City – “a point of economic growth and social development”. Or otherwise?

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| Key points                                                                 | Characteristics                                                                 |
|---------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| 1 **A concept of primary and non-primary city activities:** city justifies its existence and development in case if it can provide for: – external functions: reproduction processes conditioned by social and territorial division of labor and aimed at the communication with the outside world; – internal functions: reproduction processes satisfying various needs of city-dwellers themselves and intraurban needs (Raman, 2010) | Comprehensive approach to development of cities taking into account economic and social aspects. |
| 2 **A concept of local communities:** city may function properly if a combination of production factors in this city provides for the income which is normal for such community and for the corresponding level of satisfaction of the population needs (Karkavin, 2001). | Social development of the territory is of the highest priority. |
| 3 **A concept of sustainable development:** combines the aims of stable and dynamic social and economic growth on the one hand and reliable natural, resource and ecological safety of development on the other hand (Krynychky, Bezrukov, Lavrentyev, 2015, Bogomolov, Mashencova, 2015). | System approach taking into account not only economic and social aspects but also the ecological aspect which includes limitations on the growth of large cities. |
| 4 **“Smart city” concept:** city “incorporating the engineering infrastructure, IT-infrastructure, social infrastructure, and business infrastructure to use the collective mental capacity of the city”. (Estevez, Vasco, Janowski, 2017; Harrison, Donnelly, 2011; Caragliu, Del Bo Ch. and Nijkamp, 2011; Komninos, 2015; Lazaroiu, Roscia, 2012; Pierce P., Andersson B., 2017 etc.) | Environmental pressure release, massive use of innovations; “smart city” structure is heterogeneous, its basis – developed urban infrastructure. Structural components are bound by the digital environment. |
### Table 2 - Econometric models used to investigate the sustainable development of the city economy

| Author, source, city | Findings |
|----------------------|----------|
| Bogomolova I.V., Mashentsova L.S., (2015), Volgograd | Qualitative factors of the city sustainable development are transformed into quantitative indicators: city functionality; relation of salary towards the minimum of subsistence; retail and public catering turnover per capita in relation to the minimum of subsistence; life expectancy; number of officially registered unemployed. Each factor is assigned with its own weight and has its own scale of indicators which is identified based on socioeconomic and statistical studies. |
| Khabibrakhma-nova R.R., (2011), Kazan | Developed econometric models showing how the gross municipal product (GMP) volumes and GMP per head of urban population depend on the change of various factors: industrial product output, investment in fixed capital, and retail turnover. Elasticity coefficients have been calculated to determine the degree of sensitivity of GMP volumes and GMP per head of population to their change. |
| Manaeva I.V., Rastvortseva S.N., (2016), single-industry towns in the Central Federal District of Russia | Developed models showing the influence of endogenous and exogenous factors on economic and social conditions of a single-industry town: industrial output is chosen as a resulting indicator of the economic status, and local budget revenue per capita – as a resulting indicator of the social status. Model components: proportion of population involved in the enterprise; population involved in the town economy; investment in the town budget; density of public hard-top motor roads in a single-industry town. |
| Belova T.A., Bakhitova R.Kh., Lakman I.A., (2016), Ufa | Production function has been made based on panel data for urban economy sectors: industrial production, construction, wholesale and retail trade, transport and communications. |
| Krinichansky K.V., Bezrukov A.V., Lavrentyev A.S., (2015), towns of Chelyabinsk region Russia | The assessed dependency of the gross municipal product (calculated using a factorial method) on the municipal spending on education and public medical care, proportion of population involved in small business, and investment in fixed capital. |
Fig. 1  Indicators of city attractiveness and economic growth
Evaluate growth of a city population.

As for short-term forecasting and evaluation of population growth, it is suggested to use the Holt–Winters adaptive model (Hyndman, Koehler, Ord, Snyder, 2008) which is a modification of the exponential smoothing method. Holt–Winters model-based forecast for \( p \) periods ahead is determined by expression (1):

\[
\hat{X}_{t+p} = (F_t + pC_t)M_{t+p-k}
\]

where \( k \) is the number of phases in a full seasonal cycle, \( X_t \) – original time series, each element of which is a migration balance, i.e. difference between the number of persons arriving in the city and number of persons leaving the city during the same year.

The coefficients are updated as follows (2):

\[
\begin{align*}
F_t &= \alpha_F \frac{X_t}{M_{t-k}} + (1 - \alpha_F)(F_{t-1} + C_{t-1}) \\
C_t &= \alpha_C (F_t - F_{t-1}) + (1 - \alpha_C)C_{t-1} \\
M_t &= \alpha_M \frac{X_t}{F_t} + (1 - \alpha_M)M_{t-k}
\end{align*}
\]

where \( \alpha_F, \alpha_M \) and \( \alpha_C \) are parameters of adaptation. Each parameter belongs to interval \([0;1]\), and the nearer a parameter is to one, the greater weight is ascribed to latest observations. The criterion for parameter selection is minimization of the model’s mean relative error. Initial values of \( F_0 \) and \( C_0 \) are evaluated using the method of least squares

\[
X_t = F_0 + C_0 t + \varepsilon t
\]
Step 1  Selection and rationing of indicators

Step 2
Building a GMP time series – annual gross municipal product per capita. Series levels are calculated according to formula (4)

\[ \text{GMP} = \text{NC} \times \text{VRP} \times \frac{m}{\text{NR}} \]  

where NC – number of city inhabitants; VRP – gross regional product; NR – size of the region’s population;
\[ m = 1 + \Delta \text{NC}, \] correction factor enabling to smooth violent fluctuations of the population size, \( \Delta \text{NC} \) – annual rate of the city population growth.

Step 3.
Building ARIMA (Reiss, Wolak, 2007) model reflecting the GMP’s dynamics and determining investment lags.

Step 4.
Identifying indicators that form the GMP’s tendency: economic, ecological, social. Indicators are grouped and represented in the form of the X-matrix.
Step 5. Transfer to the aggregates that characterize the economic and social aspects of the city life.

\[ z_{ki} = \sum_{j=1}^{m_k} w_{kj} * x_{ij}^k / m_k \]  

(5)

where \( z_{ki} \) – \( i \)th element of \( k \)-aggregate;

\( m_k \) – number of indicators in the group which is related to \( k \)-factor;

\( x_{ij}^k \) – \( i \)th value of the \( j \)th indicator included in \( k \)-group;

\( w_{kj} \) – weight of \( j \)th indicator in \( k \)-group which is calculated according to the formula (6)

\[ w_{kj} = R_{YXj}^k / \sum_{j=1}^{m_k} R_{YXj}^k \]  

(6)

where \( Y \)– vector of GMP values for the selected period of record;

\( R_{YXj}^k \) – correlation factor between \( j \)th indicator in group \( k \) (the corresponding column of the X-matrix) and the vector of GMP values.

Step 6. Building a multiple linear regressive model based on the aggregates

Selecting a most significant factor.
Migration balance in Vladivostok during 2000-2017, persons

\[ \alpha_F = 0.795; \alpha_M = 0.01; \alpha_C = 0.95 \] (Formulas 2)

In accordance with the obtained adaptation parameters, our forecast for 2020 based on Formula (3) is 110 persons or twice less than mean expected growth of population.
Fig. 2 The dynamics of the integral index of attractiveness

Table 1 Calculation results of ARIMA (2, 1, 1) model coefficients

| Coefficient | St. error | z       | P-value |
|-------------|-----------|---------|---------|
| const       | 0.0191301 | -3.232  | 0.0012*** |
| phi_2       | 0.0404941 | -1.651  | 0.0987*   |
| theta_1     | 1.035000  | -4.051  | 5.10e-05*** |

Mean square error (MSE) 0.020671
Root of mean square error (RMSE) 0.14377
Mean absolute error (MAE) 0.10387
Average absolute percentage error (MAPE) 8.6796
U- Teil's statistics (Theil's U) 0.7474
95% confidence interval (0.775218, 1.25715)

Annual GMP growth rates for a period of record from 2003 to 2016.

Prediction GMP growth rates 2017
1,01618

Prediction GMP 2017
228.4 thousand rubles/person
Correlation coefficients between the GMP and the volume of investments raised by the municipal budget with time lags of 1-4 years:

\[ R_1 = 0.222; \quad R_2 = 0.589; \quad R_3 = 0.656; \quad R_4 = 0.327. \]

Fig. 3 The dynamics of investment in fixed capital in Vladivostok city and GMP trend deviations
Table 2. Assessment of factors of development of Vladivostok city, for the period of 2002-2018

| Factor | Indicators of the level of development of Vladivostok city, modified to the level of 2002, % | Weight factors $w_i$ | Regression coefficients | Elasticity | Factor rank |
|--------|--------------------------------------------------------------------------------------------|----------------------|------------------------|------------|-------------|
| $Z_1$, $m_1=3$ Economic | $X_1$ Mining operation | 0.30 | 0.79 | 0.44 | 2 |
| | $X_2$ Manufacturing | 0.35 | | | | |
| | $X_3$ Generation and distribution of power, gas and water | 0.35 | | | | |
| $Z_2$, $m_2=4$ Social | $X_4$ Average monthly salary | 0.43 | | | | |
| | $X_5$ Amount of registered crimes | 0.28 | | | | |
| | $X_6$ Number of passengers carried by buses per year using intraurban routes | 0.19 | 0.86 | 1.54 | 1 |
| | $X_7$ Area of built domestic houses | 0.10 | | | | |
| $Z_3$, $m_3=4$ Ecological | $X_8$ Atmospheric emissions of particulate matters | 0.31 | | | | |
| | $X_9$ Nitrogen dioxide emissions | 0.16 | -0.48 | -0.09 | 3 |
| | $X_{10}$ Sulphur dioxide emissions | 0.38 | | | | |
| | $X_{11}$ Carbon dioxide emissions | 0.15 | | | | |
Fig. 4  Pattern of interaction between city structures
Thank you for your attention!!

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