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Forecasting Inflation Rate In Malaysia Using Artificial Neural Network (ANN) Approach

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***Abstract*—Forecasting is very important for planning and decision-making in all fields to predict the conditions and cases surrounding the problem under study before making any decision. Hence, many forecasting methods have been developed to produce accurate predicted values. Inflation rates provide appropriate and timely information about the trend changes, which affect the economy of Malaysia because of the different uses in many ways. It can be used as an economic indicator that is beneficial for policy makers, investors, and consumers to make a planning and decision. It also used as a supplement for statistical chains to predict future values rate to make sure that the data accurately reflect the pattern of the inflation rate in Malaysia. Therefore, the main objective of this study is to construct an inflation rate model for Malaysia and make a prediction of inflation rate for upcoming six months in 2023 by using artificial neural network (ANN). The proposed ANN model consists of an input layer, hidden layer, and output layer, while it applies the tangent function (TanH) as a testing and validation algorithm in the hidden layer. Finally, the predicted values of inflation rate are compared with the measured values. The proposed ANN model with four hidden nodes is more efficient than other models in predicting inflation rate after considering parsimonious architecture. The obtained Coefficient of Determination and Root Mean Squared Error (RMSE) values using the ANN method is 0.6399 and 0.9879 respectively. This study presents a new model for forecasting inflation rate values that are beneficial for many parties. The model was used to predict upcoming months then compared to the actual data.**

Keywords— Artificial Neural Network, forecasting, inflation rate, hidden layer, model parsimony

I. Introduction

Inflation, defined as the rise in prices and a decline in purchasing power over time, is a critical macroeconomic factor faced by many developing nations [1]. However, maintaining a lower and stable inflation rate is essential for sustainable economic growth. It plays a crucial role in determining the cost of living for consumers and impacts various sectors of the economy [2]. Recent data from Malaysia indicates fluctuations in consumer prices, emphasizing the importance of understanding these changes for informed decision-making by individuals, businesses, and policymakers [3]. Accurate inflation forecasting is vital for businesses, allowing them to prepare for potential cost increases, adjust pricing strategies, and plan investments [4]. Additionally, individuals benefit from inflation forecasting by making informed financial commitments and investment choices to safeguard their purchasing power. Overall, inflation forecasting is a valuable tool for both economic stability and individual financial well-being.

The increasing inflation rate serves as the primary driver behind the escalating prices of goods, typically occurring when the money supply expands significantly relative to the size of the economy. This expansion leads to a decrease in the currency's unit value, eroding its purchasing power and resulting in price inflation. Malaysia, for instance, has raised its price ceiling for standard chicken, which will soon take effect, further exacerbating the challenges consumers face in coping with a higher cost of living [4]. Notably, in March 2020 alone, Malaysia received 8,555 complaints regarding the soaring prices of goods, highlighting the burden on consumers [5]. The historical fluctuations in Malaysia's inflation rate, dating back to 1960, continue to pose significant implications for investors [6]. In order to generate real profits in the stock market, stock prices must outpace inflation rates, or investors risk financial losses. Moreover, daily changes in the inflation rate can significantly impact a nation's economic indicators, adding to the complexity faced by policymakers striving to enhance Malaysia's economy [7]. Predicting future inflation rates becomes a challenge, underscoring the need for consistent efforts by the government and policymakers to maintain a low and declining inflation rate, effectively addressing domestic policy concerns.

II. METHODS

A. Descriptive Data

The data used for this study consists of various economic variables collected from multiple sources spanning from 2010 to 2022 on a monthly basis. The dependent variable in this analysis is the Inflation Rate, sourced from the World Bank data. It is measured quantitatively as a ratio and expressed in percentage terms. The independent variables include Government Expenditure, retrieved from the World Bank National Accounts data and The Organization for Economic Cooperation and Development (OECD) Nationals Account datafile, with measurements in millions of U.S. Dollars. Exchange Rate data, obtained from Fred Economic Data, is measured quantitatively as a ratio and expressed in Ringgit Malaysia. Unemployment Rate, sourced from the Department of Statistics Malaysia (DOSM), is also a quantitative ratio expressed in percentage terms. Additionally, the study incorporates the Consumer Price Index (CPI) from Bank Negara Malaysia (BNM) and the Producer Price Index (PPI) from the Malaysia Open Data Portal, both of which are measured quantitatively as ratios and expressed as percentages. This comprehensive dataset offers valuable insights into the interplay between inflation and various economic factors over the years, facilitating a thorough analysis of economic trends and relationships.

B. Artificial Neural Networks

Using an Artificial Neural Network (ANN) model to forecast the inflation rate in this study is a judicious choice due to the multifaceted nature of inflation dynamics. Inflation is influenced by numerous variables with intricate, non-linear relationships, and ANNs excel at capturing these complexities [8]. They offer a data-driven approach, adapt to changing economic conditions, handle complex interdependencies among factors such as government expenditure, exchange rates, and unemployment rates, and excel in time-series analysis, making them ideal for monthly inflation rate prediction. Their versatility, ability to process large datasets, and the potential for model improvement over time make ANNs a robust choice for this task [9]. Nevertheless, researchers should be aware of the computational demands and potential interpretability challenges associated with ANNs and carefully weigh these factors against the forecasting objectives of the study.

C. Forecasting

Leveraging the capabilities of the best-performing Artificial Neural Network (ANN) model can indeed yield highly accurate predictions for the future. The ANN model, with its ability to capture intricate, non-linear relationships within the data, offers a robust framework for forecasting [10]. Furthermore, the employment of Microsoft Excel's Forecast Sheet tools provides an additional layer of forecasting technique. These tools in Excel are designed to simplify the forecasting process, aiding in generating precise predictions by considering historical data trends and seasonality. When combined with the advanced learning capabilities of ANNs, this dual approach enhances the reliability of future predictions, enabling stakeholders, policymakers, and researchers to make more informed decisions and anticipate economic trends with a high degree of accuracy. This synergistic approach aligns the strengths of ANNs with user-friendly forecasting tools to harness the power of data-driven insights for more confident and data-driven decision-making in the face of economic uncertainty.

III. RESULTS AND FINDINGS

A. Descriptive Statistics

Descriptive statistics play a vital role in analyzing datasets by offering a concise overview of essential characteristics, such as measures of central tendency, dispersion, and range. This preliminary step is instrumental in preparing data for normalization, a crucial process that paves the way for subsequent analytical steps in the study or analysis.

Table 1. Descriptive Statistics of The Inflation Rate Data

Minimum	Maximum	Mean	Standard Deviation
-2.9	4.9	2.005128205	1.513116624

Table 1 showed the lowest inflation rate observed from 2010 to 2022 was -2.9, while the highest was 4.9. The mean value, calculated at 2.005128205, represents the average, indicating central tendency. The standard deviation, 1.513116624, measures the data's spread around the mean. A higher standard deviation suggests more variability, whereas a lower value means data points are closer to the mean.

B. Artificial Neural Network Model Development

The model consists of three layers: input for data reception, hidden for information processing, and output for predictions. To assess performance, ten models with varying hidden nodes were systematically created using JMP15 Software. These models differed in complexity due to the number of hidden nodes. In all cases, inflation rates served as the output layer, facilitating effectiveness evaluation. The dataset was split for training (70%) and testing (30%) to determine model outcomes. This approach comprehensively explores the model's capacity to capture dataset relationships and generate reliable predictions.

a) Result of Effectiveness

To rigorously assess the model's predictive performance for inflation rates, we utilized two essential metrics: the coefficient of determination (R^2) and root mean square error (RMSE) [11]. R^2, known as the goodness-of-fit statistic, gauges how much of the variation in the inflation rate is explained by the model's independent variables. A higher R^2 indicates a better fit and a more reliable model. RMSE measures the average difference between predicted and actual values, with lower values indicating more accurate predictions and higher values signifying larger prediction errors. These metrics are vital for evaluating the model's effectiveness.

Table 2. Prediction Performance for All Models Produced by Using ANN

Model	Hidden Node	R^2	$RMSE$
Model 1	1	0.3057	1.3717
Model 2	2	0.5737	1.0749
Model 3	3	0.5842	1.0616
Model 4	4	0.6399	0.9879
Model 5	5	0.5977	1.0442
Model 6	6	0.6421	0.9849
Model 7	7	0.6115	1.0262
Model 8	8	0.6637	0.9547
Model 9	9	0.5926	1.0507
Model 10	10	0.6268	1.0057

Among the various models tested as shown in Table 2, Model 8 stood out as the most accurate for predicting inflation in Malaysia. This model used five different variables as input, and it had eight hidden nodes. Its accuracy is mainly because it achieved the highest R^2 value of 0.6637, which means it explains a significant portion of the inflation rate's variability. Additionally, it had the lowest RMSE value of 0.9547, indicating that its predictions were very close to the actual values. In simpler terms, Model 8 outperformed the others by giving the best estimates for inflation in Malaysia, as it had the highest R^2 and the lowest RMSE values.

b) Model Parsimony

In the realm of Artificial Neural Networks (ANNs), the principle of model parsimony advocates for a prudent choice of hidden nodes, usually fewer in number than the input nodes. This strategy serves as a precautionary measure against overfitting, a scenario in which the network grows overly intricate, essentially memorizing insignificant noise or random fluctuations within the training data [12]. By maintaining a balance where the number of hidden nodes is less than that of the input nodes, we ensure that the model remains focused on the meaningful patterns and relationships in the data, enhancing its capacity for generalization and effective prediction. Even after evaluating several models, Model 8 has not definitively emerged as the best model, prompting the need for additional investigation through the critical process of model parsimony.

The structure of Model 4 in Fig. 1 demonstrates a noteworthy trait by featuring fewer hidden nodes than the number of input nodes. This adherence to the principle of model parsimony is in alignment with the objective of averting overfitting and enhancing the model's capacity for generalization. By sustaining a more streamlined architecture, Model 4 sidesteps the risk of memorizing irrelevant noise or idiosyncratic patterns in the training data. This, in turn, results in improved performance when the model is applied to unseen data. The emphasis on simplicity in Model 4's design underscores its potential to provide robust and reliable predictions.

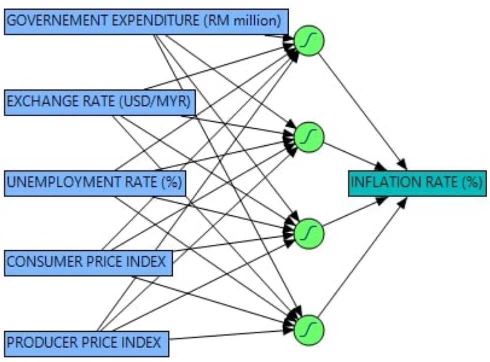

Fig. 1. Figure of Model 4 Construction

C. Forecasting

To project the economic landscape for the forthcoming six-month period, commencing in January 2023, the study harnessed the forecasting capabilities embedded within Microsoft Excel's Forecast Sheet tools. These tools, rooted in historical data, play a pivotal role in extrapolating future trends, offering a critical vantage point to discern and evaluate anticipated economic conditions during this time frame. By delving into the historical patterns and trends inherent in the data, these tools employ a data-driven methodology, aligning with modern data analytics and forecasting techniques. This approach empowers decision-makers with a robust foundation of information, aiding them in making informed decisions and predictions for the early months of 2023. The utilization of Microsoft Excel's Forecast Sheet tools not only simplifies the forecasting process but also provides valuable insights for strategic planning and preparedness in an ever-evolving economic landscape.

Table 3. Result of Forecasting

Month	Predicted Inflation Rate (%)	Actual Inflation Rate (%)
Jan23	3.7487	3.70
Feb23	3.6879	3.70
Mar23	3.5128	3.40
Apr23	3.3888	3.30
May23	2.9999	3.80
Jun23	2.3561	2.40

The results based on the predicted inflation rate derived from Model 4 are quite compelling as shown in Table 3. They strongly suggest that this model possesses a remarkable capability to forecast the inflation rate with an impressive level of accuracy, demonstrating a close alignment with the actual observed inflation rate. The predictions generated by Model 4 exhibit a high degree of agreement with the real-world inflation values, indicating that the model effectively captures the underlying patterns and trends in the inflation data. This close correspondence between the predicted and actual inflation rates not only signifies the model's robust performance but also underscores its capacity to generalize well beyond the training data. In simpler terms, Model 4 excels in making precise and reliable forecasts, bolstering confidence in its predictive abilities.

IV. CONCLUSIONS

Based on the extensive analysis conducted, the Artificial Neural Network (ANN) model featuring four hidden layers has unequivocally emerged as the most adept predictive model within the scope of this study. This assertion is reinforced by its deliberately streamlined architecture, a notably higher R^2 value, and the lowest RMSE among the models considered. This model consistently exhibited precise forecasting performance, signifying its potential as a reliable tool for short-term inflation rate predictions. This heightened forecasting accuracy holds significant value for policymakers, businesses, and individuals, empowering them to make well-informed decisions, manage inflation-related risks, and plan strategically. To sum it up, these results show that the ANN model with four hidden layers is a powerful tool for predicting inflation rates in this study. It performed exceptionally well in different measurements, indicating that it has the potential to help with decisions about inflation and its impact on the economy, both in education and in the broader community. This also suggests that it could be a valuable product for commercialization.

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