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MATHEMATICAL DYNAMIC MODEL FOR "GREEN FINANCE" SUSTAINABLE GROwth

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 the financially sustainable growth of the 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 considered by a sustainable growth model. A new mathematical dynamic model, 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 weights 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*

1. Introduction

An every economic sector is a complex continuous system (Richardson, 2017)(Solé and Montoya, 2001). System analysis allows selecting many interaction links that perform various functions (Von Bertalanffy, 1968). Among the 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 units 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 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 parts can build a mathematical model and analyze the model' dynamic behavior (Mastepanov, 2009)(Road, 1995) (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,

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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 essentially to look through new ways 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 an economic model of sustainable development based on Lagrange Resilience Points' concept. Niu Venyuan' concept helped 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 growth, social impacts, ecology protection) [1], [2], [3]. According to experts, expected that China 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 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.)

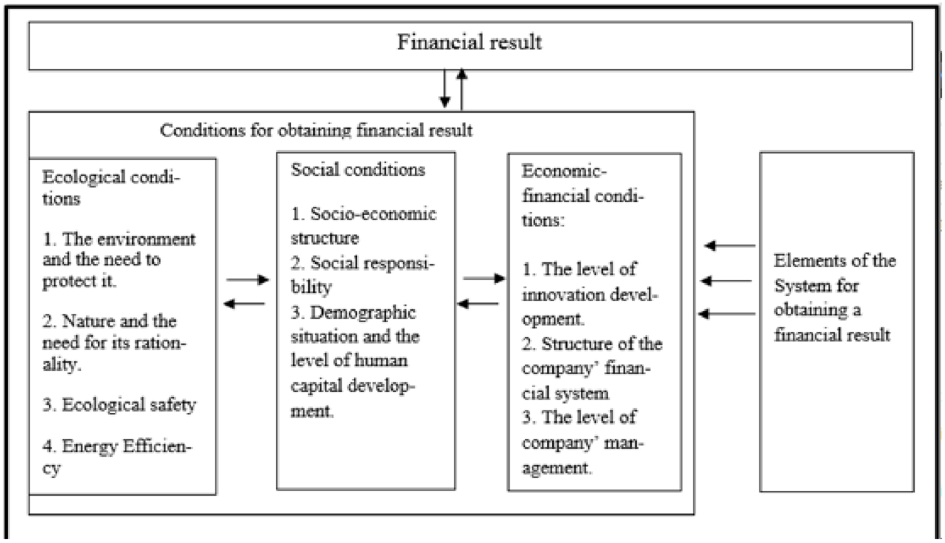

Figure 1. Key elements of the sustainable system for obtaining the financial result. Source: (Bragina, 2013)(Sheremet, 2017)

Nowadays contradictions of the sustainable financial growth traditional organization model as "alone" functional focused on the finance aspects only. When we talk about the existing system of financial growth (Hubert, 2011)(Lambert *et al.*, 2012), we understand that there are too many theoretical points of view. However, in practice, there is no toolkit for dynamic systems that would describe methods for achieving sustainable growth with accent on environmental protection, energy efficiency 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 is 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 subblocks, there is a dialectic relationship (direct and inverse). Thus, 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, that allows analyzing all elements of the economic system. Appeal to ecosystems is part of the main disciplinary direction of economic science development, associated with the transition from mechanical analogies to physical, biological, linguistic and other models. Ecosystems are part of the economic science' development direction, 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, 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 set 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).

2. Theoretical background

2.1. Task formulation

The study we done on the base of Russia and China oil and gas industry' actual data (29 indicators for 98 quarters) (Gazprom, 2017) (Murray, Platonova-Oquab and International Energy Agency., 2006)(Novatek, 2018)(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 system sustainable development, we understand the behavior in which all indicators will increase, and the growth rate of all indices will be in consistency. To characterize sustainable development, Authors developed sustainable system index, which was designated as 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);

4) Financial indicators- a group of indices reflecting the development of financial system (Amouzesh, 2011).

Research goal is to create a mathematical model that allows analyzing of the system growth sustainability. 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.

2.2. Ricci Curvature

Ricci curvature methodology (Ollivier, 2010) (Rudelius and Hubbard, 2012)(Matthias, 1997) we can see in Riemannian geometry. The Ricci curvature ensures a vital place in the geometric evaluation of Riemannian manifolds. The Ricci tensor (by the Ricci-Curbastro), describes way to measure the manifold 'curvature. It 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 deformation volume, that is, the degree of difference between n-dimensional domains of an n-dimensional manifold and similar domains of Euclidean space. The Ricci tensor is a symmetrical bilinear mode on the tangent space of a Riemannian manifold.

We formulate fundamental 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 unit weights depend on the adopted coordinate system and change when moving to other coordinates. After the transformation (change) of the parts, specific individual values (weights) remain invariant.

The metric tensor is a rule for calculating the length of any vector by the values of its parts. 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.

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

Replace the lower indices: $k \to i, l \to k, j \to l$ $R^i_{kil} = \sum_i R^i_{kil}$

$$R_{kl} = \partial_i \Gamma^i_{kl} - \partial_l \Gamma^i_{ki} + \Gamma^m_{kl}\Gamma^i_{mi} - \Gamma^m_{ki}\Gamma^i_{ml}$$

From the Ricci tensor, the Ricci scalar can be calculated by lifting one 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

$$R^k_l = g^{kl} R_{li}$$

$$R^i_i = g^{il} R_{li} = R = 2K$$

where, Γ^i_{lk}- 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 Einstein' rule, emphasized that for an index that occurs twice (once at the top, another at the bottom), the summation implied.

$$\mathrm{A}^{tk}\mathrm{B}_{tmn} = \sum_t \mathrm{A}^{tk}\mathrm{B}_{tmn} = \mathrm{C}_{mn}^{k}$$

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

2.3. 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 metric spaces Markov chains' Ricci curvature (Lin and Lu, 2010) (Lin and Yau, 2012).

We define the local Ricci curvature according to Yann Olliver explanation:

Definition 1. Let (X, d) be a Polish metric space from Borel sigma algebra. The random walk m on X is a probability measure mx (.) On X for any x∈X that respondes the next two suggestions: (i) the measure mx depends on the point x∈X; (ii) each measure mx has a finite first moment. Definition 2. Let (X, d) be a "metric space", and let µ1 and µ2 be two probabilistic measures on X. A metric is introduced: the distance between µ1 and µ2 is:

$$\tau(\mu_1, \mu_2) \coloneqq \inf_{\varepsilon\in\Pi} \int_{(x,y)\in X\times X} \mathrm{d}(x,y)\mathrm{d}\varepsilon(x,y)\ ,$$

Where,

Π= Π *(μ1, μ2)* – this set of measures on X × X projected onto µ1 and µ2.

$\mathrm{d}(x,y)$ – 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:

$$\mathbf{k}(\boldsymbol{x},\boldsymbol{y}) \coloneqq \mathbf{1} - \frac{\boldsymbol{\tau}(\boldsymbol{m}_x, \boldsymbol{m}_y)}{\boldsymbol{d}(\boldsymbol{x},\boldsymbol{y})}$$

3. Methodology

3.1. 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 a new algorithm. 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:

$$\mathrm{r}_{xy} = \frac{\sum(\mathrm{x}_i - \mathrm{M}_x)(\mathrm{y}_i - \mathrm{M}_y)}{\sqrt{\sum(\mathrm{x}_i - \mathrm{M}_x)^2\,(\mathrm{y}_i - {\mathrm{M}_y}^2)}}$$

where x*i* – the X values; y*i* – the Y values; 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 a correlation network. The vertices of the frame 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 facets with a weight (correlation coefficient) greater than 0.7 are marked with a bold line, edges with a heft of less than 0.7 indicated with a dashed line.

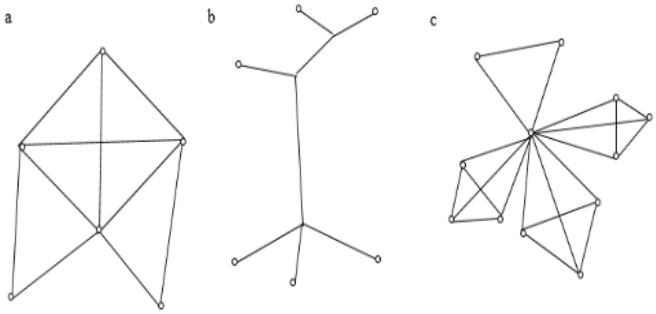

Fig 2. Nodes. (a) Node n has V = 5 neighbors and T = 5 triangles, thus curvature (n) = ½; b) Tree, each nodes has a curvature of 0 node; (c) is a hub with curvature ≈ 1 / v. Source: (Watts and Strogatz, 1998)

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 the Watts-Strogatz formula for solving the clustering problem (Watts and Strogatz, 1998): $curv(A)=t/(v(v-1)/2)$.

Here v is the vertices (number) and t is the triangles (number) 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 max. number of triangles, which could be compiled using all the vertices of the graph. Hence, curve (A) lies between 0 and 1. In

Studies show that the curvature is usually shallow in random graphs. High curvature clusters have a high 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.

3.2. 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 indices, we found estimates of paired correlation coefficients. A fragment of the pairwise 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 we can see at the Fig. 2. In Fig. 1, bold lines indicate edges, for which corr (u, v)> h. The threshold h splits the graph into clusters. In Fig 1, we obtained a set of vertices interconnectes 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:

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

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

A program developed for computing the graph vertices curvatures for analyzing the system sustainability. Thus, 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" (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))

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

$$\mathrm{node\ curvature} = \mathrm{tri}/(\mathrm{n}(\mathrm{n}-1))$$

headers2: = remaining nodes in graph Gs

4. Results

We describe the main calculations' outputs. 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. Highlighted lines in 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 version include the top of the three groups: the environment, social and financial indices.

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

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

We consider a final graph with selected vertices and edges in dynamics and we study the graph' changes used geometry, specifically, by evaluation changes in the graph vertices local coefficients curv (.). Thus, we divided entire database into three periods (I-III), for each period it was built correlation graph, was calculated the curv (.) values of all the all vertices. Then, the average curvature weight calculated for each period using Eq. (2). For sustainable growth intensity analysis, we compared X, X1, X2, X3 every period the average values of indices and the graph' average weights 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.

Similar calculations we conducted for China oil and gas industry' sustainable growth system. All figures and tables are the same as for Russia but with different results. They are presented in Fig. 3,4 and Tab. 3.

On the graph (Fig. 5) we observed elements that have the closest connection with each other and constructed 7 important links: ROCE- ROA, PRP - WACC, DOL-CL, Footprint- biocapacity- CO2 emission, EBIT- RoL, ROEsr- DER- LEI- NPG, NWC- ER- RER.

Table. 3 The average values matrix for the China oil and gas sustainable growth system

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

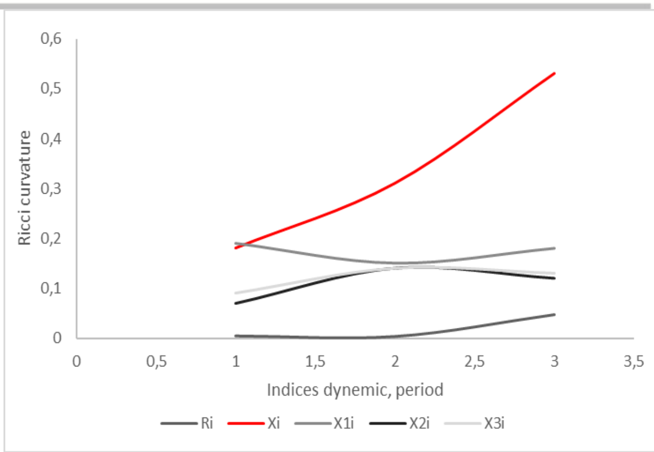

Fig. 3. Russian oil and gas industry indices dynamics. Source: based on data (Gazprom, 2017)(Rosneft, 2016)(Lukoil, 2016)(Novatek, 2018)(Nogovitsyn and Sokolov, 2014)(Perman *et al.*, 2003)(Lambert *et al.*, 2014)by use of Python 3.6. system growth model

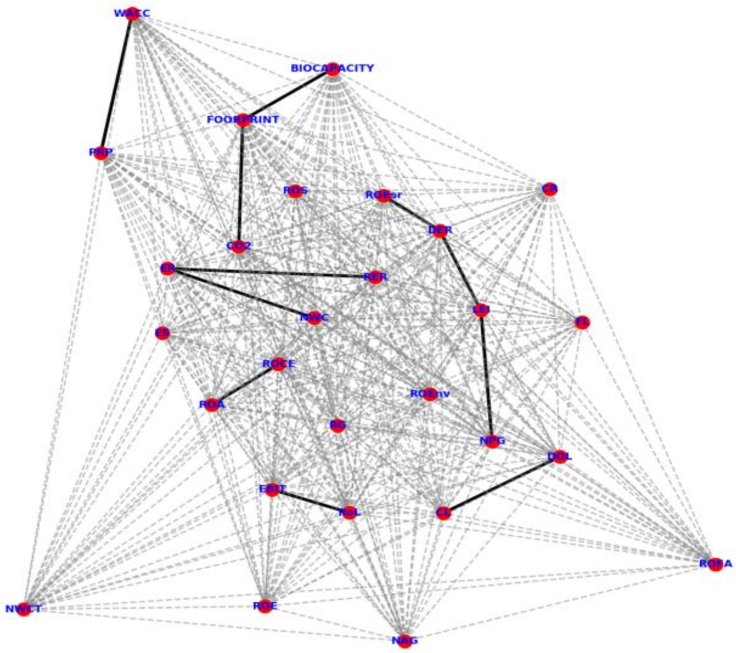

Fig. 4. Russia' oil and gas industry sustainable growth correlation network (I-III period model see in attachment programme files to this article). Source: Authors calculations

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.

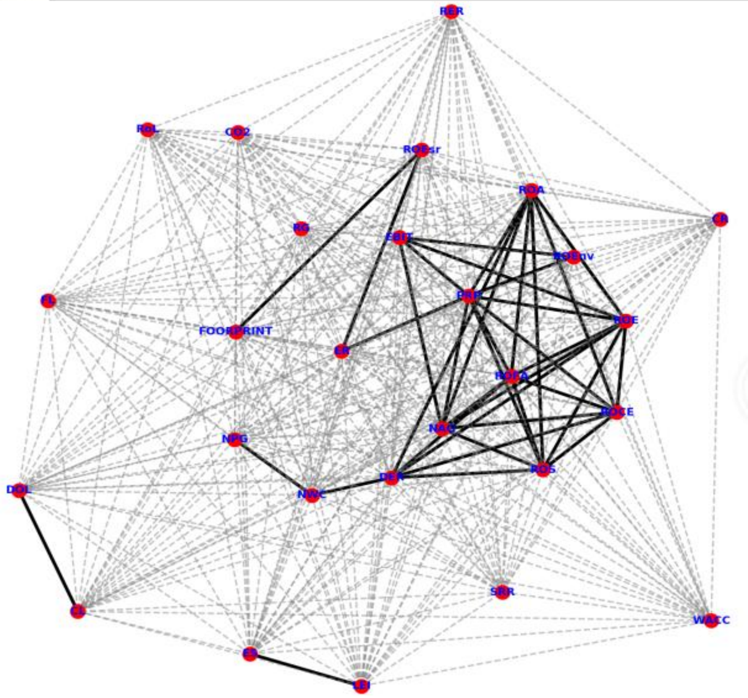

Fig. 5. China oil and gas industry correlation network (I-III period model see in attachment programme files to this article). Source: Authors calculationsA comparative analysis of indices R- Ricci curvature, X – Financial Sustainable Growth Index, X1 – Higgins' Sustainable Growth Index, X2 - Ivashkovskaya' 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 financially sustainable growth with sustainable nonfinancial factors.

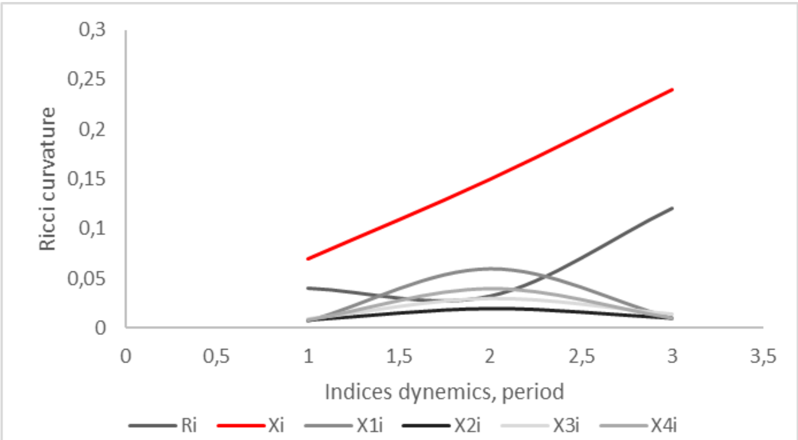

Fig. 6. China oil and gas industry indices dynamics. Source: based on data (CNPC, 2016)(Sinopec, 2017)(CNOOC, 2017)(Ma *et al.*, 2011)(Lambert *et al.*, 2014) by use of Python 3.6. system growth model.

5. Conclusion

Studies show that geometric methods allow us to find new ways to assess the system dynamic 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. We built the system growth dynamic mathematical model. Characteristics of the Author's mathematical 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. It was found the links between financial sustainability and factors, such as LEI, PRP, Footprint, Biocapacity, ROEenv, ROEsr, ER, ES, ROL, RER As 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 $\text{non} - \text{financial}$ factors to contribute to financial sustainability. That is why Authors decided to include nonfinancial factors to Financial Sustainable growth index and strongly recommended companies input this index as KPI into financial statement. Evaluation results shows that China and Russian gas companies are financially attractive and have stable results, but must improve Financial Strategies according to Sustainable Growth point of view. It is controversial 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. 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.

6. Discussion

Ideas and principles of Russian and Chinese gas companies' sustainable growth 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. The Chinese oil and gas companies the fuller measure can follow the principles of sustainable development in connection with adverse ecological situation in the country (Ma *et al.*, 2011). Nevertheless, current Russian and Chinese gas companies' financial policy results not concluded sustainability factors, such as environmental, energy and social indices. We observed the structure of their transversal boundaries and concluded that financially sustainable system can be influenced not only financial factors but also by nonfinancial factors, like energy saving factor, environmental protection factor and social responsibility factors. The most important problem is the study of the interrelations among four systems inside one. Authors' also have 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, into specific ring-shaped structures comprising four systems of different types (tetrads). Companies' sustainable growth can be evaluated be the intensity of interaction between factors. In perspective view, financial sustainability in the context of sustainable growth in the field of future investigations and gains. However, 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 is that financially sustainable index must build as system index. However, we are firmly intended to research all-level-equilibrium financial sustainable growth model. Researchers need to deepen the financial growth system' classification according to space-time analysis, combined with a behavioural classification.

7. Limitations and future Research

Research has several constraints, which also sustain exciting avenues for future analysis. First, the Russian gas industry companies, restricting the generalizability of research findings, limit the Study data. Second, following other recent sustainability studies with the accent on 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), we accepted that this research might not be complete. Because of data availability problem in Russia before the 1996 year (USSR collapse), we could also not take to account how financial sustainability was managed before. Thus, Author emphasizes 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 is why, Author encourages future research to examine how financial sustainability influence sustainability as a whole and nonfinancial sustainable factors on financial factors in particular. Besides, 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.

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