *Hashmi A. (2013)* , but it is true only for industries on the technology frontier. *Jones C*. (2005), and *Toivanen O., L. Väänänen* (2010) studied the impact of education on innovation activity. The results of both studies proved that education level positively affects innovation activity.

At the same time there is no consensus on impact of FDI on innovation and R&D development. Some researchers argued that technology import (as part of FDI) compliment domestic R&D, others suggest that such import will lead to shrinking of domestic S&T activities in developing countries (*Kathuria V.*, 2008).

Given that this paper is an attempt to find correlation between macroeconomic indicators and R&D development in global context.

Data

The quality of data is an important issue that affects the results of every study. To avoid major problems on comparability of data among countries we used only two databases. World Bank Indicators covers data on a lot of macroeconomic indicators as well as covers other specific fields like S&T and education. The database of UNESCO Institute of Statistic is the second source. There are more detailed data on R&D financing in this database.

Initially we planned to cover all 214 countries presented in the World Bank Indicators database. But only approx. 70 of them provided necessary data on more or less regular basis. The rest of countries are very small and their economies are poor (with few exceptions, like Israel) we consider that they will not affect much our results

Methods

To achieve the aim of our study we decided to use quite simple technique of scatter plotting. Despite econometric modelling which has strict requirements to quality of the data, scatter plots provide general insight on the correlations between different issues.

The level of R&D expenditures as percent of GDP (R&D intensity) is depended variable representing S&T area. Additionally we used the level of expenditures on R&D conducted by business sector as percent of GDP (business R&D intensity). It helped us to address innovation oriented activity.

There were following macroeconomic indicators used in the analysis:

- real GDP growth (higher growth might lead to higher innovation and R&D expenditures),
- standard deviation of real GDP growth (as a proxy of stability, we expect that higher instability negatively correlate with R&D development)
- budget revenues as percent of GDP (more money government has more expenditure might be directed on R&D),
- cash deficit (we suppose that there is no correlation between cash deficit and S&T financing, while some governors in developing countries try to cut R&D expenditures when cash deficit is high),
- real interest rate (it reflects the cost of money for business sector, so it may be expected that there is negative correlation with business expenditures on R&D),
- inflation (as it reflects macroeconomic stability, we expect that high level of inflation will negatively correlate with R&D expenditures),
- share of value added generated by industry (one may expect that more industrially developed country is then more innovation and R&D developed it should be);
- share of profit tax in general amount of enterprise profit (it should be negative correlations among these indicators, as amount of money which enterprise may spend on innovation or R&D will be lower with increasing the tax burden),
- FDI as percent of GDP (it might be expected that more FDI coming into economy will lead to innovation activity increasing, but also it may damage in-house R&D),
- natural resources rent as percent of GDP (higher rent means that country's economy is not innovative driven so R&D activity should be low);

- receipts for the use of intellectual property as percent of GDP (it reflects economic output of R&D effeciency and it is expected that there is a positive link with the R&D expenditures).

To capture possible differences caused by the size of economy and level of economic development we divided analysed countries into 3 groups (low, middle and high income countries) by the level of GPD income per capita. We did not use World Bank classification, and calculated the limits through percentiles (33 and 67%). So, low income group were presented by countries with GDP per capita lower than 1100 USD in 2000, high income group respectively – more than 6500 USD (in constant dollars 2005).

The scope of the study covers all countries in the world which send their data to the World Bank database and UNESCO Institute of statistic during 2000-2011. Analysed period reflects one full business cycle from the end of previous crisis (end of 90es) to the end of the last one (end of 2000-es). As we used the data on 11 years, we took average means respectively to the data type. So for shares we calculated simple averages and used median in some cases, that helped us to address long and medium terms effects. For rates we calculated average using geometrical means.

It should be noted that depended variable were calculated for 2009-2011 as it should reflect macroeconomic conditions impact.

Results

Analysis of GDP growth and economic stability was the first part of the study. At the first look there is no evidence about statistical correlation between GDP growth rates and R&D intensity and even opposite the higher speed development corresponds with lower intensity. But this situation has very logic and robust explanation when we deep into countries' specific. Macao, Equatorial Guinea and Myanmar were countries with the highest growth in 2000-2011. The economic development of these countries is not relying on innovations and R&D. From the other hand, countries with the high R&D intensity and developed S&T sector an the same time usually have high income, and annual rates of GDP growth on 3-4% is quite normal for them.

Given this we looked at the data on middle income countries as Ukraine and Romania in 2000 (see fig. 1)

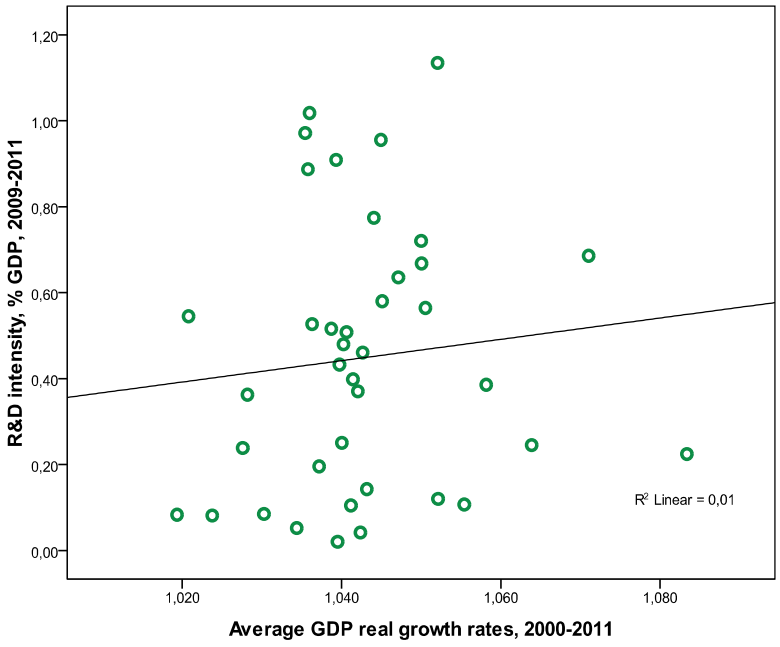

Figure 1. Relation between economic dynamic and R&D intensity in the middle income countries

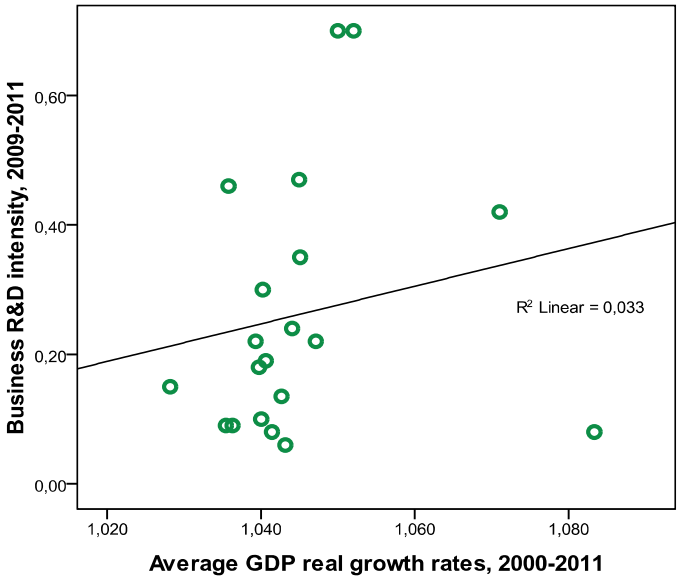

Figure 2. Relation between economic dynamic and business R&D intensity in the middle income countries

Source: World Bank, UNESCO Institute of Statistics.

These figures show correlation between R&D intensity and speed of GDP growth more obvious, but still the scattering is quite large. It is interesting that the R&D intensity of middle income countries is less than 1,2% of GDP, but in many cases it was even less than 0,2%. Nevertheless theses countries experienced quite high rates of economic development (annually 3-5%). It means that a lot of countries are dependent on external environment or global developments because their economies are based on primary industries, mostly managed by foreigners.

This statement is partially illustrated by the figure 2 where correlation between business R&D intensity and GDP growth in middle income countries is presented. In comparison with the overall R&D intensity business R&D is more interconnected with GDP growth. In such case higher R&D business expenditure will lead to faster economic development in the middle income countries.

Given that overal picture with GDP growth rates is not very precise we have found another indicator which illustrate the link of R&D to economic outputs in context of international trade. The receipts for the use of intellectual property (IP) is a charge, payed by nonresidents, for authorized use of proprietary rights (such as patents, trademarks, copyrights, industrial processes and designs including trade secrets, and franchises) and for the use, through licensing agreements, of produced originals or prototypes (such as copyrights on books and manuscripts, computer software, cinematographic works, and sound recordings) and related rights. Therefore it is a good proxy for R&D economic output. The scatter plot of expenditures on R&D and the charges for use of IP rights quite clearly shows the positive relation between these indicatores (figure 3).

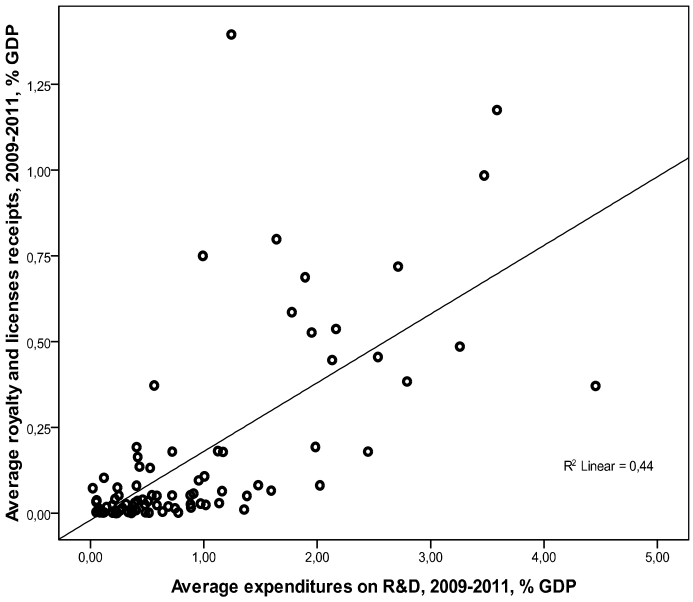

Figure 3. R&D intensity and receipts for the use of IP rights

Source: World Bank

So, it could be treated as a direct evidence of how R&D contribute to ecnomic development of any country. And the next issues will try to answer on question what conditions should be provided to make R&D the most effective tool for economic development.

First of all, we also found some evidence on reverse correlation regarding economic instability, which proves our hypothesis (figure 4). The measure of economic instability is standard deviation of annual GDP growth rates. We realize that instability is common result generated by wide list of factors both external and internal. It also includes public governance issues. The empirical data shows that large instability causes or related with low S&T activity, as business and government during volatile period pay not enough attention to R&D policy measures. So this is an important policy implication that it is vitally for successful R&D to establish quite stable economic environment.

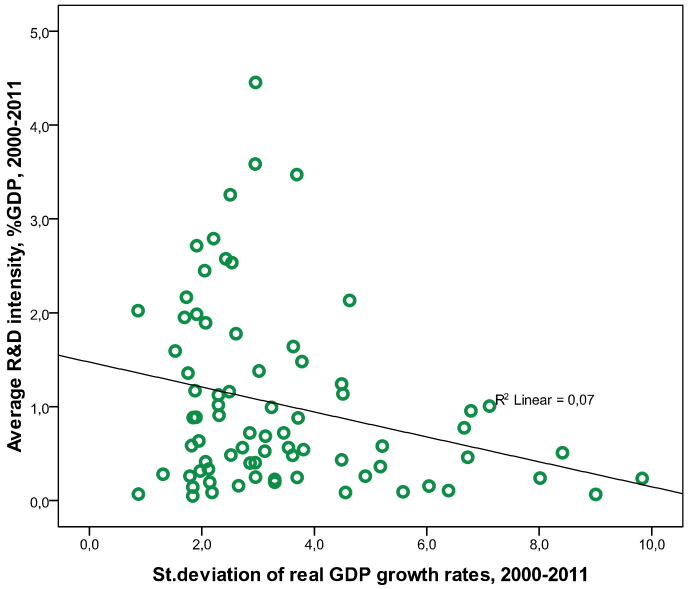

Figure 4. Relation between economic instability and R&D

Source: World Bank, UNESCO Institute of Statistics.

This statement is also confirmed by reverse correlation between inflation (measured as CPI) and R&D intensity. Notable, that strength of relationship between them is much stronger than in previous case. Countries with average inflation more than 6% were not able to keep expenditures on R&D more than 1% of GDP. Moreover the high inflation rates will lead with high probability to decreasing of R&D expenditures because government have to focus efforts on macroeconomic

stabilization. In such situation business will cut their risky projects, that are R&D projects in the most cases.

Country dependence on natural resources depletion and R&D development will be the next issue under discussion (figure 5).

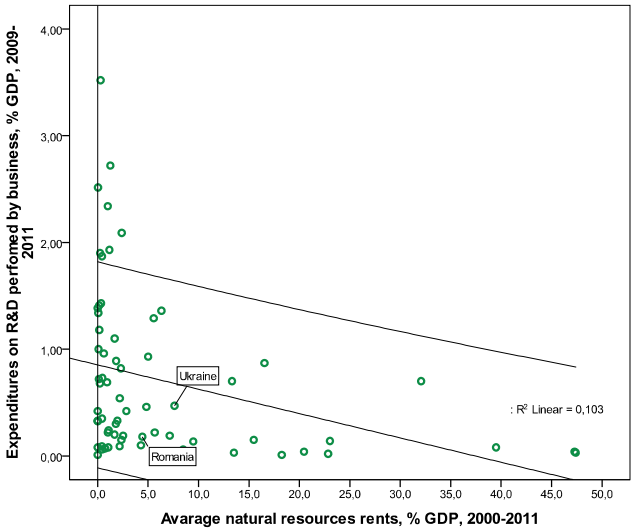

Figure 5. Relation between natural resources endowment and R&D.
Source: World Bank, UNESCO Institute of Statistics.

It is robust evidence of our hypothesis that high dependence on resources damages the opportunity for R&D development. It could be figured out that if the share of natural rent is higher than 5% of GDP, country is not interested in diversification of economy and developing R&D as well.

Continuing analysis of economies' structure it is necessary to look at the industry as a factor of S&T activity. From one side, industry, in particular manufacturing is a key chain of innovation diffusion, and from the other side, there was a trend of deindustrialisation due to increasing role of intangibles. In the same time more and more governments have realized that it is impossible to maintain sustainable economic development without solid industrial base equipped with advanced technologies. USA, France, and even Russia are among countries declared new industrialisation programs.

Statistical data shows that industrial sector of 60% of countries in the world provided 20-40% of value added in the early of 2000s as well as in 2010-2011. Countries with underdeveloped industrial sector usually have R&D intensity below 0,5% of GDP. And R&D intensity may be a little bit higher in case of over industrialized countries (figure 6). In both cases domestic S&T sector does not play an important role in supporting of economic development of the country.

Among low income countries only India has relatively high R&D intensity (0.75% of GDP, the same as Ukraine has now) and in the same time India increased their industrial base from 26% to 30% during 2000-2010. For middle income countries the correlation between industrialisation and R&D intensity is positive. It could be explained by the fact that these countries more rely on own industrial base as the internal market has enough capacity to absorb domestic goods.

The high income group of countries is the most heterogeneous. It could be divided into three subgroups. First subgroup covers small countries with economic development based on hydrocarbon or other natural resources (Brunei, Kuweit etc) and therefore with low R&D intensity. Second group includes countries with moderate S&T sector (R&D intensity is 0.9 – 1.6% of GDP). Irland, Estonia, Italy, Spain, Norway are in these group. And the third one is highly developed countries with high R&D intensity, like USA, Japan, Finland etc.

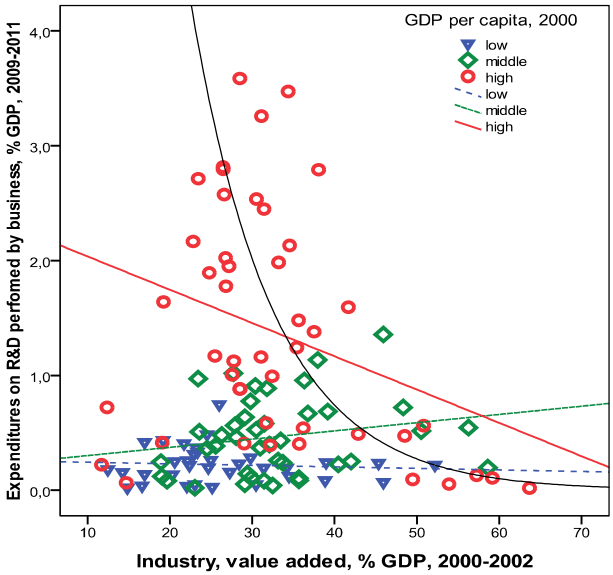

Figure 6. Industrialization and R&D intensity.
Source: World Bank, UNESCO Institute of Statistics.

Influence of FDI on S&T activity was the next issue we studied. Statistical data shows that while FDI positively correlated with GDP growth (the strongest correlation is within low income countries), there is negative correlation within all income groups, except low income. It led us to the conclusion that FDI doesn't contribute to S&T development. The reason could be that foreign investors bring also own technologies and they even don't need domestic R&D capacities to adjust it. Moreover, they will rather be against any improvements and competetive researches from the domestic agents. It is important notion for policy makers proving that FDI couldn't be a driver for activation of S&T development, even if they boost short or medium term development.

The next block of results deals with the financial issues and its impact on R&D intensity. From the policy making point of view, in particular in budgeting process, whether we should cut R&D expenditure in case of large cash deficit or increase it vice versa is an important question. The results of our study show that there is no statistical correlation between R&D expenditures and cash deficit. Moreover the most countries in the world is experiencing cash deficit. Its size is up to -5,0% of GDP, and it doesn't shrink R&D financing. Notably, 60% of countries with high R&D intensity (over 2% of GDP) experienced cash deficit.

The governments could cover the deficit by effective use of investments and other loans. These funds should not be wasted, but invested in infrastructure, education, S&T etc., used in a way that in the future will bring additional income.

The price of capital, which was measured through real interest rate was the next issue for analysis. It affects business more, as entrepreneurs are worrying about cost of capital and profit they could get. So, the scatter plot presented on figure 7 shows that in countries with high real interest rate (over 5%) S&T activity is quite small. It is normal and suitable when the real cost of capital does not exceed 5% that allow to business invest money, including investments in R&D projects.

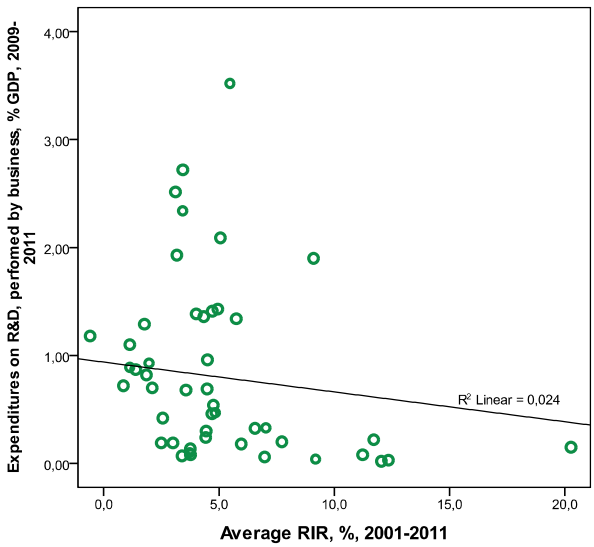

Figure 7. The relation between cost of capital and business R&D intensity.
Source: World Bank, UNESCO Institute of Statistics.

Another important issue deals with the taxation system, so we looked at the relation between business R&D intensity and the share of taxes in their profit (figure 8). If we look at the low income countries, we see that tax burden doesn't correlate with R&D intensity, that is because S&T sector there is very poor (*Goni E., Maloney W.F., 2014*) and the firms don't need R&D as well.

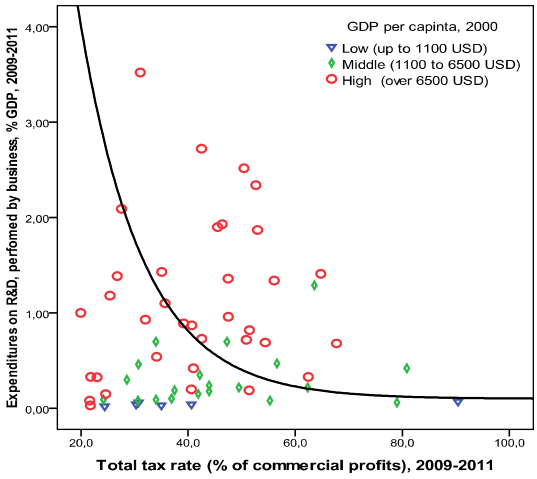

Figure 8. Relation between tax burden and business R&D intensity.
Source: World Bank, UNESCO Institute of Statistics.

But situation is changing drastically when we look at the middle and high income countries, where taxation plays more important role in the innovation process. Obtained data shows nonlinear relation between two variables, but the character is negative. The larger tax burden will reduce business capacity to finance R&D. The data allows to identify the optimal level of tax burden on business is between 30 and 50% of profit, that look the most balanced in term of public and private interests.

Taking into consideration that businessmen are worrying about their property rights one of the indicator presented in the World Bank Database is designed to measure the degree to which collateral and bankruptcy laws protect the rights of borrowers and lenders and thus facilitate lending. So we matched the corresponding assessments with the data on business R&D intensity and revealed that in countries with stronger legal rights protection business is more open for R&D and innovation as well.

Conclusions

The study of macroeconomic conditions impact on S&T activity is quite complicated task, as it deals with a huge heterogeneity of objects. Each country has a unique economic model that generates a large scattering of economic as well as other indicators. This paper is examined the links between basic macroeconomic conditions and S&T activity starting from simple and basic techniques

instead of complicated econometric models. However, from the one hand we got some results that might be interesting for policy makers and, from the other hand, it is worthwhile to expand further the study applying new variables and more comprehensive tools of analysis.

We draw following points regarding policy implications. First of all, it is need to provide nominal economic stability to create necessary economic environment for R&D and S&T activity. At least government should stabilize prices, and maintain stable medium term growth rates. Second point is that cost of capital determines amount of financial resources, which business can afford to invest on R&D. If it is high, the business will prefer to earn money in other way, instead of innovations. Third point deals with applied economic policy. The international experience showed that amount of financing that governments allocated to R&D was not dependent on the state of macrofinancial situation, in particular, on cash balance.

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