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MEASUREMENT FRAMEWORK OF INNOVATION ACTIVITY: THEORETICAL APPROACHES' ANALYSIS

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Abstract. In contemporary economy innovations by the scientists are seen as a driving force of the economic development. Innovation performance is vital to achieve sustainable country's competition and to stay in pace with other developed economies (Grossmann 2009).
The paper aims to reveal theoretical aspects of innovation activity, to systemize and analyze the key elements of measurement framework and relationship between the innovative activity and patents, research and development (R&D). The study is devoted to describing the conceptual elements of innovation, assessing if prevailing understanding about innovation performance approves theoretical approaches and reviewing innovation tendencies in Lithuania. Obtained results lead to get the general view about the innovation activity development.
The research methodology is based on theoretical approaches' comparative analysis, academics' survey examination and generalization.

Keywords: Innovations, R&D, Measurement Framework, Patent, Driving Forces.

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1. Introduction

The systems of innovation approaches (Nelson 1993; Lundvall et al. 2002; Edquist 2005; Korsakienė et al. 2006) focus on how these interactions operate and on the role of cultural, organizational and institutional factors in affecting innovation. The concept of national innovation systems has become very widely used as a perspective both in thinking about innovation and in analyzing science and technology policy. The importance of innovations is discussed by the scientists all over the world. Edquist (1997; 2005) approves that the definition of innovation systems should include "all important economic, social, political, organizational, institutional and other factors that influence the development, diffusion and use of innovations". In contemporary economy innovations are seen as one of the key factors of development of the whole economy and enterprises (Korsakienė et al. 2006). Some scientists illustrate a range of context, within which innovation performance arises (Ginevičius, Tvaronavičienė 2004; Adekola et.al. 2008). Prevailing understanding of innovation performance related with the new products or services, new processes, and new organizational structures as well as with the adoption of a new idea, product, developed internally or acquired from the external environment as a function of a firm's technical, strategic, and administrative skills.

Since the beginning of 1980s, the measurement of innovation activity has grown at a rapid pace. Innovation surveys were conducted in a broad range of countries, including those of the European Union (EU). Bloch (2007) in his paper explains that small and medium-sized enterprises (SME) innovating successfully in the UK tend to have dense external networks involving

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other firms, universities and research institutions. The firms that introduce technological innovation are more likely to establish partnerships for all technological, market and organizational reasons compared to the firms that do not. Chang (2003) sees the relationship between the inter-organizational cooperation and innovative performance. Gans and Hayes (2008) accent that measuring innovative performance is essential for effective innovation policy and economic growth. They agree that it is difficult to obtain precise measurement system of innovations due to their complexity. The importance and use of measuring innovation processes is directly related to the links between innovation, genuine improvements in competitiveness, economic growth and levels of well-being of the societies (Lugones 2008). Despite a compelling economic case for innovation as a policy priority, innovative performance is not assessed regularly as macroeconomic indicators like unemployment or inflation. Without a good measure, innovation performance will continue to languish as an item on the economic in generating economic growth and the failure of markets to deliver it at an optimal rate (Gans and Hayes 2008). Compared with monetary policy, which can have an impact on inflation, unemployment or the exchange rate, innovation policy can take many years for the full effects to be realized. This is well outside the necessary time frame for a mechanism that would signal policy makers that policy is off course and needs to change direction (Gans and Hayes 2008).

Adekola et al. (2008) analyze innovation performance and innovation policy of the Lithuanian companies. The prevalence of traditional industries, high energy consumption in industry, and a low productivity rate are the major factors restricting country's competitiveness on the international markets and create preconditions to search for the new development resources.

Various indicators are used to measure innovation activity. Patents have been used as the indicators of the inventive activity in a large number of scientific papers. Patent-based statistics reflect the inventive performance of countries, regions, firms, as well as other aspects of the dynamics of the innovation process. Another widely used measure of innovation is R&D expenditure. R&D data are available for decades back and can be used to form consistent time series.

This study analyzes various aspects of innovations, especially paying attention to the key elements (patents, R&D expenditure as well as relationships between these two categories) of the measurement framework.

2. Conceptual Elements of Innovation Performance: Different Approaches Analysis

Paul (2007) mentions that the first definition of innovation was proposed by Schumpeter (1934), who distinguished five types of innovative activities:

- Introduction of a new product or a qualitative change in an existing product;
- Process innovation new to an industry;
- The opening of a new market;
- Development of new sources of supply for raw materials or other inputs;
- Changes in industrial organization.

However, counting years to up to date, the elements included in innovation activity varied and many authors defined them in different ways.

Paul (2007) and Lugones (2008) defined innovations as comprising implemented technologically new products, processes and significant technological improvements in products and processes. They offer the view of innovation as a part of Knowledge Society.

Innovation appears to be necessary to respond to the increased competition and to be possible thanks to the tools implemented by the Knowledge Society. As it was already stated, the increased innovation leads to the new demand for the higher education graduates to be able to adapt themselves to the innovative environment, to produce innovation and to transfer them.

In formation of the international guidelines of measurement system of innovation activity, different manuals have had a substantial influence on the development, both in terms of survey type and content (Bloch 2007). The Frascatti Manual deals with the measurement of human and financial resources devoted to the research and experimental development (R&D). The second one, the Canberra Manual aims at measuring human resources in science and technology. And the third one, the Oslo Manual, offers guidelines for collecting and interpreting technological innovation data (Paul 2007). Bloch (2007) in his survey described three editions of Oslo Manual and analyzed the evolution of the measurement system of innovation activity. The first edition of the Oslo Manual, published in 1992, was a synthesis of the experiences from a broad group of innovation surveys in the late 1980s, providing a standardized framework for collecting firm-level data on technological product and process (TPP) innovation in manufacturing industries (OECD 1992; Smith 1992). It was primarily based on R&D and patent data. This framework was later updated in the second edition in 1997 and included innovation in service sectors (OECD 1997). The third edition of the Oslo Manual involved marketing and organizational innovations, expanded coverage of knowledge flows and the role of linkages in the innovation process (OECD 2005; Bloch 2007).

According to Fagerberg (2003), innovating involves combining several different types of knowledge, capabilities, skills and resources in the search for a competitive advantage, either through reducing production costs, the development of new products or changes to existing ones. Far from being passive, this combination involves making explicit efforts to improve or create technological capacities and skills.

Lugones (2008) distinguishes a common statement usually made in the literature that innovation is between radical and incremental innovations, depending on the breadth and depth of the changes introduced. He argues that innovation activity includes such elements, as follows:
• Research and Development (R&D),
• Acquisition of embodied (equipment, hardware and software) and disembodied (license, patents) technology;
• Contracting consultancy firms and technical assistance;
• Engineering and Industrial Design activities;
• Personnel training;
• Marketing activities.

Various authors, conducting surveys of innovations, accent the concept of learning and construct increasingly comprehensive classifications of different learning processes (Lundvall 1992; Cooke 2001; Lam and Lundvall 2006). The essential thing is to understand that learning processes are never automatic but require specific investment of resources of varying quality and amount depending on the case. Firms learn in different ways, each leading to improvements of knowledge and specific technological capacities of the firms, which in turn generate a range of paths for technological progress. Learning causes inventions to undergo changes during their life cycle, leading to perhaps greater productivity increases than those resulting from the original invention.

There is a conception (now becoming less accepted) of the process of technological change that is based on the marked distinction between innovation and diffusion of technology. This vision underlines that the former activities are concentrated in the developed countries and their outcome is the creation of technologies that are incorporated into "production capacity", i.e., the stock of capital goods and the operating know-how required to manufacture those goods within the bounds of productive efficiency (Paul 2007).

A distinction should be made between technical change and technological learning (or accumulation). The former concept includes any form in which new technologies are incorporated into a firm's productive capacity (through new equipment or plant, incremental changes). Indeed, technological learning refers to any process that boosts the capacity to generate and administer technical change. These intangible resources are increasingly important, reflecting a rise in "knowledge intensity" in industrial production (Lugones 2008).

A wide variety of scientific literature highlights the positive impact of innovation on the principal performance indicators of the enterprise. In fact, those firms that engage in the innovation activities reveal better indicators in terms of sales, export, productivity and employment. Particular emphasis should be placed on the fact that the best performance does not only refer to a stronger positive trend, but also to the more stable development paths (Davila et al. 2006; Drucker 2006; Hesselbein et al. 2006; Hahn 2010; Leiponen et al. 2010).

Table 1. Prevailing concepts of innovation activity

Concepts	The main elements of innovation activity
Neo-classical	Innovations associate with formal R&D activity.
Evolutionism	Innovation associate with learning process.

To sum up the points of views about innovation activity, the following two concepts are prevailing in the scientific literature: neo-classical and evolutionism (Table 1). In contrast to the neo-classical concept, which generally associates innovation with formal R&D activities, evolutionism stresses the importance of learning processes. Not going deeper into the analysis of theoretical approaches, let us support the point of view that innovation related with something new, involving the development of new products and services, technologies, business models as well as learning process having the purpose to create additional value added. Taking into account the importance of innovation activity, the question arises concerning the measurement tools.

3. Measurement Framework of Innovation Activity

Measurement of innovation activity remains an open issue. Many researches were done regarding this issue, but the unique system of measurement describing the innovation process in the best way has not been proposed. To sum up the surveys and opinions of different scientists, two widely used elements of measurement framework - patents and R&D expenditure - are analyzed in this part trying to assess their advantages and shortcomings as the key elements of measurement system.

3.1. Patent as a Measure of Innovations

Patents have been used as indicators of the location of inventive activity in a large number of papers (Canibano et al. 2000; Parchomovsky et al. 2005; Lanjouw et al. 2006; Ejermo 2009). Patents data provides a rich source of information which is standardized and therefore consistently measured at the micro level both across countries and over time. Patent documents include detailed and complex information about the invention, inventor, applicant, time path of the application, procedure used to file the application, etc. Certain methodological choices have to be made to select the relevant information from patent documents. The relevant criteria to reflect innovative activities are: inventor's country of residence, priority date (the first date of filling in a patent application anywhere in the world to protect an invention), and fractional counts. Patents' data allow a consideration of firms' activities in many countries. This level of details regarding the location of innovative activity is not found in other data. One reason that may be particularly interesting is the number of inventors as a measure of innovative activity. It may be that the highest spillovers from innovative activity result from the interactions between people, to the extent that knowledge is tacit and that innovators are the people who have most tacit knowledge (Abramovsky et al. 2008). The propensity to patent varies both across the industries and time and this needs to be accounted for in any analysis. Many productivity enhancing innovations do not require patenting and certain industrial sectors traditionally rely on secrecy as a way of protecting their intellectual property. Moreover, patenting may be used by firms to determine entry rather than to protect real innovations. The value of patents can be heterogeneous and its distribution very highly skewed. While some patents have little or no industrial application and therefore low economic value, others are of substantial value (Abramovsky et al. 2008).

Barkley et al.(2000) argue that previous measures of the innovative process generally focus on: (1) inputs into the processes such as public and private expenditures for research and development or employment in scientific and technical occupations; (2) an intermediate output measure such as patents; or (3) proxy measures for innovative output and capacity as reflected in the employment in high technology and information technology industries, new product development as reflected in trade and technical publications or venture capital funding for new enterprises. Among these alternatives, patents have become a popular measure for innovative activity at the local level. Alternatively, innovation measures such as new products, private research and development expenditures, and venture capital funding are not available for many non-metropolitan countries because of data collection costs or data disclosure regulations.

Patent counts are not without shortcomings when used to represent innovation (Canibano et al. 2000; Acs et al. 2002; Lanjouwet et al. 2006). First, all inventions are not patented and all patented inventions are not of equal consequence with respect to new products or production processes. Second, the key to new high-technology industries is the presence of "star scientists" and not the scientists' "disembodied discoveries". Patents tend to diffuse over time while the science and engineering stars become more concentrated. Third, patenting activity is concentrated in manufacturing. Innovative activities in trade and service industries are less likely to be patented and the use of patent data may over-represent the relative innovative activity of countries with significant manufacturing sectors. Finally, patents are credited to the home address of the lead scientist on the patent. This location may not be the same country where the research and development occurred or where the new product/process was implemented. The surveys revealed a reasonably high correlation between patent and innovation counts at the metropolitan level, plus patent and innovation counts are associated in a similar manner to explanatory variables included in regional knowledge production functions. The authors conclude that "the empirical evidence suggests that patents provide a fairly reliable measure of innovative activity".

Patents are legal means for monopolizing technology for a potential 20 years (Gans et al. 2008; Ejermo 2009). In return for this monopoly, society demands that patented technology must be disclosed so that rivals know what is protected. Disclosure also ensures that the knowledge enters the public domain when the patent expires. This availability is assured through computerized online records, which entail a number of advantages for the researchers. Patent requirements are also slowly changing and therefore data are reasonably comparable over the time. The major advantage is that they are good at indicating geographical location compared with other indicators. Addresses are available from the European Patent Office data and are given for the inventors as well as applicants. Economists have considered patent data useful since they seem to provide a short-cut to the collection of economy-wide indicators of inventive activity. Patents can be viewed as the output and input indicators because patents are used as a source of information by subsequent inventors.

To sum up, like any other indicator, patent indicators have many advantages and disadvantages. The advantages are: a) patents have a close link to inventions; b) patents cover a broad range of technologies on which there are sometimes a few other data sources; c) the contents of patent documents are a rich source of information (on the applicant, inventor, technology category, claims, etc.); and d) patent data are readily available from patent offices (Canibano at al. 2000; Gans et al 2008; Ejermo 2009).

However, patents are subject to certain drawbacks: a) the value distribution of patents is skewed as many patents have no industrial application (and hence of little value to the society) whereas a few are of substantial value; b) many inventions are not patented because they are not patentable or inventors may protect the inventions using other methods, such as secrecy, lead time, etc.; c) the propensity to patent differs across the countries and industries; d) differences in patent regulations make it difficult to compare counts across the countries; and e) changes in patent law over the years make it difficult to analyze trends over time (Canibano at al. 2000; Gans et al 2008; Ejermo 2009).

3.2. R&D Linkages to Innovations

R&D is defined by the Frascati Manual as covering three activities: basic research, applied research, and experimental development (Paul 2007). Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of the phenomena and observable facts without any particular application or use in the view. Applied research is also original investigation undertaken in order to acquire new knowledge. It is directed primarily towards a specific aim or objective. Experimental development is systematic work, drawing on existing knowledge gained from research or practical experience that is directed to producing new materials, products, installing new processes, systems or services, or improving substantially those already produced or installed. According to the Manual, the basic criterion for distinguishing R&D from related activities is the presence in R&D of the appreciable element of novelty and the resolution of scientific or technological uncertainty, i.e. when the solution to a problem is not readily apparent to someone familiar with the basic stock of commonly used knowledge and techniques in the area concerned.

R&D data is probably the oldest consistent innovation indicator. The data is available for decades back in time and can be used to form consistent time series. R&D comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. The small lines of businesses, though, more rarely undertake such activities as systematically as large ones do. Therefore, their innovative efforts are likely to be underestimated by the R&D data. There are also biases depending on the sector in which a firm is active. For instance, in one sector firms may undertake relatively more marketing efforts in order to open up new markets, which will not fall under the heading of R&D. Service businesses also innovate differently and less "formally" may produce biases. The main problem with R&D data is that they do not represent innovation very clearly; there is no guarantee that efforts translate into innovation (OECD 1992; Tang and Le 2007; Ejermo 2009).

R&D data generally come either from micro data collected by national statistics agencies or from firm accounts. National statistics' bodies tend to report R&D expenditure at the aggregate industry level or make firm level data available under restrictive conditions. The data is usually based on activity within the geographic boundaries of a country and do not generally contain information on the activities of firms in other countries. When a country examines its R&D expenditures, its statistical contents and approach may differ from other nations. As a result, a simple comparison of the R&D expenditures among countries may not present comparable data, although it gives a general idea of a country's attitude towards science and technology (Tang and Le 2007; Abromovsky et al. 2008).

Expenditures on research and development and advertising by companies are forms of capital investment in intangible commodities as opposed to capital investment in tangible commodities, such as plant and equipment. The amounts spent on both advertising and R&D are positively related to the profitability of the enterprises. Various studies have recorded the links between R&D and advertising at the level of firms, sub-sectors and sectors of industry for particular countries (Tang and Le 2007; Blankley 2007).

The findings presented by Tang and Le (2007) indicate that the most-developed countries spend between two and six times more on R&D per capita than on advertising. In less R&D intensive economies advertising may equal or exceed R&D expenditure per capita. In the majority of the EU and other countries, for which relevant advertising and R&D data were available, significant correlation was also found between these two variables. The benefits for businesses to continue investing in both advertising and R&D, even under adverse economic conditions, are very obvious. According to the authors, as countries move from the industrial age into an information and knowledge economy, it is increasingly important to develop their intellectual capital and manage their intangible assets. In addition, businesses need to consider the importance of investments in the "soft assets" of advertising expenditure and R&D. The researches approved that the amounts spent on both advertising and R&D are positively related to the profitability of companies.

Some empirical studies find a positive effect of industrial concentration on R&D spending (Griffin et al. 1996; Vossen 1999). In these studies a variety of different measures of innovative output were used, such as productivity growth rates, number of patents, new product announcements in trade journals, sales of products new to the firm and sales of products new to the industry. This indicates that concentration exerts at least a non-positive influence on the number of innovations made in an industry. In more concentrated industries, firms spend more on R&D but this does not result in more innovative output. Moreover, the finding by Vossen (1999) that smaller firms that do engage in R&D, do so at higher levels of intensity and more efficiently than larger firms, indicates that the presence of relatively more large firms in an industry (higher concentration) would reduce the overall effectiveness of R&D in that industry.

3.3. R&D and Patents

Lanjouw and Schankerman (2004) review that research productivity, as typically measured by the ratio of patents to R&D, has declined sharply over the last 40 years in many different industries and countries. By 1990, the number of patents produced per US scientists and engineers (S&E) had fallen to just 55% of its 1970 level with even steeper declines in Europe. At any time there are also large cross-sectional differences in measured research productivity across industries and firms. These facts have attracted the increasing attention from academics and international organizations, such as the OECD, due to the concern about the apparent slowdown in total factor productivity since the late 1960s.

According to Lanjouw and Schankerman (2004), aggregate patent numbers have fluctuated widely and have grown more slowly than investments over much of the twentieth century. This fall in research productivity could simply derive from diminishing returns in the "knowledge production function". As the markets expand, the private returns to R&D increase. The induced rise in the level of R&D investment leads to a fall in research productivity. Thus, the evidence of declining research productivity raises the spectra of technological exhaustion - getting less inventive output for any given level of the R&D investment. A process of technological exhaustion would lower innovative output directly and, by reducing the private returns to R&D, it would also bring down the equilibrium level of private R&D investment (Lanjouw and Schankerman 2004). In their survey the scholars reveal that these two features of technological exhaustion could undermine our ability to sustain growth in total factor productivity. This process could be countered with government policies to provide stronger R&D incentives recharging the pool of invention potential through government-funded R&D and programs to strengthen industry-government research links. Therefore, a key question is whether we can take the decline in the ratio of patents to R&D as indicating a decline in the reproduction of R&D, i.e. as deterioration in the underlying knowledge production function. Academics propose that in considering this question it is useful to break the patent to R&D ratio into its two component parts: the patent to invention ratio and the invention to R&D ratio. A fall in measured research productivity may be real – a declining invention/R&D ratio – or only apparent – a declining patent/invention ratio. Since we do not normally have information on the number of inventions, there is an identification of a problem in interpreting the changes in the patent to the R&D ratio. What appears to be technological exhaustion may simply be mismeasurement. Inventors may be making less use of a patent system perhaps because the costs of obtaining and enforcing patents have risen relatively to the alternative protection mechanisms. If so, the observed growth in the number of patents over time understates growth in innovation. Furthermore, the average value of an innovation covered by a patent may be increasing over time. Both of these measurement issues imply that counting patents can give a misleading impression of the true output of the research process.

When looking for evidence of technological exhaustion, a common approach taken in the literature is to look for a decline in the R&D elasticity in production function or total factor productivity regressions. Focusing on R&D inputs avoids the potential pitfalls of measuring invention output. However, it involves other serious problems associated with productivity measurement. The R&D elasticity in the production function reflects two distinct factors: the impact of R&D on invention, which could exhibit technological exhaustion, and the effect of invention on productivity. The latter depends on other characteristics of the firm and market, including the level of demand and the ability of the firm to appropriate the rents from invention. Both technological exhaustion and decline in demand or appropriation imply that the rate of return to R&D would fall. Econometric estimates at the firm and industry level do not show any systematic decline in the output elasticity of R&D through the mid-1980s and thus the evidence of exhaustion is at best inconclusive (Lanjouw and Schankerman 2004).

Ejermo (2009) states that patenting does not require formal R&D and it would also be premature to separate the two processes of R&D and patenting in a linear sequence. The contemporaneous relationship found between R&D and patenting can be explained by the fact that a lot of developmental work to adapt to production processes has to take place after formally applying for patents. For these and other reasons, patents have well-known problems, such as innovation indicators. For the companies active in the industries where an appropriation mechanism, such as secrecy, is important, patenting plays a subordinate role due to its disclosure function. There may be alternative ways to reach a technological solution for a company and efforts in between invention and innovation may become patented. As a reaction to the negative conclusions for patents listed, attempts have been made to gauge the quality of patents. Patent documents contain citations that have two major uses for innovation studies. The first concerns the quality and the second the study of the geographical reach of the spillovers (Ejermo (2009).

Patent intensity over industry-financed R&D expenditure is reviewed by Khan and Dernis (2006). There is a strong positive correlation between the number of triadic patent families and industry-financed research and development (R&D) expenditure. The countries with high level of industry-financed R&D expenditures (such as the United States, Japan and Germany) also have large numbers of triadic patent families. In contrast, countries with a low level of industry-financed R&D expenditure (such as Latvia, Estonia, and Iceland) have small numbers of triadic patent families. The triadic patent intensity (triadic patent families divided by industry-financed R&D) of the three OECD regions has followed similar patterns and appears to be cyclical: it decreased during the late 1980s and increased in the mid-1990s. However, there is an important difference in the magnitude and ranking of patent intensity. The high patent intensity ratio for the European countries and the United States in their respective domestic market is mostly due to the "home advantage" factor – domestic applicants tend to file more patents in their home country compared to foreign applicants (Khan and Dernis 2006).

4. Innovation Activity Review in Lithuania

Adekola et al. (2008) analyze innovation activity and policy in Lithuania. The prevalence of traditional industries, high energy consumption in industry, and a low productivity rate are the major factors restricting country's competitiveness in the international markets and create preconditions to search for the new development resources.

Scholars (Korsakienė et al. 2006; Tvaronavičius and Tvaronavičienė 2008; Adekola et.al.) state that one of the most distinctive features of the new theories of growth has been the increasing importance attributed to human capital and productive knowledge and to the interaction of these two factors. Innovations are one of the key factors of development of the country's economy and enterprises. It is widely agreed that the development and intensification of innovation activities enable multiform modernization of the production and service structures, creation of new and improvement of existent products and used technologies as well as increasing their competitiveness on the international scale, which is one of the main factors of the country's economy development. Innovation is a source of profit and high added value until the innovation is spread around and the competitive advantage provided by it disappears. In the global economy, the competitive advantages lie increasingly in the local variables, such as knowledge, relationships, and motivation. The major challenge Lithuania faces today is upgrading its sustained traditional industries towards the high value-added, knowledge-intensive modern industrial sectors regardless of their position in the low high-tech industrial classification. It should be noted that in recent years Lithuania has made progress in innovation policy-making and implementation. The Lisbon Process and the implementation of the National Reform Program (NRP) are seen as the major contributors to this progress. For instance, structural funds gave Lithuania a real base for implementing and sustaining a wide range of innovation support measures, both in the public and private business domains. Furthermore, knowledge and human resources development capacities are being upgraded for the national economy needs.

According to the World Bank's studies, Knowledge Economy Index (KEI) of Lithuania, representing the overall preparedness of a country towards the knowledge economy, rose from 43rd in 1995 to the 31st position in the 2007 rankings and now amounts 7.49. It should be noted that this index aggregates volumes and status of human resources, innovative policy, information technologies and innovative business. Lithuania has an overall innovation performance, that places it among the group of "catching-up countries" with a performance that is well below the EU average but is increasing over time. Other EU countries within this group and with a similar level of performance are Malta, Latvia, Hungary, Greece, Slovakia, Poland, Portugal, Bulgaria and Romania .Over the past 5 years Lithuania's innovation performance has increased rapidly and based on this trend it would reach the EU average level of performance within 10 years (Tvaronavičienė et al. 2008).

The analysis allows us to make conclusion that Lithuania is less efficient compared with the EU average in transforming innovation inputs into outputs (Tvaronavičienė and Degutis 2007; Adekola et al. 2008). Lithuania performs well according to the innovation drivers which are measured by the share of the graduates per 1000 population, the share of working age population with a tertiary education, the broadband penetration rate, and the share of working age population active. Lithuania performs particularly strongly according to the business R&D expenditures, public funding innovation, high-tech exports, and employment in high-tech manufacturing. By the mentioned indicators Lithuania is above the EU average.

The research of the Lithuanian companies leads us to the generalizations about innovation management practice. The survey was based on questioning 429 randomly chosen companies in Lithuania. The results signal that companies do not identify clearly directions of innovative activity development, innovation measurement system seems to be poorly developed and that does not allow to set targets and monitor deviations (Tvaronavičius el al. 2010).

Conclusions

- Critical overview of scientific literature reveals that the whole set of innovation metrics seems to lack systematic approach to innovation performance measurement. Innovation measurement system seems to be poorly developed. It does not allow managing innovation development efficiently.
- To sum up the points of view of different academics, two concepts are prevailing in the scientific literature: neo-classical and evolutionism. In contrast to the neo-classical conception, which generally associates innovation with formal R&D activities, evolutionism stresses the importance of the learning processes.
- Summary of analyzed scientific literature shows the complexity of innovation process, which combines a wide spectrum of activities (Appendix A). Different studies are addressed to reveal particular dimensions of innovation activity. It approves the opinion, that

there is a lack of systematic approach to the innovation process, its measurement and management.

• Patents have been used as the indicator of inventive activity in a large number of surveys. Patents data provides a rich source of information which is standardized and consistently measured. However, the use of patent data in measuring innovative activity is questionable. On the basis of scientific literature analysis, the authors reveal the main advantages and disadvantages of the patent indicators.

• The advantages of the patent indicators are as follows: a) patents have a close link to inventions; b) patents cover a broad range of technologies; c) the contents of patent documents are a rich source of information; and d) patent data are readily available from the patent offices. However, patents are subject to certain drawbacks: a) the value distribution of patents is skewed as many patents have no industrial application whereas a few are of substantial value; b) many inventions are not patented because they are not patentable or inventors protect the inventions using other methods; c) the propensity to patent differs across countries and industries; d) differences in patent regulations make it difficult to compare counts across countries; and e) changes in patent law over the years make it difficult to analyze trends over time.

• Mostly all scientists agree that R&D data is the oldest consistent innovation indicator. However, R&D data sometimes is difficult to pinpoint to a geographical location. The findings of many authors present the facts that the most-developed countries spend between two and six times more on R&D per capita than on advertising.

• Most empirical studies find a positive effect of industrial concentration on R&D spending. The main problem with R&D data is that it does not represent innovation very clearly. In more concentrated industries firms spend more on R&D but this does not result in the more innovative output. This happens because of the number of rivals, which can lead to reduce the overall effectiveness of R&D in that industry.

• There is a strong positive correlation between the number of triadic patent families and industry-financed research and development (R&D) expenditure. The countries with high level of industry-financed R&D expenditures (such as the United States, Japan and Germany) also have large numbers of triadic patent families. In contrast, the countries with a low level of industry-financed R&D expenditure (such as Latvia, Estonia, and Iceland) have small numbers of triadic patent families.

• The analysis of scientific literature reveals that structural funds gave Lithuania a real base for implementing and sustaining a wide range of innovation support measures, both in the public and private business. The Knowledge Economy Index (KEI) of Lithuania, representing the overall preparedness of a country towards the knowledge economy, had been rising from 43rd position in 1995 to 31st position in 2007.

• Lithuania is less efficient compared with the EU average in transforming innovation inputs into outputs. However, Lithuania performs particularly strongly according to the business R&D expenditures, public funding innovation, high-tech exports, and employment in high-tech manufacturing. By the mentioned indicators Lithuania is above the EU average.

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