Model for assessing and implementing resource-efficient strategy of industry

Nadiia Shmygol[1[0000-0001-5932-6580]], Francesco Schiavone[2[0000-0001-9219-6714]], Olena Trokhymets[3[0000-0001-7587-7948]], Dariusz Pawliszczy[4[0000-0003-1328-7891]], Viktor Koval[5[0000-0003-2562-4373]], Ruslan Zavgorodniy[3[0000-0002-6137-1310]] and Andrii Vorfolomeiev[6[0000-0001-5789-5149]]

[1] National University "Zaporizhzhia Polytehnic", 64 Zhukovsky Str., Zaporizhzhia, 69063, Ukraine
[2] Parthenope University of Naples, 38 Via Ammiraglio Ferdinando Acton, 80133 Napoli, Italy
[3] Classic Private University, 70B Zhukovsky Str., Zaporizhzhia, 69602, Ukraine
[4] Gromadka Commune Office, 9 General Wł. Sikorskiy Str., Gromadka, 59-706, Poland
[5] Kyiv National University of Trade and Economics, 19 Kyoto Str., Kyiv, 02156, Ukraine
[6] National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", 37 Peremohy Ave., Kyiv, 03056, Ukraine
nadezdash@ua.fm

Abstract. The authors of the article determined that a number of scientists were involved in the development of a balanced system of indicators of the development of the oil and gas sector. Though an urgent scientific problem that needs further consideration is the development of a model of resource efficiency diagnostics in the oil and gas sector of the economy of Ukraine, taking into account the peculiarities of statistical monitoring. The scientific novelty of the paper is: this study improved the model of diagnostics of resource efficiency in oil and gas sector in the economy of Ukraine based on the additive-multiplicative compression of the formed system, which, unlike the existing ones, takes into account their variation while defining weighting coefficients which show the experts' system of preferences. It is reasonable to use the proposed model at the further economic assessment of the consequences of realization of resource-efficient strategy at enterprises of the oil and gas sector of the economy of Ukraine.

Keywords: resource-efficient strategy, oil and gas complex, model of assessment.

1 Introduction

The concept of resource efficiency in the modern and current practice of economic activity analysis has been widespread, since the efficient consumption of economic resources of any kind is associated, first of all, with intensive economic growth. That is why a lot of scientists addressed the issues of ensuring a resource-efficient economy as a necessary condition for sustainable development. According to 2018 the oil and gas sector of Ukraine provided more than 40% of the economy's needs for energy resources. At the same time oil and gas sector accounted for 42.2% of total consumption. Due to high dependency, the research of many domestic scientists is devoted to various aspects of the operation of oil and gas extraction and processing enterprises.

2 Actual scientific researches and issues analysis and the research objective

Management of any economic system is always based on its current state, the definition of which is a separate scientific task. The main tendencies of development and value of innovative technologies in the oil and gas sector were studied by foreign scientists, the following scientists are among them: Adi Karev [8], Konstantin N. Milovidov [12] and others. Various scientists were involved in the methodological bases of economic diagnostics, including the development of a balanced system of indicators for the development of the oil and gas sector, including Inesa Khvostina [9], T. F. Mantserova [10], Dani Rodrik [18], O. A. Tolpegina [26] and others.

This demonstrates that the scientific problem that needs to be solved in the framework of this research is the development of a model of resource efficiency diagnostics in the oil and gas sector of the economy of Ukraine, taking into account the existing peculiarities of statistical monitoring by the State statistical authorities.

The methods of economic analysis for estimation of resource efficiency, normalization method for bringing indicators to comparative appearance, method of additive-multiplicative convolution (compression) for generalization of results in different directions of evaluation, statistical methods of estimation of variation for substantiation of values of weight coefficients in the model of diagnostics were used.

3 Tools and models for effective development of resource efficiency in the oil and gas sector of Ukraine

In order to develop action for effective development of the resource-efficiency in the oil and gas sector of Ukraine we use the following [6; 25]:

- a system of indicators for assessing the resource efficiency of the oil and gas sector. Taking into account peculiarities of the measurement of the studied object by the State Statistics Service of Ukraine, the effective development of resource efficiency in any field of activity requires consideration in the analysis of all types of economic resources: raw materials, fixed assets, labor resources, total capital (aggregate capital);
- a model of the index of resource efficiency IRE based on the additive-multiplicative convolution (compression). Convolution of indicators is carried out by weighing their normalized o standard values on the basis of an agreed system of expert preferences. In this case, it is believed that individual indicators with equal

level of influence on the group should have the same values of the root-mean-square deviates;
- intersectoral comparative analysis of resource intensity (resource capacity) and structure of added value in the oil and gas sector. The need for this analysis is due to the fact that to diagnose the current state and efficiency of the enterprises' activity, it is appropriate to use the relevant base of comparison in economic analysis;
- scenario analysis of price equilibrium in oil and gas sector with the help of intersectoral Leontiev's model. It allows not only to perform appropriate calculations, but also to find out how these changes affect resource efficiency, including by changing the ratios of direct costs, intermediate consumption, added value and gross profit;
- assessment of the consequences of resource efficiency based on the IRE model. This allows getting recommendations on areas and mechanisms to ensure resource efficiency in the production and processing of oil and gas.

The peculiarities of the measurement of resource efficiency in oil and gas sector of economy of Ukraine include:

1. The available volume of input statistics on the basis of the State Statistics Service of Ukraine reports, with free access, significantly limits the possibilities for comprehensive assessment of the resource efficiency by all types of economic resources used in public production;
2. The change in methodology of organization of statistical observation during the recent years, and, accordingly, reporting instruments and documentation do not allow to carry out a retrospective analysis of resource efficiency indicators over a long-term period. The geopolitical changes that occurred in 2014 in the South-East of Ukraine resulted in temporary occupation of the Crimea and parts of Donetsk and Luhansk Regions, have undoubtedly had a significant impact on the oil and gas sector activity as well. That is why comparative analysis of the time periods cannot provide with objective information on the dynamics of the target indicators due to alterations in the special aggregate according to which they are calculated;
3. Some of the input data for 2016-2018 are not shown in the State Statistic Service reports due to its confidential status. First of all, it concerns assets conditions, volume of production and corresponding costs, fixed assets and a number of employees, financial results of crude oil production, natural gas extraction and production of refine products [6; 25].
4. Any diagnostics in economic analysis is possible if there is a respective base of comparisons. In scoring models of diagnostics such a turning point are the classes of indicators stability; in the models of multiplicative discriminant analysis – the intervals of stability of integral index that determine the probability of the bankruptcy of economic entities; in the express-analysis – industry standards and cross-industry comparisons; in complex analysis – dynamics and plan value of indicators, industry standards etc. As for the oil and gas sector of the economy, for the diagnostics of its resource efficiency considering available data, we will use

cross-industry comparison and analysis of time periods applying methods of statistic theory.

4 The model of resource efficiency in oil and gas sector of economy of Ukraine diagnostics

Thus, taking into account the leading experience of analysis of economic activity [1; 14; 15; 21; 22; 24; 28] and mentioned above peculiarities of information support, a model of diagnostics of resource efficiency of oil and gas sector of the economy of Ukraine has a set of indicators as its basis, which consist of the following areas of assessment: material resources, fixed assets, labor resources and aggregate capital. Let's consider them in more detail.

1. Material resources (MR_1). Technological underdevelopment (backwardness), associated with initial processing of resources, is always characterized by low added value and high material (output) ratio. That is why effective use of material resources is the priority in the development not only of oil and gas sector, but of the economy of Ukraine. This group consists of the following indicators:

– material productivity (K_{11}) – characterizes the volume of output of the inquiry period by 1 UAH of material costs. This indicator should be maximized and is calculated by the formula:

$$K_{11} = \frac{VO_1}{MC_1}, \tag{1}$$

where VO_1, MC_1 – accordingly, volume of output and material costs in the inquiry period.

– net profit (income) for 1 UAH of material costs (K_{12}), should be maximized. According to its economic essence, this indicator is the analogue of cost effectiveness (profitability), which allows to evaluate the efficiency of raw materials and supplies in the process of profit generation in the enterprises of the industry:

$$K_{12} = \frac{NP_1}{MC_1}, \tag{2}$$

where NP_1 – net profit in the inquiry period.

– coefficient of correlation of the growth rate of product output and material costs (K_{13}). Intensive economic development involves obtaining the final result not due to the greater consumption of resource productivity. That is why this coefficient should be $K_{13} > 1$.

$$K_{13} = \frac{VPO_1}{VPO_0} : \frac{MC_1}{MC_0}, \tag{3}$$

where VPO_0, MC_0 – accordingly, volume of product output and material costs in base period.

- the share of material costs in the cost of production (K_{14}). According to 2018, material costs for the economy in general were 74.3% from the cumulative costs (total costs) for production output. Accordingly, depreciation accounted for 6.7%, labor costs – 14.1%, benefits related deduction – 2.9%, and other costs – 2.0% from cumulative costs (total costs).

As we can see, the high share of material costs – is a system problem for the entire economy of Ukraine. It indicates not only the low level of social production, but also hinders increase in wages and living standards of the population. That is why this indicator should be minimized and calculated by the formula:

$$K_{14} = \frac{MC_1}{VCCP_1}, \quad (4)$$

where $VCCP_1$ – volume of cumulative costs (total costs) for production in the inquiry period.

The main production factors which are part of economic resources, are fixed assets and labor resources (human capital). In most cases they determine the production capacity of business entities and industries of the economy in general.

According to the results of 2018, the residual value of fixed assets in Ukraine was 3783.5 billion UAH, and the volume of production – 6207.7 billion UAH. Accordingly, return on assets was 1.64 UAH. The number of employed population for the same period was 16360.9 thousand persons. Thus, the annual labor productivity was 379.4 thousand UAH per employee or 31.6 thousand UAH monthly.

Thus, complex diagnostics of the resource efficiency of oil and gas sector should include comparative assessment in these areas.

2. Fixed assets (K_2). This group includes the following indicators:

- return on assets (K_{21}) – characterizes the volume of production output for the inquiry period at the rate of 1 UAH of residual value of fixed assets, and should be maximized:

$$K_{21} = \frac{VO_1}{FA_1}, \quad (5)$$

where FA_1 – the value of fixed assets in the inquiry period.

- return on assets (K_{22}) – equals the net profit on 1 UAH of residual value of fixed assets, and it should be maximized:

$$K_{22} = \frac{NP_1}{FA_1}, \quad (6)$$

- coefficient of correlation of the growth rate of product output and fixed assets costs (K_{23}). Intensive development implies an increase in aggregate production output not at the expense of additional production capacity attraction, but due to the return on assets increase. That is why this coefficient should have the inequality $K_{23} > 1$.

$$K_{23} = \frac{VO_1}{VO_0} : \frac{FA_1}{FA_0}, \quad (7)$$

where FA_0 – residual value of fixed assets in base period.

3. Labor resources (K_3). The indicators of resource efficiency of this group include:

– labor productivity (K_{31}) – characterizes the production output for the inquiry period per one employee and should be maximized:

$$K_{31} = \frac{VO_1}{AAEP_1}, \quad (8)$$

where $AAEP_1$ – average annual number of employed population in the inquiry period.

– ROI of employees (K_{32}) – equals net profit per one employee, and should be maximized:

$$K_{32} = \frac{NP_1}{AAEP_1}, \quad (9)$$

– share of labor costs in the cost of production (K_{33}). According to statistics, in most of Eurozone countries this indicator is 30-35%, which is more than 2 times ahead of the similar level of the economy of Ukraine. That is why one of the reserves for the growth of the average level of remuneration of labor is adjustment of the production cost structure, and should be maximized K_{33}:

$$K_{33} = \frac{RL_1}{VCCP_1}, \quad (10)$$

where RL_1 – amount of remuneration of labor cost in the inquiry period.

Aggregate capital is generated from both equity and borrowed sources and is allocated to fixed assets and current assets and is also an economic resource and a focus of the researches interest in terms of its effective use.

4. Aggregate capital (total capital) (K_4). In order to characterize the efficiency of capital use, in the practice of financial analysis, along with profitability indicators, indicators of turnover and duration of turnover are calculated. Let's consider them in more detail.

– aggregate capital (total capital) turnover (K_{41}) – shows how many the income of the inquiry period exceeds the corresponding amount of the raised total capital The increase in turnover shows an increase of its use:

$$K_{41} = \frac{CI_1}{CK_1}, \quad (11)$$

where CI_1 – cumulative income of the inquiry period from all types of economic activity; CK_1 – average annual amount of capital of the inquiry period, taking into account own and borrowed sources of income.

- return on aggregate capital (total capital) (K_{42}). Any borrowed capital, involved in the activity of business entities, has its price. The condition of the expediency of its use is always the excess of return on aggregate capital (total capital) over the weighted average price of the loan. Otherwise, according to financial leverage effect, economic activity will lead to a gradual decrease in equity.

$$K_{42} = \frac{BP_1}{CK_1}, \tag{12}$$

where BP_1 – balance (gross) profit of the inquiry period, excluding income tax.

- duration of circulation of aggregate (total) capital (K_{43}) – shows how many days it will take for the income received during economic activity to be equal to the amount of attracted aggregate (total) capital Speeding up the turnover means reduction of the duration of circulation and vice versa. The formula for K_{43} calculation is the following:

$$K_{43} = \frac{365}{K_{41}}, \tag{13}$$

In the numerator, in this case, there is a number of days for the inquiry period.

Fixed assets form production capacity of the economic entities and do not directly participate in the circulation. The efficiency of the use of aggregate (total) capital is directly influenced by the turnover of the operating capital according to the formula:

$$K_{44} = \frac{CI_1}{OC_1}, \tag{14}$$

where OC_1 – average annual amount of the operating capital in the inquiry period.

- duration of operation capital turnover (K_{45}) – shows how many days it will take for the received income to be equal to the amount of operating capital and is calculated by the formula:

$$K_{45} = K_{43} \times \frac{OC_1}{CK_1}, \tag{15}$$

Thus, we have formed a system of indicators for assessing the resource efficiency of oil and gas sector of the economy of Ukraine taking into account available statistics. Taking into account that all the indicators are relative indicators we will use cross-industry comparisons for diagnostics of its condition.

By direct comparison we have an opportunity to define competitive advantages or backlog of the oil and gas sector by every indicator. However, summarizing the results of such multifactor evaluation requires the corresponding compression based on the integrated index. For this reason, first of all, it is necessary to bring the value of all indicator of resource efficiency to one base of comparison, which means to normalize them. The current practice of rationing involves setting up values to the range [0, 1] using formula:

$$K' = \frac{K - K_w}{K_b - K_w}, \tag{16}$$

where K, K' – accordingly, input and normalized value of resource efficiency indicator, which belong to i group; K_w, K_b – accordingly, the worst and the best value of the indicator K, among other industries.

Since there are some indicators that should be maximized as well as minimized, then to determine the worst indicators K_w and the best indicators K_b we should follow the rule:

- if K should be maximized, then $K_b = max(K)$, $K_w = min(K)$;
- if K should be minimized, then $K_b = min(K)$, $K_w = max(K)$.

The use of formula (16), observing the rule, allows to arrange the normalized values of indicators in such a way that the best value of indicator corresponds with the normalized and vice versa.

With its help, each of the indicators (1) - (15) is reduced to a comparative form. The compression of normalized values to group and integral indexes is based on the additive-multiplicative model:

$$IPE = \sum_{i=1}^{n}(a_i \times K_i),\ K_i = \sum_{j=1}^{m_i}\left(a_{ij} \times K'_{ij}\right) \tag{17}$$

for all $i = 1...n$, where IPE – integral index of resource efficiency; K_i, a_i – accordingly, summary (consolidated) index of resource efficiency of i group and its weighing coefficient; K'_{ij}, a_{ij} – accordingly, normalized j indicator of i group and its weighing coefficient; n – a number of indicator groups; m_i – a number of indicators of i group.

There are certain limitations for weighing coefficients a_i and a_{ij}. First of all, their values should range from 0 to 1; second of all, the sum of coefficients of a certain group should equal 1.

Considering the mentioned above information, we have obtained a system of equations using numerical method for diagnostics of resource efficiency in oil and gas sector in the economy of Ukraine, taking into account equal influence of indicators, which allowed presenting a more detailed equation (18):

$$\begin{gathered} IPE = 0.328K_1 + 0.261K_2 + 0.244K_3 + 0.167K_4, \\ K_1 = 0.162K_{11} + 0.267K_{12} + 0.452K_{13} + 0.119K_{14}, \\ K_2 = 0.325K_{21} + 0.318K_{22} + 0.358K_{23}, \\ K_3 = 0.290K_{31} + 0.354K_{32} + 0.356K_{33}, \\ K_4 = 0.183K_{41} + 0.241K_{42} + 0.191K_{43} + 0.210K_{44} + 0.174K_{45}. \end{gathered} \tag{18}$$

5 Diagnosis of resource efficiency of the oil and gas sector of Ukraine taking into account the opinions of experts

If, according to the experts' preferences, individual indicators should influence differently on the group or integral index of resource efficiency, this also should be reflected in the proportions between root-mean-square deviants of such indicators considering corrective weighing coefficients.

In this case, there is a need for quantitative coordination of expert judgments, based on qualitative initial assessments. Therefore, the sequence of actions, taking into account the theory of decision-making, should be the following [24]:

1. Each of the experts, based on their personal system of preferences, organizes the sequence of evaluation of the components of the index of resource efficiency according to their importance.
2. On the basis of individual rankings of the experts, with the help of the methods of arithmetic mean ranks calculation of the generalized group ranking is carried out.
3. Verification of the consistency of the results of individual assessments of experts is performed using the variance (dispersion) coefficient of concordance.
4. If at the previous stage the verification was successfully passed, on the basis of application of procedure of pair comparison for each direction of an estimation of an index of resource efficiency, the calculation of correction factors is carried out. If the concordance coefficient indicates a high inconsistency of experts' opinions, the procedure for adjusting the parameters of equations (18) should be interrupted to find out the reasons for such inconsistency.
5. Based on the calculation of the correcting coefficients, the parameters of equations (18) are changed in order to consider the agreed and confirmed experts' opinion on the importance of areas for assessing the components of resource efficiency.

Methodical support of the planned sequence of actions should be considered in more detail. In particular, in order to decide on the correction of the parameters of equations (18), according the experts' estimation, the following are used: the method of arithmetic mean ranks, the variance (dispersion) coefficient of concordance and the method of pairwise comparison [24; 27].

To apply the arithmetic mean method, each of the experts makes individual rankings regarding the weight of the factors that affect the target coefficient. Moreover, the most important factors have the lowest rank and vice versa. Let's indicate the corresponding set of matrixes as following:

$$[r_{is}]_{\ md},\ \left(s = \overline{1, d}\ ;\ i = \overline{1, m}\right), \qquad (19)$$

where m – the number of factors by which the expert assessment is conducted; d – the number of experts; r_{is} – the ranks of the i factor, which was given by the s expert.

Next, for each factor, the sum of the ranks assigned by the experts is calculated and divided by their number. Thus, the arithmetic mean simple is calculated. The weighted average can be used if the experts have different levels of competence.

Generalized group ranking $[R_i]_m$ is obtained on the basis of the calculated arithmetic means.

A measure of consistency of the experts' estimations is the variance (dispersion) coefficient of concordance *W*. Depending on the nature of the input data, its calculation is carried out as following:

— if individual expert assessments do not contain related ranks:

$$W = \frac{12}{d^2(m^3-m)} \times S, \tag{20}$$

$$S = \sum_{i=1}^{m}(\sum_{s=1}^{d} r_{is} - \overline{r})^2, \tag{21}$$

$$\overline{r} = \frac{1}{m}\sum_{i=1}^{m}\sum_{s=1}^{d} r_{is}, \tag{22}$$

— if individual expert assessments contain related ranks:

$$W = \frac{12S}{d^2(m^3-m)-d\sum_{s=1}^{d} T_s}, \tag{23}$$

$$T_s = \sum_{k=1}^{H_s}\left(h_k^3 - h_k\right), \tag{24}$$

where T_s – indicator of the related ranks of the *s* expert; H_s – the number of groups of equal rank in the assessment of the *s* expert; h_k – the number of ranks equal to each other of the *k* group of related ranks of the s expert.

It's necessary to mention, that the formula (20) is a partial or a finite case (23). If the expert assessemnts do not contain related ranks, then we will have: $H_s = 0$; $h_k = 0$; $T_s = 0$. Accordingly, (23) is transformed into (20).

The variance (dispersion) coefficient of concordance changes within $0 \le W \le 1$. If *W*=1, then all individual rankings of experts are similar to each other and vice versa. The following scale is used to interpret its values: $W \in [0, 0.3]$ – the level of consistency of expert assessments is very weak; $W \in [0.3, 0.5)$ – weak; $W \in [0.5, 0.7)$ – average (moderate, medium); $W \in [0.7, 0.9)$ – high; $W \in [0.9, 1]$ – very high.

High inconsistency of experts assessments, if $W < 0.7$, it may indicate a low level of competence of individual members of the group, or a low awareness of this issue. In this case, after additional study of the problem situation, it is necessary to repeat the expert survey (questionary).

We use the method of pairwise comparison to define adjusted coefficients on the basis of a generalized group ranking $[R_i]_m$ in the case if $W \ge 0.7$. The elements of the matrix of pairwise comparisons s$C = \left[C_{ij}\right]_{mm}$ are determined on the basis of the rule:

$$\begin{cases} C_{ij} = 2, & if \quad R_i \succ R_j \\ C_{ij} = 1, & if \quad R_i \approx R_j, \\ C_{ij} = 0, & if \quad R_i \prec R_j \end{cases} \tag{25}$$

Then, the adjusted coefficients of the parameters of equations (25) are calculated by the formula:

$$g_i = \frac{\sum_{j=1}^{m} c_{ij}}{\sum_{i=1}^{m} \sum_{j=1}^{m} c_{ij}}, \tag{26}$$

Accordingly, the adjusted weighting coefficients of the integrated resource efficiency index, taking into account the agreed opinion of the expert group, should satisfy the ratio: $\sigma(a_i K_i)/\sigma(a_j K_j) = g_i/g_j$, for all $i \neq j$, or $\sigma(a_{ij} K'_{ij})/\sigma(a_{iz} K'_{iz}) = g_{ij}/g_{iz}$, for all $i = 1, \ldots, n$, $j \neq z$. That is, the ratio between the standard deviations of each weighted factor should be equal to the corresponding ratio between the adjusted coefficients of the generalized ranking of experts.

Within the framework of this study, the expert group consisted of three experts who expressed their opinion on the importance of the components of the resource efficiency index of the oil and gas sector of Ukraine. The difficulty of objectively assessing individual preferences for the efficient use of material resources, fixed assets, labor resources and total capital was due to the crucial role of each component in the formation of the target indicator. That is why, first of all, it was decided to perform an expert assessment based on the existing advantages and disadvantages in the resource efficiency of oil and gas sector enterprises, compared to other industries and the economy of Ukraine in general [24]. And since the enterprises of the oil and gas sector are part of both the extractive and processing industries, it is advisable to make intersectoral comparisons with them [5; 13; 16; 17].

Taking into account the developed model (18), the results of diagnostics of resource efficiency for 2015-2018 are presented in table 1.

Table 1. The results of diagnostics of the resource efficiency of oil and gas sector of the economy of Ukraine according of data of 2015-2018 years.

Industries of the economy	**Years**	**P_1**	**P_2**	**P_3**	**P_4**	**IPE**
Total	2015	0.293	0.345	0.260	0.306	0.301
	2018	0.316	0.388	0.334	0.466	0.364
Industry, including:	2015	0.281	0.360	0.233	0.540	0.333
	2018	0.297	0.435	0.327	0.661	0.401
Mining industry (primary sector) and quarrying, including:	2015	0.300	0.382	0.283	0.483	0.348
	2018	0.391	0.468	0.500	0.670	0.484
Crude oil and natural gas production*, including:	2015	0.372	0.406	0.266	0.666	0.404
	2018	0.667	0.468	0.786	0.751	0.658
Crude oil production*	2015	0.276	0.252	0.252	0.500	0.301
Extraction of natural gas*	2015	0.448	0.548	0.320	0.785	0.499
Provision of ancillary services in the field of oil and natural gas*	2015	0.306	0.252	0.345	0.577	0.347
	2018	0.300	0.735	0.395	0.861	0.530
Processing industry, including:	2015	0.272	0.387	0.213	0.609	0.344
	2018	0.285	0.542	0.300	0.748	0.433
Production of oil processing*	2015	0.255	0.503	0.223	0.733	0.392
Gas production, distribution of gaseous fuel through local pipelines*	2015	0.312	0.593	0.366	0.190	0.378
	2018	0.243	0.285	0.350	0.195	0.272

In the table 1 the asterisk symbol marks the types of economic activity which are a part of oil and gas sector. As for the separate crude oil production and natural gas extraction, and refined products production in 2018 as well, the access to the relevant statistics is limited due to their confidential character.

Special qualitative changes have taken place in the consumption of raw materials and the use of labor resources. The result of such changes was that the oil and gas sector began to outrun the extractive and all industries, as well as the average level of Ukraine's economy in terms of resource efficiency. Thus, on the one hand, we had a positive trend of increasing resource efficiency [3; 4; 11; 29]. On the other hand, it was achieved by a significant increase in product prices in recent years.

Regarding the production of oil and gas products, as well as the gas distribution system, it can be seen that in terms of the use of fixed assets and capital there is a significant lag behind other enterprises of the processing industry and the average level in the economy [2; 19; 30].

Thus, the diagnosis of resource efficiency of the oil and gas sector indicated the existing problems at refineries and significant improvements in oil and gas production [7; 20; 23]. That is why, in the formation of individual preferences, experts proceeded from the most important problems of resource efficiency in enterprises for the production of refined products and gas, table 1.

The system of preferences or advantages of each of the experts had the form:

- the first expert – $K_1 \approx K_4 \succ K_2 \approx K_3$, which means the equivalence of indicators of efficiency of use of material resources and total capital due to their importance, as refineries in the oil and gas sector have the biggest problems in these areas of assessment. Therefore, these groups of indicators are more important than the efficiency of use of fixed assets and labor resources, which are also equivalent to each other;
- the second expert – $K_1 \succ K_2 \approx K_3 \approx K_4$, that is, the problem of ensuring the efficient use of material resources, taking into account the current situation, outweighs other areas of assessment that are equivalent to each other;
- the third expert – $K_1 \succ K_4 \succ K_2 \approx K_3$. In contrast to the first system of advantages or preferences, the group of indicators K_4 is inferior to K_1 in terms of importance.

The results of the calculation of the generalized group ranking by the method of arithmetic mean ranks, taking into account the individual preferences of experts, are given in table 2. As we see, it completely coincides with the assessment of the third expert.

Table 2. The results of the calculation of generalized group ranking by the method of arithmetic mean ranks.

Group of indicators	**Individual ranking**			**Arithmetic mean ranks**	**Generalized group ranking**
	Expert I	**Expert II**	**Expert III**		
K_1	1.5	1	1	1.167	1
K_2	3.5	3	3.5	3.333	3.5
K_3	3.5	3	3.5	3.333	3.5
K_4	1.5	3	2	2.167	2

In order to use the generalized group ranking in further calculations, we will assess the consistency of experts' opinions using the variance coefficient of concordance W. Since their individual rankings had related ranks, the calculation of W was performed by the formula (23):

$$W = \frac{12S}{d^2(m^3-m)-d\sum_{s=1}^{d} T_s} = \frac{12\times 29.5}{3^2\times(4^3-4)-3\times 42} = 0.855$$

Since W ∊ [0.7, 0.9), it can be stated that we have a high level of consistency of expert assessments. Therefore, generalized ranking can be used to calculate unknown parameters. To do this, the calculation of the adjusted coefficients g_i was performed by the method of pairwise comparisons, the results of which are shown in the table 3.

Table 3. The results of the calculation of the adjusted coefficients by the method of pairwise comparisons.

Groups of indicators	**K1**	**K2**	**K3**	**K4**	**Sum**	**The adjusted coefficients g_i**
K_1	1	2	3	4	7	0.438
K_2	0	1	1	0	2	0.125
K_3	0	1	1	0	2	0.125
K_4	0	2	2	1	5	0.313
Sum	–	–	–	–	16	–

As it was noticed before, the adjusted coefficients determine the ratio between the standard deviations of each weighted factor of the IRE model as follows: $\sigma(a_iK_i)/\sigma(a_jK_j) = g_i/g_j$ for all $i \neq j$. Considering this factor, unknown parameters of the equation were obtained by numerical methods:

$$IPE = 0.555K_1 + 0.126K_2 + 0.118K_3 + 0.201K_4 \quad (27)$$

In determining the weighing coefficients in the equation (27) the variation of each indicator was: $\sigma(a_1K_1) = 0.054$, $\sigma(a_2K_2) = 0.016$, $\sigma(a_3K_3) = 0.016$, $\sigma(a_1K_1) = 0{,}039$.

6 Measures to implement a resource-efficient strategy at the enterprises of the oil and gas sector of Ukraine

In order to develop further measures t_i implement a resource-efficiency strategy at the enterprises of oil and gas sector of Ukraine let's consider the components of the IRE index in more detail. Table 4 illustrates the results of the relevant calculations according to the year 2018 data and considering price adjustments in production and processing.

Table 4. The results of the calculation of controlled indicators of resource efficiency of the oil and gas sector of Ukraine

Indicators	Oil and gas extraction	Gas production and distribution

	2018	Price adjustment	2018	Price adjustment
Resource efficiency index IRE	0.673	0.502	0.251	0.422
Material resources K_1	0.667	0.500	0.243	0.368
K_{11}	0.809	0.639	0.107	0.171
K_{12}	1.000	0.680	0.430	0.624
K_{13}	0.353	0.231	0.159	0.293
K_{14}	0.922	0.928	0.329	0.345
Fixed assets K_2	0.468	0.291	0.285	0.641
K_{21}	0.177	0.125	0.617	0.767
K_{22}	0.989	0.675	0.000	0.769
K_{23}	0.270	0.101	0.239	0.414
Labour resources K_3	0.786	0.627	0.350	0.482
K_{31}	1.000	1.000	0.156	0.254
K_{32}	1.000	0.551	0.173	0.436
K_{33}	0.399	0.398	0.684	0.713
Aggregate capital K_4	0.751	0.567	0.195	0.399
K_{41}	0.358	0.204	0.133	0.251
K_{42}	1.000	0.749	0.408	0.799
K_{43}	0.750	0.543	0.000	0.057
K_{44}	0.656	0.468	0.346	0.534
K_{45}	0.932	0.843	0.000	0.216

As can be seen from table 4, in oil and gas production, after the scenario price adjustment, almost all indicators have decreased. The exceptions were labor productivity K_{31}, as well as the share of material costs and wages in the cost of production, K_{14} and K_{33}, respectively. In this case, we can distinguish 3 main groups:

1. Indicators with a slight deterioration in their values, which remain at a competitive level relative to other industries and the economy of Ukraine in general. This group includes: K_{11}, K_{14}, K_{31}, K_{33}, K_{42} and K_{45}. Their dynamics and condition do not raise concerns about possible problems in the future. Therefore, special attention should be paid to the indicators that are part of the following two groups when developing measures to optimize the use of resources.
2. Indicators that have significantly lost their positions, however, their values still remain high. These include: K_{12}, K_{22}, K_{32}, K_{43} and K_{44}.

The first three indicators in this list are related to the reduction of profits, in relation to the volume of use of material and labor resources, as well as fixed assets. This is an objective consequence of the necessary price adjustment, which revealed the real situation with resource efficiency in oil and gas production. The recommendation, in this case, may be to optimize the number of labor resources to increase productivity K_{32}, without reducing the cost of its payment.

The last two indicators characterize the slowdown in working capital due to reduced revenues from sales. The specificity of the oil and gas sector is the high capital intensity associated with the technological features of extraction, storage and transportation. That is why the growth reserves of K_{43} and K_{44} are limited.

3. Indicators with a low level of resource efficiency, compared to other industries and the economy in general: K_{13}, K_{21}, K_{23} and K_{41}.

The coefficients K_{13} and K_{23} characterize the ratio of growth rates of output with the consumption of material resources and the volume of fixed assets. After the implementation of the proposed price adjustment, these indicators will return to the level of the last reporting period, which is positive. Reserves for further growth of K_{13} are the introduction of new technologies, which requires significant capital investment and, in the current economic stagnation, is impossible. At the same time, the increase in K_{23} is directly related to the fullest possible utilization of available production capacity. Therefore, the restoration of positive dynamics in this area of assessment is possible in conditions of economic growth.

The low return on capital K_{21} and the turnover of total capital K_{41} are associated with a high share of non-current assets (fixed assets) in their total volume. For comparison, the average for the economy in 2018 it was 42.1%; in industry – 44.2%; in the mining industry – 53.4%; in oil and gas production – 67.9%; oil – 49.1%; gas – 70.4%. For this reason, our object of study is significantly inferior to other industries and the effective use of available current assets cannot correct the situation. Therefore, the recommendations, in this case, are the decommissioning of obsolete fixed assets and those that are not used for a long time, or with a low level of load, if it is possible.

With regard to gas production and distribution companies, as a result of the proposed price adjustment, all indicators of resource efficiency included in the IRE model had a positive upward trend. The exception is a certain set of indicators, which received a positive increase, but remained low: K_{11}, K_{13}, K_{31}, K_{41}, K_{43} and K_{45}.

The high material consumption of processed products will not allow K_{11} and K_{13} to take on competitive values in the future.

The real problem that has prospects for its solution is to increase labor productivity K_{31} by reasonably optimizing the number of employees.

Problems with the turnover of working capital are caused by its high share, K_{43} and K_{45}. Thus, in gas production and distribution in 2018 it was 83.6%, and in oil refining – 73.3%. An additional financial problem of these enterprises is the negative amount of total capital due to retained losses of previous years.

7 Conclusions

Analysis of the dynamics of oil and gas production shows that during 2015-2018 these enterprises significantly improved their indicators of resource efficiency on all the areas of research, resulting in an integral index increase from 0.404 to 0.658, which is positive. Significant qualitative shifts occurred in consumption of raw materials and supplies and labor resources use. The result of such changes was that the oil and gas sector outperformed both the primary (extraction) industry and the entire industry, as well as the average level in the economy of Ukraine in terms of resource efficiency. Thus, on the one hand, we had a positive trend in resource efficiency increase. On the other hand, it was achieved by a significant increase in product prices in recent years.

Thus, the obtained model of estimating the resource efficiency index takes into account the agreed and confirmed opinion of experts on the impact of each of the factors on the performance (effective) indicator. It is reasonable to use it in further economic assessment of the consequences of the implementation of resource-efficient strategy at the enterprises of the oil and gas sector of the economy of Ukraine.

Regarding the oil and gas refining, as well as gas distribution system we can observe that according to the indicators of fixed assets and capital use there is a significant lag from other enterprises of the processing industry and average level in the economy in general.

Thus, the diagnostics of resource efficiency of oil and gas sector pointed to existing problems faced by refinery enterprises and significant improvement in oil and gas production field.

This study improved the model of diagnostics of resource efficiency in oil and gas sector in the economy of Ukraine based on the additive-multiplicative compression of the formed system, which, unlike the existing ones, takes into account their variation while defining weighting coefficients which show the experts' system of preferences.

Thus, the implementation of a resource-efficient strategy in the oil and gas sector of Ukraine should include the following practical measures:

1. Creating conditions for the redistribution of value added between extractive and processing enterprises of this sector in favor of the latter, through market pricing in a demonopolized market.
2. Measures must be taken at oil and gas production enterprises to: optimize the number of labor resources to increase labor productivity; the fullest use of existing production capacity in the current economic stagnation and the lack of significant capital investment in technological re-equipment; decommissioning of obsolete fixed assets and those that are not used, or with a low level of load.
3. At oil and gas processing enterprises it is necessary to implement resource-saving measures to: increase labor productivity by reasonably reducing the number of employees; reduction of short-term receivables to increase capital turnover, etc.

References

1. Boiko, V., Kwilinski, A., Misiuk, M., Boiko, L.: Competitive advantages of wholesale markets of agricultural products as a type of entrepreneurial activity: the experience of Ukraine and Poland. Ec. An.-XXI. 175(1-2), 68-72 (2019). doi:10.21003/ea.V175-12
2. Bringezu, S., Bleischwitz, R. (eds.): Sustainable Resource Management: Global Trends, Visions and Policies. Routledge, New York (2017)
3. De Besi, M., McCormick, K.: Towards a bioeconomy in Europe: National, regional and industrial strategies. Sustainability **7**(8), 10461–10478 (2015)
4. Domenech, T., Bahn-Walkowiak, B.: Transition towards a resource efficient circular economy in Europe: policy lessons from the EU and the member states. Ecological Economics **155**, 7–19 (2019)
5. Duflou, J.R., Sutherland, J.W., Dornfeld, D., Herrmann, C., Jeswiet, J., Kara, S., Hauschild, M., Kellens, K.: Towards energy and resource efficient manufacturing: A processes and systems approach. CIRP annals **61**(2), 587-609 (2012). doi:10.1016/j.cirp.2012.05.002
6. Fryzorenko, A.O. (ed.): Ukraine's fuel and energy resources. Statistical collection. State Statistics Service of Ukraine, Kyiv (2019)
7. Jovovic, R., Draskovic, M., Delibasic, M., Jovovic, M.: The concept of sustainable regional development – institutional aspects, policies and prospects. Journal of International Studies **10**(1), 255-266 (2017). doi:10.14254/2071-8330.2017/10- 1/18
8. Karev, A.: Top Trends in the Oil and Gas Sector. J Petrol. Tech. **65**(9), 102–106 (2015). doi:10.2118/0913-0102-JPT
9. Khvostina, I., Havadzyn, N., Horal, L., Yurchenko, N.: Emergent properties manifestation in the risk assessment of oil and gas companies. CEUR Workshop Proceedings **2422**, 157–168 (2019)
10. Mantserova, T.F., Lapchenko, D.A.: The Main Approaches to Economic Diagnostics of the Power Engineering Enterprises. ENER. Pr. CIS H. Educ. Inst. P. Eng. Assoc. **62**(4), 362–376 (2019). doi:10.21122/1029-7448-2019-62-4-362-376
11. Matopoulos, A., Barros, A.C., van der Vorst, J.G.A.J.: Resource-efficient supply chains: a research framework, literature review and research agenda. Supply Chain Management, **20**, 218–236 (2015). doi:10.1108/SCM-03-2014-0090
12. Milovidov, K.N.: Global investment in upstream oil and gas sector. Probl. Econ. Manag. Oil Gas Compl. 2(170), 46–54 (2019). doi:10.33285/1999-6942-2019-2(170)-46-54
13. Ness, D.A., Xing, K.: Toward a Resource-Efficient Built Environment: A Literature Review and Conceptual Model. Journal of Industrial Ecology **21**(3), 572–592 (2017)
14. Perevozova, I., Shmygol, N., Tereshchenko, D., Kandahura, K., Katerna, O.: Introduction of creative economy in international relations: aspects of development security. J. Sec. Sust. **9**(1), 139–154 (2019). doi:10.9770/jssi.2019.9.1(11)
15. Pinchuk, A., Tkalenko, N., Marhasova, V.: Implementation of Circular Economy Elements in the Mining Regions. E3S Web of Conferences **105**, 04048 (2019)
16. Raitu, C., Anderson, B.B., Sfakianaki, E.: Resource-efficient construction: Rethinking construction towards sustainability. World Journal of Science, Technology and Sustainable Development **12**(3), 233–242 (2015). doi:10.1108/WJSTSD-03-2015-0016
17. Ramazanov, S.: Development, Management and Forecasting in a Green Innovative Economy, Based on the Integral Dynamics Model in the Conditions of 'Industry–4.0'. ACCESS Journal: Access to science-business-innovation in digital economy **1**(1), 9–29 (2020)
18. Rodrik, D.: A Research Agenda in Economic Diagnostics. American Economic

Association, Ten Years and Beyond: Economists Answer NSF's Call for Long-Term Research Agendas. SSRN (2010). doi:10.2139/ssrn.1889365

19. Ross, J.W., Weill, P., Robertson, D.C.: Enterprise Architecture as Strategy: Creating a Foundation for Business Execution. Harvard Business School Press, Boston (2006)
20. Sandvall, A.F., Ahlgren, E.O., Ekvall, T.: Cost-efficiency of urban heating strategies–Modelling scale effects of low-energy building heat supply. Energy strategy reviews **18**, 212–223 (2017)
21. Savchenko, T., Basiurkina, N., Rodina, O., Kwilinski, A.: Improvement of the assessment methods of product competitiveness of the specialized poultry enterprises. Manag. Th. St. Rur. Bus. Infr. Dev. **41**(1), 43–61 (2019). doi:10.15544/mts.2019.05
22. Savitskaya, G.V.: Metodika kompleksnogo analiza hozyaystvennoy deyatelnosti (Methodology of a comprehensive analysis of economic activity). INFRA-M, Moscow (2007)
23. Shinkevich, A.I., Kudryavtseva, S.S., Ershova, I.G.: Modelling of Energy Efficiency Factors of Petrochemical Industry. International Journal of Energy Economics and Policy **10**(3), 465–470 (2020)
24. Shmygol, N., Łuczka, W., Trokhymets, O., Pawliszczy, D., Zavgorodniy, R.: Model of diagnostics of resource efficiency in oil and gas sector of economy of Ukraine. E3S Web of Conferences **166**, 13005 (2020). doi:10.1051/e3sconf/202016613005
25. State Statistics Service of Ukraine: Ekonomichna statystyka: diialnist pidpryiemstv. http://www.ukrstat.gov.ua/operativ/menu/menu_u/sze.htm (2019). Accessed 02 Feb 2020
26. Tolpegina, O.A.: Methodological principles of classification of types of economic diagnostics. Eff. Cr. Manag. 1–2, 64–73 (2017). doi:10.17747/2078-8886-2017-1-2-64-73
27. Tukker, A.: Product services for a resource-efficient and circular economy – a review. Journal of cleaner production **97**, 76-91 (2015)
28. Yale Center for Environmental Law & Policy: Environment Performance Index. Methodology. https://epi.envirocenter.yale.edu/2018-epi-report/methodology (2018). Accessed 02 Feb 2020
29. Zhernov, E., Nekhoda, E., Petrova, M.: Economic Transformation Impact on the Modernization of a Mineral Resource Industry Cluster. E3S Web of Conf. **174**, 04003 (2020). doi:10.1051/e3sconf/202017404003
30. Zhou, Q., Liu, R.: Strategy optimization of resource scheduling based on cluster rendering. Cluster Computing **19**(4), 2109–2117 (2016)