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MATHEMATICAL DYNAMIC MODEL FOR "GREEN FINANCE" SUSTAINABLE GROWTH

Abstract: *Financial decisions that take into account long-term social, energy and environmental consequences should be determined as the the key point for the sustainable growth of the oil and gas industries in many countries all over the world, including Russia and China. The oil and gas industry transition to "Green Finance" in these two countries is represented by a new mathematical dynamic model, which uses the Ricci tensor analysis. For a sustainable growth analysis (a) Financial sustainable growth index (FSI), (b) Higgins' sustainable growth rate (SGR Higgins), (c) Ivashkovskaya' sustainable growth index (SGI Iv), (d) Varaya' sustainable growth index modification (SGI modif) was analyzed and the graph' average weights of the Ricci curvatures (Re) are compared. The links between financial sustainability and nonfinancial factors were found. Comparative analysis of the development of the China and Russia petroleum industries shows that China is developing more steadily. The R- values for each period are higher for China than for Russia.*

Keywords: *Financial Sustainable Growth; System Dynamic modeling; Green Finance; Ricci Curvature; Coarse Ricci Curvature.*

1. Introduction

Every economic sector is a complex continuous system. 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 units are objective, but realized in the process of conscious activity of people. The complexity of managing an economic system is based on relation to the system as a whole (Von Bertalanffy, 1968) (Kornai, 2016). Economy is a Complex System, where all the elements are interconnected, that is why we can build a mathematical model and analyze the model only by taking into account interrelations between dynamic behavior of the parts (Minsky, 1986).

The most famous mathematical models of the economic system are the Leontief model (Kurz and Salvadori, 2000) and the Neumann model (Neumann, 1945) (Kaufmann et al., 2001) (Friedman & Allen, 2011). For example, Leontief inter-sectoral balance model operates with pure industries, but reflects the interrelation between sectors only indirectly, not taking into account the system dynamics. The Neumann model tells us that we can formulate various optimization problems. The solutions of these problems represent trajectories of intensive development. Neumann model, a model of

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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 very important to look for the new ways of 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). According to experts, it was expected that China will achieve sustainable development indicators in 64 years (in 2079) (Steblyanskaya et al, 2019). Considering the fact that the structure of the energy sector in China and the economic model of the state complement each other, Niu Venyuan proved that China state development model determines its energy profile. Therefore, China's oil and gas companies also were considered as a progressive driving force of society. In the author's sustainable growth system, we distinguish three blocks. The first one is the financial result of the economic system, represented by the financial index. The second block is about the conditions for its achievement (receipt) and the third block tells about elements of a system for obtaining financial results (Figure 1).

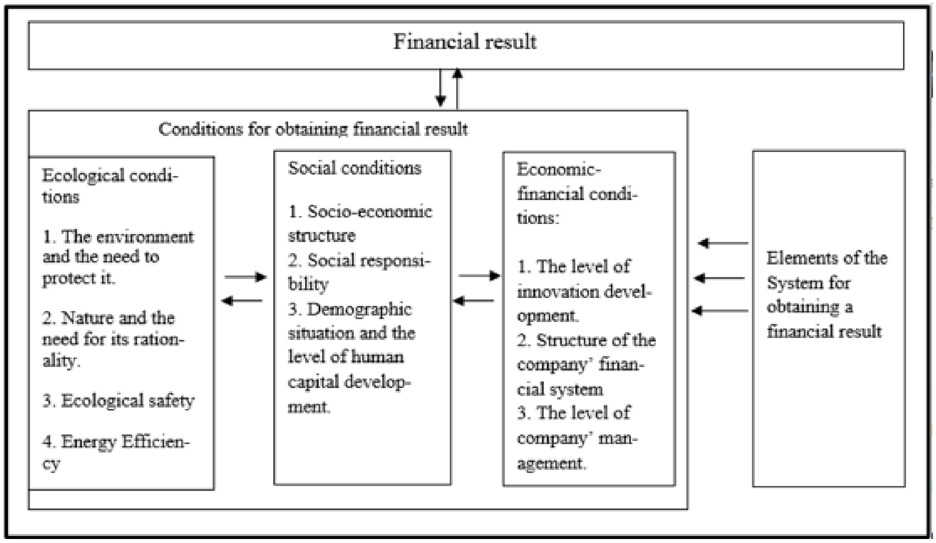

Figure 1. The key elements of the sustainable system for obtaining the financial result.
Source: (Sheremet, 2017), (Steblyanskaya et al., 2019)

Nowadays contradictions of the traditional model of sustainable financial growth are focused only on the financial aspects. When we talk about the existing system of financial growth (Lambert et al., 2014), 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 (Gupta et al., 2013). Higgins defines the sustainable growth as “the percentage of sales annual growth that is in agreement with the company's established financial policies” (Higgins, 1977). However, according to today’s reality, “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 supplemented by physical constraints on substitution among the factors. We claim that energy, environment and social responsibility are the most essential factors for financially sustainable growth. There is a dialectic relationship (direct and inverse) between these subblocks. Thus, all the variety of direct and inverse relationships in this system is investigated by the Authors. Results of these interrelations were taken into consideration. That allowed analyzing all the elements of the economic system. Appealing to ecosystems is a part of the main disciplinary direction of the 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 will reflect the properties of nature and people will be involved in economic modeling (Stenlyanskaya et al, 2019). 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 (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. Here we could analyze four skills of system thinking, 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 was done on the base of Russian and Chinese oil and gas industry’s actual data (29 indicators for 98 quarters) (Gazprom, 2017), (Novatek, 2018) (Nogovitsyn & Sokolov, 2014) (Rosneft, 2016) (Lukoil, 2017) (CNPC, 2018) (Sinopec, 2017), (CNOOC, 2018).

Measuring the financial sustainability of the system occurs in many cases. 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 note that the increased sensitivity or the tendency of the system to failure 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.

What is system sustainable development? We understand it as the behavior where 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.

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);

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 will properly analyze the system growth sustainability. The presence of such a model will make 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

We can find Ricci curvature methodology (Ollivier, 2010) (Rudelius & Hubbard, 2012) (Matthias,1997) 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 the 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. In brief, 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. 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_{lkj}^{i} by folding and convolving the upper index with the lower one.

$$\mathrm{R}_{lkj}^{i} = \partial_k \Gamma_{lj}^{i} - \partial_j \Gamma_{lk}^{i} + \Gamma_{lj}^{m} \Gamma_{mk}^{i} - \Gamma_{lk}^{m} \Gamma_{mj}^{i}$$

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

$$\mathrm{R}_{kl} = \partial_i \Gamma_{kl}^{i} - \partial_l \Gamma_{ki}^{i} + \Gamma_{kl}^{m} \Gamma_{mi}^{i} - \Gamma_{ki}^{m} \Gamma_{ml}^{i}$$

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

$$\mathrm{R}_{l}^{k} = \mathrm{g}^{kl} \mathrm{R}_{li}$$

$$\mathrm{R}_{i}^{i} = \mathrm{g}^{il} \mathrm{R}_{li} = \mathrm{R} = 2\mathrm{K}$$

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 Einstein' rule, which emphasizes that for an index that occurs twice (once at the top, another at the bottom) the summation is 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

The concept of Ricci curvature first appeared in the works of Bakri and Emery. It has been studied extensively in recent context. In 2009, Olivier defined the coarse Ricci curvature on Markov chains, which are used for metric spaces generated by graphs (Ollivier, 2010). Chung and Yau first introduced the Ricci curvature definition for graphs in 1996 (Chung and Yau, 2000). In 2011, Lin, Lu, Yau modified the Olivier definition for the metric spaces Markov chains' Ricci curvature.

We define the local Ricci curvature according to Yann Olliver's 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:

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

Where,

$\Pi = \Pi$ (μ_1, μ_2) – this set of measures on X × X projected onto μ1 and μ2.

$d(x,y)$ – 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:

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

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 this problem, we use the concept of a local clustering coefficient, which shows the density of triangular relations.

In general, this is the formula for calculating the correlation coefficient:

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

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. You can find an example of a correlation network in Figure 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.

The correlation network was considered as an undirected graph. We have removed the edges with a weight of less than 0.7 to show a non-oriented graph. For the resulting graph we have calculated 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 is important for us to know, which vertices were included in the connected graph and what is the form of the vertex connection. 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.

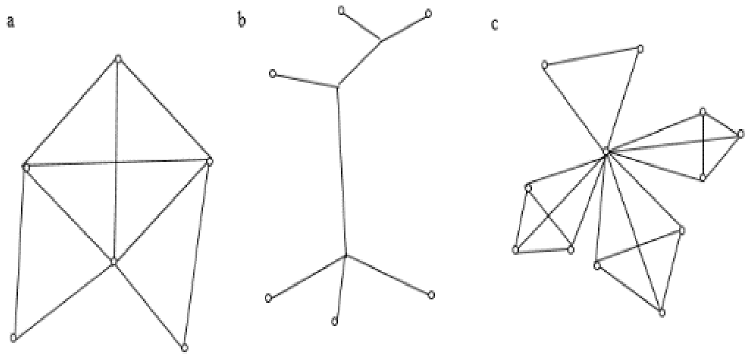

Figure 2. Nodes. (a) Node n has V = 5 neighbors and T = 5 triangles, thus curvature (n) = ½; (b) Tree, each nodes have a curvature of 0 node; (c) is a hub with curvature ≈ 1 / v.
Source: Watts and Strogatz, 1998

Hence, curve (A) lies between 0 and 1. In Figure 2 shows examples of graphs and curvatures. Curve (v) is the local clustering coefficient.

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

3.2. Research algorithm

Authors selected 29 indicators for 98 periods of the oil and gas industry analysis. With a sample of indices, we found estimates of paired correlation coefficients. A fragment of the pairwise correlation matrix presented in Table 1. Then, a correlation network was 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 have obtained a lot of 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 Figure 3. In Figure 3, bold lines indicate edges, for which corr (u, v)> h.

The threshold h splits the graph into clusters. In Figure 3, the authors 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:

$K_i = \text{curv}(G_i) = \sum_{j=1}^{n_i} \text{curv}(j)$,

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

A program was 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, we used the open library in Python “NetworkX”.

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

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

headers2: = remaining nodes in graph Gs

4. Results

The authors have described the main calculations and comparative analysis outputs. Firstly, the authors considered Russia and China models separately. Table 1 shows a sample correlation coefficients’ fragment of calculations according to sustainable coefficients influenced on Russian oil and gas companies’ sustainable financial growth indices. Constructed correlation network could be seen in Figure 3.

Table 1. The nonfinancial factors matrix pair correlations (system dynamic model calculations)

	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

Highlighted lines in Figure 4 show links with a correlation coefficient higher than 0.7. Authors have removed the edges with a correlation coefficient of less than 0.7 and only took the remaining graph for analysis. It is important that the final version includes 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

We have considered a final graph with selected vertices and edges in dynamics and we have studied the graph' changes using geometry, specifically by evaluation changes in the graph vertices local coefficients curv(.). Thus, we have divided entire database into three periods (I-III), for each period the correlation graph was built, the curv (.) values of all the vertices were calculated. Then, the average curvature weight was calculated for each period. 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) (Table 2).

Figure 3 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.

We have done similar calculations for China oil and gas industry' sustainable growth system. All figures and tables were the same, but have shown different results. They are presented in Figure 4, 5, 6 and Table 3.

On the graph (Figure 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- CO_2 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

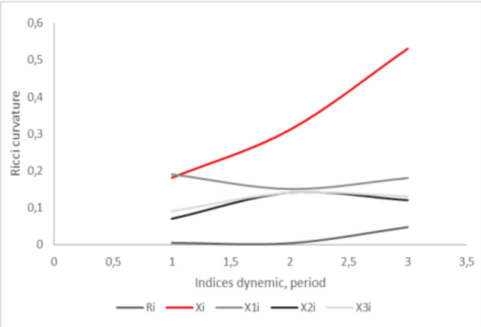

Figure 3. Russia' oil and gas industry indices dynamics. Source: authors methodology

Figure 3, 4 show that FSI more correlated to the nonfinancial factors than other sustainable coefficients. Thus, we can observe the impact of investments in personnel welfare, energy and environmental efficiency on sustainable financial growth in the Russia and China oil and gas industry.

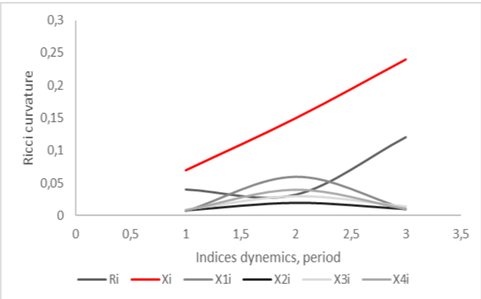

Figure 4. China oil and gas industry indices dynamics. Source: authors methodology

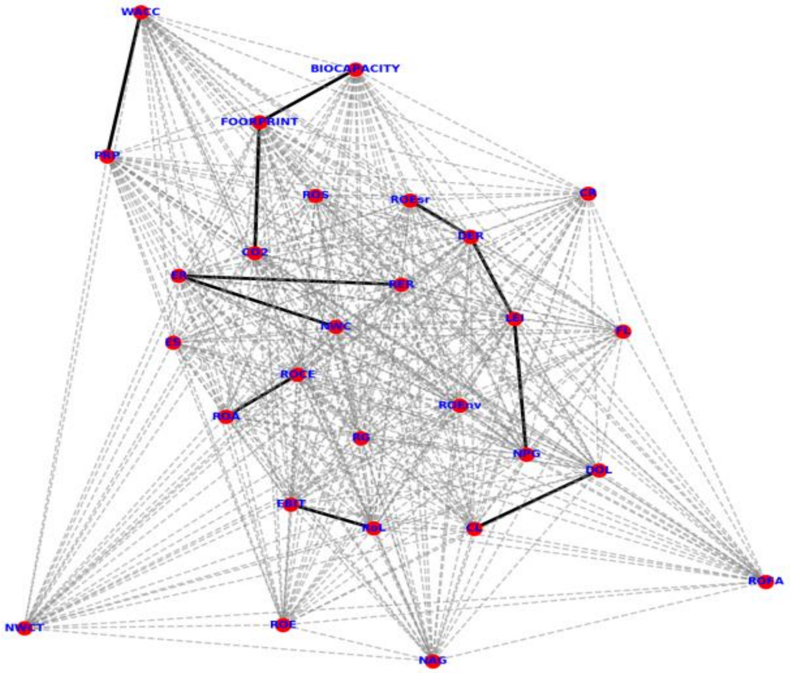

Figure 5. Russia' oil and gas industry sustainable growth correlation network (I-III period model see in attachment programme files to this article)
Source: Authors calculations

Comparative analysis of indices R- Ricci curvature, X – Financial Sustainable Growth Index, X1 – Higgins' Sustainable Growth Rate, X2 - Ivashkovskaya' Sustainable Growth Index (Ivashkovskaya (2014), X3- Varaya' Sustainable Growth Index shows that indicators X and R are in better agreement with each other and brightly indicate development intensity of the financially sustainable growth with sustainable nonfinancial factors.

In Russian oil companies the energy subsystem, social and environmental ones are developing more systematically, with an emphasis on the social subsystem. The situation is deteriorating both in China and in the Russian Federation. The system of "green" sustainable financial growth is the most stable in the Russian Federation and less stable in the PRC. It is interesting to note that, despite the decreasing in financial performance, the index of sustainable financial growth in Chinese oil companies is being maintained at a sufficient level, which indicates that they are adhering to a sustainable development policy. In the Russian Federation, this indicator has been making a jump upward in recent years as a result of planned measures to maintain sustainable growth in oil and gas companies.

A comparative analysis of the development of the Chinese and Russian 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. As we see in the Figure 6, in China oil and gas industry FSI is more correlated to the nonfinancial factors than other sustainable coefficients. Thus, the authors received confirmation of the theory that the sustainability of financial growth depends on the interactions with energy, environmental and social processes.

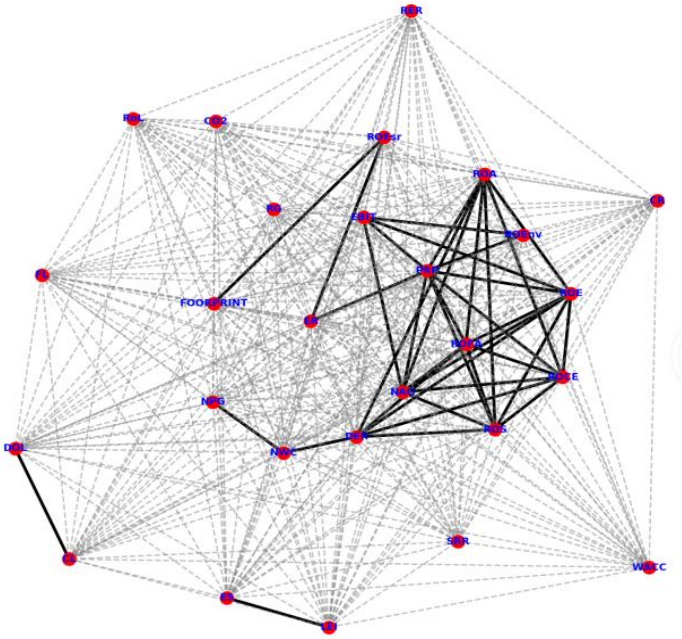

Figure 6. China oil and gas industry correlation network (I-III period model see in attachment programme files to this article)
Source: Authors calculations

The financial component prevails in Chinese oil companies. The ecological subsystem is developing there. The state of the social subsystem shows bad results. The situation is deteriorating both in China and in the Russian Federation. The system of “green” sustainable financial growth is the most stable in the Russian Federation and less stable in the PRC.

5. Conclusions

Studies show that geometric methods allow us to find new ways to assess system sustainable growth by use non-financial indicators. Research allowed to find some new methods of governance the oil and gas industry companies’ financial sustainable growth. The authors’ emphasized that including non-financial factors to the financial statements could determine natural resources preservation, as well as improving quality of the social responsibility with the achieving financial goals of the oil and gas industry companies. The authors have built a sustainable growth dynamic mathematical model. The new mathematical system dynamic model has the following characteristics: responsive to changes, self-organizing, adaptive, self-developing, synergistic and systemic.

Russian and Chinese oil and gas companies’ financial policy results also should depend on sustainable factors. The links between financial sustainability and non-financial factors, such as LEI, PRP, Footprint, Biocapacity, ROEenv, ROEsr, ER, ES, ROL, RER were found. Thus, we know that financial sustainable coefficients related to $ROA, ROCE, WACC, NWC, CL\ and\ DOL$ to contribute to financial sustainability, so we should give better attention to these financial coefficients that have great influence on financial sustainable growth rate. However, financial sustainable indices also related to non − financial factors to contribute to financial sustainability. That is why Authors decided to include nonfinancial factors to

Financial sustainable growth index and recommended companies to input the new index as KPI into financial statement. Evaluation results shows that China and Russian gas companies are financially attractive and have stable results, however, they can improve financial strategies according to sustainable growth point of view. It is a controversial question - which factors has more influence on financial sustainable index. However, people should try 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 exicting sustainable growth rates and indices not fully reflect financial capabilities of the companies. That's why in this research non-financial indicators as a possible direction for sustainable growth theory further development are taken into account.

Since the concept of sustainable growth is associated with environmental protection, energy savings, and social factors, the authors have added to the model some non-financial factors. The authors obtained the dependence on as LEI, PRP, Footprint, Biocapacity, ROEenv, ROEsr, ER, ES, RoL, RER for both Chinese and Russian gas market companies. We 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 Rate, 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 Chinese and Russian 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

The idea and principles of Russian and Chinese gas companies' sustainable growth outlined in the UN Action Plan for Sustainable Development known as Agenda 21. 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 including economic growth and equity, conservation of natural resources and environmental protection, social development. The Chinese oil and gas companies can follow the principles of sustainable development in connection with adverse ecological situation in the country (Ma L. et al., 2011) (Steblyanskaya A; et all. Nevertheless, current Russian and Chinese gas companies' financial policy results have not concluded sustainability factors, such as environmental, energy and social indices. We have observed the structure of their transversal boundaries and have concluded that financially sustainable system can be influenced not only by 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 by the intensity of interaction between factors. In the future financial sustainability will be in the context of sustainable growth and in the field of future investigations and gains. However, the central controversial question of this Research is – Should sustainable growth be optimal harmonic or balanced? Financial sustainable growth must be balanced, so all the parts of the model should be equal at the end or this model will not be useful in our society. Today our common conclusion is that financially sustainable index should be built 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. Firstly, the Russian gas industry companies, restricting the generalizability of research findings, limit the Study data. Secondly, 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 & Hall, 2011). We assume that this research might not be complete. We could not also take into account how financial sustainability was managed before, because of data availability problem in Russia before the 1996 year (USSR collapse). Thus, the authors emphasize that there are three directions of sustainable growth analysis methods improvement. The first direction is development of social, environmental and energy indicators system, influencing on financial factors. The second direction is developing stochastic analysis methods to know 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 the Author encourages future research to examine how financial sustainability influences on sustainability as a whole and, in particular, the influence of nonfinancial sustainable factors on financial factors. Besides, this Research will be continued in the "sustainability- harmonic" point of view: can be sustainability balanced or can be harmonic growth sustainable? Especially noteworthy is to continue this research concerning environmental and energy sustainable factors.

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