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Comparative Assessment of Resource Productivity Factors in the Oil and Gas Companies

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Abstract

The study provides a method using econometric analysis to create corporate organizational knowledge in order to enhance innovation and competitiveness of the corporation. Improving the efficiency of industrial business processes involves analyzing cost information using specialized statistical and econometric software. Gretl package fully solves the problem of determining the relationship between performance, cost center classification, forecasting and simulating the consequences of the decisions taken, highlighting the segments and building predictive profiles of each costs segment. The authors demonstrate capabilities of panel data to prove the necessity of modern analysis methods in the management of business processes. To this end, the paper suggests the methodical approach to measuring drivers of resource productivity on the basis of panel data models, taking into account the individual differences between the economic units by the example of oil production. Measuring and identifying the drivers of business processes efficiency on the basis of panel data models can be one of the possible areas of management cognitive supporting. The results obtained with the use of Gretl software of empirical assessment confirmed their feasibility in the management of business processes in oil and gas production.

Keywords: Resource productivity; Innovation; oil; Corporate knowledge; Panel data models; Econometric analysis; Heterogeneity; Productivity.

1. Introduction

Various views of scholars on the problems and on the study of economic growth determined the variety of classification criteria of growth factors. Modern growth theories are focused on the study of endogenous monetary, institutional and technological factors of economic growth (Ablaev, 2015; Jones, 1999; Kadochnikova and Ismigilov, 2014; Samerkhanova and Kadochnikova, 2015). The assumption of constant technology levels in a neo-classical production function F(K,L,T) (Khasanova *et al.*, 2015). Is now waning. Technological factors of economic growth are generated through innovation - new knowledge in knowledge-intensive forms of production and services. New knowledge as the basis of important organizational performance and competitiveness of corporations, economic activities, meso- and macroeconomics (Kadochnikova and Ismigilov, 2014). require the creation of direct management tools of their life cycle in the micro, meso and macroeconomics. In turn, cognitivization of economy as a deep foundation of continuous and large-scale innovation is associated with the identification of specific features and with characteristics of corporate knowledge. Research results in management of institutional, project, organizational and economic corporate knowledge are targeted at cognitive supporting of management activities and at the expanded reproduction of innovation. Therefore, the aim of this paper is the use of econometric methods in analytical work of the oil corporation for the creation and applying of corporate organizational and economic knowledge. The methodical approach presented in the paper to the analysis of resources productivity on the basis of panel data models can be useful to improve the analytical work to justify management decisions in the field of technological innovation aimed at improving resource productivity of business processes of oil and gas production (Galunic and Rodan, 1998; Tsertseil, 2015).

2. Materials and Methods

The study uses panel data (sample of 48 observations from 2013 to 2015 on a quarterly basis for the four units) on oil and gas production of Oil and Gas Administration. As variables were used resource productivity of products, kop. (Y);

Oil production, tons (X1); coefficient of well operation (X2); labor productivity, t (X3); oil content in fluid,% (X4). The method of least squares and generalized method of least squares, respectively, evaluated parameters of

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panel data models with fixed-effects and panel data models with random effects. Simulation is performed using Gretl 1.9.11 (Adkins, 2014). Panel data consist of repeated observations of the same sampling units, which are carried out in successive periods of time.

Unidirectional panel data models include:

- the combined model:

$$Y_{it} = \alpha + X_{it}\beta + \varepsilon_{it} \; ; \quad (1)$$

- fixed effects model:

$$Y_{it} = \alpha_i + X_{it}\beta + \varepsilon_{it}, \alpha_i = z_i\alpha \; ; \quad (2)$$

- random effects model:

$$Y_{it} = X_{it}\beta + \alpha + m_i + \varepsilon_{it} \quad (3)$$

The fixed effects model simulates the effect of heterogeneity between the objects of observation with parameter of characteristic αi which is invariant with respect to time, but specific to each of the observed object. This is exactly the model with dummy variables. The model with fixed effects is a simple regression model, the parameter estimates are tested by conventional t- and F - tests.

The random effects model simulates the effect of the heterogeneity of the objects of observation by introducing error term mi that is constant in time, but specific to each object of observation which is assumed to be independent from the rest of uit error.

$$y_{it} = \alpha_i + x'_{it}\beta + u_{it}$$
$$u_{it} = m_i + \varepsilon_{it} \quad (4)$$

The combined model assumes that the statistical units have no individual differences. A fixed effects model assumes that each unit has its own specific set of individual characteristics that are specific to each object that are constant over time. If the statistical units differ in their individual characteristics, but these differences are random, then in this case it is better to consider a model with random effects.

The problem of selecting models is achieved by testing hypotheses. When choosing a combined model against the fixed effects model, null hypothesis is tested for no individual effects. To test the null hypothesis, Chow test is used. The observed value of F-test is determined:

$$F = \frac{(SS_R - SS_{UR})/(N-1)}{SS_{UR}/(NT - N - K)}; F = \frac{R_1^2}{v_1} \div \frac{R_0^2}{v_2};$$
$$v_1 = N - 1; v_2 = NT - N - K$$
$$F > F_{\alpha, v_1, v_2} \rightarrow H_1 : R_1^2 > R_0^2 \quad (5)$$

where SSR - the residual sum of squares in the combined model;

SSUR - the residual sum of squares in the model with fixed effects;

R_1^2 - the determination coefficient for the fixed effects model;

R_0^2 - the determination coefficient for the pooled model without taking into account the panel structure of the data;

v1,v2 - degrees of freedom, v1 = N-1, v2 = NT-N-K;

N - number of panels, T - time periods, K - number of parameters before the independent variables.

If the calculated value of F-test is greater than the critical value, F>F(a,N-1,NT-N-K), for a given level of significance, it is possible to reject the null hypothesis, and to accept the alternative hypothesis of the presence of the individual effects, i.e. opt for a model with fixed effects.

When choosing a fixed effects model against the random effects model, we test the null hypothesis for no correlation between the individual effects and the regressors (the presence of random effects). To test the null hypothesis, the Hausman specification test is used. The observed value of QH statistics is determined:

$$Q_H = (\hat{\beta}_{intra} - \hat{\beta}_{FGLS})'\left[\hat{V}(\hat{\beta}_{intra}) - V(\hat{\beta}_{FGLS})\right]^{-1}(\hat{\beta}_{intra} - \hat{\beta}_{FGLS}) \quad (6)$$

where $\hat{\beta}_{intra}$ - intra-class assessment;

$\hat{\beta}_{FGLS}$ - evaluation of feasible generalized least squares method.

If QH-statistics is greater than the critical value of c2- distribution with kw degrees of freedom, where kw – the number of covariates in the intra-class model, then one can reject the null hypothesis and opt for a model with fixed effects.

3. Results

Based on the matrix of linear coefficients of pair correlation we formed three models of panel data with fixed effects to analyze the use efficiency of material resources (resource productivity) to identify individual differences of resource productivity by oil and gas production units:

$$Y_x = a_1 i_1 + a_2 i_2 + a_3 i_3 + a_4 i_4 + b_1 X_1 + b_3 X_3 \quad (7.1)$$

$$Y_x = a_1 i_1 + a_2 i_2 + a_3 i_3 + a_4 i_4 + b_1 X_1 + b_4 X_4 \quad (7.2)$$

$$Y_x = a_1 i_1 + a_2 i_2 + a_3 i_3 + a_4 i_4 + b_2 X_2 + b_4 X_4 \quad (7.3)$$

where a1, a2, a3, a4 – OLS estimates of model parameters before categorical variables filters;
b1, b2, b3, b4 - OLS estimates of the models parameters before the independent variables - regressors.
To test the null hypothesis of no fixed group effects were used random variables with Fisher distribution (5):

$$F = \frac{R_1^2}{v_1} \div \frac{R_0^2}{v_2}$$

$$F > F_{\alpha, v_1, v_2} \rightarrow H_1 : R_1^2 > R_0^2$$

$$v_1 = 3; v_2 = 42; F_{0,05;3;42} = 2{,}82705$$

The estimation results of fixed effects models of resource productivity using the method of least squares are presented in Table 1.

Table-1. Fixed effects model of resource productivity

№	Type of model	R_1^2	R_0^2	F
7.1	$Y_x = -13{,}6812 i_1 - 16{,}1980 i_2 - 11{,}7672 i_3 - 14{,}5087 i_4 + 8{,}4843 X_1 + 0{,}0074 X_3$	0,959	0,911	14,726
7.2	$Y_x = -30{,}1713 i_1 - 23{,}1278 i_2 - 22{,}5869 i_3 - 29{,}7389 i_4 + 2{,}9057 X_1 + 1{,}6966 X_4$	0,923	0,655	19,722
7.3	$Y_x = -58{,}3168 i_1 - 55{,}4298 i_2 - 54{,}8514 i_3 - 62{,}2649 i_4 + 36{,}5021 X_2 + 1{,}58823 X_4$	0,848	0,579	20,520

According to Fisher's test, each of the three models should reject the null hypothesis of no fixed group effects: 14.7262 > 2.82705; 19.7222 > 2.82705; 20.5201> 2.82705.

Implicit heterogeneity due to differences in the use efficiency of material resources by units can be found in models of panel data with random effects:

$$Y_x = \mu + b_1 X_1 + b_3 X_3 \quad (8.1)$$

$$Y_x = \mu + b_1 X_1 + b_4 X_4 \quad (8.2)$$

$$Y_x = \mu + b_2 X_2 + b_4 X_4 \quad (8.3)$$

where μ - individual random component of the model and the constant term;
b1, b2, b3, b4 - OLS estimates of the models parameters before the independent variables - regressors.
The results of models estimation with random effects using the generalized least squares method are presented in Table 2.

Table-2. Random effects model of resource productivity

№	Type of model	p-value (Hausman specification test)	theta	Se
8.1	$Y_x = -9{,}4220 + 9{,}8388 X_1 + 0{,}0022 X_3$	1,93485e-012	0,00	1,884
8.2	$Y_x = -26{,}1813 + 2{,}9276 X_1 + 1{,}6843 X_4$	0,2200000	0,85	4,022
8.3	$Y_x = -57{,}7157 + 37{,}3122 X_2 + 1{,}5453 X_4$	0,0615132	0,74	3,557

Results of modeling generalization are presented in Table 3.

Table-3. Summary table models of resource productivity

Fixed effects model			Random effects model		
Type of model	R_1^2	Se	Type of model	theta	Se
$Y_x = -13{,}6812 i_1 - 16{,}1980 i_2 - 11{,}7672 i_3 - 14{,}5087 i_4 + 8{,}4843 X_1 + 0{,}0074 X_3$	0,9	1,34	$Y_x = -9{,}4220 + 9{,}8388 X_1 + 0{,}0022 X_3$	0,0	1,88
$Y_x = -30{,}1713 i_1 - 23{,}1278 i_2 - 22{,}5869 i_3 - 29{,}7389 i_4 + 2{,}9057 X_1 + 1{,}6966 X_4$	0,9	1,84	$Y_x = -26{,}1813 + 2{,}9276 X_1 + 1{,}6843 X_4$	0,9	4,02
$Y_x = -58{,}3168 i_1 - 55{,}4298 i_2 - 54{,}8514 i_3 - 62{,}2649 i_4 + 36{,}5021 X_2 + 1{,}58823 X_4$	0,8	2,09	$Y_x = -57{,}7157 + 37{,}3122 X_2 + 1{,}5453 X_4$	0,7	3,55

4. Discussion

The paper seeks to demonstrate the need to improve the analytical work through the use of econometric analysis to create and distribute organizational and economic knowledge. The main advantages of panel data (Anand and Bärnighausen, 2004). enable to build more flexible and meaningful models and answer questions that are not available within the models based on spatial data. Data panels provide a researcher with a large number of observations, increasing the number of degrees of freedom and reducing the relationship between the explanatory variables and, consequently, the standard error estimates (Ho *et al.*, 2016). Another significant advantage of panel data models is that they make it possible to trace the individual evolution of the characteristics of all sampling in time.

Due to the nature of extracting industry, resource productivity of oil and gas corporation depends on the amount of commodity products - oil produced and the cost of material resources involved in oil and gas production process, as well as the level of selling prices (Samerkhanova and Kadochnikova, 2015). Owing to the use of panel data it becomes possible to account and analyze the differences between the individual economic units - oil and gas production units, which cannot be done within the framework of the standard regression models (Ismagilov and Khasanova, 2015).

Model (7.1) explains almost 96% of the resource productivity variation around its mean value. With an increase in oil production (X1) by a ton, resource productivity increases by average of 8.48 rubles, and with the increase in labor productivity (X3) by one ruble, resource productivity increases by an average of 0.007 rubles. Parameters before i categorical variables-filters take into account the heterogeneity effect of resource productivity between units and can be interpreted as a deviation from the mean resource productivity per totality of units. Therefore, it can be assumed that the most significant negative deviation from the mean resource productivity influenced by factors X1, X3 is observed in the second oil and gas production unit. Model (7.2) explains almost 92% of the resource productivity variation around its mean value. With the increase in oil production (X1) by 1 ton, resource productivity increases by an average of 2.91 rubles, and with an increase in the percentage of oil content in fluid (X4) by one percent, resource productivity increases by an average of 1.70 rubles. It can be assumed that the most significant negative deviation from the mean resource productivity under the influence of factors X1, X4 is observed in the first oil and gas production unit. Model (7.3) explains almost 85% of the resource productivity variation around its mean value. With an increase in the coefficient of well operation (X2) by one point, resource productivity increases on average by 36.50 rubles, while with increasing percentage of oil content in fluid (X4) by one percent, resource productivity increases by an average of 1.59 rubles. It can be assumed that the most significant negative deviation from the mean resource productivity is observed under the influence of factors, X2, X4 in the fourth unit. In general, in every unit resource productivity is below the average than for the units together.

Model (8.1) shows that with an increase in oil output (X1) by a ton, resource productivity increases by an average of 9.84 rubles, and with the increase in labor productivity (X3) by one ruble, resource productivity increases by an average of 0.002 rubles. Hausman specification test (null hypothesis about the adequacy of the random effects model to a fixed effects model) shows failure of estimates in the random effects model (p-value = 1,93485e-012 <0.05). The model (8.2) shows that with an increase in oil production (X1) by a ton, resource productivity increases by an average of 2.93 rubles, and with an increase of percentage of oil content in fluid (X4) by one percent, resource productivity increases by an average of 1.68 rubles. Hausman specification test shows the consistency of the estimates in the random effects model (p-value = 0.22> 0.05). Model (8.3) shows that with increasing in coefficient of well operation (X2) by 1 point, resource productivity increases on average by 37.31 rubles, while with increasing percentage of oil content in fluid (X4) by one percent, resource productivity increases by an average of 1.55 rubles. Hausman specification test shows the consistency of the estimates in the random effects model (p-value = 0.0615132> 0.05). It is obvious that in every unit resource productivity is below the average for the units together. μ parameter can be interpreted as a deviation from the average resource productivity for the totality of units under the influence of factors X1, X3 (model 2.1), X1, X4 (model 2.2), X2, X4 (model 8.3)

Based on the fixed effects models one can observe the following signs of resource productivity heterogeneity by oil and gas production units that indicate the drivers of its increase. In the first unit the most significant negative deviation from the mean resource productivity is observed under the influence of oil production, t (X1), and oil content in the fluid, % (X4). In the second unit the most significant deviation from the average resource productivity is observed under the influence of oil production, tons (X1) and the productivity of labor, t (X3). In the fourth unit the most significant deviation from the average resource productivity is observed under the influence of the coefficient of wells operation (X2) and the oil content in the fluid% (X4). In the third unit the best use of material resources is observed, it has the smallest deviation from the mean resource productivity.

5. Conclusion

The performed regression analysis of panel data allowed to formulate the following practical conclusions:

In order to improve the use efficiency of material resources in the first oil and gas production unit, it is recommended to undertake measures to enhance oil production and quality of raw materials. In the second oil and gas production unit it is also recommended to take actions to enhance oil production and to increase labor productivity. In the fourth oil and gas production unit, practical activities to increase well operation and improve the quality of raw materials are necessary.

The random effects models confirmed that the most significant negative deviation from the mean resource productivity is observed under the influence of the coefficient of well operation (X2) and the oil content in fluid, % (X4).

Measurement of both explicit and implicit heterogeneity due to differences in the use efficiency of material resources by units showed a negative deviation from the mean resource productivity and confirmed the need for measures to improve resource productivity in each unit.

In general, the creation, dissemination and use of new organizational and economic corporate knowledge through econometric analysis determines the new direction of improving the analytical work - the identification and measurement of the drivers of business processes efficiency of oil and gas production with the view to improving and reengineering. Therefore, future studies may carry more detailed developments and experimental calculations of methods of management analysis in oil and gas corporations.

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