ISSN 1392-3110
Socialiniai tyrimai / Social Research. 2012. Nr. 4 (29), 45–58

Evaluation of Innovations as a Labour Productivity Increasing Factor: The Case of the European Union Countries

Alma Maciulyte-Sniukiene, Kristina Montvilaite
Siauliai University, Architektu Str. 1, Siauliai
E-mail: alma.m@splius.lt; kristinamontvilaite@yahoo.com

Abstract

The paper reveals the concept of innovations and briefly discusses the development of models of the innovation process. To evaluate the impact of innovation development on labour productivity retrospective research of the correlations of innovations and labour productivity was carried out. This enabled to generate the evaluation scheme of innovations as the factor that increases labour productivity. The research was performed using data of EU-27 of 2001-2010. After ranking the EU states according to labour productivity, summarised the innovative index and R&D expenditures it was established that the states of high labour productivity demonstrate bigger gaps in ranking; therefore, in the first research stage it was assumed that correlation between innovation development and labour productivity is stronger in the countries of lower labour productivity. Proceeding analysis this assumption was checked by indicating correlation between the key indicator that reflects innovation development (R&D) and labour productivity using the correlation-regressive analysis. Its results show that innovation development is not the factor that predetermines labour productivity in the countries of high labour productivity; however, the impact of innovations on labour productivity in medium and low productivity countries is direct and significant, with few exceptional cases. The conclusion here might be that innovations are resources for labour productivity increase in medium and low productivity countries.

Keywords: innovations, innovation process, labour productivity

Introduction

Innovations in labour productivity play a crucial role in the process of economic growth. "Productivity growth is a crucial factor in long-term goals to ensure the growth of economy and living standards. In short and medium terms, productivity also has an impact on business development, inflation, currency rate and other essential macroeconomic variables, such as consumption, investments and employment" (Gomez-Salvador at al. 2006). According to W. Souma at al. (2009), productivity is an important quantity to discuss economic conditions and national power. According to A. Sabonienė, Ž.Karazijienė (2012), the productivity parameter often serves as an equivalent for competitiveness and may be applied both at national and industrial levels as well as for individual firms. Speeding up labour productivity growth in the context of economic globalization and international openness it is one of the most relevant goals of each country‘s economic policy, especially in low labour productivity countries. It should be noted that in 2010 labour productivity, expressed by the added value per employee, was lower than the EU average (94.3 Euro/h) in 13 EU member-states out of 27. In Bulgaria, the lowest labour productivity country, the added value per employee was 4.11 times lower than in Luxemburg, the country with the highest productivity. Hence, it is necessary to search for methods and tools to increase labour productivity both in medium and low productivity countries.

Innovation development may serve as one of the resources of labour productivity. Today innovation is considered as one of the key elements for business success as well as economic wealth of the country and competitive advantage of single state groups. According M. A. Gooble (2012), "innovation is a key part of any journey to the future". A positive role of investments into innovation development of both the state and the private sector is unquestionable, but only research can prove it as a crucial factor. It is very likely that the role of innovation development in labour productivity of different countries and how large this role is depends on the economic situation of such country, its material and human resources and other factors. Thus, it is reasonable to determine in which EU member-states additional investments should be made in innovation development in order to speed up the growth of labour productivity.

Research aim: to evaluate innovations as the factor of labour productivity increase in ES-27 member-states.

To achieve the set aim the following objectives were set:

1. To explain the concept of innovations;
2. To discuss retrospective research of correlation of innovations and labour productivity;

3. Based on retrospective research to generate the evaluation model of innovations as the factor of labour productivity increase;
4. To study correlation between innovations and labour productivity in the cases of ES-27 member-states in 2001-2010.

Research methods: scientific literature study, its methodizing, comparison and interpretation; data classification and grouping, ranking, comparative analysis; statistics methods: averaging, correlative regression analysis.

Research novelty. A relatively low labour productivity at both micro and micro levels has been one of the oldest economic issues. Economists and managers in various countries have searched for solutions to this problem. Scientific literature indicates innovations as one of resources of labour productivity increase. Correlations of innovation development and labour productivity has been investigated by a number of authors, including Z. Gliliches (1979, 1995, 2000), J. Mairesse (1982), K. Wakelin (2001), H. Lööf (2002, 2004), N. Janz, H. Lööf and B. Peters (2003), K.H. Tsai and J.C. Wang (2004), S. Robin, J. Mairesse (2008), R. Ortega-Argiles, L. Potters and M. Vivarelli (2008), P. Hanel (2008), F. Bogliacino and M. Pianta (2009), G. Crespi, P. Zuñiga (2010) and others. Studies of the said authors cover different periods, they use data of various countries and their groups. Moreover, in some cases relation between labour productivity and innovation development has been studied at a micro level, in the other cases – at a branch level. It should be noted that not in all cases the same indicators are used defining innovation development. For these reasons study results contradict. In some cases relations between innovation development and labour productivity have been proved, in the other cases not; moreover, the strength of relations also differs.

The present research seeks to systematically evaluate innovations as the factor of labour productivity increase in all E-27 member-states using data of 2001-2010, what has not been done in either of the said studies. Furthermore, to determine relations between labour productivity and innovation development, ranking and comparison of these countries according to the indicators of labour productivity and innovation is used, what enables to make assumptions on the interaction of labour productivity and innovations. In addition, the evaluation model of innovations as the factor of labour productivity increase was generated and can be used in situational studies of other countries.

Innovation concept

Innovation analysis and evaluation are greatly influenced by the context of the science field and trends. A different concept is delivered when innovations are studied from the historical, technological, managing, and economic or another point of view. Therefore, a number of interpretations of innovation definitions is also great. Additionally, definitions found in scientific resources differ in the amount of information they provide and its scope. According to A. Jakubavičius et al. (2003), American scientist W. R. Maclaurin defines innovation as an invention commercialized so that produced or improved products become a novelty. In this sense, innovation is perceived as the result of the process. However, the definition of innovation may include the innovation process itself. As explained by E. Milbergs, N. Vonortas (2012), innovation is the process when a nation creates new knowledge and technologies and transfers them to goods, services or processes intended for the local or global market, in this way the added value is created for concerned countries and a higher living standard is ensured. This definition differs from the one above because it includes not only the innovation process itself and its result but also its main goal (creation of the added value and growth of the living standard); on top of that, innovation is defined at a macro level. One more unmentioned aspect is reflected in the definition of innovation by O. Manuel (2005) who suggests: innovation is a new or significantly improved product (a good or service) or process, new pricing or organizational models are integrated in the practice of a business, work organization or external relations. This definition clarifies that innovation is not necessarily new products, processes, business methods; they can be improved. This interpretation of innovations by O. Manuel (2005) is used by B. H. Hall (2011), Sh. Kamalodin, D. Pilic and M. Verduijn (2011). The fact that innovation covers not only technologically new products and processes but also improvements is also emphasized by J. Fagerberg, S. Martin and B. Verspagen (2009).

Proceeding with the analysis of innovation definitions, terms of innovation creativeness should be distinguished. J. Loche states they are often used as synonyms, but creativeness is only one component of the innovative process. Creativeness becomes innovation only after its commercialization. This aspect is also reflected in the definition discovered and given by M. Rogers (1998): innovation is any new or significantly improved product or service, which has been commercialised or any new or significantly improved process of production or service rendering. In his work the author provides several interpretations of the innovation definition encountered in some other resources:

- Innovations at the level of individual enterprises can be treated as new for the enterprise ideas realized in products, processes, services or work organization, management or marketing systems (Department of Industry Science and Tourism - DIST);

- In business innovation is something new and significantly improved, enabling direct increase of the added value for the company and/or for consumers directly (Business Council of Australia).

Here innovations are defined at a micro level, but it basically repeat the aspects of the innovation concept above as well as the other ones found in scientific literature:

- Innovation is a continuous activity of search and investigations that result in new products, new processes, new organizational forms and new markets (Lundvall, 1992);
- An idea, activity or any material object new to people, their group or organization realized and used may be treated as innovation (Melnikas, Jakubavičius, Strazdas, 2000);
- Innovation is development and commercialization of new untested technologies and untried processes or products (Goldberg at al. 2006).

To sum up analysis of interpretations of innovation definitions, it might be stated that the innovation concept covers the entire innovation process: problem occurrence, ideas, research (fundamental and applied), development and commercialization. It should be noted here that approaches to the innovation process and its components has changed in time. At the beginning linear models of the innovation process were created. S. J. Kline, N. Rosenberg (1986), having analysed process models existing at that time, state that the first linear model of the innovation process included four stages: *Research→ Development → Production → Marketing*. According to B. Godin (2006), the first linear model included: *Basic research → Applied research → Development → Production and Diffusion*. As obvious in the both models, the stages are basically the same; still, the second model distributes research into fundamental and applied. Nevertheless, it should be taken into account that already back in 1983 Rogers distinguished six stages in the linear innovation development model*: need/problem → studies →development → commercialisation → distribution and acceptance → consequences* (Godin, 2006). As J. Buijs (2003) states, in the linear innovation process model presented by Saren in 1984, six following stages appear: *idea generation → selection → commercial evaluation → technical development → testing → commercialization*. The author also presents the innovation process model developed by Acher in 1971 that covers the following stages: s*trategic planning → studies → designing → development → production marketing start → production and sales.* It should be noted that only the main stages of the model are named here and the author details them in the study. In parallel to linear innovation process models, they started development chain related models as well. One of the pilots was the model developed by Kline in 1985 (see Fig. 1).

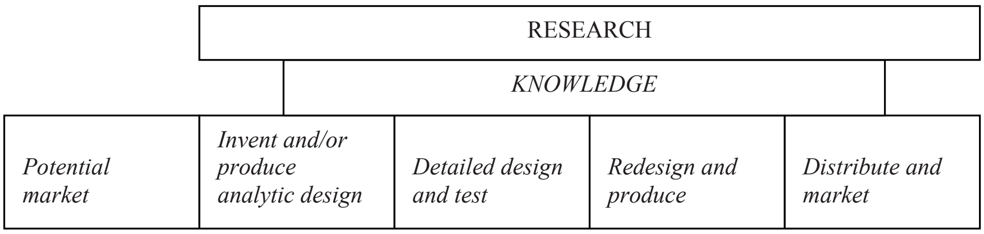

Fig. 1. Chain-related innovation process model

Source: Kline S. J., Rosenberg N. (1986). An Overview of Innovation. The National Academy of Science, p. 289.

Chain related models were replaced by circulating innovation process models. J. Buijs (2003) introduced the first circulating model formed in 2002 where, under the influence of a competitive environment, the following components of this process interact: strategy formation, project formation, product development, product launching and usage. In addition, Buijs (2003) formed and presented a detailed circulating innovation process model of a product that includes 26 components (see the source). It should be noted, however, that the linear innovation process model has not lost its popularity. It has been developed and used. L. Morris (2011) presented the linear model consisting of seven steps:

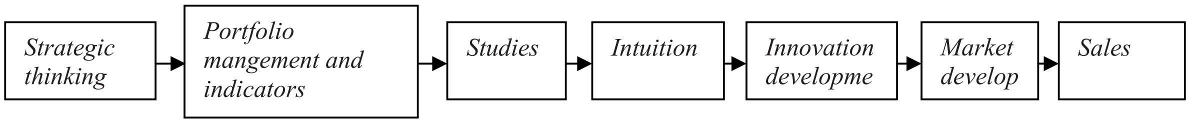

Fig. 2. 7-step linear model of the innovation process
Source: compiled by the authors according to L. Morris (2011).
The Innovation Master Plan: The CEO's Guide to Innovation.

The latest innovation process models emphasize yet unmentioned stages: intellectual property defence, patents and product licensing.

Having briefly overviewed innovation process models, it can be stated that the initial models include the most essential stages of the innovation process; in the models developed afterwards these stages are diffused and/or detailed. In any case, the innovation definition covers the whole innovation process and its final result.

Overview of studies on correlation between innovations and labour productivity

In 2009 F. Bogliacino and M. Pianta investigated correlation between innovation and labour productivity and in their report the authors also surveyed other available prior research. They (Bogliacino, Pianta, 2009) state that the initial research intended to determine correlation between innovation and productivity performed by Z. Gliliches (1979, 1995, 2000). Z. Gliliches investigated the impact of R&D expenditure on productivity at the national, branch and company level and set a positive significant impact of certain strength variations. It should be noted that in these studies productivity is measured by the added value per employee, i.e. the impact of R&D on labour productivity. F. Bogliacino and M. Pianta (2009) also indicate that such kind of studies at the micro level were performed by Z.Griliches and J. Mairesse (1982) using data from the USA and France, and P. Cuneo and J. Mairesse using data of French companies only. They studied companies related to science and the rest ones separately and determined that in companies related to science the impact of R&D was twice bigger than in the rest ones. It should be noted that in this case the impact was evaluated by R&D elasticity of productivity. According to the authors (Bogliacino, Pianta, 2009), a positive and significant impact of R&D on productivity was also determined by K. Wakelin (2001) using data of 170 companies quoted in the UK Stock Exchange in 1988, 1992. K.H. Tsai and J.C. Wang (2004) analysed data of 156 big Thai companies in 1994-2000 and, having calculated R&D elasticity of productivity, determined a positive and significant impact of R&D on productivity. It is necessary to note that productivity was more R&D elastic in larger companies. R. Ortega-Argiles, L. Potters and M. Vivarelli (2008) performed a study employing data of 532 European manufacturing companies investing into R&D and established that the impact of R&D on productivity was stronger in companies of a medium technological level to compare with a low technological level. Meanwhile the results of B. Verspagen's study (1995) were opposite. Using R&D supplemented by the manufacturing function he determined that in case of OECD countries the role of R&D in output was positive and significant in the sector of high technologies only, and R&D did not influence productivity in the sector of medium and low technologies. The authors themselves (Bogliacino, Pianta, 2009) investigated correlation between innovations and labour productivity in the production and service sectors employing data of 8 European countries (Germany, France, Italy, Norway, the Netherlands, Portugal, Spain and the United Kingdom) of 1996-2006 provided in the Sectoral Innovation Database (SID). While analysing they applied the method of regressive analysis and established that R&D expenses per employee had a significant impact on the productivity of companies receptive to knowledge of the both, production and service, sectors.

P. Hanel (2008) also studied and summarized already performed research on correlation between innovations and productivity. The author states in his overview that research performed in the USA expressly reveal a positive and strong relation between labour productivity and innovations and between total productivity of production factors and innovations. Meanwhile, in the case of Canada, research results on R&D expenditures and productivity correlation vary. The author (Hanel, 2008) points out that research was performed with data of the industrial sector of 1960-1970, and they did not specify any significant impact of R&D expenditures on productivity. Still, Khanam and Au (2004), after their research with data on the Canadian industrial sector of 1972-2000, established a positive significant relation between productivity and innovations. What is more, they found that the total payoff on R&D expenditure is higher in manufacturing companies of high technologies. The author himself (Hanel) performed a study in 2000 and indicated a positive significant relation between R&D

and productivity in 22 cases of the studied Canadian manufacturing companies. It should be noted that P. Hanel (2008) analysed correlation between the National Innovation Capacity Index and Gross Domestic Product (GDP) per employee with data from 80 countries and defined that relation between these indicators is direct and strong (R=0,83).

H. Lööf (2002, 2004) investigated correlation between innovations and labour productivity using data of 607 manufacturing and 538 service companies operating in Sweden. The author determined a positive significant correlation between R&D expenditures, innovations and labour productivity in companies of the both industrial and service sectors investing in knowledge. Studying correlation between innovations and labour productivity the results of regressive analysis were, in fact, similar in industrial and service companies (coefficients fluctuate within the same range).

N. Janz, H. Lööf and B. Peters (2003) studied relation among labour productivity, R&D expenditures and innovation output analysing data of 1049 German and Swedish companies with the number of employees from 10 to 999 (53% assigned to innovative companies). The authors concluded that innovations were a determinant resource for labour productivity increase.

C. Lee (2008) intended to determine correlation of innovations (product and process), productivity and trade intensity studying data from the Malaysian companies of the manufacturing sector of 2002-2004. The research revealed that investment intensity, product innovations, process innovations and labour quality are significant variables that influence labour productivity. The author (Lee, 2008) found that product innovations have a negative impact on productivity, while process innovations have a positive one.

J. Haskel et al. (2009) investigated investments of the United Kingdom into innovations and their role in productivity growth and determined that in 2000 production volumes per one working hour increased by 1.81% due to innovation development.

The factors of technological innovations and their impact on labour productivity in 6 Latin American countries, Argentina, Chile, Columbia, Costa Rica, Panama and Uruguay, were studied by G. Crespi and P.Zuñiga (2010). They used micro data taken from innovation research (reviews). They employed the structural CDM model, named after its creators Crepon, Duget and Mairesse (1998). This model was designed to determine innovation factors and their impact on labour productivity. The authors of the study found strong relation between innovation costs and output and between innovation output and labour productivity. Connections of innovations with labour productivity were also indicated by S. Ahn (2002), S. Arvanitis (2006), Ph. Aghion, Ph, et al (2006), R. Griffith, E. Huergo, J. Mairesse, B. Peters (2006), T. Paas, H. Potimäe (2012), M. Pianta, A.Vaona (2005), K. Uppenberg, H. Strauss (2010), P. Vahter, J. Masso (2011), etc.

Summarizing overview of studies on correlation between innovations and labour productivity it can be stated that the results of related research are contradictory: in some cases correlation was proved, in other cases denied. Moreover, it was concluded that different strengths of relations between labour productivity and innovation development resulted from the country's economic situation, research level (micro, macro, and branch), studied period, study scope and methods. Hence, in order to evaluate innovations as the factor of labour productivity increase, study must use data of a particular country that the situation needs to be evaluated, data covering at least the last decade. Study results should not be considered as abstract.

Methods of the analysis of innovation and labour productivity correlation

Analysis of retrospective studies on innovations and labour productivity correlation showed that R&D supplemented by the production function was the most frequently used to define the impact of innovations on labour productivity (Gliliches, 2000; Janz, Lööf ir Peters, 2003; Lööf, 2004; Lee, 2008, etc.). According to S.Valentinavicius (2005), financial resources allocated for R&D indicate innovation potential of the economy. R&D, as the indicator of innovation development, was used in the studies of M.N. Baily and A.K. Chakrabarti (1985), F. Crespi and M. Pianta (2006), P. Hanel (2008), F. Bogliacino and M. Pianta (2009), J. Haskel et al (2009), A. Cassoni and M. Ramada (2010), G. Crespi, P. Zuñiga (2010), T.U. Nguyen Thi and M. Ludivine (2010) and others. P. Hanel reviewed studies on innovations and productivity (including labour productivity) in 2008 and also indicated that R&D was the most often used indicator of innovation activity in research. Acceptability of this indicator for innovation measurement was also proved by D. Castelani, A. Zanfei (2005), B.H. Hall, F. Lotti, J. Mairesse (2008), A. Cassoni and M. Ramada (2010). Thus, it can be reasonably stated that R&D is an appropriate indicator for defining innovation activity; therefore, it has been used in this study for analysis of correlation between innovations and labour productivity in E-27 member-states.

Overview of retrospective studies also revealed that correlative-regressive analysis is used most often to determine relations between innovation and productivity (total factor productivity, or labour and capital productivity) (Gliliches, 2000; Lööf, 2004; Lee, 2008; Bogliacino and Pianta, 2009; Cassoni and Ramada, 2010; Crespi and Zuñiga, 2010; Nguyen Thi and Ludivine, 2010, etc.). In some cases, R&D elasticity of productivity was also calculated. These methods will be also used to study correlation between innovations and labour productivity in this work. Notwithstanding, R&D partially reflects innovation development, so various international organizations calculate different indices of the country's innovation to evaluate the situation of the country's innovative activity. One of them is the Summary Innovation Index (SII) calculated by the Research and Innovation Union. According to R. Vitkauskaitė, V. Pukelienė (2010), SII is suitable for qualitative assessment of innovation. It should be noted that the methods of calculating this indicator have been changed. As H. Hollanders (2009) states, selection of innovation indicators and methods of index calculation have changed in time: include more indicators and more countries, expand innovation studies, and use summary indicators since 2003. In 2010 the Summary Innovation Index consisted of 3 sub-indices: opportunities, firm activities and output. All indicators of SII are given in Table 1.

Table 1

Structure of the Summary Innovation Index

Summary Innovation Index (SII)	**Opportunities**	*Human recourses*	New doctorate graduates
			Population aged 30-34 with tertiary education
			Youth with at least upper secondary education
		Open, excellent, attractive research system	International scientific co-publications
			Top 10% most cited scientific publications
			Non-EU doctorate students
		Finance and support	R&D expenditure in the public sector
			Venture capital
	Firm activities	*Firm investments*	R&D expenditure in the business sector
			Non-R&D innovation expenditure
		Linkages & entrepreneurship	SMEs innovating in house
			Innovative SMEs collaborating with others
			Public-private co-publications
		Intellectual assets	PCT patent applications
			PCT patent applications in societal challenges
			Community trademarks
			Community designs
	Outputs	*Innovators*	SMEs with product or process innovations
			SMEs with marketing or organizational innovations
			High-growth innovative firms
		Economic effects	Employment in knowledge-intensive activities
			Medium & high technology product exports
			Knowledge-intensive services exports
			Sales of new to the market and new to the firm innovations
			License and patent revenues from abroad

Source: Innovation Union Scoreboard 2011, p. 11.

As Table 1 shows, the Summary Innovation Index includes 25 determining indicators that influence the level of the country's innovation; therefore, after ranking countries according to labour productivity and this index, it is possible to find out whether the most innovative country is leading from the point of view of labour productivity too, and conversely, whether the country with the lowest innovation level demonstrates the lowest labour productivity, which would prove (or deny) connections between innovation development and labour productivity. That is one of the stages of this study. The entire process of the study is given in Figure 3.

As Figure 3 shows, ***in the first stage of the study*** data of EU-27 member-states productivity, SII and R&D expenditure in 2001-2010 were collected and systemized. According to J. Rutkauskas, E. Paulavičienė (2005), productivity in the economic position is defined as relation between output and input. Labour productivity was measured as the added value per employee (Euro) in this paper. ***In the second stage of the study,*** EU-27 member-states were ranked according to labour productivity, SII and R&D, gaps between the country's rank according to the productivity criterion and the country's rank according to SII and R&D were measured. That enabled the authors to determine whether the most innovative countries are the most productive as well.

In the third stage, EU-27 member-states were divided into 3 groups according to the same criteria: labour productivity, SII and R&D. Based on labour productivity, the countries were divided into high, medium and low productivity countries. *High productivity* countries were those with the added value per employee over 100 Euro. *Medium productivity* countries included the ones with the added value per employee of 75 to 100 Euro; and countries where the added value per employee was under 0.75 Euro were assigned to *low productivity ones.*

Based on SII, EU-27 member-states also fell into 3 groups: high, medium and low innovation. *Countries of high innovation* were those with SII up to 0.55; *medium innovation* – with SII from 0.35 to 0.55. Countries with SII under 0.35 were assigned to the group of *low innovation. C*ountries were also divided into 3 groups according to R&D. *Countries of high R&D expenditures* were those where R&D expenditure comprises 1.7% of GDP. Countries, where R&D expenditure fluctuated in the range of 1.2% – 7% of GDP, fell into the group of *medium R&D expenditures. Countries of low R&D expenditures* included those with R&D expenditure under 1.2% of GDP. After grouping the EU-27 member-states according to the said criteria, it was studied whether the same countries fall into: 1) high innovation and high productivity groups; medium innovation and medium productivity groups and low innovation and low labour productivity groups; 2) high productivity and high R&D expenditure groups; medium labour productivity and medium R&D expenditure groups and low labour productivity and low R&D expenditures groups. Such study also provided a possibility to make assumptions on relations of labour productivity and innovation development of the countries.

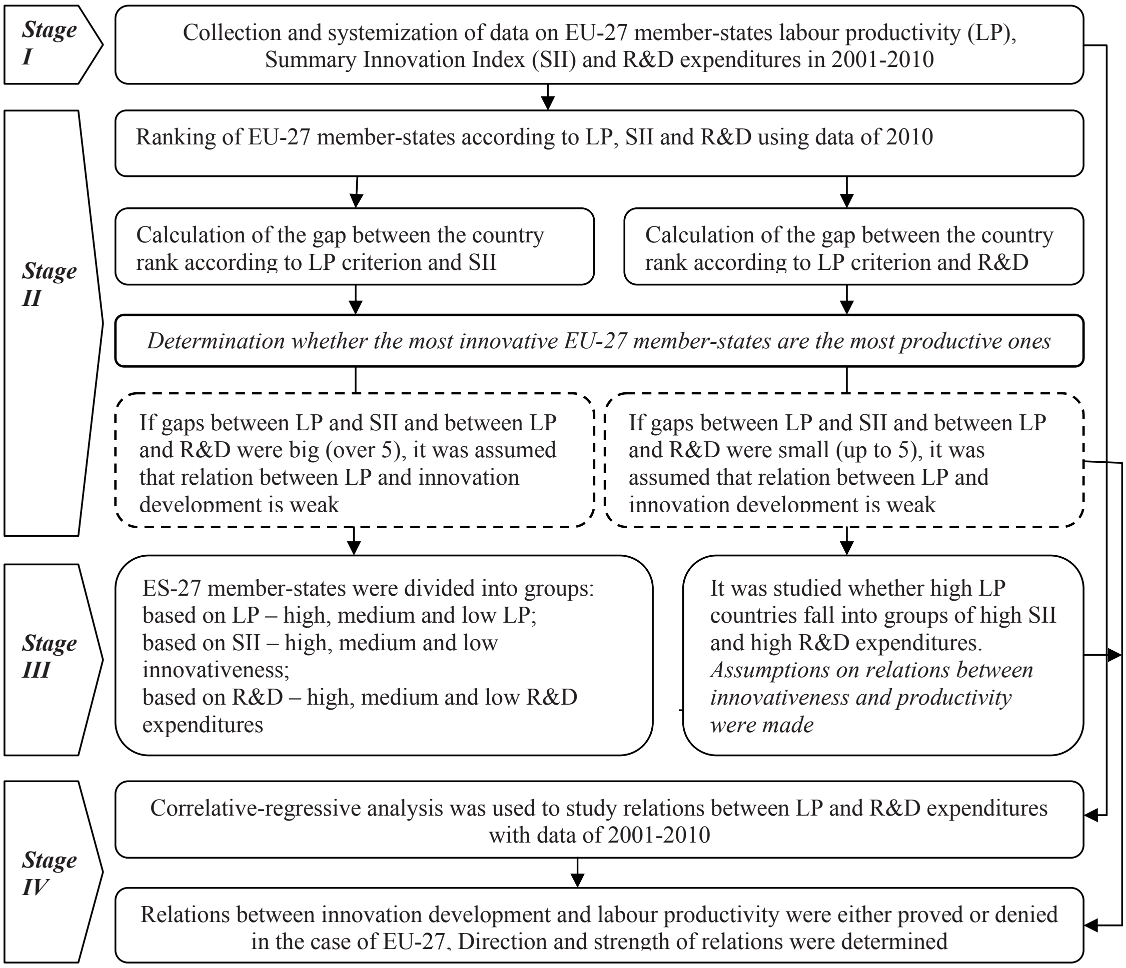

Fig. 3. Evaluation model of innovations as the factor of labour productivity increase
Source: compiled by the authors

In the fourth stage influence of innovation development on labour productivity in EU-27 member-states was evaluated after correlative-regressive analysis. Innovation development here was measured by R&D expenditures per employee (Euro). Labour productivity was measured by the added value per employee. Initially, in this stage the correlation coefficient (R), indicating the existence of correlation between the country's labour productivity and R&D expenditures and its strength, was calculated. Reliability of such correlation coefficient was checked using *t statistics* of the sample with the reliability level of 95% (α=0.05). Where *t* is higher than *t critical*, it can be stated that R is reliable. Having calculated R and verified its reliability, the regression coefficients (a and b) and the determination coefficient R^2 were calculated in the cases when relations between labour productivity and R&D had been proved. The estimated regression coefficient b shows average change of labour productivity in the country when R&D expenditures per employee increase by 1 Euro. The estimated b shows the average value of the indicator of labour productivity acquired if not influenced by the factor of R&D expenditures. Adequacy of the results of regressive analysis to the real situation was verified calculating *F statistics* and comparing it to the critical value with the reliability level of 95% (α=0,05). When *F* value was higher than the *F critical value*, the statement that the results of regressive analysis are adequate to the real situation was correct. The determination coefficient R^2 allowed to evaluate what part of labour productivity change can be explained by the change of R&D expenditures.

Analysis of correlation between innovations and labour productivity in the case of the European Union member-states

In order to determine relations between innovations and labour productivity according to the scheme given in the methods, connections between the Summary Innovation Index (SII) and labour productivity (LP) and between R&D expenditures and labour productivity shall be indicated. Having ranked (indicator descending) EU-27 member-states according to the Summary Innovation Index of 2010 and the added value per employee (Euro) produced in the country in the same year (Euro), it was established that the most innovative countries did not demonstrate the highest added value (see Table 2).

For instance, Sweden was ranked 1st according to SII but 6th according to labour productivity. Germany was the 2nd according to SII but only the 13th according to labour productivity. Finland took the 3rd position according to SII, and according to labour productivity – the 9th. The lowest SII was of Latvia (27th position), and its rank according to labour productivity was very close to it – the 25th. Bulgaria's ranking showed the 2nd position from the end according to SII (26th) and the very last (27th) – according to labour productivity, and Lithuania was in the 26th position according to SII and took the 24th position according to labour productivity. Analysis results showed that difference between ranked positions according to SII and labour productivity fluctuating from 1 to 11, was bigger in the countries of high innovation and smaller in the low ones. Here we can assume that correlation between innovations and labour productivity is stronger in the low productivity countries.

As the research continued, E-27 member-states were divided into 3 groups according to SII: of high, medium and low innovation. *High innovation countries* included the ones with SII up to 0.55: Sweden, Germany, Finland, Denmark, Luxemburg, Austria, Belgium, the United Kingdom, the Netherlands and Ireland. The group of *medium innovation* included the countries with SII from 0.35 to 0.55: France, Slovenia, Estonia, Cyprus, Italy, Portugal, Spain, the Czech Republic and Malta. The countries with SII under 0.35 fell into the group of *low innovation.* These included: Greece, Hungary, Slovakia, Poland, Rumania, Lithuania, Bulgaria and Latvia. In parallel, the countries were also divided into 3 groups according to labour productivity. *High productivity* countries were the ones with the added value per employee over 100 Euro: Luxemburg, Ireland, Belgium, France, Austria, Sweden, the Netherlands, Denmark, Finland, Italy, Spain, the United Kingdom and Germany. The countries of *medium productivity* – with the added value per employee within the range from 75 to 100 Euro: Greece, Malta, Cyprus, Slovakia, Slovenia, and Portugal. Where the added value per employee was under 0.75 Euro, those countries were assigned to the group of *low productivity.* These were: the Czech Republic, Hungary, Estonia, Poland, Lithuania, Latvia, Rumania and Bulgaria. This division is reflected in Columns 2 and 4 of Table 2 according to colour mark.

As the table shows, having grouped EU-27 member-states according to the level of innovations and labour productivity, in the majority of cases the countries of high innovation fell into the group of high labour productivity, the medium innovation countries - into the group of medium labour productivity, and the low innovation countries were grouped with low labour productivity countries. Exceptions included: 1) the Czech Republic and Estonia where the labour productivity level was low, even though these countries were assigned to the group of medium innovation countries, 2) Greece and Slovakia where, despite a high innovation index, labour productivity was only medium, 3) the labour productivity level was high in Italy and France, and the innovation level there was medium. The results of the study also showed dependence of labour productivity and innovation, but it is likely that strength in different countries varies.

Analogous results were also received when comparing country rankings according to labour productivity and the key indicator of innovation development – R&D expenditures (% of GDP). Having ranked the countries based on these indicators, it was determined that the countries where more funds are allocated to R&D development, the level of labour productivity is not the highest one. For example, Finland was ranked the 1st according to R&D expenditures (% of GDP), but according to labour productivity it took only the 9th position. Sweden was the 2nd according to R&D expenditures and the 6th according to labour productivity. If R&D expenditures brought Denmark to the 3rd place, labour productivity moved it to the 8th position. However, it was determined at the same time that the gap according to labour productivity rank and R&D expenditures was smaller in the countries of low productivity; for instance, Bulgaria was the 27th in the labour productivity ranking and the 24th in the R&D expenditures ranking; Rumania's labour productivity was the 26th and R&D expenditures – the 27th; the 25th position in labour productivity of Latvia equalled with its R&D expenditures ranking. That confirms again the assumption that correlation between innovation development and labour productivity is stronger in low productivity countries.

Table 2

SII, labour productivity, R&D expenditures and ranking of EU-27 according to these indicators

Country	SII	Rank acc.SII	LP	Rank acc. LP	Position difference (SII and LP)	R&D (% of GDP)	Position acc. SRED	Position difference (R&D and LP)	Position difference (SII and R&D)
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Ireland	0,571	10	136,9	2	*8*	1,79	10	*8*	*0*
Austria	0,626	6	115,3	5	*1*	2,76	5	*0*	*1*
Belgium	0,625	7	128,3	3	*4*	1,99	8	*5*	*-1*
Bulgaria	0,216	26	41,3	27	*-1*	0,6	24	*-3*	*2*
Czech Rep.	0,400	18	73,4	20	*-2*	1,56	15	*-5*	*3*
Denmark	0,704	4	110,6	8	*-4*	3,06	3	*-5*	*1*
Estonia	0,492	13	69,2	22	*-9*	1,62	13	*-9*	*0*
Greece	0,339	20	94,7	14	*6*	0,61	23	*9*	*-3*
Spain	0,410	17	108,9	11	*6*	1,39	16	*5*	*1*
Italy	0,429	15	109,3	10	*5*	1,26	17	*7*	*-2*
United Kingdom	0,599	8	106,7	12	*-4*	1,77	11	*-1*	*-3*
Cyprus	0,483	14	90,3	16	*-2*	0,5	26	*10*	*-12*
Latvia	0,213	27	54,6	25	*2*	0,6	25	*0*	*2*
Poland	0,304	23	66,8	23	*0*	0,74	20	*-3*	*3*
Lithuania	0,258	25	62,3	24	*1*	0,79	19	*-5*	*6*
Luxembourg	0,651	5	169,8	1	*4*	1,63	12	*11*	*-7*
Malta	0,383	19	91,3	15	*4*	0,63	21	*6*	*-2*
Netherlands	0,595	9	113,3	7	*2*	1,83	9	*2*	*0*
Portugal	0,426	16	76,4	19	*-3*	1,59	14	*-5*	*2*
France	0,540	11	115,8	4	*7*	2,26	6	*2*	*5*
Romania	0,259	24	48,9	26	*-2*	0,47	27	*1*	*-3*
Slovakia	0,322	22	81,3	17	*5*	0,63	22	*5*	*0*
Slovenia	0,499	12	80,4	18	*-6*	2,11	7	*-11*	*5*
Finland	0,708	3	109,6	9	*-6*	3,87	1	*-8*	*2*
Sweden	0,766	1	114,5	6	*-5*	3,42	2	*-4*	*-1*
Hungary	0,333	21	71,1	21	*0*	1,16	18	*-3*	*3*
Germany	0,711	2	105,1	13	*-11*	2,82	4	*-9*	*-2*

Source: of the authors based on data of Eurostat and Innovation Union Scoreboard 2011.

Marking given in Table 2

Colour	*Definition*
(dark grey)	Column 2: low innovation country, Column 4: low productivity country, Column 7: low R&D expenditures country
(light grey)	Column 2: medium innovation country, Column 4: medium productivity country, Column 7: medium R&D expenditures country
	Column 2: high innovation country, Column 4: high productivity country, Column 7: high R&D expenditures country

As the study continued, all ES-27 countries were also divided into 3 groups according to R&D expenditures (% of GDP) (see Table 2). The group of high R&D expenditures combined the countries where R&D expenditure was up to 1.7% of GDP (Ireland, Austria, Belgium, Denmark, the United Kingdom, the Netherlands, France, Slovenia, Finland, Sweden and Germany). It should be noted that all countries but France were also assigned to high innovation ones based on SII. Notwithstanding, it should be considered that France lacked only 0.01 point to get into the group of high innovation. Medium R&D expenditure countries were those where R&D expenditures fluctuated from 1.2% to 1.7% of GDP (the Czech Republic, Estonia, Spain, Italy, Luxemburg and Hungary). Low R&D expenditure countries were those with R&D expenditures under 1.2% of GDP (Bulgaria, Greece, Cyprus, Latvia, Lithuania, Malta, Rumania and Slovakia). Having analysed it was established that the majority of countries with high R&D expenditures got into the group of high labour productivity, with medium R&D expenditures – into medium labour productivity and with low R&D expenditures – into low labour productivity groups, except for: 1) the Czech Republic and Estonia where R&D expenditures were relatively high, but labour productivity remained low, 2) Greece, Cyprus, Malta and Slovakia with low R&D expenditures demonstrated medium labour productivity, 3) Spain, Italy, Luxemburg where labour productivity was high even though R&D expenditures were only medium. Hence, R&D expenditures were not always a crucial factor for labour productivity.

The fourth stage of the study included correlative-regressive analysis used to investigate correlations between labour productivity and innovation development. In this case, productivity was measured by the added value per employee (Euro). As the indicator of innovation development, R&D expenditures per employee (Euro) were used here.

First, in the cases of all EU-27 member-states with data of one decade (2001-2010), the correlation coefficients were calculated. Their significance was verified using the sample statistics *t* at the reliability level of 95% (α=0,05). The results are given in Table 3.

Table 3

Summary of the results of analysis of correlation between labour productivity and innovation development

High LP countries	*R*	*t*	*t critical*	*Medium LP countries*	*R*	*t*	*t critical*	*Low LP countries*	*R*	*t*	*t critical*
Belgium	-0,88	5,24	1,860	Greece	-0,66	1,96	2,015	Bulgaria	0,99	1,96	1,860
Denmark	-0,17	0,49	1,860	Cyprus	0,67	2,55	1,860	Czech Rep	0,80	2,55	1,860
Germany	-0,35	1,06	1,860	Malta	-0,62	2,09	1,895	Estonia	0,95	2,24	1,860
Ireland	-0,01	0,08	1,860	Portugal	0,90	5,84	1,860	Latvia	0,84	5,84	1,860
France	-0,54	1,81	1,860	Slovakia	0,93	7,16	1,860	Poland	0,77	7,16	1,860
Luxembourg	0,44	1,4	1,943	Slovenia	0,43	1,35	1,860	Lithuania	0,95	8,61	1,860
Netherlands	0,31	0,92	1,860	Hungary	0,93	7,16	1,860	Romania	0,92	7,16	1,860
Austria	-0,86	4,68	1,860								
Finland	-0,23	0,67	1,860								
Sweden	0,46	1,47	1,860								
United Kingdom	0,26	0,76	1,860								
Spain	0,45	1,41	1,860								
Italy	-0,75	3,21	1,860								

After correlation analysis, to confirm the assumption that there exists a direct relation between labour productivity and innovation development (expressed by R&D expenditures per employee) and assess its strength, it was concluded that in the high productivity countries where the added value was over 100 Euro, no correlation between labour productivity and R&D expenditures was found. Such conclusion was made considering that when verifying significance of the calculated correlation coefficients, t statistics values were lower than the critical ones, except for cases of Belgium, Austria and Italy. Here, the t value was higher than the critical one, so the correlation coefficient can be treated as significant. Still, in these cases, there was a reverse relation between the said determined indicators. It is likely that the so called false correlation appeared in these cases, or there are reasons due to which relations between labour productivity and R&D development was reverse in Belgium Austria and Italy.

Meanwhile, close correlation between labour productivity and R&D expenditures was determined in the medium and low productivity countries, except for Greece and Slovenia. In their case, while verifying reliability of the correlation coefficients R, the t statistics values were lower than the critical ones; therefore, it cannot be stated that the coefficients are significant. That was proved by the previous assumption that labour productivity in these countries depended on other factors not mentioned in the study. Yet, in the cases of Slovakia, Hungary, Bulgaria, Estonia, Lithuania and Rumania a very strong correlation between labour productivity and R&D expenditures was determined; in the Czech Republic, Latvia and Poland this correlation was strong, and in Cyprus – a noticeable one. However, in Malta's case reverse noticeable correlation between these indicators was discovered, but it was assumed based on previous results that this was the case of false correlation.

Having analysed correlations between the added value and R&D expenditures in EU-27 member-states, in the cases of the countries with verified close correlations between these indicators regressive analysis was performed. This analysis helped to indicate an average shift of labour productivity while increasing R&D expenditures per employee. It should be noted that reliability of these results was verified using F statistics. Since the F value was higher than the F critical value equal to 5.3177 (α=0.05) in the cases of all countries, it can be stated that the results of regressive analysis were adequate to the real situation. The results are given in Table 4.

Table 4

Summary of the results of the study on labour productivity dependence on R&D expenditures

Low LP country	*R*	*R^2*	*a*	*b*	*Medium LP country*	*R*	*R^2*	*a*	*b*
Bulgaria	0,99	0,9734	0,44	29,30	Cyprus	0,67	0,4472	0,10	78,16
Czech Republic	0,80	0,6436	0,04	66,05	Portugal	0,90	0,8118	0,03	68,25
Estonia	0,95	0,9048	0,13	47,52	Slovakia	0,93	0,8630	0,45	51,53
Latvia	0,84	0,7042	0,21	40,57	Hungary	0,93	0,8581	0,15	54,70
Poland	0,77	0,5956	0,17	54,62					
Lithuania	0,95	0,9028	0,27	42,12					
Rumania	0,92	0,8492	0,76	24,07					

The results show that when R&D expenditures per employee increased by 1 Euro, the added value per employee increased most in Rumania – by 0.76 Euro on average, least - in the Czech Republic – by 0.04 Euro, and in Lithuania – by 0.27 Euro. That is demonstrated by the value of the estimate *a* while the estimate b shows the level of the country's labour productivity if R&D expenditures equalled 0. Thus, it is likely that labour productivity of the Czech Republic, without investments into R&D development, would reach 66.06 Euro on average, while in 2010 it reached 73.4 Euro.; Rumania's labour productivity would be around 24.07 Euro, while in 2010 it was 48.9 Euro; labour productivity in Lithuania would be around 42.12 Euro, while it was measured at 62.3 Euro in 2010.

The determination coefficient R^2 shows percentage of variations of labour productivity possible to explain by R&D expenditures. The results enabled us to state that in the case of Cyprus, shifts in labour productivity were caused by R&D expenditures only by 44.72%, the rest part of the shift resulted from factors outside this study. Still, in Lithuania R&D expenditures explain 90.28% of the country's labour productivity change, and in Bulgaria – even 97.34%. Thus, the impact of innovation development on labour productivity in Bulgaria, the Czech Republic, Estonia, Latvia, Poland, Rumania, Cyprus, Portugal, Slovakia and Hungary is obvious.

Conclusions

Having revealed innovation concepts provided by various authors, an expanded definition of innovations was formed. Innovation is the process of development and implementation of new or improved goods, services and/or management, pricing, training and learning methods where human and technological resources are involved, and its result provides a possibility to directly increase the added value to the company and indirectly to the consumer, increasing the level of competitiveness of the country at the same time. After analysis of retrospective relations between labour productivity and innovation, it was determined that when data of different periods is used, correlations of different strength were indicated in the cases of different countries.

After analysis of the methods employed in retrospective studies of correlations between labour productivity and innovations, it was concluded that it was reasonable to use the production function to define this correlation, expanding it with the indicators of innovation development. Additionally, it was determined that R&D is the most frequently used indicator of the measurement of innovation development. In order to evaluate the level of the country's innovation, the Summary Innovation Index (SII) can be employed. Correlations between labour productivity and innovations are often studied using correlative-regressive analysis. Considering these conclusions, the study scheme was generated, including the methods already mentioned and the country ranking and comparison according to the criteria of labour productivity, SII and R&D.

Having ranked EU-27 member-states according to labour productivity and SII and R&D expenditures, having calculated gaps between ranks and having performed comparative analysis, it was concluded that correlation between innovation development and labour productivity is stronger in low productivity EU member-states. This implication was also verified when EU-27 member-states were divided into high, medium and low productivity countries; high, medium and low SII and high, medium and low R&D expenditure groups, and when comparative analysis was performed.

Having analysed relations between innovation development and labour productivity in EU-27 member-states according to data of 2001-2010, it was concluded that innovations act as a crucial factor on labour productivity in Bulgaria, the Czech Republic, Estonia, Latvia, Poland, Lithuania, Rumania, Cyprus, Portugal, Slovakia and Hungry. It is likely that additional investments in innovation development will markedly increase labour productivity in these countries; however, further studies are necessary to determine what innovations should be invested in what branches and how to stimulate innovation development.

References

1. Ahn, S. (2002). Competition, Innovation and Productivity Growth: A Review of Theory and Evidence, OECD Economics Department Working Papers, No. 317, doc. 10.1787/182144868160.
2. Arvanitis, S. (2006). Innovation and Labour Productivity in the Swiss Manufacturing Sector: An Analysis Based on Firm Panel Data. Swiss Federal Institute of Technology Zurich. Working Paper No. 149.
3. Aghion, Ph. et al. (2006). The Effects of Entry on Incumbent Innovation and Productivity. National Bureau of Economic Research, Working Paper 12027.
4. Baily, M. N.; Chakrabarti, A. K. (1985). Innovation and Productivity in U.S. Industry. Brookings Papers on Economic Activity, No. 2., p. 609-639.
5. Bogliacino, F.; Pianta, M. (2009). The impact of innovation on labour productivity growth in European industries: Does it depend on forms‘ competitiveness strategies? IPT Working Paper on Corporate R&D and innovation, No. 13. Available online at: http://iri.jrc.es/papers/13_IPTS_WP_JRC53698.pdf
6. Castellani, D.; Zanfei, A. (2006) Multinational Firms, Innovation and Productivity. Available online at: http://www.siepi.univpm.it/sites/www.siepi.univpm.it/files/siepi/papers/20070116-CZ_MIP.pdf
7. Cassoni, A.; Ramada, M. (2010). Innovation, R&D and Productivity: The Uruguayan Manufacturing Sector. IDB Working Paper 191. Washington, DC, United States: Inter-American Development Bank.
8. Crespi, F.; Pianta, M. (2006). Diversity in innovation and productivity in Europe. Paper submitted for publication in the proceedings of the 2006 Schumpeter Society Conference.
9. Crespi, G., Zuñiga, P. (2010). Innovation and Productivity: Evidence from Six Latin American Countries. Inter-American Development Bank.
10. Gomez-Salvador, R.; Musso, A.; Stocker, M.; Turunen, J. (2006). Labour Productivity development in the Euro area. Available online at: http://www.ecb.int/pub/pdf/scpops/ecbocp53.pdf
11. Gooble, M.A.M. (2012). Innovations and Strategy. Research-Technology Management, May-June, p. 63-68, DOI: 10.5437/08956308X5503005.
12. Griliches, Z. (2000). R&D, Education, and Productivity. Cambridge, MA: Harvard University Press.
13. Griffith, R.; Huergo, E.; Mairesse, J.; Peters, B. (2006). Innovation and Productivity Across Four European Countries. National Bureau of Economic Research. Working Paper 12722. Accessed at: http://www.nber.org/papers/w12722.
14. Fagerberg, J.; Srholec, M.; Verspagen, B. (2009). Innovation and Economic Development. UNU-MERIT Working Papers. Available online at: http://www.merit.unu.edu/publications/wppdf/2009/wp2009-032.pdf
15. Jakubavičius, A.; Strazdas, R.; Gečas, K. (2003). Inovacijos. Procesai, valdymo modeliai, galimybės. Vilnius: Lietuvos inovacijų centras
16. Janz, N;, Lööf, H.; Peters, B. (2003). Firm Level Innovation and Productivity - Is there a Common Story Across Countries? Centre for European Economic Research: Electronic Working Paper Series, Paper No. 24.
17. Hall, B. H. (2011). Using productivity growth as an innovation indicator. University of Maastricht and UC Berkeley: Report for the High Level Panel on Measuring Innovation, DG Research, European Commission. Available online at: http://ec.europa.eu/commission_2010-2014/geoghegan-quinn/hlp/documents/20120309-hlp-productivity-innovation_en.pdf
18. Hall, B.H. (2011). Innovation and Productivity. National Bureau of Economic Research. Available online at: http://elsa.berkeley.edu/~bhhall/papers/BHH11_In

novation%20and%20Productivity_NEPR.pdf.
19. Hall, B.H.; Lotti, F.; Mairesse, J. (2008). Innovation and Productivity in SMEs. Empirical Evidence for Italy. National Bureau of Economic Research. Working paper No. 14594. Available online at: http://scifiglow.cepr.org/HallLotti&Mairesse.pdf_AN.pdf.
20. Hanel, P. (2008). Productivity and Innovation: An Overview of the Issues. Centre interuniversitaire de researche sur la science et la technologie: Note de researche.
21. Haskel, J. and atc.(2009). Innovation, knowledge spending and productivity growth in the UK. National Endowment for Science, Technology and the Arts: Index Report.
22. Kamalodin, Sh.; Pilic, D.; Verduijn, M. (2011). The Rabo Innovation Index. Rabo bank. Available online at: http://www.rabobank.com/content/images/SP-1105ska_mve_dpi%20The%20Rabo%20Innovation%20Index_tcm43-147225.pdf
23. Kline, S.J.; Rosenberg, N. (1986). An Overview of Innovation. Available online at: http://www.flacso.edu.mx/openseminar/downloads/innovation_overview.pdf
24. Lee, C. (2008). The Relationship Between Innovation, Productivity and Exports: Some Preliminary Evidence from the Malaysian Manufacturing Sector, Economics Bulletin, Vol. 12, No. 31, p. -13.
25. Loche, J. What are Innovation, Creativity and Design? Available online at: http://media.wiley.com/product_data/excerpt/85/04708470/0470847085.pdf
26. Lööf, H. (2004). A Comparative Perspective on Innovation and Productivity in Manufacturing and Services. CESIS: Electronic Working Paper Series, paper No. 1.
27. Lundvall, B.A. (1992). National System of Innovation: Towards a Theory of Innovation and Interactive Learning. London: Frances Printer.
28. Melnikas, B.; Jokubavičius, A.; Stazdas, R. (2000). Inovacijų vadyba. Mokomoji knyga. Vilnius: Technika.
29. Milbergs, E., Vonortas, N. (2012). Innovation Metrics: Measurement to Insight. National Innovation Initiative 21st Century Working Group. Accessed at: http://www.innovationtools.com/pdf/innovation-metrics-nii.pdf
30. Morris, L. (2008). Innovation Metrics. The Innovation Process and How to Measure It. An InnovationLabs White Paper.
31. Morris, L. (2011). *The Innovation Master Plan: The CEO's Guide to Innovation.* Available online at: http://www.innovationmanagement.se/wp-content/uploads/2011/09/Innovation-Master-Plan_Chapter-5.pdf.
32. Nguyen Thi, T.U.; Ludivine, M. (2010). The Relationship between Innovation and Productivity conditional to R&D and ICT use. An empirical analysis for firm in Luxembourg. Submission paper for the 3rd Vietnam Economist Annual Meeting (VEAM).
33. Paas, T.; Potimäe, H. (2012). Consistency between innovation indicators and national innovation performance in the case of small economies. Eastern Journal of European Studies, Vol. 3, Issue 1, p. 101-121.
34. Pianta, M.; Vaona, A. (2005). Innovation and productivity in European industries. Paper for the ISAE-CEIS Monitoring Italy Conference, Rome, 7 June 2005
35. Robin, S.; Mairesse, J. (2008). Innovation and productivity: a firm-level analysis for French Manufacturing and Services using CIS3 and CIS4 data (1998-2000 and 2002-2004). Paper to be presented at the 25th Celebration Conference on Entrepreneurship and innovation – Organizations, Institutions, Systems and Regions. Denmark: Copenhagen.
36. Rogers, M. (1998). The Definition and Measurement of Innovation. Melbourne Institute Working Paper No. 10/9.
37. Ruktkauskas, J., Paulavičius, E. (2005). Concept of Productivity in Service Sector. Engineering Economics. No. 3(43), p. 29-34.
38. Sabonienė, A., Karazijienė, Ž. (2012). Productivity Dynamics in Lithuanian Manufacturing Industry. Economics and Management. Vol. 17, No 2, p. 650-566.
39. Souma, W.; Ikeda, Y.; Iyetomi, H.; Fujiwara, Y. (2009). Distribution of Labour Productivity in Japan over the Period 1996-2006. Economics. Volume 3, No. 14. Available online at: http://www. Economics-ejournal.org/economics/journalarticles/2009-14
40. Uppenberg, K.; Strauss, H. (2010). Innovation and productivity growth in the EU services sector. European Investment Bank.
41. Vahter, P.;Masso, J. (2011). The Link between Innovation and Productivity in Estonia's Service Sectors. William Davidson Institute Working Paper Number 1012.
42. Valentinavičius, S. (2005). Innovation as an accelerator of competitiveness and economic development. Ekonomika. No 70, p. 100-112.
43. Vitkauskaitė, R., Pukelienė, V. (2010). Inovacijų kiekybinis vertinimas: suminis inovacijų indeksas Lietuvoje. Taikomoji ekonomika: sisteminiai tyrimai. No. 4/2, p. 31-46.

Mačiulytė-Šniukienė, A., Montvilaitė, K.

Inovacijų kaip darbo produktyvumo didinimo veiksnio vertinimas: Europos Sąjungos šalių atvejis

Santrauka

Straipsnyje atskleista inovacijų samprata, trumpai aptarta inovacinio proceso modelių raida. Atlikus inovacijos sąvokų interpretacijų analizę, prieita išvados, kad inovacijos samprata apima visą inovacinį procesą: problemos atsiradimą, idėjas, tyrimus (fundamentinius ir taikomuosius), plėtrą ir komercializavimą. Taip pat nustatyta, kad požiūris į inovacinį procesą ir jo sudedamąsias dalis laiko tėkmėje kito. Pirmiausia buvo sudaryti linijiniai inovacinio proceso modeliai. Lygiagrečiai linijiniams inovacinio proceso modeliams pradėti plėtoti ir grandine susieti modeliai, kuriuos pakeitė cirkuliaciniai inovacinio proceso modeliai. Naujausiuose inovacinio proceso modeliuose akcentuojami papildomi etapai: intelektinės nuosavybės apsauga, patentai ir produkto licencijavimas. Bet kuriuo atveju inovacijų sąvoka apima visą inovacinį procesą ir galutinį jo rezultatą.

Atskleidus įvairių autorių inovacijų sampratas, suformuotas praplėstas inovacijų apibrėžimas: inovacija tai naujų arba patobulintų prekių, paslaugų ir / ar vadybos, rinkodaros, mokymo ir mokymosi metodų kūrimo ir diegimo į praktiką procesas, kuriame naudojami žmogiškieji ir technologiniai ištekliai, bei jo rezultatas, suteikiantis galimybę tiesiogiai padidinti pridedamąją vertę įmonei, ir netiesiogiai – vartotojui, kartu didinantis šalies konkurencingumo lygį.

Siekiant įvertinti inovacijų plėtros poveikį darbo produktyvumui, apžvelgti inovacijų ir darbo produktyvumo tarpusavio ryšių retrospektyviniai tyrimai ir jų rezultatai. Ryšius tarp inovacijų plėtros ir darbo produktyvumo tyrė daugelis autorių: Gliliches (1979, 1995, 2000), Mairesse (1982), Wakelin (2001), Lööf (2002, 2004), Janz, Lööf ir Peters (2003), Tsai ir Wang (2004), Ortega-Argiles, Potters ir Vivarelli (2008), Hanel (2008), Bogliacino ir Pianta (2009), Crespi, Zuñiga (2010) ir kt. Išvardytų autorių tyrimai apima skirtingus laikotarpius ir juose naudojami skirtingų šalių ar šalių grupių duomenys. Be to, kai kuriais atvejais ryšys tarp darbo produktyvumo ir inovacijų plėtros tiriamas mikro-, kai kuriais atvejais – makrolygmeniu, o kai kuriais atvejais – šakos lygmeniu. Pažymėtina ir tai, kad ne visais atvejais naudojami tie patys rodikliai inovacijų plėtrai apibrėžti. Šios priežastys lėmė tyrimuose gautų rezultatų prieštaringumą. Vienais atvejais ryšiai tarp inovacijų plėtros ir darbo produktyvumo pasitvirtino, kitais atvejais – ne, be to, ryšių stiprumas taip pat skirtingas. Atsižvelgiantį į šiuos rezultatus prieita išvados, kad norint įvertinti inovacijas kaip darbo produktyvumo didinimo veiksnį, būtina analizę atlikti konkrečios šalies(-ių) atveju, naudojant naujausius duomenis.

Išanalizavus darbo produktyvumo ir inovacijų tarpusavio ryšių tyrimo metodologijas, taikomas retrospektyviniuose tyrimuose, prieita išvados, kad šiam ryšiui aprašyti tikslinga naudoti gamybos funkciją, ją praplečiant inovacinės plėtros rodikliais. Taip pat nustatyta, kad plačiausiai naudojamas rodiklis inovacinei plėtrai matuoti yra MTEP. Siekiant įvertinti šalies inovatyvumo lygį, gali būti naudojamas suminis inovatyvumo indeksas (SII). Ryšiams tarp darbo produktyvumo ir inovacijų tirti dažniausia naudojama koreliacinė-regresinė analizė. Atsižvelgiant į šias išvadas, suformuota tyrimo schema, apimanti jau paminėtus metodus bei šalių rangavimą ir lyginimą pagal darbo produktyvumo, SII ir MTEP kriterijus.

Tyrimas atliktas naudojant ES-27 šalių 2001–2010 m. duomenis. ES šalis išrangavus pagal darbo produktyvumą ir pagal suminį inovatyvumo indeksą bei MTEP, nustatyta, kad atotrūkis tarp rangų yra didesnis aukšto darbo produktyvumo šalyse, todėl pirmajame tyrimo etape daroma prielaida, kad inovacijų plėtros ir darbo produktyvumo ryšis yra stipresnis žemo produktyvumo šalyse. Ši prielaida patvirtinta ir suskirsčius ES-27 šalis į aukšto, žemo ir vidutinio produktyvumo; aukšto, vidutinio ir žemo SII bei didelių, vidutinių ir mažų MTEP išlaidų grupes ir atlikus lyginamąją analizę.

Tęsiant analizę, ši prielaida patikrinta nustatant tarpusavio ryšius tarp pagrindinio inovacijų plėtrą atspindinčio rodiklio (MTEP) ir darbo produktyvumo, naudojant koreliacinę-regresinę analizę. Jos rezultatai parodė, kad inovacijų plėtra nėra darbo produktyvumą lemiantis veiksnys aukšto darbo produktyvumo šalyse, tačiau inovacijų įtaka vidutinio ir žemo produktyvumo šalių darbo produktyvumui yra tiesioginė ir stipri, išskyrus keletą išimtinių atvejų. Tai leidžia daryti išvadą, kad inovacijos – darbo produktyvumo didinimo šaltinis ES vidutinio ir žemo darbo produktyvumo šalyse (Bulgarijoje, Čekijoje, Estijoje, Latvijoje, Lenkijoje, Lietuvoje, Rumunijoje, Kipre, Portugalijoje, Slovakijoje ir Vengrijoje). Tikėtina, kad papildomos investicijos į inovacijų plėtrą gerokai padidintų šių šalių darbo produktyvumą. Tačiau siekiant nustatyti, į kokias inovacijas, kokiose šakose investuoti, kaip galima būtų paskatinti inovacijų plėtrą, būtina atlikti papildomą tyrimą.

Pagrindiniai žodžiai: inovacijos, inovacinis procesas, darbo produktyvumas.

The article has been reviewed.
Received in September 2012; accepted in November 2012.