CONTEMPORARY ISSUES IN BUSINESS, MANAGEMENT AND EDUCATION‘2012
ISSN 2029-7963/ISBN 978-609-457-323-1
doi:10.3846/cibme.2012.37

# SUSTAINABILITY AS VALID COMPOSITION OF EFFICIENCY AND RELIABILITY

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**Abstract.** Sustainability as an integral attribute of systems, processes, activities or states gains exceptional attention while analyzing the efficiency and reliability of the mentioned objects, also while fostering management possibilities and developing management principles. To tell the truth, sustainability as an attribute of the mentioned objects has not got yet any unambiguous content and does not have neither the scale, nor dimension of the unified quantitative measurement. The paper aims to measure the sustainability of a system, process, activity or state using a valid composition of efficiency and reliability of the mentioned object. The idea of utility function perfectly suits this mission, which determines the reliability or simply guaranty of every possibility of object existence result. In many fields of practice and science the product of the magnitude and reliability of effect existence is used to apply as an adequate expression of integration of efficiency and reliability indicators. In the paper the application of this methodical principle is practically illustrated by the preparation of the mechanism for small country development universal sustainability possibilities' analysis and realization. In the paper particular attention is paid to the optimal resource allocation among the implementation of social-demographic, economic, ecological and technological objectives, determining the general success of country development. The concept and scheme of rational resource allocation under conditions of uncertainty is presented.

**Keywords:** sustainability, efficiency, reliability, universally-sustainable development of a country.

**Jel classification:** C15, Q01, Q56.

## 1. Introduction

In the paper the following questions will be attempted to answer, along with that using the following sequence of presentation. First of all, development of sustainability concept while searching for its quantitative measuring possibilities will be analysed. Then the problems of ensuring the sustainability of national and regional development will be disclosed through describing the reasons and prerequisites of country (Lithuania) enshrining as a self-sufficient system. The core premise of national development success is stated to be the intelligent use of natural and human-possessed and created resources.

In the third section of the paper a lot of attention is given to the intelligence – the main way of selecting the trends and strategies for systems, subsystems and their interaction. Intelligent investment strategy becomes a constructive decision reasoning means and criterion for resource allocation among the most important trends of development and their determining factors. The premises and metrics of self-sufficient state survival are proposed, which become the historically set intelligence of self-sufficiency retention and development, as well as ability to generate and implement intelligent investment strategies.

Finally, stochastically informed expertise is presented as the main tool of sustainable development management, problem formulation, decision search and implementation.

The purpose of the research is to propose the reasonable quantitative model for the measurement of development sustainability of the systems, processes and dependencies, along with that describing the possibilities and methodology how to realize the proposed model in practice. The further improvement of the universally sustainable development model for Lithuania serves as a practical utilization of the proposed development sustainability measurement model and its realization means.

## 2. Concretization of sustainability concept searching for its quantitative measurement possibilities

A question how to measure the sustainability of a system or a process, especially when this system is a country, region or any other complex system, is in its beginning decision stage (Karakosta *et al*. 2009; Ang *et al*. 2011; Liobikienė, Mandravickaitė 2011; Raslavičius, Strakšas 2011). The research of sustainability of such subsystems as economic, ecological, social-demographical processes continues to analyse them together, as well as separately for a long time; however, there are neither complete methodological principles nor metrics that would help fostering the sustainability of systems or processes (Janicke 2008; Streimikiene *et al*. 2009; Yildiz, Yercan 2011; Zaccai 2012; Makiela, Misztur 2012; Urban, Govender 2012). Such metrics are usually perceived as various indicators, benchmarks, evaluations of consequences or possibilities' projects. May be for this reason the objective of sustainability measuring is defined as measuring the immeasurable (Bell, Morse 2008; Böhringer, Jochem 2012).

Thus there is no doubt that it is necessary to understand the content of sustainability as a phenomenon more deeply and thoroughly, as well as the power of its impact on a process or system with which this phenomenon is linked. The question – what characteristic of sustainability and in what units we can measure – is equally important. This issue is especially relevant, because there is no doubt that a phenomenon of sustainability must be related to system or process effectiveness and efficiency, as well as to the factors influencing and retaining these forces.

If we further perceive sustainability as an attribute of a system or process *to sustain ability*, then a perception will be formed that sustainability can be interpreted as reliability. Taking into account that the concept of reliability is strongly established in technical as well as in biological systems, when we talk about real functioning processes, also in formal disciplines, such as mathematics, the concept of reliability would allow to measure the impact of sustainability attribute on process or system evolution, in the same time disclosing what factors form sustainability and how the resources should be managed in order to foster sustainability.

Even if the initial concept of sustainability looks quite specific: sustainability is perceived as an ability to survive, however, for every person a question appears – how and in what role to survive? Probably, the definition of sustainability provided by the Brundtland Commission was very wise; sustainability has been defined as the ability of current generation to satisfy its needs, allowing to continue the same process for the next generations (Barnaby 1987; WCED 1987; Sneddon *et al*. 2006; Sinclair 2011). It is clear that needs' satisfaction is quite a difficult complex of processes, but this definition reveals the contents of sustainability. Often in even very complicated problems the content of sustainability can be converged to more perceptible attributes. For example, how to sustain ability to return a debt for a creditor, how to sustain ability to finish the distance race faster than in 3 hours, etc. Thus sustainability, when it is perceived as sustaining the ability to implement certain functions, becomes a whole of constructive requirements.

However, using the concept of sustainability and its contents a circumstance is revealed stating that the complexity of this operation mainly depends on our analysed object, system or process. Here usually we cannot avoid the values measured in different dimensions or commensuration of processes, i.e. their comparison. This is usually done in quantitative language (Moles 2008; Munitlak Ivanovic *et al.* 2009).

Reliability itself does not generate validity, while this attribute is naturally appropriate and necessary for sustainability. That is why integrating the contents of the following categories – efficiency, reliability and validity – we should get a logical structure and a possibility to form a system of quantitative models, which would not only allow to commensurate the efficiency and reliability of a process or system, but also would create a scheme of optimal resource allocation in order to get the highest effect measurable using adequate utility function.

The category of validity is not a category of unambiguous prototype moving from one activity or field of cognition to another one. The word "validity" itself is derived from Latin word "valid", what means "strong". For example, if we talk about measuring tool, validity means that this tool can reach the projected degree of precision. In science and in statistics validity means certainty that assumptions, measurements and conclusions correspond to the reality.

In our case the validity of efficiency and reliability composition will be understood as such a combination of these categories, which:

- Is conceptually meaningful and can be identified with the help of statistical data or expert ratings;

– There exists a possibility of quantitative description of efficiency and reliability interaction, which allows to determine the ratio between the units of these indicators.

While analyzing quantitative measurement of sustainability, the closest logics to its contents is the logic of survival function – $P\{\xi>x\} = P(x)$. In the same time, survival function directly depends on variation, under which directly or using a certain function the riskiness of a process is measured. The survival analysis is formed in biological science and is consistently developed in engineering as reliability theory and a tool of analysis, as well as in economics as duration modeling and analysis scheme, and also in other fields of science. It is worth noticing that in engineering as well as in economics the application of these categories is directed towards getting an answer to the question: how many resources do we need in order for a process or system to sustain its current state, or to say that it is inefficient or impossible?

In finance the certain attributes of multiplication of possibility x and its reliability $x\times P\{\xi>x\}$ become an efficient criterion for decisions on formation and management of investment portfolios in foreign exchange and capital markets, as well as for solving other problems that require integrated evaluation of efficiency and reliability of a factor or possibility.

If stochastic systems are being used, i.e. if variables and their interdependencies, as well as various constraints are of stochastic nature, then the technique of stochastic values and processes becomes the main instrument of modeling. If the object of our cognition is the development of process reliability measurement and management mechanisms, then exceptional attention should be paid to the adequacy of survival functions while analyzing systems' reliability problems in engineering and variety of analysis of duration problems.

If we concentrate on perception and solving of processes' and systems' evolution and development sustainability problems, there is a need to understand the concept of validity in a universal linguistic manner, as well as perceive the subtlety and versatility of its intersection with survival concept while analyzing sustainability management problems.

Slightly simplifying the content of sustainability concept it can be said that sustainability is like a valid composition of efficiency and reliability.

## 3. Dependence of sustainability concept and methods on the nature of object under analysis

The technique of sustainability analysis and management should necessarily be universal and allowing to solve the main problems as independently as possible from the nature of the object being analysed. However, the validity category, which becomes an especially important component of sustainability management problem, often requires the correction or even research of the principal attributes of the subject.

As it was mentioned in the beginning of the paper, the object of the research is the problem of development sustainability of an independent country, having small geographic territory, sparse natural resources and in the same time moderate results of economic activity. Even though functioning of the state is perceived as a system of dependencies of complex interactions and dependencies, this system must be able to react sensitively to global changes, as well as to local and regional ones. Though the concept of a system has changed since the times of Plato, Aristotle or Euclides, but discussing system sustainability still the centrifugal is being held in mind, that is the guaranty of system existence. There is a truth in such thinking. Of course, such a power can be substituted with an interest, for which artificial systems have been developed; also the ability to sustain historically ordered system, etc.

Thus, when we speak not about physical power (the gravity of sun) or simply designed by engineering (water supply system), it is very important to understand the interests and resources that are core in ensuring the sustainability of the systems in their constantly changing state, when the renewal should be identical to improvement, because otherwise any system is subject to fall.

The particular object of the current research is the strategies of sustainable system retention and development in Lithuania as in independent country. These strategies are based on historically formed country need for self-sufficiency retention and ability to generate and implement intelligent development strategies. The guarantee and motto of Lithuanian survival as a self-sufficient country is historically formed self-sufficiency retention and development intelligence. Immediate assumption of country self-sufficient survival and successful development strategies' implementation is an intelligent use of natural and human possessed and developed resources. The context of main country development efficiency and success guarantee is a universal sustainable development. In order to consider all the development focuses and use all the creative powers, the following country sustainable development subsystems have been distinguished (Fig. 1).

| **INVESTMENT DEVELOPMENT SUSTAINABILITY** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SOCIAL-DEMOGRAPHIC SUSTAINABILITY | ECOLOGICAL SUSTAINABILITY | ECONOMIC SUSTAINABILITY | ENERGY (POWER) SUSTAINABILITY | INNOVATIVE-TECHNOLOGICAL SUSTAINABILITY | EDUCATIONAL, PROFESSIONAL AND CREATIVE SUSTAINABILITY | FINANCIAL SUSTAINABILITY | POLITICAL SUSTAINABILITY | RELIGIOUS SUSTAINABILITY |
| **SUSTAINABLE COUNTRY (REGION) DEVELOPMENT** | | | | | | | | |

**Fig. 1.** The structure of country universal sustainability development (Rutkauskas 2012)

Every subsystem is described in details in the previous work of the author (Rutkauskas, Stasytytė 2012).

Further in order to use our preferred analytics of sustainability concept and seeking more apparently to disclose the adequacy of the proposed instrumentation for the solution of the analysed problems, it is worth distinguishing the social-demographic, economic, ecological and technological subsystems out of all subsystems of universal sustainability as the most often cited ones in academic literature. Along with that we will apply the flying balloon allegory to illustrate the reality of small country development sustainability (Fig. 2).

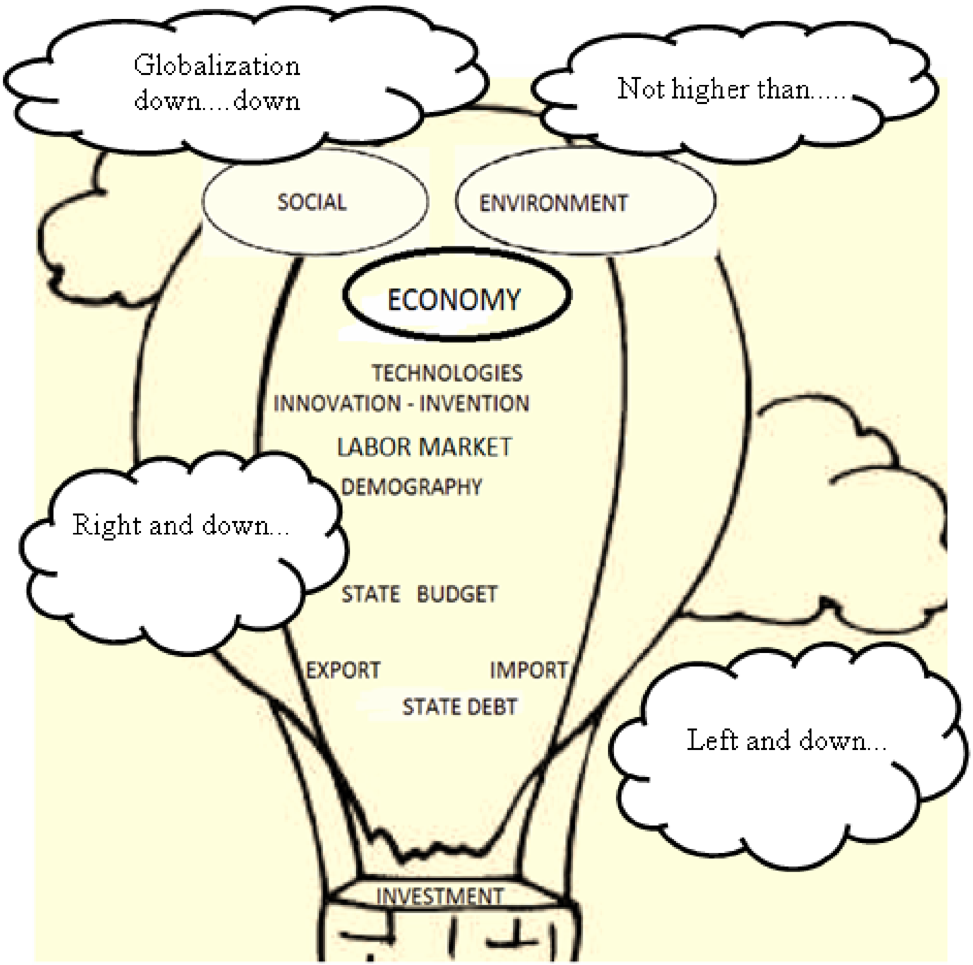



**Fig. 2.** The flying of the balloon as a "purposeful" implementation of the small country sustainable development strategy (Source: compiled by author)

Even though it is not the style of analytical argumentation, but talking about small countries' or regions' development possibilities for the future, it is possible to provide an allegory with the flying balloon where usually the direction of flying does not depend on the balloon team wishes and even efforts. The long-term strategic flying of the small country is fully influenced by the globalization processes, as well as by the expression of the powerful countries' political and economic interests. Seriously, every economically small country, especially the countries of transition economy in fostering their development strategies continuously encounter the flying balloon analogue management possibilities, when the requirements of the strong globalization appear and the interests of powerful world countries dominate. However, no country wants to hear a compliment that its decision is always right because there is no possibility to know where you fly.

May be not only for the mentioned reason, but still all countries without exception (self-sufficient countries) foster their development strategies. It is important for us that more and more scientists and politics argue that only the countries using the sustainability potency can substantially increase the effect of their efforts. Let's try to evaluate further how in our proposed case the sustainability identification with the activities' efficiency and sustainability composition would look like while evaluating the possibilities of validity.

Let us suppose that using the detailed calculations or expert systems it is possible to form the indices of the main indicators characterizing the country development state:

The index of social-demographic state – $I^{SD}$;

The index of economic state – $I^{EC}$;

The index of ecological state – $I^{EN}$;

The index of technological state – $I^{TCH}$.

Appropriate composition of these indices can fully disclose the country state on the whole. There is no doubt that these indicators are linked by the most complex dependencies, which exist in reality as vectors, the separate components of which represent the particular fields of activity or other stratification features. Often these indices – separately or combined as factors of certain functions – are used for countries' or regions' rating according their progress level. Also, the same indices, as well as their generalizing functions are treated as unambiguous determined indicators. But talking about index application to see and describe the perspective, their change cannot be treated as determined changing values. There is no doubt that these are stochastic processes and their possibilities in particular time moments can be adequately analysed only as stochastic values. Thus after sustainability grafter we will not be able unambiguously see the perspective of these indicators, but only the probability distributions of possibilities of the separate indices and their integral resultant.

However, this does not diminish our analytical possibilities, but guarantees that with the help of adequate subsystems' indices composition we can get the expression of the state index I through the composition of efficiency index $I^e$ and sustainability index $I^s$:

$$I = I^{SD} \times I^{EC} \times I^{EN} \times I^{TCH} = I^e \times I^s \quad (1)$$

Further the description of development analysis and management possibilities will continue using four main aspects disclosing the country state, as well as indices measuring them. These indices have been already mentioned earlier. To repeat: $I^{EC}$ – the index of economic state; $I^{SD}$ – the index of social-demographic state; $I^{EN}$ – the index of ecological state; $I^{TCH}$ – the index of technological state. Let us recall that the integral indicator of country state is accepted as a certain composition of the separate selected state indices. It is clear that integral index formation logics and analytical expression should depend on what states of the processes the separate indices describe and what analysis and management problems will be solved using particular indices and an integral index.

Many situations are adequately described if we choose the integral index as a geometric mean ($I_g^B$) or a partial mean ($I_a^B$) of separate indices. Further in the text the concept of geometric mean index will be used, i.e. the calculated index of the selected four indices' geometric means:

$$I_g^B = \prod_{i=1}^{4} \left(I^i\right)^{B_i} \quad (2)$$

where $I_g$ – the integral index of the state; $I^i$ – the indices of particular resultants' state; $B_i$ – weights of the parameters that are accepted in determining the integral index;

$$\sum_i B_i = 1, \quad B_i \rangle 0$$

## 4. Formation of the stochastically informed index of development possibilities– an initial step in development sustainability management

The adequate country development possibilities' analysis and management system would become cumbersome enough if we take into account all objects presented in Fig. 1 and disaggregate processes and dependencies till the separate activities.

The detailed substitute of models' system of the whole system under analysis, as well as even a constructive logical scheme of decision making can become the system of stochastic models, structured with regard to logical-statistical observations and concretized with the help of expert valuations, in which the formation and application of the efficiency and reliability combination evaluation scheme supplemented with validity possibilities' aspect should appear in the spotlight, stressing the application of development sustainability power to the system's development management, as especially important factor of development efficiency increasing.

The problem of country development integrated index management can serve as an informative-descriptive example of the stated situation, when it is being concretized on the basis of statistical observations and stochastically informed expertise. The preparation of such expert system will be analysed further in the text.

Let us suppose that in a stochastically informed expertise situation, i.e. when the evaluations of parameters, interactions' coefficients and some other expert valuations are presented as probability distributions of attributes' possibilities. Assume that with regard to the distinguished parameters – $I^{SD}$, $I^{EC}$, $I^{EN}$, $I^{TCH}$ the experts have formed the possibilities of such marginal investment unit impact on every mentioned index, which is treated as units and expressed in stochastic values:

$I^{SD}$ = N (a = 1,04; σ = 0,01);

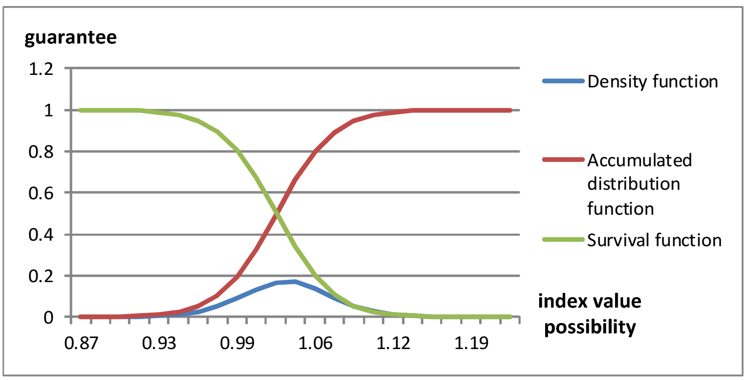
$I^{EC}$ = LP (a = 1,02; σ = 0,015);

$I^{EN}$ = LN (a = 0,0097; σ = 0,0277);

$I^{TCH}$ = GMB (a = 1; σ = 0,025).

where: N – Normal; LP – La Place; LN – Lognormal; GMB – Gumbel probability distributions.

Section a. Density and distribution functions




Section b. Survival function

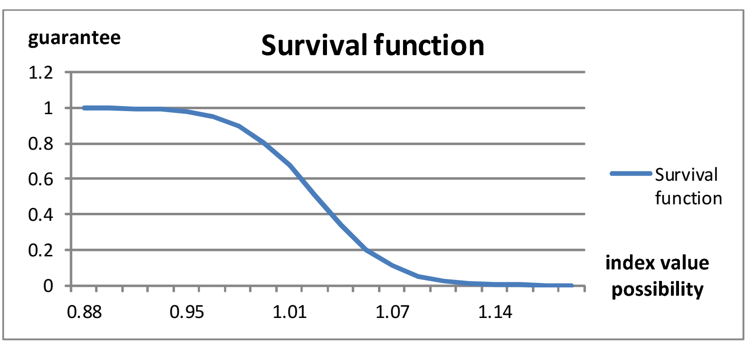



**Fig. 3.** Probability distribution of the integral development index possibilities (Source: compiled by author)

Let us evaluate the integral development possibilities' index with the already mentioned geometric mean of the analysed indices:

$$\begin{cases} I_g^B = \left( I^{SD} \times I^{EC} \times I^{EN} \times I^{TCH} \right)^{\frac{1}{4}}, \\ Corr\left( I^{EC}, I^{TCH} \right) = 0,55, \\ Corr\left( I^{SD}, I^{TCH} \right) = 0,6, \end{cases} \tag{3}$$

considering statistically estimated correlation between certain indices.

Using imitative modeling system GoldSIM, we get a general view of probability distribution of the integral development index possibilities (density function, distribution function) (Fig. 3 section a) and separately presented the so-called survival function (Fig. 3 section b). It can be seen that every possibility of index (abscissa) goes together with its guaranty, i.e. the probability $P\{\xi > x\}$ (ordinate).

It is interesting and important to find such a distribution of possessed investments among the named processes, i.e. to find such proportions for resource allocation $w_i$

$$w_1, w_2, w_3, w_4 \geq 0, \quad \sum_i w_i = 1, \tag{4}$$

that would allow us to get the highest value of the integrated index I, measured according the utility function adequate for the subject.

## 5. A search for optimal solution

Further the problems of country development universal measurement and management using the composition of factors' efficiency and reliability indices will be described in details. The aim is to optimize utilization of investment resources, allocating them among the four distinguished country development subsystems and seeking to adequately select the maximum of the utility function.

Previously in the paper the expert valuations have been presented, the purpose of which is to describe how the index $I_{t,\tau}^i$ of subsystem *i* could change due to the investments accumulated in period (t - τ, t) and intended for the development of subsystem *i* in year *t*.

Let us assume the integral index $I_{t,\tau}^B$ of four subsystems as the geometric mean of the mentioned four subsystems

$$I_{t,\tau}^B = \left( \prod_{i=1}^4 I_{t,\tau}^i \right)^{\frac{1}{4}} \tag{5}$$

where: $I_{t,\tau}^B$ – the growth of the general index in year *t*, $I_{t,\tau}^i$ – the changes of subsystem *i* expressed by the ratio $I_{t,\tau}^B$.

Along with that we will illustrate how the problem of optimal allocation of investments, directed towards the development of the selected subsystems, can be solved, when investments are allocated between separate subsystems in order to reach the highest utility and measuring this growth according the integral index.

The mentioned problem can be treated as a stochastic optimization task when the projected investments for country development should be allocated among the separate subsystems, the changes of which are estimated by the changes of their indices (Rutkauskas *et al.* 2011; Rutkauskas 2012). The changes of the indices as random variables are integrated into the integral common index, which in turn is treated as a stochastic value. The adequate portfolio scheme is selected as the decision algorithm (Rutkauskas *et al.* 2009; Rutkauskas, Stasytytė 2010; Rutkauskas, Ginevičius 2011; Rutkauskas, Stasytytė 2011a). The scheme and principles of decision making are presented in Fig. 3. Perceiving the integral index as a geometric mean of subsystem indices and applying the discrete management schemes one can see that the surface of index possibilities can be interpreted as a network of survival functions and isoguarantees of random values (Rutkauskas 2006; Rutkauskas, Stasytytė 2011b), which approaches the continuous surface with continuous improvement of network. In turn, the same happens with utility function N:

$$N = \frac{e_j \times p_{ej}}{r_j} \tag{6}$$

where: $e_j$ is the possibility of integral index in the survival function $j$ (probability distribution), $p_{ej}$ – the reliability of the possibility, $r_j$ – riskiness of the mentioned distribution.

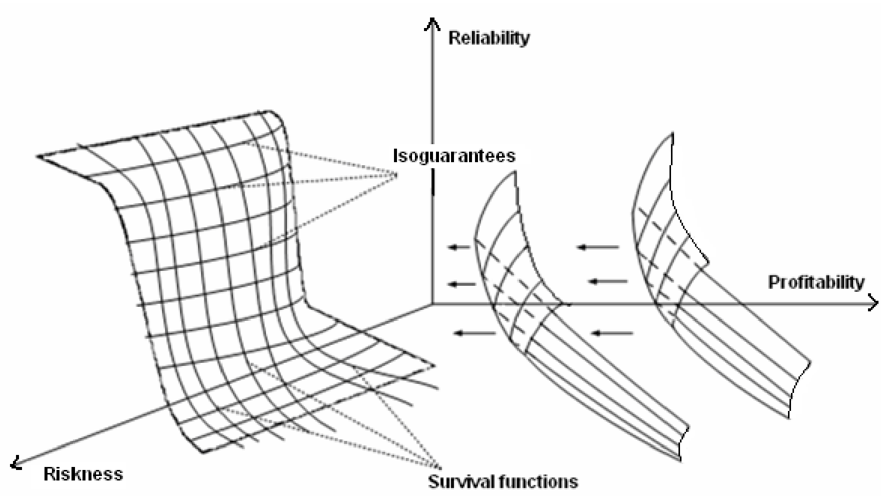
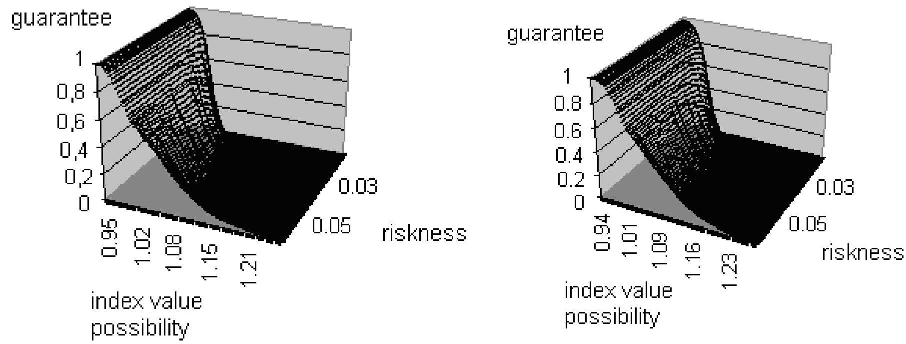
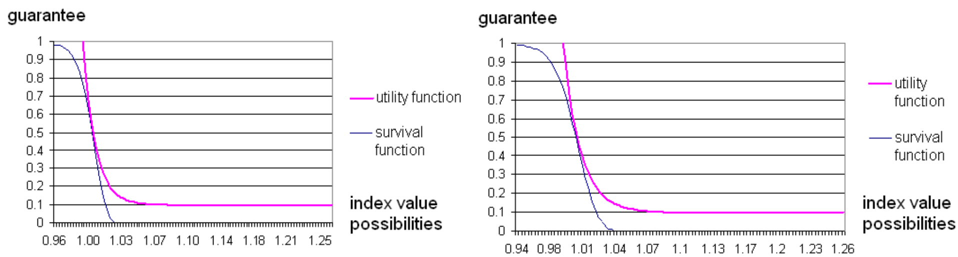



**Fig. 4.** The general view of three-dimensional efficient surface and respective utility functions (Rutkauskas 2006)

Section a. Possibilities' surface




Section b. Intersection of utility surface with one of survival functions




Section c. Parameters and structure of the optimal solution

| Parameters | |
|---|---|
| e | 1,002 |
| $p_e$ | 0,98 |
| r | 0,014 |
| Structure | |
| $w_1$ | 0,02 |
| $w_2$ | 0,02 |
| $w_3$ | 0,24 |
| $w_4$ | 0,72 |

| Parameters | |
|---|---|
| e | 0,998 |
| $p_e$ | 0,58 |
| r | 0,017 |
| Structure | |
| $w_1$ | 0,08 |
| $w_2$ | 0 |
| $w_3$ | 0,2 |
| $w_4$ | 0,72 |

**Fig. 5.** Formation of indices' portfolio according the adequate portfolio model (on the left side – non-correlated values, on the right side – correlated) (Source: compiled by author)

In Fig. 4 we have an illustrative scheme, which allows to perceive the decision of the complex problem, and in Fig. 5 a real situation is presented, when integral index $I_{t,\tau}^{B}$ is the adequate portfolio, and its assets are indices $I_{t,\tau}^{EC}$, $I_{t,\tau}^{SD}$, $I_{t,\tau}^{EN}$, $I_{t,\tau}^{TCH}$ having determined forms of the extent and parameters of random variables. According the presented data the possibility surfaces on Fig. 5 are formed (section a), as well as utility surface intersection with one of utility functions (section b). Also, the coordinates of the intersection point – e, $p_e$ and r – are presented, along with the structure providing this point, i.e. the optimal solution: $w_1$, $w_2$, $w_3$, $w_4$ (section c).

## 6. Conclusions

1. For the significant group of systems, processes and dependences the sustainability idea becomes a unique efficiency and reliable integration possibility and the means to manage the state and dynamics of these systems, processes and dependences.
2. The valid composition of the described object development efficiency and reliability indicators should become a tool for quantitative measurement of sustainability, which would reveal the possibilities for quantitative commensuration of efficiency and riskiness, at the same time allowing to analyse quantitatively the uncertainty and risk not only like the causes of failures or losses, but also like a source of possible success.
3. The concept of sustainability and the original method of subject's existence productivity measurement developed on its basis allows to prepare the constructive investment strategies, considering investment as a main informative signal of present for the future about its intentions and possibilities, at the same time ensuring rational investment allocation among future objectives.
4. Investment more often is being understood not as refusal of free funds, but like a necessary transaction with the future, while the financial system generally with the help of financial markets concentrates the investors' interests by allocating sufficient investments for the future and in the same time ensuring priorities for activities, which foster social and economic development and rational use of resources.
5. Investment system management requires creating the adequate informative system and knowledge systems that let unify – use in the general course – the form and dynamics of different development aspects.
6. The concept of universally-sustainable development selected for the analysis of Lithuanian state self-sufficiency retention and full-rate different possibilities use in order to display social and economic prosperity, have been disclosed as unique development strategy successfully able to implement a set of strategic objectives in an optimal way.
7. The formation and implementation of universally-sustainable development strategy will certainly require a set of unique researches about changes in humanity, earth and environment where we exist.

## References


Ang, F.; Van Passel, S.; Mathijs, E. 2011. An Aggregate Resource Efficiency Perspective on Sustainability: A Sustainable Value Application to the EU-15 Countries, *Ecological Economics* 71: 99–110. http://dx.doi.org/10.1016/j.ecolecon.2011.08.008

Barnaby, F. 1987. Our Common Future: The "Brundtland Commission" Report. Synopsis, *Ambio* 16(4): 217–218.

Bell, S.; Morse, S. 2008. *Sustainability Indicators – Measuring the Immeasurable?* 2nd edition. London: Earthscan. 223 p.

Böhringer, Ch.; Jochem, P. Measuring the Immeasurable: A Survey of Sustainability Indices. Discussion Paper No. 06-073. Centre for European Economic Research ZEW. [online] [accessed 28 August 2012]. Available from Internet: <ftp://ftp.zew.de/pub/zew-docs/dp/dp06073.pdf>

Janicke, M. 2008. Ecological Modernisation: New Perspectives, *Journal of Cleaner Production* 16: 557–565. http://dx.doi.org/10.1016/j.jclepro.2007.02.011

Karakosta, Ch.; Doukas, H.; Psarras, J. 2009. Directing Clean Development Mechanism towards Developing Countries' Sustainable Development Priorities, *Energy for Sustainable Development* 13: 77–84. http://dx.doi.org/10.1016/j.esd.2009.04.001

Liobikienė, G. Mandravickaitė, J. 2011. Sustainable Development During the Integration Process into the European Union, *Technological and Economic Development of Economy* 17(1): 62–73. http://dx.doi.org/10.3846/13928619.2011.554000

Makiela, K.; Misztur, T. 2012. Going Green versus Economic Performance, *Inzinerine Ekonomika-Engineering Economics* 23(2): 137–143. http://dx.doi.org/10.5755/j01.ee.23.2.1546

Moles, R.; Foley, W.; Morrissey, J.; O'Regan, B. 2008. Practical Appraisal of Sustainable Development – Methodologies for Sustainability Measurement at Settlement Level, *Environmental Impact Assessment Review* 28: 144–165. http://dx.doi.org/10.1016/j.eiar.2007.06.003

Munitlak Ivanovic, O. D.; Golusin, M. T.; Dodic, S. N.; Dodoc, J. M. 2009. Perspectives of Sustainable Development in Countries of Southeastern Europe, *Renewable and Sustainable Energy Reviews* 13: 2079–2087. http://dx.doi.org/10.1016/j.rser.2009.03.004

Raslavičius, L.; Strakšas, A. 2011. Motor Biofuel-powered CHP Plants – a Step towards Sustainable Development of Rural Lithuania, *Technological and Economic Development of Economy* 17(1): 189–205. http://dx.doi.org/10.3846/13928619.2011.560639

Rutkauskas, A. V. 2006. Adequate Investment Portfolio Anatomy and Decisions, Applying Imitative Technologies, *Economics* 75: 52–76.

Rutkauskas, A. V.; Stasytytė, V.; Borisova, J. 2009. Adequate Portfolio as a Conceptual Model of Investment Profitability, Risk and Reliability Adjustment to Investor's Interests, *Economics & Management* 14: 1170–1174.

Rutkauskas, A. V.; Stasytytė, V. 2010. Effectiveness, Reliability and Subject Risk – Shaping Drivers for the Set of Possibilities and Utility Function when Investment Decision is Made under Uncertainty, in *The 6th International Scientific Conference "Business and Management 2010". Vilnius, Lithuania, May 13-14, 2010.* Selected papers, Vol. 1. Vilnius: Technika, 2010, 176–183. ISSN 2029-4441.

Rutkauskas, A. V.; Ginevičius, A. 2011. Integrated Management of Marketing Risk and Efficiency, *Journal of Business Economics and Management* 12(1): 5–23. http://dx.doi.org/10.3846/16111699.2011.555357

Rutkauskas, A. V.; Stasytytė, V. 2011a. Optimal Portfolio Search using Efficient Surface and Three-Dimensional Utility Function, *Technological and Economic Development of Economy* 17: 305–326. http://dx.doi.org/10.3846/20294913.2011.580589

Rutkauskas, A. V.; Stasytytė, V. 2011b. Markowitz Random Field as a Stand for Investment Analysis and Decision Making, in *The 15th World Multi-Conference on Systemics, Cybernetics and Informatics: WMSCI 2011*, Orlando, Florida, USA, July 19th - July 22nd, 2011, 131–136.

Rutkauskas, A. V.; Stasytytė, V.; Lapinskaitė, I. 2011. Sustainabilities Portfolio as System to Envisage and Manage Universal Sustainability, *First World Sustainability Forum*, 1-30 November, 2011. [online]. Available from Internet: <http://www.sciforum.net/presentation/657>.

Rutkauskas, A. V. 2012. Using Sustainability Engineering to Gain Universal Sustainability Efficiency, *Sustainability* 4(6): 1135–1153. http://dx.doi.org/10.3390/su4061135

Rutkauskas, A. V.; Stasytytė, V. 2012. With Sustainability Engineering to Sustainability Efficiency, in *The 7th International Scientific Conference "Business and Management 2012". Vilnius, Lithuania, May 10-11, 2012.* Selected papers, Vol. 1. Vilnius: Technika, 2012, 173–184. ISSN 2029-4441.

Sinclair, Ph. 2011. "Describing the Elephant": A Framework for Supporting Sustainable Development Processes, *Renewable and Sustainable Energy Reviews* 15(6): 2990–2998. http://dx.doi.org/10.1016/j.rser.2011.03.012

Sneddon, Ch.; Howarth, R. B.; Norgaard, R. B. 2006. Sustainable Development in a Post-Brundtland World, *Ecological Economics* 57: 253–268. http://dx.doi.org/10.1016/j.ecolecon.2005.04.013

Streimikiene, D.; Simanaviciene, Z.; Kovaliov, R. 2009. Corporate Social Responsibility for Implementation of Sustainable Energy Development in Baltic States, *Renewable and Sustainable Energy Reviews* 13(4): 813–824. http://dx.doi.org/10.1016/j.rser.2008.01.007

Urban, B.; Govender, D. P. 2012. Empirical Evidence on Environmental Management Practices, *Inzinerine Ekonomika-Engineering Economics* 23(2): 209–215. http://dx.doi.org/10.5755/j01.ee.23.2.1549

WCED – World Commission on Environment and Development. 1987. Our Common Future. Oxford: Oxford University Press. 27 p.

Yildiz, T.; Yercan, F. 2011.Environmental Reporting of Industrial and Supply Chain Business Processes within the Context of Sustainable Development, *Business: Theory and Practice* 12(1): 5–14. http://dx.doi.org/10.3846/btp.2011.01

Zaccai, E. 2012. Over Two Decades in pursuit of Sustainable Development: Influence, Transformations, Limits, *Environmental Development* 1: 79–90. http://dx.doi.org/10.1016/j.envdev.2011.11.002

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