CHAPTER 1
INTRODUCTION

This chapter delineates the contextual framework of the study by elucidating its background and the underlying impetus for conducting the research, research questions, objectives, benefits, limitations, and the overall organization of the thesis. These sections provide the foundation for understanding the purpose and scope of the research.

1.1 Background

A stable inflation rate has long been considered a defining hallmark of a country's macroeconomic condition because it reflects the overall stability of prices and economic activity [1]. The term “inflation” is generally understood by the public as a general rise in prices that leads to a decline in purchasing power [2]. Therefore, controlling inflation is necessary to maintain economic stability, one of which is through inflation forecasting to understand future economic conditions. Inflation forecasting is important because maintaining price stability is the central bank’s primary task, making inflation forecasting a crucial component of monetary policy [3]. Inflation forecasting is necessary to assist the government in maintaining inflation stability [4]. In developing countries such as Indonesia, dynamic changes in economic conditions make it difficult for policymakers to understand inflation trends, so inflation forecasting is needed as a basis for decision making in efforts to achieve price stability [5]. On the other hand, market participants and businesses use inflation forecasts to help plan strategies and make long-term investment decisions [6].

Inflation in Indonesia tends to fluctuate from year to year in response to economic conditions and external factors. According to inflation data released by Central Agency of Statistics (BPS), during the COVID-19 pandemic, inflation declined due to changes in household consumption patterns resulting from mobility restrictions, which led to a decrease in demand. The post-COVID-19 period showed the economy entering a recovery phase as activity restrictions were lifted and consumer demand increased, accompanied by rising energy and food prices. During this period, inflation rose sharply, reaching a peak of 5.95% in September 2022 [7].

The current annual inflation rate, based on Bank Indonesia's October 2025 inflation analysis, has risen to its highest level at 2.86% since April 2024. This rise in inflation was driven by a surge in gold prices, the weakening of the rupiah, and increases in some food commodities, as well as government-mandated price adjustments for items such as cigarettes, air travel, and subsidized fuel. As inflation has risen in 2025, the government and Bank Indonesia continue to work to keep inflation within the target range [8]. This indicates that economic stability in Indonesia remains highly vulnerable to volatility in inflationary components.

Inflation forecasting often requires models that are capable of utilizing both historical observations and external macroeconomic information. For this reason, ARIMAX is adopted because it extends the conventional ARIMA framework by incorporating exogenous variables into the forecasting process [8]. Novianda (2025) demonstrated that integrating indicators such as the money supply and exchange rate improves the model's ability to represent linear inflation dynamics [9]. Nevertheless, ARIMAX is fundamentally based on linear assumptions, making it less effective when inflation is influenced by complex nonlinear interactions. Such nonlinear behaviour commonly occurs during periods of economic disruption, including the COVID-19 pandemic, where sudden structural changes affect inflation movements [9]. Similar characteristics are also observed in macroeconomic variables that are influenced by policy adjustments, financial market fluctuations, and other external events. As a result, the residuals generated by ARIMAX may still contain meaningful nonlinear information, indicating the need for complementary modeling approaches capable of learning these remaining patterns.

To complement the limitations of linear statistical models, this study employs LightGBM as the nonlinear learning component. Built upon the Gradient Boosting Decision Tree (GBDT) framework, LightGBM is designed to efficiently process high-dimensional datasets while maintaining strong predictive capability [10]. When applied to time series forecasting, historical observations are transformed into lag-based and rolling statistical features, enabling the algorithm to identify nonlinear relationships that may remain unexplained by ARIMAX [11]. Although LightGBM provides flexible nonlinear learning, it does not explicitly model

temporal dependence, highlighting the importance of integrating it with statistical forecasting approaches. Despite its strong predictive capability, LightGBM does not explicitly account for the sequential dependence that naturally exists in time series data because it does not include autoregressive or integrated components. Consequently, when used as a standalone model, its ability to represent the temporal characteristics of inflation may be limited [12]. In contrast, classical time series models are specifically designed to capture temporal dependencies, although they often struggle to represent complex nonlinear relationships. Therefore, combining the strengths of statistical and machine learning approaches provides a more suitable strategy for inflation forecasting. Because the predictive performance of LightGBM is highly influenced by the choice of hyperparameter values, an optimization procedure is required to obtain the most appropriate model configuration. Hyperparameter optimization plays an essential role in improving prediction accuracy by systematically identifying parameter combinations that produce the best model performance [13]. In this study, the optimization process is performed using the Optuna framework, which automatically searches for an efficient hyperparameter configuration, enabling the LightGBM model to achieve more accurate and reliable forecasting results.

Based on these strengths and limitations, a hybrid approach has become one alternative for modeling the characteristics of inflation data more comprehensively. Previous studies have shown that the application of hybrid models combining statistical and machine learning methods, such as ARIMA-ANFIS, can provide better forecasting performance compared to the use of a single model in predicting Indonesian inflation based on univariate data [14]. These findings indicate that combining linear and nonlinear approaches has the potential to improve the model's ability to capture inflation dynamics. Therefore, this study uses ARIMAX to capture the linear components and the influence of macroeconomic variables, while LightGBM with Optuna hyperparameter optimization is expected to capture the remaining nonlinear patterns in the multivariate inflation data.

1.2 Research Questions

Based on the research background presented above, the following research questions are proposed to guide this study:

1. How can an ARIMAX-LightGBM hybrid model optimized using Optuna be developed to forecast Indonesian inflation based on macroeconomic indicators?
2. What are the results of the performance evaluation of the ARIMAX-LightGBM model with Optuna hyperparameter optimization for predicting Indonesian inflation using macroeconomic indicators?

1.3 Research Objectives

The objectives of this study were formulated in line with the research questions established as the focus of the discussion, as follows:

1. To develop a system for predicting inflation in Indonesia based on macroeconomic indicators using the ARIMAX-LightGBM model with Optuna optimization.
2. To evaluate and analyze the performance of the ARIMAX-LightGBM model with Optuna optimization using the RMSE, MAE, MBE, and R^2 metrics.

1.4 Research Benefits

This study was conducted with the hope of providing the following relevant benefits:

1. This study contributes to the application of hybrid statistical and machine learning methods for multivariate inflation forecasting. The proposed ARIMAX-LightGBM model optimized with Optuna is expected to enrich the existing literature on inflation prediction using macroeconomic indicators.
2. To provide the results of inflation forecasting models for Indonesia based on macroeconomic indicators, which can be used as an academic reference in analyzing inflation dynamics under changing economic conditions.

1.5 Research Limitations

The problems in this study are limited by several aspects and the scope of the research, as follows:

1. This study uses Indonesia's month over month (MoM) inflation as the target variable in the predictive model.
2. The explanatory variables focus on macroeconomic indicators relevant to changes in inflation and available from official sources such as Bank Indonesia and Central Agency of Statistics (BPS).