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# Regional development and R&D activity: international comparison

**Abstract.** As countries could be stratified by the level of economic development, they should have differences in the levels of influence of various factors on GDP. Movement of the global economy towards the knowledge economy has various asymmetries and we believe that research and development activity is one of them. In order to identify reform priorities for Ukrainian economy the paper tested the hypothesis that R&D activity as a factor that contributes to GDP at the local level in countries with different levels of economic development vary. The article provides comparison of the relationship of the main indicators of the R&D activities of the regional GDP per capita in developed countries (the USA and EU) and Ukraine. To meet the aim the author has conducted generalization of scientific periodicals, identified key parameters and used correlation analysis of the relationship of selected indicators. The findings show that there are significant differences at the levels of correlation of basic research indicators with GDP in different levels of development of countries and their regions. The results confirm the law of diminishing returns on an example of R&D. The USA are close to the limits of R&D as a factor of economic growth, the EU lags behind the USA and Ukraine lags far behind the EU. It is the result of long-term efforts that the USA has been taking since the mid-1950s and effectiveness of American world-class research universities. The effective use of the results may create a long-term growth point of Ukrainian economy. This means that investments in R&D could contribute to economic development of Ukraine with higher returns in comparison with the USA and EU.
**Keywords:** University; Research Activity; R&D; Regional Development; Patent; USA; EU; Ukraine
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**Науково-дослідницька діяльність та регіональний розвиток: міжнародне порівняння**
**Анотація.** Для визначення пріоритетів реформ у вітчизняній економіці в роботі проведено порівняння взаємозв'язку основних показників, що характеризують дослідницьку діяльність (далі – ДД), з ВВП регіонів на душу населення в розвинених країнах (США та ЄС) і Україні. Для обґрунтування отриманих результатів проведено узагальнення наукової періодики, визначені ключові показники та проведено кореляційний аналіз щільності взаємозв'язку показників. Виявлено суттєві відмінності рівнів кореляції основних науково-дослідницьких показників (далі – НДП) та ВВП у різних за рівнем розвитку країнах та їх регіонах, на основі чого зроблено висновок, що зі зростанням рівня економічного розвитку економіки зростає нелінійний взаємозв'язок між ДД та ВВП регіонів. Результати підтверджують дію закону знижувальної продуктивності факторів виробництва на прикладі ДД, найбільшу частку якої здійснюють університети. США підійшли до межі продуктивності досліджень як фактору зростання економіки, ЄС відстають від США, а Україна значно відстає від ЄС. Ефективне використання отриманих результатів може сприяти довгостроковому зростанню вітчизняної економіки.
**Ключові слова:** університет; дослідницька діяльність; регіональний розвиток; патент; США; ЄС; Україна.

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**Научно-исследовательская деятельность и региональное развитие: международное сравнение**
**Аннотация.** С целью определения приоритетов реформ в отечественной экономике в работе проведено сравнение взаимосвязи основных показателей, характеризующих исследовательскую деятельность, с ВВП регионов на душу населения в развитых странах (США и ЕС) и Украине. Для обоснования полученных результатов проведено обобщение научной периодики, определены ключевые показатели и проведен корреляционный анализ плотности взаимосвязи показателей. Выявлено, что имеют место существенные различия в уровнях корреляции основных научно-исследовательских показателей с ВВП в разных по уровню развития странах и их регионах. Результаты подтверждают действие закона убывающей производительности факторов производства на примере исследовательской деятельности. США подошли к границе производительности исследований как фактора роста экономики, ЕС отстают от США, а Украина значительно отстает от ЕС. Эффективное использование полученных результатов может создать точки долгосрочного роста отечественной экономики.
**Ключевые слова:** университет; исследовательская деятельность; региональное развитие; патент; США; ЕС; Украина.

## 1. Introduction

Reforming national scientific and educational space should be based on the results of the studies and comparison of world experience, identification of international proportions and competitive positions. To determine the priorities it is necessary to determine the factors that affect regional GDP the most, so efficient use of which could create long-term growth of the national economy. European integration priorities bring in the need of awareness of role and place of universities in the knowledge economy, which have reached the highest levels in the USA and EU.

## 2. Brief Literature Review

In the last 3 years there has been a growing number of publications devoted to higher education and regional development within the entire period of their accumulation in international scientific databases (Table 1). However, there is a lack of modern publications devoted to advanced study of the role and place of universities in regional development. Thus the integration of universities in regional development is relevant not only in Ukraine, but also worldwide.

Among foreign authors we rely on the papers written by Marginson & Rhoades (2002), who outlined a heuristic role of

Tab. 1: **Number of publications in international scientific database ScienceDirect**

| Year | Keywords | | | | |
|---|---|---|---|---|---|
| | Education | Higher education | University | Regional development | University and regional development |
| 2015 | 1,929 | 202 | 382 | 38 | 1 |
| 2014 | 3,338 | 393 | 554 | 76 | 4 |
| 2013 | 2,878 | 275 | 526 | 38 | 3 |
| 2012 | 2,691 | 261 | 461 | 47 | 2 |
| 2011 | 2,097 | 200 | 417 | 31 | 2 |
| 2010 | 2,289 | 213 | 360 | 21 | 1 |
| 2009 | 1,557 | 88 | 198 | 56 | 2 |
| 2008 | 1,245 | 68 | 188 | 14 | 2 |
| 2007 | 1,039 | 53 | 166 | 22 | - |
| 2006 | 1,039 | 57 | 138 | 10 | - |
| **Total** | **26,174** | **2,038** | **4,240** | **478** | **15** |

Source: Compiled by author using keyword search of [1]

higher education institutions from local to global levels of socioeconomic development; Johannessen & Olsen (2010), who revealed the need for cooperation of institutions in the global knowledge economy; Youtie & Shapira (2008), who identified the transformation of the role of universities in regional development [2-4]. In shaping the modern university paradigm of economic development in conditions of global competition an important role played the papers written by Atkinson (2008), Goldstein (1995), Carrillo (2002), Leydesdorff (2010), Teece (1986) [5-9].

Ukrainian scholars also have significant theoretical achievements in this area, but most works are devoted only to certain aspects. For example, Boychenko (2011) compiled possible indicators for assessing the impact of the university on innovative regional development [10]. Kolchuhina (2008) proves the feasibility of using education and science as an innovative resource [11]. Kalenyuk (2001, 2009) considers national and international dimensions of higher education but he does not go into regional development [12; 13]. Semerikov et al. (2010) examines regional innovation university complex in the context of fundamental education on the example of Dnipropetrovsk region [14]. Serhiychuk & Sembrat (2013) examined possible regional university complex systems of pedagogical education [15]. An original analysis of international experience of development of research universities is a collective work [16]. Still, there is no paper that would investigate linear relations between GDP per capita in the region and R&D indicators in the available literature.

**3. Purpose** of the article is to test a hypothesis that there is a different impact of R&D indicators on regional GDP per capita depending on the level of socio-economic development of regions of nations and countries of integration unions, various intensity and effectiveness of R&D. To achieve the aim we have conducted a generalization of scientific periodicals, defined analytical indicators and made an analysis of the correlations.

**4. Results**

Higher education and knowledge are simultaneously local, national and global, but international knowledge activity is growing at a faster pace [2]. Although globally information and knowledge are distributed unevenly and asymmetrically, their value is primarily observed in organizational structures that operate within networks combining information, knowledge and competencies based on mutually beneficial cooperation [3]. These structures grow over local to global character to form clusters of competencies as structurally combined networks of institutions that are distributed globally and combine both global and local economic mechanisms with other mechanisms and relations at the levels of economy and knowledge.

Over the past decades, in developed countries there have been significant changes in the mode of university activities. Mode 3 has almost clearly shaped itself, in which research, especially university research, is transforming local development [4]. It should be borne in mind that the transition to a knowledge economy paradigm must be accompanied by a simultaneous reform of higher education (Table 2) [17]. The mission of the university to involve the regional economic development is most noticeable in comparison with traditional missions of education and research.

Scientists argue that effective functioning of universities as a catalyst to create new knowledge and attitudes in conditions of social and environmental pressure is necessary to establish a two-way exchange of knowledge, competencies, information between universities and other representatives of society [18]. The role of catalyst should be extended to a tool for selection of knowledge globally, which is especially important in the face of the deteriorating global problems while solutions can begin with local, regional initiatives which support sustainable development and which provide opportunities to experiment in finding the best solutions. With the development of networks, local and global, making projects and experiments universities can offer humanity a wide range of new opportunities.

The analysis of theoretical bases of scientific, technological and innovation policies has discovered their important evolution [19]. Neoclassical theory does not differentiate levels of public intervention, but implementation of the Schumpeterian theory of growth implies a focus on the national level with an accent on more developed regions. The regional level and the national level with a regional (decentralized) focus are in the focal point of the Neomarshalian theory, but the Institutional theory considers both national and regional levels for interventions in scientific, technological and innovation policies. The culmination is the Evolutionary theory, which defines multi-level interventions and balances centralized with decentralized interventions.

Tab. 2: **The evolution of the concept of university in economic context**

| Mode | Past | Modern | Evolution |
|---|---|---|---|
| | 1 | 2 | 3 |
| **University mission** | storage of knowledge | knowledge factory | centre of knowledge attention |
| **Brief description of university** | bureaucratic elite; is above society | provider of «raw» resources and «results»; develops technologies | integrated institution in the intellectual region; promotes local development by creating new opportunities |
| **Economic context** | single production | mass industrial production | post-industrial knowledge driven age |

Source: Compiled by the author using [9]

Increasing intensity of international competition between regions, development of knowledge economy and key technologies, and continued impact of globalization accompanied with other factors transform the structure of regional industries, employment and productivity of occupations. However, international studies prove that modern methodology for analysis of economic indicators in full does not answer questions related to the impact of knowledge economy and universities on regional development [20]. Virtually every research has to substantiate a unique system of indicators, reveal their relationships and influences. Therefore, it was decided to use two most common indicators that characterize R&D at regional level – availability of resources (employees in research organizations and expenditure on R&D) and results (filing applications for patents). They were used for conducting a comparative analysis and testing the hypothesis on the example of the national levels of the USA, EU and Ukrainian regions. Unfortunately, lack of data does not let us distinguish research universities, but their leading role was considered an axiom proved by fundamental works.

Research universities in the United States are called the most important economic institutions of the 20th century [5]. The growth of the US economy in the 20th century to the level of world leader was possible due a number of factors, including implementation of the principle of simultaneous local and state control over development of the education system and provision of sufficient funding for implementation of academic initiatives [21]. Research universities provide results that have economic

impact, namely: creation of new knowledge, shaping of human capital, transfer of the existing know-how (tacit knowledge), technological innovation, capital investment, regional leadership, knowledge production infrastructure, impact on regional environment [6].

Long-lasting policy for development of universities produces results. According to the Association of University Technology Managers there is a growth both in number of new university patents from 13700 in 2003 to 18200 in 2009, and their use – from 7200 to 11300 respectively [22]. For comparison, in 2009 in the USA, there were issued 95 patents, so about 14-19% patents have university origin.

A small amount of knowledge created in universities receives protection as intellectual property and is commercially successful. Only half of university inventions in the USA come to the stage of applying for a patent, half of which really gets the patent, and only one third is further licensed and only 10-20 licenses do generate rather large income [23]. Thus, only about 1-2% of inventions successfully reach the market [24]. The rest of new knowledge is in the form of tacit knowledge, use of which as economic resource requires proximity to their source [25]. Meanwhile patents, articles, books can be easily moved over long distances. Obviously, geographical proximity is not enough, because it must be accompanied by targeted activities of universities to overflow knowledge, entrepreneurial behaviour of all stakeholders.

In some years there will be a significant growth in university revenues from sale and licensing of intellectual property. Jumps often brought by the fact that universities agree to sell property rights of the IP with high market price. For example, in 2007 University of New-York sold Remicade® global rights to Royalty Pharma for USD 650M with certain conditions that protect rights of researchers and university; in 2005, Emory University received USD 525M compensation for Emtrivia® [22].

Calculations of correlation of applications for patents, government agencies spending on R&D, number of employees in R&D in science and engineering with size of per capita GDP of US states in 2005-2013 found that it is so small, that stays close to the level of statistical error (Table 3; Table 4). We can name the following explanations for this: error in data sources used, wrong choice of indicators, or, which is more likely, high level of competition and efficiency of R&D in the context of their impact on GDP, existence of functional relationships. A weak linear relationship can testify to high efficiency of factors and existence of others that impact GDP per capita.

The EU is important for a global comparison, because integration efforts are being made to overcome the gap with the USA and support global competitive leadership. Since 1984, the EU framework programs have been playing a key role in the development of interdisciplinary research and have become the main instrument for financing research [34]. The European Research Area (according to the Lisbon Strategy, 2000) aims to combine national and joint research programs, basic research institutions, universities, libraries, centres and schools into a single network [35]. The EU applies research not only to ensure global competitive leadership but also to promote regional development. Basic emphasis is on development of R&D activities, but not institutions, which makes difficult the identification of real place of research universities in economic development. The main efforts in this area concern individual research initiatives.

It is recognized that in the world there is clear asymmetry between shares of patenting and production by key economic players, and it makes difficult the identification of linkages between R&D and regional development. Examples of asymmetries between knowledge production and actual manufacturing include the following: 31% of patents for lithium-ion batteries are received in Europe, but 87% of their production is in Asia; in biotechnology the EU patents comprise about 36%, but only 5% of global bioethanol production is in the region; in the field of photovoltaics the share of patents is 29%, its production is 13%, and the world market has 77%; the EU hosted only one company producing semiconductors, but there are 20 such companies in Asia [29].

In search for factors that determine the quality of university patents in the EU, researchers have found that in 1998-2004 about 74% of quality patents were received by universities only from 13% of EU regions [30]. At the same time 6 out of 10 most patent active regions were in the UK and had clear a sectoral specialization. It was found out that the number of patents applied for by universities exceeds the number of patents held by universities [31]. Until recently, more than 10% of patents in Italy, France and Sweden were owned by universities, whereas in the USA their share reached 69% in some years and sectors [32]. We can assume that the EU will trend to increase this share as a result of reforms aimed at improving the use of IP in universities [33].

Researching patent activity in European universities, we should take into account that applications for patents in the European Patent Office (EPO) shows a relatively low correlation coefficients related to the size of regional GDP per capita (Table 5). Higher correlation coefficients for the EU compared with the USA may indicate the existence of unused capacity of their impact on socio-economic development of regions. In some EU regions such influence can be high or even decisive in some years. For example, in 2009, the University of Cambridge (Eastern England, UK) and the science park around it were named the most research-intensive EU region and along with 5 leading UK regions it had 4.1% of EU research spendings [34]. A similar pattern was observed in Belgium, France and Austria.

Data analysis for 2006-2011 showed that the Ukrainian higher education sector received from 52% to 59.1% of all patents annually, making it the main supplier of new knowledge [40-42]. Changes in methods of calculations let us identify the exact place of scientific and educational institutions, which received 90% of patents for inventions and utility models among all the domestic legal institutions and more than half of the patents for utility models and about a quarter of patents for inventions among all the owners. Such a dominant share raises the question of efficiency of commercialization of patents by universities, but lack of appropriate disclosure of reports limits analysis of the actual state of affairs. These limitations can be overcome either by adjusting collection and disclosure of relevant reports by the government (the State Statistics Service of Ukraine, the State Intellectual Property Service) or by researches, surveys of scientific and educational institutions as it is often done in the USA and EU.

The analysis of the correlation of main R&D indicators with the size of per capita GDP in the regions of Ukraine demonstrates its high level, which is significantly higher than the corresponding figures in the USA and EU (Table 6). It is obvious that Ukraine has yet to develop an effective system of use of domestic intellectual capital and R&D commercialization or rely on the foreign one.

One of the explanations for such a situation is that the companies which carried out technological innovations in almost all the regions transform into research institutes and universities as source of information for innovation in the last order [44, 242]. A similar situation exists in the EU, which is already working on

Tab. 3: **Correlation of R&D indicators with size of per capita GDP of US states**

| Indicators of resources | 2006 | 2007 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|
| Government agencies spendings for research and development | -0.0227 | -0.0213 | -0.0352 | -0.0333 | -0.0542 |
| Number of employees in R&D in science and engineering | 0.0650 | 0.0677 | 0.0430 | 0.0219 | 0.0365 |

Source: Compiled by the author using [26, 27]

Tab. 4: **Correlation of patent activity with the size of per capita GDP of US states**

| Indicators of performance | 2005 | 2010 | 2012 | 2013 |
|---|---|---|---|---|
| Applications for patents to the US Patent and Trademark Office | 0.0367 | 0.0198 | 0.0275 | 0.0298 |

Source: Compiled by the author using [26, 28]

Tab. 5: **Correlation of R&D indicators with size of per capita GDP of EU countries**

| Indicators | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| Volume of domestic R&D expenditure | 0.8516 | 0.8682 | 0.8340 | 0.8472 | 0.8635 | 0.8520 | 0.8397 | 0.8219 |
| Employees in research organizations | 0.1472 | 0.2338 | 0.1131 | 0.2506 | 0.1186 | 0.2348 | 0.1145 | 0.2716 |
| Applications for patents to the EPO | 0.2056 | 0.1978 | 0.1811 | 0.1988 | 0.2088 | 0.2091 | 0.2089 | 0.2127 |

Source: Compiled by the author using [36-39]

Tab. 6: **Correlation of R&D indicators with size of per capita regional product in Ukraine**

| Indicators | 2005 | 2010 | 2012 | 2013 |
|---|---|---|---|---|
| **Indicators of resources** | | | | |
| Number of organizations carrying out scientific and technical works | 0.8636 | 0.8452 | 0.8378 | 0.8457 |
| Employees of main activity of scientific organizations | 0.9073 | 0.9016 | 0.9028 | 0.9170 |
| Financing of scientific and technical activities | 0.9159 | 0.8964 | 0.8873 | 0.9051 |
| Number of researchers with scientific degrees | 0.9094* | 0.8989 | 0.9015 | 0.9186 |
| **Indicators of performance** | | | | |
| Applications for patents to State intellectual property service of Ukraine (SIPSU) | 0.9095** | 0.8612 | 0.9205 | 0.9108 |
| Patents obtained in SIPSU | 0.9246** | 0.8734 | 0.9033 | 0.9139 |
| Number printed publications | 0.8548 | 0.8270 | 0.8513 | 0.8572 |
| Number of new advanced technologies | - | 0.9122 | 0.8702 | 0.8362 |

* - Data for 2006; ** - Data for 2007

Source: Compiled by the author using [40-45]

fixing it [46]. The exceptions were Dnipropetrovsk and Odesa regions with over 17% of these enterprises in 2010-2012 while the national average was 7.2%. In addition, more than 5% of companies with technological innovations were receiving financial support from local and regional authorities in Poltava, Kherson, Khmelnytskyi regions. Thus, it can be argued that the movement has started in the right direction.

**5. Conclusions.**

The identified differences related to the levels of correlation between the main R&D indicators and the regional GDP per capita in countries with different levels of development such as the USA, EU and Ukraine, support the law of diminishing returns. Therefore, we can say that the USA has come to the edge of research productivity as a factor in economic growth, the EU is lagging behind the USA and Ukraine lags far behind the EU. There is a non-linear relationship between indicators of R&D and regional GDP in developed countries that need further research in this direction.

The increasing number of received patents for results of R&D at universities and publicly funded research institutes and laboratories, which was observed after the reforms in the USA in late 1970s - early 1980s, later manifested in Europe [47]. From 1954 to 2004 the expenditures of the USA university expenditures for R&D were increasing at a higher rate than the rate of economic growth [4]. Long-lasting and weighty support of researches has given the USA an opportunity to gain global competitive leadership through their productivity and effective use of results.

In most EU countries regional development programs in terms of knowledge management are, to a higher extent, at a theoretical level, which is far from the practice of national development [7]. Even less developed regional dimension of research policy is applied in Ukraine. Obviously, it is pending in a complex reforms of municipal management and higher education.

The results obtained in the research can be used as an argument to undertake a comprehensive study in this regard. In particular, it is expedient to conduct a factor analysis to identify factors and their hierarchy relevance to the size of GDP or a benchmark analysis. For Ukraine, it is necessary to continue studying the experience of the USA and EU, especially in the early years of reforms related to interconnected research, education, innovation segments of national economies [16].

Bearing in mind that with increasing geographic distance from the place of generation of knowledge the spillover effect decreases, it is advisable to consider it in the region of creation [19]. Our findings confirm its feasibility and a need to revitalize university activities for commercialization of R&D, and to be able to do this, universities must effectively use their autonomy to develop cooperation with the market, especially the market for venture capitals. Local stakeholders (governments, companies, communities) also have to find the source of competitive advantage in universities and in results of their research.

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