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Modeling of small and medium enterprises' sustainable development

Modelización del desarrollo sostenible de las pequeñas y medianas empresas

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Content

ABSTRACT:
Necessity for modeling of processes of small and medium-sized businesses development to ensure their sustainability has been highlighted in the paper. Modeling for sustainability enhancement was carried out through a system of indicators characterizing the development of small and medium enterprises (SMEs), which consists of three groups: parameters of the SMEs system; indicators of disturbances to the entrepreneurial system; controlled variables of SMEs. Trend analysis and forecasting were used in the paper as key statistic methods of implementing a model of small and medium enterprises' sustainable development.
Keywords: Sustainability, SMEs, system, economic and mathematical modeling, forecasting, trend analysis

RESUMEN:
La necesidad de modelar procesos de desarrollo de pequeñas y medianas empresas para asegurar su sostenibilidad ha sido destacada en el documento. El modelado para la mejora de la sostenibilidad se llevó a cabo a través de un sistema de indicadores que caracterizan el desarrollo de pequeñas y medianas empresas (PYME), que consta de tres grupos: parámetros del sistema de PYMES; Indicadores de perturbaciones del sistema empresarial; Variables controladas de PYME. El análisis de tendencias y la predicción se utilizaron en el documento como métodos estadísticos clave para implementar un modelo de desarrollo sostenible de las pequeñas y medianas empresas.
Palabras clave: Sostenibilidad, PYME, sistema, modelización económica y matemática, previsión, análisis de tendencias

1. Introduction

The development of small and medium enterprises (SMEs) in Russia is relatively stable by nature. In recent years, there has been a dynamic stability both in the number of small enterprises, and in the share of employees in small enterprises, and, very importantly, the value added GDP, an indicator most fully and purposefully reflecting the new level of quality characteristics of small businesses growth. However, the trend of sustainable growth is minimal, and in comparison with foreign countries, where the level of entrepreneurial activity has a long-term traditional and historical perspective, Russia has a high level of retard in some qualitative indicators of small business development. Functional and generally accepted indicators for assessing the sustainability of country' economic development, industries and businesses are the growth rate of GDP and the share of their economies in it. Thus, according to the Ministry of economic development of the Russian Federation, by the end of 2013 the contribution of small and medium enterprises in the country's GDP amounted for 21%. While this rate in the USA and Germany was at the level of 50-52%, in France - 56-62%, in Japan - 52-55%. By share of employment in SMEs in total employment, Russia ranks 25,2 % (for comparison: the US and France - 54%, Germany - 46%, Japan 78%). The target is declared by the Russian government to achieve the level of 50-60% (Cantillon 1755).

All this has led to the formation a new model of small and medium enterprises sustainable development. Such modeling will allow solving a number of problems:

1. Forming the trajectory of SMEs' system development through analysis of time series;

2. Monitoring the processes of SMEs' system development in a certain point or period in their development;

3. Diagnosing the sustainability of SMEs' development processes according to the monitoring results;

4. Predicting pre-crisis or crisis situations to determine the possibility of confrontation or prevent their occurrence;

5. Ensuring the sustainability of SMEs system with the transition to a new stage of development through timely arrangements correcting the trajectory of the system under investigation.

Implementation of the model mentioned above will allow SMEs in the pre-crisis or crisis to come to a new level and gain the ability in the course of development to achieve strategic objectives for the formation of competitive advantages and efficiency of operation. In addition, sustainable growth should occur in conditions where the entrepreneurial risk factors and the changing business environment have a significant impact on the state of equilibrium and directions to achieve the maximum stable growth of entrepreneurial income (Juglar 1868).

2. Method

Modeling in given conditions is a necessary tool in the sustainable development of complex socio-economic systems, including the system of SMEs.

An extremely important stage of any modeling is the choice of indicators that reflect both the object of modeling and its external environment and the relationships between them. The solution to this problem is very difficult, since it is associated with following the contradictory requirements of completeness and simplicity. In addition, as we know, socio-economic systems are described by a huge number of various indicators (Bondarenko 2005; Greiner 1972).

From the standpoint of system analysis, synthesis sustainability of SMEs systemic development is possible only with the use of interrelated indicators system, each of which characterizes a particular facet of the investigated processes and phenomena.

In the process of studying the stability of small and medium-sized businesses, we have found the need to allocate three main groups of indicators characterizing respectively:

- У = (y1, y2,…, yn) – parameters of the system development of SMEs;
- X = (x1, x2,…, xm) – driven (active / reactive) system variables SMEs in sustainable development;
- Z = (z1, z2,…,zk) – indicators of disturbance variables on the entrepreneurial system (external and

internal).

The decision-making about the use of an indicator should be based on several aspects that determine the feasibility and effectiveness of its use (Levuchkina 2013). It is important to note that the choice of indicators is not a localized procedure for each of them. The system of interrelated and interdependent metrics demonstrating integrity and completeness in the framework of the challenge of ensuring the sustainability of the system development of SMEs is being built. This system is a dynamic object that requires periodic updating and composition of indicators and their significance (Kitchin 1923).

Based on the above, we have proposed the following system of indicators for use in the process of ensuring the sustainability of the system development of small and medium enterprises (Table 1). Note that this list of indicators can be widened or narrowed depending on tasks, socio-economic situation and the availability of information and analytical resources.

2.1 Modeling methodology to ensure the sustainability of the small and medium enterprises systemic development

Mathematical modeling algorithm of sustainable development is carried out in the following areas:

1. The formation of the trajectory of system development in SMEs:

- quantitative justification of parameter values and states of motion of a system;
- SMEs and the environment in the course of this cycle of development (at the fixed points);
- definition of tolerance values of indicators of entrepreneurial development system and its external environment - parallelepipeds for all variables defined by the vectors X, Y, Z, $\frac{dY}{dt}$, in all the fixed points;
- construction of the matrix phase states of the SMEs system.

2. Monitoring of development processes of SMEs system:

- building trends of the studied parameters;
- obtaining forecasts;
- adaptive forecasting.

Table 1. System of indicators for assessment the SMEs' sustainable development

Production potential	Financial opportunities	Organizational and management activity
Managed (active-reactive) variables X of SMEs system		
fixed assets (income ratios, disposal, depreciation); turnover; cost of production; number of innovative enterprises; costs of technological innovation proportion of enterprises with technological innovation; coefficient of internal funds availability	investment in fixed assets; equity and debt; proportion of funding sources to power its own funds and long-term liabilities	number of enterprises; average number of employees; number of newly established and liquidated companies; average wage; competitiveness; turnover rate; skill level of workers; fund utilization rates of working time; index of business activity

Parameters of Y development of SMEs		
profitability (total, production);	return on assets;	net profit per 1 ruble turnover;
operational performance	financial stability; profit per enterprise - growth rates; liquidity; trial balance financial result	volume of 1 ruble wages; return on sales; share of profitable enterprises

Indicators of disturbances Z on the SMEs system	
Internal	External
composition and use of fixed assets; movement of working capital; consumption of materials; efficient use of human resources; level of marketability of production; selling expenses (internal pricing mechanism)	inflation and price indices; budget expenditure for the implementation of state support for SMEs; interest on the loan; regional average wages; rates of taxes and fees; deductions for social insurance, health insurance, the Pension Fund, the State Fund for Employment of the Russian Federation; natural resource potential; purchasing power of the population; rental fee; Indicators of the competitive environment; economically active population.

3. Diagnosis sustainability of SMEs development processes:

- establishment of belonging indicator values of the respective parallelepipeds;
- predictive analysis of the situation;
- measurement of sustainability levels and sustainability trends in the time series of the parameters for SMEs;
- identification phase state;
- identification of crisis situations.

4. Diagnosis of crisis situations:

- characterization of pre-crisis or crisis phase - occurring or projected;
- identifying the nature of the violation on the natural phase state of the SMEs system;
- analysis and assessment of the characteristics of pre-crisis or crisis situations with the use of sustainability indicators defined by the vectors $У(t), \frac{dY(t)}{dt}, Z(t)$ и $X(t)$;
- analysis and assessment of the characteristics of the pre-crisis or crisis situations with the use of sustainability indicators defined by the vectors $У(t), \frac{dY(t)}{dt}, Z(t)$ и $X(t)$.

5. Sustainable development of the SMEs system:

- quantitative substantiation of the response of X to disturbances Z based on the use of correlation

and regression analysis;
- quantitative justification of the adjustment path of development;
- quantitative justification of the transition to a new development cycle;
- quantitative justification of the transition to a new life cycle of converted SMEs system.

2.2 Mechanism of modeling sustainable development for small and medium enterprises

General scheme of using mathematical modeling methods in the sustainable development of the SMEs system is presented in figure 1. It should be noted that mathematical modeling is required to serve all stages of the algorithm ensure the sustainability of SMEs system development, and that is reflected on the submitted scheme (Litvak 2004).

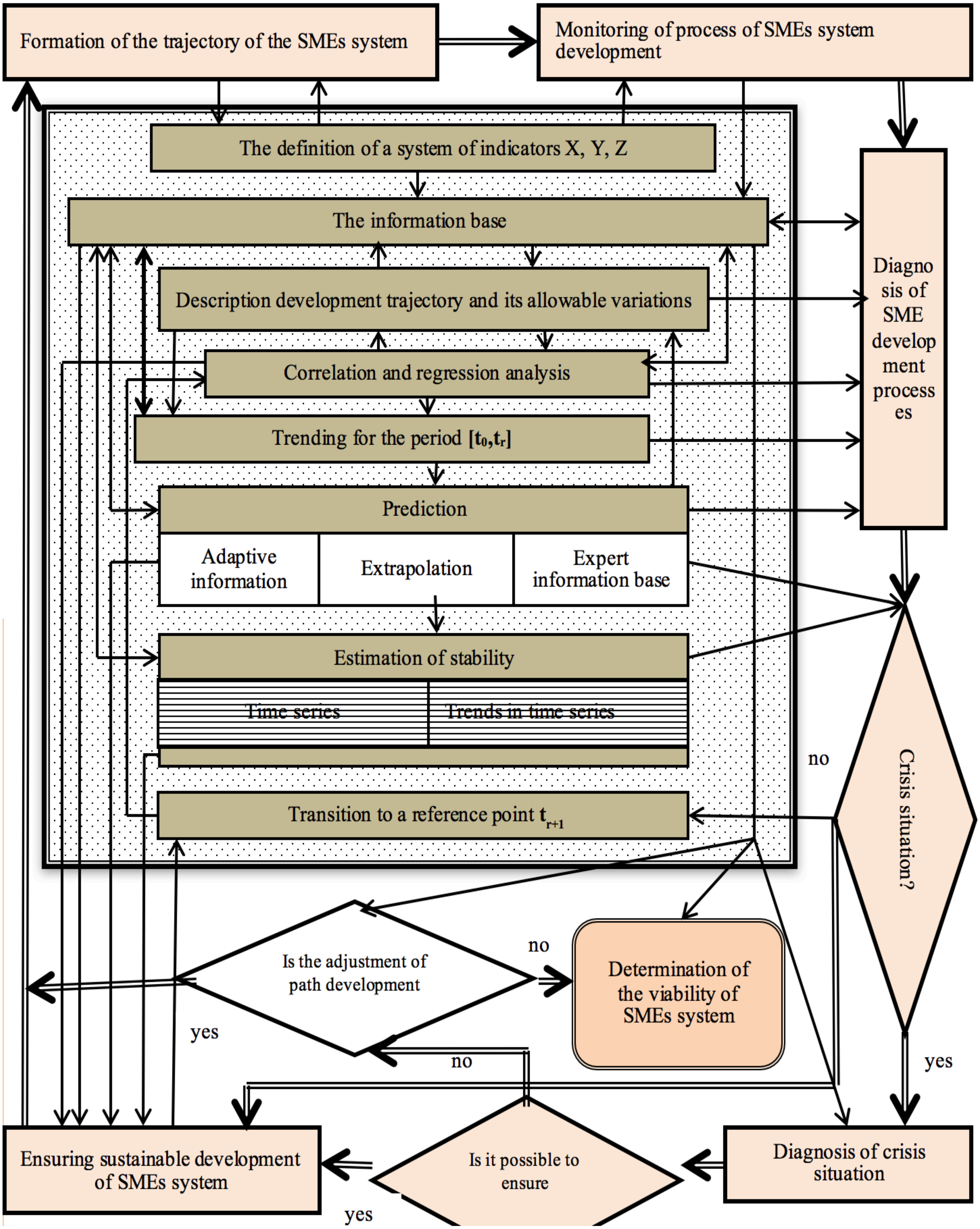

Figure 1. Mathematical modeling in the sustainable development of SMEs system

The definition of indicators X, Y, Z system on the one hand is a common problem, and its solution is associated with many problems: informational, analytical, financial. Despite existing both its own and similar business systems' experience, it often requires taking into account specifics of both a particular system SMEs and chronotopes features of a certain socio-economic situation should be taken into consideration. Here appropriate expert technology should be used in the framework of the organization of the information and analytical processes (Levushkina, et. al. 2016).

The formation and use of the information base to ensure stability of the system development of SMEs should occur continuously. It should reflect each step of the algorithm as a whole, and mathematical modeling in particular. Taking into account the scale of tasks, the necessary condition for the success of their solution is the use of modern computer technology.

Description of the trajectory for SMEs system development is carried out in terms of indicators X, Y, Z system, that is, the trajectory includes not only the expected outcomes of the development and the efforts of X to ensure their sustainability, but also predictable disturbance Z - external and internal. This means you must use a generalized notion of a trajectory of the system development of SMEs, which is a system of sub trajectories defined by the vectors X, Y, $\frac{dY}{dt}$, Z. A temporal reference point $t_r \in [t_0, T]$, r = 1, 2,..., p is determined initially to set the trajectory, throughout the development cycle of the SMEs system, which must necessarily include phase transitions of the development cycle. Further the values are defined by the vectors $X(t_r)$, $Y(t_r)$, $\frac{dY(t_r)}{dt}$, $Z(t_r)$, in each of the reference points:

$Y_r = Y(t_r) = (y_1(t_r), y_2(t_r),..., y_n(t_r))$ – benchmark parameter values of the system development of SMEs in the control (reference) points $t_r \in [t_0, T]$, r = 1, 2,..., p; $t_r \in \Phi_j, j = 1,2, \dots ,5$; $Z_r = Z(t_r) = (z_1(t_r), z_2(t_r),..., z_k(t_r))$ - values for the indicators disturbing effects on the system of SMEs in the control (reference) points $t_r \in [t_0, T]$, r = 1, 2,..., p;

$X_r = X(t_r) = (x_1(t_r), x_2(t_r),..., x_m(t_r))$ - values of governors (reactive or proactive, active) variables in the control (reference) points $t_r \in [t_0, T]$, r = 1, 2,..., p.

Thus we form a generalized point of the trajectory of the system development of SMEs.

However, the probability that the development will be fully and accurately answer a given point of the trajectory is negligible. Although theoretically this type of scenario, of course, is not excluded. Generalized trajectory of the SMEs system acts as a certain corridor, or rather a system of corridors that define changes in the constituent vectors $X(t_r)$, $Y(t_r)$, $\frac{dY(t_r)}{dt}$, $Z(t_r)$.

These corridors are defined by a set of parallelepipeds $\Pi_{Yr}, \Pi_{Xr}, \Pi^{d}_{Yr}, \Pi_{Zr}$, где$\Pi_{Yr}$- a box that defines the valid values for the parameters of the system development SME at time t_r, respectively, defined by the inequalities:

$$\{y^0_{1r} \le y_1(t_r) \le y^1_{1r}; y^0_{2r} \le y_2(t_r) \le y^1_{2r}; \dots, y^0_{nr} \le y_n(t_r) \le y^1_{nr}\}, (1)$$

in which the value y^{d0}_{lr}, y^{d1}_{lr}, l = 1, 2,..., n, as in the case of the stability condition specified in the determination or adjustment of the trajectory of the system development of SMEs.

$$Z(t_r) \in \Pi_{Zr} = \{z^0_{1r} \le z_1(t_r) \le z^1_{1r}; z^0_{2r} \le z_2(t_r) \le z^1_{2r}; \dots, z^0_{kr} \le z_k(t_r) \le z^1_{kr}\}, (3)$$

$$X(t_r) \in \Pi_{Xr} = \{x^0_{1r} \le x_1(t_r) \le x^1_{1r}; x^0_{2r} \le x_2(t_r) \le x^1_{2r}; \dots, x^0_{mr} \le x_m(t_r) \le x^1_{mr}\}, (4)$$

in which the value z^0_{lr}, z^1_{lr}, l = 1, 2,..., k ; x^0_{lr}, x^1_{lr} , l = 1, 2,..., m, as in the case of other values are specified in the determination or adjustment of the path (cycle) of the system development of SMEs.

2.3 Problems of realization the small and medium enterprises sustainable development model

The main problem here is to find the values of quantities y_{lr}^{0}, y_{lr}^{1} , l = 1, 2,..., n; y_{lr}^{d0}, y_{lr}^{d1} , l = 1, 2,..., n; z_{lr}^{0}, z_{lr}^{1} ,l = 1, 2,..., k; x_{lr}^{0}, x_{lr}^{1} , l = 1, 2,..., m, defining the boundaries of the above parallelepipeds. Here in a particular combination we apply the following approaches: using previous experience (its own and similar business structures), analog, design, forecasting, expert.

As a result we get for each of the 2n + k + m parameters set by the vectors X, У, $\frac{dY}{dt}$, Z, their own projected corridor for the acceptable values change throughout the development cycle of the system SMEs (Fig. 2).
This corridor, in addition to the states of the system SMEs and the environment in each fixed point determines the possibility of a steady transition to the next state. Referring to this corridor the stability condition for each indicator is the value in a preset condition matching a given datum point, and the stability of motion with respect to the indicator is finding an appropriate motion vector in a given sector.

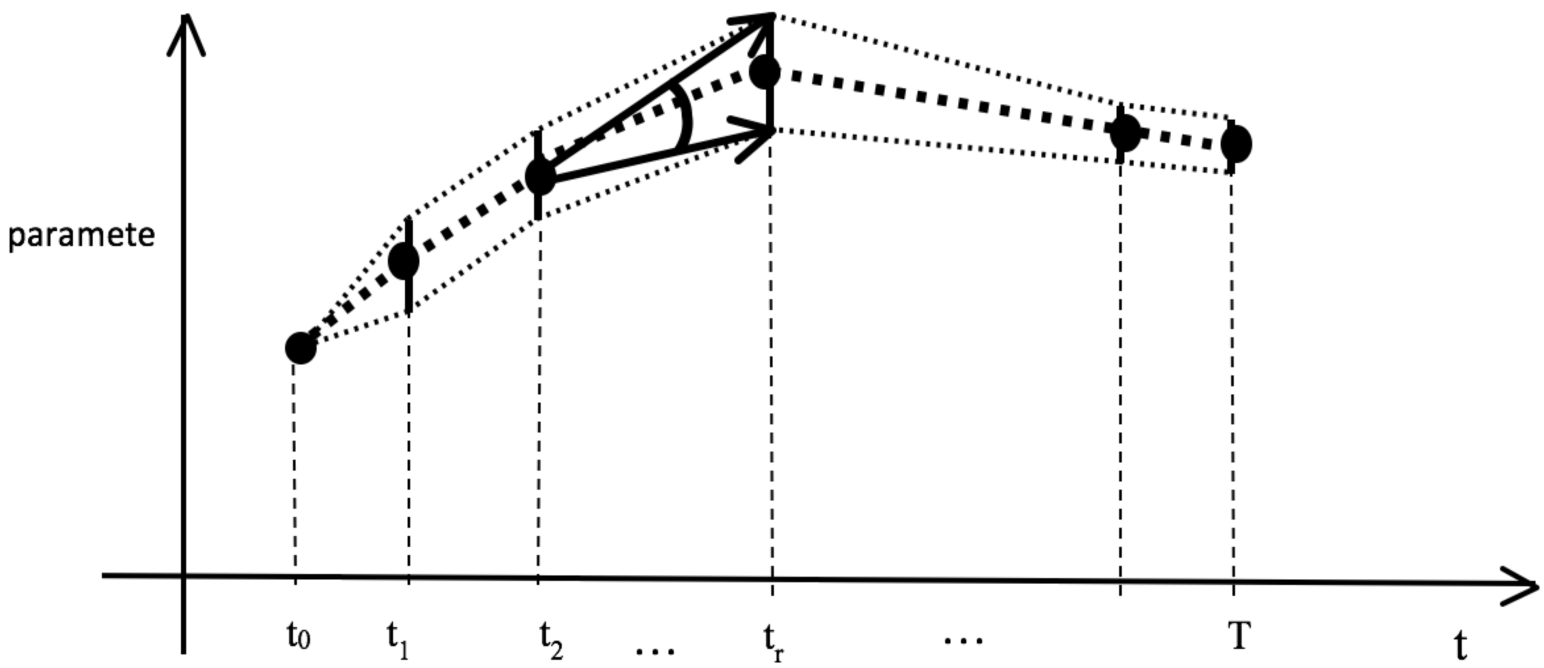

Figure 2. Acceptable variations of the parameter

The determination of changes stability in the parameters of SMEs development should be based not only on hit test or not getting the values defined by the vectors X(t_r), У(t_r), $\frac{dY(tr)}{dt}$, Z(t_r) at the fixed points t_r, corresponding to the appropriate parallelepipeds. One should also monitor the affiliation of the predicted values of the coordinates of the vectors X(t_{r+1}), У(t_{r+1}), $\frac{dY(t_{r+1})}{dt}$, Z(t_{r+1}) parallelepipeds for reference points t_{r+1}, and in critical cases for subsequent reference points too. This is not always enough for such complex and dynamic systems as SMEs. It is especially applied to crises - actual and/or projected (Nikitenko, et. al. 2015).

During the implementation cycle of SMEs development in the result of monitoring of development processes time series for all monitored parameters are generated. Measurement of their sustainability provides quantitative indicators for assessing the sustainability of the business system as a whole.

The stability of time series is usually considered in two aspects - the resistance levels of the time series and sustainability trends. We need to monitor changes in the values of the two groups of indicators, as well as the dynamics of their values for the following time periods (and corresponding time series of values of indicators): [t0, tr], [t0, tr+1], [tr-1, tr], [tr, tr+1]. This approach allows us to assess the sustainability of the system development of SMEs taking into account historical data, current situation and predicted values of the studied variables (Kuznets 1973).

In this case, we assume that for sufficiently large systems due to their inertia, the development processes in the absence of crisis conditions occur evenly, smoothly. Violation of this uniformity can also be seen as symptoms of unsustainable development of SMEs, and often as signs of a crisis.

Usually the sustainability indicators time series are considered from the point of view of preserving the desired trend. In our case, the role of this trend, or rather, because of the multiplicity of indicators, trends, is given to the generalized trajectory of the system development of SMEs, which is determined by the vector of the resulting indicators У(t) = (y1(t), y2(t),…, yn(t)), variable on the interval [t0, T] at the fixed points. Moreover, a generalized trajectory can be set both to reflect certain points and "corridors" . The first one serves as the basis for calculation of indicators of sustainable development, and the second one defines the boundaries of acceptable variations in the values of these indicators. It is also obligatory to calculate indicators of stability of the time series, reflecting disturbance (vector Z) on the studied entrepreneurial system, and the available means to counteract with them (the vector X).

2.4. Methods of assessing the time series sustainability

Approaches discussed below to assess the time series sustainability are applicable to all of the above indicators. We will bring them to the resulting indicators Y(t) = (y1(t), y2(t),…, yn(t)). In this case, we assume that the interval [t0, tr] contains sufficient for the correct calculation number of reference points and therefore members of the time series. Members of a time series can be both actual and projected.

The magnitude of variability average time series for indicator development yi(t), i = 1, 2,…, n, at the time of passing the reference point tr is calculated from the classification levels of the time series corresponding to favorable or non- favorable values of this indicator. In particular, one can use the following formula

$$R_{y_{ir}} = \bar{y}_{ir_B} - \bar{y}_{ir_H}, (5)$$

where $\bar{y}_{ir_B}$ - the average value of the levels of the time series for the interval $[t_0, t_r]$ situated above a predetermined path of development - favorable outcome;

$\bar{y}_{ir_H}$- average value of the time series for the interval $[t_0, t_r]$, located below the trajectory of development - not favorable outcome (Juglar 1862).

If all the considered time series levels are above or below the path of development for this indicator, it is possible to conclude favorable or not favorable business development situation, depending on the fact whether excess or downgrade is favorable or non-favorable for the test indicator $y_i(t)$ development of SMEs.

Instead of absolute indicator (5) you can also use a relative indicator of sustainability - the sustainability index

$$I_{y_{ir}} = \frac{\bar{y}_{ir_B}}{\bar{y}_{ir_H}} * 100 \ (6)$$

Without loss of generality we assume that the course of events is favorable , when the value of the index $y_i(t)$ in a fixed point is higher than the corresponding values of the trajectory of development. Then, as the most favorable it is possible to consider the case when $I_{y_{ir}} = \infty$, that is $\bar{y}_{ir_H} = 0$, and not favorable when $I_{y_{ir}} = 0$, that is, $\bar{y}_{ir_B} = 0$. In general, the closer to 100 the index value, the smaller the variability index and higher stability (Woldie & Leighton 2008).

3. Results

In our opinion, one should take into account the situations where the levels of the time series being located above or below the trajectory for this indicator, may go beyond the specified corridor of its variations, that is, not to get into the appropriate parallelepipeds . Then, for generalization of formulas (5) and (6), it is advisable to use the following situational gradation depending on the location level time series in relation to the trajectory of development for this indicator, namely, the level of the time series is:

- higher trajectory and is within a specified corridor - favorable outcome;
- below trajectory and is within a specified corridor - relatively unfavorable outcome;
- higher trajectory, but misses the specified corridor - conditionally favorable outcome;
- lower trajectory, but misses the specified corridor - unfavorable outcome.

However, one should take into account the fact that in the study of stability of development of SMEs in each situation one determines which provisions are favorable or not favorable (Lyles, et. al. 2004).

The variability of the values of *yi(t)* and hence their stability on the interval [t0, tr] in absolute values represent the average linear and the mean square deviation. Usually these deviations are calculated relative to the mean value of the values on an interval or relative trend that represents the trend on the interval [t0, tr]. We as a reference point we start from the set indicator trajectory of development for this segment. As a result we get the formula for each datum point tr:
average linear deviation -

$$d_{y_i}(t_r) = \frac{\sum_{j=1}^{r} |y_i(t_j) - \tilde{y}_i(t_j)|}{r}; \quad (7)$$

standard deviation

$$s_{y_i}(t_r) = \sqrt{\frac{\sum_{j=1}^{r} (y_i(t_j) - \tilde{y}_i(t_j))^2}{r}}, \quad (8)$$

where $y_i(t_j)$- the metric actual value $y_i(t)$ to the reference point tj;

$\tilde{y}_i(t_j)$ – value of the index $y_i(t)$ at the reference point t_j given to it on the trajectory of development;

r – number of reference point in which research on sustainable development is being produced.

Instead of absolute sustainability indicators (7) and (8) it is better to use the relative ratios. In particular they can be:

the coefficient of line variability -

$$V_{y_i}^{d}(t_r) = \frac{d_{y_i}(t_r)}{\bar{y}_{ir}}, \quad (9)$$

the coefficient of variability -

$$V_{y_i}(t_r) = \frac{s_{y_i}(t_r)}{\bar{y}_{ir}}, \quad (10)$$

where $\bar{y}_{ir}$– average time series for the interval $[t_0, t_r]$.

However, in our opinion, these formulas are too average deviation of the actual trajectory of development from planning. It is therefore advisable to use the following values:

relative linear deviation -

$$\bar{d}_{y_i}(t_r) = \frac{1}{r} \sum_{j=1}^{r} \frac{|y_i(t_j) - \tilde{y}_i(t_j)|}{|\tilde{y}_i(t_j)|} * 100, \quad (11)$$

relative standard deviation -

$$s_{y_i}(t_r) = \sqrt{\frac{1}{r} \cdot \frac{\sum_{j=1}^{r} (y_i(t_j) - \tilde{y}_i(t_j))^2}{\tilde{y}_i(t_j)^2}} * 100 \;. \quad (12)$$

If the critical from the point of view of a crisis are upper or lower boundaries of the corridor development path for indicator $y_i(t)$ (or both at the same time, or certain parts of the upper or lower bound), then the formulas (7) - (12) instead of the values of $\tilde{y}_i(t_j)$ can respectively use a value y_{ij}^0 and y_{ij}^1 from the description parallelepipedus defining the boundaries of the corridor at the fixed points, and instead of the average value $\bar{y}_{ir}$ respectively $\bar{y}_{ir\text{H}}$ and $\bar{y}_{ir\text{B}}$ - arithmetic average of these upper and lower boundary parameters (Baidakov, et. al. 2015; Blanford 1983).

The above formulas are designed primarily to assess the stability conditions of the system development of SMEs in the fixed points. Although it should be noted that their application to the performance of the group $\frac{dY}{dt}$ can be related to the study of stability of motion.

To characterize the stability of the time series, according to D. Blanford and S. Offut , you can also use the indicators: percentage range (Percentage Range - PR), moving averages (Moving Average - MA), the average percentage change (Average Percentage Change - APC). These indicators are of the nature of the formation and meaning, similar to those reported in (11), (12), which, however, unlike them are directly aimed at the assessment of deviations from specified development paths and are more in line with the goals of our research (Levushkina, et. al. 2015).

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4. Discussion

To study the stability of the dynamics of the time series $y_i(t)$at the fixed points of the segment $[t_0, t_r]$ - the stability of motion - you can use the coefficient of the Spearman rank correlation :
for incoherent ranks –

$$\rho = 1 - \frac{6\sum_{j=1}^{r}\left(q_j - s_j\right)^2}{r^3 - r}, \quad (13)$$

where q_j and s_j are respectively the ranks of a time series of actual values of $y_i(t)$at the fixed points and the corresponding series of values of the predetermined path of development;
for cohesive ranks –

$$\rho = 1 - \frac{6\sum_{j=1}^{r}\left(q_j - s_j\right)^2 - A - \tilde{A}}{\sqrt{\left(\frac{r^3 - r}{6} - 2A\right)\left(\frac{r^3 - r}{6} - 2\tilde{A}\right)}}, \quad (14)$$

where $A = \frac{1}{12}\sum_{j=1}^{m}(A_j^3 - A_j)$; $\tilde{A} = \frac{1}{12}\sum_{j=1}^{k}(A_j^3 - A_j)$;
m, k is the number of cohesive groups of ranks, respectively, the time series of actual values of indicator $y_i(t)$ at the fixed points and the corresponding values of the predetermined path of development;

Aj is the number of connected ranks in the j-th group (Juglar 1868).

The following properties of the Spearman coefficient are related to our study:

- ρ = 1 - factual development is fully consistent with the shape of the trajectory of development;
- ρ = -1 is the actual course of development of the situation on the indicator in a feedback path of development;
- the closer ρ to 1, the closer the shape of the curve of the actual parameter values to the shape of the development trajectory.

It should be noted, however, that the Spearman coefficient makes it possible to check the conformity of the directions of development of the desired way of development - sustainability development. However, the numerical values of the actual parameter values and the given ones can vary widely, going even beyond the specified corridor, that is, may not have the stability conditions of the system development of SMEs. It certainly should evaluate the stability of the state and the stability of motion in a single complex channel of each indicator (Afanasev 2010).

If $|t_{fact}|$ is higher than the critical value for a given significance level α and (r - 2) degrees of freedom, the coefficient ρ is statistically significant, otherwise it is not statistically significant (Alrabeei & Kasi 2014).

When assessing the sustainable development of business systems, it is important to assess the sustainability of the emerging trends of those indicators, in particular determining the disturbance on the system of SMEs. Here one should divide three stages:

1. identifying trends;
2. comparison of the trends with the corresponding parameters of the trajectory of development;
3. checking the stability trend.

The definition of trends in changes of values and plotting the corresponding trends is carried out by applying econometric methods. If they meet the predicted when planning development course of events, it confirms the stability of the system of SMEs. If not, you should take adequate measures to ensure the specified resistance. In any case, it is necessary to ensure the sustainability of the identified trends.

In the case of trends, extended on the interval [t_0, t_r] by linear trend $y_i = a + bt$,, you can use the indicator of sustainability trends:

$$K(t_r) = \frac{b}{s_{y_i}(t_r)}, \quad (15)$$

where $s_{y_i}(t_r)$ is calculated by formula (11), but with values y_i determined by a linear trend.

With increasing magnitude *K* the probability of reducing the level of a time series the following fixed point decreases. Thus, in particular, when K = 1, the decrease probability will ammount to 0.16.

Such indicators can be constructed and used for other types of trends, but statistically meaningful use requires sufficiently long time series for the exponential trend - 11-15 members of the series, for a parabolic - not less than 20. This restriction is essential, if measurement is conducted, for example, once a year. And for a sufficiently long period of time, the trend may change – both efficiently, and from the point of view of parameter changes of its trend. Therefore, the use of a linear trend is more practically applicable (Zaitseva, et. al. 2016).

5. Conclusion

Thus, when building areas of possible changes in the parameters - coordinates of the vectors X, У, , Z it is necessary to apply prognostic studies using retrospective information available at the time of development characteristics of a new cycle of development of SMEs (Malthus 1820).

After passage of a sufficient number of reference points one should conduct correlation and regression analysis with the inclusion of the greatest possible number of variables characterizing the system itself SMEs and the impact on it. Its results allow us to establish correlations between the variables of interest and, where possible, to build the regression equation for the resulting indicators of development, where the factor variables are the parameters defined by the vectors X and Z. That is, one should seek to identify and use in the sustainable development of the SMEs system of regression equations of the form Y = F(Z, X). These equations allow us to quantitatively justify actions to ensure the sustainability of development. Very useful is also the dependencies of the form X=F(Z, Y), which determine the values of control actions X to achieve the required level of development of the system in the presence of perturbations Z (Savitskaya 2008).

The use of predictive methods is an essential tool for the sustainable development of the SMEs system. Thus, it is necessary to point out some aspects of the use of the results of predictive activity:

- Justification of the quantitative characteristics of the new cycle of the system development of SMEs;
- Adjustment of the current trajectory of development of business systems;
- Analysis of the implementation of the development cycle;
- A priori estimate of the stability of time series describing the processes of development;
- Provision of pre-emptive action to ensure sustainability;
- Prognostic studies on the occurrence and development of crisis situations - predictive analysis and assessment of extreme socio-economic situation.
- We should separately indicate the feasibility of conducting a trend analysis, which allows you:
- To establish the presence or absence of statistically significant trends in the values of indices;
- A comparative analysis of the changes dynamics in the various indicators.

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