مجلة تنمية الرافدين

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Research Paper

Applying Forecasting Algorithms to Improve Budget Preparation Procedures in Government Units

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Abstract

It is necessary to use contemporary techniques to anticipate government budget items in light of the financial difficulties that governments face, especially scarce resources and growing spending demands. Using forecasting algorithms as a sophisticated technique to estimate government units' expenditures and revenues for the upcoming fiscal years. The study's problem is that the traditional technique of producing the government budget confronts numerous problems, the most serious of which is the reliance on human estimates to determine the demands for various types of spending, resulting in a waste of public funds. Furthermore. The study's goal is to forecast future general budget expenditures, improve decision-making efficiency, and ensure accurate financial reporting by using accounting models supported by intelligent systems capable of continuous learning and development. In this study, the ARIMA statistical forecasting model was utilized to forecast budget items for 2021 based on historical data. The ARIMA statistical forecasting model performed well in forecasting budget items related to expenditures for the year 2021, with an amount of (177,165,336,299) and a slight downward trend, and the expected values were very close to the actual values, which were (179,228,498,212). Among the researcher's most important conclusions: forecasting algorithms represent a rational scientific method due to their ease of application and speed of data processing , while the most important recommendations is to use forecasting algorithms in the government budget preparation process, given their ability to handle massive amounts of data while producing results quickly and at the lowest possible cost.

Keywords:
Forecasting algorithms, budgets, ARIMA.

ورقة بحثية

تطبيق خوارزميات التنبؤ في تحسين إجراءات إعداد الموازنة في الوحدات الحكومية

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المستخلص

من الضروري استخدام الأساليب المعاصرة للتنبؤ ببنود الموازنة الحكومية في ظل الصعوبات المالية التي تواجهها الحكومات، وخاصة شح الموارد وتزايد متطلبات الإنفاق. إذ يُعَدّ استخدام خوارزميات التنبؤ تقنية متقدمة لتقدير نفقات وإيرادات الوحدات الحكومية للسنوات المالية القادمة. وتتمثل مشكلة الدراسة في أن الأسلوب التقليدي لإعداد الموازنة الحكومية يواجه العديد من الإشكالات، أبرزها الاعتماد على التقديرات البشرية لتحديد متطلبات أنواع الإنفاق المختلفة، مما يؤدي إلى هدر الأموال العامة . كما تهدف الدراسة إلى التنبؤ بنفقات الموازنة العامة المستقبلية، وتحسين كفاءة اتخاذ القرار، وضمان دقة التقارير المالية من خلال استخدام نماذج محاسبية مدعومة بأنظمة ذكية قادرة على التعلم والتطور المستمر. وفي هذه الدراسة، تم استخدام نموذج التنبؤ الإحصائي ARIMA للتنبؤ ببنود الموازنة لعام 2021 بالاعتماد على البيانات التاريخية. وقد أظهر نموذج ARIMA أداءً جيداً في التنبؤ ببنود الموازنة المتعلقة بالنفقات لسنة 2021، حيث بلغت القيمة المتوقعة (177,165,336,299) مع اتجاه طفيف نحو الانخفاض، وكانت القيم المتوقعة قريبة جداً من القيم الفعلية التي بلغت(179,228,498,212) . ومن أبرز استنتاجات الباحث: أن خوارزميات التنبؤ تمثل أسلوباً علمياً عقلانياً نظراً لسهولة تطبيقها وسرعة معالجتها للبيانات، في حين أن أهم التوصيات هي ضرورة استخدام خوارزميات التنبؤ في عملية إعداد الموازنة الحكومية لما لها من قدرة على التعامل مع كميات ضخمة من البيانات مع إنتاج نتائج سريعة وبأقل تكلفة ممكنة.

الكلمات الرئيسة:

خوارزميات التنبؤ، الموازنة، ARIMA.

مجلة

تنمية الرافدين

***(TANRA):* مجلة علمية، فصلية، دولية، مفتوحة الوصول، محكمة.**

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1. Introduction

Given the massive technological changes occurring in all areas of production, services, and industry, the government must step in to ensure its long-term survival in various areas. The utilization of contemporary technological methods has become essential for directing scarce resources effectively. Additionally, government budget preparation requires the availability of accounting data that is not predictive in itself, but can serve as a foundation for future projections by decision-makers. This data indicates the degree of deficit or abundance. Forecasting algorithms are used as a sophisticated method for forecasting unit expenditures and revenues.

The study problem is that the traditional method of preparing the government budget has faced numerous criticisms, the most serious of which is the use of personal estimates in determining needs for various types of expenses, which results in a waste of public money. Furthermore, failure to use scientific methods in preparing the government budget results in a loss of the benefits of these methods, including forecasting algorithms, when preparing these budgets. This includes reduced time, effort, and cost, as well as the inability to accurately estimate the need for expenditures. The following set of questions can be used to formulate the research problem:

1. Is it possible to estimate expenses and revenues using forecasting algorithms?
2. Does the use of statistical forecasting algorithms in budget preparation reduce budget approval controversy by providing a logical and scientific method acceptable to all parties?

The significance of the study is embodied in the need to use modern techniques represented by forecasting algorithms to prepare budgets in government units, due to the increasing need to make decisions with speed and accuracy, as the success of the government unit in achieving its goals is dependent on the information provided by the financial accounting information system. Any flaw in the credibility of the information will hurt the desired outcomes and the timely budget approval process.

The study aims to demonstrate the importance of using statistical forecasting techniques in accounting operations, particularly in the process of preparing and approving budgets on time. This enables more efficient decision-making and supports expert systems in solving problems through training and continuous learning from repeated errors.

In (Anabella, 2023), the study aims to create a prediction model to determine students' odds of passing their classes at the start of the semester in order to successfully identify a suitable prediction model with a high rate of acceptability, accuracy, and precision that yields a valuable outcome for educational systems' decision-making processes, thereby improving information transfer. The model used in this study will significantly impact how teachers identify and assess their students' areas of weakness in the classroom, enhance the effectiveness of their student-centered learning processes, reduce the rate of academic failure, and help administrators adjust learning system outcomes.

In Shahot & Shatwan (2023), the authors develop a multiple linear regression model to predict sales of construction materials in Misurata, aiming to identify the best linear model to represent sales volume and understand the various relationships between the independent variables, as well as their impact on sales volume. The conclusions indicate that multiple linear regression models can be used to forecast future sales. This model helps estimate sales that cause an imbalance in the process of balancing sales volume and production volume, as well as the associated additional expenses and their impact on competitiveness.

In Kim & Barutha (2023), the authors illustrate data-driven machine learning techniques for capital construction budget forecasting. In this study, data from capital construction projects in New York City with a minimum value of $25 million were subjected to machine learning algorithms. The aim was to identify the most effective model for forecasting the final budget, taking into account the project's type, execution stage, budget modifications, and schedule adjustments. The study's results demonstrate how machine learning can reliably predict the costs and benefits of a project. The outcome will help stakeholders make decisions by projecting the final capital construction budget at any point during the project's duration.

2. The Conceptual Framework of the Budget in the Government Unit

The concepts of the budget, its primary characteristics, and its goals are explained in subsequent sections.

2.1 The Concept of Budget

According to studies on developing countries, poor and financially challenged countries engage in repetitive budgeting, sometimes referred to as continuous budgeting or re-budgeting. This typically means that after the budget has been approved, significant changes must be made to budget plans, including estimates established before the fiscal year begins. Therefore, as a tool for accounting or finance, this type of budget is unlikely to be very effective.

Although the budget is a fundamental legislative requirement for all government entities, the perspectives on it vary among central government entities, autonomous government entities, and governmental and non-governmental entities (Williams *&* Calabrese, 2016).

The budget is the cornerstone of the government's financial activities. Since the budget was created to accommodate different governments' political systems, it can have a significant impact on how well these entities function financially. However, this document is no longer just a collection of static numbers; rather, it represents dynamic figures aimed at achieving specific, pre-planned goals within a defined time period.

According to American law, the general budget is an instrument that estimates the expenses and revenues for the following year, in compliance with relevant legislation at the time of submission, including collection proposals (Al-Ramli, 2022).

The budget is also referred to as one of the most crucial financial planning instruments, as it is the fundamental tool that establishes the government's objectives, policies, and programs, as well as how to utilize and distribute resources. It is

frequently acknowledged that no nation, no matter how wealthy, can acquire an infinite amount of resources (Sanor I, 2017).

2.2 General Budget Characteristics

The general budget is distinguished by several features, the most important of which are as follows (Al-Ramli, 2022):

1. A budget is a document that outlines the executive authority's expectations for the amount of revenues and expenditures in a given time frame, often one year.
2. The budget reflects the state's objectives. The state budget is an ongoing economic process in which the present is seen as an extension of the past and the future as a continuation of the present. It comprises a stream of economic operations and explains the state's fiscal policy goals for the upcoming years, as well as a record of its past accomplishments.
3. Legislative Authority Approval: The government's projections for future public spending and revenue are ratified when the legislative authority approves the general budget. Therefore, unless it is accepted and ratified by the legislative body, the general budget is not regarded as final.
4. An accounting document is a collection of financial and administrative actions that are subject to the accounting formalities enforced by the public accounting system. These formalities are based on splitting the budget into two parts, namely revenues and expenditures, and then further subdividing each side into branches, chapters, articles, and paragraphs. The state has begun the process of implementing its fiscal policies.

2.3 Budget objectives

The budget accomplishes two primary objectives of planning and coordination (Ali et al., 2016). Planning entails creating a detailed strategy that takes into account the following:

1. Establish the primary and secondary objectives of the unit, whether they are short-term or long-term.
2. Create the plan using particular units of measurement, such as the number of products, working hours, or quantity of supplies, and then translate it into financial terms while attempting to attain an economic and financial balance for the unit.
3. Assign tasks to staff members in order to assess their performance.
4. Oversight and performance evaluation.
5. Planning is the first step in activity control. The plan should be followed, monitored, and controlled during implementation; otherwise, it will be a pointless estimate. Thus, the actual function of the budget is oversight, which is accomplished by the following:
   - ✓ Observe how the actions are actually carried out.
   - ✓ Examine the difference between the planned and actual performance.
   - ✓ Analyze deviations, determine their causes, and take immediate corrective action.

Through this process, the budget enables the administration to fulfill its goal by managing by exception, focusing on areas that are not part of the plan.
For planning to be successful, coordination is essential. A plan cannot succeed if activities are uncoordinated across employees, subunits, and other components. Planning entails the coordination process to resolve secondary conflicts of objectives and achieve the unit's primary goal.

According to Al-Uzzi (2014), the general budget also encompasses programs aimed at achieving several other objectives.

1. Social objectives: Address poverty and unemployment, provide aid to the underprivileged in order to reduce the disparity between social classes, and achieve equality. It also intends to implement programs to enhance the quality of social services, assist the expansion of small enterprises that employ people, train the workforce, and improve the quality of social services.
2. Scientific objectives: Encourage scientific research and the use of modern technologies to ensure and develop societal progress.
3. Environmental objectives: Include policies to reduce pollution, extend and safeguard agricultural lands, and address water scarcity.

3. The Process of Predictive Analytics

The reliability of an analytical model will be significantly impacted by the preparation of a training dataset for machine learning-based analytical processing. The following are the four steps in predictive analytics (Theng& Theng,2020):

1. Pre-processing: gathering and pre-processing raw data.
2. Data transformation or feature selection: using a suitable machine learning technique to transform pre-processed data into an easily manageable format (by choosing the most pertinent information or attributes according to the problem need).
3. Training: using the transformed data to build the learning model?
4. Testing or prediction: using a previously developed learning model to report predictions.

4. Machine Learning Algorithms

Numerous algorithms are available in machine learning (ML) technology to address a range of problems. The goal of these algorithms is to use available data to learn and predict future states of a process. Numerous ML techniques have been employed by researchers, including fuzzy inference systems, response surface methods (RSMs), neural networks (NNs), and genetic algorithms (GAs) (Inayathullah & Buddala, 2025). The standard machine learning algorithms are (Kumar&Sowmya, 2021):

4.1 Linear Regression Algorithm

Algorithms for supervised learning include regression techniques. This method makes predictions using continuous variables. Regression algorithms use a labeled input variable to predict the value of a continuous output variable. Through

regularization, linear regression can reduce overfitting and is simple to comprehend. Linear regression is suitable when a linear relationship exists between the input and output variables.

4.2 Multivariate Regression Analysis.

In simple linear regression, one independent variable is used to determine the output variable (dependent variable). Due to the complexity of real-time applications, extracting model answers with a single variable is not feasible. Multiple independent variables are usually correlated with a single output (dependent) variable.

4.3 Naive Bayes (NB)

Among its many benefits are ease of implementation, high performance, low training data requirements, linear scalability with predictors and data points, the ability to handle both continuous and discrete data, the capacity to address binary and multi-class classification problems, and the capability to make probabilistic predictions.

4.4 Support Vector Machines (SVM)

It offers the following advantages:

- ✓ It can handle both structured and semi-structured data.
- ✓ If the proper kernel function is chosen, it can handle complex functions.
- ✓ Because of its generalization method, SVM lowers the chance of overfitting.
- ✓ It can handle multidimensional data.

However, due to its long training times, SVM has the disadvantage of being unable to handle large datasets effectively. SVM is used for diagnosis, credit card fraud detection, facial recognition, handwriting recognition, and text classification.

5. Forecasting Techniques

For businesses to anticipate future trends, make informed decisions, and prepare for various scenarios, forecasting tools are essential. Every one of these strategies has unique benefits, drawbacks, and applications. They fall into two categories: qualitative and quantitative.

Qualitative forecasting utilizes subjective judgments, expert opinions, and qualitative data to forecast future outcomes. The Delphi Method and market research are all examples of standard procedures. These approaches are adaptive, flexible, and appropriate for scenarios with limited historical data or high ambiguity. They may, however, be subjective, biased, or unreliable if based on insufficient or incorrect information.

The Delphi method is defined as a dynamic and engaging organized social research process that involves using a group of trained experts to analyze a specific issue and share their opinions. This method serves as the basis for upcoming studies, including those by Hafez (2025).

- ✓ Obtaining the opinions of a group of experts.
- ✓ It is a cooperative, expert-led approach, instead of being competitive.
- ✓ It uses consecutive questionnaires to obtain expert opinions; the Delphi process necessitates several rounds, and experts are notified of the outcomes of each round. Participant commitment is necessary to organize the Delphi procedure.

- ✓ The Delphi method works well for qualitative research, where gathering data using other techniques could be challenging.
- ✓ Feedback is one of the most prominent features of the Delphi method, through which study participants learn about the attitudes of the rest of the study members.

On the other hand, the quantitative forecasting makes predictions using mathematical models, historical data, and statistical analysis. Machine learning algorithms, regression analysis, and time series analysis are examples of standard techniques. To predict future values based on historical observations, time series models such as ARIMA, exponential smoothing, and moving averages are employed. Regression analysis employs models such as logistic regression, multiple regression, and linear regression to examine the relationship between independent and dependent variables.

Machine learning techniques, such as random forests, decision trees, and neural networks, can effectively handle complex data due to their ability to manage variables, large datasets, and nonlinear dynamics, making them suitable for a range of forecasting applications. Their sensitivity to outliers, anomalies in the data, and model assumptions, however, may lead to bias or error. Additionally, because they rely on sufficient prior data, they may overlook qualitative components or unforeseen events that impact future outcomes (Bacia, 2024).

5.1 ARIMA Model

The **ARIMA Model** is a logical progression of the Auto Regressive (AR) and Moving Average (MA) models. Using a succession of differences, ARIMA can transform a non-stationary series into a stationary series, in addition to its other features and benefits. It has become the most reliable forecasting algorithm for use with any data set and serves as a benchmark to compare with other forecasting algorithms by incorporating these differences. In essence, it may reduce non-stationary data to a stationary process by continually adding the difference. By adding AR order, differencing, and MA order, ARIMA becomes more flexible and dependable for forecasting time series data. Additionally, by incorporating the seasonal component, ARIMA enhances the underlying model, facilitating direct modeling with seasonal components (Hasan et al., 2022). When it comes to time series forecasting, the linearity of the dataset that ARIMA is designed to predict is a crucial consideration. The basic version of the ARIMA algorithm focuses on linear relationships between data. However, with the use of various transformations, its range of practical forecasting applications can be significantly expanded, allowing it to handle non-linear time series as well. A widely used set of these transformations is the Box-Cox family, which includes both power and logarithmic transformations (Kontopoulou et al., 2023).

The fundamentals of ARIMA modeling typically involve the following steps: problem formulation, dataset collection and analysis, model design and optimization, forecasting, and evaluation, all applied to time series data (Zhou et al., 2020).

To address the limitations of ARIMA, a hybrid ARIMA-MLP model was developed as a more comprehensive approach to time series forecasting. This method combines the strengths of both ARIMA and multilayer perceptron (MLP). After fitting ARIMA models to the linear components of the data, the residuals, which capture the nonlinear patterns, are then modeled using an MLP. This division of labor allows the hybrid model to capture both linear and nonlinear structures more effectively than either model alone. As a result, the hybrid ARIMA-MLP approach improves overall prediction accuracy by addressing the weaknesses of both techniques (Ziyu Lin et al., 2024).

6. Methodology

This study utilizes historical data spanning five years to forecast budget items for an institutional government using a statistical forecasting model (ARIMA). Prior to applying preprocessing techniques, which are essential for any forecasting system, the data are first gathered and prepared for the period from 2017 to 2021. They are then divided into training and testing, with four years dedicated to training and one year for testing. To forecast the 2021 budget, the forecasting model is now applied to this data.

Evaluation metrics that quantify the difference between the actual and fitted or anticipated values, such as Mean Squared Error (MSE) and Mean Absolute Error MAE, are used to assess the performance of the proposed methodology. Table 1 shows the government's five-year budget items.

Table 1. Government Budget Items for five years

Years	Fixed assets	Other expenses	Maintenance of assets	Service supplies	Commodity supplies	Employee compensations	Total
2017	197,708,500	18,605,250	1,859,369,549	687,104,816	161,760,950	174,613,252,637	177,537,801,702
2018	95,136,100	19,891,250	529,942,625	509,363,442	187,353,825	180,925,765,832	182,267,453,074
2019	152,979,890	63,317,050	1,189,201,650	537,720,993	264,788,700	183,068,270,000	185,276,278,283
2020	93,589,000	27,750,000	395,873,402	384,507,130	124,843,805	175,743,396,816	176,769,960,153
2021	0	14,758,750	156,570,950	44,798,050	50,056,400	178,962,314,062	**179,228,498,212**

7. Results and Discussion

The ARIMA model performed well after applying the suggested methods to historical data, exhibiting a modest downward trend and predicted values that were extremely close to the actual values, with MSE and MAE of 2.063 and 1.913, respectively. The deviations remained within acceptable bounds. This is because ARIMA, based on data from prior years, is accurate in detecting linear trends and basic seasonal variations. Table 2 shows the expected, minimum, and maximum expected values for each budget Item after using the ARIMA model.

Table 2. Expected, Minimum, and Maximum Values for Each Budget Item Using the ARIMA Model

Budget Item /ARIMA Model	Expected value	Minimum Value	Maximum Value
Employee compensations	175,479,461,545	164,912,162,990	186,046,760,100
Commodity supplies	144,948,816	0	307,708,990
Service supplies	424,445,931	220,950,104	627,941,759
Maintenance of assets	938,566,198	359,469,707	1,517,662,690
Other expenses	51,074,086	0	112,690,791
Fixed assets	126,839,722	94,522,327	159,157,118
Total	**177,165,336,299**	___	___

The ARIMA model exhibits generally acceptable performance across various budget items, as shown in Figures 1 to 7. In relatively stable categories such as employee compensation and fixed assets, the model captures the overall trend with minimal deviation. For more dynamic components, such as commodity and service supplies, as well as maintenance and other expenses, the model effectively reflects the general direction, despite some fluctuations in actual values. Overall, ARIMA proves to be a valuable tool for identifying underlying patterns and providing baseline forecasts within the budget framework.

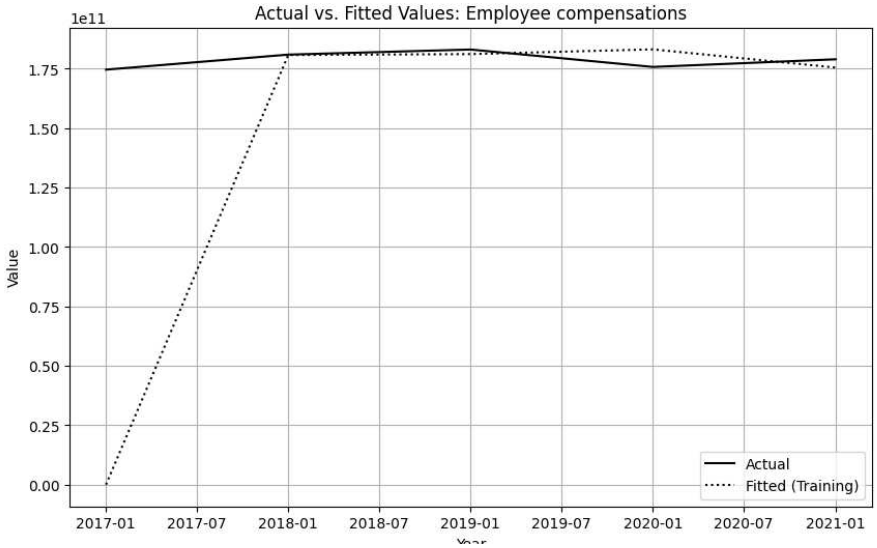


Figure 1. Actual Vs. Fitted Values for Employee Compensation (ARIMA Model)

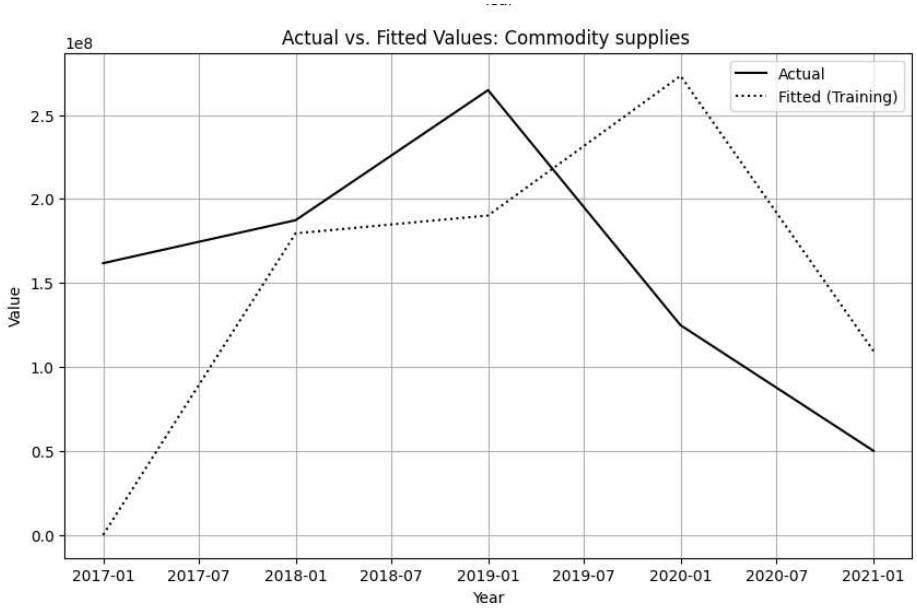


Figure 2. Actual Vs. Fitted Values for Commodity Supplies (ARIMA Model)

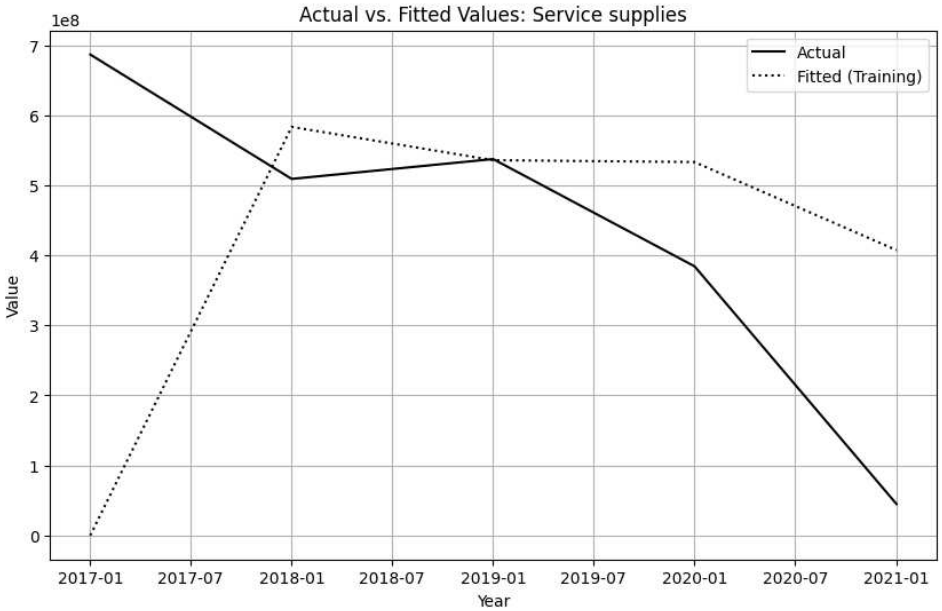


Figure 3. Actual Vs. Fitted Values for Service Supplies
(ARIMA Model)

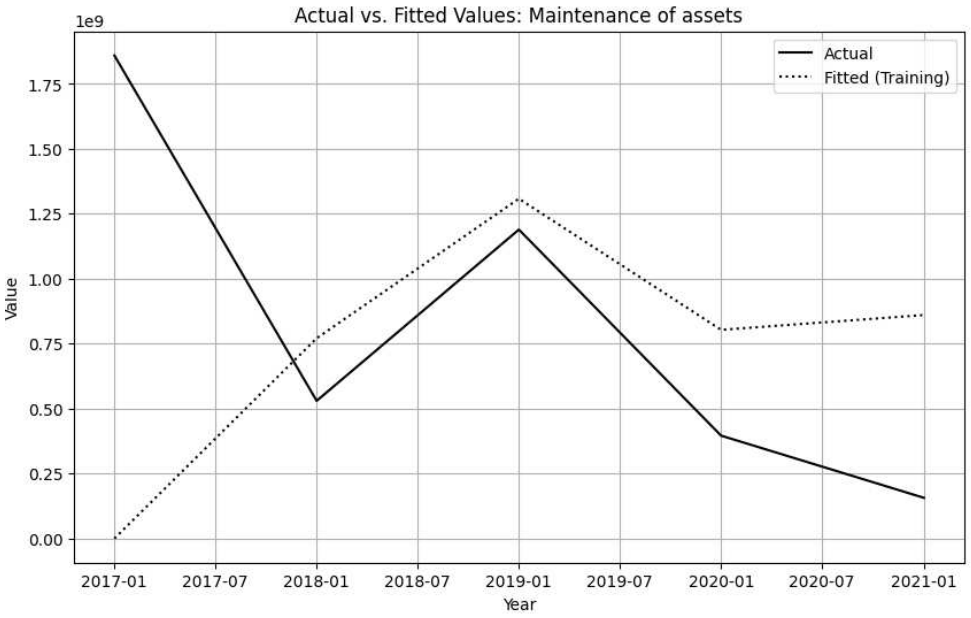


Figure 4. Actual Vs. Fitted Values for Maintenance of Assets (ARIMA Model)

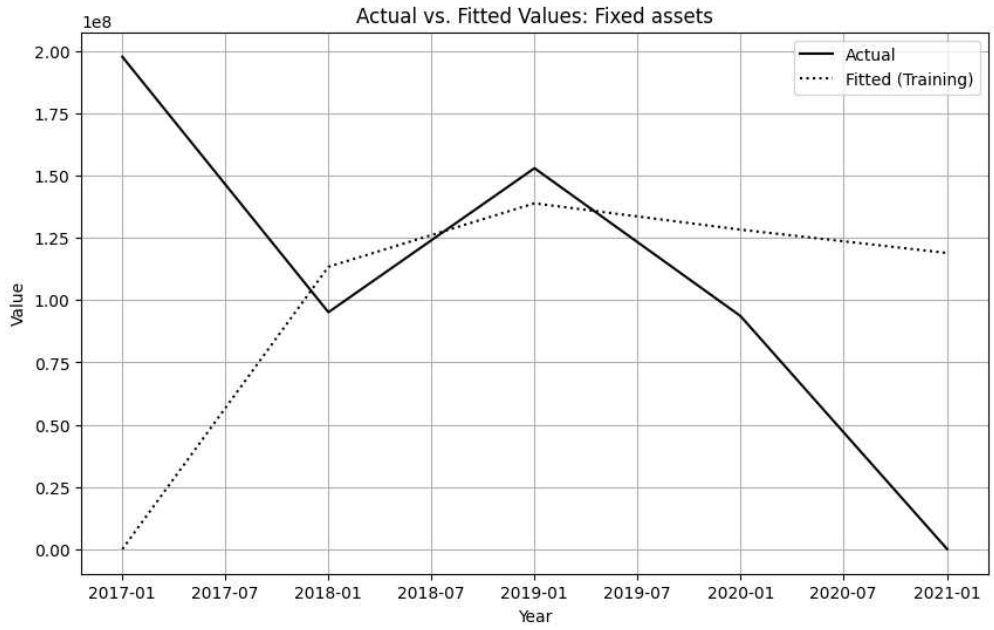


Figure 5. Actual Vs. Fitted Values for Fixed Assets (ARIMA Model)

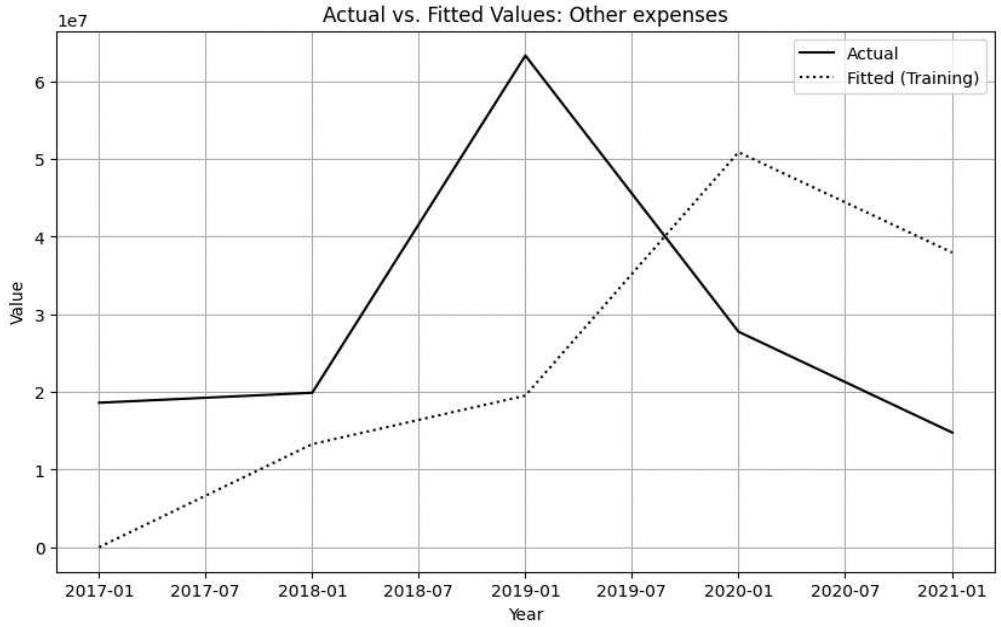


Figure 6. Actual Vs. Fitted Values for Other Expenses (ARIMA Model)

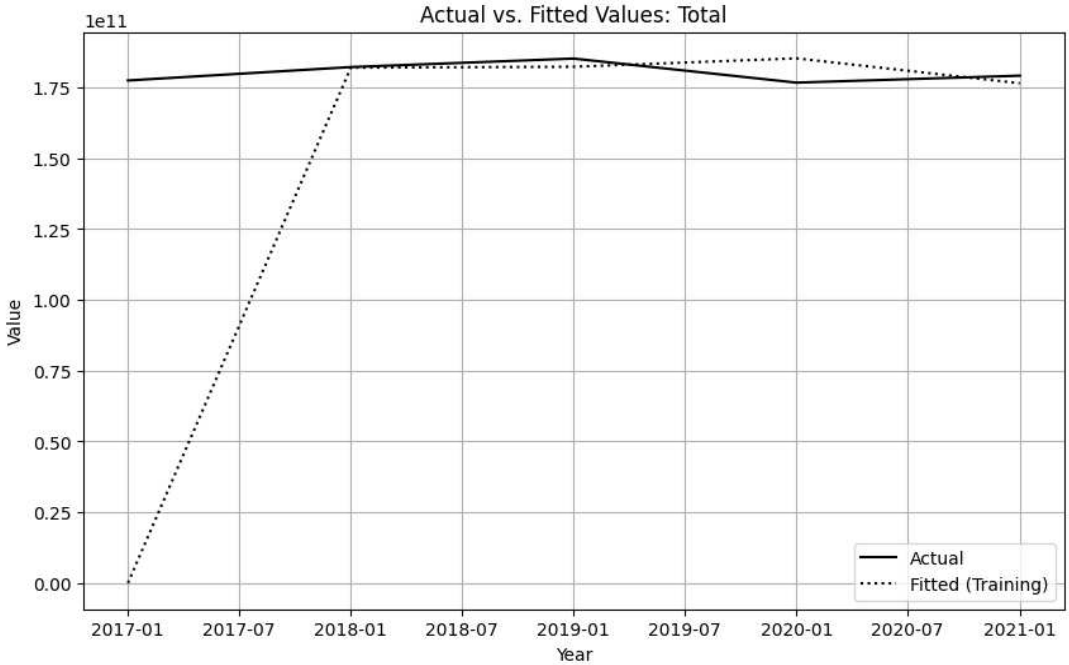


Figure 7. Actual Vs. Fitted Values for Total Budget Item (ARIMA Model)

8. Conclusions and Recommendations

In government entities, the budget is created using the traditional cumulative method, which relies on the previous year's forecasts as well as a percentage based on the personal estimate. These estimates are often inaccurate, resulting in the wasteful expenditure of public funds. Therefore, forecasting algorithms are a rational scientific technique due to their ease of application, speed of data processing, and ability to predict events and areas in general, as well as in the field of government budget preparation specifically. The use of forecasting algorithms requires the establishment of an extensive database to carry out the necessary treatments. The ARIMA model is more suitable for estimating short-term budgets based on limited data, as its MSE and MAE metrics are small, and it performs well in forecasting the total government budget.

Forecasting algorithms are essential for government agencies, service providers, and financial institutions involved in creating the government budget, due to their ability to handle vast volumes of data and provide results at the lowest feasible cost.

The study recommended that providing training sessions that greatly aid employees in understanding the concept and nature of forecasting algorithms would enhance their cultural experience. As a result, employees will be better equipped to utilize modern techniques. Statistical forecasting models should be utilized as a tool to aid in financial planning decisions, and the models should be updated regularly with new data to close the gap between projected and actual values.

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