Journal of Information Technology and Cyber Security 4(2) July 2026: 68-76 EISSN 2987-386X | PISSN 2987-3878
DOI:10.30996/jitcs.12520

Financial Ratio Prediction for Accounting Information System Using Holt-Winters Exponential Smoothing

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Received: 01 January 2025
Accepted: 22 July 2026
Revised: 22 July 2026
Available online: 12 August 2026

To cite this article: Dzikria, I., Fahriono, M. I., Hukum, R. R. H, Ferianto, M., Sudigto, A. R., & Murwato, S. A. (2026). Financial Ratio Prediction for Accounting Information System Using Holt-Winters Exponential Smoothing. *Journal of Information Technology and Cyber Security, 4*(2), 68-76. https://doi.org/10.30996/jitcs.12520

Abstract
Financial ratio analysis serves as a vital tool for assessing organizational performance and supporting decision-making processes. This study developed an accounting information system featuring financial ratio prediction capabilities powered by the Holt-Winters Exponential Smoothing algorithm—a method capable of handling time-series data characterized by trends and seasonality. Functional testing demonstrated that the system operates according to design, achieving a 94% success rate. Prediction results varied in accuracy: the current ratio achieved a Mean Absolute Percentage Error (MAPE) of 8.3%, indicating a favorable prediction outcome. Conversely, the Return on Investment (ROI), Return on Equity (ROE), and debt-to-equity ratios yielded MAPE values exceeding 20%, signaling a need for improved accuracy. These findings suggest that the system can serve as a relevant analytical tool for financial management; however, further development is required, particularly regarding algorithm parameter optimization and the provision of higher-quality data.
Keywords: accounting information system, holt-winters exponential smoothing, financial ratio.

1. Introduction

Financial management is a crucial aspect of maintaining the sustainability of operational activities. As non-profit organizations, foundations are required to manage funds transparently and accountably in order to carry out their social and educational functions sustainably. Larasati, Nurdiwaty, & Kurniawan (2023) explained that educational foundations derive their funding from donations, grants, *waqf* (endowments), and other sources, necessitating an accountable and efficient financial management system.

However, many foundations still face challenges in financial management because recording and reporting processes are carried out manually using standalone applications, such as spreadsheets. This situation can lead to a lack of data integration and delays in the preparation of financial reports. Therefore, an accounting information system is needed that can manage financial data in an integrated manner and provide accurate information to support decision-making processes (Febrianti & Fitri, 2020).

Accounting information systems play a crucial role in helping organizations plan, monitor, and evaluate financial performance (Nurmalasari, Anna, & Ariyanti, 2021). Key features of this system include budget management, financial reporting, asset management, and financial ratio analysis. Financial ratio

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forecasting is a required analytical feature, as it can be used to evaluate performance, plan financial strategies, and improve the efficiency of fund management.

To address this need, this study employs the Holt-Winters Exponential Smoothing method, which is effective for forecasting historical data exhibiting trend and seasonal patterns (Sinay, Pentury, & Anakotta, 2017). This method can be used to predict various financial ratios—such as liquidity, profitability, and solvency—based on financial statement data.

Based on this background, the objective of this research is to design and develop an accounting information system based on financial ratio forecasting using the Holt-Winters Exponential Smoothing method, which is expected to assist educational foundations in managing finances, budgets, and assets more efficiently and accurately.

2. Literature Review

2.1. Accounting Information System

An Accounting Information System plays a vital role in organizing coordinated forms, records, and reports to generate the financial information required by management for decision-making, while simultaneously facilitating the overall management of the organization (Rahmasari, 2019).

According to Ruspendi (2020), an accounting information system consists of five main components: (1) forms, used to record transactions such as invoices and checks; (2) journals, serving as initial records for classifying financial data; (3) the general ledger, which summarizes transactions from the journals; (4) subsidiary ledgers, which detail specific financial data such as accounts receivable; and (5) financial statements, including the income statement, statement of changes in equity, cost of goods manufactured statement, and schedule of liabilities.

Saragih, Harahap, & Nurlaila (2023) emphasized that an accounting information system (AIS) plays a critical role in managing transaction flows and supporting managerial control, including inventory management and the recording of cash and credit transactions. In higher education foundations, the implementation of an AIS can strengthen financial management, improve operational efficiency, and support the sustainable development of educational services. More broadly, an AIS comprises several key functions, including budget management, financial management, asset management, and financial ratio reporting, which collectively provide essential information for effective managerial decision-making.

2.1.1. Budget, financial, and asset management

Budget management is a form of organizational responsibility for managing budget utilization to ensure it is effective, efficient, and aligned with established targets (Ginting, 2018). Budgetary control within a sound accounting system is essential to ensure the precision and accuracy of operating costs and to support the achievement of organizational goals.

Financial management encompasses the activities of acquiring, managing, and utilizing funds efficiently to support operations (Astuti, et al., 2022). This management encompasses revenue, expenses, and the preparation of financial statements, which serve as a tool for oversight and a basis for management decision-making (Miftahurrohman & Kartika, 2023).

Furthermore, asset management plays a role in managing an organization's assets through an effective process encompassing planning, acquisition, maintenance, and disposal (Yainahu, Leiwakabessy, & Latuny, 2022). Asset depreciation is the systematic allocation of an asset's value over its useful life (Purnama, Sokibi, & Parman, 2024), and the application of an appropriate method, such as straight-line or declining balance, will help preserve the asset's value and prevent financial loss.

2.1.2. Financial ratio prediction

Financial ratio analysis is used not only to understand a company's financial position during a specific period but also to predict future financial conditions by observing trends and patterns of change. A company's performance in the financial sector can be assessed through financial ratio analysis, which reveals changes in financial conditions and identifies potential future risks and opportunities (Tyas, 2020).

In a financial context, forecasting plays a crucial role in projecting future performance based on historical data. Forecasting methods enable management to anticipate changes in financial conditions, plan strategies, and make more informed decisions. Consequently, incorporating financial ratio prediction into accounting information systems adds value by allowing management to conduct financial projections more accurately and efficiently (Herwanto, Marliani, Rosida, & Herdyansyah, 2023).

2.2. Holt Winter Exponential Smoothing

Holt-Winters exponential smoothing is a technique developed from the simple exponential smoothing method that incorporates three constant parameters: trend, level, and seasonality (Prasetyo, Mahdiyah, &

Swanjaya, 2023). In this method, predictions are made by assigning weights to each parameter using values between 0 and 1 (Almaretha & Murni, 2024). There are two seasonal models in the Holt-Winters Exponential Smoothing forecasting method: the additive model and the multiplicative model (Prasetyo, Mahdiyah, & Swanjaya, 2023).

According to Almaretha & Murni (2024), the stages of using the Holt-Winters algorithm in their research are as follows:

1) Determine the initial seasonal value (S_t) or initialization begins using the trend value (B_s) and level (L_s) in the s period as a reference.
   a) Initial level value

$$L_s = \frac{1}{s}(X_1 + X_2 + \cdots + X_s) \quad (1)$$

   where on Eq. (1), L_s is initial level value, X_s is data value, and s is the period length.
   b) Initial trend value

$$B_s = \frac{1}{s}\left(\frac{X_{s+1}X_1}{s} + \frac{X_{s+2}-X_2}{s} + \cdots + \frac{X_{s+s}-X_s}{s}\right) \quad (2)$$

   Where on Eq. (2), B_s is trend initial value, X_s is data value until $(s+1)$ period, and s is the period length.
   c) Initial season value

$$S_t = \frac{X_t}{L_s} \quad (3)$$

   Where on Eq. (3), S_t is the initial season value, X_s is the data value, L_s is the initial level value, and t is the period length.
2) Determine parameter values of level (α), trend (β), and season (γ) that will be used for smoothing.
   α: Smoothing factor for level $(0 < \alpha < 1)$.
   β: Smoothing factor for trend $(0 < \beta < 1)$.
   γ: Smoothing factor for season $(0 < \gamma < 1)$.
3) After obtaining the parameter values of level (α), trend (β), and seasons (γ), calculations are then performed to determine the Holt-Winters equation.
   a) Level Smoothing

$$L_t = \alpha\left(\frac{X_t}{S_{t-s}}\right) + (1-\alpha)(L_{t-1} + B_{t-1}) \quad (4)$$

   b) Trend Smoothing

$$B_t = \beta(L_t - L_{t-1}) + (1-\beta)B_{t-1} \quad (5)$$

   c) Seasonal smoothing Pemulusan musiman (seasonal smoothing)

$$S_t = \gamma\left(\frac{X_t}{L_t}\right) + (1-\gamma)S_{t-s} \quad (6)$$

   d) Prediction m on the next period

$$F_{t+m} = (L_t + B_t m)S_{t-s+m} \quad (7)$$

   Where on Eq. (4), Eq. (5), Eq. (6), dan Eq. (7), L_t is level on period t, L_{t-a} is level on period $t-a$, B_t is trend on period t, B_{t-a} is trend on periode $t-a$, S_t is season on year t, S_{t-s} is smoothing of seasonal factor, Y_t is data on period t, s is the period length, t is season period, m is the predicted time period, α is the parameter of weight level $(0 < \alpha < 1)$, β is the pramater of weight level $(0 < \beta < 1)$, and γ is the pramater of weight level$(0 < \gamma < 1)$.
4) The subsequent step involves evaluating the prediction error using the Mean Absolute Percentage Error (MAPE), as given by the following formula:

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{X_t - F_t}{X_t}\right| \times 100\% \quad (8)$$

Where on Eq. (8), X_t is the value of actual data on period t, F_t is forecasting value or prediction period t, n is the amount of data, and t is the forecasting period.

Table 1
Sample functional requirements

Code	Functional Requirement	Actor
KF-07	Manage COA category data	Superadmin
KF-08	Manage revenue category data	Superadmin, Accountant
KF-09	Manage expense category data	Superadmin, Accountant
KF-10	Manage COA data	Superadmin, Accountant
KF-11	Manage bank data	Superadmin, Accountant
KF-12	Manage revenue data	Superadmin, Accountant
KF-13	Manage expense data	Accountant, Unit
KF-14	View revenue reports	Superadmin, Accountant
KF-15	View expense reports	Superadmin, Accountant
KF-16	View comprehensive income reports	Superadmin, Accountant
KF-18	Manage asset requirement plans	All Actors
KF-19	Manage asset additions	Superadmin
KF-20	View asset inventory	All Actors
KF-21	View asset depreciation	All Actors
KF-23	Manage asset write-offs	All Actors
KF-24	Manage asset transfers	All Actors
KF-25	Manage asset categories	Superadmin
KF-26	View asset depreciation reports	All Actors
KF-27	Approve asset requirement plans, write-offs, and transfers	Director
KF-31	View financial overview	Director
KF-32	View profit and loss reports (bar chart)	Director
KF-33	View revenue proportion by category (pie chart)	Director
KF-34	View ratio percentages (table)	Director
KF-36	Manage financial report data	Director
KF-38	View financial ratios	Director
KF-39	Forecast financial ratios	Director
KF-40	Manage budget submissions	User
KF-41	Submit budget requests	User
KF-42	Validate budget submissions	Director,
KF-43	Assess recommended budget submissions	System
KF-44	Finalize funded budget submissions	Director
KF-45	Disburse budget funds	Accountant
KF-46	Manage accountability reporting	User
KF-47	Submit accountability reports	User
KF-48	Validate accountability reports	Director

3. Methods

This study employs the Waterfall system development method. In the context of software development, the Waterfall model refers to a development approach that follows a linear and sequential order. It provides a structured process comprising requirements analysis, analysis, design, coding, testing, and maintenance (Yusron & Huda, 2021). According to Hermansyah, Wijaya, & Utomo (2023) The waterfall method comprises the following stages:

3.1. Requirement Analysis

The study involves understanding issues and identifying system requirements through interviews and field observations. The outcome of this process is a list of functional and non-functional requirements for the accounting information system. Additionally, financial report data from a company listed on the Indonesia Stock Exchange is utilized as a case study to apply the Holt-Winters Exponential Smoothing prediction algorithm.

Functional requirements—or system requirements—are those directly related to the system's functions and operations, encompassing the features, processes, and services necessary to meet user expectations and achieve desired performance (Damayanti, Megawati, Santia, & Kurniawan, 2020). In this

requirements analysis phase, the research identified 48 primary functional requirements, with a sample of 35 listed in Table 1. Meanwhile, the system's non-functional requirements focus on reliability, security, and performance.

3.2. System Design

System design is a process encompassing the creation of use case diagrams, activity diagrams, sequence diagrams, and entity-relationship diagrams, as well as the design of the accounting information system's user interface. The design of the accounting information system in this study is based on the functional requirements outlined in Table 1. Several design components were produced, namely use case diagrams, activity diagrams, sequence diagrams, and entity diagrams. The actors within this accounting information system include the User, Accountant, Director, and Super Admin—who operate the application—as well as the System itself, which facilitates the application's operations.

This study produced a use case diagram comprising 13 primary use cases. These primary use cases were further developed into 13 activity diagrams illustrating the various activities performed by the relevant actors.

Each activity diagram was subsequently developed into a sequence diagram to depict the flow of interactions among system components—ranging from actors, interfaces, classes, and objects to the accounting information system's database tables—resulting in a total of 13 sequence diagrams. Additionally, the study produced a system prototype serving as a reference for interface development; a low-fidelity prototype was created based on the sequence diagrams.

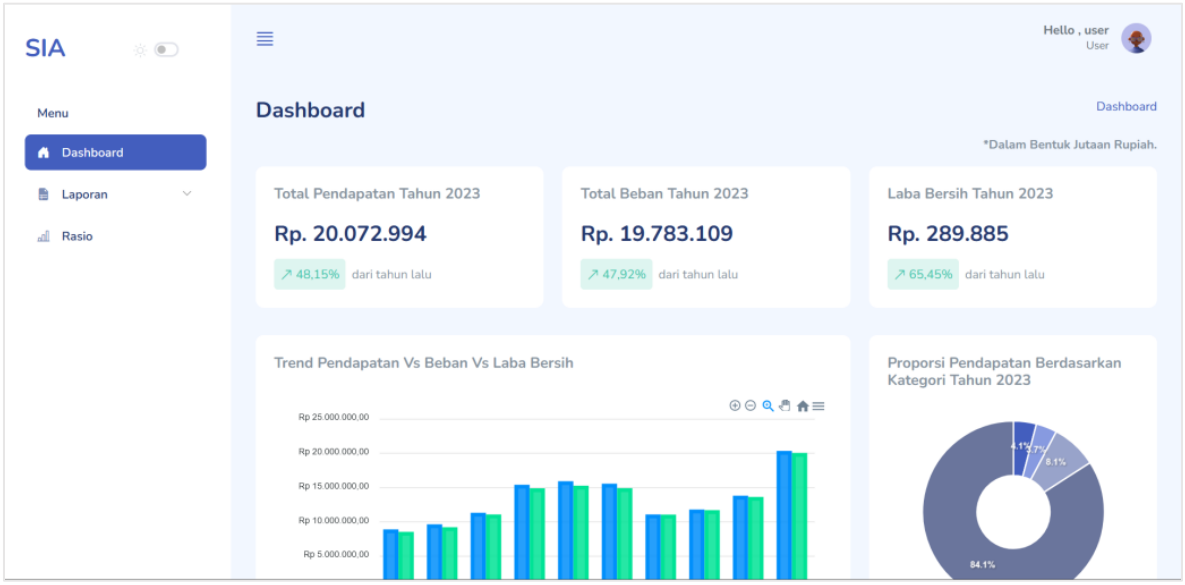


Fig. 1. Accounting information system interface for the financial ratio prediction module.

3.3. System Implementation

This implementation phase is the process of building the system using the Laravel framework, based on the system design from the previous stage.

3.4. Testing

The program testing phase is conducted to ensure that the system operates as planned. Testing for this research employs the black-box method. Black-box testing is a software testing technique—also known as functional testing or input-output driven testing—in which the tester has no knowledge of the application's internal workings (Dzikria & Nizar, 2023).

3.5. Maintenance

The final stage is evaluation and maintenance. At this stage, the system has already been implemented for the users.

4. Results and Discussion

4.1. System Implementation

This accounting information system can be used to manage the foundation's assets, featuring capabilities such as asset requirement planning, asset acquisition, inventory management, maintenance, transfer, disposal, and fixed asset depreciation. Fig. 1 displays the system's interface for the foundation's

financial ratio prediction module; here, users—specifically the director—can view a main financial overview dashboard and access features to examine financial reports for the current year and previous years.

This study employs Holt-Winters Exponential Smoothing to forecast financial ratios, utilizing current ratio data spanning ten years. The first step involves establishing the initial level value based on the average of data from the first five years (2014–2018) using Eq. (1), resulting in a mean of 132.814. The initial trend value is determined using Eq. (2) by calculating the average difference in current ratio data over the five-year period, yielding a value of 0.0675. Following the determination of the initial trend value, the next step is to establish the initial seasonal value using Eq. (3), with the results presented in Table 2.

After obtaining the three initial values—level, trend, and seasonality—Eqs. (4), (5), and (6) were used to calculate the smoothed (or updated) values for these three components for the years 2019–2023; the results are presented in Table 3.

Subsequently, this study forecasted the current ratio data for the period of 2019 to 2023 using Eq. (7). The Mean Absolute Percentage Error (MAPE) was also calculated to assess prediction error using Eq. (8); the results are shown in Table 4.

Future forecasting can be performed by using the most recent level and trend values—specifically those from 2023—as the basis for the forecast. The level is added to the trend and multiplied by m, and the result is then multiplied by the seasonal value from the corresponding period t of the previous year.

Table 2
Initial seasonal values.

Year	Current Ratio	Seasonal Value
2014	133.82	1.007574503
2015	144.68	1.089342991
2016	111.16	0.836959959
2017	140.32	1.056515126

Table 3
Smoothing level, trend, and seasonal value calculation results.

Year	Current Ratio	Level	Trend	Seasonal Value
2019	123.42	129.7647048	-0.867538563	0.990633977
2020	111.11	120.8271943	-3.288530146	1.03841342
2021	101.52	118.6659025	-2.950358648	0.84252531
2022	120.28	115.1546747	-3.118619388	1.052913043
2023	115.12	112.6325942	-2.939657703	1.013350468

Table 4
Current ratio prediction data (2019–2023).

Year	Current Ratio	Forecast	Error	Absolute Error	MAPE (%)
2019	123.42	133.8880113	-10.46801128	10.46801128	8.5
2020	111.11	140.4132246	-29.30322458	29.30322458	26.4
2021	101.52	98.37515552	3.144844479	3.144844479	3.1
2022	120.28	122.2552224	-1.975222402	1.975222402	1.6
2023	115.12	113.1124328	2.007567164	2.007567164	1.7
				Average	8.3

Table 5
Current ratio prediction results.

Year	Level	Trend	Seasonal Value	Predicted Result
2024	112.6325942	-2.939657703	0.990633977	108.6655499
2025	112.6325942	-2.939657703	1.03841342	110.8540374
2026	112.6325942	-2.939657703	0.84252531	87.4650328

For instance, to predict the third period, the calculation is performed up to $m = 3$. The calculation results are presented in Table 5.

4.2. Testing

This study evaluates the accounting information system developed for the Foundation using black-box testing. The testing was conducted to ensure the system functions effectively in supporting the management of finances, budgets, financial ratio forecasting, and Foundation assets. The black-box testing

method was employed to verify that the application operates according to user requirements, without regard to the system's internal structure (Sembiring, Irawan, & Siregar, 2024).

Test results indicate that 87.61% of the functionality operates correctly and aligns with test cases based on functional requirements; the system successfully processes data accurately, generates reports efficiently, and displays easily understandable information, although there are some functions that do not meet user requirements.

5. Conclusions

This study demonstrates that the implementation of an accounting information system for the foundation enhances the effectiveness of financial management, budgeting, financial ratio analysis, and asset management. The developed system successfully addresses various challenges previously associated with manual processes, such as the risk of data loss, calculation errors, and delays in financial report preparation.

Conceptually, this research contributes to the development of accounting information systems featuring financial ratio prediction capabilities. The resulting system not only improves operational efficiency but also provides projected financial performance information to support managerial decision-making.

However, this study is subject to limitations regarding the organization's characteristics, which differ from those of public sector entities or publicly traded companies. Furthermore, the long-term impact of the system's usage requires further monitoring. Consequently, future research should expand the scope of study to include diverse types of organizations and conduct a comprehensive evaluation of the implementation.

6. Declaration of AI and AI assisted technologies in the writing process

During the preparation of this work, the author(s) used ChatGPT for language refinement. After using this tool, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

7. CRediT Authorship Contribution Statement

Intan Dzikria: Conceptualization, supervision, methodology, validation, resources, and writing – review & editing. **Muhammad Ikraam Fahriono**: Data curation, formal analysis, software, and writing – original draft. **Muhammad Ferianto**: Data curation, formal analysis, software, and writing – original draft. **Acxell Rizada Sudigto**: Data curation, formal analysis, software, and writing – original draft. **Rayhan Rizaldi Hi Hukum**: Data curation, formal analysis, software, and writing – original draft. **Sigit Ananda Murwato**: Supervision, formal analysis, validation, and writing – review & editing.

8. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

9. Acknowledgments

The author wishes to thank the anonymous reviewers for their helpful comments and suggestions.

10. Data Availability

Data will be made available on request.

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