Identification of business processes of the enterprise by intrinsic states method

V.G. Pluzhnikov[1,*], *S.I.* Kukharenko[1], and *S.A.* Shikina[1]

[1]South Ural State university, Chelyabinsk, Russia

Abstract. The identification of business processes of the industrial enterprise in the course of its operation process is considered in this article. These problems are solved by developing a model of the enterprise by intrinsic states method. Studying of parameters, which characterize the business processes, performs by principal component analysis. The proposed approach makes it possible to verify identity of links between the business processes parameters of the enterprise. The effectiveness of this approach demonstrates in terms of analysis and evaluation of business processes of the particular industrial enterprise.

1 Introduction

Today the role and the value of economic analysis of business processes indicators of industrial enterprises increase in modern economy. The existence of a set of functional strategy with contradictiry purposes is characteristic for the industrial enterprises (further the enterprise) in the course of its development. In this case need arises for the tool allowing to reach compromise as between purposes of an enterprise in general, as the purposes of separate subsystems in business processes (Mokeev, 2014).

In economics for the analysis of the effectiveness of an enterprise processes and the simulation of sustainable development the most common methods are used: financial analysis (Kovalyov, 2004), economic analysis (Watshem and Parramou, 1999), regression analysis (Uotsh, 1999; Pluzhnikov, 2015), simulation (Platonov, 2010), systems analysis using fuzzy logic (Nedosekin, 2003), data envelopment analysis (DEA - Data envelopment analysis) and principal component analysis (PCA) (Mokeev and Vorobyev, 2014).

However, the use of classical analysis and forecasting methods does not meet the quality requirements for results of business process analysis. Therefore it is necessary to talk about the need of development and use of new tools of analysis and forecasting of business processes parameters in the course of its development. This need has led to the creation and development of new methodological approaches in the context of the analysis of the efficiency of an enterprise functioning in general and the individual business processes.

The concept of the business process is currently no single definition (Andersen 2003). Specialists of organizational design represent some different definitions of business processes:

• first, they are treated as a set of different activities in which "input" is used one or more types of resources, as a result of this activity the "output" creates a product that represents value to the consumer (Hammer and Champy, 1997);
• secondly, a set of interrelated or interacting activities which transforms inputs into outputs, representing the value to the customer (Andersen 2003);
• third, as a stable, purposeful set of interrelated activities that transforms "inputs" into "outputs" representing the value to the end-consumer (International Standard ISO 9000: 2000).

Thus, the business process is understood as a set of procedures implementing the specific objectives of the subsystem in the sustainable development of the socio-economic system.

As part of the common goals of development of industrial enterprise are singled out as a research subject the following business processes:
• operating activity - aimed at the formation and support of the current activity;
• investment - associated with the process of investing in competition basis;
• increasing the efficiency of resource use (assets) - aims to increase the returns of resource use.

Research of business processes parameters and the identification of cause-and-effect relationships between them in the course of sustainable operation of business in the rapidly changing market conditions, is carried out by intrinsic states. It is the one of the directions of the principal component analysis method (PCA) Select the main component in the intrinsic method is carried out on the basis of the requirements for the development of socio-economic system. The origins of principal component analysis can be found in the following works: (Pearson, 1901), (Hotelling, 1933), (Frisch, 1901), (Rao, 1964), (Gunst, 1983),

* Corresponding author: Pvg777@bk.ru

(Bendoly, 2009) (Mokeev and Vorobiev, 2014) (Bunova and Krepak 2014).

The intrinsic states method allows to decompose the object state, presenting it as a set of noncollinear components. Because the principal components are independent with each other, their correlation coefficient tends to zero. This allows to pass on to a system of independent vectors (non-collinear) describing the (predictive) multicollinear dynamic system parameters.

Summary of intrinsic states method comes down to the calculation of eigenvectors and eigenvalues of the covariance matrix of the original data. The number of dimensions of the eigenvectors has the same number of dimensions as the original vectors of economic entity condition (and Mokeev, 2014).

Suppose the enterprise is described by a set of parameters x_{ki}^0, where i – parameter number (i=1, 2, 3,...,n), k – point number of timeframe (k = 1, 2, 3, ... ,m). The values of each parameter in different time points (k) form a temporal series, which is denoted by the vector x_i^0. Thus, the space parameter SPP can be represented as a matrix of the original vectors:

$$X^0 = \begin{bmatrix} x_{11}^0 & x_{12}^0 & \cdots & x_{1i}^0 & \cdots & x_{1n}^0 \\ x_{21}^0 & x_{22}^0 & \cdots & x_{2i}^0 & \cdots & x_{2n}^0 \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ x_{i1}^0 & x_{i2}^0 & \cdots & x_{ii}^0 & \cdots & x_{in}^0 \\ \vdots & \vdots & \cdots & \vdots & \cdots & \vdots \\ x_{m1}^0 & x_{m2}^0 & \cdots & x_{mi}^0 & \cdots & x_{mn}^0 \end{bmatrix}. \quad (1)$$

In this case, the normalizing of the matrix about the arithmetic values is carried out in such a manner:

$$x_{ji} = x_{ji}^0 - \overline{x_i}. \quad (2)$$

On the basis of the obtained matrix X the covariance matrix is rated:

$$A = (1/k)X^T X, \quad (3)$$

where X – parent matrix; X^T – transpose of parent matrix.

In the next stage, the calculation of the eigenvalues and eigenvectors of the matrix A is carried out, i.e. , its decomposition:

$$A = VLV^T, \quad (4)$$

where L - scalar matrix, which diagonal sorted by descending eigenvalues, V - orthogonal matrices matrix of eigenvectors.

Eigenvector has property of orthogonality and is rated within the accuracy of factor that allows to get a quantitative estimation of baseline factors intercommunication (Mokeev 2014). This vector has the number of dimension as the original vectors of economic entity condition. Thus, the state of an enterprise can be described by a set of principal components, where each principal component reflects not separate original parameter, and shows the quantitative estimation of the impact of the original factors in each business process group:

$$z_{kj} = \sum v_{kj}(x_{ki} - \overline{x_i}) \quad (5)$$

where *Zkj* – the value of principal component of j-th new factor at k-th time point, *Vkj*– coefficient of j-th intrinsic state, corresponding to *k* – time point and *i* – base value.

Thus, the state of socio-economic system at any given time can be assumed as a weighted combination of intrinsic states.

The important point is the opportunity to research the original enterprise parameters in the system of independent (orthogonal) eigenvectors reflecting the behavior of the original (multicollinear) indicators. In addition, each main component is based on a group of input parameters defined by the requirements of the selected business process models (Pluzhnikov and Shikina, 2014).

Parameter analysis of business processes of social economic system in terms of an industrial enterprise. So as to analyze the parameters of an industrial enterprise in the framework of the above problem, select the following indicators: non-current assets (NcA); current assets (CA); equity capital (EC); non-current liabilities (NL); current liabilities (CL); cost price (Zcp); net profit (NP); the value of investments (Inv). The value of investments is rated by increment of real total assets value (Shikina and Pluzhnikov, 2010).

As the object of research the industrial enterprise public limited company (OAO "VMZ") is chosen (Pluzhnikov 2015; "VMZ" 2015). The results of activity of OAO "VMZ" over 2006 to 2014 period are presented in Table I. Dynamics of the basic indicators of the enterprise activity is presented in Figure I.

Table 1. Parameters of the basic indicators, RUB bn.

Date	Parameters							
	NcA	**CA**	**EC**	**NL**	**CL**	**Zcp**	**Inv**	**NP**
01.01.2006	11.9	17.4	14.0	5.3	10.1	26.0	5.7	2.8
01.01.2007	14.6	29.9	20.6	7.7	16.1	43.5	16.4	6.7
01.01.2008	19.0	31.1	29.5	8.3	12.3	48.8	7.1	10.9
01.01.2009	22.0	55.5	35.4	12.0	30.0	51.9	29.1	5.9
01.01.2010	26.9	58.9	40.2	13.1	32.6	59.5	10.2	7.8
01.01.2011	44.2	54.2	57.6	18.1	22.7	67.9	14.5	19.4
01.01.2012	55.5	51.9	61.9	16.0	29.6	72.2	14.3	8.8
01.01.2013	60.8	53.3	64.7	15.3	34.1	62.2	12.2	5.1
01.01.2014	63.1	57.2	68.2	24.6	27.5	61.8	11.8	4.8

The analysis of the dynamics of the base values of OAO “VMZ ” indicates their irregular growth, which is caused by factors of external and internal environment.

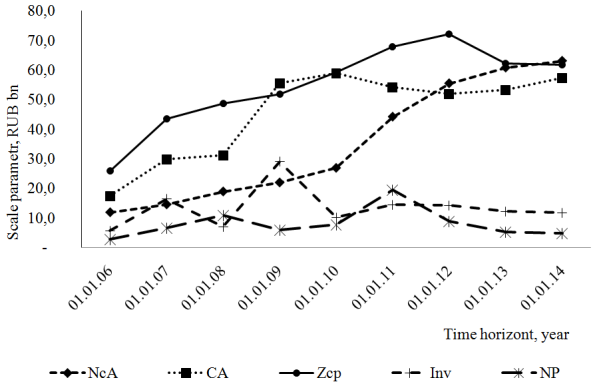

Fig. 1. Dynamics of the basic indicators of the OAO "VMZ" activity over the 2006 to 2014 period.

Evaluation of economic performances is based on analysis of the value and / or the rate of change in the analysis of the effectiveness of operation of the business. But we need not evaluate individual performance, but the total sum of parameter changes. So as to do this, we place demands on the economic-mathematical model that can help assess not only the dynamics of all parameters and trends in their change relative to each other (dynamic business process characterization).

We perform this assessment using the proposed approach. We carry out the selection of considerations for the selection of intrinsic states in accordance with the applied requirements to the specified business processes.

As part of operating activities - increase in production (directly determined by the cost of production Zcp), usually accompanied by the increase: the value of non-current (NcA) and current (CA) assets; the value of property (EC) and non-current (NL) of short-term (CL) liabilities sources; net profit (NP).

As part of the investment activity the growth of investments (Inv) is usually accompanied by the increase of (Kovalev, 2004):

• production (Zcp), more efficient use of non-current assets (NcA);
• current assets (CA) due to increased production (Zcp);
• debt financing sources (NL and CL);
• efficiency of production and net profit (NP),

In the framework of resource efficiency use increasing in production leads to:

• the reduction in requirement for working capital (CA) and non-current (NcA) resources;
• the reduction in requirement for borrowed resources (NL and CL);
• the increase the net profit (NP).

We determine the ratios of their intrinsic states, in accordance with the research (Makeev, 2014). The result is eight coefficients of intrinsic states shown in Table II. The coefficients of the eigenvectors have different values in various states. This means that the parameters growth with a positive value within the limits of its intrinsic state, leads to an increasing in the other and vice versa. Such parametric variation characterizes trends for the intrinsic state. To form the economic model will analyze the intrinsic states in accordance with the requirements for the selected business processes.

Table 2. Coefficients of intrinsic states.

Name title	Eigen-vectors							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
NcA	0.56	-0.50	-0.24	0.14	0.12	0.04	0.37	-0.45
CA	0.38	0.61	-0.12	-0.30	-0.41	0.02	-0.12	-0.45
EC	0.58	-0.20	0.05	0.08	-0.15	0.23	-0.59	0.45
NL	0.16	-0.03	-0.02	0.06	-0.57	-0.47	0.47	0.45
CL	0.21	0.33	-0.40	-0.29	0.43	0.30	0.36	0.45
Zcp	0.37	0.23	0.60	0.00	0.48	-0.46	0.03	0.00
Inv	0.03	0.41	-0.22	0.88	0.07	0.02	-0.01	0.00
NP	0.03	0.07	0.60	0.12	-0.21	0.65	0.39	0.00

The first intrinsic state characterizes the basic trend of enterprise development (83.59% variance of all parameters), in which the increase in production (Zcp) is accompanied by the growth of all parameters (NcA, CA; EC; NL, CL, Inv, NP). These parameters reflect the business operating.

The second intrinsic state characterizes the trend of enterprise development (9.83% variation of parameters), in which the increase in production (Zcp) lead to the increase in working capital (CA) with the decrease in non-current (NcA) assets that may have caused the increase in efficiency of use of the latter. The process is accompanied by the increase in short-term obligations (CL) and investments (Inv). These parameters characterize the business processes of investment activity.

The third intrinsic state reflects the trend of enterprise development (3.63% variation of parameters), in which the increase in production (Zcp) lead to the increase in net profit (the NP), to the reduction in requirement for borrowed capital (NL, KO) and the reduction in requirement for non-current and current (NcA, CA) assets. These parameters correspond to the business processes aimed at the growth of returns, effective asset application.

All other values of intrinsic states are insignificant (less than 2.95% of variation of all parameters) we leave them outside the research.

Thus, the first intrinsic state reflects the business operating, the second intrinsic state reflects the business processes of investment activity, the third intrinsic state reflects the business processes to improve resource efficiency.

2 Approvement

Calculate the values of model parameters for the selected principal components. Calculation of model parameters is performed according to the method presented in the paper (Mokeev and Vorobyev, 2014). In our case, we choose to test the identified first, second and third principal components (Table II).

We perform analysis of the obtained comparative evaluation by the method of closeness estimate of the actual values to the model ones [11]. Calculate the

average of the absolute percentage error (MAPE) by the formula:

$$E_1 = \frac{1}{m} \cdot \Sigma \left| \frac{x_{ki} - \hat{x}_{ki}}{x_{ki}} \right|^* \cdot 100\% , \quad (6)$$

where m – number of observations, – fitted value of the i-th factor in the k-th period, x_{ki} – actual value of the i-th factor in the k-th period.

Obtained results are shown in Table III.

Table 3. Value of average relative approximation error.

Name title	Value description							
	NcA	**CA**	**EC**	**NL**	**CL**	**Zcp**	**Inv**	**NP**
E, %	+2.98	+4.12	+2.27	+9.67	+6.49	+2.80	+23.84	+17.31

The average approximation error stays within the range from 2.27% to 23.84%, which leads to the conclusion that the development of the industrial enterprise corresponds to the model of effective trend. The values of the mean relative approximation error of the values Inv and NP contain higher values, they are listed in the Table III. These deviations can be explained by the influence of unaccounted factors (such as changes in demand, changes in the conditions of attraction of investments, lending rates, etc.). Nevertheless, the results allows for the conclusion about the degree of accuracy of coincidence of the results within the selected three intrinsic states.

3 Conclusion

The developed model is a promising tool for the comprehensive analysis and evaluation of the effectiveness of the business processes of the industrial enterprise.

Analysis of the enterprise behavior results in the form of business processes allows to develop an economic-mathematical model of the real activity of the enterprise and to forecast its activity.

The work was supported by Act 211 Government of the Russian Federation, contract № 02.A03.21.0011.

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