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IMPACT OF INFRASTRUCTURE COMPONENT ON SOCIOECONOMIC APPROACH TO MODERNIZATION OF THE REGION

Abstract. Innovative list of components and indicators of socioeconomic modernization of regions was formed to identify the region by comparing the integral indexes with integral threshold values, which allows using adaptive management techniques to solve the problem of required values synthesis of the components and their indicators as being the strategic benchmarks for possible scenarios of Development strategies. The current state of infrastructure development of Donetsk region as part of the macroeconomic development was identified as well as t strategic benchmarks for indicators were defined providing rapid infrastructure development up to 2020, the quantitative impact of infrastructure development on the macroeconomic development was shown.

Keywords: regions, modernization, infrastructure indicators, integral index, strategic benchmark, scenario development

Formulas: 5, fig.: 3, tabl.: 3, bibl.: 27

JEL Classification: E17, O18, C13, R20, R40

Introduction. Proof of steady and secure functioning of integral economic and social systems of state, efficient collaboration of its regions appears to be an urgent

problem of nowadays. The theory of scientific knowledge is a historical assumption of considering social and economic systems of Ukraine and its regions as a complex of structural elements with a complicated schematic model for both internal and external relations with the environment. Economy of the region at the very core has a specific nature and capacity to create definite methodological difficulties with indicator analysis both at the stage of reproduction process and at the stage of approval thereof.

Founders of different theories and models of regional economy are the following scientists W. Izard, A. Weber, A. Losch, A. Marshall, R. Solow, T. Swan, G. Mankiw, D. Romer, G. Myrdal, F. Perroux, A. Hirschman and others.

None of the established economic growth models considers trans-regional movement of goods and services as well as shadow factor of business operations, without which evaluation of the level of socio-economic development does not correspond to the real economy. Thence, the efficiency of subsystem interaction should be determined taking into account its specific nature and obligatory inclusion of shadow factor analysis and trans-regional cross flows that significantly converts the idea of economic space and requires new analytical approach.

Growth of infrastructure share in world public production and distribution requires further rise of economic efficiency in all its sectors and most significantly in transport. In this regard determination of the indicators that define economic development of the region to the full extent of its interrelations in order to identify current condition becomes of great current interest, what forms the basis for the development of Socioeconomic approach to modernization.

Literature review and the problem statement. Problems of domestic development of the economy of Ukraine, dynamic changes in world economic space and increase in national economy transparency provide for objective necessity to improve methodology of assessment of the level of social and economic development of the regions (economic zones) for the purpose of adequate and prompt response to internal and external disturbing factors. In respect of functional and structural aspect the category of notion "social and economic development" of the region is defined by the combination of interconnected components of development whereof the fundamental are *macro economical, finance and investment, innovative, sociodemographic, ecological and foreign economics* [Blagodarnyi, Tolmachova, Kvilinskyi 2014; Ivanov, Lyashenko, Tolmachova, Kvilinskyi 2016; Lyashenko, Kvilinskyi 2016; Lyashenko, Tolmachova, Kvilinskyi 2016; Kvilinskyi 2012; Meshkov, Bondaryeva, Kvilinskyi 2016; Pajak, Lyashenko, Kvilinskyi 2015].

Macro-economic development includes *structural, formal and informal, and infrastructural components.* Infrastructure is considered to be the most significant factor of development and distribution of productive forces. Infrastructural component of macro-economic development basically means the condition of transport infrastructure, in terms of complex of ways of communication, transportation facilities, technical equipment and means, means of control and communication, which functions as a well-developed system of economical, market, technological, mechanical, ecological, information and legal relations providing maximum gratification of wants of national economy and population through cargo and passenger transport [Kudritskaya 2010, pp. 9-10].

Over the last years strategic role of transport increased dramatically and there grew the relation between its development objectives and priorities for social and economic changes – technological and structural modernization. Transport as an infrastructural branch provides basic standards of living and development of state, its regions and society [Aushauer 1989, pp. 177–200; Nadiri, Mamuneas 1994, pp. 189–198]. NISS analytical report [Sobkevich, Mykhailychenko, Yemelianova 2013] includes an analysis of individual indicators of transport infrastructure as reported by State Statistics Service of Ukraine, but it does not define the dynamics of condition level thereof, neither it states its performance criteria and defines quantity influence of modernization measures on the level of economical growth, what is important for the modernization strategy development.

Similar remarks can be referred to the work of the Institute of Economics and Forecasting [Nykyforuk 2014], the positive point of which is an assessment of the impact of infrastructure on the economic growth through an expanded regional aggregate Cobb-Douglas production function on account of infrastructural capital. Another printed work of this Institute is worth looking at [Piriashvili, Chyrkyn, Nykyforuk 2014], where consideration is given to the impact of production infrastructure on complementary sectors of economy within the context of sustainable development through input-output coefficient and other characteristics of the table "input-output" within the differentiation of sectoral structure of domestic economy.

Unfortunately, efficiency of transport system and speed for cargo and passenger transport in the regions of Ukraine does not correspond to the up-to-date requirements. State policy of reforming and development of transport infrastructure of Ukraine is based on Transport Strategy of Ukraine for the period through to 2020 [Order of the Cabinet of Ministers of Ukraine dated 20.10.2010] that determines principal guidelines and priorities for Strategy implementation by means of declaring requisite measures such as: *collateral security, upgrading, establishing, organization, renovation, implementation, streamlining, procurement and development.*

Meanwhile, determination of priority guidelines for Transport Strategy does not guarantee expected fulfillment of deliberate policy of the state, because it does not provide accurate specific results – quantitative strategic benchmarks indicators, monitoring whereof would allow to control the process of development of specific guidelines. In other words determination of guidelines and priorities for modernization is necessary but insufficient condition.

Object of an article is scientific evidence of quantitative strategic benchmarks for components and indicators of infrastructural development for project scenario of strategy on social and economic modernization of the regions.

Research results. Contemporary state of social and economic development of the regions is defined by nearly one hundred of indicators. Each of these indicators in a definite period of time can grow and decline. However this brings up the question: which period under report has a better social and economic development of the region? When there are more than three indicators the task becomes considerably complicated. To evaluate the level of social and economic development of the region analyzing separate indicators which have limited value is not enough. It is necessary to estimate the general tendency that reflects mutual interaction of all indicators in consideration of their weight. That is why to answer this question it is required to build an integrated test ratio on the basis of gradual convolution of indicators and threshold limit value thereof.

Each region (economic zone) is characterized by index of industrial, post-industrial and neo-industrial modernization [Lyashenko, Kotov 2015], where neo-industrial (integrated) modernization means composite state of industrial and post-industrial modernization that reflects the nature of their inter-coordination and difference from leading similar world class coordination.

It is the absence of comparison between dynamics of integrated index and integrated threshold limit value that leads to improper conclusion about its maximization. In practice it is required to ensure such managing of social and economic development that allows integrated index to fall within the limits of threshold (better maximum) limit value. Evaluation of dynamics of integrated index of social and economic development and its deviation from threshold limit value defines required regulatory activity and offers an opportunity for scientific evidence of strategic benchmarks for different scenario of development Strategies.

Filling of components of social and economic development of the regions by specific indicators is necessary for state identification of the region. Unfortunately, official statistics do not provide fairly complete and absolutely accurate information on many aspects of trans-regional economic interactions. Thus to solve this task one shall apply macroeconomic model of general economic equilibrium "Alpha" [Kharazashvili 2007; Sukhorukov, Kharazashvili 2012], which is adjusted for regional level what makes it possible to define the majority of the following indicators of listed components.

Indicators of structural and technological modernization of the regions, where stimulant (S) – indicator, increase of which brings improvement and disincentive (D) – indicator, increase of which brings degradation of the situation:

1. Macro-economic development:

1.1. Structural component:
- Gross Regional Product (GRP, nominal par) per person, hrn/person (S);
- value added ratio in the agricultural sector in GRP, % (D);
- industrial value added ration to GRP, % (D);
- value added ratio in the service sector, % (S);
- farm workers ratio to total employment, % (D);
- industrial workers ratio to total employment, % (D);
- service workers ratio to total employment, % (S)ю

1.2. Formal and informal components:
- general performance capacity (output per production unit) (S);
- growth rate of GRP, % (S);
- manufacturing process rate (share of GRP in output) (S);
- shadow economy rate, % against official GRP (D);
- potential capacity utilization (potential GRP of full utilization of macro-factors) (S);
- shadow capital utilization ratio (D);
- shadow intermediate consumption rate, % against official (D).

1.3. Infrastructural component:
- railroad transport capacity GRP, equated t-km/$, (D);
- motor transport capacity GRP, equated t-km/$, (D);
- public railway tracks density, 1/km (S);
- public roadways density, 1/km (S);
- cargo density by motor transport, t/km (S);
- passenger density by motor transport, person/km (S);
- passenger density by railroad, person/km (S);
- cargo density by railroad, t/km (S).

2. Finance and investment development:

***2.1. Investment component*:**
- rate of investment (ratio of capital investment to GRP), % (S);
- increment share of direct foreign investment (stock capital) against GRP, % (S);
- capital assets renovation, % (S).

***2.2. Finance component*:**
- rate of second distribution of GRP by means of consolidated budget (ratio of consolidated budget revenue to GRP), % (S);
- budgetary gap, % against GRP (D);
- rate of transfer through the budget against GRP, % (D);
- consolidated budget spending level against average annual number of population, thousands of hrn/person (S);
- rate of shadow revenue of consolidated budget, % against GRP (D);
- inflation, CPI increment per year, % (D);
- bank loan value, % per year (D);
- rate of lending to the real economy, % against GRP (S);
- credit tranche to processing industries in business loans, % (S);

3. Innovative development:
- spending level on scientific and technological works % against GRP (S);
- academic and technological progress pace, % per year (S);
- financing of innovative activities, % against GRP (S);
- scientific experts ratio, persons per 1000 of employers, % (S);
- ratio of enterprises that performed innovative activities from total number of industrial enterprises, % (S);
- ratio of enterprises that implemented innovative activities from total number of industrial enterprises, % (S);
- ratio of enterprises that sold innovative goods from total number of industrial enterprises, % (S);
- ratio of consummated innovative goods from total volume of consummated industrial goods, % (S);
- ratio of college educated persons (students going to college) with age-appropriate population, % (S);
- human contribution to innovations to knowledge (number of scientists and engineers fully involved in Research and Advanced Development, per 10000 of population), persons (S);
- rate of inventive activity (number of obtained documents of title – licenses per 1 million of employed population), (S).

4. Social and demographic development:

4.1. Social component:
- labor service (ratio of ideal labor market to its demand) (S);
- rate of remuneration in output (social equity index) (S);
- rate of shadow salary against official (D);
- spending level on education against GRP, % (S);
- spending level on health care against GRP, % (S);
- ratio of average salary to minimum wage (S);
-salary ratio within household income, % (S);
- spending level of households on food commodities, as a % to total spending (D).

4.2. Demographic component:
- life expectancy at birth, years (S);
- depopulation index (D);
- crude death rate (number of deceased per 1000 persons of present population), *permille* (D);
- infant death rate (number of children who died before 1, per 1000 of newborns), *permille* (D);
- crude birth rate, *permille* (S);
- morbidity rate (number of first reported cases) per 100000 of population (D);
- demographic burden of incapacitated persons against able-bodied population (efficient number of payers of insurance), % (D);
- urban saturation (urban population ratio, % (S);
- medical service rate (number of doctors per 1000 of inhabitants), % (S).

5. **Domestic-foreign economic growth:**
- index of economy transparency (S);
- export-import coverage ratio (S);
- rate of innovative goods in export, % (S);
- export dependence rate, % against GRP (S);
- import dependence rate, % against GRP (D);
- import ratio in domestic consumption, % (D);
- economical dependence rate (trans regional cross-flows of additional net export), % against GRP (D);

- shadow net export rate, % against GRP (D);
- ratio of high-technology products in export, % (S);
- ratio of high-technology products in import, % (D);
- technological dependence rate (ratio of import volume of high-technology products to export volume of high-technology products), (D).

6. Ecological and recreation development:

***6.1. Recreational and tourist component*:**
- ratio of resort and recreational territory from total area of the region, % (S);
- proportion of places in health resort institutions to 1000 of population, (S);
- making use of hotel bed-space, (S).

***6.2. Ecological component*:**
- level of emissions of pollutants into the atmospheric air per 1 km^2, t (D);
- fresh water utilization rate per 1 person, mln. m^3 (D);
- volume of process and re-used water per 1 person, mln. m^3 (S);
- rate of dirty discharge into surface-water body per 1 person, mln. m^3 (D);
- sewage treatment plant capacity per year, mln. m^3 (S);
- level of forest reproduction per 1 person, (S).

To determine the dynamics of integrated index on efficiency level of transport infrastructure we use present-day developments in integrated evaluation of safety level [Kharazishvili, Dron 2015, pp. 3–21; Kharazishvili, Dron 2014, p. 117], precisely:

Form of integrated index – *multiplicative* (1):

$$I_t = \prod_{i=1}^{n} z_{i,t}^{a_i}; \quad \sum a_i = 1; \quad a_i \geq 0, \tag{1}$$

where I - is an integrated index; z - standardized indicator; a - weighing coefficient.

Normalization principle – *combined* (2):

$$S: z_i = \frac{x_i}{k_{st}}, \qquad D: z_i = \frac{k_{st} - x_i}{k_{st}}, \quad k_{st} > x_{\max}, \tag{2}$$

where x - indicator value; k_{st} - standardized coefficient.

Weighing coefficients – *dynamic*: based on application of "*Key Component*" method and "*sliding matrix*" method (3):

$$C_i \times D_i = \begin{pmatrix} d_1 c_{11} + d_2 c_{12} + \ldots + d_j c_{1j} \\ d_1 c_{21} + d_2 c_{22} + \ldots + d_j c_{2j} \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ d_1 c_{j1} + d_2 c_{j2} + \ldots + d_j c_{jj} \end{pmatrix} = \begin{pmatrix} w_1 \\ w_2 \\ \ldots \\ w_j \end{pmatrix}, \quad a_i = \frac{w_i}{\sum w_i}, \tag{3}$$

where C - absolute value matrix of factor loadings; D - vector - variance matrix.

To define dynamic weighing coefficients that consider changes in political and foreign economic situation we propose to use "*sliding matrix*" method based on use of "*key component*" method and involving successive shift of matrix of minimum required order along time frame and evaluation of weighing coefficients over given period of time. Minimum required matrix order (number of lines (n) – periods of time) is determined from the condition of equality of the amount of indicators (number of columns (m) – key component) to the amount of positive eigen-value of this matrix. As a rule, minimum required matrix order is equal to $(n+1) \times n$.

Threshold limit values – *are calculation data using mix of methods with domination of analytical approach*: functional dependence, macroeconomic models, stochastic nonlinear dynamics, legislative approach, heuristic, analog approach, expert judgment; account of assessment by international organizations.

Therefore, for each indicator of social and economic development a vector of threshold limit value is designated such as: lower threshold (x_{thr}^{l}), lower optimal (x_{op}^{l}), upper optimal (x_{op}^{u}), upper threshold (x_{thr}^{u}). Effective values of indicators characterize safe range of values, within which favorable conditions for system performance are created. Threshold limit values of indicators – are quantitative values, violation of which causes adverse economic trend of region or state. For advanced research it is advisable to expand the vector of threshold limit values by adding two more threshold limit values as suggested in Methodology

Ministry of Economic Development and Trade–2007 [Methods of calculation of level of economic safety of Ukraine, approved by the order of Ministry of Economics of Ukraine]: lower critical (x_{cr}^{l}), upper critical (x_{cr}^{u}), violation of which can lead to system breakdown.

Considering definition of vector for threshold limit values it is provided to expand "*homeostatic plateau*" [Kachynskyy 2013]: (figure 1).

Thence the main task of maintaining social and economic growth is not maximization of development level but control its staying within threshold better yet optimum values (within "*homeostatic plateau*"). At each side of "homeostatic plateau" there are located areas with neutral and positive feedback staying wherein is dangerous or threatens the system. In this regard it becomes significantly important to monitor status of social and economic development on the whole and its separate components and indicators in order to determine existing condition compared to threshold limit values, estimate threats, specify strategic benchmarks of development for mid-term and long term.

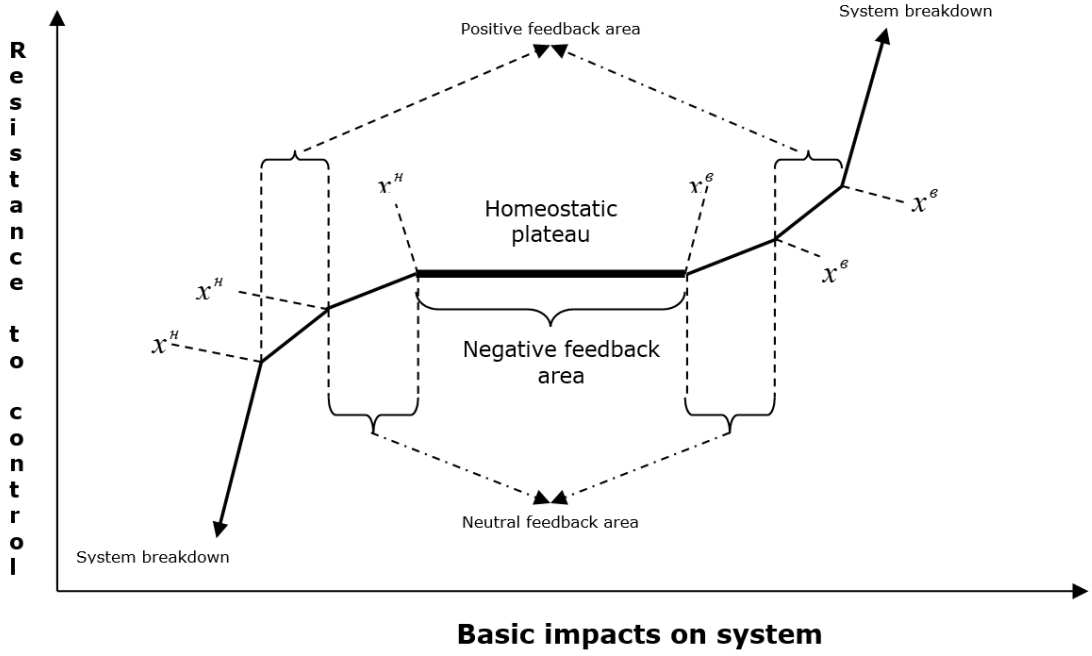

Figure 1 - "Homeostatic plateau" of dynamic system
Source: compiled by the authors

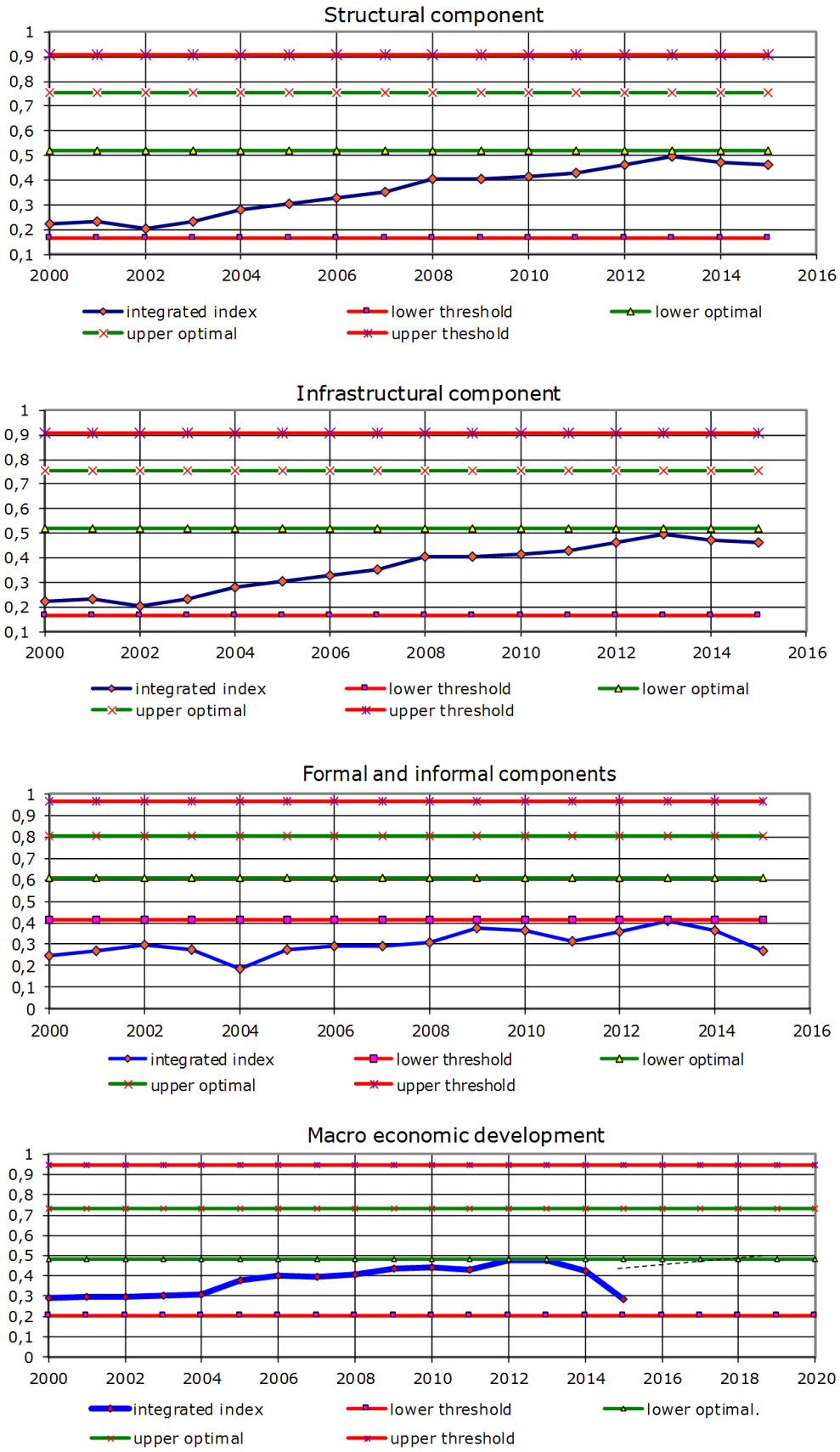

Figure 2 - Dynamics of integrated indexes of macro-economic development of Donetsk region

Source: compiled by the authors

Integrated assessment of macro-economic development level (structural, formal and informal, infrastructure component) of Donetsk region based on applicable indicators over the period of 2000-2015 looks the following way (figure 2). It stands to reason that indicators shall influence differently the dynamics of integrated indexes of different components of the development over different periods of time in different regions (economic zones), what is reflected in weighing coefficients thereof calculated by formal approach.

Out of three components of macro-economic development only structural component has satisfactory value (close to lower optimal value), other components as well as macro-economic development on the whole remind "*diving*" economy. Such situation is a result of unsuccessful economic policy that grew dramatically over 2013-2015 due to occupation of part of Donetsk and Luhansk regions by Russian Federation. Let us assume that there is a strategic goal for the next five years to reach increment of integrated index of macro-economic development that equals maximum increment for the last five years over the period of 2000-2013 (refer to figure 2, *g*).

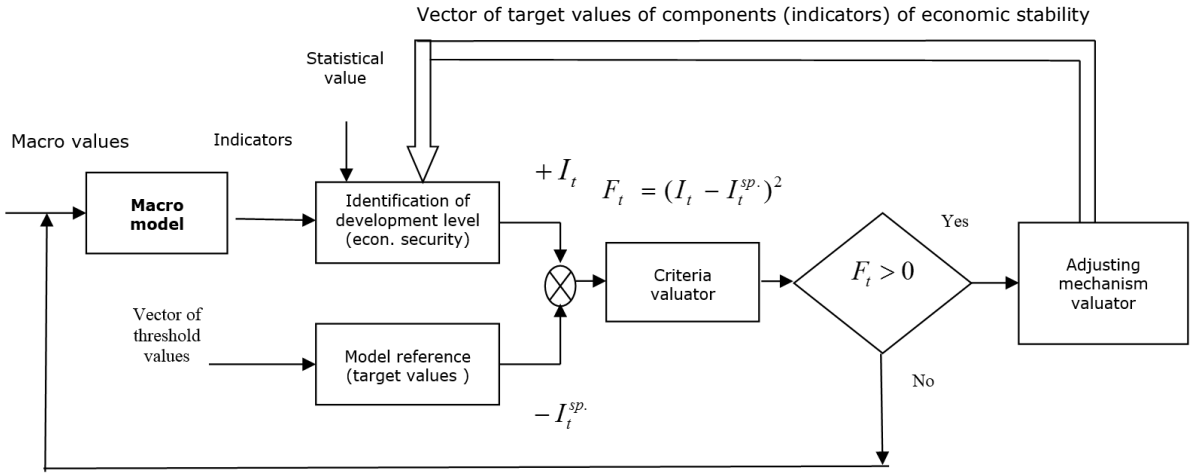

Figure 3 - General chart of adaptive control system
Source: compiled by the authors

Knowledge of strategic benchmarks dictates the need for problem analysis of decomposition of integrated index, ie synthesis of target values of components and indicators in order to fix integrated index within the specified limits. Solving of this task (reverse) for each component of social and economic development, when its target value is known (or specified), permits with allowance made for sensitivity of components or indicators, weighing coefficients of impact and adaptive methods of regulation [Leondes 1970] thru management to define target values of components and indicators over a period of forecasting every year. At first this procedure is carried out with components of integrated index and then with indicators of each component, in other words decomposition synthesis of integrated index is realized [Kharazishvili, Dron 2014, pp. 28–45] (figure 3).

General principle of operation of adjusting mechanism is minimization of quadratic error function and its derivatives with standard gradient methods of optimization, it being understood that all functions are continuous and minimum differentiated twice (4):

$$F_t = (I_t - I_t^{sp.})^2 \quad (4)$$

Use of such approach provides the following results for strategic benchmarks for components of macro-economic development of Donetsk region (table 2).

Table 2 - Strategic benchmarks for integrated indexes of macro-economic development of Donetsk region* (component level)

Development component	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Macroeconomic:	0,28373	0,30972	0,33571	0,36170	0,38769	0,41368
Structural	0,46163	0,46988	0,47929	0,48947	0,50005	0,51214
Formal and informal	0,18207	0,21432	0,24704	0,27977	0,31182	0,34591
Infrastructural	0,32639	0,34508	0,36536	0,38694	0,40877	0,43304

Source: calculations made by the authors

The given values for components of macro-economic development are calculated with allowance made for weighing coefficients of impact of every component on macro-economic development on the whole, thence we can determine elasticity coefficients for each component (5) showing how much percent output value (y) shall be different if input value (x) is changed by 1% (Table 3):

$$E = \frac{\Delta y}{\Delta x} \cdot \frac{x}{y}. \quad (5)$$

Table 3 - Elasticity coefficients for components of macro-economic development

Development component	Structural	Formal and informal	Infrastructural
Elasticity coefficient	4,185	0,508	1,401

Source: calculations made by the authors

Therefore, structural component and then infrastructural have the biggest impact on macro-economic development.

Table 4 - Strategic benchmarks for socioeconomic modernization of infrastructural development of Donetsk region (indicator level)

Indicators of infrastructural development	***2015*** *in entry measure*	***2015*** *norm. value*	***2016*** *norm. value*	***2017*** *norm. value*	***2018*** *norm. value*	***2019*** *norm. value*	***2020*** *norm. value*	***2020*** *in entry measure*
1. Transport capacity GRP railroad (D), *bln. equated. t. km/USD*	***3,8638***	0,9678	0,9705	0,9738	0,9779	0,9826	0,9884	**1,388**
2. Transport capacity GRP motor transport (D), *bln. equated. t. km/USD*	***2,0009***	0,5998	0,6046	0,6106	0,6179	0,6261	0,6262	**1,819**
3. Density, railroad (S), *km/thousand km²*	***59,000***	0,7866	0,7902	0,7947	0,8000	0,8062	0,8138	**61,036**
4. Density, motor tranport (S), *km/thousand km²*	***302,00***	0,2013	0,2059	0,2115	0,2182	0,2257	0,2347	**352,09**
5. Cargo transport density motor transport (S), *thous. t/km*	***527,7***	0,3769	0,3770	0,3831	0,3951	0,4064	0,4204	**588,5**
6. Passenger transport density motor transport (S), *thous. pers./km*	***246,9***	0,2743	0,2744	0,2862	0,3086	0,3288	0,3544	**318,1**
7. Passenger transport density railroad (S), *mln. pers./km*	***0,463***	0,2104	0,2104	0,2105	0,2257	0,2537	0,2785	**0,6774**
8. Cargo transport density railroad (S), *mln. t/km*	***3,858***	0,1543	0,1543	0,1802	0,1973	0,2101	0,2404	**6,885**

Source: calculations made by the authors

The next step is use of received strategic benchmarks of integrated indexes for components of macro-economic development as standard values; buildup of quality criteria and inverse modeling for well-grounded calculation of desired value for indicators of each component by way of adaptive adjustment. In this case an inverse problem is solved at the level of indicators of infrastructural development when values of integrated index for future periods are known providing the following results of rapid socioeconomic modernization of infrastructural development of Donetsk region (Table 4).

Therefore, use of adaptive method for level control of socioeconomic modernization of Donetsk region allowed defining strategic benchmarks for indicators of macro-economic development, which guarantee fulfillment of criteria in accordance with the given scenario. That is how one shall define the strategic benchmarks for other components and indicators, wherefore decomposition of integrated index is carried out at first at the component level and then at the indicator level of each component. Use of applicable formula to calculate the indicators for each component gives target values for key macro-economic indicators, which provide expected level of socioeconomic modernization.

Conclusions.

1. Innovative list of components and indicators of socioeconomic modernization of the regions was recommended, which permits to trace the current state thereof in complex, including: capital traffic (load), scientific and technological progress speed, shadow economy, trans-regional flow of goods and services.

2. A method of integrated assessment is used to define the level of socioeconomic modernization that is model of integrated index – *multiplicative;* normalization principle – *combined*; weighing coefficients – *dynamic*: based on use of "*key component*" method and "*sliding matrix*" method; threshold limit values – *complex of methods with analytical approaches prevailing.*

3. For scientific evidence of strategic benchmarks for socioeconomic modernization at component and indicator level the use of adaptive approach is proposed that is solving of inverse problem of target values synthesis for components (indicators) in order to define integrated index within given (threshold or optimal) values.

4. Strategic benchmarks of socioeconomic modernization of infrastructural development were scientifically proven using Donetsk region as an example defined in main components and key indicators, which are foundation for strategic planning of the Strategy of rapid infrastructural development of the region.

5. Suggested approach can be used for any country, economic zone or region for scenario generation of Mid-term and long-term development strategies.

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