A model for assessing the development of the economy of the "future cities" based on the regression data parameter Constructive Coste Model

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Abstract. The purpose of the scientific article is the formation of a model for assessing the development of the economy of the "future cities". The model tool is the regression data parameter Constructive Coste Model. The author suggests an aggregated model for assessing the development of the economy of a municipal formation. In the scientific article, the methods of situational modeling, imitation modeling, approximation, grouping of specific elements of a structural object, algorithmization of functional processes. The emphasis of the article is on the methodological apparatus of the subjective author's opinion. The methodological apparatus takes into account external changes in the economy of the city. Methodological approaches include: entropy of scientific knowledge, aberration, ap-proximation, robustness. In the course of the study, the following conclusions were obtained: the municipal economy is in the process of transformation; The aggregated model is an effective tool for assessing the development of the economy of the "future cities"; the accuracy of the model for assessing the development of the economy of the "future cities" has been confirmed criterial.

1. Introduction

The digital transformation of the Russian economy helps to change the national development priorities. Technological society implies fundamental changes in economic systems. The amendments concern municipalities. Municipalities are limited by financial resources and authority to transform the paradigm of economic development. The highlighted circumstance acquires a negative evaluation. It shows the lability and robustness of change. The economy of municipalities can't predict development. The presence of problems of municipalities leads to ensuring the current needs of the population and not the formation of a Smart environment. Dedicated circumstance negatively affects the implementation of ideas for building the economy of the "future cities" [18], [21]. The theoretical basis of the scientific article is manifested in the approaches of foreign authors. The digitalization of the economy of the "future cities" is seen as a system of interrelationships between stable technological institutions and the modeling of a new theory of economic systems [5], [10], [13]. Theoretical compilation of new laws and concepts of forming the economy of the "future cities" is traced in the studies [7]. The creation of a methodological apparatus for the formation of the economy of the "future cities" is connected with practical measures for the transformation of city priorities [2], [12]. This aspect is occupied by foreign scientists with non-standard ideological approaches to the

question of forming the economy of the "future cities" within specific territorial formations. Particular attention should be paid to the tools of aggregation and proto-typing. To achieve this goal, you must perform the following tasks:
- to offer a toolkit of the aggregated model for assessing the development of the economy of the "future cities";
- to allocate a criterial range of research of the regression data model of the Constructive Coste Model (COCOMO).

2. Methodology

The study of the theoretical and methodological tools for the readiness of the development of the "future cities" can traced in the works of foreign and Russian scientists. Many studies are based on determining the readiness of cities to implement Smart City technologies through the construction of a statistical model. The key models of these studies are: the regression statistical model [19], the statistical test model [1], the statistical model of the robustness of the results obtained [4], the statistical model of the transition matrix [15], and the estimation model for questionable results [6]. In an analysis of a large amount of da-ta, automation of the proposed indicators (indicators) of the evaluation is re-quired. For this, the simulation tools are used. Simulation data modeling is one of the convenient and practical tools for assessing the development of the economy of the "future cities" [11]. The simulation of the economic development of the "future cities" is connected with the concept of Smart City. The following models are of interest: the agent model [9], the system dynamics model [8], the determination model [3], the discrete-event model [20]. In this toolkit there is no single model for assessing the development of the economies of the "future cities". It does not take into account the importance of developing the economies of the "future cities" in accordance with the concept of Smart City. International models and ratings of the economy readiness study of the "future cities" with the concept of Smart City are at the testing stage and are used to solve specific practical is-sues. To solve this problem, the author suggests applying the Constructive Coste Model (COCOMO) regression parameter. This aspect confirms the relevance of the topic and justifies the novelty of the research.

The aggregated model for assessing the development of the economy of the "future cities" is based on the aggregate regression data parameter Constructive Coste Model (COCOMO). The first model was used to estimate the cost of software development. Subsequently, the model was further developed taking in-to account the addition of indicators of the laboriousness of the process of creating a software product. The application of the principles of the Constructive Coste Model (COCOMO) is based on the adoption of an algorithmic methodology for determining the final result of the development of the economy of the "future cities". Criteria ranges and applied formulas for estimating the indicators of the aggregated model are adapted to the conditions of the urban economy. Let us consider an aggregated model for assessing the development of the economy of the "future cities".

The aggregated economic model evaluation "future cities" is based:

Model 1. "Basic" – "Evaluation of the process of economic management". This model includes: the indicator of renewal of the city infrastructure, the indicator of the standard of living of the population, the indicator of budgetary return, the indicator of the level of municipal debt, the indicator of investment activity. Grouped indicators of changes in Model 1. "Basic" are calculated by the following formulas (1):

$$I_{OMI} = \frac{O_i + O_o}{O_{i-1} + O_{o-1}} - \frac{O_t}{O_{t-1}}, \tag{1}$$

where I_{OMI} is the indicator of renewal of municipal infrastructure, O_i is the volume of works on replacement of objects of innovative infrastructure for the current year, O_{i-1} is the volume of works on replacement of objects of innovative infrastructure in the base year, O_o is the volume of works for the replacement of urban infrastructure facilities for the current year, O_{o-1} is the volume of works for the replacement of urban infrastructure facilities for the base year, O_t is the necessary amount of work

on the replacement of urban infrastructure in the current years, O_{t-1} is the necessary amount of work on the replacement of urban infrastructure in the base years;

– the indicator of the standard of living of the population:

$$I_j = \frac{(\overline{Z_j} \times T_j) + (\overline{P_j} \times K_j) + (\overline{S_j} \times C_j)}{\overline{Z_{j-1}} \times T_{j-1} + (\overline{P_{j-1}} \times K_{j-1}) + (\overline{S_{j-1}} \times C_{j-1})}, \tag{2}$$

where I_j is the indicator of the standard of living of the population, $\overline{Z_j}$ is the average wage of the able-bodied population in the current year, $\overline{Z_{j-1}}$ is the average wage of the able-bodied population in the base year, T_j is the number of able-bodied population for the current year, T_{j-1} is the number of able-bodied population for the base year, $\overline{P_j}$ is the average pension for the current year, $\overline{P_{j-1}}$ is the average pension for the base year, K_j is the number of pensioners living in the city in the current year, K_{j-1} is the number of pensioners living in the city in the base year, $\overline{S_j}$ is the average scholarship of students of universities and colleges in current years, $\overline{S_{j-1}}$ is the average scholarship of students of universities and colleges in base years, C_j is the number of students at universities and colleges in the current year, C_{j-1} is the number of students at universities and colleges in base year;

– the indicator of budgetary return:

$$I_b = \frac{P_b}{P_{b-1}} - \frac{R_b}{R_{b-1}}, \tag{3}$$

where I_b is the indicator of budgetary return, P_b is incomes of the city budget in the current year, P_{b-1} is incomes of the city budget in the base year, R_b is expenditures of the city budget in the current year, R_{b-1} is expenditures of the city budget in the base year;

– the indicator of the level of municipal debt:

$$I_d = \frac{M_d}{M_{d-1}}, \tag{4}$$

where I_d is the indicator of the level of municipal debt, M_d is the level of municipal debt in the current year, M_{d-1} is level of municipal debt in the base year;

– the indicator of investment activity:

$$I_i = \frac{I_k}{I_{k-1}} \times k_i, \tag{5}$$

$$k_i = \frac{I_r}{P_r}, \tag{6}$$

where I_i is the indicator of investment activity, I_k is the investment in the fixed capital of the city in the current year, I_{k-1} is the investment in the fixed capital of the city in the base year, k_i is coefficient of investment assistance, I_r is the number of investment projects realized for the year, P_r is the number of investment appeals placed for the year.

Model 2. "Built-in" - "State of the municipal economy". The model assesses the status indicators: the indicator of innovative production of the municipal formation, the indicator of investment saturation of the municipal formation, the indicator of communication and information availability, the indicator of financial independence, the indicator of the development of the consumer market. Grouped indicators of changes in Model 2. "Built-in" are calculated by the following formulas (7):
– the indicator of innovative production of the municipal formation:

$$I_p = \frac{V_i + V_v}{V_n}, \qquad (7)$$

where I_p is the indicator of innovative production of the municipal formation, V_i is the volume shipped goods of innovative production, V_v is the volume of shipped goods of the most important types of industrial products, V_n is the total volume of goods shipped works performed and services provided by city enterprises;
– the indicator of investment saturation of the municipal formation:

$$I_i = \frac{I_n}{I_p}, \qquad (8)$$

where I_i is the indicator of investment saturation of the municipal formation, I_n is the volume of investments in fixed assets due to all sources of financing (the current period), I_p is the volume of investments in fixed assets due to all sources of financing (the planning period);
– the indicator of communication and information availability:

$$I_k = \frac{W_i + W_c}{100\%}, \qquad$$

(9)
where I_k is the indicator of communication and information availability, W_i is the indicator of the network coverage of the Internet territory of the city, W_c is the indicator of the capacity of communication in the city;
– the indicator of the development of the consumer market:

$$I_r = \frac{O_t}{R_m}, \qquad (10)$$

where I_r is the indicator of the development of the consumer market, O_t is the retail trade turnover in city economy, R_m is the gross territorial product;
– the indicator of financial independence:

$$I_f = \frac{P_f + D_b}{U_f + R_b}, \qquad (11)$$

where I_f is the indicator of financial independence, P_f is the profit of large and medium enterprises of the city, U_f is loss of large and medium enterprises of the city, D_b is incomes of the city budget, R_b is expenses of the city budget.

Model 3. "Detailed" - "Smart-design technologies". This model is based on the assessment of indicators: Smart Energy, Smart Government, Smart Buildings, Smart Infrastructure, Smart Creative. The availability indicators are expressed in terms of the parameter values: 0 – the condition is not observed (the low level), 0.5 – the condition is met partially (the sufficient level), 1.00 – the condition is met completely (the high level).
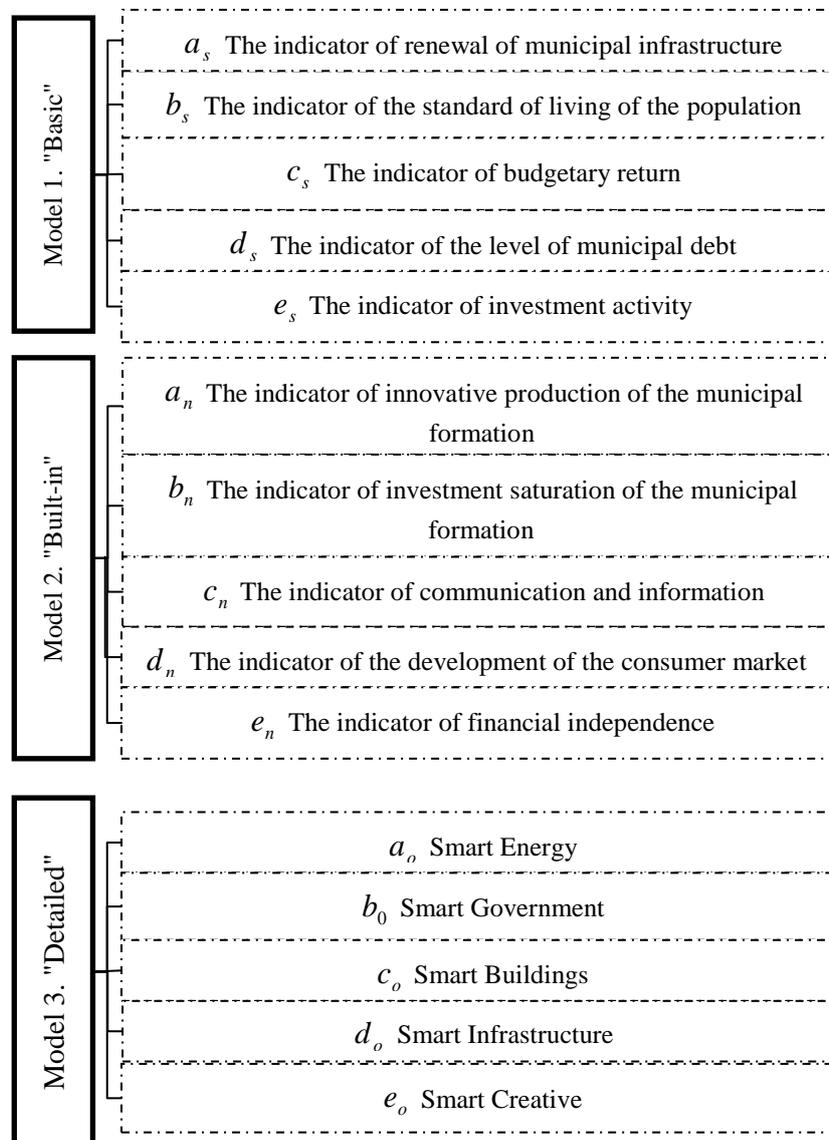
Figure 1. The aggregated model for assessing the development of the economy of a municipal formation based on the regression data parameter Constructive Cost Model.

The presented indicators reflect the essence of the development of the economy of the "future cities". The generalized values of the indicators reflect the criterial ranges of the economy of the "future cities".

3. Result

Criteria levels of the estimated values of economic development of the "future cities" are formed on the basis of a simple regression formula with parameters. Criteria levels transformed under the conditions for calculating the maximum economic development ranges of the "future cities" in accordance with the Smart City concept:

$$Model1 = \frac{a_d(a_s + b_s + c_s + d_s + e_s)^{b_d}}{c_d \times d_d}, \tag{12}$$

where $Model1$ is maximum model range Model 1. "Basic", a_s is the indicator of renewal of city infrastructure, b_s is the indicator of the standard of living of the population, c_s is the indicator of budgetary return, d_s is the indicator of the level of municipal debt, e_s is the indicator of investment activity, a_d, b_d, c_d, d_d, e_d is coefficients for calculating the levels of the Model.

$$Model2 = \frac{a_d(a_n + b_n + c_n + d_n + e_n)}{b_d \times c_d \times d_d}, \tag{13}$$

where $Model2$ is maximum model range Model 2. "Built-in", a_n is the indicator of innovative production of the municipal formation, b_n is the indicator of investment saturation of the municipal formation, c_n is the indicator of communication and information availability, d_n is the indicator of financial independence, e_n is the indicator of the development of the consumer market, a_d, b_d, c_d, d_d, e_d is coefficients for calculating the levels of the Model.

$$Model3 = a_d \times d_d \frac{(a_o + b_o + c_o + d_o + e_o)}{b_d \times c_d}, \tag{14}$$

where $Model3$ is maximum model range Model 3. "Detailed", a_o is the indicator "Smart Energy", b_o is the indicator "Smart Government", c_o is the indicator "Smart Buildings", d_o is the indicator "Smart Infrastructure", e_o is the indicator "Smart Creative", a_d, b_d, c_d, d_d, e_d is coefficients for calculating the levels of the Model.

The coefficients for calculating the levels of the Model are presented in table 1.

Table 1. Coefficients of the levels of the economic development model of "future cities"

The levels of the model	a_d	b_d	c_d	d_d
Model 1. "Basic"	2.4	1.05	2.5	0.38
Model 2. "Built-in"	3.0	1.12	2.5	0.35
Model 3. "Detailed"	3.6	1.20	2.5	0.32

Formulas 11-13 allow to set the maximal values of Model. The existing gaps be-tween the criteria form the economic development ranges of the "future cities". The final indicators of the level of economic development of the "future cities" are de-termined on the basis of the average level of the aggregated model (table 2).

Table 2. Mid-level ranges of the economic development model of the "future cities" in accordance with the Smart City concept

Model	The "low level"	The "sufficient level"	The "high level"
Model 1. "Basic"	0–6.50	6.51–13.00	over 13.00
Model 2. "Built-in"	0–12.0	12.01–15.00	over 15.00
Model 3. "Detailed"	1.15	1.16–1.90	over 1.91
E (The intermediate model level)	0.35–6.20	6.21—9.50	over 9.50

As part of the identification, the economy of the "future cities" will evolve according to the concept of Smart City. Indicators for the development of the "future cities" economy are the intermediate

model level. The intermediate model level is calculated on the basis of parametric coefficients. To calculate the coefficients COCOMO II - Constructive Cost Model calculator: $a_i = 3,2; b_i = 1,05$; $R(f) = 3 \times b_i$. Calculated by the ranges, the parameters for assessing the development of the economy of future cities vary within the limits of:

- the "low level" - the indicator parameter is in the range of 0.35-6.20;
- the "sufficient level" - the indicator parameter is in the range of values 6.21-9.52;
- the "high level" - the indicator parameter is in the range of values exceeding 9.50.

The presented model has various applications. Industry is one of the areas of use of the Constructive Cost Model. Firstly, the Constructive Cost Model simulates industrial processes. The proposed algorithm must be adapted to industrial characteristics. The basis of the Constructive Cost Model simulation will be the result of determining the readiness of the industrial sector to transition to Smart City technologies. At the enterprise level, research can be local. Municipal research reflects the industrial properties of the urban environment. Secondly, the Constructive Cost Model can be the starting point for the formation of the "smart" industry of the municipal economy. The "Smart" industry provides an analytical platform that determines: information flow, product application areas, support for strategic decisions, tactical management, thematic reality. The smart industry is based on Industry 4.0. The Industry 4.0 is based on digital productions. The production data is the backbone of the economy with Smart City technology.

4. Conclusion

The model for assessing the development of the economy of the "future cities" based on the regression parameter data of the Constructive Coste Model is formed by the author of the scientific article. This model is necessary to determine the level of economic development of the "future cities". The basics of this model correspond to the principles of the Constructive Cost Model. The instrument of the model for assessing the development of the economy of "future cities" is the regression of the data parameter. The model for assessing the development of the economy of the "future cities" includes the following blocks: basic, in-built, detailed. Each block (Model) has a group of indicators. Indicators Model should be evaluated. Criteria levels are calculated on the basis of maximum range formulas in Model 1, Model 2, Model 3. The final indicator is the average level of the aggregated model. Using the regression data model Constructive Coste Model is necessary to deter-mine the readiness of cities to develop in accordance with the Smart City concept. The principle of universality allows us to adapt the model for assessing the development of the economy of the "future cities" to changes in the external environment. This condition involves the addition and adjustment of regression parameter indicators data of Constructive Coste Model.

5. References

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