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Bayesian Network Predictive Model for Regional Inflation: Case Study of East Kalimantan and Rupiah Exchange Rate

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Abstract: This research is important because fluctuations in inflation and exchange rates have a significant impact on regional economic stability. Therefore, the purpose of this study is to apply the Bayesian Network method in forecasting the next five years of inflation data in East Kalimantan based on actual data from 2015-2024. Data was obtained from the Central Bureau of Statistics and Bank Indonesia, then analyzed using MATLAB software. The results showed that the Bayesian Network model was able to predict the upward trend of inflation from 3.95% in 2025 to 4.30% in 2029, as well as the trend of the exchange rate from Rp15,839.20 to Rp18,021.02. The Mean Absolute Percentage Error (MAPE) value for inflation prediction is 29.34%, while for the exchange rate is 6.27%. The implications of the results of this study indicate that the Bayesian Network model is more accurate in predicting exchange rates than inflation, and can be used as a tool for regional economic policy planning to maintain price stability and currency value.

Keywords: Bayesian Network, Inflation, Exchange Rate.

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A. INTRODUCTION

Research on predicting inflation and economic factors in East Kalimantan has used various methods. Backpropagation Neural Network (BPNN) was used to predict the inflation rate in Samarinda with a low error rate (Wong et al., 2020). Another study that examined the impact of GDP growth and inflation on non-performing loans at Bank Kaltimtara found that inflation had a negative effect on the NPL rate (Darma, 2020). For non-oil and gas exports, ARIMA modeling is applied to forecast export values, with ARIMA (0,1,[1,12]) providing the best results based on RMSE and sMAPE metrics (Hayati et al., 2022). In addition, research on the effect of Ramadan on inflation in East Kalimantan using the ARMA model shows that of the ten main commodities studied, two food commodities and one non-food commodity affect inflation during Ramadan (Gani, 2020). This research contributes to understanding economic trends and forecasting methods in the region.

Several forecasting methods can be applied to inflation and exchange rate data. For exchange rates, Moving Average and Exponential Smoothing have been used, with Exponential Smoothing (α=0.9) proven to be the most accurate in predicting the IDR to USD exchange rate (Isnurrini Hidayat Susilowati & Rosento Rosento, 2020). For inflation forecasting, the Autoregressive Integrated Moving Average (ARIMA) model has been effective, with ARIMA(2,1,2) producing reliable predictions for Indonesian inflation (YWA Nanlohy & Samsul Bahri Loklomin, 2023). Double Exponential Smoothing has also been

applied to monthly inflation data, providing forecasts with low error rates (Dwi Retno & P. Sari, 2022). A comparative study of forecasting methods for education inflation in Bandung found Naïve Approach with drift strategy to be the most accurate, outperforming Exponential Smoothing and Linear Trend methods (Eva Nurlatifah et al., 2023). These methods offer various options for forecasting inflation and exchange rates, depending on the specific data characteristics.

Bayesian networks are probabilistic graphical models used to represent causal relationships between variables and calculate probabilities (Sari et al., 2024). These networks have been applied in various domains, including medical diagnosis of bipolar disorder (Sari et al., 2024) and skin diseases (Hartatik & Safitri, 2021). The implementation of Bayesian networks involves steps such as parameter determination, creation of a Conditional Probability Table (CPT), calculating a Joint Probability Distribution (JPD), and performing probabilistic inference (Hartatik & Safitri, 2021). Compared to other machine learning methods such as Naive Bayes, Bayesian networks can provide higher accuracy and reduced complexity when variables are not independent (Sari et al., 2024). However, in some applications such as intrusion detection systems, other methods such as K-Nearest Neighbor can outperform Naive Bayes in terms of accuracy (Iqbal et al., 2022). Naive Bayes, a related probabilistic method, has also been widely applied in expert systems in various fields (Lutfi et al., 2022).

Recent research on Bayesian network models in Indonesia has explored various applications. In karate competitions, Bayesian networks were used to model the probability of rule violations, achieving a shared information value of 2.01% (Yudha Permadya Putra et al., 2021). To analyze stunting in South Sulawesi, a Bayesian spatial Conditional Autoregressive (CAR) Leroux model was used, identifying poverty and malnutrition as significant factors (A. Aswi & S. Sukarna, 2022). In machine learning models, Bayesian methods play an important role because they allow the integration of informative prior knowledge with existing data, which according to research results can improve parameter estimates and increase model robustness to complex data variations (Syaharuddin, 2024, p. 140). Finally, a Bayesian network model was applied to analyze Indonesia's green economy during the pandemic, using big data on economic activity, air quality, mobility, and COVID-19 cases. The model achieved 0.83 accuracy in predicting GDP classes and revealed that economic growth has not been aligned with maintaining air quality (Salwa Rizqina Putri et al., 2021). The purpose of this research is to apply the Bayesian Network method to model the relationship between inflation and the rupiah exchange rate in East Kalimantan.

B. METHOD

This research belongs to the category of quantitative research with a non-experimental approach, because it utilizes historical data without giving direct treatment to the variables under study. The main focus of this research is to analyze the relationship between inflation and exchange rate data using the Bayesian network model. The data used is secondary time series data, which is obtained from official institutions such as the Central Bureau of Statistics (BPS) and Bank Indonesia (BI). The data is then processed and analyzed computationally using MATLAB software to build a probabilistic structure in a Bayesian network.

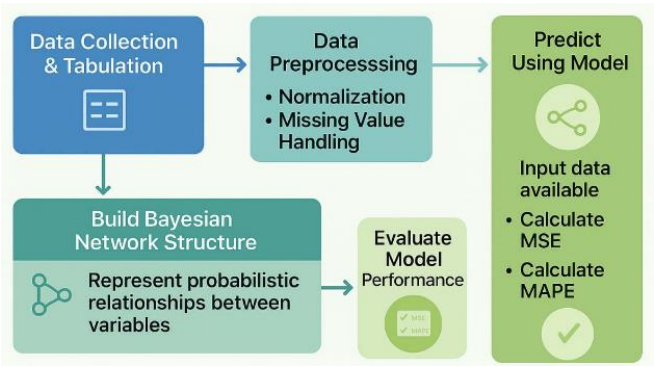

Figure 1. Bayesian Network Modeling

The research procedure begins with data collection and tabulation, followed by preprocessing stages such as normalization and missing value handling. Next, a Bayesian network structure is built that represents the probabilistic relationship between variables. This model is then used to make predictions based on the available input data. Evaluation of the model performance is done by calculating the Mean Squared Error (MSE) and Mean Absolute Percentage Error (MAPE) values, which measure the mean squared error and mean absolute percentage error between the predicted and actual data, respectively. The results of the analysis are then interpreted to assess the effectiveness of the model in predicting the economic variables in question, and are used as a basis for drawing research conclusions. The general equation form of the Bayesian Network Method usually refers to the factorization of the joint probability of a set of random variables. The equation:

$$P(X_1,X_2,\ldots,X_n) = \prod_{i=1}^{n} P(X_1 \mid \text{Pa}\ (X_i))$$

Where:

- $X_1,X_2,\ldots,X_n$ are random variables in the network,
- Pa (X_i) is the set of parent variables of X_i in the Bayesian Network structure.

This means that the combined probability of all variables is the product of their individual probabilities.

C. RESULTS AND DISCUSSION

1. Data Description

This study utilizes inflation data in East Kalimantan Province as well as data on the rupiah exchange rate against foreign currencies, which covers the time span from January 1, 2015 to December 31, 2024.

Table 1. East Kalimantan inflation and exchange rate data

Year	Inflation (%)	Exchange Rate (IDR)
2015	7,65	12,440
2016	3,10	13,795
2017	3,90	13,436
2018	3,50	13,380

Year	Inflation (%)	Exchange Rate (IDR)
2019	2,90	14,237
2020	1,50	14,146
2021	1,70	14,577
2022	4,20	14,308
2023	3,10	14,876
2024	2,13	15,416

Based on East Kalimantan inflation and exchange rate data from 2015 to 2024 in the table above, it can be seen that inflation shows a gradual downward trend. The highest inflation occurred in 2015 at 7.65%, while the lowest value was recorded in 2020 at 1.50%. The average inflation during the period was around 3.08%. On the other hand, the exchange rate experienced a general upward trend, starting from Rp12,440 in 2015 to reach Rp15,416 in 2024, with an average of Rp14,270. Although there are slight fluctuations in certain years, the direction of exchange rate movements tends to increase. This data indicates an improvement in price stability in East Kalimantan over time, but is accompanied by an upward trend in the exchange rate.

2. Forecasting Results and Decision Making

Based on the results of forecasting using the Bayesian Network method, estimates of East Kalimantan inflation and Exchange Rate for the next five years are obtained. The following table presents the prediction of inflation in East Kalimantan and the Exchange Rate from 2025 to 2029.

Table 2. 5-Year Prediction Results

Year	Inflation (%)	Exchange Rate (IDR)
2025	3,95	15.839,20
2026	3,95	16.102,08
2027	4,00	16.887,80
2028	4,15	17.796,67
2029	4,30	18.021,02

Based on the prediction results for the next five years, inflation in East Kalimantan shows a gradual upward trend from 3.95% in 2025 to reach 4.30% in 2029. Inflation is expected to remain stable at 3.95% at the beginning of the period (2025-2026), then begin to increase to 4.00% in 2027 and continue to rise to 4.30% in 2029. Although the increase is relatively moderate, it still reflects sustained price pressures and has the potential to affect people's purchasing power if not matched by appropriate economic policies.

At the same time, the exchange rate of the rupiah against foreign currencies also shows an increasing trend, from IDR 15,839.20 in 2025 to IDR 18,021.02 in 2029. This increase in the exchange rate indicates a weakening of the local currency, as more rupiahs are needed for the same exchange rate. Comparatively, the increase in inflation over the five years is 0.35 percentage points, while the exchange rate has increased by IDR 2,181.82. This pattern shows a parallel relationship between inflation and the exchange rate, where rising inflation can

contribute to currency depreciation. Therefore, inflation control strategies and efforts to maintain exchange rate stability are needed as part of measures to maintain economic stability in the region and increase confidence in the local currency.

Bayesian Network Predictive Math Model

Model structure:

$P(\text{Inflation}_t, \text{Exchange Rate}_t) = P(\text{Inflation}_t) \times P(\text{ Exchange Rate}_t \mid \text{Inflation}_t)$

Inflation Growth Model:

$$\text{Inflation}_t = 3{,}95 + 0{,}0875 \times (t - 2025)$$

Exchange Rate Growth Model:

$$\text{Exchange Rate}_t = 15,839{,}20 \times e^{0{,}0335 \times (t-2025)}$$

The figure below shows the results of forecasting inflation and exchange rates in East Kalimantan for the next five years (2025-2029) based on historical data from 2014 to 2023. The first graph illustrates the trend of inflation which declined sharply between 2015 and 2020, then increased significantly again in 2022 before declining slightly in 2023. Based on the prediction results (red line), inflation is expected to stabilize in the range of 3.95% to 4.30%, with a gradual upward trend. This indicates that inflationary pressures are expected to remain, although not extreme.

The second graph shows the trend of the Rupiah exchange rate against the US Dollar. Historical data shows fluctuations, but in general there is an upward trend since 2014. The prediction results show that the exchange rate will continue to increase from around IDR15,416 in 2024 to close to IDR18,021 in 2029. This indicates a weakening of the Rupiah exchange rate in the future. If observed closely, both inflation and exchange rate show an increasing trend in the next five years, which reinforces the notion that there is a positive relationship between inflation and exchange rate depreciation. Therefore, controlling inflation is of key importance to maintain economic stability and currency value in East Kalimantan.

Table 3 shows the Mean Squared Error (MSE) and Mean Absolute Percentage Error (MAPE) values of the inflation and exchange rate variable forecasting results. MSE is used to measure the average squared error between the actual data and the predicted data, while MAPE shows the average absolute percentage error, which illustrates the relative accuracy of prediction.

Based on the table, the MSE value of inflation of 2.0613 with a MAPE of 29.34% indicates that the relative error rate of inflation prediction is quite high, so the model is less accurate in forecasting inflation. In contrast, the prediction of the exchange rate has an MSE of 54,557.2894 but with a MAPE of only 6.27%, which indicates that although the absolute difference is quite large (because the unit is large), the accuracy of the model on the exchange rate is relatively high. This means that the model is better able to predict the exchange rate than inflation.

Table 3. Table of MSE and MAPE Values

Variable	MSE	MAPE
Inflation	2,0613	29,34%
Exchange Rate	54.557,2894	6,27%

D. CONCLUSIONS AND SUGGESTIONS

Based on data analysis of inflation and exchange rates in East Kalimantan during 2015-2024, a downward trend in the inflation rate was found, from 7.65% in 2015 to 1.50% in 2020, with an average inflation of 3.08%. This decline reflects improved price control effectiveness and local economic stability. In contrast, the rupiah exchange rate against foreign currencies experienced a gradual increase from Rp12,440 to Rp15,416, with an average of Rp14,270, indicating a depreciation of the rupiah. Although exchange rate depreciation is not always followed by extreme inflation spikes, pressure on the exchange rate still has the potential to trigger inflation in the future.

This finding indicates a moderate relationship between inflation and exchange rate in East Kalimantan. Therefore, it is recommended that local governments integrate inflation control and exchange rate stabilization strategies through strengthening local production, economic diversification, and non-oil and gas sector development. The implementation of a regional economic monitoring system and the utilization of predictive models such as Bayesian Networks are also needed to support data-driven adaptive policy planning, in order to maintain stability and improve regional economic competitiveness.

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