Milorad Stamenović

ORIGINALNI NAUČNI RAD
UDK: 338.45:604
330.341.1:604

DOI: 10.5937/Rev2090007S

QUANTITATIVE ANALYSIS OF BIOTECHNOLOGY PATENTS NEXUS TO NATIONAL ECONOMIES AND POLICIES

INTRODUCTION AND LITERATURE REVIEW

This paper deals with influence of patents on national economies of developed countries. Relationship between patents and economical development have been studied for decades and one of first attempts was described by Solow (1956) using growth accounting theory in order to find specific correlations between progress of technology and overall growth (1, 65-94). However, first indexes related to patent protection have become available in 1990 (2, 75-102). Further research on those indexes was provided by Ginarte and Park in 1997 (3, 283-301). Also, Romer (1990) was dealing with correlation between knowledge, ideas and GDP analysing labour productivity (4, 71-102). UNCTAD (1996) has published work related to filed of influence of patents on national economies and implied that patents have implications on overall inventive activity and broader use of new technology in scope of national economies (5, 281-307). Further conclusions were also connected with diffusion of patents (considering technology) into national economies. From the side of policies, there is variety of papers that discussed influence of patent related policies and its impact in specific understanding of influence of patents on economic indicators (6, 557-574); (7, 143-157). Newer research shows tight correlation between patents and GDP and implies that quantity and quality of innovation are important for economic growth (8, 1264-1276); (9, 358-375). Within research performed on cases of 52 countries it was noted that countries with higher number of quality patents also increased economic growth (8, 1264-1276). However, some researchers argued that the question of how patents affect technology use and economic growth still remain question to be answe-

SUMMARY

Key words: biotechnology industry, patents, economic growth, policies

This paper deals with the impact of biotechnology patents on national economic growth. Biotechnology was selected as one of the highest growing industries oriented to field of R&D. It was noted that upward trend of growth of biotechnology industry is also related to industry dispersion in terms of different areas of R&D. Existing literature has connected patents with national economies in terms of overall inventive activity and broader use of new technology in scope of national economies considering relevancy for policy changes. Research results of regression analysis shown significant impact of biotechnology patents on Economic growth. Results were interpreted in a way to implicate requirements for further policies adaptation.

Milorad Stamenović, PhD, SKEMA Business School, Université Côte d'Azur, France, e-mail: milorad.stamenovic@skema.edu

red (10, 197-205). As this paper is based on quantitative methods (including regression model) and our intention to seek for correlation and plausibility of results in practice within different set of variables that influences economic growth - we have reviewed literature related to similar analysis that have been done in past. For example, Maskus and Penubarti (1995) have performed statistical analysis that resulted in statistical significance and positively correlated of GNP per capita and Patent Index in study that evaluates 48 countries (11, 227-248). Park and Ginarte (1997) identified a positive and statistically significant estimated coefficient for GDP per capita (in a regression) to Patent Index (12, 289-328). Maskus (2000) identified U-shaped relations between GNP and Patent index (13, 365-387). Maskus further performed regression analysis on 72 countries (for period 1985-1990) using Patent index (Park-Ginarte) as dependent variable and concluded that correlation is positive and statistically significant.

In this research we have concentrated on 6 developed European countries with highest number of registered patents in period after the Global financial crisis (2008) up to current moment. Patent count for those 6 countries was observed for period 2009-2018 and in accordance with methodology it represent dependable variable. For independent variable in regression analysis were selected indicators that we consider relevant for analysis: *Gross Domestic Products per capita in Euro (GDP), Research and Development(R&D) Expenditure, Research and Development(R&D) Personnel count, Unemployment rate, Investment by GDP and High Technology Export ratio*. As already mentioned it was implied that patents have implications on overall inventive activity and broader use of new technology in scope of national economies (5, 281-307). In addition, Szarowska (2017) has proven correlation between R&D expenditure and its impact on Economic growth (14, 90-103). Therefore we consider major indicator for economic growth – GDP, and also indicators that are related to broader use of technology (defined through policies) : *R&D Expenditure and R&D Personnel count.* In case there is significant correlation between number of patents in biotechnology industry and GDP, R&D Expenditure and R&D Personel count, relevant influence of biotechnology patents might be in significant correlation with requirements of goverment policies.

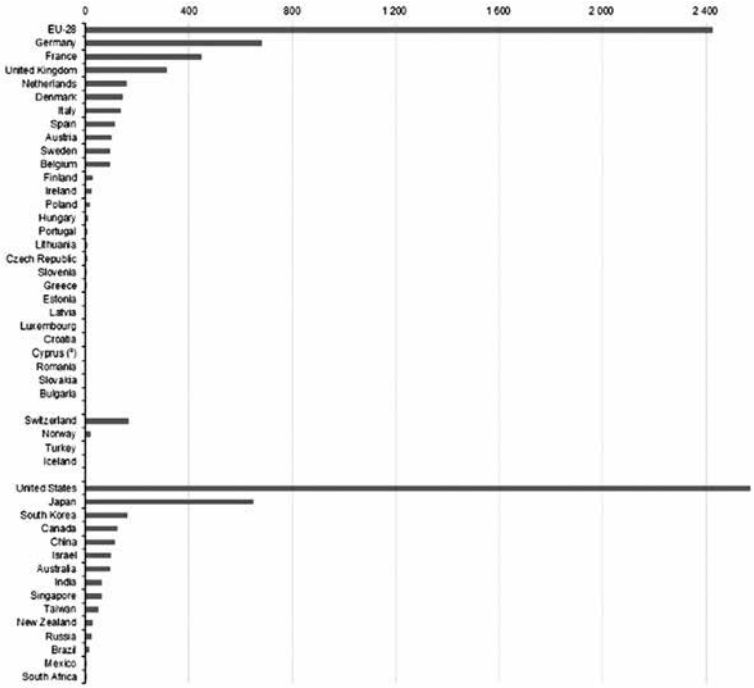
WHY FACTORS OF BIOTECHNOLOGY INDUSTRY AND PATENTS ARE RELEVANT FOR THIS RESEARCH?

Within this paper we were particularly interested in patents registration number and correlation with certain economic indi-

cators. Registered patents as variable have been chosen to be used in this analysis due to its significance and overall impact on market and industries. Looking from the perspective of importance of innovation - position of EU Commission on innovations shows significance by itself (European Commission declared innovation as a „key *factor in the competitiveness of European industry*.") (15). There are numerous reasons why to choose biotechnology industry among others, and we were concentrated on fact this industry represents one of the fastest growing industries globally which is connected with increasing level of science and knowledge in related scientific disciplines (e.g. genetic engineering). By definition, biotechnology is the application of scientific and engineering principles to the processing of materials by biological agents to provide goods and services (16, 49-209). Although biotechnology industry is mainly referred as industry for drugs production, in its history it was concentrated to solving problems related to agriculture and food. However, modern association on biotechnology as drug oriented industry shows significant connection between fields of agriculture and pharmaceutical industries. In many countries policies regulating those fields are not primarily organised within same institution although in some other countries this is the case (e.g. Federal Drug Agency in USA). This paper primarily deals with influence of biotechnology industry registration patents on national economies of 6 developed countries within Europe. Therefore, it was important to understand significance of this industry on EU countries and to understand official EU institutions approach to this industry framework and further development. European Commission defines impact of this industry on economy as significant and its main applications were categorised in 3 different groups: healthcare and pharmaceutical applications, agriculture, livestock, veterinary products, and aquaculture, industrial processes and manufacturing (17). In addition, relevance of biotechnology industry might be seen through analysis of all industries growth in EU. Biotechnology industry experiences higher than average growth rate in terms of patents applications and patent number rose for 10,5% annually for observed period 1990-2000 comparing to 5% overall increase of patents (18).

Biotechnology industry is mainly referred as industry for drugs production, in its history it was concentrated to solving problems related to agriculture and food.

It was also considered as important to understand current and future potentials for development of biotechnology industry (future forecasting of influence of biotechnology industry development, innovation development and its implications to the national economies). Therefore we also considered role of diversification in biotechnology industry. Biotechnology industry framework is "guided" in different areas of research and development such as: immune therapies, service providers,



Graph 1. Patent applications to the EPO – biotechnology (2012) (19)

advanced-medical products, metabolic diseases, brain and neuronal therapies, drug delivery, antibodies and other. Diversification in firms performance is closely related to industry price-cost margins and therefore there was noted correlation (20, 146-155). This practically means that diversity in biotechnology industry might be the key for further industry development having stronger impact on national economies and therefore relevance for choosing this industry for analysis is significant.

Diversification in firms performance is closely related to industry price-cost margins.

POLICIES IMPLICATIONS IN BIOTECHNOLOGY INDUSTRY PATENTS

Major point in discussing EU policies in this research is based on fact that one of the potential implications of research exploring correlations between patents and economic growth might result in different understanding of framework and thus requires policy changes. Results of evidence based and strong correlation between registered patents and economy growth pushed policy makers to influence on reducing country level patent protection, which enables firms to produce products patented in observed countries (10). In case of European Union

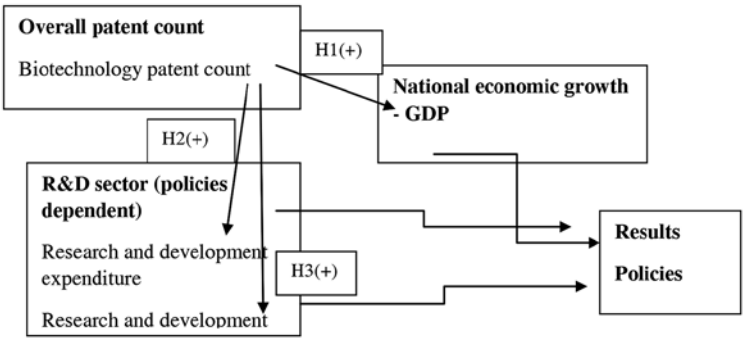
were noted various policies and programmes that supports the development of innovation in order to positively influence on research and development and to accelerate process of delivering innovation from research to market (21). Major EU policies achievements in field of biotechnology innovation were related to the harmonisation of patent law on biotechnological inventions in 1998 when was adopted EU Directive 98/44/EC known as Biotech Directive. Expert groups were organised by European Commission in order to work further on creating better environment for biotechnology industry research and development. Implications of different policies on national and industry level of EU might highly influence research and development. There are many different implications of policies, and some of those are related to government spending on research and development through direct funding, non profit arrangements and government run laboratories. Another example are tax breaks for research and development which implies supporting R&D which was proven through history as successful. Also, cooperative research between educational and scientific institutions and private-public sector involved in research and development in biotechnology sector might brings efficient results (22); (23, 76-78); (24, 172-176).

METHODOLOGY

Research topic considered in this paper is related to the field of innovation development and its economical impact (i.e. Biotechnology industry patents). We have defined research question as follows: *How biotechnology industry patents registration influences National economy parameters?* This research considers quantitative methods in order to emphasize measurements of objectives in order to perform statistical analysis of available data. Quantitative research in general is focused on collecting data sets and generalization in order to define specific phenomenon (25). Within this research we were concentrated on correlation and effects between patent count in biotechnology industry and impact on economy growth. In this paper data sets were obtained from relevant sources including: European Patent organization; International Monetary Fund; European Commission and EuroStat (27) (28) (29) (30).

Quantitative data were collected from various databases which are public sources and includes different types of data gathered through time (defined per year). It was searched for the connection between *Patent counts, (especially Biotech Patent count)*, and economic variables such as: *Gross Domestic Products per capita in Euro (GDP), Research and Development(R&D) Expen-*

diture, Research and Development(R&D) Personnel count, Unemployment rate, Investment by GDP and High Technology Export ratio. Patent related dataset was collected from European Patent Office (EPO) database whose main activity is based on searching and working on patent applications (26). In the patent data, we concentrated on Biotech Patent counts.



Schema 1. Model approach

Following economic indicators have been used (as independent variables) : *GDP; Research and Development Expenditure; Research and Development Personnel count; Unemployment rate; Total Investment percent of GDP and High Technology Export ratio* (29). During analysis, coding was done in terms of naming convention. Based on the theory (including model approach) and research question we have formed following hypothesis for this research:

H1:	*If number of patents in biotechnology industry in developed countries increase – GDP will increase*
H2:	*If number of patents increase in biotechnology industry in developed countries – R&D expenditure will increase*
H3:	*If number of patents increase in biotechnology industry in developed countries – R&D personal will increase*

In terms of location of research and timeframe for analysis, there were selected 6 European countries depending on their total patent counts and Biotech patent counts respectively (France, Germany, Netherlands, Switzerland, Denmark and United Kingdom - it was decided to include all of these 6 European countries in terms of biotech patent count performance to better understand the effect of patent count in general). Although not all of selected countries are part of European Union (e.g. Switzerland), economies of observed countries are ranked as developed and their geographical position is also

concentrated within area of Europe. In addition, there are current negotiations regarding change in EU membership status of United Kingdom (i.e. Brexit), but those negotiations were still not finalised at the time of this research. In terms of timeframe, there have been collected data for period 2009-2018 and this particular period was selected based on ground that Financial Economic Crisis occurred in 2008 and we wanted to observe period after major impacts that occurred within that year and post-crisis effect.

In terms of analysis, firstly there have been analysed means and standard deviation of observed variables. Following this analysis, Annova test was performed (through SPSS software). Linear Regression is one of the most used statistical process (predictive analysis) to explore and interpret data. Depending on dataset Linear Regression might be used as a way to explain one dependent variable with the help of one independent variable. In our case, Ordinary Least Square (OLS) as a type of linear least square method for calculate the parameters in a linear regression model is used. OLS uses Least Square principle which calculate explanatory variables in the dataset by minimizing the sum of the squares of the differences between values of the predicted variable in dataset and calculated in linear function (32,15). In order to perform linear regression, we used SPSS software (IBM, v.2011).

RESULTS

Descriptive statistics (i.e. mean; std.deviation; sum of squares; mean square) was performed via SPSS software (v.2011) and there were noted following results:

Table 2. Descriptive statistics

Descriptive Statistics

	Mean	Std. Deviation	N
BIO_PATENTS	402.0667	198.01009	60
RnDExP	34523.21755	26595.46135	60
RnDPersonel	279566.9667	209447.8450	60
Unenployment	6.1103167	2.20904742	60
GDP	39634.67	9497.693	60

Source: SPSS results

Anova statistical test was performed via SPSS software (v.2011) and in table bellow are presented results:

Table 3. Anova test

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1534198.034	4	383549.509	27.077	.000[b]
	Residual	779073.699	55	14164.976		
	Total	2313271.733	59			

a. Dependent Variable: BIO_PATENTS

Source: SPSS results

Multiple Linear regression was used and *P-value*, as known as "Probability Value", is one of our criteria which explains the probability of hypothesis. For *p-value*, it is relevant if less than 5% (or 0,05). *R-Squared* is the term for explaining the success rate of the final equation regression provides. *Confidence Level* is another criteria which explains the probability for given confidence level that true value of data will be contained in specified interval (33,120-148). The most used confidence level is 95% (34, 43–45). In the confidence interval, change of the sign of the variable is not acceptable because of the uncertainty of its effect on the equation. Based on those information results were interpreted. Following results, it was decided not to proceed with use of following variables *Unemployment rate, Total investment percent of GDP, High Technology Export Ratio (as independent variables)* due to resulted changes in Confidence Interval values and high p-values. Then, we made our second regression with the meaningful independent variables in our data. From the results, it was noted that there is a correlation between *GDP, R&D Investment, R&D Personnel Count and Biotech Patent Count*. For our independent variables, *P-value, Lower and Upper CI* is considered as acceptable. However, statistically, coefficients are not so high meaning that change in our independent variables affect the Bi-

otech patent counts very powerlessly. R-Square says that our model is explaining this correlation with %65 success. Between Biotech patent counts and GDP and R&D Person Count, there is a negative relation. Between Biotech patent counts and R&D Investment, there is a positive relation.

CONCLUSION

This paper deals with nexus between National economies and number of patents (patent count) in biotechnology industry. Research was based on conclusions that patents have implications on overall inventive activity and broader use of new technology in scope of national economies. To remind that previous research has proven correlation between R&D expenditure and its impact on Economic growth, based on which we consider major indicator for economic growth – GDP, and also indicators that are related to broader use of technology (defined through policies) – *R&D Expenditure and R&D Personnel count.* In case there is significant correlation between number of patents in biotechnology industry and *GDP, R&D Expenditure and R&D Personel count*, relevant influence of biotechnology patents migh be in significant correlation with requirements of goverment policies. Also, previous research defined within literature review section of this paper was explaining the impact of labour on national growth through factors of ideas and technology and also showing positive correlation between patent index and economic growth. Our results have shown that unemployment indicator itself do not have significant nor positive correlation with biotechnology patent count. From the other hand, there was evidence of moderate correlation between *biotechnology patent count and GDP, R&D Expenditure and R&D personal count*. This shows that policies that are implemented on observed territory of Europe have significance in terms of support of patent development in biotechnology industry. Also, it was shown that biotechnology patents have direct implications on GDP which confirms previous analysis for other industries.

In regards of results and implications to public policies changes, there would be proposition to further reshape policies in terms of better overall support to biotechnology industry (R&D sector) that would result in increased number of patents. Regression analysis results were interpreted in a way to implicate requirements for further policies adaptation in terms of support to higher R&D Expenditure and increasing number of employees in R&D sector, referring especially to policies that "fosters innovations" in this particular industry. This study was performed on limited sample of 6 developed countries in

Europe with largest number of biotechnology patents for period 2009-2018. Additionally, this exercise should include more control variables in order to clarify endogeneity of results. Study limitations are potentially affected with data set size and in case that more countries were selected with wider timeframe analysis, results would be potentially able to show higher level of generalisation.

ACKNOWLEDGEMENTS

This paper is initial research on the topic of nexus among biotechnology patents, national economies and stimulus policies that was presented in draft form at Postgraduate Statistical Course at SKEMA Business School, Universite Cote D'Azur, Republic of France (2020). Thanks to the master students of SKEMA Business School Delicik Seckin (Turkey) for data collection and analysis and Azar Alaie (Iran) for insights on policies questions.

LITERATURA

1. Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. The quarterly journal of economics, 70(1), 65-94.
2. Rapp, R. and R. Rozek, (1990). "Benefits and Costs of Intellectual Property Protection in Developing Countries", Journal of World Trade 24(5), 75-102.
3. Ginarte, J. C. and G.P. Walter. (1997). "Determinants of Patent Rights: A CrossNational Study", Research Policy 26(3), 283-301
4. Romer, P. M. (1990). Endogenous Technological Change, Journal of Political Economy 98(5, Part 2): The Problem of Development: A Conference of the Institute for the Study of Free Enterprise Systems, 71-102
5. UNCTAD. (1996). The Trips Agreement and Developing Countries. UNCTAD/ITE/1, Geneve., 1(2), 281-307
6. Maskus, K. E. McDaniel, C. (1999). Impacts of the Japanese patent system on productivity growth. Japan and the World Economy, 11(4), 557-574
7. Ernst, H. (2001). Patent applications and subsequent changes of performance: evidence from time-series crosssection analyses on the firm level. Research Policy, 30(1), 143-157
8. Hasan, I.,Tucci, C. L. (2010). The innovation–economic growth nexus: Global evidence. Research Policy, 39(10), 1264-1276
9. Kim, Y. K., Lee, K., Park, W. G., & Choo, K. (2012). Appropriate intellectual property protection and economic growth in countries at different levels of development. Research Policy, 41(2), 358-375
10. Khalili,F et al. CHEONG (2016). International Journal of Economic Per--spectives, 2016, Volume 10, Issue 4, 197-205. Patent Application – GDP Growth Nexus: The Case of Japan
11. Maskus, K. and M. Penubarti, 1995. "How Trade-Related are Intellectual Property Right?" Journal of International Economics 39, 227-248.
12. Park, W. G.,(2008). "Intellectual Property Rights and International Innovation", In K. Maskus, ed., Intellectual Property Rights and Technical Change. Vol. 1, Frontiers of Economics and Globalization. New York: Elsevier, 289-328. Pitkethly, 1999.
13. Maskus, K.(2000). Intellectual Property Rights in the Global Economy. International Organization 51, 365-387.

14. Szarowska,I.(2017). Does Public R&DExpenditure matter for economic growth? GMM Aproach.Journal of International studies, 10 (2), 90-103
15. EC, 2019. https://ec.europa.eu/growth/industry_en. Accessed on 22/10/2019
16. Bud, Robert; Cantley, Mark F. (1994). The Uses of Life: A History of Biotechnology. London: Cambridge University Press Cox D.R., Hinkley D.V. (1974) Theoretical Statistics, Chapman & Hall
17. EC, 2019. https://ec.europa.eu/growth/industry_en. Assessed on 22/10/2019
18. OECD, Genetic Inventions, IPRs and Licensing Practices, 2002. Available at: https://pandas.pydata.org, Assessed on 18/10/2019
19. EC,2012.Patent applications to the EPO – biotechnology industry. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Patent_applications_to_the_EPO_biotechnology,_2012_(%C2%B9)_(number)_YB16.png, Assessed on 22/10/2019
20. Stephen A. RhoadesThe Review of Economics and Statistics. Vol. 55, No. 2 (May, 1973), 146-155
21. EC. 2019. Internal Market. Available at: https://ec.europa.eu/growth/sectors/biotechnology_en. Assessed on 22/10/2019
22. WIPO, (2018).WIPO IP Portal. Available at: www.wipo.int.patent. Assessed on 18/10/2019
23. Jelisavac Trosic S, Todic D& Stamenovic M. (2018). Svetska trgovinska organizacija - životna sredina i sistem zdravstvene zastite. Institut za medjunarodnu politiku i privredu. Beograd
24. Stamenovic, M. Biotehnološka i farmaceutska industrija kao razvojna šansa Republike Srbije. Strane direktne investicije - novi pogledi. Institut za međunarodnu politiku i privredu, Beograd, 2019
25. Babbie, Earl R. The Practice of Social Research. 12th ed. Belmont, CA: Wadsworth Cengage, 2010; Muijs, Daniel. Doing Quantitative Research in Education with SPSS. 2nd edition. London: SAGE Publications, 2010.
26. EPO, (2019). https://www.epo.org/about-us/services-and-activities.html, Assessed on 18/10/2019
27. European Patent organization. Patent statistics. Available at: https://www.epo.org/about-us/annual-reports-statistics/statistics.html#applicatios, Accessed on 22/10/2019
28. International Monetary Fund. World economic Outlook Database. Available at: https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/download.aspx, Accessed on 22/10/2019
29. European Commission. General government gross debt - annual data. Available at: https://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=teina225&language=en. Accessed on 22/10/2019
30. EuroStat . European statistics Data set. Available at: https://ec.europa.eu/eurostat/data/database, Accessed on 22/10/2019
31. Freedman, 2009 David A. Freedman (2009). Statistical Models: Theory and Practice. Cambridge University Press.
32. Hayashi, Fumio (2000). Econometics. Princeton University Press.
33. Kendall, M.G. and Stuart, D.G. (1973) The Advanced Theory of Statistics. Vol 2: Inference and Relationship, Griffin, London.
34. Zar, Jerrold H. (199). Biostatistical Analysis (4th ed.). Upper Saddle River, N.J.: Prentice Hall

KVANTITATIVNA ANALIZA UTICAJA BIOTEHNOLOŠKIH PATENATA NA NACIONALNE EKONOMIJE I FORMIRANJE ZAKONA I PROPISA

REZIME

Ključne reči: biotehnološka industrija, patenti, ekonomski rast, zakoni i propisi.

Ovaj rad se bavi uticajem biotehnoloških patenata na nacionalni ekonomski rast. Biotehnologija je izabrana kao jedna od industrija sa najvišim rastom koja je orijentisana na područje istraživanja i razvoja. Primećeno je da je uzlazni trend rasta biotehnološke industrije takođe povezan sa industrijskom disperzijom u pogledu različitih oblasti R&D. Postojeća literatura povezivala je patente sa nacionalnim ekonomijama u pogledu ukupne inventivne aktivnosti i šire upotrebe nove tehnologije u dometu nacionalnih ekonomija obayiruí se na relevantnost rezultata za promenu zakona i propisa. Rezultati istraživanja regresione analize pokazali su značajan uticaj biotehnoloških patenata na ekonomski rast. Rezultati su protumačeni na način da impliciraju zahteve za dalje prilagođavanje politika.