Selective Adaptive Model for Forecasting of Regional Development Unevenness Indexes

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Abstract. The article deals with the issue of unevenness and asymmetry in the development of regions. Particular attention has been given to current approaches for assessing and forecasting the unevenness level. The paper analyzes the possibilities of adaptive smoothing techniques for predicting multidimensional objects. The advantages and disadvantages of existing methods of predictive analytics for the study of unevenness and asymmetry are shown. The adaptive selective model for predicting the unevenness indicators of socio-economic development of regions was developed based on the methods of multidimensional objects mathematical modeling. The selective adaptive model is based on a combination of the exponential smoothing model and the Holt model. The suitability analysis of models for forecasting the values of unevenness level of socio-economic development of regions was conducted. The forecast of indicators was calculated using the combined method of adaptive smoothing based on the selective model for groups of regions with high and low socio-economic development. The forecasts were obtained for the following indicators: number of marriages, average wage, number of households with children, number of patients with active tuberculosis, number of detected crimes, water pollution level, retail turnover, number of mobile subscribers, import of services. Due to the developed selective model, the quality of the forecast was significantly increased. The obtained models make it possible to improve the quality of decision-making on managing regional socio-economic development.

Keywords: Region, System, Unevenness, Socio-Economic Development, Indicator, Model, Estimation, Adaptive Forecasting, Management.

1 Introduction

In today's world, there are a large number of uncertainty factors that have a significant impact on the development of regions, regional formations and countries. They are fluctuations in the process of economic development and affect the main areas of balanced development. It is the deep socio-economic disparity between the regions that is closely linked to the heterogeneity and imbalance of the economic space of the country. Therefore, retrospective and prospective detailed analysis of the heterogeneity indicators of the regional economy development is relevant. The decision-making process in managing the economic development of regions under conditions of incomplete information should take into account the factors of unevenness and asymmetry of territorial development.

Comprehensive mathematical modeling of the uneven socio-economic development of the region is of scientific and practical interest and is of particular importance for the regional policy development.

This makes it possible to ensure a balanced development of the economy of the region and the country as a whole. This is confirmed by the fact that in the practice of regional management due to the great diversity of subjects, complexity and multifaceted tasks, there are significant differences regarding the unified and generally recognized methodology for assessing the unevenness level of socio-economic development of regions. All of the above made the topic of this study relevant.

2 Literature Review

The process of improving theoretical and methodological developments on the problem of estimating and forecasting the unevenness level of socio-economic development of regions is currently underway in Ukraine. The conducted analysis of modern scientific literature [1 – 4, 6, 7, 9 – 21, 23 – 25, 27, 28, 30, 32 – 47, 49 – 53] has shown that the topic of socio-economic uneven development of regional systems is one of the most discussed in the world.

Many scientists, economists and sociologists talk about the asymmetry of regional development [14, 17, 34, 37, 38,], the growth of uneven development of territories [2, 9, 11, 19, 51], divergence [6, 22, 25], differentiation [7, 53, 15] and imbalance [4, 13, 24, 46]. in the development of countries and regions. It should be noted that each of these concepts is substantially related to the differences that characterize the uneven socio-economic development. It should also be noted that some scientists distinguish separate phases of non-uniformity - differentiation, asymmetry, polarization. As noted in [34], the influence of some objective factors causes the inequality, then the combination of factors increases and the links between them and socio-economic processes are complicated. This leads to an increase in differences, further exacerbating differences, reflecting a degree of division of the territory.

The emphasis in modern research has shifted towards studying the structural characteristics of the economic space [15], the features of the uneven development of territories of different hierarchical levels [1], as the increasing unevenness begins to create threats to sustainable progressive development. In the paper, we will use the definition given in [34], that the uneven socio-economic development is understood as a type of regional development, in which there is an increase in differences between regions in terms of accumulated economic potential, the degree of population well-being, as well as other characteristics of economic and the social sphere of the regions.

In addition to differences in approaches to identifying regional disparities, there are also differing views on assessing and forecasting both unevenness indicators and assessing the level and status of regional development disparities. Practical interest in issues related to the development of methods of diagnosis and assessment of irregularities is growing. The analysis of the peculiarities of methodological approaches makes it possible to conclude that in most methods the assessment is carried out on the integral index of socio-economic development indicators. This makes it possible to make an assessment in dynamics, which allows for comparative analysis at different time intervals. But along with these benefits, there are a number of disadvantages:

- lack of a unified system of indicators for assessing uneven regional development of the country; taking into account a large number of indicators, on the one hand, significantly improves the quality of the information model, but on the other hand, leads to information overload of decision-making processes and complicates the interpretation of the results.
- systems of indicators that form an integral level of development are not always comparable due to the inclusion of indicators specific to a particular region. The formed system should provide the ability to conduct a comparative (background) analysis of the socio-economic development of regions over time.
- the models do not take into account the possibility of adapting model parameters in accordance with a change in the direction of economic development

Thus, the theoretical foundations of developing models for balanced socio-economic development of the regions are fully reflected in scientific papers. However, a number of issues related to modeling the socio-economic development of regions in the context of a cyclical crisis, assessing the heterogeneity of the economic space, identifying factors-sources of development asymmetry, were not found most fully in modern researches.

3 Problem Formulation, Methods

The purpose of the study is to develop an adaptive selective model for predicting indicators of uneven socio-economic development of regions based on methods of predictive analytics and multidimensional objects modeling.

To achieve the purpose, the following tasks should be conducted:

- form a basic set of models included in the adaptive selective model;
- estimate the parameters and quality of models;

- conduct a comparative analysis of the results obtained for each base model individually and the selective model as a whole;
- get a forecast of the regional development unevenness Indexes according to the resulting model.

Forecasting the state of the regions is an important component of its assessment, which will allow to assess later the unevenness level and the directions of strategic planning. To develop a model basis for predicting the uneven socio-economic development of regions, the results of the study [8], were used, which suggested a conceptual basis for assessing and analyzing the unevenness of regional development. According to the complex, a system of information representative indicators of uneven socio-economic development was proposed. The grouping of regions by the level of socio-economic development made it possible to assess the homogeneity and sustainability of the groups obtained, determine the place of each region in the initial set, identify structural deformations within the groups. Based on the study, two groups of regions were identified and a model for recognizing the state of uneven socio-economic development was constructed. As a result of the analysis of the indicators average values, regions with a high and low level of socio-economic development were identified. The conceptual basis allowed to form an information base for the development of a selective adaptive model for predicting the level of unevenness and individual structural components of the unevenness indicator.

The dynamic nature of the development of financial and economic processes often outweighs the property of inertia, so adaptive methods that take into account information heterogeneity of data are more effective. Adaptive forecasting methods aim at constructing models that can independently adjust parameters and take into account the informational value of different members of the time series and give fairly accurate estimates of future members of the series. And if these methods are used simultaneously, i.e. in combination or selectively, the quality of short-term time series forecasting can be improved significantly.

Let's analyze the peculiarities of short-term adaptive forecasting methods [5, 22, 26, 29, 31]. Exponential smoothing is most commonly used to smooth time series and obtain short-term forecasts when series' length is rather short.

The essence of the method of exponential observation is that in the procedure of searching for the smoothed level only values of the previous levels of a series taken with a certain weight are used, and the weight of the observation decreases with the distance from the time for which the smoothed value of the row level is determined. Consider a time series of observations $y_1, y_2, \dots, y_n$. The formula for calculating the exponential mean is:

$$q_t = ay_t + (1-a)q_{t-1}, \quad (0 \le a \le 1, a - const) \tag{1}$$

where a – smoothing parameter.

The value of q_t, $t = \overline{1, n}$, calculated for the moment t, can be considered as the prediction of the value of the level y_t at the time $t+1$: $\tilde{y}_{t+1} = q_t$, where $\tilde{y}_{t+1}$ – predictive value of the level. The forecast for the y_t level is the exponential mean

q_{t-1}, calculated at time $t-2$. Then the prediction error at time t will be equal to the formulas:

$$e_t = y_t - \hat{y}_t = y_t - q_{t-1}, \quad (2)$$

The forecast made using the exponential mean at time t is equal to the forecast made at time $t-1$ plus some correction that depends on the forecast error for time t. This is called the exponential mean adaptation. In essence, there is no adaptation, since all the corrections are made with a constant coefficient a [5, 23, 28]. And since the actual value of y_{t+1}, is unknown, and hence the error e_{t+1}, then we have to replace e_{t+1} with the mathematical expectation $E[e_{t+1}]$, which is zero for any t.

The following problems arise when using the exponential smoothing method:

1. parameter a choice. If it is necessary to increase the contribution of the previous value, a is chosen close to 1; if the aim is to eliminate the influence of the individual previous values of the time series, then the sufficiently small values of parameter a are used;
2. select the initial value of q_0. It is usually taken to be equal to the first value of the time series, or the arithmetic mean of several initial levels of the series.3) Exponential averages are particularly poor when the series has a downward or upward trend. In these cases, the forecasts become either too high or too low. The larger width of the confidence interval indicates the poor adequacy of the forecast model. All forecasts for moments greater than $t+1$, will be constant and equal to $\tilde{y}_t - 1 = q_t$. This fact is a major drawback of the exponential mean as a predictive tool.
3. The disadvantage of the exponential mean model is the delay (shift) effect. A decrease in the smoothing parameter leads to shift increase and vice versa. If the time series increases, then the shift is positive, that is, the forecasts will be below the true values, and if the time series decreases, the shift is negative, that is, the forecasts will be higher than the true values.

The development of adaptive smoothing models are models that combine the elements of exponential smoothing and allow the effects of linear trends to be distinguished. One such model is the Holt model. Holt was the first to use two smoothing parameters to construct forecasts using a linear model:

$$\hat{y}_{t+\mathrm{L}} = a_0(t) + a_1(t)L \quad (3)$$

where $a_0(t)$ – parameter that characterizes the change in the average process level; $a_1(t)$– parameter that determines the variability (increment) of the process per unit time.

When you receive more data, formulas to improve forecasts will be as follows [22].

$$a_0(t) = \alpha_1 y_t + (1-\alpha_1)a_0(\mathrm{t}-1) + (1-\alpha_1)a_1(t-1) \quad (4)$$

where $0 \leq \alpha_1 \leq 1$ – first smoothing parameter.

In general, estimating a prediction error when using a Holt model is a very time-consuming task. The coefficient $a_1(t)$ is defined as the exponential mean for the increments of the parameter$a_0(t)$:

$$a_1(t) \;=\; \alpha_2(a_0(t) - a_0(t-1)) \;+\; (1-\alpha_2)a_1(t-1), \tag{5}$$

where $0 \leq \alpha_2 \leq 1$ – second smoothing parameter.

As noted in [31], the lack of classical models can be eliminated by more flexible combined forecasting models, which include several simpler adaptive models. Therefore, it is proposed to use an adaptive selective prediction model to overcome the shortcomings of the above models. In combined models of selective type, at each step, automatic selection according to the given criterion of the best model from among those included in the basic set is organized. Thus, adaptation occurs at two levels: by structure or type of model and by parameters. In a combined hybrid model, the forecast is formed as a weighted sum of forecasts obtained by alternative models. The weights are adaptive.

The essence of this model is as follows. At each step, several base models define predictive values that are compared to actual ones. Then the best performing model is used to find new predictive values. In the next step, the procedure is repeated [31]. Thus, the forecast for τ steps is determined as follows:

$$\hat{y}_{t+\tau} \;=\; \hat{y}^{(j_i^*)}_{t+\tau}, \tau > 0, \tag{6}$$

where $\hat{y}^{(j_i^*)}_{t+\tau}$ – model forecast number j_t^* at time t for τ steps.

The model number at time t is defined as follows:

$$j_i^* \;=\; arg\, min_{j-1,\ldots,k}\, \tilde{\delta}_{t,j} \qquad (11)7$$

where k – number of base set of models;

$\tilde{\delta}_{t,j}$ – exponentially smoothed mean square error of the j^{th} model at time t:

The basic set of adaptive selective models is formed automatically. The calculations of the future values of the series are performed for each of them individually, but the estimated value obtained by the model that best reflects the real process at a given time interval is selected as a forecast.

The best model is selected according to the specified selection criterion. The criterion for the average absolute percentage error for a given prediction period is also used to select the best model variant.

$$m.a.p.e. = \frac{1}{n} \cdot \sum_{t=1}^{n} \frac{|y_t - \hat{y}_t|}{y_t} \cdot 100\,\% = \frac{1}{n} \cdot \sum_{t=1}^{n} \frac{|e_t|}{y_t} \cdot 100\,\%$$

The smaller the value of this indicator, the better the quality of the model being selected, ie the theoretical values are closer to the real values of y_t. The model is considered to provide a sufficiently high prediction accuracy if the average absolute error (m.a.p.e.) does not exceed 10%. If (m.a.p.e.) is in the range of 10% to 20%, then one can speak of a satisfactory forecast accuracy.

Switching to a specific model is carried out when its selection criterion is minimal compared to the same indicator for the rest of the models in the base set. It should be noted that the use of an adaptive selective model is effective when the basic models are significantly different.

Thus, in the short-term forecasting, the dynamics of the studied indicator at the end of the observation period is usually more important, rather than the tendency in its average development, which has developed over the whole retrospective period.

4 Findings

In accordance with the considered concept of the study, models of prediction of input indicators of unevenness was developed for the following groups of indicators: social, economic and agricultural potential and security. These groups contain the following indicators: number of marriages, number of households with children, number of crimes detected, average monthly wage of workers, incidence of active tuberculosis, discharge of contaminated return water into surface water bodies, retail turnover, number of mobile subscribers, import of services, GRP per capita, capital investments per capita, volume of industrial production per capita, profitability of operating activities of enterprises, labor productivity in agricultural enterprises [48].

Consider the forecasting of 14 indexes of regional unevenness development by the adaptive selective model. The set of indexes was determined from the previously research: Number of marriages, Average wage, Number of households with children, Number of patients with active tuberculosis, Number of crimes detected, Water pollution level, Retail turnover, Mobile subscribers, Import of services [8]. Let's consider the forecasting of variables on the example of the average wage coefficient in Ukraine by region. The training and forecasting set are based on the monthly data of Kharkiv region for 2016-2017, since the considered annual data for 2010-2017 are very volatile, so the sample will be 24 periods [48]. In this case, a short-term forecast of the dynamics of the average wage in the Kharkiv region for the 1 period forward – 1 month is constructed. The coefficient values are predicted using a selective adaptive model, which is based on a combination of the exponential smoothing model and the Holt model. Both models are used in short-term time series forecasting. Consider the dynamics of average wages in the Kharkiv region in dynamics (Fig. 1).

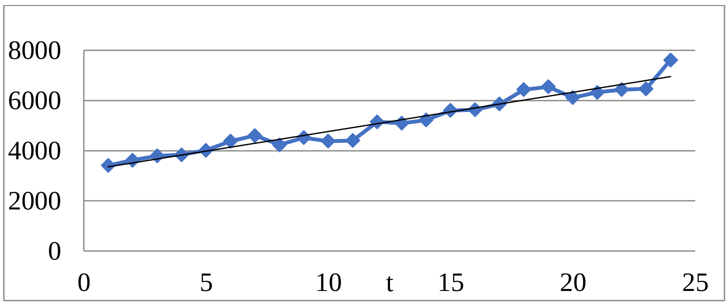

Fig. 1. Dynamics of the average wage in the Kharkiv region

The time series will be divided into two parts. For the first part, which is a sample of 14 values, we construct exponential smoothing model and the Holt model. Then we make forecasts for each model for one step ahead. Further, in order to estimate the forecasts obtained, we compare them with the actual value on the observation, using the average absolute percentage error as the measure of the forecast quality. Finally, we will summarize all the results obtained in a single table. According to the results of the forecast for the one step forward (15 period), we will select the most adequate model. It will be the basis for building an adaptive selective model for the last 10 periods. As a result, the forecast for the25-th period will be obtained.

First step. Construction of an exponential smoothing model. We carry out exponential smoothing at a = 0.9. As the initial value of the exponential mean, we take the arithmetic mean of the levels of the series, which equals 4621.6 UAH in a sample of 14 values. The obtained model of exponential smoothing with a forecast of 1 step forward is presented in Fig. 2.

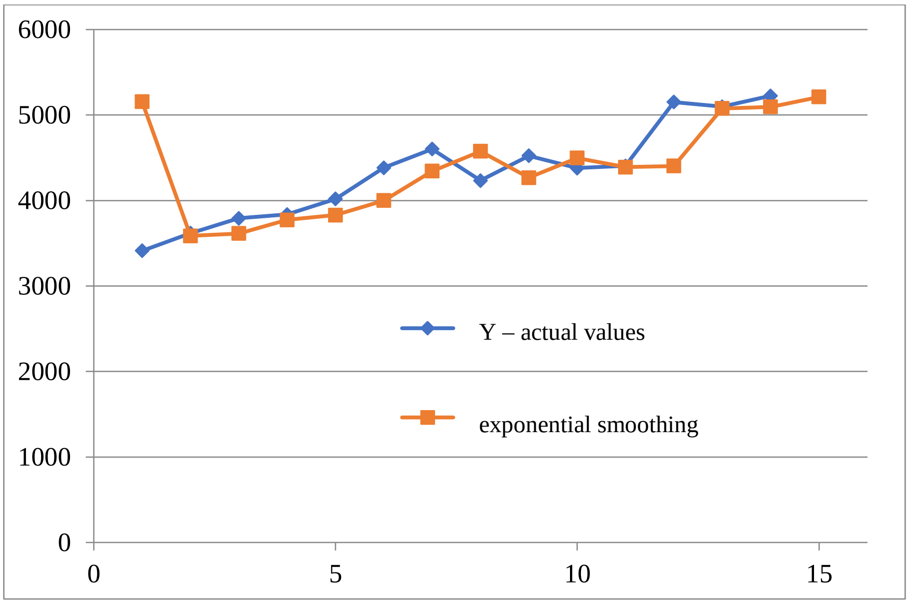

Fig. 2. Actual and calculated values (exponential smoothing model)

According to the results we can see that the forecast value for the 15th period equals 5481.7 UAH, that is, the model predicts a decrease in wages. Also, on this chart, you can see the disadvantage of exponential smoothing - the shift effect presence. In shift cases, the forecasts become either too high or too low, as shown in the graph.

The second step. The Holt model was built for a1 = 0.9 and a2 = 0.7. The initial values of the Holt model indices are the linear trend OLS estimates. The results of the model with the forecast for 1 period are presented in Fig. 3.

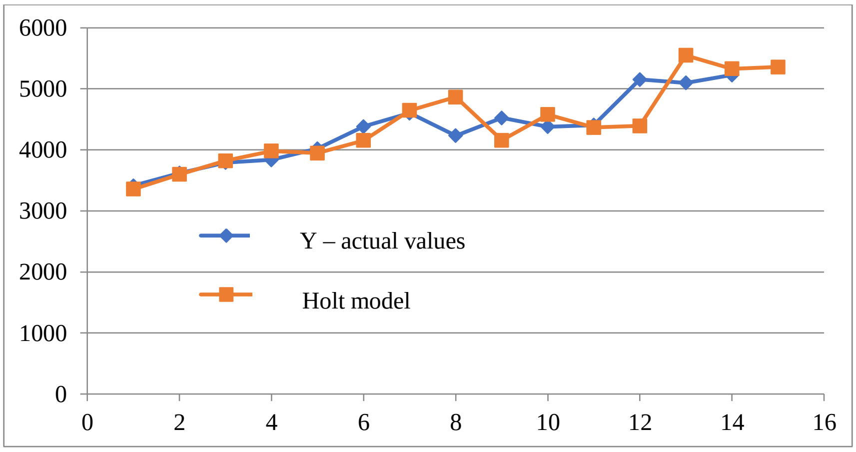

Fig. 3. Actual and calculated values (Holt model)

The quality of this forecast will be determined in the next stage of the work. In this case, when comparing the obtained calculations with the actual values, we see that the Holt model also has a delay effect. However, unlike the exponential smoothing model, the result on the graph is better. Let's check this assumption in the next step.

The third step. The criterion for the mean absolute percentage error (M.A.P.E.) is used to select the best model variant. The smaller the value of this indicator, the better the quality of the model, because the theoretical values of Yi are closer to the real values. The model is considered to provide a fairly high prediction accuracy if M.A.P.E. does not exceed 10 %. If M.A.P.E. is in the range of 10 % to 20 %, then we can speak about the satisfactory accuracy of the forecast. Comparative analysis of the calculated models has the following results (Fig. 4).

Exponential smoothing

M.A.P.E. = 0,053908	5,39 %	Excellent forecast quality

Holt model

M.A.P.E. = 0,046854	4,69 %	Excellent forecast quality

Fig. 4. M.A.P.E. value for forecasting models

M.A.P.E. for the exponential smoothing model at a = 0.9 is 5.39 %, for the Holt model at a_1 = 0.9 and a_2 = 0.7 equals 4.69 %. Thus, we see that both models can be accepted for prediction, but Holt's model provides higher accuracy of prediction.

Let's start with building an adaptive selective model. The essence of such an adaptive selective composition of models is as follows. At each step, several base models are used to determine the predicted values, then the obtained values should be compared with the actual ones. The model that showed better results is used to find new predictive values. In the next step, the procedure is repeated.

In the previous stage, a forecast of a step forward, that is, for the 15th period, was calculated using exponential smoothing and Holt models. Let's compare the results with the actual value, calculate M.A.P.E. and determine which model will be included in the selective model forecast at this stage. In the first stage, we obtain the results shown on Fig. 5.

Time period	Actual value	Forecast	
		Exponential smoothing	Holt model
15	5893	5481,47	5637,04
		M.A.P.E.	
		6,983%	4,343%

Fig. 5. Actual values and predictive values for 15th period

Thus, in the 15th period, the best result was shown by the Holt model, this result will be used for the selective model. From the same algorithm, we build a step-by-step adaptive model of the average wage in the Kharkiv region. The results are presented in Table.1.

Table 1. Step by step calculation and best model choice

Time period	Actual value	Exponential smoothing		Holt model	
		Forecast	M.A.P.E.	Forecast	M.A.P.E.
15	5893	5481,47	6,98%	5637,04	4,34%
16	5848	5851,85	0,07%	6170,42	5,51%
17	5945	5848,38	1,63%	5980,13	0,59%
18	6468	5935,34	8,24%	6026,27	6,83%
19	6449	6414,73	0,53%	6779,87	5,13%
20	6224	6445,57	3,56%	6629,68	6,52%
21	6660	6246,16	6,21%	6156,58	7,56%
22	6593	6618,62	0,39%	6818,83	3,43%
23	6634	6595,56	0,58%	6682,48	0,73%
24	7447	6630,16	10,97%	6675,20	10,36%
Forecast 25 period		7365,3156		7892,407	

We see that the chosen combined method of model construction justifies its importance, because at certain stages of model development, the quality of the forecast changes significantly and the models are interchangeable, thereby covering the under-medication at each stage and improving the quality of the forecast. Thus, the selective adaptive model has the following data, which is given in Table 2.

Table 2. Selective adaptive forecasting model results

Time period	Actual value	Selective adaptive model	Final model choice
15	5893	5637,04	Holt
16	5848	5851,85	ES
17	5945	5980,13	Holt
18	6468	6026,27	Holt
19	6449	6414,73	ES
20	6224	6445,57	ES
21	6660	6246,16	ES
22	6593	6618,62	ES
23	6634	6595,56	ES
24	7447	6675,20	Holt
M.A.P.E.	4,569%		
According to UkrStat		Forecast	
25* (June 2018)	7789	7892,40	Holt
M.A.P.E.	2,65%		

We see that the forecast value, which compares with the known actual value of the average wage for the first month of 2017, has a small margin of error and excellent forecast quality. A graphical comparison of the actual values with the calculated values is presented in Fig. 6.

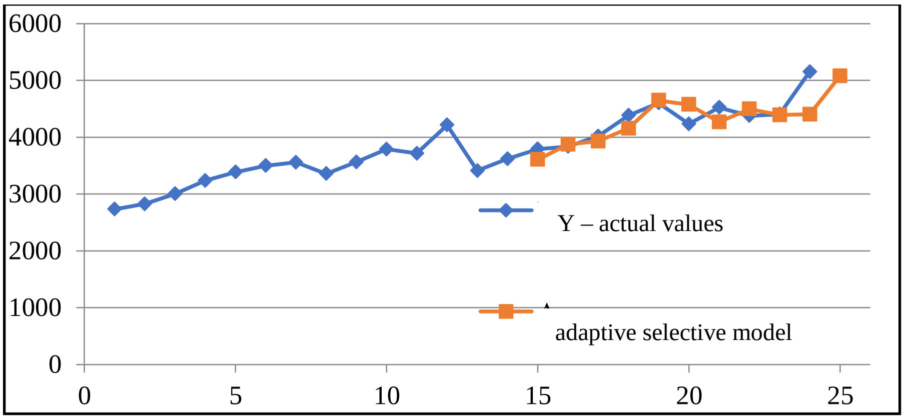

Fig. 6. Actual and calculated values of Index

The developed adaptive selective model made it possible to build a better model than the models provided separately. So, the shortcomings of one model can be blocked by another, thereby increasing the result.

Comparison of the forecast quality of the developed models is presented in Fig. 7.

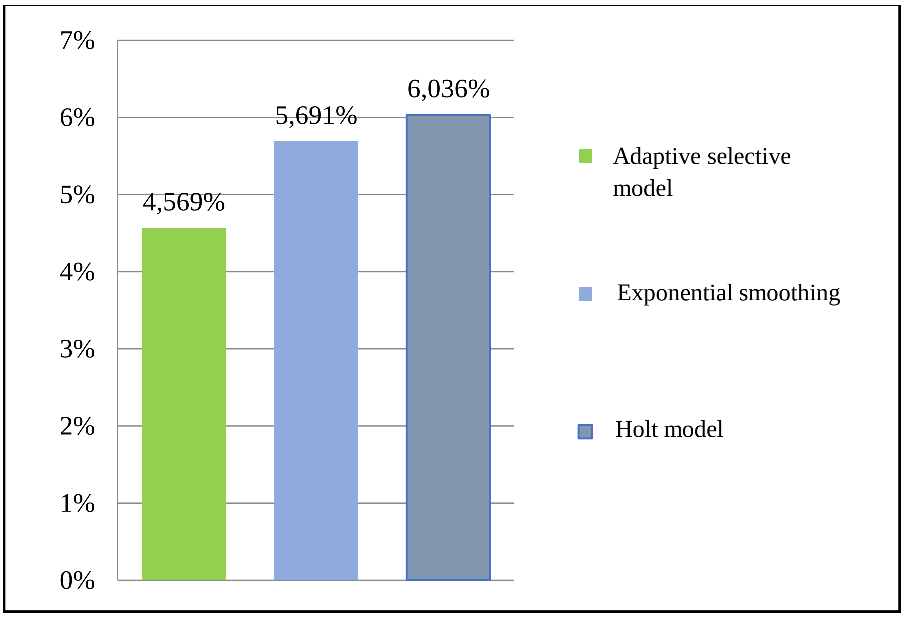

Fig. 7. Forecast quality comparison

We see that due to the developed selective model we managed to increase the efficiency and quality of the forecast by 1.52 times. In this case, this is a great result, since a change of 1% means a big change in the original data. With the help of an adaptive selective model, a 2-step forecast has been constructed. According to the same methodology, all other regions are forecasted for the other 14 indexes, which was determined from the previously constructed study models [8]. The set of regional socio-economic unevenness indexes is formed according to the following factorial groups of indicators: social and demography, foreign economic activity (x_4 – Number of marriages, x_{14} – Average monthly nominal wages of full-time employees, x_{18} – Number of households with children, x_{26} – Incidence of active tuberculosis, x_{29} – Number of detected crimes, x_{40} – Reset contaminated return water in surface water objects, x_{46} – Retail turnover, x_{55} – Mobile subscribers, x_{60} – Total imports of services), economic resulting and financial potential (x_{43} – Gross regional product per capita, x_{44} – Cost-effectiveness of operating activities of enterprises, x_{47} – Capital investment per capita, x_{51} – Volume of sold industrial products (goods, services) per person), agricultural potential (x_{50} – Labor productivity in agricultural enterprises).

The forecast will provide an opportunity to predict the state of socio-economic development of the region, as well as to estimate the overall level of unevenness. Forecasted value of indicators of social and economic development of regions for 2018 and 2019 are shown at the table. 3, 4.

Table 3. Estimated values for the social potential group

№	Region	Indexes						
		x_4	x_{14}	x_{18}	x_{26}	x_{29}	x_{40}	x_{46}
1	Vinnitska	11105.7	8247.5	218.7	498.3	13304.1	1	49780.6
2	Volinska	6963.7	7861	159.6	521.1	12396.8	1	30448.9
3	Dniprope-trovska	24112.8	9290.2	456.7	1737.8	44563.2	235	133948.2
4	Donetska	5101.4	10813.2	237.3	952.5	28876.2	143.6	39845.5
5	Gitomirska	8721.1	7806.4	180.7	612.4	15812.9	3	38726.1
6	Zakarpatska	8281.4	8883	192.1	667.9	9628.1	3.9	37847.2
7	Zaporigska	12114.1	8904	246.5	822.7	49901.9	61.9	67143.2
8	Ivano-Fran-kivska	8744.7	7716.9	213.7	664.7	10722.2	1	47521
9	Kyivska	15634.9	9393.9	244.1	1059.7	37277.6	5.1	82948.5
10	Kiro-vogradska	6411.7	7622.9	136.6	658.2	18333.3	1.7	31278.6
11	Luganska	1183	8209	96.5	314.8	12654.7	19	6543.3
12	Lvivska	17451.6	8524.1	375.7	1032.9	40890.8	46.3	93593.4
13	Mykolaivska	8081.8	8964.7	172.6	557.8	15987.8	21.2	40978.5
14	Odeska	20392.9	9135.6	340.5	2529	36504	28.7	116794
15	Poltavska	10335.8	9027.6	185.9	682.2	23964.2	3.7	46027.7
16	Rivnenska	7323.6	8195.4	177.4	360.2	11975.4	6	30138.4
17	Sumska	6761.9	7981	150.4	561	15301.3	24	33314.2
18	Ternopilska	6146.3	7354.3	163.2	280	7041.7	2	25298.4
19	Kharkivska	20830.2	8415	371.7	975.9	63900.1	11	118224.2
20	Khersonska	7709	7814.4	142.4	721.8	17076	1	38633.2
21	Khmelnitska	8597.6	8277.6	185.2	497.7	13108.7	1	36235.4
22	Cherkaska	7930.3	7913.2	173.4	552.3	22040.8	7.2	39931.9
23	Chernivetska	6046.7	7861.7	154.8	264.3	10430.9	2	22661.2
24	Chernigivska	6451	7948.2	142.5	534.3	15668.8	6.1	29611.1

Table 4. Estimated values for the economic and agricultural potential groups

№	Region	Indexes						
		x_{55}	x_{60}	x_{43}	x_{44}	x_{47}	x_{51}	x_{50}
1	Vinnitska	1225.9	12.7	66259.4	13.7	9072.3	53826.8	374167.5
2	Volinska	1150	18.7	45347.1	4.3	8267.9	32279.1	392304.2

3	Dniprope-trovska	4033.1	181	96464.1	5.5	16114	153478	307816
4	Donetska	5868.4	198.2	34582.1	-2.4	3228.7	61535	293479.1
5	Gitomirska	908.2	12.3	52649	9.2	8056.4	37087.4	328044.4
6	Zakarpatska	1157.3	13.6	32073.3	7.8	5372.6	20134.2	157698.8
7	Zaporigska	2104.3	54.7	81324.5	12.8	11341.1	101827	230907
8	Ivano-Frankivska	1265.6	16	47718.7	5.6	8010.6	41141.2	283321.3
9	Kyivska	1248.3	115.1	100817	4.3	23290.3	78337.8	258188.4
10	Kiro-vogradska	1057.2	6.7	65861.8	7.3	9395.1	29906.6	220972.2
11	Luganska	2548.1	23.3	11231.3	-9.1	1799.7	7543.45	245346.4
12	Lvivska	2197.1	48.2	61430.9	6.3	11786.3	40027.6	489314.8
13	Mykolaivska	1343.3	53	68045.4	6.3	12374.7	54705.8	233176.7
14	Odeska	3078.9	197.2	66369.4	3	11358.9	32875.3	244867.3
15	Poltavska	1653.9	121.1	105284	8.5	13413.9	161166	229374.4
16	Rivnenska	1026.8	19.5	44702.5	2.1	6430.9	35922.8	367367.4
17	Sumska	1310.6	42.3	56250.3	16.3	8045.2	40842.4	341233.9
18	Ternopilska	604.6	9.2	38455	6.8	8374.6	18629.1	469373.8
19	Kharkivska	3989	36.3	76867.6	5.2	8470.3	76243.9	296067.2
20	Khersonska	1307.1	10.7	50067	9	8606	35424.2	282400.4
21	Khmelnitska	769	13.9	51433.6	14	10557.2	36291.4	400251.4
22	Cherkaska	1091.5	10.8	65479.9	11	8374.3	55330.3	288584.1
23	Chernivetska	956.5	1.4	29559.9	3.4	3569.8	159937.3	247513
24	Chernigivska	1098.9	20.3	56532.8	8.2	8988.1	61322.8	324271.9

Let's look at the dynamics of the predicted values of social potential indicators for regions from the group with high potential of development (see Table 5)

Table 5. Predicted values increments of social potential indicators for regions from the group with high potential of development

№	Indicator	Peri-od	Region						
			Dne-prope-trovsk	Do-netsk	Za-porizhzhya	Kyiv	Lviv	Odessa	Khar-kiv
x_4	Number of marriages	25	1,120	0,780	1,097	1,119	1,059	1,099	1,081
		26	1,022	0,578	1,024	1,110	1,028	1,084	1,079
x_{14}	Average wage	25	1,259	1,252	1,196	1,197	1,214	1,246	1,264

		26	1,064	1,113	1,085	1,092	1,099	1,121	1,066
x_{18}	Number of households with children	25	0,990	0,882	0,990	0,997	0,995	0,996	0,994
		26	0,990	0,901	0,988	0,994	0,998	0,998	0,995
x_{26}	Number of patients with active tuberculosis	25	0,965	0,947	0,924	0,960	0,881	0,993	0,883
		26	0,865	0,872	0,872	0,952	0,864	0,994	0,969
x_{29}	Number of crimes detected	25	0,997	1,005	1,034	1,082	1,029	1,021	1,069
		26	0,986	0,991	1,025	1,078	1,049	1,021	1,070
x_{40}	Water pollu-tion level	25	0,999	0,935	0,985	1,040	0,970	0,942	0,909
		26	0,984	0,919	0,998	0,975	1,015	0,983	1,100
x_{46}	Retail turnover	25	1,081	1,018	1,072	1,098	1,102	1,092	1,078
		26	1,075	1,036	1,066	1,090	1,095	1,089	1,071
x_{55}	Mobile subscribers	25	0,986	0,966	0,972	0,856	0,909	0,978	0,965
		26	0,980	0,966	0,969	0,841	0,903	0,971	0,969
x_{60}	Import of services	25	0,924	0,887	1,009	1,014	1,135	0,972	0,905
		26	0,766	1,119	1,048	0,741	0,729	1,107	0,903

Thus, Kyiv region is the most important, which is the leader in this classification of regions. The Dnipropetrovsk region should be mentioned next. Donetsk region has the lowest values in 2018-2019 (25 – 26 period). Since this region is not economically stable, it is likely that it will move to the second class - with low level of socio-economic development.

5 Discussion and Conclusion

According to the research results it was proved that the current stage of development of the Ukrainian economy is characterized by structural imbalances of regional development, manifested in the unbalanced growth rates of groups of donor and recipient regions, unbalanced growth rates of economic and social spheres of different regions. Significant regional disparities are a deterrent to ensuring high rates of economic growth throughout the country. Thus, the analysis of the uneven socio-economic development of the regions of Ukraine made it possible to conclude that the problem is highly relevant.

The possibilities of adaptive smoothing techniques for the prediction of multidimensional objects have been analyzed in the paper. Advantages and disadvantages of existing methods of predictive analytics were shown. An attempt is made to build selective models, the composition (basic set) of which includes several simpler adaptive models. The selective adaptive model is based on a combination of the exponential smoothing model and the Holt model. In combined models of the selective type, at each step, automatic selection by the given criterion of the best model is organized. Thus, adaptation takes place at two levels: level 1 (according to the structure of the model or type of model) and level 2 (according to the parameters of the model). In the combined hybrid model, the forecast is formed as a weighted sum of forecasts obtained by alternative models. The weighting coefficients of smoothing are adaptive in this case. An adaptive selective model for predicting indicators of uneven socio-economic development of regions was developed based on Data Science methods. The suitability analysis of models for forecasting the values of unevenness level of socio-economic development of regions was conducted. Prospects for further research include the possibility of identification of the most significant strategic levers of balancing regional development disproportions This provides the basis for identifying priority vectors for crisis management in the region, achieving a proper economic status, further sustainable development of both individual regions and the country as a whole.

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