

Forecasting Library Visitation at UMSU: A Comparative Analysis of Linear Regression and Trend Moment

Yohanni Syahra*, Amrullah

Faculty of Computer Science and Information Technology, Information Systems, Universitas Muhammadiyah Sumatera Utara, Medan, Indonesia

Email: ^{1,*}yohanisyahra@umsu.ac.id, ²amrullah@umsu.ac.id

Correspondence Author Email: yohanisyahra@umsu.ac.id*

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Abstract - Libraries play an important role in supporting academic activities by providing access to information, learning resources, and research materials. To improve the quality of library services, it is necessary to understand visitor attendance patterns and estimate the number of visits in future periods. This study aims to forecast library visitation at UMSU using the Linear Regression and Trend Moment methods, and to compare the accuracy of both methods using Mean Absolute Percentage Error (MAPE). Historical visitation data were used as the basis for the forecasting analysis. The results show that the Linear Regression method produces a forecast value of 1.65 for the next period with a MAPE value of 4.59%, while the Trend Moment method produces a forecast value of 1.77 with a MAPE value of 5.86%. Based on the comparison of MAPE values, Linear Regression provides better forecasting accuracy than the Trend Moment method because it has a lower error rate. Therefore, Linear Regression is considered more suitable for forecasting library visitation in this study. These findings are expected to support library management in service planning, resource allocation, and the improvement of data-driven decision-making.

Keywords: Library Visits; Forecasting; Linear Regression; Trend Moment; MAPE

1. INTRODUCTION

Libraries are one of the important supporting facilities in higher education institutions because they function as centers of information, learning resources, and academic development [1], [2]. In the university environment, libraries are not only used as places to borrow and read books, but also as spaces that support learning activities, research, discussion, and access to various scientific references. The existence of a library with good service quality can contribute significantly to improving the effectiveness of the learning process and the academic performance of students[3], [4]. Therefore, the management of library services needs to be carried out properly, systematically, and based on actual user needs.

One of the important aspects in library management is understanding the pattern of visitor attendance over time. The number of library visits can fluctuate due to various factors, such as academic schedules, examination periods, assignment loads, institutional policies, and changes in students' information-seeking behavior. These fluctuations need to be analyzed carefully because they can affect the readiness of facilities, the availability of human resources, the circulation of collections, and the overall quality of service provided by the library. If the pattern of visits is not identified properly, library management may face difficulties in planning effective and efficient services [5], [6].

In this context, forecasting becomes an important approach that can be used to estimate the number of visits in future periods based on historical data. Forecasting is a process of predicting future events by utilizing past data patterns and trends[7], [8]. In library services, forecasting can provide useful information for management in preparing strategies and policies, such as staffing needs, service hour arrangements, facility readiness, and collection management. With more accurate forecasting results, the library can optimize its resources and improve service quality in a more measurable way. The use of forecasting methods in data analysis has developed widely and is increasingly relevant in supporting decision-making processes[9], [10], [11]. Historical visit data can be processed using quantitative methods to identify trends and estimate possible values in the next period. Through this approach, decision-making is no longer based solely on assumptions or subjective judgment, but on measurable numerical calculations. This is important because data-driven planning tends to be more objective, efficient, and accountable, especially in institutions that aim to continuously improve their service performance.

Among the various forecasting methods available, Linear Regression and Trend Moment are two methods that can be used to analyze and predict time-based data patterns[12], [13]. Linear Regression is a statistical method used to model the relationship between variables in the form of a linear equation, so that it can produce predicted values based on observed trends[14], [15]. This method is often used because it is relatively simple, easy to implement, and able to describe the general direction of data movement. Meanwhile, the Trend Moment method is used to identify trend patterns from historical data through mathematical calculations that form a straight-line function representing the movement of data over time[16], [17]. Both methods have their own characteristics and advantages, so it is necessary to evaluate their performance to determine which method is more suitable for forecasting library visits.

To determine the quality of forecasting results, an accuracy measurement method is required. In this study, forecasting accuracy is evaluated using Mean Absolute Percentage Error (MAPE). MAPE is one of the commonly used metrics in forecasting studies because it measures the average percentage error between actual values and predicted values[16], [18]. The smaller the MAPE value, the better the forecasting model in representing actual conditions. Therefore, MAPE is considered suitable for comparing the performance of Linear Regression and Trend Moment in predicting library visit data. Forecasting library visits is important not only from a technical or statistical perspective, but also from a managerial perspective. By knowing the estimated number of future visits, library managers can make better decisions related to service development and operational planning. For example, if the number of visits is predicted to increase, the library can anticipate this by improving service readiness, increasing staff allocation, and ensuring the availability of facilities and reading materials. On the other hand, if visits are predicted to decrease, the institution can evaluate the causes and develop strategies to increase user interest in utilizing library services. In this way, forecasting can serve as a supporting tool in improving both efficiency and service effectiveness.

In addition, this study is relevant because the utilization of data in the field of library management is becoming increasingly important in the digital era. Libraries are currently required not only to provide access to information, but also to adapt to changes in user behavior and technological developments. Data-based analysis, including forecasting, can help libraries become more adaptive and responsive in facing these changes. The results of forecasting can also be used as evaluation material for institutional policies in order to strengthen the role of the library as an essential academic support unit in higher education. Based on the background above, this study aims to forecast library visits at UMSU by applying the Linear Regression and Trend Moment methods, and then comparing the level of accuracy of the two methods using MAPE[19], [20]. Through this study, it is expected that the most appropriate forecasting method can be identified for predicting library visit trends. The results are expected to provide practical benefits for library management in improving planning and service quality, as well as theoretical benefits in enriching forecasting studies in the field of information systems and library service management.

Although forecasting methods have been widely applied in sales, finance, tourism, and inventory studies, their application in forecasting university library visits remains relatively limited. Previous studies have generally focused on commercial and operational forecasting contexts, while fewer studies have examined how simple forecasting methods can support service planning in academic libraries. This condition creates a research gap in the application and comparison of accessible forecasting methods, particularly Linear Regression and Trend Moment, for estimating library visit patterns. Therefore, this study addresses that gap by comparing both methods in the context of UMSU library visit forecasting using MAPE as the accuracy measurement.

The contribution of this study is twofold. Practically, the findings provide library management with a data-driven basis for estimating future visitation levels, preparing service capacity, and allocating resources more effectively. Theoretically, this study enriches forecasting research in academic library management by comparing Linear Regression and Trend Moment methods using historical library visitation data.

2. RESEARCH METHODOLOGY

2.1. Method

To achieve the objectives of this research, we will apply a systematic and structured method. The method involves several main stages, which include data collection, analysis, model building, method comparison, evaluation, and dissemination of results. The following is a detailed description of the research method and stages:

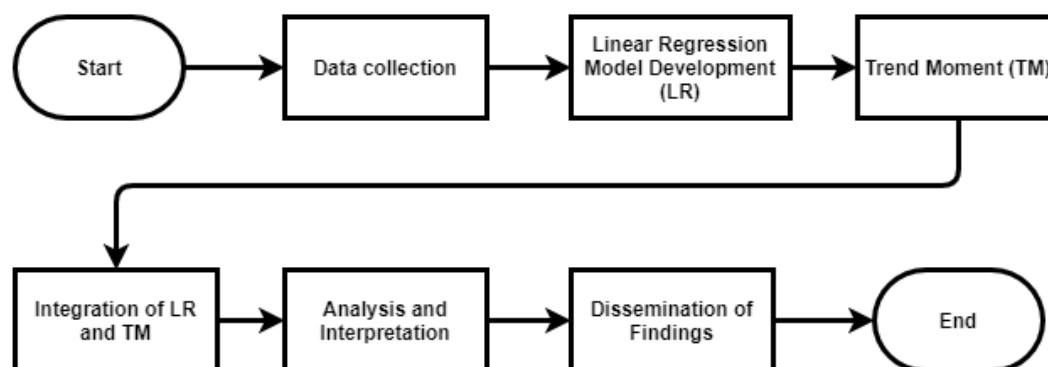


Figure 1. Research methods

1. Data Collection

The data used in this study were historical monthly library visit records obtained from UMSU library documentation. The dataset consists of monthly visitation data from 2023 to 2025 and was used as the basis for forecasting future library visits. The data were arranged chronologically to identify visitation patterns and to support the comparison between the Linear Regression and Trend Moment methods.

2. Linear Regression (LR) Model Development

Description: Building a Linear Regression model using the time index as the independent variable and library visit values as the dependent variable.

Activity: Calculating the regression equation based on historical monthly visit data.

Outcome Indicator: Forecasted library visit values are obtained using the Linear Regression method.

3. Trend Moment (TM)

The Trend Moment method was applied to identify the tendency of library visit changes over time by forming a linear trend equation based on historical visitation data. This method estimates future visit values using time-indexed historical data and was then compared with the Linear Regression method using MAPE.

4. Comparison of Linear Regression and Trend Moment

Description: Comparing the forecasting results of Linear Regression and Trend Moment to determine which method provides better accuracy.

Activity: Calculating the forecasted visit values using both methods and evaluating their accuracy using MAPE.

Outcome Indicator: The method with the lower MAPE value is identified as the more accurate forecasting method for the dataset.

5. Analysis and Interpretation

Description: Analyzing model results to evaluate effectiveness and interpretation of findings.

Activity:

Analysis of prediction results and interpretation of factors affecting the model. Sensitivity modeling to identify potential improvements.

Outcome Indicator: Clear findings on the comparative accuracy of Linear Regression and Trend Moment in forecasting library visits.

6. Dissemination of Findings

Description: Preparing research reports and presenting them at conferences and seminars.

Activity: Preparing scientific reports and publications.

Achievement Indicators: Publications accepted and presentations made at academic forums.

2.2.1. Linear Regression Method

Linear regression is a statistical analysis that models the relationship of several variables according to the form of an explicit linear equation relationship. Linear regression is a prediction or forecasting method that uses a straight line to describe the relationship between two or more variables. This method is used to predict a target value based on several input variables through the formation of a numerical relationship model. The linear regression method has several advantages when used in prediction. The relationship between two variables can be seen with this analysis or using a correlation coefficient calculation that expresses the closeness of the relationship between the two.

An approach method for modeling the relationship between one dependent variable and one independent variable. Simple regression analysis, the relationship between variables is linear, where changes in variable X will be followed by fixed changes in variable Y. To determine the value of the forecasting results, the formula is used [21], [22], [23], [24], [25]:

$$y = a + bx \quad (1)$$

Description:

Y = predicted variable or independent variable

X = predictor or independent variable

a = constant

b = regression coefficient parameter of independent variable

The formula for determining a and b is

$$b = \frac{n \sum xy - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2} \quad (2)$$

$$a = \bar{y} - b\bar{x} \quad (3)$$

2.2.2. Trend Moment Method

The Trend Moment method is a forecasting method used to identify the tendency of data movement over time by forming a linear trend equation from historical data. In this study, the method was applied to monthly library visit data to estimate future visitation values. The time index was used as the independent variable, while the number of library visits was used as the dependent variable. [26], [27], [28], [29], [30], [31], [32], [33]:

$$y = a + bx \quad (4)$$

$$\sum y = a.n + b.\sum x \quad (5)$$

$$\sum xy = a.\sum x + b.\sum x^2 \quad (6)$$

2.2.3. Method Mean Mean Percentage Absolute Error (MAPE)

Mean Absolute Percentage Error (MAPE) is one of the commonly used performance evaluation metrics in forecasting. MAPE measures the average absolute percentage error between actual and predicted values, and is commonly used to evaluate the performance of forecasting models. The lower the MAPE value, the better the performance of the forecasting model. To calculate MAPE, calculate using the equation:

$$MAPE = \frac{1}{n} * \sum \left(\frac{actual\ value - predicted\ value}{actual\ value} \right) * 100 \quad (7)$$

3. RESULT AND DISCUSSION

3.1. Research Data

The research method consisted of five main stages: collecting monthly library visit data, arranging the data chronologically, applying the Linear Regression method, applying the Trend Moment method, and comparing the forecasting accuracy of both methods using MAPE. The research data can be seen in table 1.

Table 1. Research Data

Year	Month	Visit
2023	January	1.05
2023	February	1.12
2023	March	1.18
2023	April	1.21
2023	May	1.25
2023	June	1.19
2023	July	1.13
2025	August	1.7
2025	November	1.76
2025	December	1.5

The monthly visitation data presented in Table 1 may also reflect seasonal patterns associated with the academic calendar, such as examination periods, semester transitions, and holidays. These seasonal effects were not explicitly modeled in the present study. Therefore, future research may incorporate seasonal adjustment factors or seasonal forecasting approaches to improve predictive accuracy and potentially reduce the MAPE value.

To see the results of the research data obtained more clearly, you can see the visualization form in Figure 2 below.

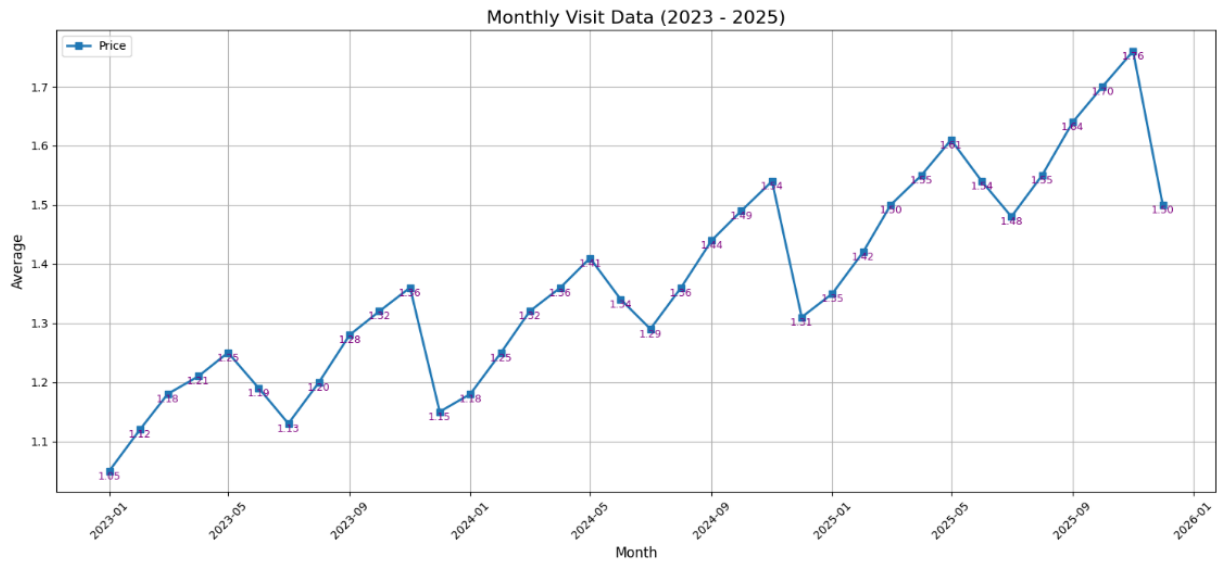


Figure 2. Monthly Library Visit Data Visualization (2023 - 2025)

From table 1, the visits will be predicted for visits in the next period using the linear regression method and the trend moment method.

3.2. Forecasting with Linear Regression Method

Forecasting using the Linear Regression method can be done by finding the value of xy , total x , total y , total xy , total x^2y , and x^2y as will be shown in the example of forecasted library visit value in the next period at Visit which can be seen in table 2.

Table 2. Forecasting with Linear Regression Method

x	y	x*y	x^2
1	1.05	1.05	1
2	1.12	2.24	4
3	1.18	3.54	9
4	1.21	4.84	16
5	1.25	6.25	25
6	1.19	7.14	36
7	1.13	7.91	49
34	1.7	57.8	1156
35	1.76	61.6	1225
36	1.5	54	1296
$\sum x = 666$	$\sum y = 49.33$	$\sum xy = 970.59$	$\sum x^2 = 16206$
$\bar{x} = 18.5$	$\bar{y} = 1.370277778$		

From the results of table 2, we can find the forecast values for linear regression using equations 1, 2, and 3. The first step is to find the value of b using equation 2.

$$b = \frac{(36 * 970.59) - (666 * 49.33)}{(36 * 16206) - (666)^2}$$

$$b = \frac{2087.46}{139860}$$

$$b = 0.014925354$$

Substitute the value of b into equation 3

$$a = 1.370277778 - 0.014925354 * 18.5 = 1.09415873$$

After getting the values of a and b, enter the values of a and b into equation 1 to get the forecast results for visits for the period 01 January 2026 using the linear regression method:

$$y = 1.09415873 + (0.014925354 * 37) = 1.646396825$$

Based on the above calculation, the number of visits during the period ending January 1, 2026, was 1.646. To measure the accuracy of this estimate, the MAPE method can be used, as shown in Table 3.

Table 3. Table for Finding the MAPE Value of the Forecasted Visit Value Using the Linear Regression Method

x	y	Predicted Value	Abs(actual value - predicted value) / actual value
1	1.05	1.109084084	0.056270556
2	1.12	1.124009438	0.003579855
3	1.18	1.138934792	0.034801024
4	1.21	1.153860146	0.046396574
5	1.25	1.1687855	0.0649716
6	1.19	1.183710854	0.005284997
7	1.13	1.198636208	0.060740007
34	1.7	1.601620764	0.057870139
35	1.76	1.616546118	0.081507888
36	1.5	1.631471471	0.087647648
Total			1.650644295

From table 3, we can find the MAPE value of the forecasted visit value using the Linear Regression method:
MAPE: $(1.650644295 / 36) * 100 = 4.5940 \%$

The MAPE value of 4.59% indicates that the Linear Regression method produces a relatively low forecasting error for the library visitation data. This result suggests that the monthly visitation pattern in the dataset is well represented by the linear trend estimated from the observed data. Linear Regression is able to adjust the prediction line based on the specific slope of the historical visitation trend, allowing it to better capture the direction of data movement. This characteristic may explain why Linear Regression achieves a lower error rate than the Trend Moment method, which relies on a more fixed mathematical trend formulation. Therefore, in this study, Linear Regression provides a more suitable representation of the visitation pattern and yields more accurate forecasting results. To present the forecasting results of the Linear Regression method more clearly, including the comparison between actual and predicted visitation values, the visualization is shown in Figure 4.

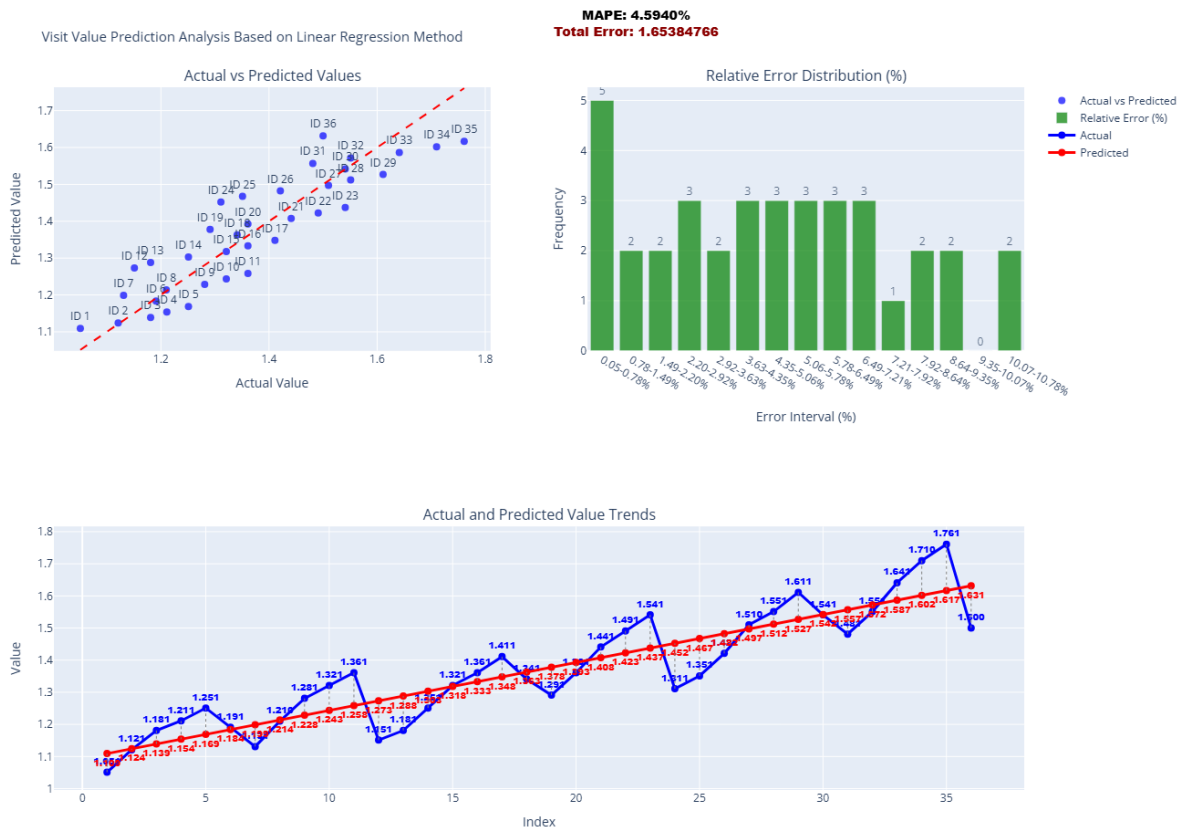


Figure 4. Library Visit Forecasting Results Using Linear Regression

3.3. Forecasting with Trend Moment Method

To find the forecasted visit value using the Trend Moment method, there are several steps that must be done. Similar to the linear regression method, the values of xy , total x , total y , total xy , total x^2 , and y^2 will be searched. The difference from the Linear Regression method is that the Trend Moment method uses a time index variable to calculate the historical sequence of library visit data. The details of finding the value of these variables can be seen in table 4.

Table 4. Forecasting Search Process with Trend Moment Method

x	y	Time index	$x \cdot y$	x^2
1	1.05	0	1.05	1
2	1.12	1	1.12	4
3	1.18	2	1.18	9
4	1.21	3	1.21	16
5	1.25	4	1.25	25
6	1.19	5	1.19	36
7	1.13	6	1.13	49
34	1.7	33	1.7	1156
35	1.76	34	1.76	1225
36	1.5	35	1.5	1296
Total	$\sum y = 49.33$	$\sum x = 630$	$\sum xy = 970.59$	$\sum x^2 = 16206$
$\bar{x} = 18.5$	$\bar{y} = 1.370277778$			

With the data in table 4, we will look for the values of a and b using equations 5 and 6, then the values of a and b will be entered into equation 4, so as to get the forecasted visit value using Trend Moment forecasting. The calculation for finding the value of b can be seen below:

$$\sum y = a.n + b.\sum x \rightarrow 49.33 = 36a + 630b$$

$$\sum xy = a.\sum x + b.\sum x^2 \rightarrow 970.59 = 630a + 16206b$$

After the elimination and substitution processes are carried out, the value of a is 1.00785 and the value of b is 0.02071 so that the value of y can be found using the trend moment method as follows:

$$y = 1.00785 + (0.02071 * 37) = 1.77412$$

Based on the calculation above, the visit for the period of January 1, 2026, was 1.77412. To measure the accuracy of the forecast results, the MAPE method can be used, as shown in Table 5.

Table 5. Table for Finding the MAPE Value of the Forecasted Visit Value Using the Trend Moment Method

x	y	Predicted Value	Abs(actual value - predicted value) / actual value
1	1.05	1.02856	0.020419048
2	1.12	1.04927	0.063151786
3	1.18	1.06998	0.093237288
4	1.21	1.09069	0.098603306
5	1.25	1.1114	0.11088
6	1.19	1.13211	0.048647059
7	1.13	1.15282	0.02019469
34	1.7	1.71199	0.007052941
35	1.76	1.7327	0.015511364
36	1.5	1.75341	0.16894
Total			2.109371998

From Table 5, the MAPE value of the forecasted visit value using the Trend Moment method is calculated as follows: MAPE: $(2.109371998 / 36) * 100 = 5.8594\%$

To more clearly see the results that have been achieved by using forecasting with the Trend Moment method and measuring the accuracy of the forecasting results using MAPE, it can be seen in Figure 5 in the form of visualization.



Figure 5. Library Visit Forecasting Results Using Trend Moment

3.4. Comparative Accuracy of the Two Methods

From the visit value search results using these two methods, the MAPE accuracy results can be viewed and compared to determine which method has the best accuracy. Table 6 displays the MAPE accuracy results in more detail, and the MAPE values for each method are averaged based on the accuracy of the last visit estimate.

Table 6. MAPE Accuracy Results of Both Methods

Visit	MAPE of Linear Regression (%)	MAPE of Trend Moment (%)
Accuracy	4.5940	5.8594

To more clearly see the accuracy results of the comparison between the two methods, it can be seen in Figure 6 in the form of visualization.

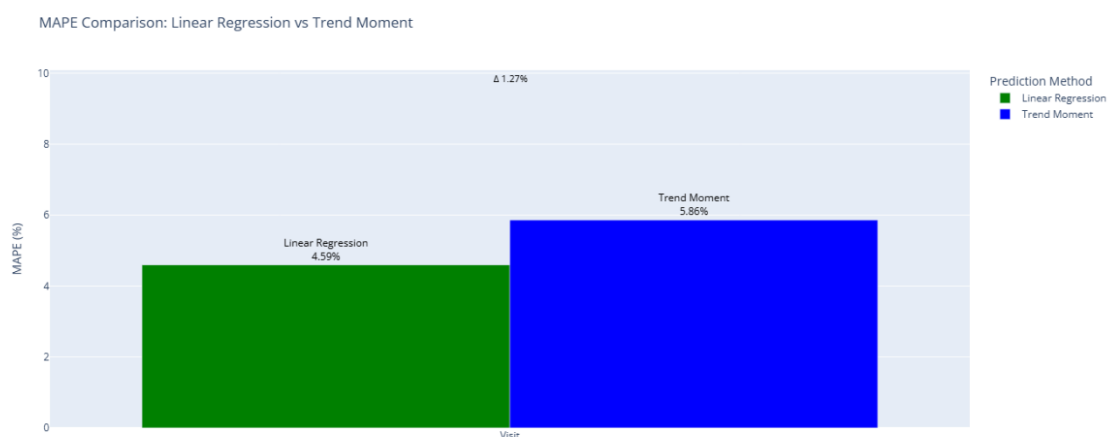


Figure 6. MAPE Comparison: Linear Regression vs Trend Moment

4. CONCLUSION

Based on the results of the study, it can be concluded that both the Linear Regression and Trend Moment methods are able to forecast library visit values for the next period based on historical data patterns. However, the Linear Regression method provides better forecasting performance than the Trend Moment method. This is shown by the forecasting result for the next period, where Linear Regression produces a predicted value of 1.646396825 with a MAPE of 4.5940%, while the Trend Moment method produces a predicted value of 1.77412 with a MAPE of 5.8594%. Since a lower MAPE value indicates better accuracy, the Linear Regression method can be considered more effective for forecasting library visits in this study. Furthermore, future studies are recommended to expand the forecasting model by testing hybrid approaches, such as combining Linear Regression with Moving Average techniques, in order to capture both long-term trends and short-term fluctuations in library visit patterns. This approach may help reduce the forecasting error below the current MAPE value and produce more stable prediction results. In addition, future research should consider adding qualitative or event-based variables into the regression model, such as examination schedules, academic calendar periods, new book arrivals, library programs, or institutional activities. These factors can be represented as dummy variables to examine how specific academic events influence the value of library visits. By incorporating hybrid models and qualitative predictors, future forecasting studies are expected to provide more comprehensive, contextual, and accurate results for supporting library service planning.

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