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METHODS FOR ASSESSING THE IMPACT OF TECHNOLOGICAL VARIABLES OF SYSTEMS ON COSTS

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Abstract

The paper considers the method of calculating costs taking into account the effect of process parameters; the model of forecasting of costs of production resources based on the matrix of costs are described; presents the methods of assess the impact of technological variables complex spatial-distributed systems on costs.

Key words: Technological Parameters, Mathematical Model, System, Complex, Process, Algorithms And Models, Method Of Calculation

For analyzing the dependency of costs on the thickness and width of metal, you can build matrices of costs for the individual cost elements, for summary of costs by stage of processing or unit. Such matrices are constructed for each steel grade separately.

If known the defining technological parameters for all cost components, we can calculate these costs during the study period.

Basic data are:

- The data on volumes products M;
- The data of the defining technological parameters for each element of cost X^Z;
- Diagonal matrix of the coefficients of proportionality for each element of cost K^{ZX} (the number of elements of costs P).

In matrix form:

$$(M*X^{(Z)})*K^{(ZX)}=Z$$

On the first phase the research the matrix of proportionality $K^{(ZX)}$ is unknown. Having the source data for a base period (for example, for the month) production volumes $M_Б$, processing technology $X_Б^{(Z)}$ and resources expended $Z_Б$, can get a matrix $K^{(ZX)}$.

$$\left(M_Б * X_Б^{(Z)}\right) * K^{(ZX)} = Z_Б$$

Multiplying by the inverse matrix:

$$\left(M_Б * X_Б^{(Z)}\right)^{-1} * \left(M_Б * X_Б^{(Z)}\right) * K^{(ZX)} = \left(M_Б * X_Б^{(Z)}\right)^{-1} * Z_Б$$

In the end, have:

$$K^{(ZX)} = \left(M_Б * X_Б^{(Z)}\right)^{-1} * Z_Б$$

On the basis of generalized matrices coefficients of proportionality K_{Σ_I} for each of the studied periods, you can forecast resource consumption at other periods in all ratios K_{Σ_I}.

Using a matrix of coefficients of proportionality in the base period $K_{\Sigma base}$ and total consumption of process parameters during the study period $diag(M * X_\Sigma)$, it is possible to predict the consumption of resources in the current period according to basic odds [5,7,9].

$$Z_{\Sigma(study/\ base)} = diag(M * X_\Sigma)_{study} * K_{\Sigma base}$$

where

$Z_{\Sigma(study/base)}$ - matrix of the total costs during the study month on the basic;

$diag(M * X_\Sigma)$ – diagonal matrix for the study period;

$K_{\Sigma base}$– the matrix of coefficients of the base period.

Similarly, define the matrix of forecasts for all *(I)* the studied periods on the coefficients of proportionality of base *J* periods.

$$Z_{\Sigma(I,J)} = diag(M \cdot X_\Sigma)_{(I)} \cdot K_{\Sigma(J)}$$

If explore a T periods, the final matrix of the forecasts will contain [T (the number of matrices $K_{\sum(J)}$)] $\cdot$ [(T-1) (the number of predicted periods), $diag(M * X_{\sum})_{(I)}$] = [T*(T-1)] lines.
The final table for each cost component has the form (table 1).

Table 1The model of calculation of cost items

Forecasts of costs for periods	Technological parameters					The actual consumption of resources $Z_{R(I)}$
	X_1	X_2	X_3	…….	X_k	
the forecast for the period 1 on the period 2						$Z_{R(1)}$
the forecast for the period 1 on the period 3		$Z^{X_K}_{R(I,J)}$				$Z_{R(2)}$
……………..						…………
the forecast for the period T on the period (T-1)						$Z_{R(12)}$

Note to table 1:

X_k - technological parameter number k; $Z^{X_K}_{R(I,J)}$ - the value of the forecast for the period J of consumption of the resource R according to the period I in the parameter X_k.
To assess the influence of individual parameters on the cost elements separate the matrices of predictions for each parameter X_n are built (table 2).

Table 2Matrix of forecasts for the parameter X_n on T periods

Base periods (J)	The studied periods (I)						
	1	…	*J*	*I*	…	*T-1*	*T*
1	$Z_{R(1)}$						
…							
J			$Z_{R(J)}$	$Z_{R(InoJ)}$			

...							
T-1							
T							$Z_{R(T)}$

If in table 2 the number of the base and studied periods are equal (I=J), instead $Z_{R(InoJ)}$ of the actual consumption of resources during the study period $Z_{R(J)}$. In the end, it is possible to obtain average forecasts for individual periods and for the entire study period (e.g. a year). The average error of forecasts for the period on the studied parameter X_L:

$$\bar{\varepsilon}_{R(I)}^{X_L} = \frac{\sum_{J=1}^{T} \left| \frac{Z_{R(I)} - Z_{R(IJ)}^{X_L}}{Z_{R(I)}} \right|}{T}$$

where

$Z_{R(I)}$ - The actual consumption of resource R during the study period *I*;

$Z_{R(IJ)}^{X_L}$ - projected expenditure of the resource *R* on a complex of parameters X_L for the period *I* in the matrix of basic coefficients for the period *J*;

T – The number of projection periods.

The average error for the entire projection period for each technological parameters

$$\bar{\varepsilon}_{R}^{X_L} = \frac{\sum_{i=1}^{I} \bar{\varepsilon}_{R(I)}^{X_L}}{I}$$

An example of a forecast of resource consumption depending on technological parameters is given in table 3.

Table 3The forecast of electric energy consumption on the total compression, kW h

electric energy	January	February	March	April	may	June	July	August	September	October	November

January	**37561,9**	32831,56	36224,41	37126,2	35152,46	32464,75	33820,29	34183,49	36334,45	21470,35	20723,6
February	39837,2	**34820,3**	38418,7	39375,1	37281,8	34431,3	35868,9	36254,1	38535,4	22770,9	21978,9
March	37625,9	32887,5	**36286,1**	37189,4	35212,3	32520,0	33877,9	34241,7	36396,3	21506,9	20758,9
April	36125,78	31576,3	34839,43	**35706,74**	33808,46	31223,51	32527,23	32876,54	34945,26	20649,47	19931,27
may	37930,08	33153,37	36579,48	37490,11	**35497,02**	32782,97	34151,8	34518,55	36690,6	21680,8	20926,73
June	38387,54	33553,23	37020,66	37942,27	35925,14	**33178,36**	34563,69	34934,87	37133,12	21942,29	21179,13
July	39445,34	34477,82	38040,79	38987,8	36915,09	34092,61	**35516,13**	35897,53	38156,35	22546,93	21762,73
August	39183,54	34248,98	37788,31	38729,03	36670,08	33866,34	35280,4	**35659,27**	37903,1	22397,28	21618,29
September	36808,51	32173,05	35497,85	36381,55	34447,39	31813,59	33141,95	33497,86	**35605,68**	21039,71	20307,94
October	37157,86	32478,41	35834,77	36726,85	34774,34	32115,55	33456,51	33815,79	35943,62	**21239,41**	20500,69
November	37748,94	32995,04	36404,79	37311,07	35327,5	32626,41	33988,7	34353,7	36515,38	21577,26	**20826,79**
the average on the month	38025,07	33037,53	36664,92	37725,95	35551,47	32793,71	34067,75	34457,42	36855,37	21758,2	20968,83
error	2,6	5,1	2,6	5,7	2,6	2,9	4,8	3,8	3,9	3,2	2,5
the average error	**3,6**										

Using the data of table 1 it is possible to construct a regression model according to the actual consumption of resources from the predicted values of technological parameters.

$$Z_i = b_0 + \sum_{j=1}^{K} b_j \cdot Z_{i(I,J)}^{X_j}, i = 1,...,R$$

Since the values of actual and projected expenditures of resources comparable in size, the coefficients of the model b_j allow to estimate the impact of the predicted value of the cost component for the corresponding technological parameter on the real value of the investigated resource [1-4, 6, 8]. To evaluate the effectiveness of the use of individual parameters to predict the cost can be received by correlation matrix in table 1.

Correlation and regression analysis allow us to estimate the influence of parameters without forecasts $Z_i^{X_j}$. In this case, it is possible to evaluate the influence of the total consumption of each technological parameter $\sum_n MX_k$ on the cost components. Table 4 is formed.

Table 4 Total consumption of process parameters and the cost elements

period	products	weight	process parameters			Total consumption of process parameters $\sum_{i=1}^{n} m_i x_{ji}$			the cost elements		
			X_1	…	X_K	X_1	…	X_K	Z_1	…	Z_P
1	1	m_{11}	x_{11}		x_{K1}						
	…	….	…		…	$\left(\sum_{i=1}^{n} m_i x_{1i}\right)_1$	…	$\left(\sum_{i=1}^{n} m_i x_{Ki}\right)_1$	Z_{11}		Z_{P1}
	n	m_{n1}	x_{1n}		x_{Kn}						
…											
T	1	m_{1T}	x_{11}		x_{K1}						
	…	….	…		…	$\left(\sum_{i=1}^{n} m_i x_{1i}\right)_T$		$\left(\sum_{i=1}^{n} m_i x_{Ki}\right)_T$	Z_{1T}		Z_{PT}
	n	m_{nT}	x_{1n}		x_{Kn}						

To assess the impact of technological factors on the consumption of resources the mass of product is determined, which covers all elements of the alphabets b_{kj_k} of these parameters $m_{b_{kj_k}t}$ during the study period *t* (table 5).

Table 5The distribution of mass of products by elements of the alphabets of the parameters

period	process parameters			the cost elements
	X_1	…	X_K	

	b_{11}	$\cdots$	b_{1j_1}	$\cdots$	b_{1J_1}		b_{K1}	$\cdots$	b_{Kj_K}	$\cdots$	b_{KJ_K}	Z_1	$\cdots$	Z_P
1	$m_{b_{11}1}$		$m_{b_{1j_1}1}$		$m_{b_{1J_1}1}$		$m_{b_{K1}1}$		$m_{b_{Kj_K}1}$		$m_{b_{KJ_K}1}$	Z_{11}		Z_{P1}
$\cdots$														
T	$m_{b_{11}T}$		$m_{b_{1j_1}T}$		$m_{b_{1J_1}T}$		$m_{b_{K1}T}$		$m_{b_{Kj_K}T}$		$m_{b_{KJ_K}T}$	Z_{1T}		Z_{PT}

According to the data obtained from table 5 it is possible to construct models predict the consumption of resources from "total consumption" process parameters according to their distribution on the elements of alphabets.

$$Z_p = c_0 + \sum_{k=1}^{K} \sum_{j_k=1}^{J_k} c_{kj_k} m_{b_{kj_k}} \tilde{b}_{kj_k}, p = 1,..,P$$

where $\tilde{b}_{kj_k}$ - the average value of the element of the alphabet.

Conclusion

The algorithms and models for prediction of resource requirements for the production are developed, allowing providing more detailed cost information and assisting in the appointment of prices for different types of products, significantly reducing response times to changing economic and technological situation.

Methods of assess the impact of technological variables complex spatial-distributed systems on costs are considered.

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