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THE DEVELOPMENT OF A MULTI-LAYER PERCEPTRON MODEL TO PREDICT THE TOURIST ARRIVAL IN MALAYSIA DURING POST-COVID-19 BASED ON ECONOMIC INDICATORS

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Abstract:

Tourism plays a vital role in Malaysia's economy, contributing significantly to GDP, employment, and infrastructure development. However, the post-COVID-19 pandemic caused a severe decline in tourist arrivals, posing challenges for the industry's recovery. In this regard, this study develops a prediction model for forecasting tourist arrivals in Malaysia using a Multi-Layer Perceptron with Backpropagation (MLP-BP) Learning Approach by considering economic indicators, namely Gross Domestic Product (GDP), inflation rate, and exchange rates. The study utilizes historical data from the Ministry of Tourism, Arts, and Culture (MOTAC) and the Department of Statistics Malaysia (DOSM), covering pre-pandemic and post-pandemic periods. Experimental results demonstrate that the MLP with 2 hidden layers demonstrated the best validation performance with a positive correlation coefficient of 0.3685. It is found that an increase in the exchange rate, higher GDP per capita, and lower inflation may attract more visitors. Consequently, this research contributes valuable insight to the development of data-driven policies for Malaysia's strategic tourism sector.

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Tourist Arrivals, Multi-Layer Perceptron, Post-COVID-19, Malaysia Tourism, Prediction Model



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Introduction

Tourism is a globally significant economic sector, contributing substantially to Gross Domestic Product (GDP) and employment (Othman et al., 2018; Trono, Schmude, & Duda, 2023). From a Malaysian perspective, the tourism industry is very important to its economy, contributing significantly to GDP, employment, and infrastructure development. According to World Travel & Tourism Council projections, Malaysia's travel and tourism sector is estimated to contribute approximately RM218.9 billion or 10.1 percent of GDP in 2024 (WTTC, 2025). Consequently, tourism is a vital economic sector for Malaysia, contributing significantly to the country's GDP and foreign exchange earnings (Nor, Masrun, & Hu, 2022).

However, the COVID-19 pandemic caused a severe downturn in the tourism industry worldwide (Khalid, Okafor, & Burzynska, 2021). This scenario caused a sharp decline in tourist arrivals, and the recovery has been slow due to changes in traveller behaviour, economic uncertainties, and global challenges (Orîndaru et al., 2021; Das, Nayak, & Naik, 2023). As recorded during the pandemic, Malaysia's international tourism receipts plunged to RM12.7 billion in 2020 and further collapsed to RM238.7 million in 2021, before rebounding modestly to RM28.2 billion in 2022, compared to the pre-pandemic level of RM86.1 billion in 2019 (Tourism Malaysia, 2023).

It is found that external factors such as inflation, GDP, and currency exchange rates significantly impact tourism demand (Abid, 2025; Mubarrok, Dewanti, & Purna, 2025). However, various studies indicated that while GDP positively correlates with tourism receipts, it does not exhibit significant long-term effects on Malaysia's tourism revenue (Kuri, Nahiduzzaman, Dhar, Shabbir, & Karim, 2025). In contrast, both inflation and exchange rates were identified as negatively significant factors in the long term, meaning higher inflation and fluctuating exchange rates in source countries discourage tourist inflows (Isik, Radulescu, & Fedajev, 2019; Athari, Alola, Ghasemi, & Alola, 2021). Consequently, there is a unidirectional causality from GDP to inflation rates and from exchange rates to tourism receipts, highlighting the interconnected nature of these economic variables.

Nevertheless, the existing approaches struggle to accurately capture the changes of these economic variables, especially in the post-pandemic period. To address this problem, this study develops a prediction model using the Multi-Layer Perceptron with Backpropagation (MLP-BP) learning approach. MLP-BP approach utilizes patterns in historical booking and travel data

to forecast tourist demand, helping businesses optimize pricing strategies, allocate resources, and improve customer satisfaction (Şeker, 2023).

Furthermore, this approach will enhance the accuracy in forecasting tourist arrival, which can provide a good suggestion to help stakeholders understand trends, plan for future demand, and create sustainable strategies (Xu et al., 2024). Thus, by improving the ability to predict tourist volume, this research supports better decision-making and long-term growth in Malaysia's tourism sector. The subsequent section details the research methodology, followed by a comprehensive presentation and discussion of the results. The paper concludes with a synthesis of the principal findings.

Methodology

This section describes the related stages in the development of a predictive model using the MLP-BP approach. It explains the data collection, data pre-processing, MLP-BP model development, model validation, and scenario analysis. Figure 1 exhibits the research flow as follows:

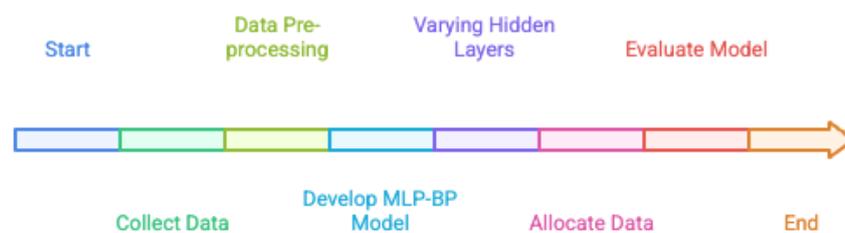


Figure 1: Research Methodology

For data collection, monthly records on exchange rates, gross domestic product (GDP), tourist arrivals, and inflation rates were utilized, covering the period from 2015 to 2023 and comprising a total of 99 observations. The data were obtained from the Department of Statistics Malaysia (DOSM) and the Ministry of Tourism, Arts, and Culture (MOTAC). In this study, GDP, inflation, and exchange rates were designated as input variables, while tourist arrivals were specified as the output variable for the model.

Moreover, a processing operation was performed to ensure the quality and usability of the collected data. Besides, this process can handle missing values. This helped to maintain data consistency and reduce noise. Furthermore, the dataset is scaled using a Min-Max scaler to compare the scales of all variables, ensuring that no single factor dominates the model due to differences in size. Through these steps, the dataset has been cleaned, standardized and is ready for further analysis.

For the development of the MLP-BP prediction model, parameters such as the number of hidden layers, activation function, and learning rate were set. The model was trained using processed data to learn patterns and relationships between input variables (GDP, inflation, and exchange rates) and output variable (tourist arrivals). This task consists of creating an initial predictive model that can capture nonlinear relationships in a data set.

Subsequently, three experiments were conducted by varying the number of hidden layers to determine the optimal prediction model configuration. In this regard, the hidden layers were set to 2 layers, 3 layers, and 4 layers for each experiment. By systematically varying hidden layer parameters, the performance of all models can be improved, and their strengths and weaknesses.

Furthermore, comparative validation through training and testing was conducted to determine which configuration provided the best results. For that purpose, the dataset is divided into 80% and 20% for training and testing sections, respectively, to optimize model learning and evaluation. To measure the performance of each model, different metrics, namely Correlation Coefficient, Mean Absolute Error, and Root Mean Squared Error, Relative Absolute Error, and Root Relative Squared Error, were considered. These measurements provide information about the accuracy and reliability of the model. Finally, the MLP-BP models were evaluated using various assumptions of changes in economic factors, i.e., GDP, inflation, and exchange rates, to predict the tourist arrivals.

Results and Discussion

This section describes the results and assessment of the developed MLP-BP prediction model for the tourist arrival based on the economic indicators with different configurations of hidden layers (2, 3, and 4). Metrics in terms of Correlation Coefficient, Mean Absolute Error, and Root Mean Squared Error, Relative Absolute Error, and Root Relative Squared Error were analyzed to evaluate the performance of the models.

Experiment 1: Two Hidden Layers

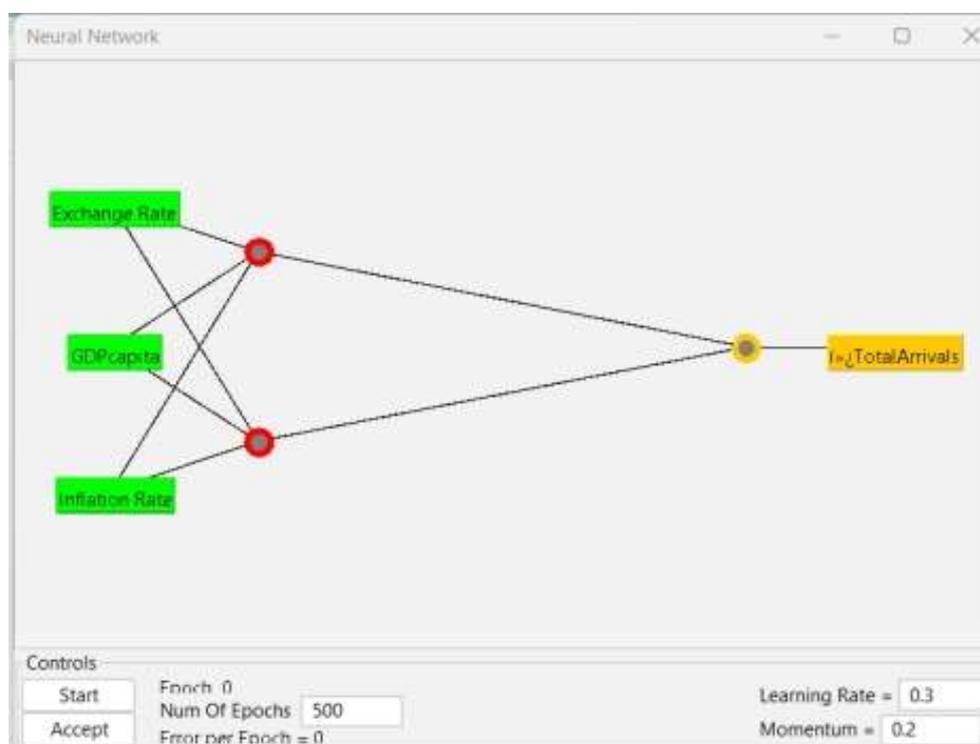


Figure 2: MLP-BP Topology for Experiment 1 (2 hidden layers)

Based the Experiment 1 (2 hidden layers), Table 1 proves that the model’s performance in the training phase indicates a low correlation coefficient (0.1962), suggesting limited predictive capability. Other than that, the Relative Absolute Error shows the high relative error values, which is 97.0829, as the indicator for prediction accuracy for further highlighting the model’s difficulty in generalizing the data pattern.

Table 1: Evaluation Metric Neural for Experiment 1 (2 hidden layers)

Metric	Value
Correlation Coefficient	0.1962
Mean Absolute Error (MAE)	0.2735
Root Mean Squared Error	0.316
Relative Absolute Error (%)	97.0829
Root Relative Squared Error (%)	101.0699
Total Instances	72

Experiment 2: Three Hidden Layers

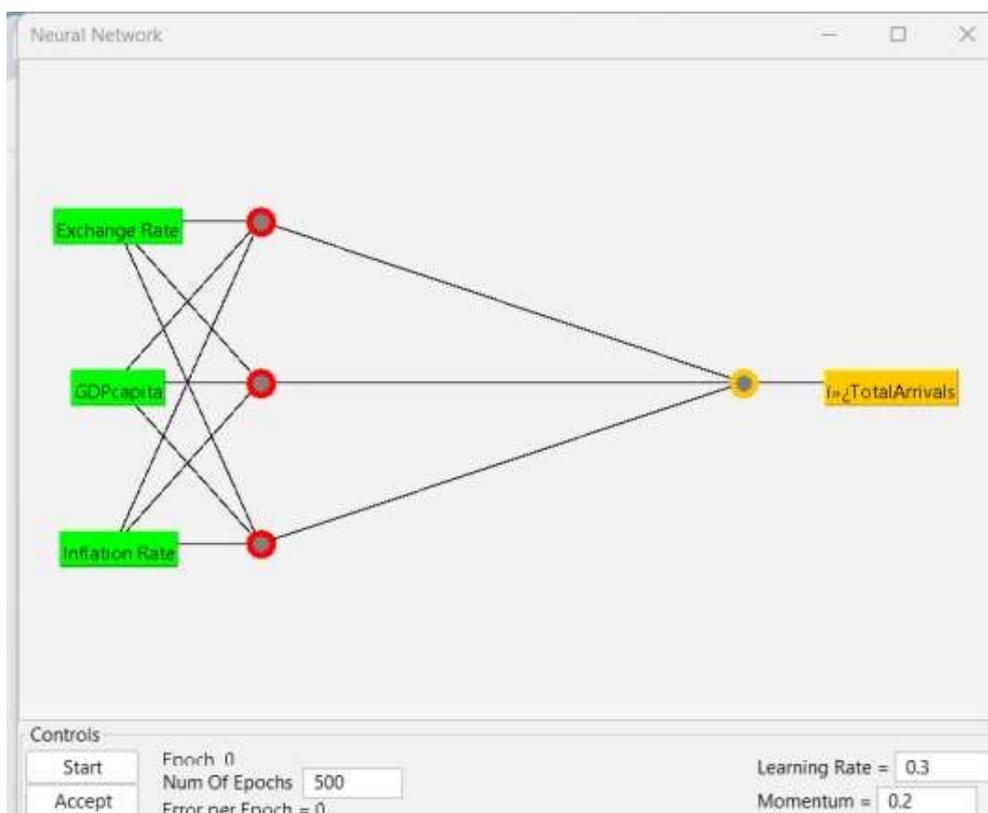


Figure 3: MLP-BP Topology for Experiment 2 (3 hidden layers)

Based the Experiment 2 (3 hidden layers), Table 2 highlights that increasing the number of hidden layers to three improved the correlation coefficient to 0.354. This indicates a better alignment of the model’s predictions with the actual data compared to the two-layer model. However, error values are still high, showing challenges in accuracy.

Table 2: Evaluation Metric Neural For Experiment 2 (3 Hidden Layers)

Metric	Value
Correlation Coefficient	0.354
Mean Absolute Error (MAE)	0.27
Root Mean Squared Error	0.3197
Relative Absolute Error (%)	95.854
Root Relative Squared Error (%)	102.2475
Total Instances	72

Experiment 3: Four Hidden Layers

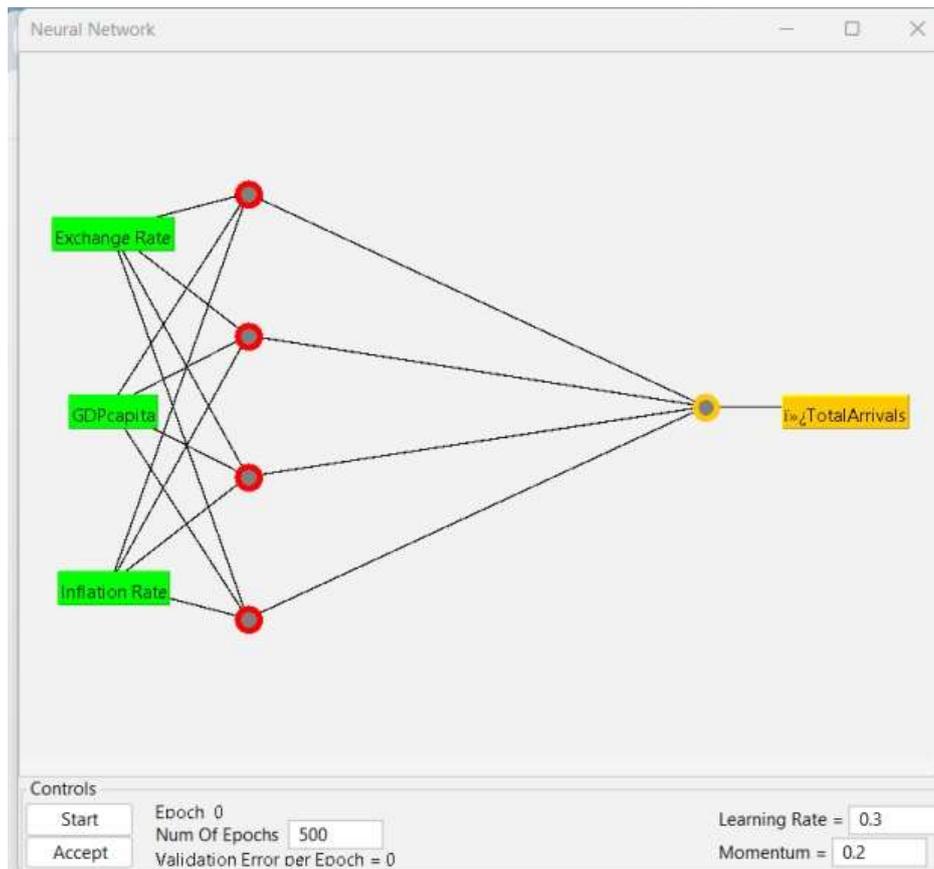


Figure 4: MLP-BP Topology for Experiment 3 (4 Hidden Layers)

Based the Experiment 3 (4 hidden layers), Table 3 reveals that reduced correlation coefficient (0.1227) compared to the three-layer model, indicating a decline in the ability to capture data patterns. While the MAE remains consistent with previous experiments, the model struggles to demonstrate improvements.

Table 3: Evaluation Metric Neural for Experiment 3 (4 Hidden Layers)

Metric	Value
Correlation Coefficient	0.1227
Mean Absolute Error (MAE)	0.2707

Root Mean Squared Error	0.3189
Relative Absolute Error (%)	96.1005
Root Relative Squared Error (%)	101.9956
Total Instances	72

Based on the comparison presented in Table 4, the model with two hidden layers (Experiment 1) was selected as the most suitable configuration for predicting tourist arrivals in Malaysia. Although the error values remain relatively high across all experiments, the two-layer model produced the highest validation correlation coefficient (0.3685) compared to the three-layer and four-layer configurations.

The higher validation correlation indicates that the model with two hidden layers is more capable of capturing the underlying relationship between the selected economic indicators and tourist arrivals. In contrast, the model with three hidden layers showed signs of overfitting, where the training correlation improved but the validation correlation became negative. Similarly, the four-layer configuration demonstrated performance deterioration, indicating that increasing model complexity does not necessarily improve predictive capability for the given dataset.

Therefore, the two hidden-layer MLP-BP model was selected as the optimal architecture due to its relatively better generalization ability and more stable predictive performance. This finding also suggests that a simpler neural network structure may be more appropriate when dealing with limited observations and macroeconomic variables.

Table 4: Comparison and Best Model Selection

Learning Parameter	Experiment 1	Experiment 2	Experiment 3
Input node	3	3	3
Hidden node	2	3	4
Output node	1	1	1
Learning rate	0.3	0.3	0.3
Momentum rate	0.2	0.2	0.2
Epoch	500	500	500
Correlation coefficient	0.3685	0.354	0.1227
Relative absolute error	97.0829	95.854	96.1005

Furthermore, Table 5 presents the new dataset utilised by the MLP-BP model for predicting international tourist arrivals under six different scenarios as follows. These values represent different possible economic conditions, where variations in the exchange rate, GDP per capita, and inflation rate allow for an assessment of how changes in these factors might influence future tourist arrivals. The results indicate how fluctuations in economic factors impact Malaysia's international tourist arrivals:

Exchange rate effect: An increase in the exchange rate (weaker currency) could potentially attract more tourists due to a more favorable exchange rate for foreign visitors. Conversely, a stronger currency may reduce arrivals.

GDP per capita influence: A higher GDP per capita might indicate stronger economic conditions, potentially leading to higher tourism growth. However, a decrease in GDP per capita could signify economic downturns, impacting travel behavior.

Inflation rate impact: A higher inflation rate could increase the cost of goods and services, potentially deterring tourists. Conversely, lower inflation creates a more stable economic environment, which may attract more visitors.

Table 5: New Data Set for Currency, GDP, and Inflation with Predicted Tourist Arrival

Currency	GDP	Inflation	Arrival
4.2	9699.584909	2.104389802	26,482,364
4.3	9555.647335	2.090566595	26,447,009
4.4	9979.704757	3.871201158	26,820,479
4.5	11073.97859	0.884709161	26,967,475
4.6	11132.10345	0.662891866	26,968,393
4	9699.584909	2.104389802	26,387,759

Implications for Forecasting Tourist Arrivals

The findings of this study provide several important implications for tourism forecasting and policy planning in Malaysia. First, the use of the Multi-Layer Perceptron with Backpropagation (MLP-BP) demonstrates the potential of machine learning techniques in capturing nonlinear relationships between macroeconomic indicators and tourism demand. Traditional forecasting models often struggle to capture complex interactions between economic variables, whereas neural network models offer a flexible structure that can better accommodate such patterns.

Second, the results highlight the importance of exchange rates, GDP per capita, and inflation as significant economic indicators influencing tourist arrivals. Policymakers and tourism planners can utilize these indicators as early signals to anticipate fluctuations in international tourist demand. For example, a depreciation of the Malaysian currency may improve Malaysia's price competitiveness as a tourism destination, thereby attracting more international visitors.

Third, tourism authorities such as the Ministry of Tourism, Arts and Culture (MOTAC) can integrate predictive models into tourism planning and destination management strategies. Accurate demand forecasts can assist in resource allocation, infrastructure planning, and marketing strategies aimed at international markets. For instance, anticipating higher tourist arrivals allows tourism stakeholders to prepare accommodation capacity, transportation services, and tourism facilities more effectively.

Finally, this predictive approach supports the development of data-driven tourism policies, particularly in the post-COVID-19 recovery phase. As tourism demand remains sensitive to global economic conditions, predictive models can assist governments in designing more responsive and adaptive tourism development strategies.

Conclusions

It has been found that exchange rate, inflation rates, and GDP per capita have been identified as affecting the arrival of tourists in Malaysia. An increase in the exchange rate, higher GDP per capita, and lower inflation may attract more visitors. The MLP-BP model performs consistently across different experimental settings. The correlation coefficient for the MLP-BP experiments ranges between 0.1227 to 0.3685, showing significant correlation between the predicted values and the actual values. Additionally, the Relative Absolute Error (RAE) for the MLP-BP model ranges between 95.9 percent and 97.1 percent, showing a reliable predictive performance despite extreme variability and poor generalization. Hence, the MLP-BP model proves a reliable tool for predicting tourist arrivals in Malaysia due to its ability to handle complex relationships within the data. For future work, the development of predictive models should incorporate additional factors such as political stability, natural disasters, and sentiment analysis to improve prediction accuracy.

This study contributes to literature in several ways. From an academic perspective, it extends existing tourism forecasting studies by applying a Multi-Layer Perceptron with Backpropagation approach using macroeconomic indicators in the context of Malaysia's post-pandemic tourism recovery. The study demonstrates how machine learning techniques can complement traditional tourism demand forecasting models.

From a socio-economic perspective, the predictive model developed in this study provides useful insights for tourism stakeholders, including tourism operators, investors, and policymakers. Accurate forecasts of tourist arrivals can support better planning of tourism services, employment opportunities, and investment in tourism infrastructure. At the national level, the findings contribute to Malaysia's broader tourism recovery strategy by supporting evidence-based decision-making. Given that tourism is one of Malaysia's key economic sectors, the ability to forecast tourist demand more accurately can help strengthen the country's tourism competitiveness and contribute to sustainable economic growth.

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