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ECONOMIC TOMOGRAPHY: THE POSSIBILITY TO ANTICIPATE AND RESPOND TO SOCIO-ECONOMIC CRISES

The article discusses an approach based on an original hypothesis related to the peculiarities of Russia's development (on the one hand, its scale, the Russian mentality and a certain closeness of the economy; on the other hand, a significant dominant resource and human potential, and, as a consequence, a genuine role in the global economic community), the diagnosis of which (at the level of the well-being of individuals and inhabited areas) can be used to identify crises, provide an early assessment of threats to socio-economic development of regions as well as help to evaluate the state of the region over a 3 to 5 year period. In other words, in order to ensure that executives have enough time to mount a sufficiently rapid response to the crises and administrative errors and to reduce the impact of emerging threats. The aim of this paper is to present theoretical and methodological tools for the recognition of the early stages of emerging threats, allowing fewer losses to be experienced during the crisis period.

Simulation experiments were carried out for the purpose of classifying previously occurring social and economic crises (9 possible variants were reviewed) and mathematically processed trajectories of change in the main indicators for the well-being of individuals and inhabited areas, taking the influence of various factors into account. On the basis of the authors' proposed approach (referred to as economic tomography) an attempt is made to comprehensively assess the state of sample representative regions of Russia.

Keywords: economic tomography, welfare of individuals and inhabited areas, autocorrelation of parameter function shearing, crisis classification, system of non-linear non-homogeneous differential equations

Implementation

Well-being is a complex socio-economic category, which quantitatively characterises the local provision of essential goods and the degree of satisfaction of the population in terms of having their needs met (discussed in detail by the authors [1, 2]). The assessment of well-being was carried out at the level of the of the individual and at the level of the inhabited areas as interrelated and indivisible spheres of the economy of the territory (region).

In giving preference to the assessment at the level of the individual, the authors make an assumption concerning the possibility of comparison of these two components.

8 modules of the well-being of the individual and inhabited areas are highlighted:

— assessment of the state of well-being at the level of the person: spiritual, vital, social and well-being module (I);

— assessment of the state of well-being at the level of the inhabited area: resource, economic and political, infrastructural and well-being module (II).

It was decided that it was not appropriate to make a mathematical evaluation of the spiritual and vital modules in the study. Their level of development was instead determined by peer review and adjusted in the overall assessment of well-being factors in the range of 0.9–1.1.

An indicative analysis of the well-being of individuals and inhabited areas for subjects of the Ural Federal District was carried out on the basis of methodological tools [2]. Selected entities appear to us according to the following types: Sverdlovsk region — industrial manufacturing region with a high degree of innovation activity and educational and research capacity; Chelyabinsk region — has the same characteristics, but with the presence of features of a border area; KhMAO and YaNAO — territories dominated by energy resource complex, features of northern living and logistics; Tyumen oblast — a region depending largely on the territorial zoning of the autonomous entities, but with its own educational and research structure; Kurgan oblast — an area insignificant in size, having a food-producing infrastructure and selected industrial enterprises.

In all, around 140 indicators were used for each territory. The period of analysis was from 1998 to 2014. The abundance of indices, their multidirectionality and possible duplication (though the evaluation was multicollinear), the difficulty of the rapid evaluation, collection and realisation of calculations forced us to resort to economic tomography for the selected indicators.

Translation

Economic tomography is the derivation of information on the distribution of the effect of factors of interest at different levels of socio-economic status, allowing the selection and assessment of preferences across different variants of its development, as well as to simulate the extreme variability of the individual modules and the system as a whole.

Selection of Indicators

The example of the Sverdlovsk region—one of the above-mentioned standard agents—is presented in the paper in terms of research dialectics. 14 primary and 17 mutually influencing indicators are selected. The main indicators of the welfare of the individual and inhabited areas are considered, taking into account the rate of change of the time series, the rate of change of the autocorrelation and the analogue of the impulse response of the indicators themselves. The analogue of the impulse response points towards the ability to change both in modulo and in vector. This characteristic will henceforth be used to determine the power characteristic that acts on the primary indicator from the other indicators.

The rate of change of an indicator. To identify an uptick of an indicator during a crisis, its rate of change was calculated $V(t = dX(t)/dt$ [3] (see. Table. 1).

The autocorrelation function. The approach taken, in connection with the determination of the autocorrelation of the parameters that are inserted in the various modules of the well-being of the individuals and inhabited areas, is informative. This approach permits the parameter having the most significant impact on well-being to be selected from the whole variety of options.

The determination of the autocorrelation function allows us to speak about the characteristics of a single parameter as well as the interconnection of different values or different parts of a single indicator. It is possible to evaluate the similarity of the two parameters and their behaviour from the behaviour of the autocorrelation function. Autocorrelation is the correlation between the values of the same process at different points in time. The function that characterises this relationship is called the autocorrelation function [3, 4]. The autocorrelation function is the characteristic of an indicator that helps us to find duplicate portions of a signal or to determine the frequency of a carrier signal that is hidden due to the superposition of noise and fluctuations at other frequencies. When analysing time series, autocorrelation characterises the internal dependence between the time series of the indicator and the same series shifted by a certain time period τ. In general, the formula for finding the shear autocorrelation function $C(\tau)$ is represented as:

$$C(\tau) = \frac{\sum_{t=1}^{k-\max\tau} X(t)X(t+\tau)}{\sum_{t=1}^{k-\max\tau} X(t)X(t)}, \quad (1)$$

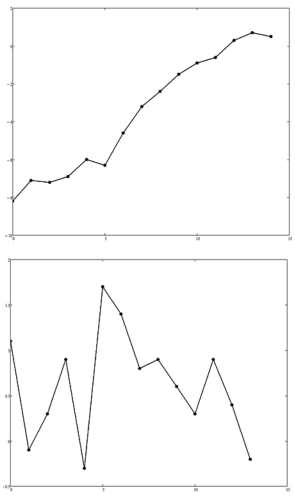
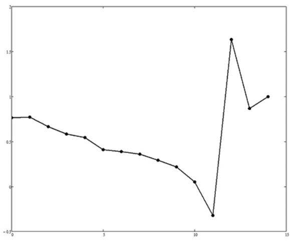
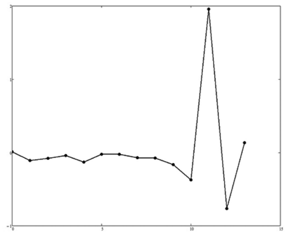
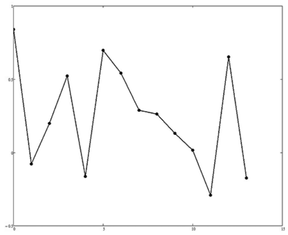
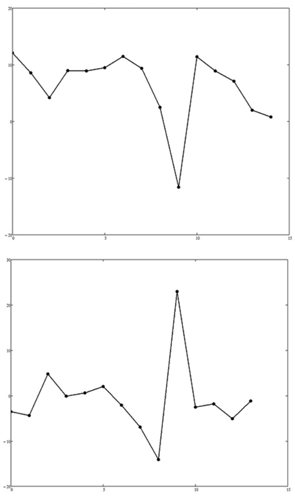
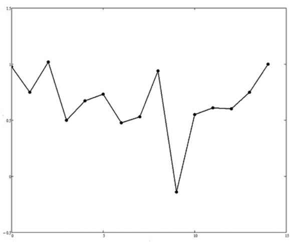
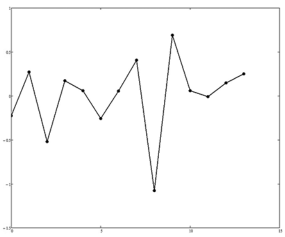
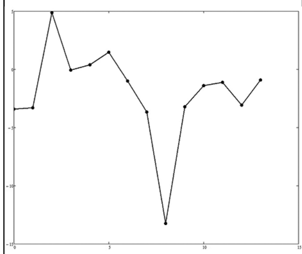
where t—time; $X(t)$—value of the indicator at time t; $X(t + \tau)$—value of the indicator with a shift in time; τ—time shift; k—maximum value of τ; $\max\tau$—maximum shift value τ.

The results of numerical calculations of the autocorrelation function of the shear parameters are presented in Table 2. In order to better identify the upsurges of the indicators at a time of crisis, a derivative of the shear autocorrelation function was constructed $dC(\text{t})/dt$ (see. Table. 1).

Translation

Table 1

Characteristics of Separate Indicators of Well-Being of Individuals and Inhabited Areas Sverdlovsk Oblast

Name of indicator	Time series of the indicator and its rate of change	Shear coefficient function autocorrelation	Rate of change of the shear autocorrelation function	Impulse response indicator
Social module				
Coefficient of natural population growth in the analysed period				
Economic and political module				
***GRP* growth rate**				

In order to determine the cross-correlation of two indicators, it is necessary to make changes to the original function (1) by changing one of the indicators. After conversion, the function will look like:

$$C(\tau) = \frac{\sum_{t=1}^{k-\max\tau} X(t)Y(t+\tau)}{\sum_{t=1}^{k-\max\tau} X(t)Y(t)}, \tag{2}$$

where $Y(t)$ is the value of the second indicator, distinguished from $X(t)$ [3]. The presence or absence of a correlation indicates the degree of randomness in the behaviour of the system under consideration. When comparing the two correlations for different components of a system, it is possible to obtain information on the cross-correlation of these components within the confines of a single study. In this way, it is also possible to determine differences in the state of the system during any given crisis.

The matrix of the indicator coupling factors was calculated on the basis of the expression (2). The secondary indicators affecting the primary indicator were identified on on the basis of an analysis of the matrix (see. Table. 2). This selection was carried out not only according to the values of the coupling factors, but also in connection with the interaction of economic indicators.

Translation

The primary three interacting parameters (8 triple pairs and 1 double pair , see. Table. 3) were selected from the entire range of basic indicators. The selection was carried out using the triple correlation function and its rate of change:

$$C(\tau)=\frac{\sum_{t=1}^{k-\max\tau} X(t)Y(t)Z(t+\tau)}{\sum_{t=1}^{k-\max\tau} X(t)Y(t)Z(t)}, \tag{3}$$

$X(t)$, $Y(t)$, $Z(t)$ — values of the indicators [10].

Power characteristics. Table. 1 shows an analog of the impulse response [5] for each of the parameters. This value shows to what extent each of the parameters is capable of changing in magnitude and direction (greater than or less than 0) as well as how strongly it can affect the other parameters. Calculations were carried out using the following formula:

$$p(\tau,t)=C(\tau)V(t)=\frac{\sum_{t=1}^{k-\max\tau} X(t)X(t+\tau)}{\sum_{t=1}^{k-\max\tau} X(t)X(t)}V(t). \tag{4}$$

The Main Types of Crisis

For a mathematical description of the interaction of the three indicators, we have proposed the following system of non-linear, non-homogeneous differential equations with constant coefficients:

$$\begin{cases} \frac{dx_0}{dt}=a_0x_0+a_1x_1+a_2x_2+a_{00}(x_0)^2+(a_{01}+a_{10})x_0x_1+(a_{02}+a_{20})x_0x_2+ \\ +a_{11}(x_1)^2+(a_{12}+a_{21})x_1x_2+a_{22}(x_2)^2+D_0, \\ \frac{dx_1}{dt}=b_0x_0+b_1x_1+b_2x_2+b_{00}(x_0)^2+(b_{01}+b_{10})x_0x_1+(b_{02}+b_{20})x_0x_2+ \\ +b_{11}(x_1)^2+(b_{12}+b_{21})x_1x_2+b_{22}(x_2)^2+D_1, \\ \frac{dx_2}{dt}=c_0x_0+c_1x_1+c_2x_2+c_{00}(x_0)^2+(c_{01}+c_{10})x_0x_1+(c_{02}+c_{20})x_0x_2+ \\ +c_{11}(x_1)^2+(c_{12}+c_{21})x_1x_2+c_{22}(x_2)^2+D_2, \end{cases} \tag{5}$$

where x_0 is the primary indicator, x_1 and x_2 is the secondary indicators of influence on the main index; a_i, b_i, c_i (i = 0, 1, 2) are the coefficients of the linear velocity of the influence indicators of change; a_{ij}, b_{ij}, c_{ij} (i = 0, 1, 2; j = 0, 1, 2) are the coefficients of pairwise effects i indicator on j and on the rate of its change. This system not only takes into account the contribution of the linear indicators, but also describes their pairwise interaction [10].

Translation

Table 2

Matrix of Interference Parameter Coefficients (Shear Cross-Correlation Function). Sverdlovsk Oblast

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1,000	0,451	0,466	0,439	0,442	0,362	0,533	0,354	0,301	0,301	0,491	0,342	0,567	0,404
2	1,019	1,000	1,026	1,027	1,027	1,030	1,022	1,035	1,035	1,035	1,024	1,033	1,020	1,029
3	0,984	0,979	1,000	0,978	0,978	0,976	0,983	0,973	0,972	0,972	0,98	0,974	0,983	0,977
4	1,035	1,046	1,045	1,000	1,047	1,051	1,041	1,056	1,055	1,055	1,043	1,053	1,036	1,049
5	1,252	1,383	1,367	1,395	1,000	1,468	1,305	1,522	1,577	1,577	1,340	1,509	1,271	1,437
6	1,179	1,228	1,224	1,232	1,231	1,000	1,202	1,273	1,261	1,261	1,216	1,255	1,189	1,241
7	0,733	0,681	0,687	0,678	0,677	0,654	1,000	0,614	0,635	0,635	0,713	0,658	0,707	0,666
8	2,471	2,673	2,650	2,694	2,637	2,818	2,458	1,000	2,725	2,725	2,582	2,760	2,429	2,726
9	1,714	2,189	2,147	2,218	2,275	2,356	1,966	2,621	1,000	2,649	2,084	2,500	1,859	2,332
10	1,115	1,153	1,150	1,156	1,156	1,169	1,135	1,187	1,186	1,000	1,142	1,177	1,120	1,165
11	0,964	0,953	0,954	0,952	0,95	0,946	0,955	0,948	0,937	0,937	1,000	0,942	0,963	0,948
12	1,373	1,557	1,541	1,570	1,581	1,628	1,473	1,729	1,732	1,732	1,513	1,000	1,418	1,614
13	0,83	0,79	0,795	0,786	0,787	0,765	0,814	0,752	0,744	0,744	0,804	0,757	1,000	0,775
14	1,159	1,227	1,221	1,233	1,237	1,259	1,193	1,292	1,301	1,301	1,208	1,278	1,172	1,000

☐ — primary influence on the primary indicator; ☐ — secondary effect on the primary indicator. Indicators: 1 — the coefficient of natural population growth in the analysed period; 2 — life expectancy at birth; 3 — consumer price index for food products; 4 — Gini Coefficient; 5 — level of debt burden on the regional budget; 6 — proportion of GRP public expenditure on education; 7 — GRP growth rate; 8 — amount of arrears on mortgage loans against the total volume of mortgage loans; 9 — ratio of budgetary spending on health to GRP; 10 — ratio of the average level of cash income of the 10 % highest income segments of the population to the 10 % lowest income segments of the population; 11 — total unemployment; 12 — fixed capital investment per capita; 13 — proportion of the population with incomes below the subsistence minimum compared with the general population14 — labour productivity.

The system was solved with the Mathsoft Apps Mathcad software using the Runge-Kutta 4th order method [6, 11].

The results of the solution of the obtained system by numerical methods [12] when the given initial conditions were obtained by the main types of crises are presented in Table 3.

Data concerning the kinds of major crises are characterised by the following parameters: speed of the entrance to the crisis (high- or low-speed input), the depth of the crisis (overcoming levels C1, C2, C3), the duration of the crisis, acceleration and slow down of indicators, initial entry point in the crisis and the response time of the relevant input at different levels of crisis.

Calculation of the Generalised Normalised Index

1. The matrix of the mutual interaction of indicators was calculated on the basis of function of the triple (double) correlation (2) and (3) and its averaging

$$\bar{C}(\tau) = \frac{\sum_{\tau=1}^{\max\tau} C(\tau)}{\max\tau}, \tag{6}$$

τ — time shift; k — maximum value τ; max τ — maximum value of the shift τ.

2. On the basis of the matrix weighted were attached to the indicators and the generalised normalised indicator calculated:

$$NE_f = \frac{\sum_{i=1}^{n} \alpha_i NE_i}{n-1}, \tag{7}$$

where NE_i is the normalised evaluation i of the indicator using a weighting coefficient α_i.

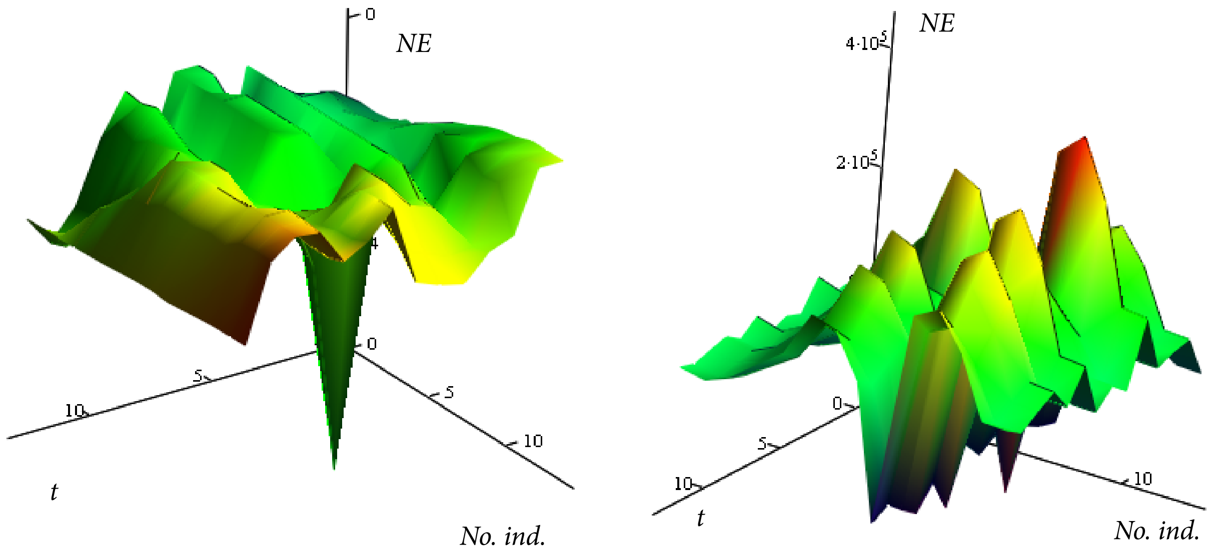
An attempt was also made to calculate the influence of the remaining uncounted indicators in general. For this, the matrix mutual interaction of indicators was calculated on the basis of the function of triple (double) correlations (2) and (3) by all the uncounted indicators; then, taking into account the sign of the impulse response (4), the normalised score was calculated:

Translation

$$NE_j = \frac{\sum_{i=1}^{n} \alpha_i NE_i sign\left(p_i\left(\tau, t\right)\right)}{n-1}, \quad (8)$$

where NE_i is the normalised score i of the indicator with a weighting coefficient α_i, $sign(p_i(\tau, t))$ is the sign of the impulse response $p_i(\tau, t)$ i of the indicator.

Each normalised score was calculated by the formula (7) and (8) separately for each year. In fig. 1a is presented a three-dimensional representation of the inverted (relative to the axis 0*Z*) normalised evaluation (*NE*) data for all 14 selected indicators, excluding a calculation of its influence. Fig. 1b shows a three-dimensional picture of the normalised evaluation taking into account the combined interactions of the indicators.



1a) 1b)

Fig. 1. *Surface of the normalised evaluation without the influence (a) and with the influence of (of the) indicators (b)*

Behaviour of the Turning Point

We consider the behaviour of points based on the following characteristics (see. fig. 2a): the rate of change indicator (normalised value) $V(t) = dX(t)/dt$, the "crisisity function" derivative $dL(t)/dt$ and the Hurst coefficient. We assume a positive indicator value, i. e. $X(t) \geq 0$, but also that its value at point 1 in Fig. 2 a is greater than at point 2 ($X(t_1) \geq X(t_2)$).

The "crisisity function" was introduced as follows:

$$L(t) = \frac{1}{2}\left(X(t)\right)^2 \geq 0. \quad (9)$$

The derivative of this function with respect to time, which has the form $dL(t)/dt = X(t)(dX(t) / dt)$, describes a sharp change in the trend of the indicator, that is to say, it captures the transitions to the levels of C1, C2 and C3. If $X(t) \geq 0$, therefore the reduction in its derivative "crisisity function" is negative, i.e., in order to capture transitions in C1, C2 and C3 it is necessary to identify temporal areas, in which $dL(t)/dt < 0$.

The Hurst coefficient H is convenient because it takes values from 0 to 1 and shows the further development trend of the indicator [7, 8]. At $0 < H < 0.5$ the indicator is derived from a local change in the trend, for example, with a decrease in a growing trend. If $0.5 < H < 1$ the trend continues, that is, if the index decreases it continues to decrease. $H = 0.5$—random process. For convenience, the calculation of the Hurst coefficient was performed on the aggregate time series [8].

Translation

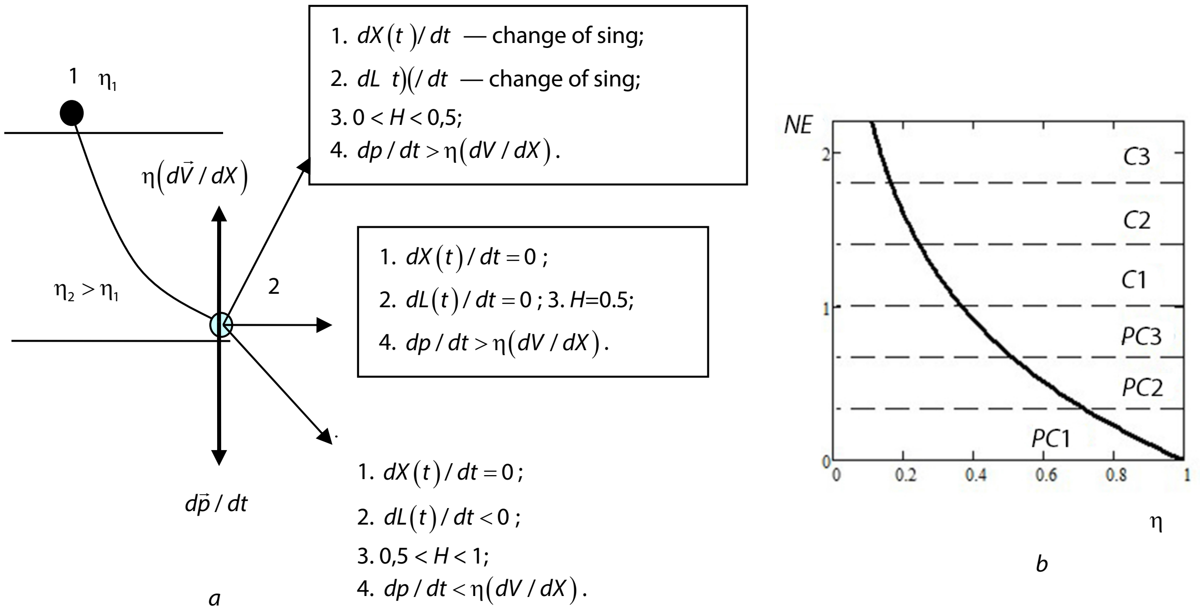


Fig. 2. *The behaviour of the turning points of the normalised evaluation of (a) its basic characteristics; b) the dependence of the viscosity of the normalised valuation levels)*

To describe the levels of crises (C1, C2, C3), we use characteristics associated with resistance to the level of crisis, and taking into account the transitions between the levels themselves or the movement inside a level [9]. Therefore, we introduce the concept of "viscosity levels", which are calculated by the following formula:

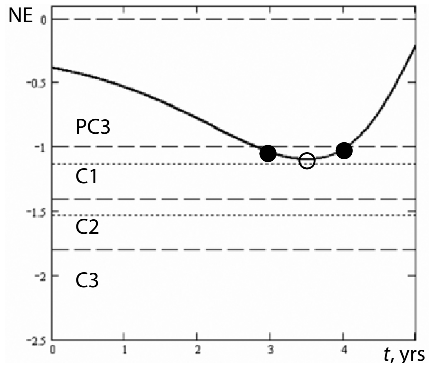
$$\eta\left(X(t)\right) = a \cdot \exp\left(bX(t)\right), \tag{10}$$

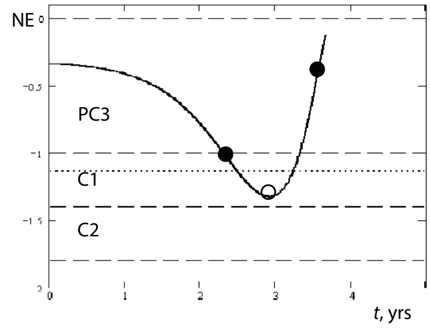
where a, b is the constant inherent in this indicator (see. Fig. 2 b). Parameters of the "viscosity levels" function: $a = 1$, $b = -1$.

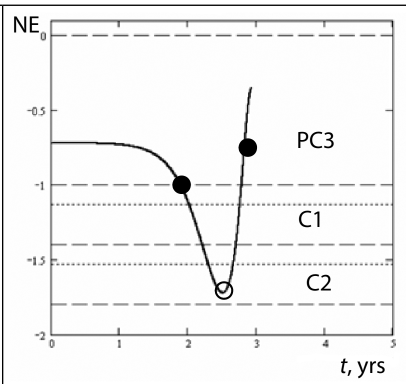
Further, using these characteristics we derive the power characteristics, i.e., $dp / dt = d(CV) / dt$ and $\eta(dV / dX)$ [5]. The analogue of the inertial force indicator describes the ability to change its speed characteristics at a given time due to the influence of other parameters, and without any particular influence. This characteristic makes it possible to track the direction of movement of the indicator. A viscous force describes to what extent levels are capable of being retained by indicators, as well as changing the quality characteristics of crisisity levels. For example, at C2 the viscosity is greater than at C1, therefore the indicator is more difficult to move from C2 to C1, than from C1 to PC3. As a result, if $dp / dt > \eta(dV / dX)$ the indicator changes tendency with a decreasing trend in its growth rate, if $dp / dt = \eta(dV / dX)$ the indicator remains within the same level, but in the case of $dp / dt < \eta(dV / dX)$ the indicator continues to decrease.

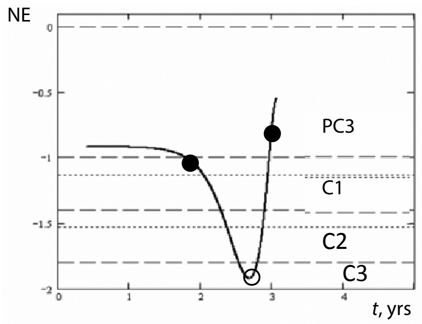
Table 3

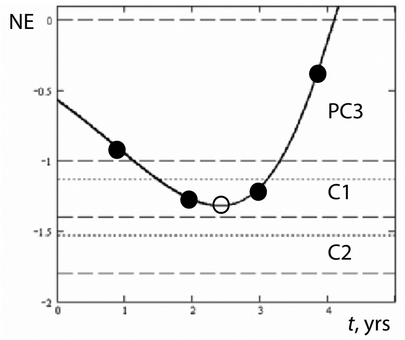
Classifier of Typical Crisis Situations

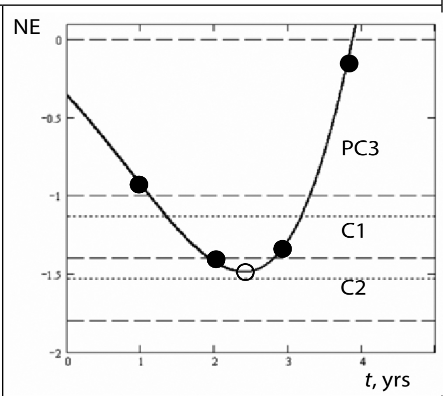
<table>
<tr><td colspan="3">I. Annual crises</td></tr>
<tr>
<td>

Slow-developing crisis, which doesn't deform the structure of indicators and does not allow 1/3 of C1 to be exceeded.
$D_0 = 1.09$, $a_0 = 0.03$, $a_{12} = 1.01$, $b_0 = -5$, $b_1 = 4.1$, $b_{01} = 4.5$, $b_{02} = 1.01$, $b_{12} = 1.01$, $c_{01} = 5.9$, $c_{12} = 1.01$</td>
<td>

Crisis that doesn't deform the structure of indicators, but exceeds 1/3 of C1.
$D_0 = 3.09$, $a_0 = 2.1$, $a_{12} = 3.03$, $b_0 = -30$, $b_1 = 4.1$, $b_{01} = 28.5$, $b_{02} = 0.07$, $b_{12} = 3.03$, $c_{01} = 43$, $c_{12} = 3.03$</td>
<td>

Crisis that doesn't deform the structure of indicators, but exceeds 1/3 of C2.
$D_0 = 6.09$, $a_0 = 2.1$, $a_{12} = 7.07$, $b_0 = -60$, $b_1 = 4.1$, $b_{01} = 28.5$, $b_{02} = 0.07$, $b_{12} = 6.09$, $c_{01} = 43$, $c_{12} = 6.06$</td>
</tr>
<tr><td>I. Annual crises</td><td colspan="2">II. Three-year crises</td></tr>
<tr>
<td>

Rapidly developing crisis that deforms the structure of indicators and exceeds 1/3 of C3.
$D_0 = 7.09$, $a_0 = 2.1$, $a_{12} = 7.07$, $b_0 = -70$, $b_1 = 4.1$, $b_{01} = 28.5$, $b_{02} = 0.07$, $b_{12} = 7.07$, $c_{01} = 43$, $c_{12} = 7.07$</td>
<td>

Three-year crisis, characterised by the following parameters: the dynamics of changes of the main indicator of the selected module does not allow the threshold from C1 to C2 to be crossed; selected auxiliary measures tend to relocate the indicators.
$D_0 = 10.09$, $a_0 = 3$, $a_{12} = 10.1$, $b_0 = -100$, $b_1 = 4.1$, $b_{01} = 4.5$, $b_{02} = 0.1$, $b_{12} = 10.1$, $c_{01} = 59$, $c_{12} = 10.1$</td>
<td>

Crisis that doesn't deform the structure of indicators and doesn't exceed 1/3 of C2.
$D_0 = 15.09$, $a_0 = 4.5$, $a_{12} = 15.01$, $b_0 = -150$, $b_1 = 60$, $b_{01} = 60.5$, $b_{02} = 0.15$, $b_{12} = 1.01$, $c_{01} = 5.9$, $c_{12} = 1.01$</td>
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<table>
<tr><td colspan="2">II. Three-year crises</td><td>III. Five-year crisis</td></tr>
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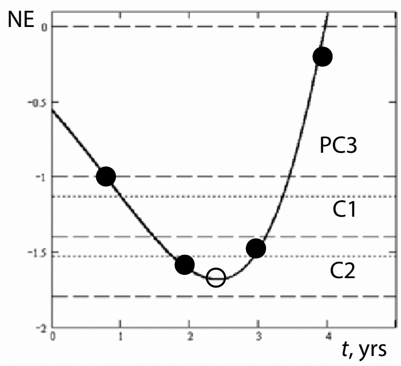
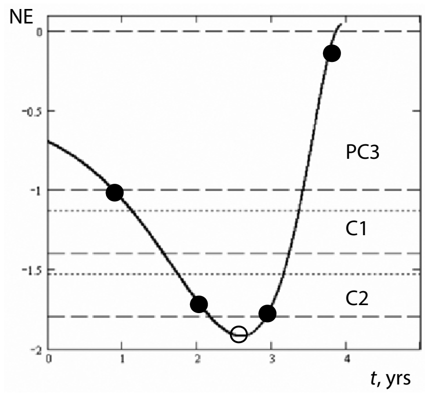
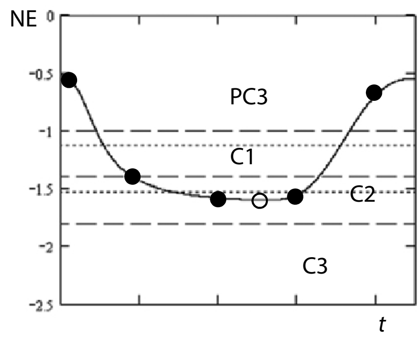
<td>

Crisis that doesn't deform the structure of indicators and exceeds 1/3 of C2.
$D_0 = 17.09$, $a_0 = 4.5$, $a_{12} = 15.01$, $b_0 = -150$, $b_1 = 60$, $b_{01} = 60.5$, $b_{02} = 0.15$, $b_{12} = 1.01$, $c_{01} = 90$, $c_{12} = 15.01$</td>
<td>

Rapidly developing crisis that deforms the structure of indicators exceeds 1/3 of C3.
$D_0 = 27.09$, $a_0 = 3$, $a_{12} = 10.1$, $b_0 = -100$, $b_1 = 4.1$, $b_{01} = 4.5$, $b_{02} = 0.1$, $b_{12} = 10.1$, $c_{01} = 59$, $c_{12} = 10.1$</td>
<td>

Five-year crisis, characterised by the following parameters: the dynamics of changes of the main indicator of the selected module allows the threshold from C1 to C2 to be crossed; selected auxiliary measures tend to relocate the indicators.
$D_0 = 0.09$, $a_0 = 0.3$, $a_{12} = 1.01$, $b_0 = -10$, $b_1 = 4{,}1$, $b_{01} = 4.5$, $b_{02} = 0.05$, $b_{12} = 1.01$, $c_{01} = 5.9$, $c_{12} = 1.01$</td>
</tr>
<tr><td colspan="3">NE — normalised evaluation;PC3 — pre-crisis 3 (from 0.666 to 0.999); C1– crisis 1 (1 to 1.399); C2 — crisis 2 (1.4 to 1.799); C3 — crisis 3 (from 1.8). Figures in parentheses are normalised estimates for this indicator. The bold points indicate annual values of normalised evaluation; ○ — turning point; D_0 — constant in the equation on the main indicator; a_0 — coefficient of linear influence of the main indicator on the rate of its change; a_{12} — coefficient of the pairwise influence of the second and third parameters on the rate of change of the main; b_0 — coefficients of the linear influence on the main indicator of the rate of change of the indicator of the first order; b_1 — coefficients of the linear influence on the indicator of the second-order of the rate of its change; $b_{01}(c_{01})$ — coefficient of the pairwise influence of the main and secondary indicators on the rate of change of the secondary (tertiary) indicator; b_{02} — coefficient of the pairwise influence of the main and tertiary indicators on the rate of change of the secondary; $b_{12}(c_{12})$ — coefficient of the pairwise influence of the secondary and tertiary indicators on the rate of change of the secondary (tertiary).</td></tr>
</table>

Analysis of the Presence of Crises (on the Example of the Sverdlovsk Oblast)

Carried out on the module of the evaluation of the welfare of individuals and inhabited areas revealed by the tomographic schema presented in Table 4[1]:

1. The social module, despite the presence, for example, of the indicator of the "rate of natural population growth" to the zone relative to the normal level (influence of demographic waves) taking into account the influence of other major indicators corresponds to the actual pre-crisis PC3 (the beginning of the five-year 2014–2018 crisis).

2. With regard to the "consumer price index for food products" (welfare module I) indicator, it is withheld due to interference of other indicators in the C1 crisis area with subsequent deterioration and balanced at the level of C2 in 2015.

The Gini coefficient, despite the more impairing complex influence of other indicators, held stable in the pre-crisis zone PC3.

3. The "increase in the regional debt burden" indicator to be located (without power support and fall) in the area of crisis C2; and in fact in the area of crisis C1.

4. The most sensitive indicator "GRP growth rate" (the economic-political unit): in 2007 was in the area of relatively normal levels; in 2008, in the pre-crisis area PC3, and in 2009, in the area of crisis C2. In fact, taking into account the interaction of other factors, in 2009, we are seeing a much smaller effect of the remaining indicators (C1 crisis), i.e. the system that characterises the socio-economic

[1] The location of the trajectory of each indicator corresponds to the location of points and mutual interaction of the remaining 13 indicators in a particular year. Only a consideration of their individual and complex influence allows us to talk about the beginning, continuation and exit from a particular type of crisis. Similarly, as the current crisis transitions to another type of crisis, for example, for a one-year crisis that does not deform structural parameters (although more than 1/3 overcomes crisis C1) to the three-year crisis (included in crisis C2).

condition of the region can resist the destructive influence of a complex crisis. In the three-dimensional representation of inverted normalised evaluation data for all 14 selected indicators, without taking into account the combined effect, we have clearly observed the failure of the indicator "GRP growth rate" (see. Fig. 1a), and its smoothing, taking into account the mutual influence (see. Fig. 1b).

5. Multidirectional mutual interaction of indicators is observed in the infrastructure and welfare II modules.

6. It can be maintained that the well-identified consequences of the default in 1998, the return to pre-crisis indicators and the crisis of 2008–2009 was the beginning of the crisis in 2014. This allows us to identify a certain lag, to recognise the potential emergence of crisis and the strength of interaction of different indicators that combine to give a different picture.

Table 4

Tomographical Representation of the Well-Being of Individuals and Inhabited Areas. Sverdlovsk Oblast

No. ind.		Years														
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Primary indicator	1	1,367	1,183	1,2	1,15	0,983	1,033	0,766	0,523	0,4	0,25	0,15	0,1	0	0	0
A	13	2,38	2,27	1,93	1,28	1,02	0,76	0,71	0,54	0,55	0,56	0,5	0,55	0,35	0,32	0,33
B		1,495	1,366	1,258	1,012	0,839	0,776	0,625	0,445	0,387	0,316	0,245	0,237	0,119	0,109	0,11
C		0,49	0,42	0,39	0,35	0,317	0,303	0,263	0,243	0,287	0,509	0,221	0,184	0,155	0,239	0,3
Aggregate influence		0,99	0,893	0,83	0,68	0,578	0,539	0,444	0,344	0,337	0,412	0,233	0,211	0,137	0,174	0,21
Primary indicator	3	1,633	1,033	0,6	0,75	0,667	0,6	0,575	1,067	1,108	0,133	0,783	0,167	0,367	0,317	1,067
A	5	0,25	0,251	0,25	0,25	0,252	0,251	0,252	0,249	0,256	0,243	0,269	0,671	0,689	1,344	1,667
B	7	0	0	0,27	0	0	0	0	0	0,833	5,533	0	0	0	1	1,4
C		0,6	0,402	0,38	0,31	0,28	0,258	0,25	0,413	0,811	2,642	0,323	0,211	0,281	0,876	1,385
D		1,100	0,94	0,87	0,78	0,725	0,697	0,604	0,57	0,668	1,104	0,533	0,446	0,383	0,568	0,7
Aggregate influence		0,85	0,671	0,63	0,55	0,503	0,477	0,427	0,491	0,74	1,873	0,428	0,329	0,332	0,722	1,041
Primary indicator	4	0,61	0,68	0,56	0,79	0,98	1,05	1,14	1,33	1,35	1,3	1,32	1,25	1,3	1,3	1,23
A	6	2,239	1,742	1,371	1,187	1,206	1,247	1,075	0,872	0,746	0,618	0,913	0,771	0,522	1,193	1,564
B	8	0	0	0	0	0	0	0	0	1,293	1,836	0,664	0,293	0,027	0	0
C		0,83	0,716	0,57	0,6	0,666	0,7	0,682	0,688	0,815	0,827	0,776	0,668	0,583	0,768	0,85
D		1,153	0,985	0,91	0,82	0,76	0,731	0,633	0,598	0,702	1,157	0,56	0,469	0,403	0,597	0,73
Aggregate influence		0,99	0,851	0,74	0,71	0,713	0,715	0,658	0,643	0,758	0,992	0,668	0,569	0,493	0,68	0,79
Primary indicator	5	0,25	0,251	0,25	0,25	0,252	0,251	0,252	0,249	0,256	0,243	0,269	0,671	0,689	1,344	1,667
A	4	0,61	0,68	0,56	0,79	0,98	1,05	1,14	1,33	1,35	1,3	1,32	1,25	1,3	1,3	1,23
B	3	1,633	1,033	0,6	0,75	0,667	0,6	0,575	1,067	1,108	0,133	0,783	0,167	0,367	0,317	1,067
C		1,110	0,864	0,61	0,78	0,827	0,827	0,855	1,166	1,197	0,718	1,037	0,854	0,975	1,171	1,595
D		1,686	1,443	1,333	1,206	1,123	1,080	0,936	0,892	1,045	1,671	0,847	0,711	0,616	0,896	1,093
Aggregate influence		1,398	1,153	0,97	0,99	0,975	0,953	0,896	1,029	1,121	1,195	0,942	0,783	0,795	1,033	1,344
Primary indicator	7	0	0	0,27	0	0	0	0	0	0,833	5,533	0	0	0	1	1,4

Translation

No. ind.		Years														
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
A	13	2,38	2,27	1,93	1,28	1,02	0,76	0,71	0,54	0,55	0,56	0,5	0,55	0,35	0,32	0,33
B	12	1,865	1,798	1,527	1,268	0,852	0,757	0,038	0	0	0	0	0	0	0	0
C		0,92	0,876	0,83	0,53	0,399	0,313	0,206	0,152	0,433	2,003	0,141	0,155	0,099	0,423	0,56
D		0,7	0,594	0,55	0,49	0,456	0,438	0,379	0,355	0,417	0,711	0,328	0,274	0,233	0,352	0,44
Aggregate influence		0,81	0,735	0,69	0,51	0,428	0,376	0,292	0,254	0,425	1,357	0,235	0,215	0,166	0,388	0,5
Primary indicator	9	1,36	1,343	1,373	1,324	1,264	1,075	1,05	0,976	0,892	0,781	0,735	0,665	0,583	0,572	0,44
A	8	0	0	0	0	0	0	0	0	1,293	1,836	0,664	0,293	0,027	0	0
B	2	1,053	0,88	0,98	1,053	0,93	0,908	0,588	0,417	0,375	0,267	0,2	0,118	0,083	0,032	0
C		1,203	1,072	1,155	1,189	1,081	1,003	0,767	0,621	0,947	0,994	0,583	0,392	0,261	0,213	0,15
D		2,386	2,042	1,882	1,708	1,595	1,532	1,332	1,278	1,501	2,376	1,225	1,030	0,897	1,297	1,578
Aggregate influence		1,794	1,557	1,519	1,448	1,338	1,268	1,050	0,949	1,224	1,685	0,904	0,711	0,579	0,755	0,86
Primary indicator	11	0,81	0,365	0,52	0,35	0,288	0,173	0,231	0	0	0,481	0,5	0,269	0	0,019	0,05
A	13	2,38	2,27	1,93	1,28	1,02	0,76	0,71	0,54	0,55	0,56	0,5	0,55	0,35	0,32	0,33
B	14	1,843	1,834	1,827	1,813	1,799	1,781	1,754	1,732	1,726	1,755	1,726	1,699	1,677	1,669	1,666
C		1,656	1,464	1,382	1,069	0,946	0,802	0,795	0,647	0,649	0,821	0,797	0,732	0,56	0,552	0,57
D		1,022	0,868	0,8	0,72	0,664	0,641	0,553	0,521	0,618	1,039	0,492	0,41	0,352	0,529	0,66
Aggregate influence		1,339	1,166	1,092	0,89	0,805	0,722	0,674	0,584	0,634	0,93	0,644	0,571	0,456	0,541	0,61
Primary indicator	12	1,865	1,798	1,527	1,268	0,852	0,757	0,038	0	0	0	0	0	0	0	0
A	14	1,843	1,834	1,827	1,813	1,799	1,781	1,754	1,732	1,726	1,755	1,726	1,699	1,677	1,669	1,666
B	6	2,239	1,742	1,371	1,187	1,206	1,247	1,075	0,872	0,746	0,618	0,913	0,771	0,522	1,193	1,564
C		1,414	1,387	1,411	1,202	1,057	1,017	0,767	0,744	1,105	3,170	0,742	0,73	0,721	1,154	1,327
D		1,683	1,439	1,330	1,201	1,118	1,074	0,932	0,887	1,042	1,685	0,842	0,706	0,61	0,893	1,092
Aggregate influence		1,548	1,413	1,370	1,201	1,088	1,046	0,85	0,816	1,074	2,428	0,792	0,718	0,666	1,024	1,210
Primary indicator	13	2,38	2,27	1,93	1,28	1,02	0,76	0,71	0,54	0,55	0,56	0,5	0,55	0,35	0,32	0,33
A	7	0	0	0,27	0	0	0	0	0	0,833	5,533	0	0	0	1	1,4
B	11	0,81	0,365	0,52	0,35	0,288	0,173	0,231	0	0	0,481	0,5	0,269	0	0,019	0,05
C		0,84	0,713	0,86	0,7	0,68	0,641	0,649	0,577	0,891	2,82	0,715	0,641	0,559	0,941	1,101
D		0,89	0,757	0,7	0,63	0,582	0,558	0,484	0,455	0,534	0,893	0,424	0,354	0,303	0,452	0,56
Aggregate influence		1,097	0,935	0,96	0,83	0,788	0,752	0,698	0,642	0,861	2,089	0,691	0,6	0,52	0,825	0,99

Generalization on All Indicators of the Sverdlovsk Region

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1,202	1,042	0,87	0,868	0,811	0,761	0,665	0,639	0,797	1,44	0,615	0,523	0,46	0,683	0,839

Translation

	N
	*PC*1
	*PC*2
	*PC*3
	*C*1
	*C*2
	*C*3

A — indicator of the primary influence on the main indicator;
B — indicator of the secondary influence on the main indicator;
C — indicator of the combined influence of A and B on the main indicator;
D — indicator of the combined influence of other indicators on the main indicator
Indicators:
1 — coefficient of natural population increase during the analysed period;
2 — life expectancy at birth;
3 — consumer price index for food products;
4 — Gini coefficient;
5 — level of debt burden on the regional budget;
6 — proportion of public expenditure on education in GRP;
7 — GRP growth rate;
8 — volume of arrears on mortgage loans against total volume of mortgage loans;
9 — proportion of budgetary spending on health to GRP;
10 — proportion of average cash income of the 10 % highest income segments of the population to the 10 % lowest income segments of the population;
11 — level of total unemployment;
12 — fixed capital investment per capita;
13 — proportion of people with incomes below the subsistence level as a percentage of the total population;
14 — labour productivity.

In terms of the scope of economic tomography, the authors identified the following:

— identification of latent trends in socio-demographic development of regions [13];

— balancing regional budgets with a focus on the coming years;

— selecting priorities in terms of socio-economic trajectories for optimising the effects of crises;

— evaluation of the viability of large-scale software and hardware measures from the standpoint of the welfare of individuals and inhabited areas;

— assessment of the regional socio-economic springboard for implementing medium-term projections [14].

Conclusion

The research and calculations made it possible to obtain a diagnostic picture of the well-being of individuals and inhabited areas for individual subjects of the Russian Federation. The authors conclude that it is possible to accurately diagnose crises, assess threats and gain more confidence in times of crisis, while relying on the least crisis-prone indicators. The internal interaction of the primary and additional indicators is revealed. The proposed crisis stencils (9 crisis variants) are mathematically processed and can be used to characterise the socio-economic development of territories. Economic tomography, as proposed in the article as an original authorial approach, not only allows the interaction of individual indicators to be described in detail, but also entire groups of indicators, as well as to obtain a developmental perspective over a period of 3–5 years.

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