Global Journal of Researches in Engineering: G
Industrial Engineering
Volume 19 Issue 1 Version 1.0 Year 2019
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

"Green Finance" Sustainable Growth Mathematical Dynamic Model: Applications to China and Russia Oil and Gas Industries

By Alina Steblyanskaya, Zhen Wang & Nailya Gabdrahmanova
China University of Petroleum (Beijing)

Abstract- The way a financially sustainable growth in a country affects the environment protection, energy efficiency and the social issues there is study. Financial decisions that take into account their long-term social, energy and environmental consequences should be central to financially sustainable growth of oil and gas industries all over the world, including Russia and China. The oil and gas industry transition to "Green Finance" in these two countries is considered on the basis of a sustainable growth model. A new financially sustainable growth mathematical dynamic model for Russia and China oil and gas industry companies, which uses the Ricci tensor, is presented. For a sustainable growth intensity analysis (a) Financial sustainable growth index (FSI), (b) Higgins' sustainable growth rate (SGI Higgins), (c) Ivashkovskaya' sustainable growth index (SGI Ivashkovskaya), (d) Varaya' sustainable growth index modification (SGImodif) indicators' average values and (e) the graph' average values of the Ricci curvatures (Re) are compared.

Keywords: financial sustainable growth, system dynamic modeling, green finance, ricci curvature, coarse ricci curvature, python 3.6. the financial sustainable growth model, financial sustainable growth index (FSI).

GJRE-G Classification: FOR Code: 290502

"Green Finance" Sustainable Growth Mathematical Dynamic Model: Applications to China and Russia Oil and Gas Industries

Alina Steblyanskaya α, Zhen Wang σ & Nailya Gabdrahmanova ρ

Abstract- The way a financially sustainable growth in a country affects the environment protection, energy efficiency and the social issues there is study. Financial decisions that take into account their long-term social, energy and environmental consequences should be central to financially sustainable growth of oil and gas industries all over the world, including Russia and China. The oil and gas industry transition to "Green Finance" in these two countries is considered on the basis of a sustainable growth model. A new financially sustainable growth mathematical dynamic model for Russia and China oil and gas industry companies, which uses the Ricci tensor, is presented. For a sustainable growth intensity analysis (a) Financial sustainable growth index (FSI), (b) Higgins' sustainable growth rate (SGI Higgins), (c) Ivashkovskaya' sustainable growth index (SGI Ivashkovskaya), (d) Varaya' sustainable growth index modification (SGImodif) indicators' average values and (e) the graph' average values of the Ricci curvatures (Re) are compared. The values of the indices (a)/(e) are used to determine parameters of the presented dynamic model for Russian and China oil and gas industries.

Keywords: financial sustainable growth, system dynamic modeling, green finance, ricci curvature, coarse ricci curvature, python 3.6. the financial sustainable growth model, financial sustainable growth index (FSI).

I. Introduction

Every economic sector is a complex continuous system (Richardson, 2017) (Solé and Montoya, 2001) (Bloom, 2009). System analysis allows selecting many interaction links that perform various functions (Von Bertalanffy, 1968). Among the most essential elements in this system are natural resources, labor resources and technological methods of production. The main feature of the economic system is that the links between the elements are objective, but realized in the process of conscious activity of people, that allows setting the system economy parts managing task. The complexity of managing an economic system is based on relation to the system as a whole (Von Bertalanffy, 1968) (Kornai, 2016). Because of Economy is a Complex System, where all the elements are interconnected, thus, only by taking into account interrelations between element can build a mathematical model and analyze the model' dynamic behavior (Mastepanov, 2009) (Road, 1995) (Heil, 2010) (Minsky, 1986).

The most famous mathematical models of the economic system are the Leontief model (Kurz and Salvadori, 2000) and the Neumann model (J.V. Neumann, no date) (Kaufmann, Gadmer and Klett, 2001) (Friedman, Neuman Allen and Allen, 2011). For example, Leontief inter-sectoral balance model operates with pure industries, but reflects the interrelation between sectors only indirectly, does not take into account the system dynamics. From the von Neumann model, various optimization problems we can formulate, the solutions of which represent development intensity trajectories preferred by the rest of its paths. Neumann model, a model of the equilibrium growth of a dynamic system, takes into account the dynamics but does not take into account the "Environment" factor, which is an integral part of Economic Growth. Thus, it is necessary to look for new approaches to analyzing the dynamics of the economic systems (including industry, company) and new methods for constructing its mathematical models.

The group, led by Professor Niu Venyuan from the Institute of Politics and Management of the Chinese Academy of Sciences, created the concept of Lagrange Resilience Points to balance the three most essential elements in their research, borrowed from physics - the ideas of the balance point between the gravitational fields of giant planets (by analogy - the balance point between the three elements of sustainable development - economic development, social progress, environmental responsibility) [1], [2], [3] and creating an economic model of sustainable development. According to experts, it is expected that China, as the largest developing country in the world, will achieve sustainable development indicators in 64 years (in 2079) [1]. Given that the structure of the energy sector in China and the economic model of the state complement each other [4], Niu Venyuan proved that the China state development model determines its energy profile [5]. Therefore, China's oil and gas companies also have

Author α σ: China University of Petroleum (Beijing), Academy of Chinese Energy Strategy, 18 Fuxue Road str., Changping District, Beijing China, 102200. e-mails: wangzhen@cup.edu.cn, asteblyanskaya@sina.cn
Author ρ: People's Friendship University of Russia, Mathematical Institute by name of S.M. Nikolsky, Miklukho-Maklaya str.6, Moscow, Russia, 117198. e-mail: gabd-nelli@yandex.ru

Global Journal of Researches in Engineering (G) Volume XIX Issue I Version I Year 2019

considered as a progressive driving force of society [5]. In the author's sustainable growth system, we distinguish three blocks. The first: financial result of the economic system, represented by the financial index. The second block - the conditions for its achievement (receipt) and the third block - elements of a system for obtaining financial results (see. Fig. 1.)

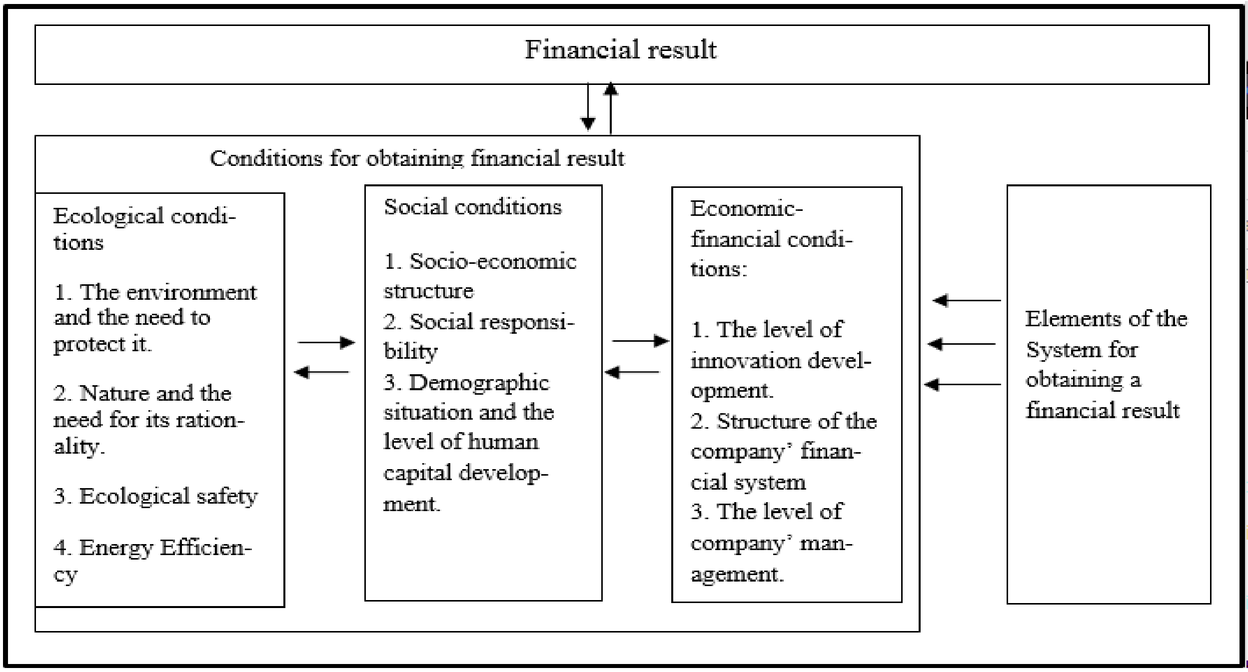

Fig. 1: Key elements of the sustainable system for obtaining financial result. Source: (Bragina, 2013) (Sheremet, 2017b)(Sheremet, 2017a), (Sheremet, 2017b)

Nowadays contradictions of the sustainable financial growth traditional organization model as "alone" functional, focused on the When we talk about the existing system of financial growth (Hubert, 2011) (Lambert *et al.*, 2012), we understand that the actual state is such that there are too many theoretical messages, but in practice, there is no toolkit that would describe methods for achieving sustainable growth of a dynamic system with accent on environmental protection and social responsibility. The existing problems of a sustainable growth system also include fragmentation, incoherence, inter-level and intra-level imbalance, imbalances of elements and discoordination (Kleiner, 2015) (Hall, 2001) (Gupta, Guha and Krishnaswami, 2013).Higgins defines that "sustainable growth is the percentage of sales annual growth that are in agreement with the company's established financial policies" (Higgins, 1977). However, according to nowadays reality, it would improve the Higgins meaning of sustainable growth as "sustainable growth is the percentage of annual growth of sales that are in agreement with the company's established financial policy in the context of environmental protection, energy efficiency, and social responsibility." This paper argues that energy, environment and social factors are added physical constraints on substitution among the factors arise. We say that energy, environment and social responsibility are much more essential factors for financially sustainable growth than companies gave attention.

Between these sub blocks, there is a dialectic relationship (direct and inverse). So all the variety of direct and inverse relationships in this system is investigated by the Authors. To fully take into account the results of these interrelations, they studied over a long period, which allows the results of the interaction of all elements of the economic system to manifest. Appeal to ecosystems is part of the chief disciplinary direction of development of economic science, associated with the transition from mechanical analogies to physical, biological, linguistic and other models. In the future, it is expected that all concepts reflecting the properties of nature and man. Ecosystems is part of the main disciplinary direction of development of economic science, associated with the transition from mechanical analogies to physical, biological, linguistic and other models. In the future, we expect that all concepts are reflecting the properties of nature and man will be involved in economic modeling (Kleiner and Rybachuk, 2016) (Kleiner, 2011) (Kleiner, 2015) (Rybachuk, 2015). Features of socio-economic ecosystems: (1) localization in space, (2) integrity (close internal relations), (3) self-production and self-development, (4) circularity (isolation, wastelessness), (5) close connection of the internal environment with the surrounding ecosystem Wednesday (6) two-sided alignment (7) a variety of scales of the internal clusters of the system (8) the presence of a core and a protective layer (9) the presence of an inner reserve and an internal system of values (10) system non-hierarchical coordination. Or here you can take 4 skills of system thinking (Cabrera et all, 2008), boundary, relationship (vicious and virtuous circles and the possible consequences of interaction), network (developing viable and highly responsible organizations at multiple levels) and perspective (development mutual understanding and agreeing solutions that people are willing to implement).

II. Theoretical Background

a) *Task formulation*

The studies were conducted on the basis of actual data of 29 indicators for 98 quarters of the oil and gas industry of Russia and China (Gazprom, 2017) (Gazprom, 2016)(Murray, Platonova-Oquab and International Energy Agency., 2006) (Novatek, 2016) (Nogovitsyn and Sokolov, 2014) (Rosneft, 2016) (Lukoil, 2016)(CNPC, 2016) (CNOOC, 2017) (Sinopec, 2017) (Sinopec, 2017)

Measuring the financial sustainability of the system occurs in many problems. Recent studies have shown that the representation of such systems in the form of a weighted graph makes it possible to obtain specific user information. Authors noted that the increased sensitivity, or the tendency of the system to failures under conditions of random perturbations, negatively correlates with the geometric concept of the Ricci curvature. In this paper, we want to give the base for the development of methods for the economic system sustainable growth.

Under the sustainable development of the system, we understand the behavior of the system in which all indicators will increase, and the growth rate of all indexes will be agreed. To characterize sustainable development, the authors developed an economic indicator, which we designated X (FSI) and called the development gauge intensity. Indicator X is built expertly, on the analysis of 29 indicators (see Appendix B).

The selected 29 indicators characterize the distribution of resources between system three critical groups:

1) Environmental indicators - a group of indices reflecting the costs of environmental conservation (Epstein, 1996) (Schaltegger, Hahn and Burritt, 2000).
2) Energy efficiency indicators (Lambert *et al.*, 2014).
3) Social indicators - a group of indices reflecting the costs of social needs (D'Amato, Henderson and Florence, 2009) (Kaspersen, 2013).
4) Financial indicators- a group of indices reflecting the development of financial production (Ivashkovskaya, 2014) (Amouzesh, 2011).

Purpose of the Research is to build a mathematical model that allows analyzing sustainability of the system growth.

The presence of such a model will make it possible to make management decisions based on calculations. In this paper, Authors use the concept of Ricci curvature and the local coefficient of clustering to study the dynamics of sustainable development of a system.

b) *Ricci Curvature*

The concept of Ricci curvature (Ollivier, 2010) (Carroll, 1997) (Rudelius and Hubbard, 2012) we can see in Riemannian geometry. The Ricci curvature plays a vital role in the geometric analysis of Riemannian manifolds. The Ricci tensor, named after the Ricci-Curbastro, defines one of the ways to measure the curvature of a manifold, that is, the degree of difference between the geometry of a manifold and the geometry of flat Euclidean space. Roughly speaking, the Ricci tensor measures the volume deformation, that is, the degree of difference between n-dimensional domains of an n-dimensional manifold and similar domains of Euclidean space. The Ricci tensor, just like the metric tensor, is a symmetric bilinear form on the tangent space of a Riemannian manifold.

We formulate the basic concepts of the Ricci curvature in a strict form.

A tensor is a mathematical representation of an object (geometric or physical) that exists in space, in the form of tables of values, is a component of the tensor. The values of the components depend on the adopted coordinate system and change when moving to other coordinates. After the transformation (change) of the components, specific individual values remain invariant.

The metric tensor is a rule for calculating the length of any vector by the values of its components. The metric tensor is also a way to convert components from contravariant to covariant and vice versa.

The Ricci tensor is a doubly covariant tensor obtained from the Riemann tensor R^i_{lkj} by folding and convolving the upper index with the lower one.

$$\mathrm{R}^i_{lkj} = \partial_k \Gamma^i_{lj} - \partial_j \Gamma^i_{lk} + \Gamma^m_{lj}\Gamma^i_{mk} - \Gamma^m_{lk}\Gamma^i_{mj} \tag{1}$$

Replace the lower indices: $k \to i, l \to k, j \to l$

$$\mathrm{R}^i_{kil} = \sum_i \mathrm{R}^i_{kil} \tag{2}$$

$$\mathrm{R}_{kl} = \partial_i \Gamma^i_{kl} - \partial_l \Gamma^i_{ki} + \Gamma^m_{kl}\Gamma^i_{mi} - \Gamma^m_{ki}\Gamma^i_{ml} \tag{3}$$

From the Ricci tensor, the Ricci scalar can be calculated by lifting 1 from the index up and performing convolution, denoted the scalar curvature by the letter R, in the case of two-dimensional surfaces it will be equal to twice the Gaussian curvature.

$$\mathrm{R}^k_l = \mathrm{g}^{kl}\mathrm{R}_{li} \tag{4}$$

Global Journal of Researches in Engineering (G) Volume XIX Issue I Version I Year 2019

$$R_i^i = g^{il} R_{li} = R = 2K \quad (5)$$

where, Γ_{lk}^{i}- symbols of Christoffel 2nd kind, g^{kl}- metric tensor, K– Gaussian curvature.

Tensor convolution operation

In cases of repeated indices with multiplication, one can perform a convolution. Convolution is carried out according to the rule of writing Einstein. The rule is that for an index that occurs twice (once at the top, another at the bottom), the summation implied.

$$A^{tk} B_{tmn} = \sum_t A^{tk} B_{tmn} = C_{mn}^{k} \quad (6)$$

With a single convolution, the rank of the tensor is reduced by 2.

c) Coarse Ricci Curvature

For metric spaces, the concept of Ricci curvature first appeared in the works of Bakri and Emery (Wei and Wylie, no date). It has been studied extensively in recent context. In 2009, Olivier defined the coarse Ricci curvature on Markov chains, which use for metric spaces generated by graphs (Ollivier, 2009). Chang and Yau first introduced the Ricci curvature definition for graphs in 1996 (Chung and Yau, 1996). In 20011, Lin, Lu, Yau modified the Olivier definition for the Ricci curvature of Markov chains on metric spaces (Lin and Lu, 2010) (Lin and Yau, 2012).

We define the local Ricci curvature according Yann Olliver explanation:

Definition 1: Let (X, d) be a Polish metric space endowed with a Borel sigma algebra. The random walk m on X is a family of probability measures m_x (.) On X for any x∈X that satisfies the following two assumptions: (i) the measure m_x depends on the point x∈X; (ii) each measure m_x has a finite first moment.

Definition 2: Let (X, d) be a metric space, and let μ_1 and μ_2 be two probability measures on X. A metric is introduced: the distance between μ_1 and μ_2 is:

$$\tau(\mu_1, \mu_2) := \inf_{\varepsilon \in \Pi} \int_{(x,y) \in X \times X} d(x,y) d\varepsilon(x,y), \quad (7)$$

where,

$\Pi = \Pi(\mu_1, \mu_2)$ –this set of measures on X × X projected onto μ_1 and μ_2.

$d(x,y)$ –This is the cost of transporting a unit mass from x to y.

Let x, y∈X be two distinct points. The formula determines the local curvature between a pair of points x, y of space:

$$k(x,y) := 1 - \frac{\tau(m_x, m_y)}{d(x,y)} \quad (8)$$

III. Methodology

a) Correlation network and clustering coefficient

We suggest the method that combines network analysis with classical correlation, graph theory and local classification coefficient. Thus, this method can provide new graphical representation of the sustainable growth system and solve the task of the system dynamic development with new methods. By analogy with the curvature in Riemannian geometry, we interpret the Ricci curvature as the amount of overlap between the neighborhoods of two adjacent vertices. To solve, we use the concept of a local clustering coefficient, which shows the density of triangular relations.

In general, the formula for calculating the correlation coefficient is as follows:

$$r_{xy} = \frac{\sum(x_i - M_x)(y_i - M_y)}{\sqrt{\sum(x_i - M_x)^2 (y_i - M_y{}^2)}} \quad (9)$$

where x_i – the values taken by the variable x; y_i – the values taken by the variable Y; M_x – X average; M_y–Y average.

The calculation of the Pearson correlation coefficient suggests that the variables X and Y have a normal distribution, thus, we constructed correlation network. The vertices of the network are economic indicators, edges connected all vertices. The weight of the edge is equal to the sample Pearson correlation coefficient. An example of a correlation network wee in Fig. 2, where edges with a weight (correlation coefficient) greater than 0.7 are marked with a bold line, edges with a weight of less than 0.7 indicated with a dashed line.

The correlation network considered as an undirected graph. Remove the edges with a weight of less than 0.7. The rest is a non-oriented graph. For the resulting graph, we calculate the local clusterization coefficient, which characterizes the density of triangular bonds. According to the calculations, the vertices of a connected graph are vertices with a high correlation. It will be important for us which vertices included in the connected graph and what is the form of the vertex connection. We believe that the situation when the vertices have a high coefficient of clusterization corresponds to a stable dynamics of development. We use Watts-Strogatz formula for solving the clustering problem (Watts and Strogatz, 1998):

$$curv(A) = t/(v(v-1)/2), \quad (10)$$

here v is the number of vertices and t is the number of triangles that are formed by the edges of the graph containing the vertex A. This function is a function of two variables. Note that the value of v (v-1) / 2 is the maximum number of triangles, which can be compiled using all the vertices of the graph. Hence curv (A) lies between 0 and 1. In Fig. 3 examples of graphs and curvatures. curv (v) is the local clustering coefficient.

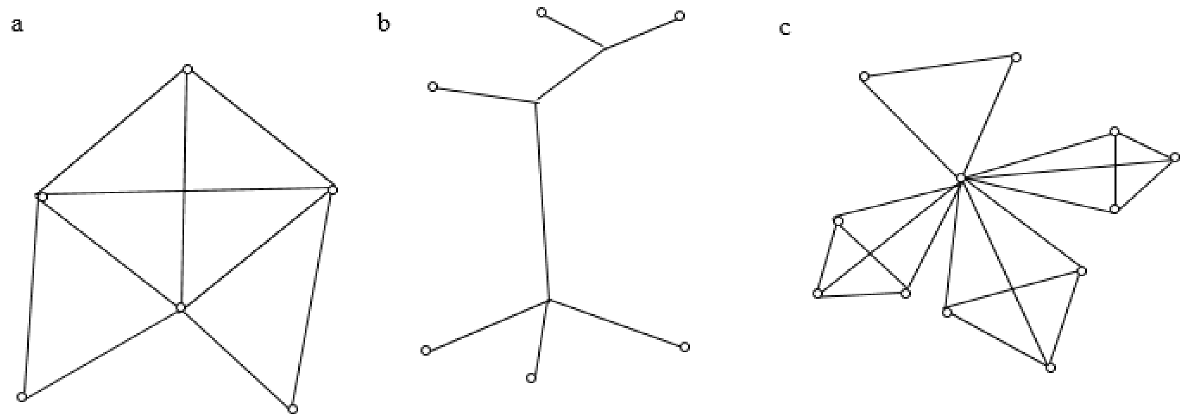

Fig. 2: Nodes. (a) Node n has V = 5 neighbors and T = 5 triangles, thus curvature (n) = ½; b) Tree, each node has a curvature of 0 node; (c) is a hub with curvature ≈ 1 / v. Source: (Watts and Strogatz, 1998)

Studies show that the curvature is usually shallow in random graphs. High curvature clusters have a very nonrandom structure. In geometry, the curvature (intuitively, a measure that quantifies the deviation of a geometric object from a flat one) plays a central role.

b) Research algorithm

Authors selected 29 indicators for 98 periods of the oil and gas industry analysis (indices list see in Appendix A). According to a sample of indicators, we found estimates of paired correlation coefficients. A fragment of the pair wise correlation matrix presented in Tab. 1. Then, a correlation network constructed, where the vertices of the graph are economic indicators, the edge weight between the vertices u and v is the correlation coefficient between the indices u and v. Conducting various numerical experiments on the constructed correlation network, we obtain much information on the dynamics of the development of the system.

We define some threshold h> 0 and remove edges for which corr (u, v) <h. The resulting graph see in Fig. 2. In Fig. 1, bold lines indicate edges, for which corr (u, v)> h.

The threshold h splits the graph into clusters. In Figure 1, we obtained a set of vertices connected by edges and a certain set of isolated vertices. To analyze the behavior of an economic system, we suggest using calculations on a connected graph. Consider the characteristics of the graph vertices in dynamics. To do this, we divide the entire interval into n periods and calculate for each period the curvature of the vertices of the graph. The curvature of the vertex of the graph estimates the density of triangular relations in the graph and calculated by the formula (1). In order to trace the dynamics of the development of the system, we track changes in the curvature values of the graph vertices. For a general description of the situation in each period, we introduced the average local clusterization coefficient:

$$\mathrm{K}_i = \mathrm{curv}(\mathrm{G}_i) = \sum_{j=1}^{n_i} \mathrm{curv}(j)\,, \qquad (11)$$

where *i* – period number (1-3), n_i - graph vertices degree of period *i* .

A program developed for computing the graph vertices curvatures. To analyze the stability of the system development, we calculate the average value of the curvatures of the graph vertices for each period and compare them with the average values of the system development intensity indices: X, X1, X2, X3. The results of system development calculations efficiency indices average values and average values of local cauterization coefficients for three periods see in Tab. 3.4.

To solve the problem, use the open library in Python "NetworkX" (Scellato, 2013) (Sarker, 2014).

Data: There is a sample of data from a certain period from 1996 to 2016.

Was used parameters 28: 8 - are environmental indicators, 3 - social indicators, 17- financial indicators.

The algorithm of the implemented program: Algorithm 1. Graph formation.

Input: correlation table corr, list of nodes in the graph headers, list of sustainable nodes headers2.

Output: weighted graph G (G: = Graph).

Combinations: = combination of all nodes of the graph in pairs.

For all pairs from the combination: if the elements of the pair not included in headers2 then G. add edge (pair, weight: = 0), otherwise: G. add edge (pair, weight: = correlation (pair)).

Global Journal of Researches in Engineering (G) Volume XIX Issue I Version I Year 2019

Algorithm 2 - 3. Update Graph.

Input: graph G, lower bound of the weight eps.

Output: Graph G updated for all edges from Graph G, if the edge weight is <eps then remove the edge for all nodes from Graph G if the degree of the node = 0 then deletes the node.

Algorithm 4-5. Calculating Ricci Curvature in Nodes.

Input: Graph G.

Output: Ricci curvature for each node, list of sustainable nodes headers2.

n: = Number of all nodes in the graph.

for all nodes from graph G

tri = Number of triangular knot connections

$$\text{node curvature} = \text{tri}/(n(n-1)) \quad (12)$$

headers2: = remaining nodes in graph Gs.

IV. Results

We describe the main results of the calculations. First, we consider Russia and China models separately. Then we conduct a comparative analysis.Tab.1 shows a sample correlation coefficients' fragment of calculations according to sustainable coefficients influenced on Russian oil and gas companies' sustainable financial growth indices (full list of correlation calculations, please, find in attached files to article). Constructed correlation network see in Fig.3.

Table 1: The matrix of nonfinancial factors pair correlations*

	LEI	PRP	ROEnv	ER	ES	CO2	FOORPRINT	BIOCAPACITY	ROL
LEI	1	0,61	0,5	0,11	0,49	0,41	0,12	0,16	0,48
PRP	0,61	1	0,32	0,28	0,31	0,54	0,2	0,17	0,73
ROEnv	0,5	0,32	1	0,21	0,45	0,3	0,08	0,02	0,28
ER	0,11	0,28	0,21	1	0,03	0,22	0,03	0,37	0,48
ES	0,49	0,31	0,45	0,03	1	0,67	0,32	0,05	0,26
CO2	0,41	0,54	0,3	0,22	0,67	1	0,24	0,33	0,42
FOORPRINT	0,12	0,2	0,08	0,03	0,32	0,24	1	0,55	0,08
BIOCAPACITY	0,16	0,17	0,02	0,37	0,05	0,33	0,55	1	0,15
ROL	0,48	0,73	0,28	0,48	0,26	0,42	0,08	0,15	1

*Python 3.6 system dynamic model calculations.

Highlighted lines in the Fig. 4 show links with a correlation coefficient higher than 0.7. Authors remove the edges with a correlation coefficient of less than 0.7 and only consider the remaining graph for analysis. It is essential that the final graph include the top of the three groups: the environment, social and financial indices.

Table 2: Average values indicator matrix

i	R_{i*}	X_i	$X1_i$	$X2_i$	$X3_i$
1	0,005	0,18	0,19	0,07	0,09
2	0,004	0,31	0,15	0,14	0,14
3	0,047	0,53	0,18	0,12	0,13

*Ricci curvature at every period.

It was considered a final graph with selected vertices and edges in dynamics and the change in the geometry of the graph was studied, specifically, changes in the vertices of the graph local coefficients curv (.). Thus, it was divided entire database into three periods (I-III), for each period it was built correlation graph, was calculated the curv (.) values of all the graph vertices. Then, average curvature value calculated for each period using Eq. (2).

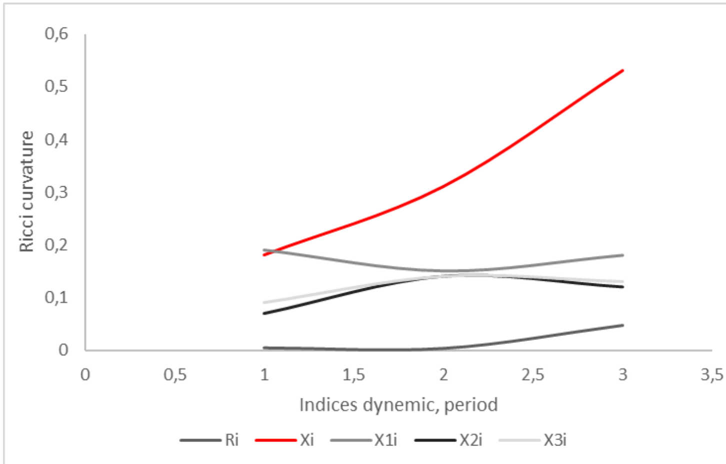

Fig. 3: Russian oil and gas industry indices dynamics. Source: based on data (Gazprom, 2016) (Rosneft, 2016) (Lukoil, 2016) (Novatek, 2016) (Nogovitsyn and Sokolov, 2014) (Perman *et al.*, 2003) (Lambert *et al.*, 2014) by use of Python 3.6. system growth model

For sustainable growth intensity analysis, we compared X, X1, X2, X3 every period indicators' average values and the graph' average values of the Ricci curvatures (R) (see Tab 2). Fig. 2 presents a schedule of changes in two quantities R and X. Period values plotted on the abscissa, the values of R and X plotted on the ordinate axis.

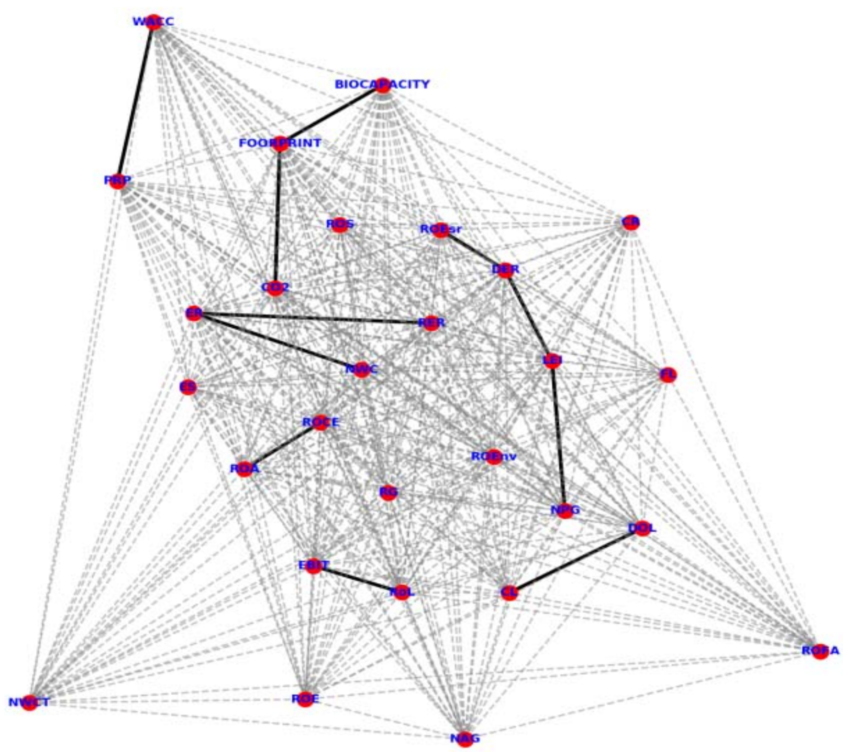

Fig. 4: Russia' oil and gas industry sustainable growth correlation network (I-III period model see in attachment programme files to this article). Source: Authors calculations

Similar studies were conducted in China. All figures and tables are the same as for Russia. They are presented in Fig. 3, 4 and Tab. 3.

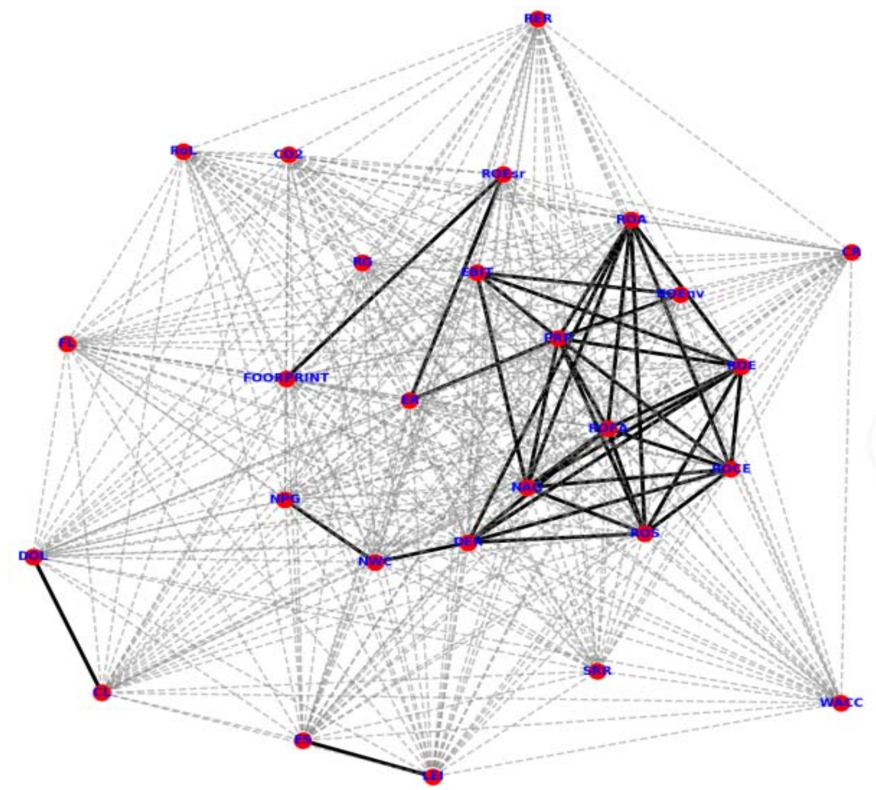

Fig. 5: China oil and gas industry correlation network (I-III period model see in attachment programme files to this article). Source: Authors calculations

On the graph (Fig. 5) we see that the following elements have the closest connection with each other to have constructed 7 important links: ROCE- ROA, PRP - WACC, DOL-CL, Footprint- biocapacity- CO_2 emission, EBIT- RoL, ROEsr- DER- LEI- NPG, NWC- ER- RER.

Table 3: Matrix of average values of development indicators for the system of China

i	R_{i*}	X_i	$X1_i$	$X2_i$	$X3_i$
1	0,04	0,07	0,007	0,008	0,009
2	0,032	0,15	0,06	0,02	0,03
3	0,12	0,24	0,01	0,01	0,014

*Ricci curvature at every period.

A comparative analysis of indices R- Ricci curvature, X – Financial Sustainable Growth Index, X1 – Higgins' Sustainable Growth Index, X2 -Ivashkovskaya' Sustainable Growth Index, X3-Varaya' Sustainable Growth Index shows that indicators X and R are in better agreement with each other and brightly indicates development intensity of the financial sustainable growth with sustainable nonfinancial factors.

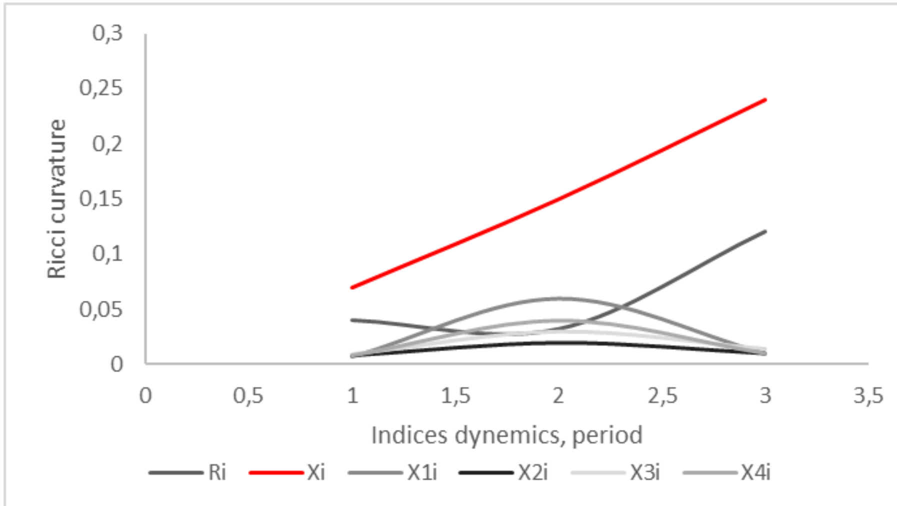

Fig. 6: China oil and gas industry indices dynamics. Source: based on data (CNPC, 2016) (Sinopec, 2017) (CNOOC, 2017) (Ma *et al.*, 2011) (Lambert *et al.*, 2014) by use of Python 3.6. system growth model

A comparative analysis of the development of the China and Russia petroleum industries concerning X and R indicators shows that China is developing more steadily. The R values for each period are higher for China than for Russia, and they are not so far behind the X indicator.

V. Concluding Remarks

Studies show that geometric methods allow us to find new ways to assess the dynamics of the complex systems growth. The paper shows that geometric methods allow us to assess the system sustainable growth by use non-financial indicators. Research allows finding new methods of managing the oil and gas industry companies' financial sustainable growth. In the future, we plan to continue research in this direction. The author's interpretation of the key non-financial factors could determine natural resources preservation, as well as improve quality of the social responsibility with the achieving financial goals of the oil and gas industry organizations. System dynamic model of sustainable financial growth has been built. Characteristics of the Author's System Dynamic model: responsive to changes, self-organizing, adaptive, self-developing, synergistic and systemic. Russian and China oil and gas companies' financial policy results must also depend on sustainable factors. As main Research conclusion, it was found the links between financial sustainability and sustainable factors, such as LEI, PRP, Footprint, Biocapacity, ROEenv, ROEsr, ER, ES, ROL, RERAs we know that financial sustainable coefficients related to $ROA, ROCE, WACC, NWC, CL\ and\ DOL$ to contribute to financial sustainability, so we must give better attention to these financial coefficients that have great influence on financial sustainable growth rate. However, financial sustainable indices also related to $\mathrm{non-financial\ factors}$ to contribute to financial sustainability. That is why Authors decided include nonfinancial factors to Financial Sustainable growth index and strongly recommended companies input this index as KPI into financial statement. Through grey correlation analysis, the Fibonacci method, Sheremet method we found equilibrium distances between index factors. Evaluation results shows that China and Russian gas companies are financially attractive and have stable results, but must improve Financial Strategies according Sustainable Growth point of view. It is contraversal question which factors has more influence on financial sustainable index because of in other circumstances results can be found not the same. However, it must be tried to find a way to implement indices influence on sustainable growth as companies KPI. It is emphasizing that analysis of the sustainable growth dynamics by means of X1, X2, X3 not fully reflect financial capabilities of the companies, that's why in this research take into account non-financial indicators as a possible direction for sustainable growth theory further development. Since the concept of sustainable growth is associated with environmental protection, energy savings, and social factors, add to the model some non-financial factors. As a result of analysis, we obtained the dependence on as LEI, PRP, Footprint, Biocapacity, ROEenv, ROEsr, ER, ES, RoL, RER for both China and Russian gas market companies. Believe that China and Russia gas market companies should pay more attention to the energy, social, environmental and economic determinants that will contribute to financially sustainable companies' growth. A comparative analysis of indices R- Ricci curvature, X – Financial Sustainable Growth Index, X1 – Higgins' Sustainable Growth Index, X2 -Ivashkovskaya' Sustainable Growth Index, X3-Varaya' Sustainable Growth Index shows that indicators X and R are in better agreement with each other and brightly indicates development intensity of the financial sustainable growth with sustainable nonfinancial factors. A comparative analysis of the development of the China and Russia petroleum industries concerning X and R indicators shows that China is developing more steadily. The R values for each period are higher for China than for Russia, and they are not so far behind the X indicator.

VI. Discussion

Sustainable growth is construed as a modern society development pattern which implies meeting the needs of the present without compromising the ability of future generations to meet their own needs. The ideas and principles of Russian and Chinese gas companies sustainable growth are outlined in the UN Action Plan for Sustainable Development known as Agenda 21 (UNCED, 1992). Russian gas companies program areas of sustainable growth approved by all of the countries that have participated in the concept related conferences and other events include economic growth and equity, conservation of natural resources and environmental protection, social development (Gazprom, 2016). The Chinese oil and gas companies in fuller measure can follow the principles of sustainable development in connection with adverse an ecological situation in the country (Ma *et al.*, 2011). Nevertheless, current Russian and Chinese gas companies' financial policy results are not concluded sustainability factors, such as environmental, energy and social indices. It has been shown that, based on the nature of their spatial and temporal boundaries, financial sustainable system can be influenced not only financial factors, but also by nonfinancial factors, like energy saving factor, environmental protection factor and social responsibility factor. The most crucial problem is the theoretical and empirical study of the interconnections among four systems inside one. It is also shown that homeostasis of the economy can be secured if the systems organize themselves, due to their functional specialization and exchange of the primary resources/capacities, into specific ring-shaped structures comprising four systems of different types (tetrads). Analysis of sustainability and balance of the companies can be performed using the technique for evaluation of the intensity of interaction between its factors. In perspective view, financial sustainability in the context of sustainable growth in the field of future investigations and gains. But the central controversial question of this Research is that sustainable growth must be optimal harmonic or balanced? Nowadays for Authors is "hot" discussion whether it is better financial sustainable growth must be balanced, so, all parts of the model must be equal at the end, or this model is not useful in our society, because of expressed only "ideal" world. Today our common conclusion that financial sustainable index must be built as "optimum value" index. But we are firmly intended to research all-level-equilibrium financial sustainable growth model. Researchers need to deepen the classification of economic systems according to parameters of localization within the space-time continuum, combined with a behavioural classification of economic systems. Besides, of significant interest are the theoretical and methodological studies of measuring and correlating systemic properties, scales and structural characteristics of systems.

VII. Limitations and Future Research

This study faces several constraints, which also provide exciting avenues for further research. First, the setting of our study is limited to sizable of the Russian and China oil and gas industry companies, restricting generalizability of our findings. Second, following other recent sustainability studies with the accent on financial questions or financial factors influences on sustainability as a whole (Endovickiy, 2016) as well as interaction energy, environmental and social factors on financial one (King and Hall, 2011) it was accepted that this research might not be complete. Finally, because of data availability problem in Russia before the 1996 year (USSR collapse), it could also not take to account how financial sustainability was managed. Thus, Authors emphasize there are three directions of sustainable growth analysis methods improvement. The first direction is a development of social, environmental and energy indicators system, influencing on financial factors. The second direction is developing stochastic analysis methods how nonfinancial factors impact on financial factors or how financial and economic indicators on environmental and social indicators. The third direction is development sustainable growth indicators system statements. That's why, Authors encourage future research to examine how financial sustainability influence sustainability as a whole and nonfinancial sustainable factors on financial factors in particular. Also, this Research will be continued in the "sustainability- harmonic" point of view: can be sustainability in balancing or can be harmonic growth sustainable? Especially noteworthy is to continue this research concerning environmental and energy sustainable factors.

Acknowledgements

We want to express our gratitude to the future anonymous reviewers, for their valuable comments and advises. This Research results was accomplished with the support of the Russian Foundation for Basic Research (RFBR) (project No. 16-08-00568).

Appendix 1

Tab. 1, App. A: Full list of indicators (Lambert *et al.*, 2014) (Ivashkovskaya, 2009) (Ivashkovaksya, 2008) (Kaspersen, 2013) (Eling, Parnitzke and Schmeiser, 2006) (Higgins, 1977) (Ryabova, 2018) (Pereira, 2018) used in Study.

Sustainability Indicators Status	Index	Proxy	Calculation method
Sustainable Growth Indices (financial)	FSI	X	see App. 2
	SGI (H)	X1	
	SGI (Iv)	X2	
	SGI (V)	X3	
	Earnings before interest and taxing	EBIT	Earnings before interest and taxing
	Return on Assets	ROA	(EBIT/Total Assets)*100%
	Return on Sales	ROS	Return on sales
	Return on Equity	ROE	Net income/Equity
	Return On Capital Employed	ROCE	EBIT/(Total Assets-Current Liabilities)
	Return on Fixed Assets	ROFA	EBIT/Fixed Assets
	Net working capital	NWC	Current assets-current liabilities
	Net working capital Turnover	NWCT	Revenue/Current Assets
	Current Ratio	CR	Current assets/current liabilities
	Revenue growth	RG	An increase of a company s sales when compared to a previous quarter s revenue performance
	Net profit growth	NPG	An increase of a company s net profit when compared to a previous quarter s net profit performance
	Net assets growth	NAG	An increase of a company s net assets when compared to a previous quarter s net assets performance. Net assets=Total assets-Total Current liabilities
	Financial leverage	FL	Total Assets/Equity
	Operation leverage degree	DOL	% change in EBIT/% change in Revenue
	Combine leverage	CL	Financial leverage*operation leverage
	Debt equity ratio	DER	Total liabilities/Equity. Total liabilities = Equity-Assets
	Weighted Average Cost Of Capital	WACC	WACC = rE × kE + rD × kD × (1 – T)
Environmental factors	Energy Indicators	LEI	Lambert Energy Index
		ES	Energy Savings
	Envoronmental indicators	ROENV	ROEnv = costs concerning environmental protection and decision of pollution question/production
		Footprint	Footprints are the impressions or images left behind by a person walking or running.
		Biocapacity	The biocapacity or biological capacity of an ecosystem is an estimate of its production of certain biological materials such as natural resources, and its absorption and filtering of other materials such as carbon dioxide from the atmosphere.
		ER	Official Russian gas conpamies Environmental ratings
Social factors	Revenue per employee ratio	RER	Total Revenue/Total Number of Employees.
	Return on social expences	ROEsr	costs concerning salary and weges and social responsibility/net profit
	Return on social expences	ROEs	costs concerning employee benefits/net profit

Appendix 2

Financial Sustainable Indices calculations

The influencing factors for sustainable growth index are complex and numerous, that is why it is significant for system analysis to analyze the correlation property among factors, to quantify the correlation degree, to sequence the correlation degree and to judge the dynamic correlation property. Grey correlation analysis is a statistic analysis technology, which is mainly used to analyze close degree between parent factors and sub-factors in the system, and identify the significant factors and sub-factors in the system, and identify the significant factors and secondary factors that lead to the development and changes of the system Grey correlation analysis is a method that can quantify and compare system dynamic development situation (Julong, 1989)(Jiqiang *et al.*, 2015).

For paper calculations, we tested four indices:

Higgins sustainable growth rate (X1 in this paper calculations)

$$g = f(P, R, A, T) \quad (1)$$

Where,

g -It is the index of sustainable growth, expressed in percent;

P – Profit after taxes;

R–The rate of reinvestment;

A –Turnover of assets;

T – The ratio of assets to equity or leverage.

2. Ivashkovskaya sustainable growth index.

Sustainable growth index proposed by Ivashkovskaya and co-authors (Ivashkovskaya, 2009) based on economic profit analysis. The growth of the ROCE - WACC spread and the stable positive indications of the spread of return over a long period contributes to the growth of economic profit. Based on these assumptions, scientists proposed the following index of growth stability:

$$SGIiv = (1 + g_s) \times \frac{l}{k} \times \sum_{i=1}^{k} \max[(0, (ROCE_i - WACC_i)] \quad (2)$$

(X2 in this paper calculations)

Where $(1 + g_s)$ – the average growth rate of sales;

1. k – The number of years of observations;
2. l –The number of years during which there was a positive spread of return on invested capital;
3. $ROCE_i$ – Return on capital employed per year;
4. $WACC_i$ –The weighted average cost of capital per year.

This indicator integrates both the primary driver of growth (sales growth rate) and the critical factors of economic profit. The higher the ratio l/k, the more robust (more substantial number of periods the company generates a positive economic profit). The last multiplier is the accumulated spread of the return on invested capital. Companies increase their economic earnings with a consistently positive yield spread. Besides, the analysis of the yield spread allows to directly display the impact on the creation of value two most important aspects: the growth of return on capital and the reduction of capital costs.

Varaya' sustainable growth index.

Profits and capital growth can occur if the rate of return on equity ROE higher than the cost of equity r_e. In study N. Varaya and co-authors we can see that financially efficient companies have a higher rate of profit growth and a positive spread of return on equity (Merikas, 2001). Thus, the modification of the index of sustainable growth by including the spread of return on equity is justified:

$$SGI_{ROE-r_e} = G_{sales}^{aver} \times \frac{l}{k} \times \sum \max[0, (ROE - r_e)] \quad (3)$$

(X3 in this paper calculations)

Where, ROE– return on equity;

r_e – The cost of equity.

The most attractive companies are those that have a positive return spread and a high rate of growth of invested capital. Indicator, which includes the spread of return on invested capital and its growth rate, will be a good proxy for qualitative growth, as it, on the one hand, reflects the strategic policy of the company (in respect of investments in future profits), on the other hand, assesses the quality of this strategy. Ivashkovskaya noted the discrepancy between the trajectories in the growth matrix based on economic gain gives us grounds to assume that the analysis of growth based on indicators of economic profit is not the most meaningful (Ivashkovaksya, 2008). In this study, it is proposed to build and analyze the index of sustainable growth by the classical instruments of the financial model analysis of the company.

We decided to check 24 financial and nonfinancial factors on Authors Sustainable Growth modified index. After grey correlation analysis results[i], correlation degree was used to describe relationship links between two systems in the process of development and changes. Using grey correlation analysis method can analyze more accurately the correlation between the two systems through a small amount of data. First, it must make data to be the average. For equilibrium modelling we use not absolute value of indicators, but values of their differences. "Method of distances" and "Rating assessment method" was offered by Sheremet.

This composition of methods' algorithm includes the following steps.

The sequence of the following actions can present the algorithm of comparative sustainable growth indicators rating assessment:

1. Primarily data are shown in aij matrix form, i.e., tables wherein the lines there are numbers of indicators (i = 1, 2, 3, …, n), and on columns – numbers of the companies (j = 1, 2, 3, …, m);
2. Concerning each indicator, it must be fined the maximum value which is brought in "model/standard company" column (m + 1);
3. Initial matrix indicators aij are standardized concerning the "model/standard company" corresponding indicator with a formula:

$$x_{ij} = \frac{a_{ij}}{\text{opt}_{\ j} a_i} \tag{4}$$

where xij - the standardized indicators of j company;

For each analyzed company the value of its rating assessment is determined by the following formulas:

$$p_j = \sqrt{(1 \pm x_{1j})^2 + (1 \pm x_{2j})^2 + \cdots + (1 \pm x_{nj})^2} \quad , \tag{5}$$

where x_{1j} , x_{2j} ..... x_{nj} – standard coefficients j company/market

Rating assessment method formula:

$$P_i = \sqrt{\sum k_i (1 \pm x_i)^2} \tag{6}$$

where k_i - coefficients of the importance, ponderability of the indicators defined if necessary in an expert way.

Further companies ranked in decreasing order. The company with the minimum value of the assessment received on a formula (1) or (2) has the highest rating. For the application of this algorithm in practice, it's no restrictions for a quantity of the compared indicators and the companies are imposed. Thus, we have used "method of distances" with one condition: the most favorable (positive) level of indicators reflecting sustainable company growth. This rating assessment algorithm sustainable growth indicators can be applied as to the comparison of several companies, as well as for one company in dynamics of the periods that are especially important for the assessment of the efficiency of sustainable growth and dynamic strategic analysis.

The analysis is carried out as of the end of the period or on average for the period and in dynamics. In the second case primary indicators calculated as tempo growth coefficients; data for the end of the period are divided into a value of the corresponding index for the beginning of the period, or the average value of an indicator of the reporting period is divided into the average value of the corresponding index of the previous period. Thus, it can be received assessment not only the current company efficiency but also the company's efforts and abilities for the change of efficiency in dynamics. Such an evaluation is the reliable measuring instrument of company competitiveness.

Inclusion in the primary data table also the tempo indicators is possible (i.e., doubling of a number of primary indicators) that allows receiving the generalized rating assessment characterizing company.

Indicators are used for research change private (different, separate, relevant) sustainable growth aspects. It will allow to extrapolating the established tendency, i.e., to predict at least the near future. The third technique is based on an integrated, multidimensional assessment approach to such difficult phenomenon as the efficiency of the organization (Sheremet, 2017b).

Thirdly, rating assessment is comparative; it is considered real achievements of all competitors.

Fourthly, for receiving rating assessment, the flexible computing algorithm realizing possibilities of the mathematical model of comparative complex company assessment for both financial and non-financial indicators is used. The offered technique does quantitatively measurable evaluation of business partner reliability which is carried out by results of the company' current and previous financial activity.

The Golden section method (Fibonacci method) was used to determine the fractions of the quotient in the model (Rose, 2014).

It was used formula:

$$\frac{x_1}{x_2} = \frac{x_2}{x_3} = \frac{x_3}{x_4} = 1{,}61 \tag{7}$$

Where x_1 - SGI, x_2 - LEI, x_3 - ROEenv, x_4 - ROEsr, x_5 - SRR;

and $x_1 + x_2 + x_3 + x_4 = 1$

The offered algorithm has to be used for the analysis and monitoring by the interested organizations, and conclusions have to be considered by preparation of administrative decisions of the Russia gas sector companies (Razmanova, 2016).

FSI - combines four factors:

SGI_{wacc} - Sustainable growth index (Ivashkovskaya);

ROE_{env} - Costs concerning environmental protection and decision of pollution question/production;

ROE_{es} - Energy saving (heat, electricity, water, etc.) to net profit;

ROE_{sr} - Social costs to net profit.

We transformed the above variables into a unit-less index between 0 and 1 using Sheremet rating assessment analysis (Sheremet, 2017a). To ensure that all variables have equal weighting we normalized the indexes from 0 to 1. Thus, FSI is generated by taking the geometric mean of the four normalized indices. It was calculated the ideal index for Russian and China oil and gas industry.

So, we normalized data on average according to the method of distances formula. Our intention here is to highlight factors ranking (k) calculated by use of the Fibonacci method with next distribution results SGI_{wacc} - 45%, LEI - 27%, ROE_{sr} - 17%. and ROE_{env} - 11%. Moreover, as a result, we have Rating Assessment, which was done according to Sheremet' analysis method with SGI_{wacc} results first by the ranking system, LEI results second, ROE_{sr} results third, ROE_{env} results as the fourth factor of our financial sustainable system model.

Authors' formula: (X in this paper calculations)

$$\mathrm{FSI} = \left[\sum \frac{\sqrt{\mathrm{k_i}\left(1+\frac{\mathrm{x_i}}{\mathrm{x_{max}}}\right)^2}}{\sqrt{\mathrm{k_j}\left(1+\frac{x_i}{\mathrm{x_{max}}}\right)^2}} - (\mathrm{A}_n^2 - 1) \right]^{-1} \quad (8)$$

Where,

FSI - Financial Sustainable Growth Index

k_j, k_i - Fibonacci method 'calculation ratio;

x_i, x_j - Correlation factor value;

x_{max} - Initial factors' maximum value;

A_n^2 - The rank number of every two from all the factors (permutation value of impact factors).

The value of the Financial Sustainable Growth Index we can interpret as follows: $0 \le \mathrm{FSI} \le 0{,}2$ - very weak system sustainability, the $0{,}2 \le \mathrm{FSI}$ 0,5th weak sustainability, $0{,}5 \le \mathrm{FSI} \le 0{,}7$ – average sustainability, the $0{,}7 \le \mathrm{FSI} \le 1$ strong sustainability.

Russian oil and gas industry financial sustainable system model results formula:

$$\mathrm{FSI} = 1{,}81\mathrm{SGI_{ce}} + 0{,}87\mathrm{ROE_{env}} + 0{,}76\mathrm{ROE_{sr}} + 0{,}57\ \mathrm{LE} \quad (9)$$

Where,

FSI - Financial Sustainable Growth index;

$\mathrm{SGI_{wacc}}$ - Sustainable Growth index (capital expenditure);

LEI - Lambert Energy Index;

$\mathrm{ROE_{sr}}$ - Return on Social Investments;

$\mathrm{ROE_{env}}$ - Return on Energy Environmental expenses.

China oil and gas industry financial sustainable system model results formula:

$$\mathrm{FSI} = 1{,}43\mathrm{SGI_{ce}} + 0{,}99\mathrm{ROE_{sr}} + 0{,}82\mathrm{ROE_{env}} + 0{,}76\ \mathrm{LEI} \quad (10)$$

Where,

FSI - Financial Sustainable Growth index;

$\mathrm{SGI_{wacc}}$ - Sustainable Growth index (capital expenditure);

LEI - Lambert Energy Index;

$\mathrm{ROE_{sr}}$ - Return on Social Investments;

$\mathrm{ROE_{env}}$ - Return on Energy Environmental expenses.

Fig. 5. Financial Sustainable System Growth.

References Références Referencias

1. Amouzesh, N. (2011) 'Sustainable Growth Rate and Firm Performance: Evidence From Iran Stock Exchange', International Journal of Business and Social Science, 2(23), pp. 249–255.
2. Von Bertalanffy, L. (1968) 'General System Theory', Georg. Braziller New York, 1, p. 289.
3. Bloom, J. (2009) 'Pattern Thinking, Systems Thinking, and Complex — Transferrable Learning in Education for Sustainability', p. 8.
4. Bragina (2013) 'Logic' paradigm (about scientific development of "social-economic systems"', Vestnik Kostroma State University, (5), pp. 108–114.
5. Carroll, S. M. (1997) 'Lecture Notes on General Relativity'. doi: 10.1134/S1061934810080083.
6. CNOOC (2017) 'Sustainability Report: China National Offshore oil corp.', (December).
7. CNPC (2016) 'Annual report'.
8. D'Amato, A., Henderson, S. and Florence, S. (2009) Corporate social responsibility and sustainable business. doi: 978-1-60491-063-6.
9. Eling, M., Parnitzke, T. and Schmeiser, H. (2006) 'Management Strategies and Dynamic Financial Analysis', Variance, 2(1), pp. 54–66.
10. Endovickiy (2016) 'From company' financial assesment to sustainable integration methodology', Economical analysis (theory and practice), Russian journal, 8725, pp. 42–65.
11. Epstein, M. (1996) 'Improving environmental management with full environmental cost accounting', Environmental Quality Management, 6(1), pp. 11–22. Available at: http://onlinelibrary.wiley.com/doi/10.1002/tqem.3310060104/abstract.
12. Friedman, B. D., Neuman Allen, K. and Allen, K. N. (2011) 'Systems theory', Theory and practice in clinical social work (2nd ed.)., pp. 3–20. doi: 10.13140/2.1.1132.9281.
13. Gazprom (2016) 'Sustainable Development report, Gazprom group (in Russian)'.
14. Gazprom (2017) 'Gazprom Annual Statement, Financial statement, Sustainability statement, Envieonmental Statement 2005-2016y.y.' Available at: http://www.gazprom.com/.
15. Gupta, P., Guha, S. and Krishnaswami, S. (2013) 'Firm growth and its determinants', Journal of Innovation and Entrepreneurship, 2(1), p. 15. doi: 10.1186/2192-5372-2-15.
16. Hall, C. A. S. (2001) 'The Need to Reintegrate the Natural Science with Economics', 51(8), pp. 663–673.
17. Heil, A. (2010) 'Systems Theory', pp. 1–9.

18. Higgins, R. (1977) 'How much growth can a firm afford?', Financial Management, 6(3), pp. 7–16. doi: 10.2307/3665251.
19. Hubert, R. (2011) 'The Challenge of Sustainable Economic Growth', (July), pp. 1–123.
20. Ivashkovaksya (2008) 'Financial Analisys of the Companies Growth', 13, pp. 0–8.
21. Ivashkovskaya (2009) 'Sustainable Growth Rate: from Russian companies evidence', 8(4), pp. 3–29.
22. Ivashkovskaya (2014) 'Does corporate financial architecture contribute to sustainable corporate growth? The evidence from Russian companies.', 4(32), pp. 11–33.
23. J.V. Neumann (no date) 'A model of General Economic Equilibrium', The review of economic studies, 13(1), pp. 1–9.
24. Jiqiang, L. et al. (2015) 'Multi-Factor Grey Correlation Analysis of Horizontal Well Development Effect in Chunguang Oilfield', pp. 253–256.
25. Julong, D. (1989) 'Introduction to Grey System Theory', The Journal of Grey System1, 1, pp. 1–24.
26. Kaspersen, M. (2013) The Construction of Social and Environmental Reporting.
27. Kaufmann, R., Gadmer, A. and Klett, R. (2001) 'Introduction to Dynamic Financial Analysis', ASTIN Bulletin, 31(01), pp. 213–249. doi: 10.2143/AST.31.1.1003.
28. King, C. W. and Hall, C. A. S. (2011) 'Relating financial and energy return on investment', Sustainability, 3(10), pp. 1810–1832. doi: 10.3390/su3101810.
29. Kleiner (2011) 'System Economic Balancing: methods, analysis and implication'.
30. Kleiner (2015) 'Sustainability of Russian economics in the System Economic Theory aspects (in Russian)', (12).
31. Kornai, J. (2016) 'The system paradigm revisited', Acta Oeconomica, 66(4), pp. 547–596. doi: 10.1556/032.2016.66.4.1.
32. Kurz, H. D. and Salvadori, N. (2000) 'The dynamic Leontief model and the theory of endogenous growth', Economic Systems Research, 12(2), pp. 255–265. doi: 10.1080/09535310050005734.
33. Lambert, J. et al. (2012) 'EROI of Global Energy Resources Preliminary Status and Trends', College of Environmental Science and Forestry (NY), (November).
34. Lambert, J. G. et al. (2014) 'Energy, EROI and quality of life', Energy Policy. Elsevier, 64, pp. 153–167. doi: 10.1016/j.enpol.2013.07.001.
35. Lukoil (2016) 'Annual Report, 2016'.
36. Ma, L. et al. (2011) 'Integrated energy strategy for the sustainable development of China', Energy. Elsevier Ltd, 36(2), pp. 1143–1154. doi: 10.1016/j.energy.2010.11.035.
37. Mastepanov (2009) Russia oil and gas complex in this century: problems and perspectives of development" (in Russian).
38. Merikas (2001) 'The Theoretical Relationship berween the strategic objective of sales growth and the financial policy of the entrepreneurial firm', in International Small Business Journal, pp. 59–67.
39. Minsky, H. P. (1986) 'Stabilizing an unstable economy', Journal of Economic Behavior & Organization, 10(2), pp. 251–253. doi: 10.1016/0167-2681(88)90050-9.
40. Murray, I., Platonova-Oquab, A. and International Energy Agency. (2006) 'Optimising Russian natural gas : reform and climate policy.', p. 200. doi: 10.1787/9789264109872-en.
41. Nogovitsyn, R. and Sokolov, A. (2014) 'Preliminary calculation of the EROI for the production of gas in Russia', Sustainability (Switzerland), 6(10), pp. 6751–6765. doi: 10.3390/su6106751.
42. Novatek (2016) 'Annual report, 2016', 2016 (May).
43. Ollivier, Y. (2010) 'A visual introduction to Riemannian curvatures and some discrete generalizations', Mathematics Subject Classification, pp. 1–24. Available at: http://books.google.com/books?hl=en&lr=&id=PfJnikY4YEoC&oi=fnd&pg=PA197&dq=A+visual+introduction+to+Riemannian+curvatures+and+some+discrete+generalizations&ots=Nklu1jW9qa&sig=u2Rz2KrelH-GiQpXm_Pqn5YjwCA.
44. Pereira (2018) 'Energy Finance', p. 622.
45. Perman, R. et al. (2003) Natural resource and environmental economics.
46. Razmanova, S. V. (2016) 'Economic systems integration based on harmonic balance', St Petersbg State Polytech Univ Journal Econ, 246(4), pp. 214–227. doi: 10.5862/JE.246.19.
47. Richardson, G. P. (2017) 'Encyclopedia of Complexity and Systems Science', pp. 1–10. doi: 10.1007/978-3-642-27737-5.
48. Road, P. (1995) 'System Complexity and the Design of Decision Support Systems', 8(5).
49. Rose, N. J. (2014) 'The Golden Mean and Fibonacci Numbers The golden mean', pp. 1–44.
50. Rosneft (2016) 'Rosneft sustainability report', p. 123.
51. Rudelius, T. and Hubbard, J. (2012) 'A Geometric Understanding of Ricci Curvature in the Context of Pseudo-Riemannian Manifolds', (April). Available at: http://www.math.cornell.edu/files/Research/SeniorTheses/rudeliusThesis.pdf.
52. Ryabova, E. (2018) 'Russian companies sustainable growth factors (in Russian)', Financial Management, 22(1), pp. 104–117. doi: 10.26794/2587-5671-2018-22-1-104.
53. Rybachuk (2015) 'Balanced system comoany structure as the main factor of sustainable system (in Russian)'.

Global Journal of Researches in Engineering (G) Volume XIX Issue I Version I Year 2019
15

54. Sarker, D. M. O. F. (2014) 'Python Network Programming', (C), p. 234. Available at: http://it-ebooks.info/book/3515.
55. Scellato (2013) 'NetworkX : Network Analysis with Python Today ' s Outline', (February), pp. 1–51.
56. Schaltegger, S., Hahn, T. and Burritt, R. (2000) 'Environmental management accounting: Overview and main approaches'.
57. Sheremet (2017a) 'Analysis and audit of sustainable development indicators', pp. 154–155.
58. Sheremet (2017b) 'Analysis and audit of sustainable development indicators at enterprise level'. Moscow: Audit and Finance Journal, pp. 1–9.
59. Sinopec (2017) 'Communication on Progress for Sustainable Development 2016 | Undertaking Responsibility of Our Era, Promoting Sustainability Together'.
60. Solé, R. V. and Montoya, J. M. (2001) 'Complexity and fragility in ecological networks', Proceedings of the Royal Society B: Biological Sciences, 268(1480), pp. 2039–2045. doi: 10.1098/rspb.2001.1767.
61. UNCED (1992) 'Earth Summit'92. The UN Conference on Environment and Development', Reproduction, Rio de Jan(June), p. 351. doi: 10.1007/s11671-008-9208-3.
62. Watts, D. J. and Strogatz, S. H. (1998) 'Collective dynamics of "small-world" networks', 393(June), pp. 440–442.

[i]Financial Sustainable Growth index calculation methodology see in Appendix B.