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MODELING OF FACTORS OF PRODUCTION INTERACTION AND EFFICIENCY OF THEIR USAGE IN ENTERPRISE COMPETITIVENESS MANAGEMENT

According to the general methodology of enterprises competitiveness management in unstable environment of internal and external transformations is determination of the nature and strength of relationships of influence of factors of production and efficiency of their use [3, 12]. Although the determining factors of high level of competitiveness is available resource potential (RP), rapid transformation of its components in activity (DA) and the balance of all processes as a whole is important, so the system of competitiveness management requires constant management transformations in the conditions of rapidly environment changing, its improvement involves aggregation and composition of all possible factors of production, which are the backbone in this complex hierarchical system [1, 9].

Thus, in the paper instrument for assessment the interaction of factors of production of resources and activity directions for analysis of balanced development

and the adequacy and speed of transformational change is proposed. This instrument consists of the effect of growing of resource and activity potential and increasing of enterprises resource activity to achieve synergies [2, 7, 8]. The economic effect of the effective implementation of resource and activity potential (RDP) is shown in the growth of indicators of resource and performance activity (RDA) and the imbalance reducing on the bases of transformations. To regard the whole set of factors that form the state of the resource and activity potential (RDP), resource and performance activity (RDA) on the bases of complex integrated indicators of development [5], evaluation of effectiveness of factors of production usage should be comprehensive and should solve the set of problems which are presented in Fig. 1.

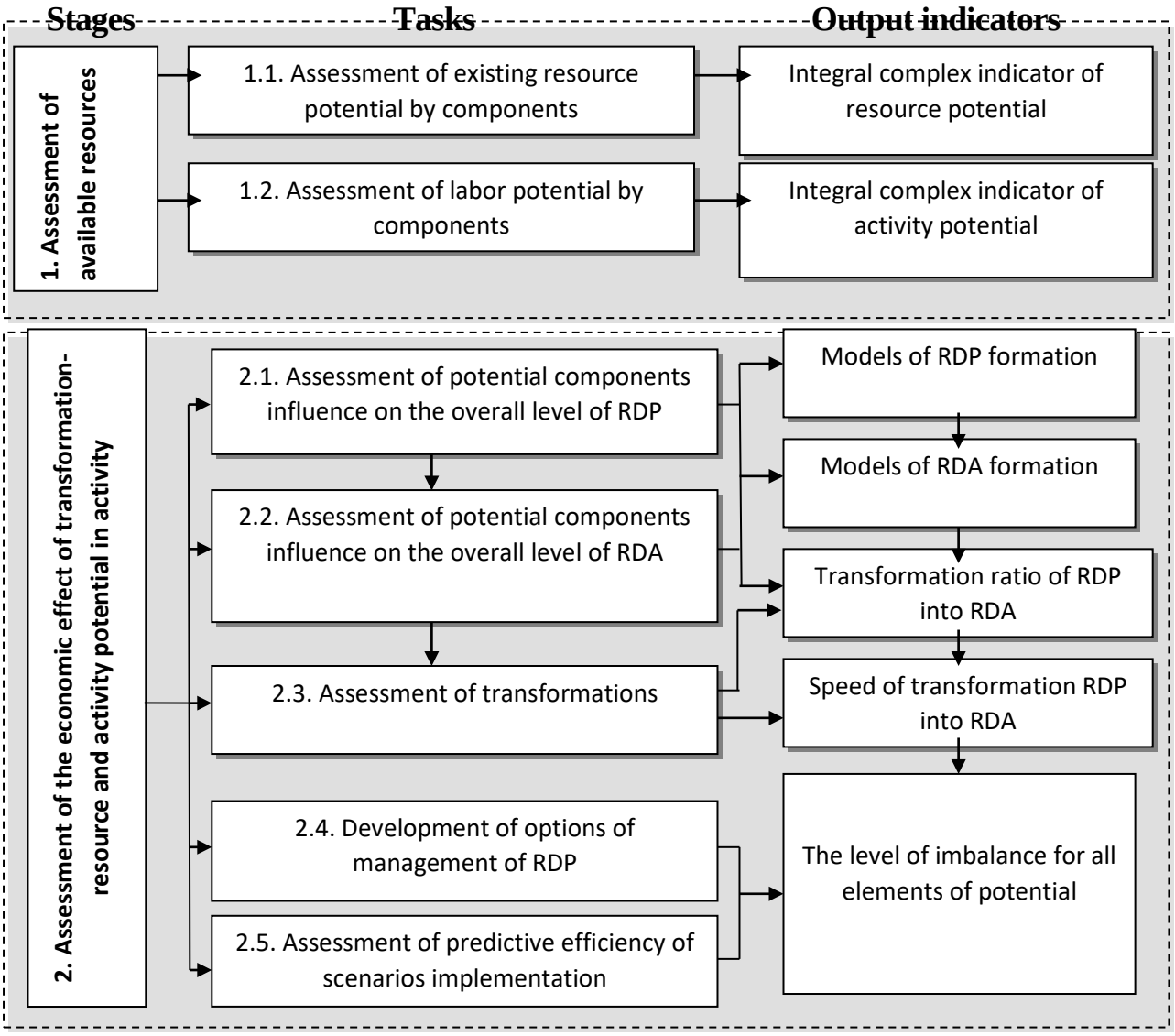


Fig. 1. Complex of tasks of assessment of efficiency of enterprises resource and activity factors of production

Indicators of assessment of factors of production by resource and activity potential and activity which are studied for 7 engineering enterprises from 2013 to 2016 are presented in Tab. 1.

Table 1

Indicators of assessment of production factors

Components of resource and activity potential (RDP)	Indicators of potential	Components of resource and performance activity (RDA)	Indicators of activity
Organizational and management potential (OUP)	Coefficient of decentralization of organizational structure of management (x1)	Marketing activity (MA)	The coefficient of efficiency of advertising and sales promotion (ax1)
	Coefficient of quantitative personnel manning (x2)	Production and staffing activity (VKA)	Capital productivity (ax2)
Production and human potential (VKP)	Coefficient of equipment intensity usage (x3)		Labor productivity (ax3)
	Coefficient of professional flexibility (x4)	Financial and economic activity (FEA)	Return on assets (ax4)
Financial and economic potential (FEP)	Turnover of accounts payable (x5)		Financial stability ratio (ax5)
	Turnover of accounts receivable (x6)		Return on borrowed banking capital (ax6)
	Coefficient of cash flows resulting from financing activities (x7)	Innovation and investment activity (IIA)	Return on investment costs (ax7)
Organization of labor activity (OTD)	Coefficient of labor division (x8)	Organization and content of labor activity (OZTDA)	Possibilities of allocation of working hours according to individual needs (ax8)
	Level of labor remuneration (x9)		Possibilities of influence on the manner / method of work (ax9)
Conditions of labor activity (UTD)	Coefficient of labor safety (x10)	Conditions of labor activity energies (UTDA)	Satisfaction of sanitary conditions in production and sanitary services (ax10)
			Satisfaction of aesthetic working conditions (ax11)

According to the tasks and solutions the research of causal interactions between factors of production, their components and elements is proposed (Module 1). The purpose of this module is identification of common trends and interactions on the bases of correlation analysis, which are characteristic of the whole sample and dynamic causal

interrelations of potential elements for studied enterprises taking into account their individual characteristics of functioning on the bases of Granger causality test [10, 11].

The correlation coefficients are calculated and the dynamics of their changing from 2013 to 2016 year is investigated in order to determine the nature and density of connection between the studied elements of resource and activity potential.

The matrix of correlations between sets of components of resource and activity potential and enterprises business activity (fragment for 2016 year) is shown in Fig. 2. Correlation matrix of interaction between two main components of potential and activity (fragment for 2016 year) is shown in Fig. 3.

2016	*OUP*	*VKP*	*FEP*	*OTD*	*UTD*
OUP	1,00				
VKP	0,80	1,00			
FEP	0,24	0,63	1,00		
OTD	0,62	0,88	0,79	1,00	
UTD	0,86	0,72	0,26	0,62	1,00

2016	*MA*	*VKA*	*FEA*	*IIA*	*OZTDA*	*UTDA*
MA	1,00					
VKA	0,75	1,00				
FEA	0,14	0,51	1,00			
IIA	0,25	0,25	0,30	1,00		
OZTDA	0,18	0,03	-0,14	0,47	1,00	
UTDA	0,44	0,88	0,78	0,26	0,06	1,00

Fig. 2. The matrix of correlations between sets of components of resource-activity potential and enterprises business activity

2015	*OUP*	*VKP*	*FEP*	*OTD*	*UTD*
MA	0,188	0,332	0,666	0,717	0,403
VKA	0,663	0,711	0,452	0,850	0,782
FEA	0,669	0,925	0,566	0,787	0,449
IIA	-0,263	0,242	0,388	0,356	-0,252
OZTDA	-0,193	0,057	0,382	0,035	-0,008
UTDA	0,852	0,918	0,465	0,850	0,795

Fig. 3. The matrix of correlations of interaction between the components of resource and activity potential and activity of enterprises

For studied engineering companies there is quite a close direct linear interaction between the elements of potential and activity, both inside of sets and between components. The most significant and constant level of connection in dynamics can provide for the following elements:

– production and human potential (VKP) and organization of labor activity (OTD);

– production and human potential (VKP) and conditions of labor activity energies (UTDA);

– conditions of labor activity (UTD) and conditions of labor activity energies (UTDA);

– organization of labor activity (OTD) and Financial and economic activity (FEA).

There is unclear level of interrelation between other components, which complicates the formation of general conclusions and makes inability to establish causality interrelation and the cause and the consequence. So the most appropriate in this case is determination the causal interrelation on the bases of Granger test [10, 11] and formation plurality of causal interrelations separately for each enterprise. Fragment of calculations of Granger causality statistics in *Eviews* [15] between elements of the resource and activity potential and business activity of enterprises with different lags of delay for JSC "FED" is presented in Fig. 4.

PairwiseGrangerCausalityTests
Sample: 20

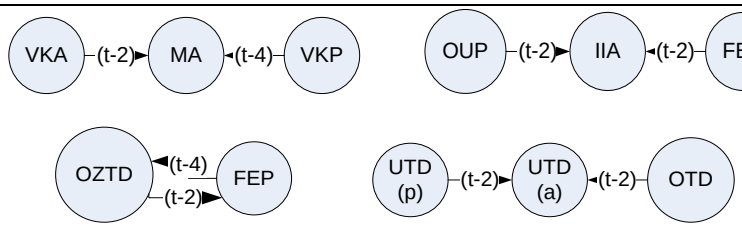
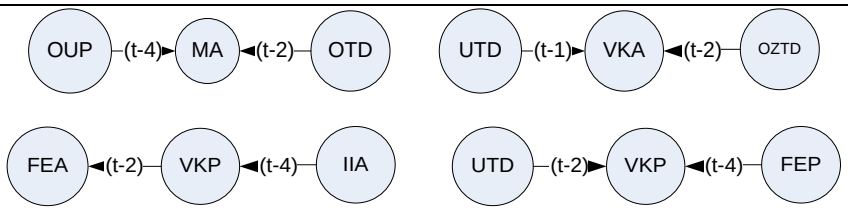
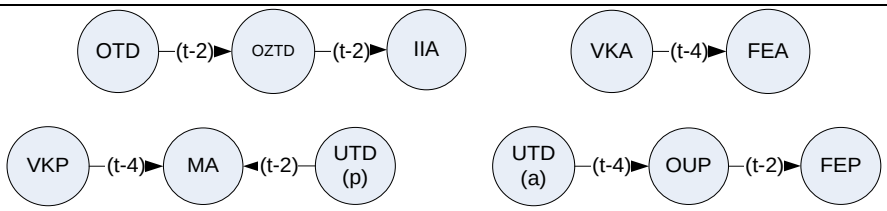
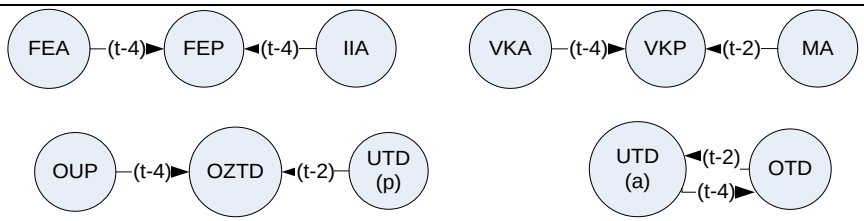
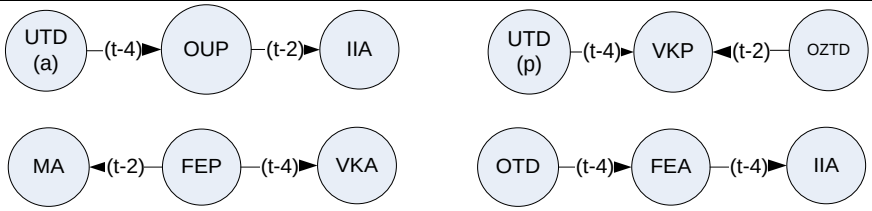
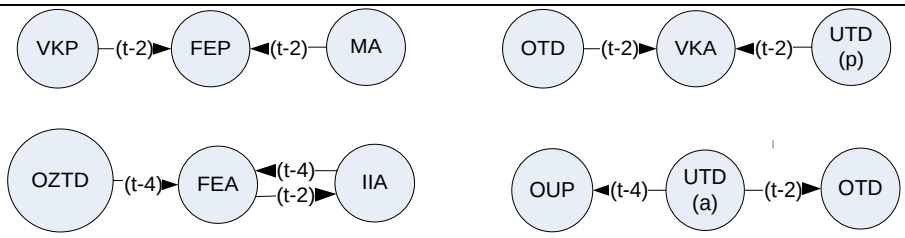
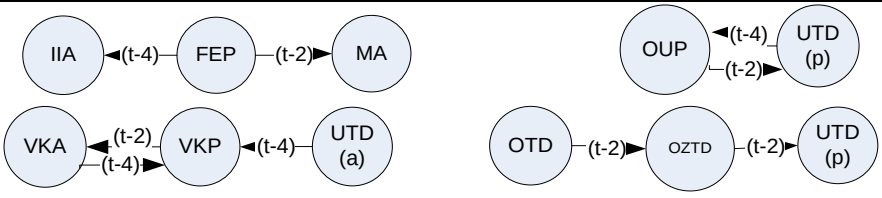
		Lags: 2		Lags 4	
NullHypothesis:	Obs	F-Statistic	Prob.	F-Statistic	Prob.
FEP does not Granger Cause OZTD	20	33.1198	8.E-15	129.775	1E-195
OZTD does not Granger Cause FEP		25.7733	1.E-11	9.26628	5.E-15
OUP does not Granger Cause IIA	20	17.2368	4.E-082.639070.0034		
FEA does not Granger Cause IIA		27.4000	2.E-125.888459.E-09		
VKA does not Granger Cause MA	20	33.0889	8.E-1511.67471.E-19		
VKP does not Granger Cause MA		10.4839	3.E-0596.07466E-154		
UTD(p) does not Granger Cause UTD(a)	20	12.0723	7.E-063.24370.0047		
OTD does not Granger Cause UTD(a)		21.3986	3.E-084.00140.0066		

Fig. 4. Fragment of calculations of Granger causality statistics

Table 2 shows the aggregated diagrams for causal interrelations between elements of resource and activity potential and business activity of enterprises.

Table 2

Assessment of causality between elements of the resource and activity potential and business activity of enterprises

Enterprise	Diagrams of causal interrelations between elements of resource and activity potential and activity of enterprises
JSC "FED"	
JSC "HARTRON"	
JSC "Dnipropetrovsk Aggregate Plant"	
State Enterprise "Antonov"	
JSC "Volchansky Aggregate Plant"	
Kharkov State Aircraft of Ordeniv of October Revolution and Red Banner of Labor	
JSC "Aviacontrol"	

So, the analysis of causality interrelations for enterprises shows that:

– almost all elements of resource and activity potential mainly determine the level

of resource and performance activity in the future with virtually constant lag of six months (2 quarters) (t = 2);

– the level of resource and performance activity components and the level of their current use in the present is the key factor of impact on the resource and activity potential in the future, but in the longer term – 1 year (4 quarters) (t = 4).

The results reveal general trends of potential elements impact on the activity of companies with a defined lag of delay and certain causal interrelations for individual enterprises can be the bases for construction of forecasting models for factors of production.

The purpose of Module 2 is analysis of the interaction of factors of production for components of resource and activity potential and activity and determination the effectiveness of the interaction of factors of production by resource costs, staff potential and resource costs activity and staff activity.

One of the tools that makes possible to do analytical calculations and to determine the efficiency and flexibility of resource and activity potential, the expediency of its further usage, planning areas of activity is the production function [4, 6, 11]. Using the production functions enables the following tasks: to assess the impact of resources in the manufacturing process; predict economic growth; develop options of the production plan; optimize system operation by this criterion and limited resources.

As the main indicators for assessment the economic efficiency of production factors on the bases of the comparison of results of transformation of resource and activity potential (RDP) in resource and performance activity (RDA) we propose to consider:

– productivity (average and margin) of resource and activity potential and activity;

– elasticity of factors of resource and activity potential and activity;

– resource efficiency of resource and activity potential;

– capacitance of resource and performance activity;

– availability of activities;

– the needs of resource and activity potential costs;

– marginal rate of substitution of elements of resource and activity potential and activity;

– the elasticity of substitution of elements of resource and activity potential and

activity.

According to the analysis of production functions features and their application for evaluation and forecasting of efficiency Cobb-Douglas production function is used in the paper [4, 11]. As the aim is determination the impact and interaction of factors of resource and activity potential and activity at some successive time intervals for studied enterprises, so for construction of production functions we use analysis method on the bases of econometric panel data models [10, 11, 13, 14].

Panel data consist of observations of the same economic phenomena in successive periods, i.e. combine spatial data type and type of time series [10, 11, 15]. Panel data models features are crucial condition for the selection of tools for building models of economic efficiency in the competitiveness management because can be identified as a sufficient number of factors that are unique to each enterprise and generally affect the final result of speed transformations.

Cobb-Douglas production function is used to build models for evaluation the effectiveness of competitiveness management on the bases of existing resource and activity potential. The general form of this function is:

$$RDP = a_0 \cdot \left(L^p\right)^{a_1} \cdot \left(K^p\right)^{a_2}, \tag{1}$$

where L^p – factor of production that characterizes the staff potential;

K^p – factor of production that characterizes the resource costs potential.

Similarly, for the construction of models for evaluating the effectiveness of competitiveness management through enterprises resource and performance activity we use Cobb-Douglas production function:

$$RDA = b_0 \cdot \left(L^a\right)^{b_1} \cdot \left(K^a\right)^{b_2}, \tag{2}$$

where L^a – factor of production that characterizes the staff activity;

K^a – factor of production that characterizes the resource costs activity.

After linearization panel data models have the following general form:

$$\ln RDP = \ln a_0 + a_1 \ln\left(L^p\right) + a_2 \ln\left(K^p\right), \tag{3}$$

$$\ln RDA = \ln b_0 + b_1 \ln\left(L^a\right) + b_2 \ln\left(K^a\right) \quad (4)$$

Choosing tools for function constructing, we give preference panel data models with individual fixed effects. Thus, the general model is:

$$\ln RDP_{it} = d_{0i} + d_0 + a_1 \ln\left(L_{it}^p\right) + a_2 \ln\left(K_{it}^p\right) + \varepsilon_{it}^p \quad (5)$$

where $d_{0i} + d_0 = \ln a_{0i}$, d_0 – fixed effect, reflecting the general economic climate in Ukraine, especially the development of the industry, affecting resource and activity potential of analyzed enterprises; d_{0i} – unobservable specific effects that reflect differences in the formation of resource and activity potential of enterprises, such as personal effects management, the more the value of the individual effect d_{0i}, the more effectively resources usage and higher enterprises RDP level; RDP_{it} – value of RDP for i – th enterprise in t-th period of time, L_{it}^p, K_{it}^p – value of factor signs for i – th enterprise in t-th period of time, ε_{it}^p – errors of model, uncorrelated with each other both for enterprises and for periods of time.

$$\ln RDA_{it} = c_{0i} + c_0 + b_1 \ln\left(L_{it}^a\right) + b_2 \ln\left(K_{it}^a\right) + \varepsilon_{it}^a . \quad (6)$$

where $c_{0i} + c_0 = \ln b_{0i}$, c_0 – fixed effect, reflecting the general economic climate in Ukraine, especially the development of the industry, affecting resource and performance activity of analyzed enterprises; c_{0i} – unobservable specific effects that reflect differences of resource and performance activity of enterprises, such as personal effects management, the more value an individual effect, the higher enterprises RDA level; RDA_{it} – values of RDA for the *i*-th enterprise in *t*-th period of time, L_{it}^a, K_{it}^a – factor variable values for the *i*-th enterprise in t-th period of time, ε_{it}^a – errors of model, uncorrelated with each other both for enterprises and for periods of time.

Model of production function of formation of resource and activity potential (RDP) depending on the factors of production (potential components) that describes staff potential, in particular the organizational and management potential (OUP) and production factors that characterizes the resource costs potential, namely financial and economic potential (FEP), is built in *Eviews* [15] and is shown in Fig. 5.

DependentVariable: RDP?
Method: Pooled EGLS (Cross-section weights)
Sample: 2013 2016
Includedobservations: 4
Cross-sectionsincluded: 7
Totalpool (balanced) observations: 28
Linear estimation after one-step weighting matrix

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.534236	0.109149	4.894568	0.0001
OUP?	0.362083	0.122857	2.877467	0.0259
FEP?	0.410741	0.080007	5.133818	0.0001
FixedEffects (Cross)				
_01--C	0.201847			
_02--C	-0.035109			
_03--C	0.029006			
_04--C	0.134374			
_05--C	0.063613			
_06--C	-0.328293			
_07--C	-0.065438			

Cross-section fixed (dummy variables)

WeightedStatistics			
R-squared	0.939269	Meandependentvar	0.947365
Adjusted R-squared	0.913699	S.D. dependentvar	0.596641
S.E. ofregression	0.162676	Sumsquaredresid	0.502807
F-statistic	36.73218	Durbin-Watsonstat	2.178268
Prob(F-statistic)	0.000000		

Fig. 5. The model of the production function of formation of resource and activity potential (RDP)

The most appropriate and economic interpreted models of resource and activity potential (RDP) formation, their elasticities and adequacy criteria are given in Tab. 3.

Table 3

Models of formation of resource and activity potential (RDP)

Factors of production		Factor of production that characterizes the resource costs potential
		FEP
Factors of production that characterizes staff potential	OUP	$RDP_i = (0.534 + a_{0i}^1) \cdot OUP^{0.36} \cdot FEP^{0.41} \quad R^2 = 0.93$
	VKP	$RDP_i = \left(0.399 + a_{0i}^2\right) \cdot VKP^{0.48} \cdot FEP^{0.37} \quad R^2 = 0.92$
	OTD	$RDP_i = \left(0.795 + a_{0i}^3\right) \cdot OTD^{0.03} \cdot FEP^{0.44} \quad R^2 = 0.93$
	UTD	$RDP_i = \left(0.577 + a_{0i}^4\right) \cdot UTD^{0.23} \cdot FEP^{0.37} \quad R^2 = 0.94$

Model of production function of resource and performance activity (RDA) depending on the factors of production that characterizes the staff activity, namely the level of organization and content of labor activity (OZTDA) and factors of production that characterizes the resource costs activity, namely the level of financial and economic activity

(FEA), is built in *Eviews* [15] and shown in Fig. 6.

DependentVariable: RDA?
Method: Pooled EGLS (Cross-section weights)
Sample: 2013 2016
Includedobservations: 4
Cross-sectionsincluded: 7
Totalpool (balanced) observations: 28
Linear estimation after one-step weighting matrix

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.482701	0.076070	6.345489	0.0000
OZTDA?	0.165388	0.040028	4.131846	0.0006
FEA?	0.086322	0.096341	2.896005	0.0315
FixedEffects (Cross)				
_01--C	0.161972			
_02--C	0.086109			
_03--C	0.027283			
_04--C	0.025439			
_05--C	0.022135			
_06--C	-0.353525			
_07--C	0.030588			
Cross-section fixed				
WeightedStatistics				
R-squared	0.943985	Meandependentvar		0.862378
Adjusted R-squared	0.920400	S.D. dependentvar		0.466422
S.E. ofregression	0.071474	Sumsquaredresid		0.097061
F-statistic	40.02427	Durbin-Watsonstat		2.148073
Prob(F-statistic)	0.000000			

Fig. 6. The model of the production function of resource and performance activity (RDA)

The most adequate and economically reasonable model of resource and performance activity (RDA), their elasticities and adequacy criteria is given in Tab. 4.

Table 4

Models of resource and performance activity (RDA)

Factors of production		Factor of production that characterizes the resource costs activity	
		FEA	IIA
Factor of production that characterizes the staff activity	OZTDA	$RDA_i = \left(0.482 + b_{0i}^1\right) \cdot OZTDA^{0.16} \cdot FEA^{0.08}$, $R^2 = 0.94$	$RDA_i = \left(0.379 + b_{0i}^4\right) \cdot OZTDA^{0.14} \cdot IIA^{0.24}$, $R^2 = 0.97$
	VKA	$RDA_i = \left(0.998 + b_{0i}^2\right) \cdot VKA^{0.78} \cdot FEA^{0.19}$, $R^2 = 0.98$	$RDA_i = \left(0.652 + b_{0i}^5\right) \cdot VKA^{0.61} \cdot IIA^{0.24}$, $R^2 = 0.97$
	UTDA	$RDA_i = \left(0.749 + b_{0i}^3\right) \cdot UTDA^{0.04} \cdot FEA^{0.18}$, $R^2 = 0.97$	–
	MA	–	$RDA_i = \left(0.715 + b_{0i}^6\right) \cdot MA^{0.39} \cdot IIA^{0.26}$, $R^2 = 0.96$

Fig. 7 and 8 shows the values of the fixed effects for models of production function of

resource and activity potential (RDP) ($a_{oi} = e^{d_0 + d_{0i}}$) and resource and performance activity (RDA) ($b_{oi} = e^{c_0 + c_{0i}}$).

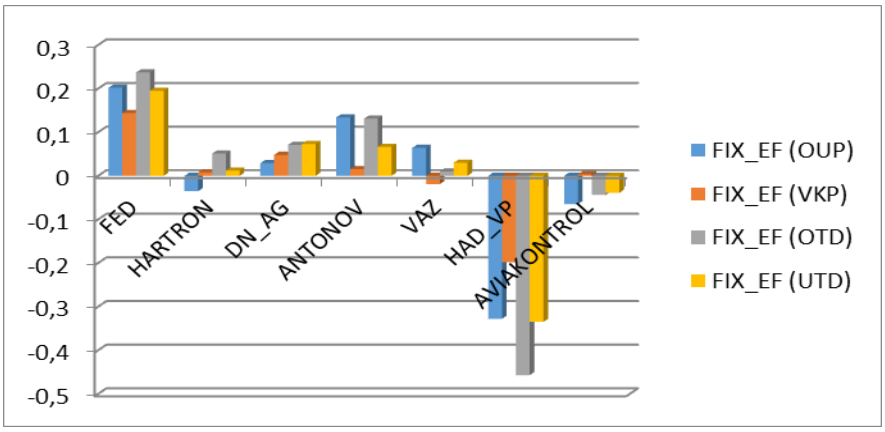


Fig. 7. Fixed effects of models of RDP formation for enterprises

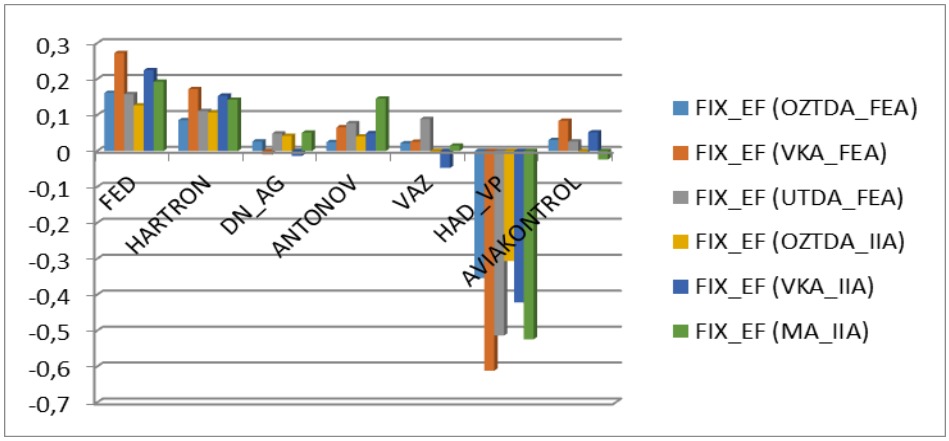


Fig. 8. Fixed effects of models of RDA formation for enterprises

Thus, on the bases of economic interpretation of fixed effects values which characterize unobservable specific characteristics and reflect differences in the formation of resource and activity potential and activity of the enterprises, such as personal effects management and the impact of environmental factors can be diagnostic assessment to identify strengths and weaknesses in management.

Thus, the modeling of RDP and RDA level for each enterprise is carried out for every dependency, as the model will vary according to the values of individual fixed effects, but calculation scheme of local components of potential and activity and their total level is the same for all enterprises. The results of calculations required to develop management measures of transformations in each situation and obtain forecasts of the effectiveness of their implementation.

The models of the production function of resource and activity potential (RDP) and resource and performance activity (RDA) make possible to provide assessment of efficient resources usage for transformations and to identify possible factors and problems in the management of production and employment. On the bases of indicators of transformation processes there is necessary to develop system-dynamic model of estimation and forecasting of imbalance for all potential elements that will predict the direct impact of the set of interrelated factors that are essential basis for management decisions in relation to stimulate transformation processes in enterprises.

So the research of economic efficiency of production factors and their transformations in Ukraine machine-building industry (for surveyed enterprises) makes possible to conclude that even a high level of resource potential in combination with activity potential without reasonable, clearly defined, adequate strategy of its sustainable usage and fast transformation processes in activity of development can't provide high competitiveness level.

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