Comparative analysis of demand forecasting methods for products of a stationery store in Minas Gerais

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ABSTRACT

This paper presents demand methods applied in a retail trading company in order to compare the performance of the models and propose the best demand forecasting model. The data used for the application of the models correspond to the back-to-school period, a period that shows an increase in sales of certain products in the company. Currently, the company uses only qualitative methods to make purchases and the results are not always satisfactory, whether they are large inventories or lack of products for the great demand. For the present work, the demand forecasting models of simple moving average, weighted moving average and exponential smoothing were analyzed. The performance of the methods was compared by means of the errors obtained, which were the Mean Absolute Deviation (MAD), the Mean Absolute Percentage Error (MAPE) and the Mean Square Error (MSE). The results obtained were not satisfactory for any of the forecasting models to be used by the company, because they presented very large errors, and the forecasting model with the smallest error was the weighted moving average.

Keywords: Demand forecasting, Retail, Quantitative analysis.

1 INTRODUCTION

In the current environment, companies seek profit and constant growth, which, consequently, reflects their concern with the management and control of their operations. In this scenario, demand forecasting is an essential tool to assist companies in decision-making and managing their needs.

For Kotler (1991), demand forecasting is the "total volume that would be purchased by a defined group of customers, in a defined geographic area, in a defined period, in a defined marketing environment, and under a defined marketing program".

According to data from the Monthly Survey of Commerce (MSC) released in February 2023, retail trade closed 2022 with growth of 1%, which is the worst result since 2016. However, among the retail segments, the books, newspapers, magazines, and stationery sector closed the year with a growth of 14.8% (AGENCIABRASIL, 2023). The expectation of the CNC (National Confederation of Commerce of Goods, Services and Tourism) for 2023 is that retail will show a growth of 0.6% compared to 2022 (BRASIL61, 2023).

São João del Rei is a small historic city in Minas Gerais that attracts tourists and visitors from all over the country and has great relevance in the region for being highlighted in the high regularity of sales. With high diversification of commerce, the city offers greater business opportunities, compared to the average of municipalities with similar population size (CARAVELA, 2023).

In view of the growth of retail and, in particular, of the stationery sector, it is important that companies are prepared for the competitiveness brought about by growth. For this, demand forecasting is of paramount importance for the survival of companies in the current scenario.

2 OBJECTIVES OF THE WORK

The general objective of this work is to identify and propose the best method of demand forecasting for the products of a stationery store in Minas Gerais through the comparison of different methods. The specific objectives are:

- Study existing demand forecasting methods;
- Select the most appropriate methods for application to the object of study;
- Collect purchase and sale history of products;
- Analyze which are the main best-selling items in the object of study for the application of the method;
- Apply the selected methods to the chosen item;
- Compare the performance of the selected methods for demand forecasting;
- Understand the results and propose the most appropriate method for applying demand forecasting to the other items of the object of study.

3 LITERATURE REVIEW

Urio (2013) conducted a case study in an automotive battery trade in order to predict the demand in the market. The study sought to determine a criterion for determining the demand forecasting method to be used through a literature review. In order to apply the forecasting methods, the author first collected quantitative and qualitative data, which were later tabulated. The forecasts were made for the year 2012 based on the previous year in order to be able to compare the actual demand of the year in which the demand forecast was made. The methods used by the author were Moving Average, Weighted Moving Average, Moving Average with Simple Exponential Smoothing, Linear Regression Method and Seasonal Adjustment. As a result, it was observed that the method that best suited to determine the demand forecast for the object of study was the Moving Average with Simple Exponential Smoothing.

Bonotto and Santos (2015) proposed a demand forecast applied to the retail sector using the *Holt-Winters* Exponential Smoothing method. The author used the NCSS computer package, which provides *forecasting* with several forecasting models. The choice of the method used was based on the visual analysis of the data, since the model describes time series formed by data that present linear trend and seasonality. As a result, a reduction in forecast error was observed, from 3.51% to 1.68%.

Ávila et al (2017) aimed to propose a method to predict the demand for a product subject to seasonality in small retail companies. The methods used in the research were Linear Regression and Double Exponential Smoothing. As a result, a divergence of only 2% with actual sales was observed.

Tomicki (2021) made a comparison of quantitative methods for demand forecasting in an auto parts store. The methods studied were: Simple Moving Average, Weighted Moving Average, Moving Average with Simple Exponential Smoothing and Simple Linear Regression. The comparison was performed using the DMA bias error. The result was not satisfactory, because the forecasts obtained were not suitable for the application in the company, presenting a great divergence in relation to the actual demand.

Alves, Magalhães and Gomes (2018) conducted an evaluation of different demand forecasting methodologies in supermarket retail in the interior of Minas Gerais. The methods evaluated in the study were: Simple Moving Average, Linear Trend, Exponential Adjustment and Simple Linear Regression. The data were compared by the Mean Absolute Deviation, and as a result, it was observed that the Linear Trend method was the most efficient, with the lowest mean absolute deviation.

Gontijo, Pozzobon and Zilli (2017) proposed an economic application of forecasts in the optimization of inventories in a company in the retail sector. The prediction models used were Exponential Adjustment and Box-Jenkins. As a conclusion, it was presented that the exponential adjustment method represented the best cost-benefit and best results.

Santos and Freitas (2020) applied the *Holt-Winters* method to a beverage company that produces mineral water and soft drinks. The method was validated by calculating the errors of the demand forecast for each product. For mineral water, an average error of 2.72% was obtained and for soft drinks, an average error of 4.41% was obtained, showing that the demand forecasting model used was adequate.

Viana et al (2020) conducted a comparative study between demand forecasting models in a jeans ready delivery company. The demand forecasting models used were Simple Moving Average, Weighted Moving Average, Exponential Moving Average and Linear Regression. The performance of the models was compared using absolute error and DMA. The most suitable model was the linear regression method.

In the study by Monegat et al (2020), an analysis of demand forecasting methods was carried out to project sales of products in a furniture industry. The following methods were analyzed: Moving Average, Simple Exponential Smoothing, Holt Exponential Smoothing and Winters Exponential Smoothing. Through the calculation of MAE, MQE and MAPE errors, it was concluded that the Winters exponential smoothing method is the most appropriate method.

4 METHODOLOGY

This work can be classified as a case study research, with an exploratory character. According to Yin (2001), the case study is an empirical investigation of some contemporary phenomenon within its

context. The exploratory case study is described by Yin (1993) as a pilot study designed to test questions, hypotheses, instruments, and procedures.

In this work, we seek to define the best demand forecasting method for a retail company in the stationery industry, with a quantitative approach. The data collection methods used are mostly archival documents and observations, and there is an interview to assist in the realization of the qualitative methods that will be presented as auxiliaries in the work.

The work was carried out in a stationery store located in the city of São João del Rei, Minas Gerais. The stationery store is a small local business, has four employees and moves, on average, R$47,000.00 (forty-five thousand reais) per month. The company, which has been present in the market for twenty-two years, works with office products, school supplies, books and gifts.

The back-to-school period is a challenge for the company, which notices the increase in sales every year. Predicting the demand for products is difficult, and inventory cannot meet demand. However, the fear of buying a large volume of products and not getting a turnover makes the owner take less risk in purchases, even with the risk of shortages.

Without the implementation of a demand forecasting system, product purchases are made intuitively by the store owner. Thus, the purchases for each year's Back to School are shown in Figure 1:

Figure 1. Flowchart of the processes carried out for the purchase of products
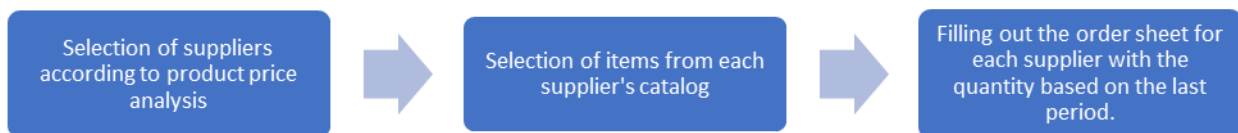
Source: Author

Figure 1 shows the flowchart that represents the steps followed by the company when purchasing products during the back-to-school period.

When there is a shortage of products during the sales period, the owner places wholesale orders to replenish the products, since the main suppliers require a minimum purchase order. In this way, in order to replenish the products quickly and not lose sales, the profit margin on these products decreases.

As shown in figure 1, it can be observed that the stage of filling out the suppliers' order sheets is the target of the study, as it seeks to define an optimized quantity of products in order to reduce shortages and avoid repetitive orders for replacement.

The steps followed to carry out the project are:

(i) Delimitation of the problem and the research objective;

(ii) Literature review;

(iii) Data collection;

(iv) Data analysis;

(v) Definition of demand forecasting models;

(vi) Validation of demand forecasting models;

(vii)Demand forecast for the proposed period;

(viii)   Comparison between actual forecast and forecasted forecast;

(ix) Conclusion on the performance of each demand forecasting method.

All steps, with the exception of steps ii, viii and ix, are steps used by Ávila et al (2017) in their research. Steps ii, viii and ix were proposed by the author herself based on the objective of the research.

The following schedule (table 1) details the estimated time for the execution of each step described above.

Table 1. Timeline for carrying out the stages

Delimitation of the problem and the research objective	1 week
Literature review	2 weeks
Data collection	3 days
Data analysis	3 weeks
Definition of demand forecasting models	1 week
Validation of Demand Forecasting Models	1 week
Demand Forecast for the Proposed Period	1 week
Comparison Between Actual Forecast and Forecasted Forecast	2 weeks
Conclusion on the performance of each demand forecasting method	1 week

Source: Author

Data collection was carried out primarily through unstructured interviews with the owner of the company, in order to obtain the items that should compose the sample. The data collected to carry out the study were the data present in the reports generated by the PVD system used in the company. The system generates sales reports for periods determined by the user himself and classifies the families of each product according to its niche. As it is a specific period (back to school), the reports generated followed the period from December of the previous year to March of the present year. In this way, the reports for the years 2022 and 2023 were obtained. All reports were generated in XLSX format and processed in Excel.

To measure the success of the work, the metrics used were the errors between the actual forecast and the forecast forecast for the proposed period. Thus, the method that presents the least error will be the most appropriate method to be implemented as a demand forecasting model in the company's other products.

The survey was carried out with the consent of the owner of the company, Papel & Cia LTDA, the data and the disclosure of the company's name were released. The data collected from the system were selected in order to follow a new consumption pattern, observed from 2022, post-pandemic. It was not

possible to collect data from other previous periods, as the sales system was not yet fully operational and the products were not registered. Thus, the data for 2022 and 2023 were stratified into weeks for better application of demand forecasting methods.

5 RESULTS AND DISCUSSION

The data extracted from the system for the study were organized in a spreadsheet according to the desired period. Thus, the 2022 back-to-school period covers the data collected from December 2021 to March 2022, just as the 2023 back-to-school period integrates the data from December 2022 to March 2023.

The product studied in this work is modeling clay with 12 colors. This product sells a lot throughout the year, but has a huge increase in sales in the back-to-school period.

The following table shows the data collected for the two periods and is stratified into weeks for better use of the data. Both periods have 17 weeks.

Table 2: Period and Sales Relationship

2022		2023	
PERIOD	SALES	PERIOD	SALES
05/12/21 - 11/12/21	6	04/12/22 - 10/12/22	7
12/12/21 - 18/12/21	3	11/12/22 - 17/12/22	26
19/12/21 - 25/12/21	1	18/12/22 - 24/12/22	15
26/12/21 - 01/01/22	14	25/12/22 - 31/12/22	4
02/01/22 - 08/01/22	33	01/01/23 - 07/01/23	61
09/01/22 - 15/01/22	21	08/01/23 - 14/01/23	56
16/01/22 - 22/01/22	38	15/01/23 - 21/01/23	91
23/01/22 - 29/01/22	69	22/01/23 - 28/01/23	87
30/01/22 - 05/02/22	69	29/01/23 - 04/02/23	196
06/02/22 - 12/02/22	29	05/02/23 - 11/02/23	40
13/02/22 - 19/02/22	15	12/02/23 - 18/02/23	15
20/02/22 - 26/02/22	9	19/02/23 - 25/02/23	10
27/02/22 - 05/03/22	4	26/02/23 - 04/03/23	10
06/03/22 - 12/03/22	14	05/03/23 - 11/03/23	14
13/03/22 - 19/03/22	13	12/03/23 - 18/03/23	11
20/03/22 - 26/03/22	6	19/03/23 - 25/03/23	15
27/03/22 - 02/04/22	9	26/03/23 - 01/04/23	1

Source: Author

The demand forecasting models used were simple moving average, weighted moving average, and exponential smoothing. For the weighted moving average, the Excel solver was used to define the best weights in order to obtain the lowest MAD (mean absolute deviation). In exponential smoothing, the prediction was calculated with three distinct alpha values, namely: 0.1, 0.2 and 0.3. The errors used to

measure the performance of the models were the mean standard deviation (MAD), mean absolute percentage error (MAPE) and the mean squared error (MSE).

The following table shows how the results of each demand forecasting model compare.

Table 3: Comparison of results

2022			
	MAD	MAP	MSE
SIMPLE MOVING AVERAGE	18	108%	491
WEIGHTED MOVING AVERAGE	13	68%	281
EXPONENTIAL SMOOTHING 0.1	17	130%	526
EXPONENTIAL SMOOTHING 0.2	17	145%	469
EXPONENTIAL SMOOTHING 0.3	17	138%	419
2023			
	MAD	MAP	MSE
SIMPLE MOVING AVERAGE	40	252%	2958
WEIGHTED MOVING AVERAGE	31	188%	2821
EXPONENTIAL SMOOTHING 0.1	39	315%	2906
EXPONENTIAL SMOOTHING 0.2	41	328%	2696
EXPONENTIAL SMOOTHING 0.3	39	284%	2520

Source: author

Table 3 shows the errors obtained from each demand forecasting method studied. It is possible to observe that the weighted moving average had lower errors compared to the other models in both periods.

6 CONCLUSION

This work was carried out in order to propose an efficient method of demand forecasting for a small stationery store. The data collected were related to the back-to-school period, a period of high sales of certain stationery products.

The results conclude that among the forecasting models applied, the one that had the best performance was the weighted moving average. However, the results were not satisfactory for a proposal to be made for the use of the demand forecasting model. Limiting factors, such as time and availability of data, compromised the best use of the work. Therefore, a more robust future study that uses other demand forecasting models is suggested to find a better model that can be applied to the research object.

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