DOI:10.23683/2073-6606-2018-16-4-66-76

INNOVATION ACTIVITIES AND THE IMPACT OF INVESTMENT IN R&D ON ECONOMIC GROWTH: ASSESSMENT AND MODELLING

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New approaches to the role of innovation activities in the context of contemporary challenges of economic growth, as well as the needs and possibilities to improve the assessment and modelling of the impact of investment into the research and development (R&D) on economic growth are presented in this publication. The main attention is focused on the processes of innovation activities and economic growth in the European Union, as well as on the goals that are formulated in the Strategy "Europe 2020" and in other documents of the European Union. The peculiarities of the application of various indicators and indices are disclosed, in particular, taking into account the needs for developing and substantiating

economic policy decisions. New aspects of the application of various innovation indexes, such as Global Innovation Index, EU Innovation Scoreboard, Competitive Industrial Performance Index, Global Competitiveness Index, Knowledge Economy Index and Innovation Capacity Index, are presented. A new method of the assessment and modelling of the impact of the investment into the R & D on economic growth is proposed and described.

Keywords: *Europe 2020; European Union; economic growth; investment in R&D; innovation activities*

JEL classifications: *032, E10, M21*

ИННОВАЦИОННАЯ ДЕЯТЕЛЬНОСТЬ И ВОЗДЕЙСТВИЕ ИНВЕСТИЦИЙ В НИОКР НА ЭКОНОМИЧЕСКИЙ РОСТ: ОЦЕНКА И МОДЕЛИРОВАНИЕ

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В этой статье представлены новые подходы к роли инновационной деятельности в контексте решения современных задач экономического роста, а также потребности и возможности для улучшения оценки и моделирования влияния инвестиций в научно-исследовательские и опытно-конструкторские работы (НИОКР) на экономический рост. Основное внимание уделяется процессам инновационной деятельности и росту экономики в Европейском Союзе, а также целям, которые сформулированы в Стратегии «Европа 2020» и в других документах Европейского Союза. Раскрываются особенности применения различных индикаторов и индексов, в частности, принимая во внимание потребности в разработке и обосновании решений экономической политики. Представлены новые аспекты применения различных инновационных индексов, таких как Глобальный индекс инноваций, Табло ЕС

инноваций, Индекс конкурентноспособной промышленной деятельности, Индекс глобальной конкурентоспособности, Индекс экономики знаний и Индекс инновационной мощности. Предлагается и описывается новый метод оценки и моделирования воздействия инвестиций в НИОКР на экономический рост.

Ключевые слова: *Европа 2020; Европейский Союз; экономический рост; инвестиции в НИОКР; инновационная деятельность*

Introduction

Innovations, their activation and the promotion of innovation are key factors that are increasingly affecting economic growth in all countries in our days. It can be emphasized that these factors are extremely important in the European Union, in particular in the light of the current challenges of globalization and the need to increase competitiveness (Janda et al., 2013; Ehrenberger et al., 2015). At the same time, it can be argued that innovations and their activation in the context of economic growth needs should be regarded as one of the most important priorities of the European Union's economic policy.

Obviously, innovations and their activation processes, as well as innovative economic policy decisions are very wide and complex area of the practical activities and of the scientific cognition. This area can be assessed as particularly difficult: in real life, it has to be constantly responding to the new and increasingly complicated challenges arising from globalization and growing international competition and existing early-stage scientific knowledge is rapidly becoming inadequate for new and rapidly changing needs.

Despite the fact that the role of innovations and their activation is well understood at the moment, and that the innovation activities and activation are encouraged and supported, especially in the European Union, nevertheless has to be noted that many issues in this area remains as it is not resolved. By the way, presently abundant theoretical approaches and scientific concepts that are applicable to activating innovations and to substantiation of relevant economic policy decisions not only have a great variety, but quite often are also highly controversial and are too difficult to apply in practice (Čábelková & Strielkowski, 2013; Kalyugina et al., 2015; or Strielkowski & Čábelková, 2015). This implies, at the same time, that it is necessary to explore and compare in a broader and deeper way the different approaches and concepts for innovation-oriented economic policy decisions: based on such studies, it is necessary to seek the development of tools that can reasonably initiate and implement various effective solutions and decisions that could be oriented to the innovations activation and economic growth.

One of the most complicated and important issues requiring both serious scientific cognition and knowledge, as well as responsible economic policy decisions, is the question of the role of the investment into research and development (R&D) and of the impact of this investment on economic growth. The essence of this question is that the ability to properly, purposefully and comprehensively measure the impact of investment in R&D on economic growth determines the ability to select the most viable and priority directions of innovations and innovation activities in the right way and, at the same time, to develop and implement effective economic policy decisions.

It goes without saying that in order to make economic policy decisions, that determine investment in R&D, to be reasonable, effective and directly oriented towards economic growth, it is necessary to develop and use appropriate instruments that allow a reasonable and complex modelling of the various investment in R&D processes and alternatives, including adequately taking into account the specificities of situation in different countries and regions.

In turn, the need to create and use the relevant instruments determines the necessity to understand and solve a scientific and practical problem, the essence of which can be described in two aspects: a) the needs of investment into R&D and the impact of this investment on economic growth are not properly taken into account in the current practice of the activation of innovations and innovation activities, as well as in the practice of preparation of the economic policy decisions; b) the modelling of the investment in R&D often does not adequately reflects the specificities of the situation in different countries and regions. Obviously, this problem is important and relevant both in scientific and practical terms.

This problem can be solved in two ways: a) assessments and modelling of the processes of innovation activities and economic growth, with main focus on the use and application of various innovation indices; b) assessments and modelling of the impact of investment into the R&D on economic growth. Essential statements in these ways are described in more detail.

Literature review

Innovation research as well as innovation policies of developed, 'knowledge-based' societies are becoming more and more involved, e.g. going reasonably beyond Schumpeter's understanding of innovation as technical progress (Lisin et al., 2014; Koudelková et al., 2015; Lisin et al., 2015; Meissner et al., 2017; Żelazny, 2017; Benešová et al., 2018; Lisin et al., 2018; Appiah et al., 2018). In terms of direction and scope, it is possible to identify common patterns as well as country-specific aspects to this development, particularly with regard to the inclusion of 'social innovation' in innovation policy (Gokhberg et al., 2016; Lisin et al., 2016; Mir-Babayev et al., 2017; Radwan, 2018; Oganisjana et al., 2018).

Innovation and R&D activities over a business cycle were reviewed by Courvisanos (2009). He stated that they are strongly connected with political decisions such as public investment (Jang et al., 2016). National governments abilities to support public R&D development were limited due to economic crisis in Europe during the last decade (Cunningham and Link, 2016).

Eventually, the importance of developing innovation has been recognised by politicians and society. Role of innovation is significantly increased in 21st century. Innovation has been placed at the heart of the Europe 2020 strategy (European Commission, 2011). Innovation is also considered to be best means for tackling major societal challenges, such as climate change, energy and resource scarcity, health and ageing (see e.g. Štreimikienė et al., 2016; Kashintseva et al., 2018; or Newbery et al. 2018).

It became obvious that in order to achieve global competitiveness at macro (national state) level the innovation development have to be stimulated systematically. A concept of National innovation system (NIS) was developed, which is usually interpreted as a specific network or set of linkages among the actors involved in innovation processes, whose interactions determine the innovation performance (Freeman, 1987; Nelson, 1993; Lundvall, 1998). Efficiency of NIS logically has to lead to the efficiency of innovation development and thus lead to the global competitiveness of a growth of national economy.

For the monitoring status and progress of the NIS various innovation indexes were developed such as Global Innovation Index, EU Innovation Scoreboard, Competitive Industrial Performance Index, Global Competitiveness Index, Knowledge Economy Index, Innovation Capacity Index and etc. Many scholars were analysed the composition of the innovation indexes (Jankowska et. al., 2017; Svagzdiene and Kuklyte, 2016; Vilys et.al., 2015; Kiseľáková et al., 2018) and found significant shortages in calculation of these indexes.

Almost all innovation indexes include and dominated by R&D spending (public or private) factor i.e. more R&D spending – better value of innovation index. R&D is defined by Frascati Manual. First official version of the Proposed Standard Practice for Surveys of Research and Development, which has come to be better known as the Frascati Manual was

developed in 1963 (OECD, 2015). The Frascati Manual has been an international standard for more than fifty years. Despite that this manual had been revised six times for reflecting and addressing new needs and practices of modern society, the main definitions of R&D are more applicable for industrial society, which were dominated by industrial companies with closed R&D and innovation development model. During this period pattern and understanding of innovation has changed significantly (Strazdas et.al. 2014). The process of innovation development is becoming much more sophisticated. Many new concepts and types of innovation have appeared, ranging from technological innovation to marketing innovation, and from closed to open innovation (OECD, 2005; Chesbrough, 2003). A broader understanding is being gained of the concept of innovation, not only of R&D-based innovations but also of creativity-based innovations such as "design-driven innovation" (Cooke & De Propris, 2011). In particular, the concept of innovation has changed in the context of the creative industry's development.

The development of the creative industry sector has shifted the understanding of innovation and increased the importance of the creator and creativity. The development of companies within the creative industry sector has been affected by creative solutions – one of the most critical aspects of this is to rearrange things that are already known by constructing new and original solutions.

The open innovation concept allows significantly increase efficiency of innovation development. The innovation development is getting more global process and involves specialists and infrastructures of different countries. Concept of NIS is getting less relevant as innovation is getting more and more global, using European innovation system or even Global innovation system (GIS). Subsequently calculation and measuring innovation indexes based only on quality of NIS is getting less and less relevant and sometime misleading. Our calculation presented further demonstrated that there is different impact of R&D expenditure on national economic growth.

European Innovation Scoreboard (EIS) provides the most widely used innovation index, which was as part of the Lisbon strategy and aims to annually measure the innovation performance of member states (Hollanders & van Cruysen 2008). The EIS consists of three main blocks, 7 dimensions, and 29 indicators (Carayannis & Grigoroudis 2016).

In recent years, the EU has reported and compared the innovation and research performance of each member state through the Innovation Union Scoreboard. Using 25 indicators that are categorized around enablers, business activities, and outputs, the innovation and research performance of each member state was quantified. In particular, the Innovation Union Scoreboard divides each Member State's innovation performance into one of four categories - leading innovators, strong innovators, moderate innovators and modest innovators - to highlight the strengths and weaknesses of national research and related innovation systems. While these efforts are important, they are more comprehensive and less focused than an assessment of policy effectiveness (Cunningham & Link 2016).

As an example, one can use the annual European Innovation Scoreboard, which provides a comparative assessment of the research and innovation performance of the EU Member States. The report claims that it demonstrates relative strengths and weaknesses of national research and innovation systems and it helps Member States assess areas in which they need to concentrate their efforts in order to boost their innovation performance. (European Commission, 2017). In this case, as we discussed earlier, the boost of national innovation performance has to lead to belter competitiveness of national economy, economic growth and etc. (European Commission, 2011). In the article we present evident that there are weak links between factors used for EIS and factors of economic growth.

The experts of European Innovation Scoreboard since the introduction of the EIS in 2001 made significantly changes and it has been recently transformed into the Innovation Union Scoreboard (IUS) in order to monitor the implementation of the Europe 2020 Innovation Union flagship (Pro Inno Europe 2011; Carayannis & Grigoroudis 2016). Significant revisions have been made in 2017 European Innovation Scoreboard. As a direct

consequence of this revision, is that results in this year's EIS report cannot be compared to the results in the EIS 2016 report. Our computation shows that even more changes to EIS computations should be made in order to better reflect global paten of innovation development in the context of the creative economy development.

Impact of investment into the R&D on economic growth: the case of modelling for the European Union

Basic idea was to develop a model which let identify the relation between GDP growth and R&D expenditure in the European Union. Major indicators which were chosen for modeling were in line with five major directions for enhancing EU competitiveness by Europe 2020 strategy:

1) employment: 75% of the EU population aged 20-64 should be employed;
2) investment in R&D: 3% of the EU's GDP should be invested in R&D;
3) «20/20/20» climate/energy targets: limiting greenhouse gas emissions at least by 20% compared to 1990 levels, creating 20% of energy needs from renewables and increasing energy efficiency by 20%;
4) education: share of early school leavers should be under 10% and at least 40% of the younger generation aged 30-34 should have a tertiary degree;
5) fighting poverty: 20 million less people should be at risk of poverty.

Therefore, Eurostat (2018) and the World Bank (2018) data for EU 28 countries were used in the fields of investment in R&D with a target to find the relation between investment in R&D and GDP growth. Also, statistical data for employment via light of education and R&D, energy, poverty and other indicators was used for model development (see figure below).

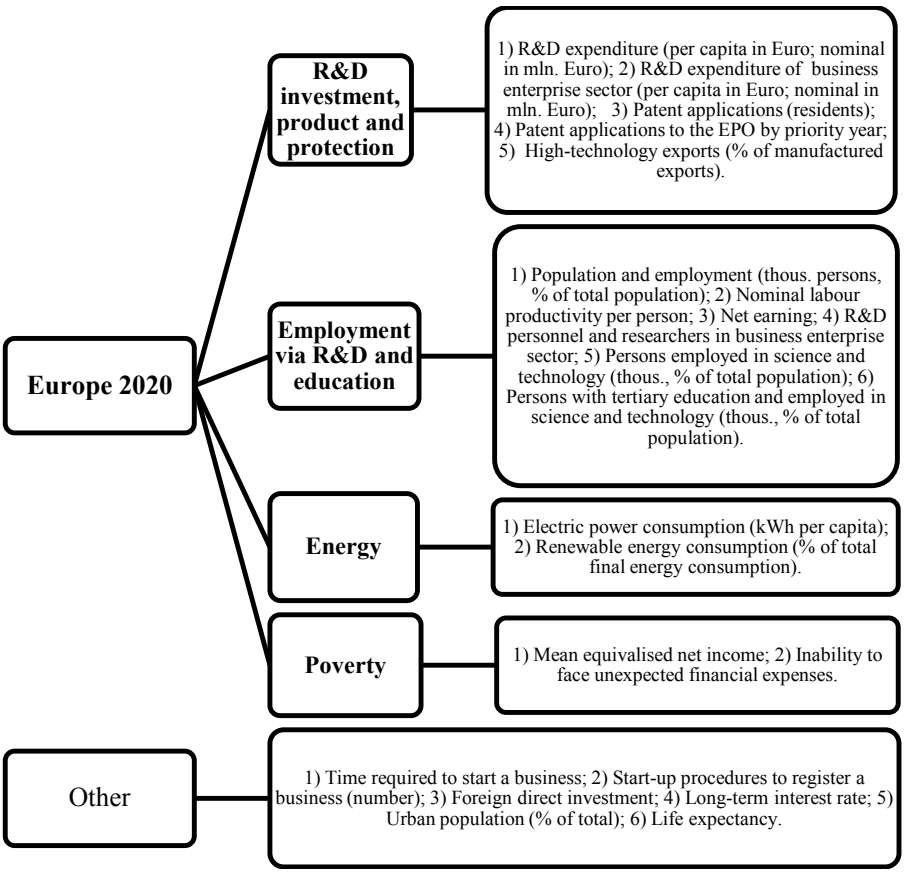

Figure 1. Variables used for modeling: exogenous/independent variables
Source: Own results.

Major equation of our model covers investment in R&D, employment and poverty indicators and expressed as a relation of GDP per capita to investment in R&D per capita. There is kept in mind that poverty indicators in their expression via income provide a picture of people who seek to improve their situation through work, innovation or acquiring new skills. Energy indicators were extracted from equations due to their insignificancy.

$$\frac{GDP}{capita} = \mathrm{a0} + \mathrm{a1}\frac{PEST}{capita} + a2\ IFUFE + a3\frac{NI}{capita} + a4\ \frac{R\&DE}{capita} + a5\ \frac{R\&DBE}{capita}(-1) + \epsilon \quad (1)$$

Where GDP/capita is the gross domestic product at market prices per capita in euros, PEST is the employment indicator of persons employed in science and technology (as % of total population aged from 15 to 74 years), IFUFE is the poverty indicator of inability to face unexpected financial expenses (% of total), NI/capita is second poverty indicator – mean equivalised net income in euros, R&DE/capita is total intramural R&D expenditure in euros per inhabitant, R&DBE/capita is R&D expenditure of business enterprise sector in euros per inhabitant.

The Panel Least Squares Method with fixed cross-section variables (dummy variables) was used in the estimations. The data for period 2005-2014 of 28 European Union countries were used for modeling. Keeping in mind the lag of R&D expenditure of business enterprise sector in basic equation, observation number is 252.

Modeling results are provided below which prove that R&D expenditure has strong impact on GDP growth but only then economy is developed – starting point in our model 10 397 euro per capita. Only after reaching this point, investment in R&D has pretty high multiplication effect and every its euro per capita is growing GDP per capita by 16.7 euro.

$$\frac{GDP}{capita} = 10397.3218 + 343.0734\frac{PEST}{capita} - 69.0987\ IFUFE + 0.5492\frac{NI}{capita} + 16.6818\ \frac{R\&DE}{capita} - 18.2886\ \frac{R\&DBE}{capita}(-1) + \epsilon \quad (2)$$

(10.0626) (5.8706) (-4.8205) (7.9267) (7.9751) (-8.9073)

R-squared (R2) = 0.9959; adjusted R-squared (R2) = 0.9953; D-W = 1.5179. Note: t-statistics are shown in brackets.

Also, our model shows positive impact on GDP of income growth as in our model expressed as an average net income per employee, and growth of part of persons employed in science and technology as a part of total population. Inability to face unexpected financial expenses has negative impact on GDP growth and this negative impact is higher in economies where people are not able to manage their financial security.

Indicator of R&D expenditure of business enterprise sector in euros per inhabitant with one-year lag was used seeking to vanish autocorrelation which arise in the model due to the R&D expenditures are being a part of GDP.

Modeling multiplication effect of R&D expenditure shows that higher multiplication effect will be in more developed economies. In economy which GDP per capita is equal 5286 euro, every euro invested in R&D per capita will raise GDP by 6.6 euro. It is 2.5 times less than in the case of economy which generate 10 397 euro per capita.

$$\frac{GDP}{capita} = 5286.3390 + 526.9658\frac{PEST}{capita} - 82.7097\ IFUFE + 0.5109\frac{NI}{capita} + 6.5639\frac{R\&DE}{capita} + 16.7396\frac{PA}{capita} + \epsilon \quad (3)$$

(4.7463) (8.3869) (-5.5155) (6.6340) (4.0445) (4.7747)

R-squared (R2) = 0.9941; adjusted R-squared (R2) = 0.9933; D-W = 1.1569.

Where PA is patent application of residents per million inhabitants. As in our basic model, this equation shows positive relations of GDP growth and R&D and employment indicators.

Working with nominal indicators as a relation of GDP in million euros to investment in R&D in million euros were noticed similar modeling results, but they will not be presented here due to its expression as GDP per capita is more convenient working with the pool of the European Union countries.

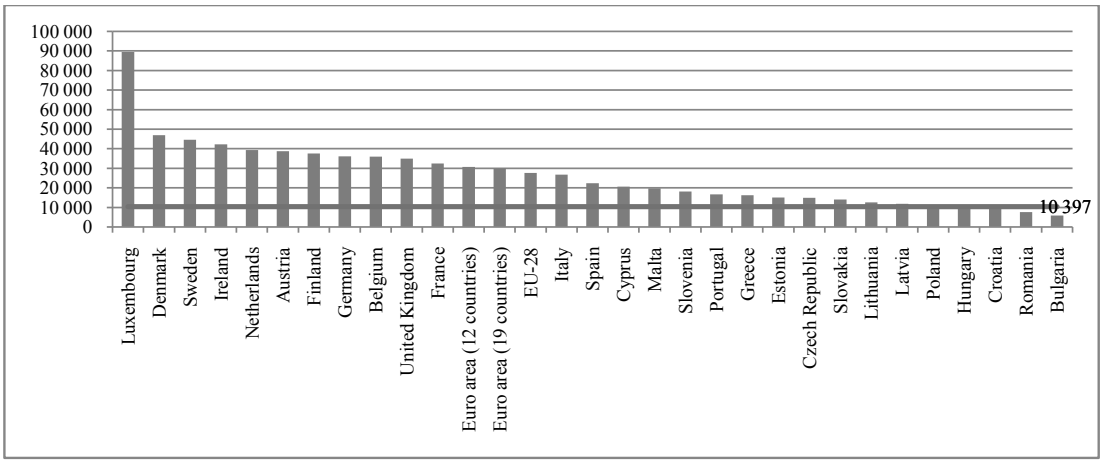

Figure 2. GDP per capita in the European Union countries (2014)
Source: Eurostat (2018).

Therefore, it could be concluded that investment in R&D has different impact on GDP growth depending on level of economy development: impact of invested euro per capita in R&D on GDP growth in countries such as Bulgaria is significantly lower than invested euro in R&D in developed EU countries.

Conclusions and discussions

Overall, innovations, as well as their activation and enhancement are the key factors that are increasingly affecting economic growth in all countries: these factors could be defined as especially important circumstances of the social and economic development, as well as of the technological progress in the European Union.

An important prerequisite for the purposeful activation of innovations and for the enhancement of their impact on economic growth is the preparation and implementation of instruments enabling the appropriate initiation and making of the relevant economic policy decisions, especially those that are intended for investment in R&D.

Of particular importance are two types of instruments: a) instruments that are based on the innovation indices and that can be applied in various cases of the promotion of Innovation activities and economic growth; b) instruments that are oriented for increasing

impact of the investment into the R&D on economic growth. The necessity and appropriateness of the use of these instruments were confirmed by studies in the case of analysis for the European Union.

Various innovation indexes could be developed for the monitoring status and progress of the National innovation system. Almost all innovation indexes include and dominated by R&D spending factor.

The modelling results proves that R&D expenditure has strong impact on GDP growth but only then economy is developed – starting point in our model is 10 397 euro per capita. Only after reaching this point, investment in R&D has pretty high multiplication effect and every its euro per capita is growing GDP per capita by 16.7 euro.

In the national economies which GDP per capita is equal 5 286 euro, every euro invested in R&D per capita will raise GDP only by 6.6 euro. It is 2.5 times less than in the case of economy which generate 10 397 euro per capita.

Concept of National innovation system is getting more and more global. The EU countries with less developed economies have difficulties to utilize the outcome of R&D expenditure and to stimulate the national economic growth. It means that the growth of less developed economies is achieved mainly by non-R&D-based innovations, therefore the weight of R&D expenditure for calculation innovation indexes for developing and developed economies have to be differentiated.

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