Application of techniques for moving dynamics series for planning and forecasting indicators in agrotourism

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Abstract. Planning and forecasting in agrotourism have their own characteristics, due to the specifics of the industry, associated with the finding of this area in close connection with agriculture and tourism. At the same time, in the planning of agricultural indicators, it is necessary to adhere to long-tested and positively proven methods based on quantitative methods. The qualitative side of agrotourism implies the need for a separate approach to planning a number of indicators, such as the price of a service. Forecasting methods here should take into account the purely market orientation of the tourist component. In addition, the field of agrotourism is mostly represented by small farms, which most often do not use professional software products for the purpose of forecasting indicators and further planning their activities on this basis. This article describes the methods of moving the dynamics series for planning and forecasting indicators in agrotourism.

1. Introduction

Issues of planning and forecasting in any sphere of the national economy have occupied and still occupy a large place in the management activities of the enterprise. This also applies to the service sector. However, here the features of services as a product do not allow us to fully realize the opportunities that can be used to solve the tasks set in the field of material production. For example, immateriality and quality instability negatively affect the accuracy of plans and do not allow you to make forecasts for the long term. This is especially true for the part of services that complement the functional value (for example, in a hotel-the actual accommodation, in catering establishments-the satisfaction of the need for food, etc.) - these are additional services that add other types of values (emotional, social, epistemic, etc.). Types of values), in general, increasing the attractiveness of the finished product in the eyes of the consumer, combining all these types of values together [1, 2].

In general, the field of agrotourism has other limitations when forming plans and building development forecasts, for example, small enterprises (namely, they account for up to 75 % of the market) can apply their own approach to planning: plans here are reduced to determining approximate directions of development (construction of additional buildings and structures for expansion, purchase or sale of equipment in the near future, etc.), and the plans themselves are often developed only for external users in order to attract additional sources of funding. For internal use, however, plans may not be drawn up at all. Forecasts may not be discussed here at all.

Further, even if there is a great desire to build an objective development plan, such companies may not have enough of their own resources: to draw up a well-thought-out plan or forecast of development
(it is for real implementation, and not fictitiously), highly qualified specialists are required, which, most often, are not in the state, and the service itself, with the involvement of third-party assistance, can be expensive on the market.

Hence, the dilemma arises – what techniques available to the farmer can be used to plan and forecast the development of agro-tourism in the selected market niche?

2. Methods and Materials

We think that planning issues in such cases should be addressed starting from the lowest stages. For example, by making a forecast of price dynamics, etc. This can be done through the application of the fundamentals of economic and statistical analysis [3, 4, 5, 6].

For example, we will make a forecast of the cost of a conditional service in the field of agrotourism for the next three years using the methods of leveling the dynamics series.

As the initial information, we will take the dynamics of the cost of a conditional service in the field of agrotourism over the past 20 years (table 1).

| Year   | Average cost, RUB | Year   | Average cost, RUB | Year   | Average cost, RUB | Year   | Average cost, RUB |
|--------|-------------------|--------|-------------------|--------|-------------------|--------|-------------------|
| 2000   | 200               | 2006   | 283               | 2012   | 475               | 2018   | 627               |
| 2001   | 251               | 2007   | 305               | 2013   | 525               | 2019   | 615               |
| 2002   | 243               | 2008   | 310               | 2014   | 532               | 2020   | 628               |
| 2003   | 274               | 2009   | 415               | 2015   | 545               | 2021   | -                 |
| 2004   | 287               | 2010   | 395               | 2016   | 586               | 2022   | -                 |
| 2005   | 295               | 2011   | 425               | 2017   | 654               | 2023   | -                 |

First, consider an example using Simple Moving Averages (SMA). This method is characterized by ease of calculation, as well as relative ease of interpretation of the results. The essence of the method is to calculate the averaged data for a certain period of time, while the levels that are taken as the basis for calculating the averages, as it were, are superimposed on each other and the effect of «moving» is obtained, for which this method got its name. The method is not only simple, but also very common, including in the financial environment, for example, when compiling stock market reports [7, 8, 9].

The SMA forecast is based on the formula (1):

\[
y_{t+1} = m_{t-1} + \frac{I}{n} \cdot (y_t - y_{t-1})
\]

where \( t \) – the year preceding the forecast; \( y_{t+1} \) – the indicator for which the forecast is made; \( m_{t-1} \) – the moving average of the indicator for two years before the forecast; \( n \) – the number of levels included in the moving interval (in our example 3); \( y_t \) – the actual value of the studied phenomenon for the previous period; \( y_{t-1} \) – the actual value of the studied phenomenon for the two years preceding the forecast.

Second, we look examples of using Exponentially Moving Averages (EMA).

We determine the value of the moving parameter by the formula (2).

\[
a = \frac{2}{r + I}
\]

where \( r \) – the number of observations included in the moving interval.

We calculate the exponentially weighted average for each period using the formula (3).
\[ U_{t+1} = \alpha \cdot y_t + (1 - \alpha) \cdot U_t \]  

where \( U_{t+1} \) is the forecast indicator; \( U_t \) is the exponentially weighted average for the period preceding the forecast period.

The error for both methods will be calculated as the average relative error of the forecast according to the standard formula (4).

\[ \varepsilon = \frac{1}{k} \sum_{i=1}^{k} \left( \frac{|m_i - y_i|}{y_i} \right) \cdot 100 \]  

where \( k \) is the number of levels for which the moving averages are calculated.

3. Results and Discussion

To begin with, we consider the classic version with the calculation of moving three-year averages (table 2). The solution can be presented in a tabular form.

To calculate the forecast value using the moving average method, you need to perform the following calculations.

Then we define the moving interval. In our example, in the first part of the task, it is equal to three \((n = 3)\).

We calculate the moving centered average \((m)\) using the arithmetic mean formula for the first three periods (2000, 2001, and 2002) and enter the resulting value in the table in the middle of the period taken (that is, for 2001).

Next, we calculate the indicator in the same way for the following three periods: 2001, 2002 and 2003, we record the result for 2002, etc.

Then we build a forecast for 2021 (5) using the formula (1):

\[ y_{2021} = m_{2019} + \frac{1}{3} \cdot (y_{2020} - y_{2019}) = 623.34 + \frac{1}{3} \cdot (628 - 615) = 627.67 \]

Next, we write the result in the table.

Next, we determine the centered moving average \(m\) for 2020 using the arithmetic mean formula, adding the values for 2019, 2020 and 2021 and dividing the result by 3 \((m_{2020} = 623.56)\). We write the result in the table.

Repeat the procedure for 2022 (6, 7) and 2023 (8, 9):

\[ y_{2022} = m_{2020} + \frac{1}{3} \cdot (y_{2021} - y_{2020}) = 623.56 + \frac{1}{3} \cdot (627.67 - 628) = 623.45 \]
\[ m_{2021} = 626.38 \]  

\[ y_{2023} = m_{2021} + \frac{1}{3} \cdot (y_{2022} - y_{2021}) = 626.38 + \frac{1}{3} \cdot (623.45 - 627.67) = 624.97 \]
\[ m_{2022} = 625.37 \]

Then we build a graph that reflects the dynamics of the studied indicator over time (figure 1).
As you can see, the trend significantly smooths out the fluctuations of the indicator (2008-2009, 2009-2010, 2016-2017). Therefore, the question arises about the accuracy of this method of predicting the indicator.

First, we calculate the average deviation of the moving values from the actual value (table 2).

Table 2. Solution through the application of moving centered three-year averages.

| Year | Average cost ($y_i$) | Moving centered three-year averages ($m_t$) | Average deviation of moving averages from the actual value |
|------|----------------------|---------------------------------------------|----------------------------------------------------------|
| 2000 | 200                  | -                                           | -                                                        |
| 2001 | 251                  | 231.34                                      | 0.079                                                    |
| 2002 | 243                  | 256.00                                      | 0.054                                                    |
| 2003 | 274                  | 268.00                                      | 0.022                                                    |
| 2004 | 287                  | 285.34                                      | 0.006                                                    |
| 2005 | 295                  | 288.34                                      | 0.023                                                    |
| 2006 | 283                  | 294.34                                      | 0.041                                                    |
| 2007 | 305                  | 299.34                                      | 0.019                                                    |
| 2008 | 310                  | 343.34                                      | 0.108                                                    |
| 2009 | 415                  | 373.34                                      | 0.101                                                    |
| 2010 | 395                  | 411.67                                      | 0.043                                                    |
| 2011 | 425                  | 431.67                                      | 0.016                                                    |
| 2012 | 475                  | 475.00                                      | 0.000                                                    |
| 2013 | 525                  | 510.67                                      | 0.028                                                    |
| 2014 | 532                  | 534.00                                      | 0.004                                                    |
Calculate the forecast error. In our example, k is 19. The sum of the average deviations of the moving averages from the actual level is 0.649. Then (10):

$$
e = \frac{1}{19} \cdot 0.649 \cdot 100 = 3.416$$

Since the obtained average relative deviation of the moving averages from the actual value (3.42 %) is less than 10 %, the forecast accuracy is high.

Now let's try to solve the problem in a different way using the tools and capabilities of MS Excel. Find the moving averages of two-, three-, four- and five-year periods (table 3).

| Year | Average cost | Non-centered moving averages |
|------|-------------|------------------------------|
|      |             | two-year | three-year | four-year | five-year |
| 2000 | 200         | -        | -          | -         | -         |
| 2001 | 251         | -        | -          | -         | -         |
| 2002 | 243         | 225.50   | -          | -         | -         |
| 2003 | 274         | 247.00   | 231.33     | -         | -         |
| 2004 | 287         | 258.50   | 256.00     | 242.00    | -         |
| 2005 | 295         | 280.50   | 268.00     | 263.75    | 251.00    |
| 2006 | 283         | 291.00   | 285.33     | 274.75    | 270.00    |
| 2007 | 305         | 289.00   | 288.33     | 284.75    | 276.40    |
| 2008 | 310         | 294.00   | 294.33     | 292.50    | 288.80    |
| 2009 | 415         | 307.50   | 299.33     | 298.25    | 296.00    |
| 2010 | 395         | 362.50   | 343.33     | 328.25    | 321.60    |
| 2011 | 425         | 405.00   | 373.33     | 356.25    | 341.60    |
| 2012 | 475         | 410.00   | 411.67     | 386.25    | 370.00    |
| 2013 | 525         | 450.00   | 431.67     | 427.50    | 404.00    |
| 2014 | 532         | 500.00   | 475.00     | 455.00    | 447.00    |
| 2015 | 545         | 528.50   | 510.67     | 489.25    | 470.40    |
| 2016 | 586         | 538.50   | 534.00     | 519.25    | 500.40    |
| 2017 | 654         | 565.50   | 554.33     | 547.00    | 532.60    |
| 2018 | 627         | 620.00   | 595.00     | 579.25    | 568.40    |
| 2019 | 615         | 640.50   | 622.33     | 603.00    | 588.80    |

$^a$ – here and further the similar indicators are calculated only for the forecast.
The calculation is made for non-centered moving averages, in which case the forecast value is calculated as a moving average from the previous number of periods taken as a basis. We found four forecast values for 2021. The obtained value according to the first method (627.67 rubles) we didn't get it, the closest ones are three- and four-year-olds.

Thus, all the values found by the first method belong to the interval (11):

$$y_{2021} \in [621.50; 631.00]$$

Next, we will build a graph that reflects the chronological series and calculated forecast values for 2021 (figure 2).

![Figure 2. Moving averages of non-centered values.](image)

From the figure, you can see that the graphs reflecting the moving values are shifted to the right relative to the actual series of dynamics. This is explained by the calculation of non-centered values: when centralization — placing the calculated moving average in the middle of the calculation period — this does not happen and the constructed graphs will be superimposed as a trend on the original values.

For clarity, we will make a graph in its original form. As you can see, as the average calculation period increases, the graph becomes more and more «moved». At the same time, periodic «jumps» of the studied indicator are no longer taken into account. Therefore, we calculate the forecast error (table 4).

**Table 4. Calculation of the average relative error.**

| Year | Average cost | The average deviation of the moving averages from the actual value |
|------|--------------|---------------------------------------------------------------|
|      |              | two-year | three-year | four-year | five-year |
| 2002 | 243          | 0.073    | -          | -         | -         |
The errors of the above calculations for the second method of calculating the moving average turned out to be at least twice as high as the value obtained for the first method. At the same time, as the period increases, the error also increases.

All this indicates a higher accuracy of the forecast made using the first method of calculating moving averages of centered values.

Next, consider an example using the exponential moving method.

The solution, as in the previous problem, can be arranged in a tabular form. To do this, we will build a table in the following form (table 5).

Calculate the moving parameter (12):

\[
\alpha = \frac{2}{2I + 1} = 0.091
\]  

(12)

We define the initial value of \( U_0 \) in two ways: with method 1, we take the arithmetic mean for the initial value \( (U_0 = 422.38) \); with method 2, we take the first value of the forecast base as the initial value \( (U_0 = 200) \).

For example, for calculation method 1 (13, 14, 15):

\[
U_{2001} = 0.091 \cdot 200 + (1 - 0.091) \cdot 422.38 = 402.14
\]  

(13)

\[
U_{2002} = 0.091 \cdot 251 + (1 - 0.091) \cdot 402.14 = 388.39
\]  

(14)

\[
U_{2003} = 0.091 \cdot 243 + (1 - 0.091) \cdot 388.39 = 377.16
\]  

(15)

– and etc. For calculation method 2 (16, 17, 18):
\[ U_{2001} = 0.091 \cdot 200 + (1 - 0.091) \cdot 200 = 200 \]  
\[ U_{2002} = 0.091 \cdot 251 + (1 - 0.091) \cdot 200 = 204.64 \]  
\[ U_{2003} = 0.091 \cdot 243 + (1 - 0.091) \cdot 204.64 = 208.13 \]  

\[ U_{2004} = 0.091 \cdot 204.64 + (1 - 0.091) \cdot 200 = 200 \cdot 0.091 \]  

\[ U_{2005} = 0.091 \cdot 204.64 + (1 - 0.091) \cdot 200 = 208.13 \]  

and etc. Using the same formula, we calculate the forecast value and enter the results in the table. For calculation method 1 (19):

\[ U_{2021} = 0.091 \cdot 476.86 + (1 - 0.091) \cdot 490.61 = 490.61 \]  

For calculation method 2 (20):

\[ U_{2021} = 0.091 \cdot 443.88 + (1 - 0.091) \cdot 460.63 = 460.63 \]  

**Table 5. Solution through the application of the exponential moving method.**

| Year | Average cost | Exponentially Moving Averages | The average deviation of the moving averages from the actual value |
|------|--------------|-------------------------------|-----------------------------------------------------------------|
|      |              | 1 calculation method | 2 calculation method | 1 calculation method | 2 calculation method |
| 2000 | 200          | 422.38                      | 200.00              | 1.11                | 0.00                |
| 2001 | 251          | 402.14                      | 200.00              | 0.60                | 0.20                |
| 2002 | 243          | 388.39                      | 204.64              | 0.60                | 0.16                |
| 2003 | 274          | 375.16                      | 208.13              | 0.37                | 0.24                |
| 2004 | 287          | 365.95                      | 214.12              | 0.28                | 0.25                |
| 2005 | 295          | 358.77                      | 220.75              | 0.22                | 0.25                |
| 2006 | 283          | 352.97                      | 227.51              | 0.25                | 0.20                |
| 2007 | 305          | 346.60                      | 232.56              | 0.14                | 0.24                |
| 2008 | 310          | 342.81                      | 239.15              | 0.11                | 0.23                |
| 2009 | 415          | 339.82                      | 245.60              | 0.18                | 0.41                |
| 2010 | 395          | 346.66                      | 261.02              | 0.12                | 0.34                |
| 2011 | 425          | 351.06                      | 273.21              | 0.17                | 0.36                |
| 2012 | 475          | 357.79                      | 287.02              | 0.25                | 0.40                |
| 2013 | 525          | 368.46                      | 304.13              | 0.30                | 0.42                |
| 2014 | 532          | 382.71                      | 324.23              | 0.28                | 0.39                |
| 2015 | 545          | 396.30                      | 343.14              | 0.27                | 0.37                |
| 2016 | 586          | 409.83                      | 361.51              | 0.30                | 0.38                |
| 2017 | 654          | 425.86                      | 381.94              | 0.35                | 0.42                |
| 2018 | 627          | 446.62                      | 406.70              | 0.29                | 0.35                |
| 2019 | 615          | 463.03                      | 426.75              | 0.25                | 0.31                |
| 2020 | 628          | 476.86                      | 443.88              | 0.24                | 0.29                |
| Total | -            | -                            | -                   | 6.68                | 6.21                |
| 2021 | -            | 490.61                      | 460.63              | -                   | -                   |
Next, we will build a graph that reflects a number of dynamics of actual indicators and calculated forecast values for 2021 using the exponential moving method in two ways (figure 3).

![Exponentially Moving Averages](image)

**Figure 3.** Exponentially Moving Averages.

The resulting chart is very different from the actual level. It is necessary to evaluate the accuracy of such a forecast. The forecast error for the first method will be 33.40 %, for the second – 31.05 %. In both cases, the accuracy of the forecast is low, which does not allow us to rely on the results obtained when planning the company's activities.

The probable cause is a high variation of the trait. Calculate the coefficient of variation for this chronological series: it is equal to 34.9 %. This indicates the heterogeneity of the series – that is, there is a large variation in the values of the relative average value.

This is also partly due to a sharp decrease in the forecast accuracy with an increase in the moving period: the forecast accuracy for two-year – 92.19 %, for five-year – 85.72 %.

4. **Conclusion**

Thus, the most accurate forecast for 2021, obtained according to the calculations, is 627.67 rubles with a forecast accuracy of 96.58 %.

Summing up the work, we conclude that it is possible to use any of the proposed methods in any of the methods considered.

At the same time, it is always necessary to evaluate the accuracy of the forecast. The use of only one of the methods is also impractical, since there may be situations, for example, as in our case - a high variation of the trait-when it is necessary to compare the results obtained with each other.

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