TRADITIONAL METHODS OF FORECASTING AND THEIR APPLICATION IN THE LOGISTICS OF AN ENTERPRISE

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Abstract

Today, in information time, creation of forecasting in an enterprise is not only associated with the preparation of plans and considerations about possible future sales of products. It is still widely and widely used in many business activities, levels e.g. maintenance, consumption of expendable supplies, transport, energy, etc. This paper shows to the continued importance of classic quantitative forecasting methods because their application is not so complicated and there is no need to have costly software to prepare forecasts from different departments of an enterprise. There are also some descriptions to the correct setting of parameters of some methods which, in addition to input data, require data for particular calculations.

Keywords: Forecasting, parameters, planning, enterprise

1. INTRODUCTION

When defining the forecasting problem in enterprise logistics, the major issue will be defined as production and sales forecasting for plan production, production scheduling, or inventory management so that the main goal is to sell all products or effective material use. [1] A typical variable of forecasting interest is therefore the demand status. Of course, there are still more situations when a forecast can be created for some other purposes and it involves other types of variables or departments of an enterprise. [2] However, it is supposed that, despite many other purposes and situations, it is possible to create a system or model that will be valid for general usability.

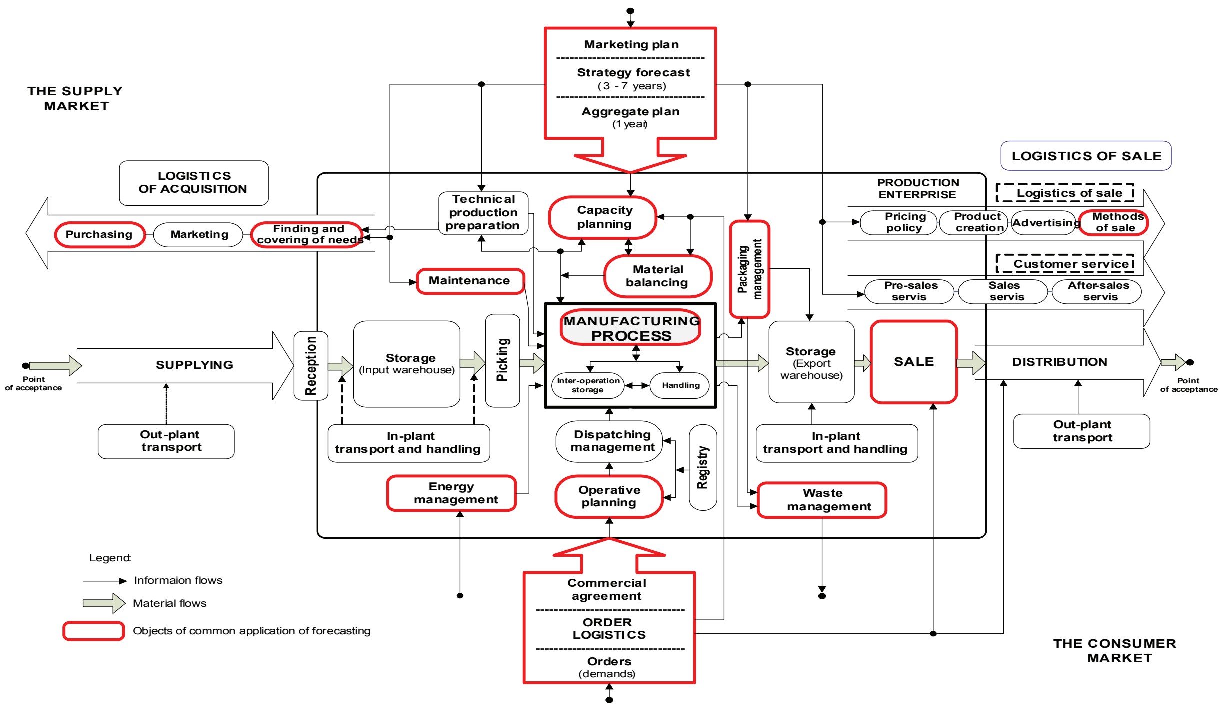


Figure 1 Common objects of forecast applications in an enterprise

At least it is possible to see the areas where the forecasting methods can be commonly applied in **Figure 1** when Looking at the general micro-logistics model of an enterprise.

If the forecasting problem is to be defined, a decision-making problem must be started with. Information from the forecasting process is needed as input into the decision process. [3] Therefore, the nature of a decision to be made will depend on the characteristics of the forecasting system. Before proposing the structure of the forecasting system, the following questions need to be answered: what is the object of the forecast, what form the forecast should have, what items (areas) will be involved in the forecast, and what accuracy is desirable.

It is necessary to define a set of variables to be analyzed and prepared for forecasting, when determining the prediction object. However, the degree of accuracy required is an important aspect, but it depends on the degree of use. For example: the production scheduling system may require a more detailed estimation of the demand in quantities (pcs, kg, l, m^3) for each type of produced products, in order to plan production in the form of detailed production schedules as well as the inventory needs. On the other hand, a sales manager may only require a preliminary estimation of total revenue (in Euros) as an input to the draft budget of an enterprise. [4] In the first case, the forecast is more challenging, because it is the forecasting for particular items and practice shows that this approach (anyhow it is created), is also less accurate. In the second case, the forecast is built on an aggregate basis, i.e. this is the forecast of a product group and it is, therefore, more accurate. At production planning, it is advisable to create a forecast at a certain aggregate level (product groups or product families) first and then to decompose these aggregate forecasts into levels of particular items [5].

2. CLASSICAL METHODS OF FORECASTING

This chapter describes experiences with the preparation of forecasts by using classical, quantitative forecasting methods. Quantitative forecasting methods can be applied when the following three conditions are fulfilled:

- Past information is available;
- This information can be quantified in the form of numerical data;
- It can be assumed that certain aspects of the past pattern (behaviour of data) will continue (imitate the past) also in the future. [3]

This last mentioned condition is known as *the premise of continuity*, it is the basic assumption of all quantitative and many qualitative forecasting methods no matter how sophisticated they may be. [6]

2.1. Moving average

The simple moving average (MA) averages a certain set of data - the number of data it averages is one of the input parameters *m*.

$$mMA_{N+1} = \frac{\sum_{i=(n-m+1)}^{n} A_i}{m} \tag{1}$$

Where: mMA_{N+1} - value of moving average for the period *N+1* pre with defined parameter *m*,

m - number of averaged values,

A_i - real *i-th* value of time series,

n - the total number of values in the time series.

Figure 2 The example of the influence of parameter *m* with the averaging and smoothing character of MA

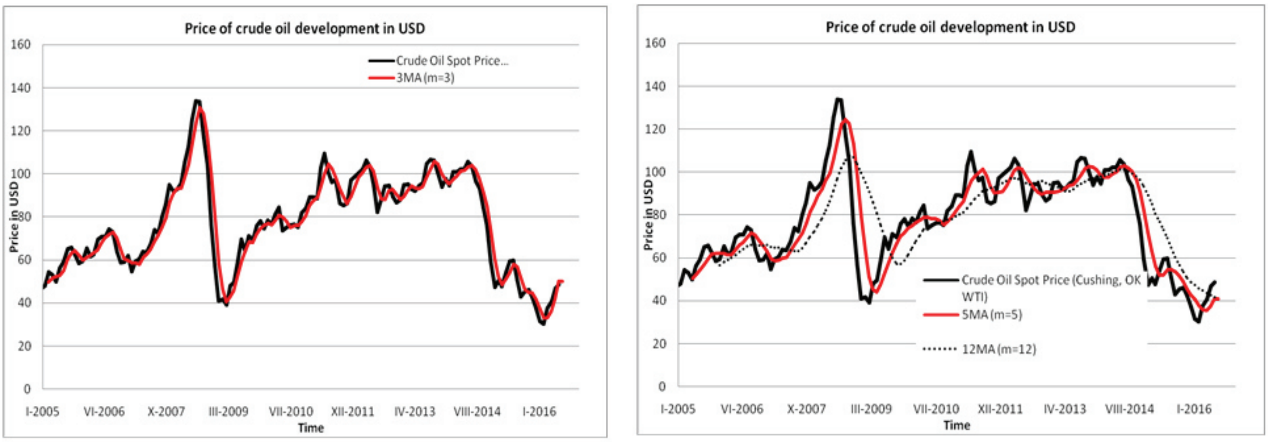


Figure 2 The example of the influence of parameter *m* with the averaging and smoothing character of MA

Other variants of the moving average are: double or multiple moving average, weighted moving average, exponential moving average.

2.2. Weighted average

Weighted average (WA) is the average calculated in the way to take into account that particular values in the data set may have a greater or smaller influence on the calculation of the average according to certain data attributes.

$$WA_{N+1} = \frac{\sum_{i=1}^{n} A_i . w_i}{\sum_{i=1}^{n} w_i} \tag{2}$$

Where: WA_{N+1} - weighted average for the period *N+1*

A_i - real *i-th* value of time series,

w_i - *i-th* weight allocated to A_i value,

n - the total number of values in the time series.

The main parameter of this method is the w_i weights that are predefined for each value. It is important, how they are defined or distributed throughout data series from the point of view of a forecasting. A study has been made by the author - how the forecast would look like, if there are used the weights distribution according to the following mathematical sequences: (arithmetic - AS, geometric - GS, power - PS, exponential - ES, logarithmic - LS, and harmonic - HS). The result is shown in the following time series:

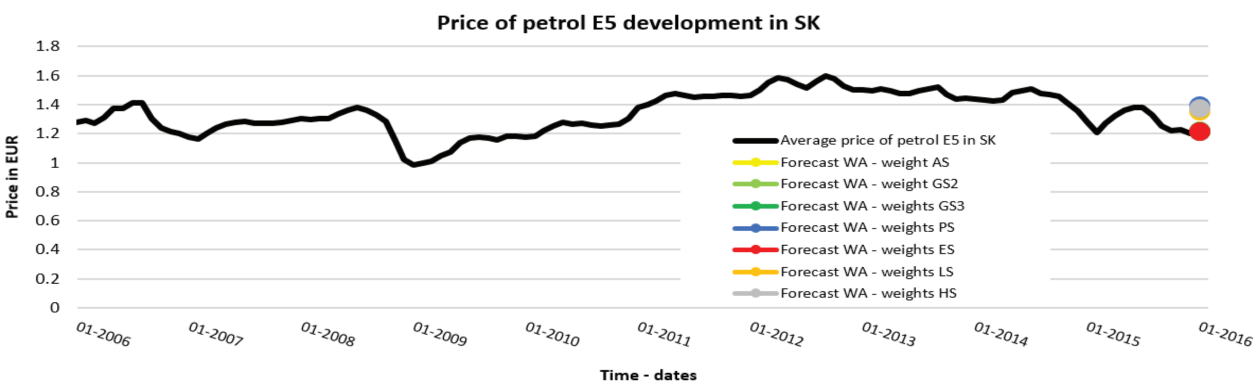


Figure 3 Time series of petrol E5 price development and variants of weighted average

There are displayed the forecasts of weight average variants for period *N+1* and real obtained value in period *N+1* to compare the accuracy of WA variants in **Table1**.

Table 1 Real data and forecast variants for period *N+1*

AS $_{d=1}$	GS $_{q=2}$	GS $_{q=3}$	PS $_{x=2}$	ES $_{x=e}$	LS $_{x=e}$	HS	Real value
1.282	1.063	1.052	1.281	1.053	1.280	1.261	0.961

The best forecast was achieved with WA variants using weights according to the geometric or exponential sequence. Similarly, this behaviour was reflected in most other cases. Therefore, it can be stated that weights with increasing differences in time are more suitable for the WA forecast.

2.3. Exponential smoothing

Simple exponential smoothing. Supposed, that there is the prediction of another value Y_{N+1} of the time series A_i, but the present period N is still not finished, so the final value A_N is still unknown. Thus, the simple exponential smoothing (SES) calculates the prognosis from the forecast from the present period N, corrected for the predicted error $(A_{N-1} - Y_{N-1})$ from the previous period ($N-1$):

$$SES_{N+1} = Y_N + \alpha(A_{N-1} - Y_{N-1}) \qquad (3)$$

where: α - smoothing constant, $\alpha \in$ <0, 1>; this constant is simply understood as a weight,

A_{N-1} - the last known real value from time series A_i.

Y_N, Y_{N-1} - forecast for the periods *N or N-1*

Holt exponential smoothing. Holt (1957) extended a simple exponential smoothing to linear exponential smoothing, allowing to respect emerging trends in forecasting. A trend component is assumed in the model, so the trend is also estimated in addition to the normal value of the variable. SES also has the disadvantage in late reaction to changes that are visible below (**Figure 4**).

$$L_N = \alpha A_N + (1-\alpha)(L_{N-1} + T_{N-1}) \qquad (4)$$

$$T_N = \beta(L_N - L_{N-1}) + (1-\beta)T_{N-1} \qquad (5)$$

$$Y_{N+1} = L_N + pT_N \qquad (6)$$

where: L_N - estimation of the level of time series in period N,

T_N - estimation of trend in period N,

A_N - the last known real value from time series A_i,

α and β- smoothing constants $\alpha \in$ <0, 1>; $\beta \in$ <0, 1>,

p - the number of periods to be forecasted (the time horizon of a forecast).

A comparison of forecast calculations using the SES and Holt methods is shown in **Figure 4**. There are used the same time series for three types of forecasts: the first by SES (value of $\alpha = 0.2$), the second also by SES (but value of $\alpha = 0.7$) and the third by Holt (values of $\alpha = 0.7$ and $\beta = 0.7$). There can be seen the influence of the constant α to the calculation and the mentioned disadvantage of SES of its late reaction to a change.

Therefore, it is advisable to use higher values of the constant α (higher than 0.5). Holt responds immediately, data behaviour is formed into a local trend. [6]

Correct setting of parameters α and β is based on the MSE error indicator and it is true that: the smaller MSE, the better α and β values. $MSE_{opt} = f(\alpha_{opt}, \beta_{opt}) \to 0$.

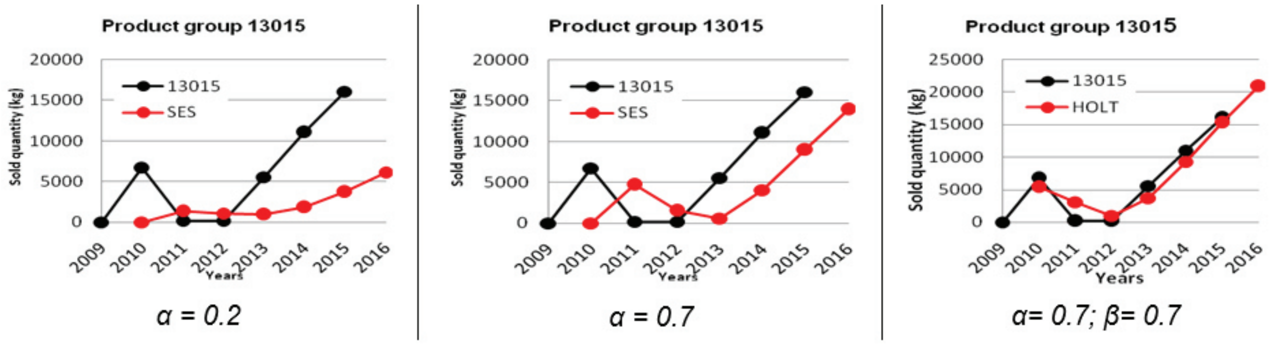


Figure 4 The comparison of forecast calculations by SES (with different constant) and by HOLT

2.4. Combination of classical methods of forecasting

Regression analysis. There can be considered linear regression as the simplest case of regression analysis. In this case, at analyzing data for the forecast, the main parameter that could be taken into account is the amount of data. If the solution is based on all data from time series, then the linear regression results so-called **global trend**. However, if the solution is based only on certain number of values from time series closed to the present, then the linear regression results to so-called **local trend**. Comparing these two trends will show whether the timeline development is steady (the local trend is identical to the global trend), or the timeline development is variable (the local trend has a different direction than the global trend). This comparison creates a new methodology that is based on simple linear regression analysis, but creates a new forecasting system.

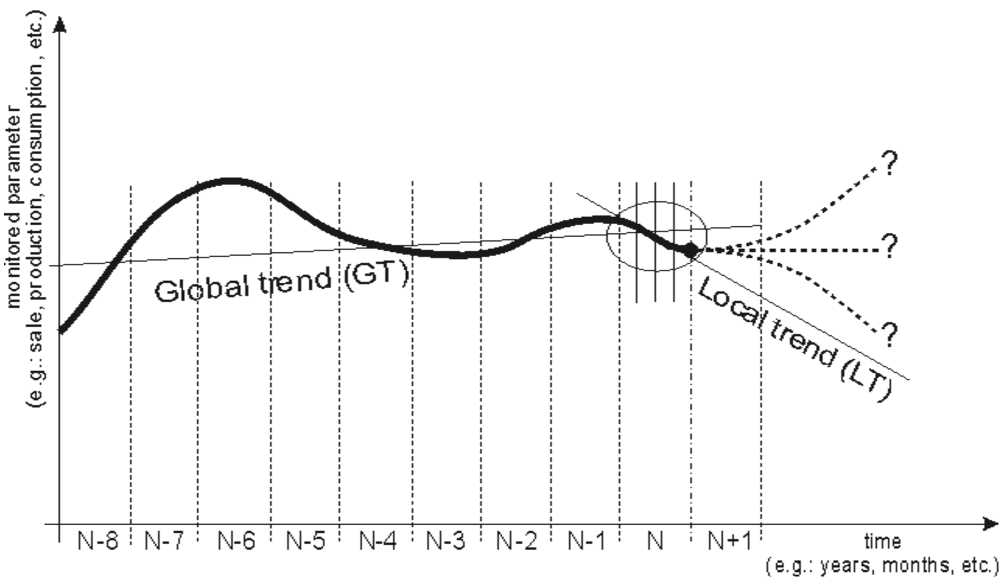


Figure 5 Comparison of the global and the local trend

Combined model of forecasting. It is the model that is based on the idea of multi-criteria decision making process and assessment of the results from several forecasting methods in order to obtain the so-called **synergistic estimation**. The method of combining of the results of particular forecasts to one objective result is based on a weighted average but with a dynamic weighting "w_j". The weights are assigned to the given method according to its suitability for use in a certain situation or for a given time series curve shape. If the methods are appropriate, the weights are higher, but always respecting the weight dividing: $\sum_{j=1}^{n} w_j = 1$

The characteristics about the weight variants were described in one of previous congress papers.

Table 2 Evaluation of chosen forecasting methods by weights according to the particular variants of time series behaviour

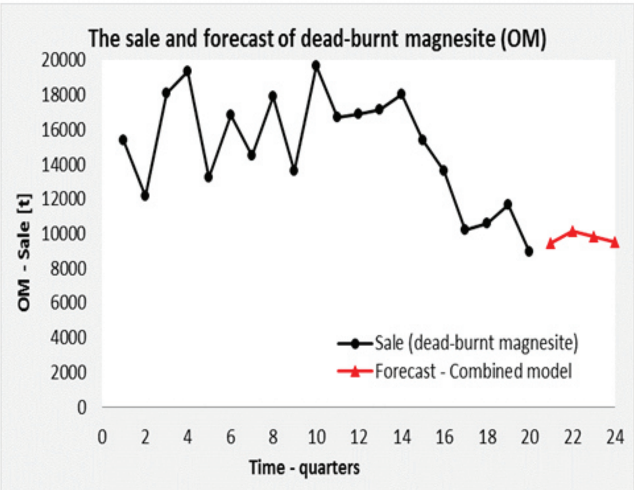
Chosen method of forecasting	Weights	1st variant of weights	2nd variant of weights	3rd variant of weights
GT vs. LT (GT/LT)	w_1 =	0.2	0.3	0.4
Harmonic weights (HW)	w_2 =	0.2	0.3	0.4
Holt (ES-Holt)	w_3 =	0.3	0.2	0.1
Weighted average (WA)	w_4 =	0.3	0.2	0.1

ARIMA Model. ARIMA Model was created from the basic ARMA model - connection of the autoregressive model (AR) and the moving average (MA), but this is a very simple way of explanation. It can be said, that this is also a kind combination of two classical methods resulted in the ARMA model value, but suitable for stationary data. Modification of this ARMA model is possible through the differentiation of the time series data for the use at forecasting with unstationary data. This model is called autoregressive (AR) integrated (I) moving average (RA) - the ARIMA model defined by George Box and Gwilim Jenkins in 1970. [Makridakis]. This model is generally known and expanded in various software applications that is why this model is not described in details here. It was used program Minitab 18 for the forecast calculation in the application below (the chapter 3). [7]

3. THE APPLICATION OF COMBINED MODEAL OF FORECASTING IN COMPARISON WITH ARIMA MODEL

The application deals with the forecast of dead-burnt magnesite (magnesite for refractory products) sale for aggregate planning of Magnesite plant in Slovakia. Dead-burnt magnesite (OM) sales data are collected from years 2009 to 2014 for the quarters that are the basis for the annual forecast creation. The forecast is calculated for year 2014 by using the combined forecast model and the ARIMA model with parameters (3, 1, 1), and the real values of sale in 2014 will serve to verify both forecasts success through the MAPE error indicators.

a) b)



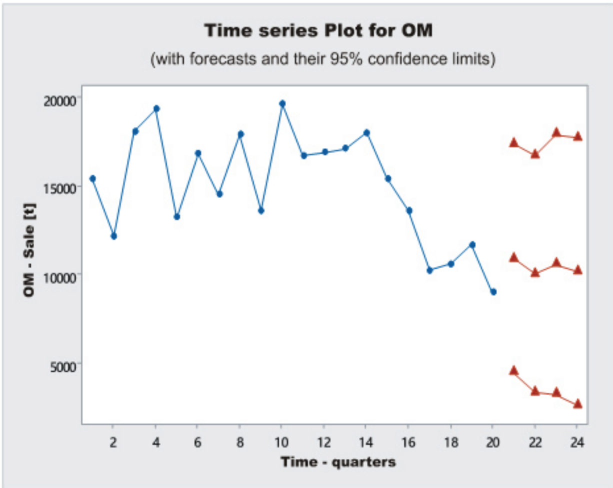


Figure 6 Comparison of the Combined model (a) and ARIMA model (b) of forecasting

The comparison of these two forecasts is done through the MAPE (Mean Absolute Percentage Error), which indicate the forecast accuracy in percentage, as shown in following table (**Table 3**).

Table 3 Forecast results and comparison of Combined model of forecasting with ARIMA

Dead-burnt magnesite sale forecast (magnesite for refractory products)		
Period	***Combined model***	***ARIMA***
1Q/2014	9476.3	10697
2Q/2014	10170.8	10132.1
3Q/2014	9842.1	10328.2
4Q/2014	9526.4	10177.9
MAPE:	**16.98%**	**12.18%**

The forecast results of the Combined model are comparable to those of the ARIMA model. The similar results were achieved with other assortments of the Mine plant and its management agreed with these forecasted values of sale. It can be stated that the Combined model use was reliable. The disadvantage of the ARIMA model is to perform multiple calculations to determine the correct p, q, r parameters for a given time series type.

4. CONCLUSION

This paper briefly points to the use of traditional quantitative methods. Although, not all of the methods from this category are mentioned and described, their common features are: the existence of history of the examined situation, the precision decreases with the increased time horizon, not every method is suitable for any situation or its behaviour, but especially fast applications with the use of ordinary office software. With the correct selection of a method or their combinations, reliable results of forecasts can be achieved in all sectors of industry and commerce. The actual application, which was briefly outlined in Chapter 3, points to the use of the forecast in a suitable combination of methods competing with the widely-known and world-wide ARIMA model, which has relatively complicated calculations.

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