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INDICATORS OF SUSTAINABLE ECONOMIC GROWTH AND THEIR MANAGEMENT

Vytas Navickas[1], Džiuljeta Ruškytė[2]

[1,2]*Lithuanian University of Educational Sciences, Faculty of Social Education*
Studentų g. 39, LT-08106 Vilnius, Lithuania
Email: vytas.navickas@leu.lt; dziuljeta.ruskyte@leu.lt

Abstract. The article discusses fundamentals of formation of sustainable economic growth indicators, criteria and factors of their qualitative and quantitative measurement, which contribute to objective orientation of development of parameters pertaining to sustainable economy. The variety of economic relations inevitably results a broad choice of parameters describing economic development. However, parameters of sustainable economic development do not serve only as a means of expression of economic processes. Additional requirements are imposed on parameters of sustainable development, which do not only allow to evaluate the becoming of economic processes but also to ensure their integrity with indicators of subsystems of sustainable development in other countries and the possibility of assessment of systemic impact of investment decisions and other kinds of solutions. Assessment of parameters of sustainable economic growth in this article will be carried out employing comparative analysis of scientific literature and methodological recommendations of international organisations. Also, the measurement indicators of environmental sustainability will be developed and analysed.

Keywords: sustainable development, economic sustainability, environmental sustainability, sustainability indicators.

JEL classification: O11, Q01, Q5, R11.

1. Introduction

Scientific literature as well as strategies of sustainable development of countries or international organisations such as the United Nations (UN), the European Union (EU) allocate a considerable attention to establishment of indicators of sustainable development. To the biggest extent, it is also predetermined by the spheres that research in sustainable development focus on. One set of indicators of sustainable growth will be considered analysing sustainable development of economic and ecological processes (sub-systems), whereas the set will be more varied if the research object embraces social, cultural or energy processes. This can be referred to as extensive factors, which condition sustainability indicators. Moreover, complicated issues are raised if the themes of sustainable development are analysed from the so-called intensive perspective, when sustainability indicators perform not only the mirror function of expression of the state of processes but also acquire the function of an indicator of sensitivity level of possible positive or negative impact, generated by changes in other sub-systems as well as by exogenous parameters, which form their dimensions.

The aim of the article is to carry out analysis of theoretical approaches towards formation of indicators of sustainable economic and ecological (environmental) development and to form their sets adapted to systematic research, which are appropriate for undertaking of experimental research on sustainable development while evaluating circumstances of uncertainty employing methodology of stochastic optimisation.

The aim of the article is attained through the following objectives:

– To carry out analysis and assessment of conditions for sustainable economic development.
– To identify the conditions necessary for assurance of justification of the indicators of the analysed sub-systems.
– To identify the main elements of investment cluster and to link them with indicators of sustainable development.
– To device a system of parameters of economic and ecological development, which ensure necessary links with investment processes.

Assessment of parameters of sustainable economic growth in this article will be carried out employing comparative analysis of scientific liter-

ature and methodological recommendations of international organisations. Also, the measurement indicators of environmental sustainability will be developed and analysed.

The elements of mathematical modelling techniques, such as KNIT (knowledge, innovations and technology) cluster technique and stochastically-informed expertise are overviewed as possible tools for integrated management of ecological and economic sustainability.

2. Theoretical aspects of sustainable economic development

Parameters of sustainable development of economy cannot be understood only as reflection of its certain momentary state through indicators, which express economic results. Indicators of sustainable economic development have to be an integral reflection of other spheres of life important for the society because sustainability of economic development is perceived as compatibility of its activities and results with the becoming of other national and global processes.

The scientific literature and works on projecting and monitoring of economic sustainability present a big number of indicators of sustainable economic development and arguments justifying them (Warhurst 2002; Indicators… 2007; Sustainable development… 2009; Sustainable Development Indicators 2010; Čiegis, Ramanauskienė 2011; Sustainable development… 2013).

However, identification of sustainable economic development parameters, which ensure a complex approach, and assurance of their integrity applying modelling technologies stand out in the variety of research and practical works.

This aspect is extensively analysed in the works by a number of researchers (Bowen, Riley 2003), where ideas of PRS (Pressure – State – Response) model of the Organization for Economic Cooperation and Development (OECD) are elaborated on (The Organization… 2014). This model of OECD links parameters of economic activities with environment (state) and reaction of society (response) to adequacy of implemented activities to interests of these spheres.

Integrating ideas of the Commission on Sustainable Development of the EU, the authors further develop this model introducing additional elements of ‘driver‘ and ‘impact‘, which refer to social-economic conditions (driving power) and to changes in social gain (impact) logic form of expression of the model acquires the shape D-P-S-I-R. Indicators, which can be applied for evaluation of sustainable economic growth, are divided into four groups: input, output, results and impact. A wide range of parameters may be employed for determination of each of the aforesaid groups (e.g., input: time, resources, staff, etc.)

An important aspect of such complex sustainability research is a thorough identification of impact spheres and evaluation of impact-response. However, frequently the efficiency of such comprehensive, logically substantiated research on cognition of processes remains untested in the experimental and practical processes of search for solutions.

Joachim H.Spangenberg (2005) also emphasizes the importance of sytematicity of indicators of sustainable economic development. He also points out that compatibility of parameters has to be ensured among economic, social, environmental and institutional dimensions. He argues that each integral part of this general system is a separate complex, self-dependently organised and developing unit.

Being an element of a general system, each unit has to have potential to persist and develop because strong systematic relations among these four elements force each sub-system to evolve.

Spangenberg (2005) compares evolution processes of economic system with a biological system and singles out four elements of economic system: an individual, an enterprise, a sector and the national economy and a number of change parameters may be identified to them: individuals (inventions), enterprises (innovations), economy sectors (structural changes) and national economy (structural diversification). Spangenberg (2005) also emphasises that due to individual pattern of behaviour of economic individuals and variety of choices, it is hardly possible to aggregate parameters of their economic activities into macroeconomic dimensions and, therefore, the model-based systemic analysis has to be substantiated by evaluation of uncertainty and only scenarios of such kind may acquire meaning for research, in fact, not expecting clearly defined future political decisions.

The concept of economic viability is very approximate to that of sustainable economic development. Without integration of its content into the understanding of sustainable economic development, the latter may formally comply with the requirements of sustainable development; however, its systematic parameters are incapable of ensuring efficient functioning of economic system.

Thus, parameters of sustainable economic development or the system of indicators, to be more exact, have to justify the state of viability of economics.

This feature of parameters of sustainable economic development is comprehensively analysed

in the Orientor Theory (Bossel 1999). According to the opinion of the supporters of the latter theory, the viability of economy is adequate to the concept of sustainable economy because only viable economy is able to properly respond to changes in other sub-systems. The viability of economy is perceived as its ability to reproduce the capital and to satisfy needs.

3. Assurance of justification of economic parameters of the national sustainable development strategy

The practical research on sustainable economic development most frequently search for ways to identify links of economic, social, environmental protection and other spheres of public life as well as to establish qualitative and quantitative links of the main parameters of sub-system processes.

The National Strategy of Sustainable Development embraces three spheres (sub-systems): environmental protection, economy and social development (Nacionalinė… 2003; Dėl nacionalinės… 2003). This is a certain reflection of the structure of sustainable development strategy of EU.

Approximately 20 indicators are applied to conduct assessment of economy and the most significant of them define general macroeconomic situation of the country:

1. GDP at current prices, LTL mill.;
2. GDP growth, percentage;
3. Increase in general value added according to fields of economic activity, percentage;
4. GDP per capita, in LTL (standard of purchasing power);
5. Government deficit-to-GDP ratio, percentage;
6. Total investment compared to GDP, %, in total and according to sectors;
7. Final energy consumption in economy sectors per unit of GDP, in total and according to economic activities.

However, the major part of indicators assigned to economic block is presented to reflect parameters, which represent the goals of one or other strategic documents:

– Consumption of water in production per unit of GDP, in total and according to economic activities.
– Consumption of biofuel in transport or its proportion to total consumption of fuel in transport, thous. of tonnes and %, etc.
– Distribution of cargoes and passengers according to kinds of transport, per mill. of tonne-km and unit of GDP, mill. of passenger-km.

However, a number of economic parameters of sustainable development are not significant evaluating influence of their changes on social as well as ecological sub-systems. For example:

– Residential water consumption, litres per capita per day.
– Length of routes of bicycle tourism, which meet the established requirements, km, etc.

The National Strategy of Sustainable Development has not only to target at identification of certain indicators and to substantiate them by requirements established in the documents or by their compliance with EU principles but also it is more important (and more complicated) to find an appropriate combination of indicators determining sub-systems, which ensure sustainable development in the range of specific dimensions and to provide for their future projections defining conditions for their attainment.

Assessing objectives of the Lithuania's Progress Strategy 'Lithuania 2030' to orient the national development towards creation of welfare state, it is expedient to clearly identify harmonious development of five spheres (Lietuvos pažangos strategija… 2011):

1. Efficiency of economy and strengthening of its viability.
2. Social cohesion and equal life opportunities for all residents of the country.
3. High employment rate and professional adequacy to demands of workplace.
4. Development of influence of social partnership and opportunities.
5. Rational coordination of salaries and justification of structure of salaries.

These are fundamental indicators that ensure economic and social harmony. Assurance of a certain level of the aforesaid indicators is of particular importance to quality of life.

A similar system of parameters has been determined by researchers and experts from Nordic countries (Kvist *et al.* 2012). In fact, approaching the sustainable development in the broader context, assurance of stability of functioning of ecological sub-system gains importance as well.

Lithuanian Development Strategies envisage that according to the main economic and social indicators, by 2020 Lithuania will have reached the average level of 2003 of EU-15 countries and will meet all the EU standards according to indicators of environment quality and the requirements provided for in the international conventions, which limit environmental pollution and impact on global climate (Nacionalinė… 2003;

Pažangaus… 2010; Lietuvos pažangos strategija… 2011; Tvarus vystymasis… 2011).

The production based on science and knowledge as well as on latest technologies that minimise environmental pollution should predetermine economic development and integration into European and global infrastructures of communications and energy, which guarantee autonomous, reliable and safe development of the country.

Employing legal and economic measures, the state has to promote sustainable development of various sectors of economy and public life, to decrease administrative burden, whereas business has to feel well-defined and long-term development priorities to be able to properly design own strategies. Rational allocation of state resources (not only financial) and EU support considering the projections of sustainable development parameters remains one of the most important objectives for a country.

Investments and economic support should target not only at enhancement of economic efficiency of production but also at increase of ecological efficiency of production, assurance of reduced negative impact on environment and human health and sustainable social development.

Though the National Sustainable Development Strategy orients investments into the sectors of production and service based on science and knowledge and making less negative impact on environment as well as into measure, which reduce nature pollution, such approach clearly lacks systematicity. Under such an attitude, the answer to the question about the structure of limited investments, which give the best effect in terms of benefit to the society, is not available. Moreover, investments, which lead to 'greener' or more efficient technologies, cannot be perceived as direct expenses of purchasing such instruments. Frequently investments of this kind naturally form a consecutive chain, i.e., a system of investments into needs of knowledge, innovations and technologies. This leads to formation of a certain cluster of science and technologies, whereof creation and assurance of harmonious functioning predetermine management of subsystems of sustainable development.

4. Investment cluster of sustainable development and its mathematical modelling

Projecting such a cluster as a self-regulating system, which may serve as resource of indicators of national sustainability development and the driving power of sustainability, it is important to adequately perceive potential of cluster of knowledge, innovations and technology (hereinafter – the cluster). Naturally, during the formation of the cluster, it is important to distinguish the value of each component and the basic functions that could be based on expert evaluation of financial resources. In turn, it is necessary to focused on the performing role of each of the components to achieve the country's objectives of the sustainable development (Rutkauskas, Račinskaja 2013; Rutkauskas *et al.* 2013).

The majority of sub-systems of the project of sustainable development are potential objects of an integral KNIT cluster, which is undergoing adapted changes. The goals of these objects may be attained employing adaptive complex system technologies or directly the cluster technology.

On the other hand, it is necessary to consider the extent to which requirements for the integral cluster should increase to enable it to adequately adapt while being applied for one object to another or in the discussed case, from one universally sustainable development project to another. The task of choosing a typical scheme or algorithm of adaptation in order not to lose efficiency of the suggested methodology is of utmost importance.

On the other hand, the highest requirement has to be imposed on the cluster itself, which, should not only retain the status of inexhaustible source of development factors while becoming an agent of social development but also should preserve its economic efficiency. Employing stochastically informative expertise, it is possible to evaluate importance of a contribution of the cluster in each sub-system of sustainable development as well as to access an optimal structure of the cluster, when the object of the cluster is the same project of sustainable development.

The concept of universally sustainable development has been widely presented to the scientific community (Rutkauskas *et al.* 2011; Rutkauskas 2012a; 2012b; Rutkauskas, Stasytytė 2012).

One of the most important goals of sustainable development of EU is to separate economic growth from impact on environment and to achieve that under conditions of growing economy, use of natural resources and pollution of environment ceases to increase or tends to go up slower. Therefore, a number of quantitative objectives provided in the Strategy for Lithuanian Sustainable Development point to ratio between rates in economic growth and increase in impact on environment. During the period of the implementation of the Strategy, some of the objectives in the environmental protection sphere target at achievement of the average level of 2020 of EU countries rather than that of 2003.

Due to particularly strong relation between economy and ecology in the structure of strategies

for sustainable development, the article will further focus on discussion of possible indicators of the aforesaid sub-systems, which are linked to various integral relations and investment clusters. The scheme of identification of sustainable development processes constructed in such a manner ensures a possibility of applying of the above-mentioned quantitative methods of stochastic optimisation and of modelling possible scenarios of sustainable development.

5. Concept of sustainability of economic system and possible indicators for measurement of sustainability

The long-term objective of sustainable development of the economy is to create a stable economy based on contemporary knowledge, innovations and modern technologies, which gradually undergoes territorial growth and ensures improvement of life quality of country's people not deteriorating the quality of the environment.

The measurement of sustainability of the economy can be expressed by the following three-level system:

Level 1. Integrating

1.1 Real GDP per capita;

1.2. GVA –gross value added per actual hour worked;

1.3. Energy susceptibility of GVA (energy intensity) Tonne of oil equivalent (TOE) / LTL 1 of real GDP.

Level 2. Detailed

2.1. Direct foreign investments;

2.2. Proportion of value added created by the high-and medium-high-technology manufacturing sectors in GDP, %;

2.3. Energy consumed by transport / LTL 1 of GDP.

Level 3. Investment

3.1. General investments (private and state without R&D);

3.2. (Total) investments into R&D:

3.2.1. Fundamental research;

3.2.2. Applied research;

3.2.3. Technologies.

3.3. Investments into reduction of CO2 levels.

The proposed indicators for measurement of sustainability of economic system were developed using scientific and practical literature (Čiegis, Zeleniūtė 2008; Misiūnas, Balsytė 2008; Sustainable Development Indicators… 2010).

Also, the contents of economic sustainability can be better viewed after disclosure of functions of economic system, economic intelligence (foresight) and directions of KNIT cluster research (Table 1).

Table 1. Functions of economic system, determinants of intelligence and scope of cluster research (source: compiled by authors)

Functions	Determinants of intelligence	Scope of cluster research
1. Production of competitive material and non-material public goods	Intelligence of economy, as production of public goods – sustainable development of progressive and innovative national business and public infrastructure, striving for growth of added value and efficiency under conditions of global competition, integrating science, innovations and technologies for productive activities.	1. Establishment of parameters of sustainable economic competitiveness in the country.
2. Production methods employing sustainable use of resources and environment protection	Incisive management of resources of economic development embraces their efficient use, which is also resistant to impacts of climate change and environment friendly, sustainable supply of current and future raw materials, their rational regional distribution.	1. Measures for improvement of integrated index of efficient consumption. 2. Identification and justification of indices of sustainable use of resources, environmental protection and climate change.
3. Quality satisfaction of needs of the society for professional activities and consumption	Intelligence: assurance of social and territorial cohesion of employment, adequacy of professional competences to the labour market, as well as assurance of financial resources for satisfaction of personal and public consumption needs due to efficient working activities.	1. Foresight into adaptivity to economic development. 2. Methods of increasing employment and activity productivity. 3. Increase in adequacy between needs and purchasing power.

6. Conception of sustainability of environmental (ecological) protection and feasible indicators of sustainability measurement

Long-term goals of environmental protection are to ensure quality of natural environment or environment affected or created by human activities preventing from physical, chemical, biological or any other negative effect or consequences while undertaking activities or exploiting natural resources.

Measurement indicators of environmental sustainability are presented below. The structure of indicators corresponds to the three-level structure of economic sustainability indicators. The proposed indicators for measurement of ecological sustainability were developed with the help of scientific and practical literature (DeSimone, Popoff 2000; Kates *et al.* 2005; Fiksel *et al.* 2012; Sustainability reporting Guidelines 2011; Green growth… 2014).

Level 1. General (integrating)

Integral indicator of ecological (environmental) sustainability.

Level 2. Specific indicators

Climate change and air quality

2.1. Amount of greenhouse gases emitted into the atmosphere in CO2 equivalent per LTL 1 mill. of GDP;

2.2. CO2 levels according to economic activities;

2.3. Average annual concentration of main air pollutants hazardous to health in cities (number of days per year, when maximum permitted concentration is exceeded).

Water quality

2.4. Level of water pollution (compliance with the maximum permitted concentration of certain substances);

2.5. Proportion of polluted water waste treated within EU standards;

2.6. Pollutants' load on the Curonian Lagoon and the Baltic Sea.

Biological and landscape diversity

2.7. Forest coverage (compared to the country's area, %);

2.8. Area of protected territories (compared to the country's area, %);

2.9. Damaged lands (active and inactive quarries, peat lands and landfills), area;

2.10. Newly build-up areas;

2.11. Ratio of forest increment to felling (in km3).

Waste management

2.12. Reuse of secondary raw material, kg;

2.13. Amount of collected industrial waste (in kg per unit of gross domestic product (GDP));

2.14. Amount of collected municipal waste (in kg per capita);

2.15. Amount of collected hazardous waste per year, kg.

Level 3. Investment

3.1. Investments into 'green technologies';

3.2. Investments into creation of alternative resources;

3.3. Investments into reduction of pollution;

3.4. Investments into collection and recycling of waste;

3.5. Investments into protection of natural resources and increase in their functionality.

Table 2 discloses the contents of ecological sustainability expressing it through the functions of national environmental protection, eco-intelligence and KNIT cluster research.

Identification of indicators of economic and ecological sub-systems and components of investment cluster, which make up the aforesaid indicators, it is possible to employ innovative methods of stochastic modelling and to systematically search for feasible scenarios of sustainable development.

In fact, developing the aforesaid research on two subsystems of sustainable development, it is important to successfully apply methods of stochastic optimisation and multi-criteria assessment because they enable experimental research, which establish possible impacts on the condition of subsystems (Rutkauskas 2006; Rutkauskas, Stasytytė 2011).

Methods of multi-criteria evaluation are of utmost significance establishing values of indices of separate sub-system functions, which reflect an integrated impact of separate elements of indices (Rutkauskas, Ginevičius 2011; Ginevičius *et al.* 2012; Ginevičius *et al.* 2013; Podvezko, Podviezko 2013). This calls for further research.

7. Conclusions

1. Establishment of parameters of sustainable development is not a sufficient condition for functional development of separate elements of sustainability.

2. Practical justification of national strategies of development has not been systemised. Making attempts to provide a practical aspect to strategies of national sustainable development, instruments are needed, which are capable of justified projection of future development scenarios.

3. Development of measurement indicators of separate subsystems of sustainability should be performed by disclosing the functions of the respective sub-system and by anticipating determinants of its intelligence (foresight).

Table 2. Functions of national system of environmental protection, determinants of eco-intelligence and scope of cluster research while nurturing environmental (ecological) sustainability (source: compiled by authors)

Functions	Determinants of intelligence	Scope of cluster research
1. Assurance of quality of air non-hazardous to health and climate change all over the country.	Important element of intelligence of the system of environmental protection is ability to recognise factors, which predetermine air quality as well as reasons for their change and methods of their management ensuring their compliance with norms and obligations through efficient managements of resources allocated to attainment of the established goals.	The scope of Knowledge-Innovation-Technology (KNIT) research is to create an index of national air quality system.
2. Assurance of quality of surface and groundwater and reliability of system of water supply.	Intelligence of assurance of water quality and its supply: rational and minimally polluting use as well as efficient and progressive system of its supply and treatment.	To create an index of sustainable use of water resources.
3. Development of coverage of waste management system and increase of its efficiency.	Intelligence related to waste management: maximal collection and reuse of municipal and industrial waste expanding the variety of waste management services and technological potential of their use, efficiently storing or utilising hazardous waste.	To create an index of sustainable use of waste.
4. Protection of biological and landscape diversity, its development and rational use.	Systemic management of biological and landscape diversity, use of natural resources and their renewal as well as their rational use for social and economic needs: the main feature of their sustainable intelligence.	To create an index of measurement of sustainable development of biological and landscape diversity.

4. Establishment of indicators of sustainable development also should be performed taking into account the scope of KNIT cluster research and considering the possibilities to efficiently allocate investment resources among the elements of the cluster: knowledge, innovations and technologies. Adequate allocation of resources would contribute to the sustainability of separate sub-systems, as well as to the integral sustainability.

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