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FORECASTING DEMAND TRENDS IN AUTOMOTIVE INDUSTRY: COMPARATIVE ANALYSIS OF EXPONENTIAL SMOOTHING AND REGRESSION ANALYSIS

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Abstract: This study analyzes demand trends using statistical methods, specifically exponential smoothing and regression analysis, applied to data from an automotive supply chain company. The analysis of order records for the first 28 weeks of the year reveals that exponential smoothing, with a smoothing parameter of α=0.5, provides more accurate forecasts compared to regression analysis. This conclusion is supported by lower forecast error values (MAPE, MSE, and MAD) for the exponential smoothing method. The findings suggest that exponential smoothing is a more reliable tool for demand forecasting in this context.

Key words: Automotive industry, Demand forecasting, Exponential smoothing, Forecast error, Regression analysis

1 INTRODUCTION

The success of industrial enterprises depends on a wide range of factors. Although there are elements that management cannot directly influence, such as economic and geopolitical conditions, competition, or societal changes, there are mechanisms available to forecast and analyze certain occurrences, enabling a prepared and appropriate response. One such factor is the change in demand for a specific product. The purpose of forecasting demand trends is to ensure the proper planning and allocation of available resources.

Resource planning and allocation are activities that play a crucial role in ensuring the long-term stability of any industrial enterprise. Through resource planning, management adjusts production and other capacities to meet the needs and demands

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of customers. As a prerequisite for conducting resource planning and allocation, management must project and analyze future demand for their products. To achieve this, management can utilize various analytical methods and techniques with the aim of predicting the quantities and types of products that will be needed by the market and customers. Based on the forecast results, management can align production capacities with customer requirements and thereby optimally allocate available resources.

In this paper, the demand forecasting was conducted using the exponential smoothing method along with regression analysis. Additionally, methods for determining forecasting errors were employed to establish which of these statistical methods provides more accurate results. The case study conducted in this paper relies on data from a company in the automotive industry, headquartered in the Šumadija District of the Republic of Serbia.

The aim of this paper is to explore and evaluate various forecasting methods to accurately predict changes in demand for specific products, with a focus on enhancing resource planning and allocation in industrial enterprises. By employing the exponential smoothing method and regression analysis, the study aims to determine the most accurate forecasting approach, which will enable management to better align production capacities with customer demands.

2 APPLICATION OF FORECASTING METHODS

For demand forecasting, numerous methods are used in the literature. Besides methods specifically designed for this problem, certain statistical and optimization methods and techniques are also employed for demand forecasting. One of the most widely used techniques is exponential smoothing, which has several variations. It is used in the automotive industry [1], medicine [2], the transport sector [3] and others.

One of the statistical methods used for demand prediction is regression analysis. It has been applied in medical forecasting [4], power production [5], [6], and ecology [7]. However, in many studies, regression analysis has been extended through the application of machine learning [5], [7].

Numerous artificial intelligence algorithms are also used for forecasting today. Their application is now very broad and includes air pollution forecasting [8], wind energy forecasting [9], ocial changes forecasting [10], and others.

In addition to the above, the literature contains studies in which authors have used various methods such as exponential smoothing, regression, series forecasting, and other methods, comparing the obtained results [11], [12], [13].

3 BENEFITS AND LIMITATIONS OF DEMAND FORECASTING

Implementing demand forecasting requires the collection, processing, and analysis of data from records, as well as significant effort, time, and sometimes the involvement of external experts. Nevertheless, an adequate demand forecast can provide certain benefits for business operations. Some of the most important benefits of demand forecasting are improved budget preparation, more reliable production planning, support for inventory storage planning, and support for developing pricing strategies [14].

Despite the benefits of demand forecasting, there are limitations to its application that should always be considered. Although useful, demand forecasting can

never be completely accurate, as future events are uncertain and subject to change. Additionally, demand forecasting requires reliable, high-quality, and sufficient input data to ensure that the analysis is as precise and practically useful as possible. A lack of quality input data, incorrect interpretation, or inadequate methodology can lead to inaccurate or unreliable forecasts.

Some of the most important limitations of demand forecasting, or factors that affect the reliability and accuracy of demand forecasts, include unexpected (unforeseen) events, limited historical data (record data), changes in customer behavior, lack of information about new products, model limitations, calculation errors, inaccurate input data, seasonal changes and fluctuations, changes in competition, and geopolitical and economic factors [15].

When conducting demand forecasting and analyzing the obtained results, it is essential to consider both the benefits and limitations mentioned in order to obtain a useful and clear picture of future demand.

4 METHODOLOGY USED FOR DEMAND FORECASTING

4.1 Exponential Smoothing

Exponential Smoothing is a demand forecasting method based on the analysis and processing of record data. It is suitable for short-term demand forecasts. The forecasted demand value using this method is determined by the following formula [16]:

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1}) \tag{1}$$

where:

$\boldsymbol{F_t}$ – forecasted demand value,
$\boldsymbol{F_{t-1}}$ – forecasted demand value for the previous period,
$\boldsymbol{A_{t-1}}$ – actual demand value in the previous time period,
$\boldsymbol{\alpha}$ – smoothing coefficient; $\boldsymbol{0 \leq \alpha \leq 1}$.

The primary advantage of the exponential smoothing method for demand forecasting is its ability to provide sufficiently reliable and accurate forecasts for short-term periods in a straightforward manner

4.2 Regression analysis

Regression Analysis is a very useful tool that can be used, among other things, for demand forecasting. This method provides insight into the relationship between a dependent variable and an independent variable, such as demand and time period, respectively.

The linear regression relationship can be represented by the regression equation [16]:

$$\boldsymbol{y_i = \hat{a} + \hat{b} \cdot x_i + \varepsilon_i} \tag{2}$$

In this equation, $\boldsymbol{\hat{a}}$ and $\boldsymbol{\hat{b}}$ denote the coefficients of the regression line, while $\boldsymbol{\varepsilon_i}$ represents the approximation error.

Regression analysis is well-known and widely used both in research and in the curricula of many academic programs. Therefore, there is no need to provide a detailed description of the application process of this analysis in this paper.

4.3 Forecasting Errors

In the literature, various methods can be found for calculating forecasting errors, all with the aim of determining which method provides the best results in addressing the problem at hand. The most well-known methods for calculating forecasting errors, which were also used in this paper, are [17]:

- Mean Absolute Percentage Error (MAPE):

$$MAPE = \frac{1}{n} \cdot \sum_{i=1,..,n} \frac{|A_i - F_i|}{A_i} \cdot 100\% \quad (3)$$

- Mean Squared Error (MSE):

$$MSE = \frac{\sum_{i=1,..,n} (A_i - F_i)^2}{n-1} \quad (4)$$

- Mean Absolute Deviation (MAD):

$$MAD = \frac{\sum_{i=1,..,n} |A_i - F_i|}{n} \quad (5)$$

All three methods are equally used for analyzing and comparing different forecasting methods, with the aim of determining which method provides the best results. It is important to note that lower values of MAPE, MSE, and MAD indicate a more accurate forecast.

5 CASE STUDY

5.1 Application of the Exponential Smoothing Method

In this paper, the demand for a product from a company that is a supplier in the automotive supply chain has been analyzed. The company manufactures aluminum parts, and its product range includes 25 related products. In this case, the focus has been on the company's most important product, which is the aluminum radiator shell.

The company maintains records of incoming orders that are registered on a weekly basis. In this case, an analysis was conducted on the received orders for the main product over the first 28 working weeks of the year. It is assumed that the demand for the considered product follows an exponential smoothing trend with a parameter $\boldsymbol{\alpha = 0.5}$. The actual and forecasted demand values using exponential smoothing are shown in Figure 1.

The forecasting errors of demand using this method are:

$$\boldsymbol{MAPE = 0.23} \qquad \boldsymbol{MSE = 2045442} \qquad \boldsymbol{MAD = 1044.83}$$

In this case, the exponential smoothing method was applied for six consecutive periods (the actual period and the five subsequent ones).

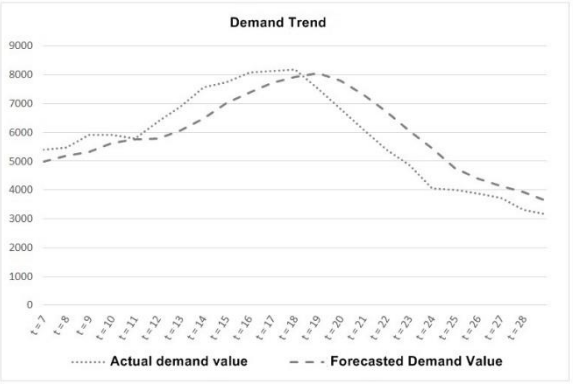

Figure 1. *Trend of actual and forecasted demand values determined using the exponential smoothing method*

5.2 Application of the Regression analysis

As previously mentioned, demand analysis can also be performed using regression analysis. The results obtained through this statistical method are presented below. Figure 2 shows the results of the regression analysis conducted in Microsoft Excel, specifically the calculated parameters of the regression line.

Regression Statistics	
Multiple R	0,460526662
R Square	0,212084806
Adjusted R Square	0,181780376
Standard Error	1868,298594
Observations	28

Figure 2. *Regression Analysis (Data Grouping Around the Regression Line)*

After conducting the regression analysis, it is necessary to test for the existence of a regression relationship. In this case, the testing was performed using the analysis of variance technique.

- Step 1: Hypothesis Formulation

H_0: There is no regression relationship.

H_1: There is a regression relationship.

- Step 2: Risk Level

The risk level is set at 5% (a common risk level).

- Step 3: Decision Statistic

The decision statistic was determined using the Data Analysis package in Microsoft Excel, as shown in Figure 3.

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	24428455,17	24428455,17	6,998475227	0,013657893
Residual	26	90754030,54	3490539,636		
Total	27	115182485,7			

Figure 3. *Decision statistic*

In Figure 3, it can be seen that the value of the decision statistic is: $\boldsymbol{F_0 = 6.998}$.

- Step 4: Criterion for Rejecting the H_0

The tabulated value of the Fisher distribution for the given risk level is $\boldsymbol{F_{0,025;26} = 4.23}$.

- Step 5: Decision

Since the decision statistic is greater than the tabulated value, the H_0 should be rejected and the alternative hypothesis H_1 accepted. In this case, it can be concluded that the demand value over time can be described by the obtained regression line (see Figure 4).

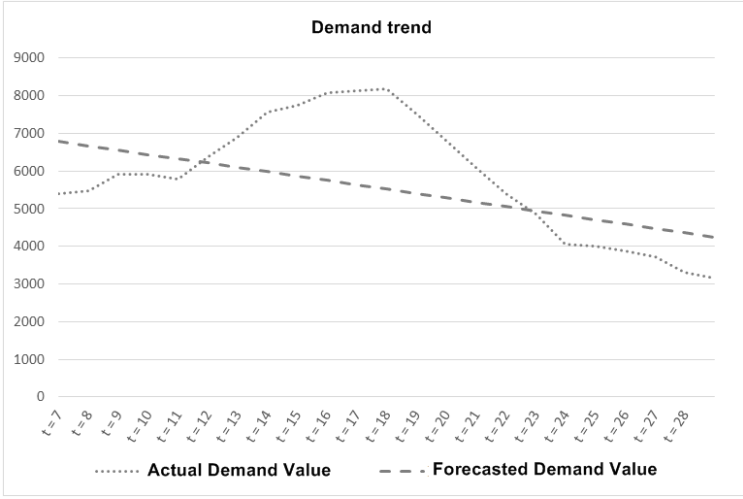

Figure 4. *Trend of actual and forecasted demand values determined using the regression analysis*

The forecasting errors of demand using this method are:

$$\boldsymbol{MAPE = 0.32} \qquad \boldsymbol{MSE = 3361260} \qquad \boldsymbol{MAD = 1558.302}$$

Based on the calculated forecasting errors, it is clear that the demand can be more accurately described by the exponential smoothing than by using regression analysis.

5.3 Discussion of obtained results

As mentioned, in this case, the exponential smoothing method yields slightly better results. Figure 1 shows the trend of actual demand values and the trend of forecasted demand values. From the figure, it is clear that the forecasted demand values are lower than the actual values until the 18th week. Between the 7th and 18th weeks, the demand for the product in question is increasing. After the 18th week, the trend in demand starts to decline.

This information is crucial for all employees at the second hierarchical level, except for the quality engineer. Based on this information, the logistics and procurement manager should plan the acquisition of raw materials for the upcoming

period to ensure an optimal quantity of raw materials for the production process. For the production and maintenance manager, the demand trend information is important for the optimal utilization of production and human resources. The financial manager, in turn, uses this information to prepare the financial plan for the upcoming period.

Regression analysis, while useful for identifying the underlying trend in data, may have limitations when it comes to capturing potential demand fluctuations. In this case, although the regression line successfully identified an upward trend in the data, it proved less effective at capturing and forecasting the variations and oscillations present in the actual demand pattern. This led to reduced accuracy in predicting demand changes, especially during periods of significant oscillations. Therefore, while regression analysis can provide valuable insights into the general trend, it may be insufficient for detailed modeling of the dynamic and unstable aspects of demand.

6 CONCLUSION

In this paper, the problem of demand forecasting based on historical data has been examined, with a case study conducted in an automotive industry company. The study involved the application of statistical methods, specifically exponential smoothing and regression analysis, to analyze demand trends. Additionally, forecasting errors were calculated in this part of the study.

The analysis revealed that the use of exponential smoothing and regression analysis yields different results. Based on the obtained results, it can be concluded that the exponential smoothing method better describes demand changes. In the case of regression analysis, the trend is described by a regression line defined based on the calculated parameters of the line. The preference for using exponential smoothing over regression analysis has been supported by the calculation of forecasting errors such as MAPE, MSE, and MAD. Each of these parameters had lower values when using the exponential smoothing method compared to regression analysis. Therefore, it can be concluded that, in this case, the exponential smoothing method is more reliable.

Future research directions may focus on applying the proposed quantitative approach to similar problems in other companies and industries. Additionally, other quantitative methods could be applied to address the same or similar problems, and a comparative analysis of results obtained using different methods could be conducted.

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