CHAPTER I
INTRODUCTION

1.1 Background

The development of information technology over the past two decades has driven a major revolution in the global economic system. One of the most influential digital innovations is the emergence of cryptocurrencies based on blockchain technology. Bitcoin, the first and most popular cryptocurrency, was introduced by Satoshi Nakamoto in 2009 as a decentralized payment system that does not require a central authority to execute transactions [1]. Since then, Bitcoin has grown rapidly and become the digital asset with the largest market capitalization in the world, significantly influencing the movements of other crypto asset markets [2].

On the other hand, Bitcoin's rapid fluctuations in value make it an asset with high price volatility. Various studies have shown that Bitcoin's price exhibits strong heteroscedasticity, where volatility can fluctuate dynamically over time [3]. Bitcoin price fluctuations are influenced not only by market supply and demand, but also by various other factors such as global stock market conditions, gold price movements, interest rates, government regulations, and social media sentiment [4],[5],[6]. With this complexity, attempts to predict Bitcoin prices using conventional approaches such as linear regression become less effective because the relationships between variables are non-linear and difficult to model simply.

Bitcoin is also often considered a high-risk speculative asset. However, in certain economic conditions, such as inflation or monetary instability, Bitcoin can serve as a hedge [7],[8]. However, these characteristics are not always consistent, adding to the challenge of accurately and sustainably predicting Bitcoin prices.

In Indonesia, the number of crypto asset users and investors has increased significantly in recent years. The government, through the Commodity Futures Trading Regulatory Agency (Bappebti), has designated Bitcoin and hundreds of other crypto assets as legally traded digital assets [9]. This legality encourages increased public participation as investors, from both beginners and institutions. However, high volatility makes investors vulnerable to significant losses if they

lack a sound strategy for analyzing and projecting Bitcoin's future price. Therefore, a scientific approach is needed that can provide more accurate Bitcoin price predictions and can be used as a basis for investment decisions.

Various platforms such as Indodax, TradingView, and Investing have provided historical data and technical indicators for analyzing Bitcoin price movements. However, these platforms generally do not provide transparent and scientifically evaluable machine learning-based price predictions. The information presented is limited to visualizations of historical data and static technical indicators, without displaying projections of future numerical values generated by a measurable prediction model.

On the other hand, high volatility and non-linear relationships between market variables often lead to the accumulation of prediction errors, especially when the forecast timeframe is extended. Many previous studies on crypto asset price forecasting have focused solely on evaluating a single, short-term time horizon. This limitation makes the resulting models less adaptable and difficult to reliably understand Bitcoin price movements across various investment timeframes.

To address this gap, a computational approach is needed that not only captures non-linear patterns in historical data but can also be rigorously evaluated across various forecast timeframes, such as 1 day, 3 days, and 7 days. Therefore, utilizing artificial intelligence technology is a highly relevant alternative solution for identifying the dynamics of this complex digital financial market.

Machine learning methods have been widely applied to model complex time series data, including financial asset prices. One widely used method is Support Vector Regression (SVR). SVR is a development of the Support Vector Machine used to perform regression on data with non-linear distributions [10],[11]. SVR has good generalization capabilities by optimizing the margin of error and minimizing overfitting on the data [12],[13],[14]. Therefore, SVR is considered potentially applicable to Bitcoin price predictions, which have complex patterns.

However, the performance of Support Vector Regression (SVR) is greatly influenced by the selection of parameter values such as C, epsilon, and gamma which function to control the model's sensitivity to errors and the complexity of the separator function [15]. Suboptimal parameter selection can reduce the accuracy of

the predictive model and even cause the model to fail to capture the true pattern of the data. The vast search space for SVR parameter combinations makes determining optimal hyperparameters a challenging optimization problem, necessitating an optimization method capable of efficiently and systematically determining the best parameters.

One of the optimization approaches widely used in determining hyperparameters of machine learning models is Bayesian Optimization. Bayesian Optimization is a probabilistic-based optimization method that models the relationship between parameter combinations and model performance using a surrogate model in the form of a Tree-structured Parzen Estimator (TPE), which models the relationship between parameter combinations and model performance probabilistically. This approach works by estimating the probability distribution of the objective function and iteratively selecting the next parameter based on the balance between exploration and exploitation through the acquisition function [16],[17].

The main advantage of Bayesian Optimization lies in its efficiency in the number of objective function evaluations. Unlike optimization methods based on random search or heuristics, Bayesian Optimization utilizes information from previous evaluations to determine the most promising parameter candidates. This makes it particularly suitable for hyperparameter optimization problems in machine learning models, where the model training process is computationally expensive [18].

Several studies have shown that applying Bayesian Optimization to hyperparameter optimization of Support Vector Machines and Support Vector Regression can significantly improve prediction accuracy compared to using default parameters or conventional search methods such as grid search. In addition to producing better performance, Bayesian Optimization also provides higher model stability because the optimization process is carried out adaptively based on the probabilistic distribution of model performance [19],[20].

Given the highly dynamic crypto market and its high risk factors, accurate Bitcoin price prediction is a crucial aspect of investment analysis. Machine learning approaches such as SVR can help capture complex and dynamic price patterns,

while Bayesian Optimization helps find the best parameters to improve model performance. Therefore, the integration of these two approaches is expected to produce a more accurate Bitcoin price prediction model that is highly adaptable to changing market dynamics.

Based on this comprehensive explanation, the study titled "Bitcoin Price Prediction Using Support Vector Regression Optimized with Bayesian Optimization" is highly crucial for developing more accurate and reliable cryptocurrency asset forecasting methods, with the ultimate goal that its empirical findings will substantially assist investors in mitigating financial decision-making risks while simultaneously fostering advanced academic research on machine learning applications within the rapidly evolving digital finance industry.

1.2 Problem Formulation

Based on the background description, the problem formulation in this research is as follows:

1. How to predict Bitcoin prices amidst its high volatility.
2. How to determine the right optimization methods and strategies to handle the non-linearity and volatility of Bitcoin prices so as to improve prediction accuracy?
3. How to build a machine learning model to predict Bitcoin price using SVR optimized by Bayesian Optimization?
4. What is the accuracy level of the SVR model optimized using Bayesian Optimization based on the evaluation metrics MAE, RMSE, MAPE, and R^2 at various prediction time horizons?

1.3 Research Objectives

The objectives of this research are as follows:

1. Building a Bitcoin price prediction model using Support Vector Regression.
2. Applying the Bayesian Optimization algorithm to optimize the parameters on SVR.
3. Analyzing the performance of Bitcoin price prediction using SVR+ Bayesian Optimization and comparing it with SVR without optimization.

1.4 Benefits of Research

This research is expected to provide the following benefits:

1. Providing scientific contributions in the development of crypto asset price prediction methods by utilizing a combination of SVR and Bayesian Optimization.
2. Providing references for investors, financial analysts, and market players in designing more effective investment strategies.
3. To become a reference in developing machine learning-based applications that can be used to support decision-making in the digital financial sector.

1.5 Problem Limitations

In order for the research to be more focused, the problem limitations in this research are:

1. The data used is limited to the historical price of Bitcoin with a time span from November 27, 2020 to November 26, 2025.
2. The prediction model used is Support Vector Regression.
3. The optimization algorithm used is limited to Bayesian Optimization.
4. The evaluation metrics used to evaluate model performance are Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and Mean Absolute Percentage Error (MAPE), Coefficient of Determination (R2).
5. The final results of this study focus on the creation of an SVR model optimized by Bayesian Optimization.