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Cenological Measurement of Productive Efficiency

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Abstract:

The article shows the big concern that is caused by the problem of spatial economical and industrial bias. The decision of the given problem by classical methods did not bring the required result testifying that such politics is based on wrong or inadequate diagnosis of the bias reason, as well as the lack of qualitative search of benchmarking target state.

The authors offer to consider a spatial and industrial bias not only as economically inefficient, but also non-equilibrium result of regulation politics. Thus, the balance can be considered as some economically-effective recombination of subjects of regional economy or branch enterprises.

It is shown that the proposed approach does not reflect the system features of real objects (region, branch etc.) to full extent as it uses a mechanical statistical combination theory, without considering the features of considered systems, being oriented to the model which is not achievable in practice.

The given downside is offered to eliminate by applying coenosis theory which uses laws of existence and development of complex systems (type "branch", "region" etc.), relying on numerous researches in various fields of knowledge. The opportunity to calculate and to generate a specified distribution option allows to use it as the starting point of recombination for more accurate definition of potential-efficiency of the structure of a branch.

Keywords: *Group efficiency, Resources allocation, coenoses, equilibrium of systems.*

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1. Introduction

The growth of "new spatial economy" has undermined classical explanations of regional and industrial economic development disparity and emphasized the importance of external state or regional influence on this problem. Nevertheless, many specialists caution against the practice of centralized planning and suggest using balance techniques based on self-organization. The response of different branch enterprises to the problem of keeping the sustainability caused by growing internal and external changes, such as, legislative standard pressure, toughening social and ecological responsibility, dynamics of expenditures factors, inside and interspecific competition, difficulties with personnel, has recently turned into some agreed self-organized form which requires an external control (Podsakoff, 2003; Phan, 2015).

In modern scientific practice this approach is considered as "pro-active sustainability strategy" based on ensuring the efficient resource management, the increase of its value, waste and emission reduction, the formation of public image, the improvement of consumer preferences, the creation of innovative capabilities (Figge, 2002; Bhupendra, 2015).

However, despite the growing interest and suggested profits from implementing this strategy, scientific literature does not reveal main factors and processes of such form of management to full extent, particularly on the regional and branch levels. This research studies the issue how the models of proactive management of sustainability, providing more rational resources allocation within aggregate enterprises with the features of economic coenosis, can be formed, relying on some objective laws. The specified assumption presumes some external single controlling centre which is presented by specific state authorities, such as a parent holding company, regional and federal Ministries, other government agencies which can have influence on forming the required industrial structure at the expense of the representation, for example, preferences for some enterprises.

The scarcity of research and methods in this area is complicated by the lack of management tools of the structure, the orientation of existing industrial management technologies to local structural value (standardization), the lack of simple methods of evaluating the efficiency of enterprise allocation in industries.

2. The synergistic effect of sectoral structural recombination

In the research based on the results of content generalization of the sustainable development theory by Crutzen and Herzig (Crutzen, 2013), as well as the resource approach suggested by Chan at the end of 2000s we put forth a theory on the presence of the interaction between unsustainable enterprises of the branch and downsides of the industrial structure which form is a result of unequal spontaneous redistribution of common scarce resources (Chan, 2005; Hart, 2011). These intersectoral and intercorporate structural recombination ensure both sustainability and economic efficiency of the whole industrial structure of enterprises.

In economics firms are often considered as entities for which economic effect is predetermined by the capability to achieve goals with minimum costs (Chuprov, 2012). In the context of the population of enterprises Farrell suggests considering structural industrial efficiency as the form of aggregate efficiency of firms presenting a branch or a holding, which is estimated by volume-weighted average individual effect and explained as following: *"... two firms taken individually, efficient each separately are inefficient in their cooperation"* (Farrell, 1957).

This concept was developed by Forsund and Hjalmarsson (1979), who suggested assessing industrial efficiency through "technical efficiency of a medium firm" with the help of parametric resource production ratio with updating on actual output. For that reason, Li and Ng's (1995) scientific approach is of great interest as they analyze industries oriented to achieve technical efficiency where resource allocation on inputs is equal to the level of used production technologies. Particularly, they demonstrate that structural efficiency of an industry on the population of input and output technologies can be used as the equivalent of technical efficiency of average entity-enterprise.

In this research we base on the concept of industrial economic efficiency presented in Nesterenko and Zelenyuk's (2007) works using specific parameterization where product prices are presented by an exogenic factor without reflecting resources use efficiency by a separate enterprise. In their model the industrial efficiency represents varied value of individual and group profitability of enterprises which range leads to different structural recombination.

In our opinion, the stated concept of technical efficiency of centralized resources allocation is of great practical application in modern economic conditions since it allows to manage the efficiency of an industry (holding) using point local impact on single branch enterprises and providing aggregate synergetic effect. The authors claim that the most significant unsolved scientific task is to define weight and structural correlation of branch enterprises. Therefore, to solve this problem, Nesterenko and Zelenyuk (2007) model will be used and updated taking into account general structural coenosis patterns.

3. The basic model for assessing the effect of sectoral structural recombination

We will conduct preliminary task formalization. Introducing designations, we receive *n* observations indexed on parameter *j* used as *m*-resource on the input x_{ij}(i=1..., m) to produce *s* products on output y_{rj}(1, ..., s). The observable input and output vectors $x_j=(x_{1j}, ..., x_{mj})' \geq 0$ and $y_j=(y_{1j}, ..., y_{sj})' \geq 0$, respectively, where the prime represents operation recombination.

Individual productive efficiency can be expressed by formula (1):

$$T = \left\{(x, y) \middle| \sum_{j-1}^{n} \lambda_j x_j \leq x, \sum_{j-1}^{n} \lambda_j y_j \leq y, \sum_{j-1}^{n} \lambda_j = 1, \lambda_j \geq 0, j \in J \right\} \quad (1)$$

where λ – vector, n×1 with components, equal λ_j and J={1 … n}. Observable input and output vectors in industry $X_0 \equiv \sum_{j-1}^{n} x_j$ and $Y_0 \equiv \sum_{j-1}^{n} y_j$ respectively. Therefore, industrial efficiency T^{IND} represents the amount of individual efficiency set

$$T^{IND} = \sum nT \quad (2)$$

as a result of summing up similar convex sets.

It is obvious that redistribution of production volume depending on the productivity will lead to raising total industrial efficiency that can be provided only due to the centralized management.

As to input prices we suggest every enterprise to address to the same exogenic vector $p = (p_1, \dots, p_m) > 0$, since the situation is quite natural for modern economy. Taking into account this assumption one can note that Koopmans showed that the existing price homogeneity among manufacturers is a necessary and sufficient condition for the efficiency according to Pareto (Koopmans, 1957).

Therefore, there is admitted the presence of some economically efficient structure of a branch described by the form of production capabilities combinations $(x_h, y_h) \in T, h = 1, \dots, k$, which minimizes the total cost of industrial output vector Y_0.

As it is noted in Cesaroni's works every firm is able to produce goods mostly within the given output vector (Cesaroni, 2015), but it is impossible to use the model of linear programming for simulation optimization due to the bugle of output requirements curve. It means that the bugle of curve of technological efficiency distribution causes the sole invariant of optimum scale, which can be determined in the context of the most effective distribution of input resource estimated, for example, within the frames of production profitability. Consequently, it is necessary to use an approach providing the imposition of probabilities spaces supplying the required level of the reliability.

In their works, Nesterenko and Zelenyuk (2007) consider general potential efficiency of a branch (potential efficiency of branch profits) from two points: as structural efficiency of the revenue and efficiency of profit redistribution. The first component –weighted average measure defined by Fäare and Zelenyuk (2014) does not assume an external impact on resources redistribution. The second component defines revenue changes due to productivity management at expense of artificial resource redistribution on all enterprises and serves as the connection between group measures: potential and structural efficiency.

Considering the given assumption, we suppose that the task of controlling structure becomes the task of maximization of individual incomes at the expense of redistribution of suboptimal income. We emphasize that any aggregation gives the researcher a complete picture of group inefficiency only if it is impossible to redistribute resources in this group that is apart from working units in accordance with the context. Due to this fact, in this research the idea of the necessity to introduce measure "potential efficiency of enterprises group" is supported and can be a criterion for identifying the sustainability of enterprises system in a whole.

The feature of Nesterenko and Zelenyuk's (2007) model is that there prevail variations and random variables, for instance, (Xi, Yi, Zi), for i = 1,…, n, where $Xi \in R^p$ - inputs, $Zi \in R^d$ represents a range of heterogeneous conditions (it can be environmental or standard conditions which are not initial in common sense but they can influence production process and are controlled by a manufacturer) and $Y_i \in R$ - output, that can be received. They present collaborative *pdf* (X, Z, Y) as united marginal result for (X, Z) and conventional *pdf* for Y of given (X, Z). Conventional Y where X = *x* and Z = *z* is characterized by formula (3):

$$Y = m(x, z) - U + V, \tag{3}$$

where m (x, z) – production frontier, $U \mid X = x, Z = z \sim D + (\mu_U (x, z), var_U (x, z))$ *c* $D + (\cdot,)$ - positive random variable with average $\mu_U (\cdot,\cdot)$ and dispersion $var_U (\cdot,)$ *u* $V \mid X = x, Z = z \sim D (0, var_V (x, z))$, где $D (0,\cdot)$ - real random variable with average and dispersion $var_V (\cdot,)$. It is suggested that conditionally *(X, Z), U* and *V* are independent random variables where *V* has symmetric distribution around zero, and *U* is a positive random variable, whose asymmetry is reflected on the efficiency of the considering set.

As in parameterized models, value *Y* is adjusted by some possible inefficiency of the level *U* and some statistical noise *V*. Two components *U* and *V* are unobservable random variables which can vary depending on input data *X*, as well as variable *Z*. Private and very common case, when variable *Z* do not influence the technology, but only the inefficiency or noise corresponds to so called "condition of separability" (Simar, 2010). Unlike parameterized approaches, it is supposed that the production frontier m (•,•) is entirely unknown to the researcher. The wider objective of the evaluation is in getting information about the production technology (scale elasticity, marginal productivity of inputs etc.) and inefficiency (whether it is present and as it relates to various factors among (x, z), taking into account some primary standard:

$$Sn = \{(Xi, Zi, Yi) \mid i = 1,. , , , n\}. \tag{4}$$

As seen from the simulation logic a significant number of results is defined by the simple method of statistical enumeration therefore this classical, entirely parameterized, homoscedastic installation SFA is, in our opinion, a good starting point for researches, but it can be very limited, imposing such form of industrial structure which is impossible to check in practice. In this work, we show the application as the basic form of industrial structure of enterprises distribution on canonical (potential) form of coenosis distribution that is defined due to the result of revealing the approximate form of ranked representation of observable results of branch enterprises such as production volume, income and so forth as:

$$f(R, w1, \beta) = \frac{w1}{R^{\beta}} \qquad (5)$$

where – R- number of ranks (in this case – branch enterprises), w_1 – volume value of enterprise production of 1st maximum rank (for instance, profitability for a period), β – characteristic measure (Kuz'minov, 2017).

Every enterprise is classified under qualitative features in the form of ordered sample:

$$\{W^{ent}_1, W^{ent}_2, W^{ent}_3, \dots W^{ent}_i, \dots, W^{ent}_n\}, \qquad (6)$$

where W^{ent}_i – production volume of i-enterprise for a year (thousands of euro), ent_i – the identifier of registration of the enterprise in sample, i- number of objects in a sample, n – total number of branch enterprises.

The procedure of ranking within each time interval allows to order the branch enterprises on increase of their output and to rank each of them. At the same time, two-dimensional matrix turns out, from which for single time interval it is possible to make an ordered sample of the production values (vector of ranked parameterized distribution) (Gnatyuk, 2017).

4. Concept of coenosis potential of industrial efficiency

The fundamental feature of coenosis analysis and management (standardization) is the possibility to interpret mathematically elements distribution of coenosis- industry and to estimate approximate curve that reflects its more optimal invariant (Kudrin, 2006; Kuzminov, 2009).

The system potential of industrial economic efficiency is the received absolute difference on designed time dimension between enterprises performance (mln euros) without implementing management procedures, on the one hand, and the performance to the appropriate upper bound of variable confidence interval, on the other hand. The production volume of industry-coenosis is calculated as the integral within limits of zero ad infinitum under the appropriate curve of ranked parameterized distribution. Furthermore, either curve received for empirical values of enterprise production, or upper bound of variable confidence interval is taken as calculated one. The calculated time interval is defined, on the one hand, by the level of the production database in the past, on which basis variable confidence interval is designed, and, on the other hand, by the required horizon of potential simulation in future.

The crucial distinction of this approach from the traditional one should be noted since production potential is understood as the sum of differences received by every single enterprise and existing production and some hypothetic value that might be if some best indexes of efficiency were implemented in it. Moreover, none of available scientific literature reveals the following key issues: firstly, on what basis the conclusion is made that the potential of the industry-coenosis possesses the feature of additivity, i.e. it can be calculated as the amount of the potentials of separate enterprises; secondly, from where it is supposed to take and how to interpret these "best indexes of efficiency"; thirdly, how the degree of availability of the best efficiency indexes for each particular enterprise is taken into account; fourthly, where there is a maximum limit of production.

Therefore, the potential efficiency of the specified industry-coenosis is a calculated value of ranked indexes of approximate curve of upper value of its confidence interval regarding its actual condition for the observable period. It is presented as:

$$\Delta W_1 = \int W(r)dr - \int W_1(r)dr \qquad (7)$$

where ΔW_1- efficiency potential of industry coenosis; W(r) – approximate curve received for actual values of enterprise-coenosis production; $W_1(r)$ – upper limit of variable confidence interval received due to data processing; r – rank of enterprise.

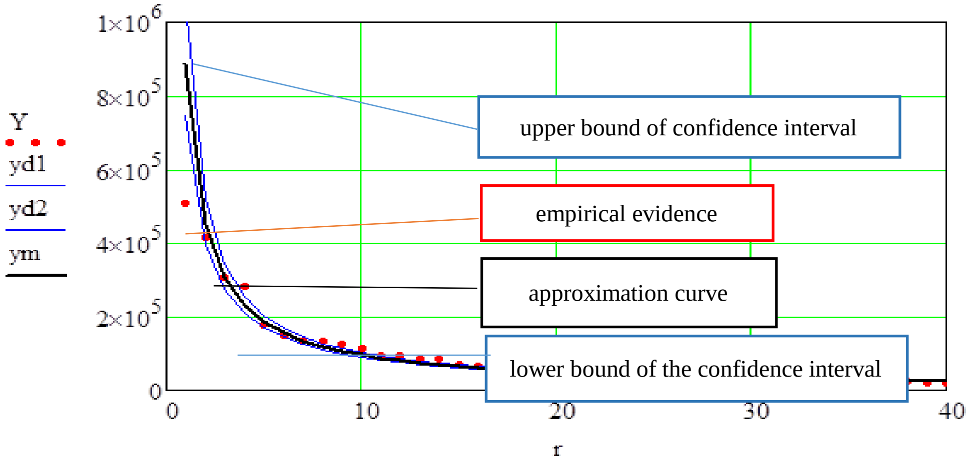
Thus, defining the coenosis potential of industrial efficiency is more accurate procedure of optimal management of industry-coenosis performance that includes identifying an integral amount of product issues, on which value the production without damage to its normal functioning should be increased on this specified time interval.

5. Results

As an example, we provide the results of analyzed economic efficiency potential of power-industry –coenosis in Rostov region, Russia for 2017 (thous, kw/h), ranked on decrease. As a result of statistical analysis on technique (Kuz'minov 2017; 2018) the following curve of total ranked parameterized distribution in linear axes was received (Figure 1).

The enterprise distribution on production volume criterion is presented by points, which demonstrate different efficiency of enterprises performance that gives the form of hyperbolic distribution ranked on the decrease of the parameter. The distribution approximation forms the basic value for calculating confidence interval of maximum and minimum values of the efficiency of separate enterprises from the point of the common coenosis stability.

Figure 1. *Hyperbolic distribution of enterprises output of power sector in Rostov region, Russia for 2017 (thousand Kwt. /h), where realization volume for a year is presented to ordinates axis, enterprise place ranked on decrease - to abscissas axis*[5].



Therefore, for each enterprise the target value of production parameters can be set (upper curve of confidence interval). It corresponds to more realistic forecast of economic growth for this system. Intergroup redistribution also provides the achievement of probable value of industrial group efficiency. Approved in a number of researches, this assumption relies on the features of large-scale systems of coenosis type, to which the industry is related. It includes the ideal theoretic form of distribution, laws of its dynamics reflecting some optimal distribution of aggregate scarce resource (Kuzminov, 2018).

The result of assessing the effects of reallocation in Nesterenko-Zelenyuk's (2007) model for this sample showed the increase in the value of group technical efficiency of income redistribution from power production in relation to the basic value by 4% (1,156/1,110). The scheme of value distribution taking into account coenosis efficiency potential accounted for 6,5% (1,182/1,110), that indicates more accurate assessment of the potential.

The stated forecast efficiency of such approach is predetermined by the fact that the probability of possible conditions space acquires the fixed pattern related to every object of industry- coenosis that raises the assessment quality of utility function of managerial decision:

$$\rho_k^{ft}(u,v) = \iint_0^{\infty} \rho(u,v)\rho\,(u,v)dudv, \qquad (8)$$

[5] *Designed by the authors based on the data of MRSKS, 2018.*

where $\rho_k^{ft}(u, v)$- expected utility of managing external impact on the structure of an industry, $\iint_0^{\infty} \rho(u, v)\rho$- integral utility function; $\rho(u, v)$ – values probability function u and v.

Such task can be classified as a step task of dynamic programming with fixed right and left ends of trajectory (fixed left end – approximate curve, fixed right end – upper bound of confidence interval in Figure 1). This task is solved by variable methods using the principle of Bellman's optimality.

Therefore, Nesterenko-Zelenyuk's (2007) model can be improved with the help of coenosis analysis presenting a system-objective invariant of coenosis development at expense of formalizing more probable form of enterprises distribution taking into account potential efficiency of external impact performance.

6. Conclusion

Our approach can be considered as a semi-parameterized version of method "modified OSL" in parametric settings defined from the point of structural coenosis stability and equation. We claim that local asymmetry of branch enterprises distribution can be identified, and it forms economic inefficiency. These assumptions provide more reliable estimates than those received with the help of approaches using methods of credibility, variation etc.

Thus, the unification of classical coenosis toolkit and parameterized analysis of efficiency allows to receive an approach, free from assumptions of technological boundary enabling to calculate a valid deviation of the values, unlike statistical noise, and to define the level of local inefficiency which influences economic benefit of all branch-coenosis. The results of assessment received with the use of coenosis toolkit and graphic presentation for illustrating real data are quite interesting and understandable since they reveal the information that is not obvious without appropriate assessment.

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