Selection of a forecasting model for Russia consumer price index based on the application of Analytic Hierarchy Process

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Abstract. The present article is dedicated to the problem of making decisions in the process of selecting a forecasting model through the example of Russia Consumer Price Index (CPI) forecast. Forecast values of CPI have been obtained for a year of 2021 using five models. Qualitative criteria for the comparability of the models have been formulated in order to select the most appropriate model. The application of the Analytic Hierarchy Process gives the opportunity to determine the optimal model for the Consumer Price Index forecast based on the synthesis of quantitative preference vectors.

1. Introduction
The Consumer Price Index (CPI) is considered to be one of the tools for measuring inflation. The development of long-range programmes all over the world is founded on applying the CPI values [1-2]. In the meantime, the estimation of CPI values presents a forecasting problem under the conditions of considerable uncertainty.

There are many forecasting methods, moreover, new methods are being worked out and the current ones are being developed. Therefore, it is definitely important to make the right choice of a forecasting model becoming the most adequate for a specific task, in a particular industry and according to a definite set of data. In the paper, some forecasting models of Russia CPI will be considered and the most preferred method will be proposed by means of the Analytic Hierarchy Process [3].

2. Russia Consumer Price Index (CPI)
Forecasting is based on analysing the series and establishing a specific regularity of dynamics of the series with reference to which a further forecast will be made.

Average CPI values in Russia by December of the previous year have been selected for modelling. Due to denomination, the years from 1999 to 2020 inclusively have been chosen to obtain qualitative and representative results. The length of the time series is equal to 22 years and considered enough for a short-term forecast taking into account the CPI nature and the statement of a forecasting problem in this particular case. The present article considers the Linear Growth Curve Model (LGCM) [4], the Quadratic Growth Curve Model (QGCM) [5], the Simple Moving Average Model (SMAM), the Linear Exponential Smoothing Model (LESM) [6], and the Quadratic Exponential Smoothing Model (QESM) [7]. The obtained forecasts are shown in Table 1.
Figure 1 presents the actual CPI values from 2017 to 2020 together with the forecast for 2021. The Mean Absolute Percentage Error (MAPE), given in Table 1, has been calculated to check the accuracy of the models. The Simple Moving Average Model (SMAM) obtains the highest accuracy.

Table 1. Forecast values of CPI for 2021 and Mean Absolute Percentage Error.

| Model                                           | Forecast | MAPE  |
|-------------------------------------------------|----------|-------|
| Linear growth curve model                       | 100.81   | 2.71% |
| Quadratic Growth Curve Model                    | 107.22   | 2.49% |
| Simple Moving Average Model                     | 104.69   | 1.09% |
| Linear exponential smoothing model              | 105.12   | 3.31% |
| Quadratic exponential smoothing model           | 103.56   | 2.67% |

3. Analytic Hierarchy Process (AHP) and Selection of the Optimal Forecasting Method

The main peculiarity of AHP is its flexibility confirmed by the recently appeared scientific works on decision-making in medicine [8], assessing landslide hazards [9] and opting for new materials and designs in industrial production [10]. In the present paper, the benefit of AHP also consists in taking into account several criteria for selecting a forecasting model.

The Analytic Hierarchy Process involves a stage of decomposing the problem into less complicated aspects and a stage of the preference vector synthesis via determining the quantitative relations through the qualitative judgments. AHP allows an expert to select the best solution out of the set of available alternatives. It is supposed that the specialist will accomplish this relying on his experience and skills in solving the similar problems and in accordance with the possible requirements to their solution.

At the initial stage, the problem has been structured in the form of a hierarchy that in its simplest state includes a purpose, criteria and alternatives. The purpose refers to selecting the optimal method of Russia CPI forecast by December of the previous year. When deciding on a forecasting model it is possible to operate with some criteria at once. The most widely spread way to select the forecast value using several models is a calculation of the forecast error.
Another way is to compare the forecasts for various models and choose the result obtained for the most models under consideration. Specialists, experienced in the field of forecasting, often make a choice on the chart based on the overall behavior of the series. In some cases, for instance, while analyzing big data, simplicity of calculations is also significant. All the above-mentioned aspects specify the selection of criteria to determine the optimal forecasting model in the given article.

Criteria: 1. Proximity of the results to other methods (PM); 2. Intuitive and visual superiority of the forecast on the chart (C); 3. Accuracy of the forecast (AF); 4. Simplicity of calculations (SC).

Alternatives: 1. Linear Growth Curve Model (LGCM); 2. Quadratic Growth Curve Model (QGSM); 3. Simple Moving Average Model (SMAM); 4. Linear Exponential Smoothing Model (LESM); 5. Quadratic Exponential Smoothing Model (QESM).

Further, an inverse-symmetric matrix of the paired comparisons for the criteria to determine their priority (according to the degree of importance for each criterion in relation to each other criterion) has been developed. The matrix is presented in Table 2.

Table 2. Matrix of paired comparisons according to the criteria and a vector of priorities.

| Criteria | Proximity | Chart | Accuracy | Calculation | Local priority | Normalized local priority |
|----------|-----------|-------|----------|-------------|----------------|--------------------------|
| Proximity | 1.00      | 2.00  | 3.00     | 7.00        | 2.546          | 0.478                    |
| Chart    | 0.50      | 1.00  | 2.00     | 6.00        | 1.565          | 0.294                    |
| Accuracy | 0.33      | 0.50  | 1.00     | 5.00        | 0.955          | 0.179                    |
| Calculation | 0.14  | 0.17  | 0.20     | 1.00        | 0.263          | 0.049                    |

For the comparison, Saaty offered to use qualitative features, later transferring into the quantitate ones, according to the 9-point scale where 1 means the same significance of the matrix elements being compared while 9 refers to the absolute significance, namely the element is highly preferable in regards to another one [14].

Then the equivalent matrix of the paired comparisons for the alternatives (four matrices with a dimension of 5x5) has been developed for each criteria and the components of vector preferences have been worked out.

The consistency ratio (CR) has been calculated and the check of expert assessments for consistency has been performed for each of the five obtained matrices, the results are given in Table 3. The assessments for all matrices proved to be consistent in the meaning proposed by T. Saaty [11], that is, all assessments have a consistency ratio of no more than 10%.

Table 3. Consistency ratio.

|                      | CR     |
|----------------------|--------|
| for criteria         | 2.83%  |
| for alternatives (PM)| 3.16%  |
| for alternatives (C) | 2.41%  |
| for alternatives (AF)| 1.26%  |
| for alternatives (SC)| 2.55%  |

At the final stage, the synthesis of local priorities has been carried out. Table 4 presents the ordered global priorities of the alternatives on the basis of which the best solution (the optimal alternative) has been selected.
Table 4. Priorities for alternatives.

| Method  | Normalized local priority | Global priority |
|---------|---------------------------|-----------------|
|         | PM | C  | AF | SC |                   |
| LGCM    | 0.043 | 0.044 | 0.143 | 0.272 | 0.072          |
| QGSM    | 0.075 | 0.425 | 0.250 | 0.166 | 0.214          |
| SMAM    | 0.343 | 0.210 | 0.405 | 0.389 | 0.318          |
| LESM    | 0.299 | 0.228 | 0.058 | 0.107 | 0.225          |
| QESM    | 0.240 | 0.093 | 0.143 | 0.066 | 0.171          |

Figure 2. Sensitivity of global priorities on Chart-factor. The numbers on the graphs give the ratio of the factors Chart/ Proximity

Let us consider the sensitivity of the solution obtained and demonstrate how the priority ratio changes with increasing the role of the second criterion (Intuitive and visual superiority of the forecast on the Chart). Figure 2 shows the dynamics of changes in the components of the global priority vector depending on the relative value of the second factor. With a significant predominance of the second criterion in relation to the first one, the SMA method keeps a leading position. This, combined with the good consistency of all matrices, indicates the stability of our solution.

4. Conclusion

The application of the Analytic Hierarchy Process by Saaty to determine the optimal forecasting model is proposed in the present article. Russia Consumer Price Index by December of the previous year has been chosen as the indicator under research. Five models have been developed: Linear Growth Curve Model (LGCM), Quadratic Growth Curve Model (QGSM), Simple Moving Average Model (SMAM),
Linear Exponential Smoothing Model (LESM), Quadratic Exponential Smoothing Model (QESM). The application of AHP allows taking into account several criteria at once when selecting a model to forecast Russia CPI - the Simple Moving Average Model proved to be optimal. The results of the given research can be used to analyze Russia CPI, to select independently the optimal forecasting model for Russia CPI by December of the previous year (since the results of Saaty AHP have a subjective nature) and for the equivalent choice of a forecasting method for other indicators. In addition, the approach, developed in the course of the present work, can be applied by researchers to become acquainted with the method of selecting a forecasting model of indicators through the example of Russia CPI and for the solution of different problems requiring the choice of an acceptable forecasting method.

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