BUSINESS, MANAGEMENT AND EDUCATION
ISSN 2029-7491 / eISSN 2029-6169
2015, 13(2): 203–219
doi:10.3846/bme.2015.299

IMPACT ASSESSMENT OF PUBLIC INNOVATION SUPPORT IN EUROPEAN ECONOMIC AREA

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Received 19 October 2015; accepted 24 November 2015

Abstract. The object of this paper is related to the public innovation support in European Economic Area and its effectiveness assessment. Main aim of the research presented in this paper is to propose new model for public innovation support effectiveness assessment, which could be relevant to the contemporary needs and would be based on new explored practice of public innovation support developments. The methods of comparative, regression, modelling analysis, multi-criteria evaluation, analogy search, logical abstraction and impact evaluation have been applied for the research presented in this paper. Proposed original system of quantitative and qualitative indicators that characterize any public innovation support system (public innovation support index) enables creation and implementation of measures devoted to the public innovation support impact improvement at EU and national level.

Keywords: innovation, public innovation support, impact assessment, index.

JEL Classification: O31, O32.

1. Introduction

Context. The current global economic crisis emphasizes the need for efficient and effective use of public funding for the benefit of public interest. Under such circumstances increased pressure is forwarded to the public budgets. According to the EU wide studies the impact of the crisis on innovation expenditures seems to be the greatest in low tech manufacturing sectors and in countries classified as "catching up" by the European Innovation Scoreboard. It could be stated that as a direct impact of the economic crisis, the innovation gap in the EU risks to be widened again. The need of new approaches for the assessment of public innovation support is caused by:

– limited understanding how to assess the relevance of public innovation support schemes to the needs of businesses and public interest;
– limited effectiveness of public innovation support;

– lack of indicator systems suitable for the comparative analysis of complex public innovation support systems at national and at EU level;
– absence of theoretical background which could justify the creation and development of complex public innovation support systems relevant to the national socio-economic challenges.

By reacting to the all above stated challenges the issues of public innovation support assessment has recently received an increasing attention among scholars and practitioners. However, only with few exceptions, scientific studies has been based on the analysis of particular innovation policies or instruments in limited manner neglecting almost completely the specific policy dilemmas arising from weak and fragmented understanding of support impact.

Topicality. In developed countries innovation has been the key engine for economic development enabling to reach international competitiveness and relevant quality of people's life. In view of the complex and strategic character of innovation processes and their significance for the country, the intervention of the public sector in the innovation development and promotion process is not only possible, but necessary.

In order to ensure qualitative development of public innovation support systems which are relevant to the needs of business but also matches the public interest it is very important to understand the synergies of multiple public support actions under holistic innovation paradigm and to suggest novel and comprehensive approach for national innovation support system assessment. It also should be stated that such assessment of public innovation support is important and topical action for the science of management at the national as well as at supranational level. This paper discusses conceptual frameworks for assessment of the impact of public innovation support while applying conventional descriptive methods to explore the changes in innovation in European Economic Area. The assessment of public innovation support effectiveness is important field for the scientific research due to the following reasons:
– creates a ground for rationalization of public innovation support policies;
– justifies appropriateness of public funds allocated for this support;
– encourage improvement of public support, its effectiveness, thus reforming current and introducing new support programs and measures.

Therefore, it is very important to explore and suggest new approaches, methods and instruments for the modern public innovation support assessment.

Object of the research presented in this paper. The research object is public innovation support in European Economic Area and its effectiveness assessment.

Aim of research presented in this paper – to propose new model for public innovation support effectiveness assessment, which is relevant to the contemporary needs and is based on explored practice of public innovation support development.

Methodology of research. The methods of comparative, cluster, regression, modelling analysis, multi-criteria evaluation, analogy search, logical abstraction and impact evaluation have been applied for the research presented in this paper.

Scientific novelty. Scientific novelty is observed by main results:

- With the definition of a new research field in the area of public innovation support effectiveness assessment a strong ground for the better perception of public support impact was created.
- Common for EU and specific to Lithuania patterns of public innovation support development practice were identified which creates new opportunities for the improvement of public support effectiveness.
- Original system of quantitative indicators enables creation and implementation of measures devoted to the public innovation support effectiveness improvement at EU and national level.
- Suggested model for the assessment of public innovation support is based on theoretical argumentation and practical verification. Its structure is based on new solutions and quantitative assessment methods.

Practical value. The presented research results can be used in creation and development of particular public innovation support measures or their systems which will be relevant to the economic development priorities and needs of businesses. The practical application of the suggested model is significant for the effectiveness improvement of public innovation support at EU as well as at Lithuanian institutions.

2. Previous research of public innovation support impact assessment

It could be stated that the emphasis on public innovation support is caused by widespread of innovation phenomena that contribute significantly to GDP and contribute to the important socioeconomic challenges. By understanding the importance of public innovation support to the development of innovation it should be clearly stated that this field is not scientifically and practically explored. Some scientific research has been made to identify the effects of public innovation support measures nevertheless this research could be considered as fragmented and scattered. By referring to the current state of the art in supporting innovation by different public actions main research areas are as follows:

- organization and institutional forms for public innovation support (Ertmer, Ottenbreit-Leftwich 2010; EUFP 2013; Goel *et al.* 2012; Luke *et al.* 2010; Minogue 2005; Fung, Wright 2001; Gavin, Muers 2002; MacPherson 2001; Straits 2002; Sherwood 2002);
- the role and models of public innovation support in fostering innovation in business (Naštase 2013; Noor Al-Jedaiah 2010; Barrett, Hill 1984; Braczyk *et al.* 1998; Miles 2004; Earl 2004; Tan 2004; Melnikas 2005);

– public sector as a main developer of innovations. The paradigm of full governmental involvement for the generation and dissemination of innovation (Pacharapha, Ractham 2012; Rutkauskas, Račinskaja 2013; Bhatta 2003; Cainelli *et al.* 2004);
– provision of innovation support services in line with other public measures. In this case the main scope of the research was to explore key elements for the efficient delivery of public support (Santos Silva 2013; Sullivan, Marvel 2011; Gallouj, Savona 2010; Insight 2007).

By summarizing different scientific suggestions (Antonelli 2009; Cassiman, Veugelers 2002; Miravete, Pern 2000; Beerepoot 2007; Blake, Hanson 2005; Blindenbach 2006) public innovation support can be defined as an activity which is planned, organized, implemented and controlled by public or private institution under the public interest with the aim to foster innovation in all possible areas. It could be suggested that government, industry and universities should work in partnership in order to take all benefits of public support measures during the current global economic crisis. Therefore the assessment of public innovation support is important action which could guarantee further development of the economy in a manner that is relevant to the needs of business but also matches the public interest.

In recent years, a substantial shift in the way the impact of public innovation support is assessed could be revealed. According to the neoclassical tradition, the discussion on rationales for public intervention is robustly linked to the notion of optimality. According to the neoclassical theory classics (Vargas-Hernandez 2011; Varghese 2013; Bator 1958; Medema 2004; Mankiw *et al.* 2002; Mohnen *et al.* 2004) public sector should intervene to solve the market failures that prevent achieving the optimal development of innovation. As opposed to the neoclassical theories, the notion of optimality is considered to be irrelevant by the Systems of innovation approach. It focuses on the evolutionary nature of innovation processes that are path dependent over time and it is not clear which path will be taken (Edquist 2001). Therefore in systems that never achieve equilibrium the notion of optimality is irrelevant. Under this paradigm the rationale for public innovation support is based on identification, analysis and elimination of systemic problems (Bastalich 2010; Boehm, Fredericks 2010; Camic *et al*. 2012; Chaminade, Edquist 2006; Hassink, Dong-Ho 2005; Lundvall 2007; Edquist 2001; Heidenreich 2004; Juma, Yee-Cheong 2005; Nelson 2002). After the in-depth analysis of different theoretical approaches the concept of holistic innovation system was selected as the background to design the model for assessment of the public innovation support. Table 1 depicts the main methods used for the assessment of public innovation support and the main results from selected recent related studies.

Table 1. Recent studies for the assessment of the public innovation support impact (compilation based on Almus, Czarnitzki 2011; Duguet 2013; Wong 2013; Schibany *et al.* 2014)

Year	Authors	Results
2012	Almus	Companies that participated in public R&D schemes increased R&D-investments with an amount corresponding to 4% of their turnover.
2013	Duguet	R&D subsidies add to the private R&D.
2013	Wong	Public subsidies add to private funding of R&D. Regression methods suggest that one additional dollar in R&D subsidy would increase private R&D by 41 cents.
2014	Schibany *et al*.	Firms with fewer than 10 employees and firms with more than 250 employees exhibit the highest leverage from public innovation support.

Taking into account the holistic innovation system approach and the scientific studies which were made to explore the impact of public innovation support further analysis was concentrated on identification and classification of various public support additionality concepts and their sub-dimensions. Additionally quantitative parameters as well as descriptive methods are used to explore how companies rate and rank the merits of public innovation support.

In the last years, a growing number of countries have adopted the system of innovation approach officially to create and disseminate public innovation support systems. Nevertheless this process requires the extensive analysis that could be supported by new models for the assessment of such systems. For this purpose further research priorities were identified:

- A research in which the possibility to apply neoclassical and systems of innovation theoretical approach to the assessment of public innovation support are evaluated.
- A research in which classification of various public support impact additionality concepts and their sub-dimensions are explored.
- A research during which the models for creation, dissemination and evaluation of public innovation support are elaborated.

3. Suggested model for effectiveness assessment of public innovation support

By following the proposed assessment principles new public innovation support effects could be identified and explained. Suggested model for the assessment of public innovation support in European economic area is depicted below (Fig. 1).

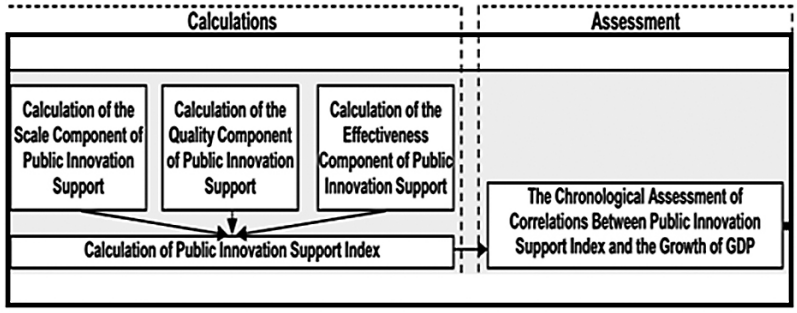

Fig. 1. The model for the assessment of public innovation support

The assessment of public innovation support impact in European Economic Area is based on public innovation support index and chronological assessment of correlations between public innovation support index and growth rate of GDP in particular country.

Public innovation support index calculation. By summarising analysed scientific literature, it can be stated that proper assessment is necessary for the better design and development of public innovation support systems. By applying common principles for assessment of existing national support schemes we will be able to compare characteristics of available international experience in designing and development of public innovation support systems. In this context, it is important to propose a new index that could help to characterize every public innovation support system in every country. In the context of social sciences index is the relative indicator of the phenomenon in question that characterizes it according to the selected reference system (Diewert 2009). For example – consumer price index is a set of prices (with a particular weigh) that is expressed in a relative, synthetic and numeric form. In the Figure 2 the summary of different indexes that could be used for public innovation support systems analysis is presented. In this case, the innovation index – the synthetic indicator that not only reflects innovation activities and related public support but also ranks countries/economies in terms of their environment to innovation and their innovation outputs.

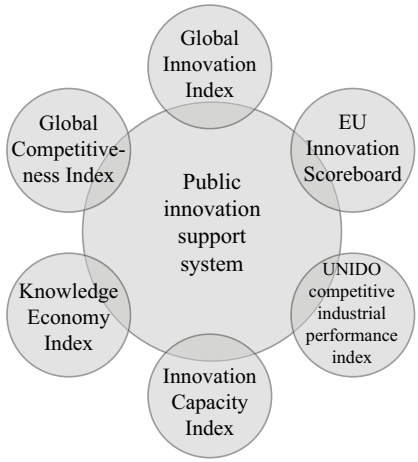

Fig. 2. Indexes applicable for the comparative analysis of public innovation support systems

With the in-depth comparative analysis of all suggested indexes that could be used to characterize the public innovation support system it was possible to identify

the limitations that are vitally important for the further development of public innovation support systems. The results of above mentioned analysis are presented in the Table 2.

Table 2. Indexes that could be used for characterization of public innovation support system (World Bank 2011; Desai 2002; UNIDO 2011; Porter, Stern 2001; UNCTAD 2011; Pro Inno Europe 2012; Claros, Yasmina 2009)

Dimension of the innovation system	CIPI	GII	IS	GCI	KEI	ICI
Investment in Innovation Activities	x	x	x	x	x	x
Output of Innovation Activities	x	x	x	x		
Impact of Innovation Activities		x		x	x	x
Scale of Public Innovation Support		x	x	x	x	x
Quality of Public Innovation Support						x
Impact of Public Innovation Support					x	
Number of indicators in the index	8	81	24	11	12	61

Acronyms:
CIPI– Competitive industrial performance index;
GII – Global Innovation Index;
IS – EU Innovation Scoreboard;
GCI – Global Competitiveness Index;
KEI – Knowledge Economy Index;
ICI – Innovation Capacity Index.

With respects to the conclusions of the comparative index analysis it is necessary to create a new, cumulative index that could reflect all important characteristics of existing public innovation support system. The proposed public innovation support index should have a composite structure of qualitative and quantitative indicators that reflect three most important dimensions of public innovation support – scale, quality and impact. The proposed set of indicators is reflected in the Table 3.

Table 3. Proposed structure of the public innovation support index

Component of the index	Indicator	Source
Scale of Public Innovation Support	Government expenditure on education (% of GDP)	UNESCO Institute for Statistics, UIS online database
	R&D expenditure in the public sector (% of GDP)	Eurostat
	State aid for R&D (% of GDP)	DG Competition, Eurostat
	Researchers in R&D (per million people)	World Development Indicators, World Bank
	New doctorate graduates (ISCED 6) per 1000 population aged 25–34	Eurostat

End of Table 3.

Component of the index	Indicator	Source
Quality of Public Innovation Support	Quality of scientific research institutions	World Economic Forum
	Quality of scientific research institutions	World Economic Forum
	Availability of scientists and engineers	World Economic Forum
	Extent of staff training	World Economic Forum
	Quality of the educational system	World Economic Forum
Impact of Public Innovation Support	Public policy stability	World Bank, Governance Indicators
	Government effectiveness index	World Bank, Governance Indicators
	Effectiveness of legal system	World Economic Forum
	Regulatory quality index	World Bank, Governance Indicators
	Rule of law index	World Economic Forum
	Regulatory quality	World Bank, World Governance Indicators
	Ease of starting a business	World Bank, Ease of Doing Business Index 2014
	Press freedom index	Reporters Without Borders, Press Freedom Index 2013
	Quality of IPR system	World Economic Forum

Since the data used for calculation of proposed innovation support index is non-homogenous it should be normalized by applying the formula below.

$$R_n = \frac{R_i - R_{\min}}{R_{\max} - R_{\min}},$$

where: R_n – normalized value of particular indicator; R_i – analysed value of particular indicator in the i country; R_{min} – lowest value of particular indicator; R_{max} – highest value of particular indicator.

Data normalization method for public innovation support index values is based on the scientific suggestions (Smith, Glass 1987; Stake 1995; Thomas Nelson 1996) and takes into account the following characteristics of data to be used: the maximum value, minimum value, variance, standard deviation.

It is possible to attribute a specific significance for every component of the proposed public innovation support index by applying the formula below.

$$I_i = \frac{I_{mi}\omega_1 + I_{ki}\omega_2 + I_{vi}\omega_3}{\omega_1 + \omega_2 + \omega_3},$$

where: I_{mi} – indicator for the scale component of public innovation support index in the country reffered as i, I_{ki} – indicator for the quality component of public innovation

support index in the country referred as i, I_{vi} – indicator for the impact component of public innovation support index in the country reffered as i, ω – significance of the particular component in question.

It is also should be considered that all public innovation support system components may be equally important for countries in the European Economic Area especially when taking into account different social, economic, and cultural context therefore it is suggested that for the sake of comparability to consider all components of the index as equally important (for example as it is a case in calculation of global Entrepreneurship and Development Index).

If calculated according to the methodological suggestions the public innovation support index not only makes it possible to measure public support for innovation in the European countries by uniform principles, but also to assess the changes over time. In this respect it is also possible to assess the effectiveness of public innovation support for the country's economic development. It could be achieved by examining the relationships between the changes of public innovation support index and the GDP growth rates.

Such assessment could be accomplished by applying regression analysis, where frequency tables of positive and negative "events" are generated. The "event" in this context is understood as a year to year increase of country's GDP growth rate in the relation to the increased public innovation support index. It is also important to consider the fact that the impact of public innovation support that results in increase of GDP growth rate could happen with some delay. Such phenomena is presented in recent scientific research (Drennan, McConnell 2007; Hood, Miller 2009; Brown 2010). Nevertheless the precise quantitative expression of the delay in question still remains unsolved. The approach suggested for solving this challenge is based on application of proposed public innovation index in regression analysis with the GDP growth rate. It is possible to calculate the delay of public innovation support by performing a series of regression analysis with variable time shift (expressed in years) values.

The chronological assessment of interrelations between public innovation support index and the GDP growth rate for the particular country should be performed by following main methodological steps as described below.

At first, the sequence of yearly innovation support index values is created for as long period as possible. In order to achieve statistical significance of the analysis this period should be at least 10 years. The sequence of innovation support indexes is expressed in the following way:

$$I = \{I_k; I_{k+1}; \ldots; I_{k+n}\},$$

where: I_k – public innovation support index of the country in the year k;
n – the number of years used in the analysis.

Based on the sequence that is expressed by function no.3 the sequence of yearly Δ is calculated:

$$\Delta I = \left\{ \Delta I_{k+1}; \Delta I_{k+2}; \ldots; \Delta I_{k+n} \right\},$$

$$\Delta I_{k+1} = I_{k+1} - I_k,$$

where: ΔI_k – the change of public innovation support index of the country in the year *k*;

By following the same principles it is important to compose the sequences of changes in GDP growth rates in the following manner:

$$\Delta GDP_g = \left\{ \Delta GDP_{g(k+1)}; \Delta GDP_{g(k+2)}; \ldots; \Delta \mathrm{GDP}_{g(k+n)} \right\},$$

where: ΔGDP_{gk} – the change of GDP growth rate of the country in the year *k*.

By linking up the sequences expressed in the function 4, 6 it is possible to compose the frequency table for the regression analysis as it is presented in the Table 4.

Table 4. Frequency table for the expression of dependence of public innovation support index, GDP growth rate

ΔBVP_g / ΔI	$\Delta BVP_g > 0$	$\Delta BVP_g = 0$	$\Delta BVP_g > 0$
$\Delta I > 0$	n_{11}	n_{12}	n_{13}
$\Delta I = 0$	n_{21}	n_{22}	n_{23}
$\Delta I < 0$	n_{31}	n_{32}	n_{33}

In this case, the frequency expressed as n11 shows the number of cases of positive change in value of public innovation support index that resulted in positive GDP growth rate in the same k year. Further on the regression analysis is performed and particular factors of regression equations are calculated. In the same manner it is possible to compose the frequency tables where the change of GDP growth rate of the country in the year *k* is compared not to the same year value change of public innovation support index but to the value change that happened earlier (for instance in the year *k-1*, *k-2, k-3…*). By doing so we are able to express and calculate the precise delay of public innovation support impact to the GDP growth rate in particular country.

4. Results of the chronological assessment of interrelations between public innovation support index and the GDP growth rate in European Economic Area

In this section the results of verification of the proposed model for the public innovation support characterization as well as for impact assessment is presented (Table 5). The following study was performed with data that covers the last 15 years of public innovation support efforts by all countries in European Economic Area in the period 1997–2012

and that was linked to the GDP growth rate accordingly following the methodological suggestions that were presented in the paragraph above. That table below presents the results of calculation of public innovation support index in the European Economic Area with the data for 2012.

Table 5. Public innovation support index in European Economic Area in 2012

No.	Country	Impact of Public Innovation Support	Scale of Public Innovation Support	Quality of Public Innovation Support	Public Innovation Support Index
1	Finland	6.23	6.07	6.37	6.22
2	Sweden	6.26	5.59	6.17	6.01
3	Denmark	6.25	5.41	6.18	5.95
4	Iceland	5.60	5.51	5.72	5.61
5	Norway	5.93	4.75	5.31	5.33
6	Netherlands	5.68	4.46	5.67	5.27
7	Ireland	5.45	4.37	5.48	5.10
8	Belgium	4.74	4.38	5.92	5.01
9	Austria	5.59	4.26	4.72	4.86
10	Germany	5.22	4.21	5.00	4.81
11	France	4.41	4.57	5.46	4.81
12	Great Britain	5.16	4.11	5.07	4.78
13	Luxembourg	5.91	3.19	3.40	4.17
14	Cyprus	4.89	3.04	4.25	4.06
15	Czech Republic	3.71	3.93	4.49	4.04
16	Estonia	5.11	3.16	3.69	3.99
17	Liechtenstein	5.73	2.84	3.22	3.93
18	Slovenia	4.06	3.98	3.73	3.92
19	Malta	4.93	2.48	3.07	3.50
20	Portugal	3.87	2.84	3.11	3.28
21	Spain	2.86	3.40	3.50	3.25
22	Hungary	3.57	2.99	2.86	3.14
23	Lithuania	3.62	2.63	2.52	2.92
24	Poland	2.75	2.73	2.99	2.82
25	Latvia	3.40	2.35	2.16	2.64
26	Greece	2.91	2.75	2.18	2.61
27	Slovakia	3.34	2.41	1.97	2.57
28	Romania	2.48	2.41	2.11	2.33
29	Italy	2.41	2.41	2.08	2.30
30	Bulgaria	1.69	2.12	1.35	1.72

Summarizing the data that is depicted in the Table 4 all the countries in the European Economic Area can by grouped according to the development level of public innovation support system that in this case is expressed by the value of the proposed public innovation support index:

- Leaders in public innovation support. In this list – first ten countries with the most developed system of public innovation support: Finland, Sweden, Denmark, Iceland, Norway, Netherlands, Ireland, Belgium, Austria and Germany. This group includes counties in which the public innovation support is developed in average more than 20% above the EU average.
- The second group of public innovation support followers includes countries with a performance close to that of the EU average i.e. less than 20% above, or more than 80% of the EU average (Great Britain, Czech Republic, Estonia, Slovenia etc.)
- The last catching-up group includes countries that show public innovation support performance level well below that of the EU average, i.e. less than 60% of the EU average. This group includes Bulgaria, Latvia, and Romania.

By following same manner the public innovation support index values were calculated for the period 1997–2012 for all countries in European Economic Area and then linked to the GDP growth rate accordingly. In conclusion the results of the regression analysis shows that there is no statistically significant links between the changes in public innovation support (expressed by proposed index) and country's GDP growth rate. In order to confirm the hypothesis that impact of public innovation support occurs with some delay the logit regression was performed repeatedly by shifting the data by one, two, three or more years. The hypothesis was confirmed when some statistically significant links between the public innovation support index values and GDP growth after 2 or more years. The findings of the research shows that the following delay could be expected to the GDP growth while improving the countries public innovation support system:

- expected public innovation support impact delay in the case of Ireland, Lithuania, Cyprus, Greece –3 years;
- expected public innovation support impact delay in the case of Germany, the Netherlands – 4 years;
- expected public innovation support impact delay in the case of Hungary, Romania – 2 years.

The empirical research confirmed appropriateness of the model for the characterization of public innovation support systems in European Economic Area and its applicability for impact assessment. Proposed methodology for the impact assessment can be applied for the further development of public innovation support systems – e.g. if the index of public innovation support $I < 3$ then the scale component of public innovation support should be developed and if the index of public innovation support $I > 3$ then the quality component of public innovation support should be developed.

5. Conclusions

1. Generation and development of innovations are extremely important for modern society beyond social and economic challenges. Innovations ensure international competitiveness and effect on sustainable technological, political, economic and social growth of each country. The following patterns for the justification of public innovation support effectiveness assessment could be identified:

- innovation is related to risk and changes which result in high technical, technological, process and market uncertainty;
- effective public innovation support is able to reduce the risk of innovation and enhances the scale and performance of innovation in business;
- the diversity of support measures is caused by high investment to the development of public innovation support systems, therefore the assessment of interdependent impacts is very complicated.

Despite of the fact that a wide range of research and theoretical studies has been made on the subject of innovation, further exploration of public innovation support is needed due to a lack of its efficiency and limited opportunities to assess its progress.

2. The comparative analysis of innovation and public innovation support theoretical frameworks and models revealed that in majority cases the challenges of support effectiveness are solved according to the neoclassical and evolutional approaches. This limits understanding of how different public innovation support measures interact and how the support effects innovation in business. Therefore in order to increase the effectiveness of public support it is very important to follow these directions for scientific research: perform complex analysis of public innovation support systems; create and apply in practice methods for assessment and interpretation of the support impact.

3. Taking into considerations the diversity of public innovation support measures the effectiveness assessment should be based on holistic innovation paradigm. By following it, public innovation support effectiveness assessment could be performed with the help of newly proposed public innovation support index.

4. The empiric study where application of proposed model was performed revealed the important patterns for the public innovation support impact assessment:

4.1. The increase of public innovation support index is a necessary but insufficient condition for the growth of the countries innovation index. In order to successfully develop public innovation support it is important to focus on effectiveness and quality parameters but not on the scale.

4.2. The impact of public innovation support occurs only in the long run, the delay of the effect exists. The study revealed that the public innovation support impact to the countries innovativeness will occur with 3 years delay (a case of Lithuania and some other EU countries).

5. The proposed index and approach for the impact assessment could be used in the development and implementation of innovation policies in order to assess the impact of public innovation support at both national and EU level. The application of the model is beneficial for: increase of efficiency of innovation support; increase of long term countries competitiveness; exploration of direct and indirect effects of public innovation support; international comparisons of public support systems according to its effectiveness.

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