SECTION 1. MODELS, METHODS AND INFORMATION TECHNOLOGIES IN ECONOMICS / МОДЕЛІ, МЕТОДИ ТА ІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ В ЕКОНОМІЦІ

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SYSTEM ANALYSIS AND MODELLING TOOLS FOR CRYPTOCURRENCY PRICE FORECASTING

Abstract. In the development of financial technology, cryptocurrencies present a complex challenge for price forecasting due to their volatile nature, influenced by various factors from market sentiment to regulatory changes. This paper examines the application of System Analysis and Machine Learning (ML) tools to enhance the accuracy of cryptocurrency price predictions. We review the literature on econometric and ML models, highlighting their potential and limitations in the context of financial markets. The study systematically assesses tools such as ARIMA and Prophet, deep learning frameworks like Keras with TensorFlow and PyTorch, and advanced neural network architectures including LSTM, Transformer, and Temporal Fusion Transformer. The findings reveal that traditional models like ARIMA offer ease of use but need help with the non-linear patterns inherent to cryptocurrency data. In contrast, models like the Temporal Fusion Transformer provide high accuracy but require substantial training time. This research suggests a synergistic approach, integrating ML predictions with system analysis to enhance forecasting accuracy. It proposes the exploration of data clustering by periods and asset types as a promising direction for future research. This composite methodology holds the potential to significantly improve economic forecasting and asset management in the cryptocurrency domain.

Analysis of recent research and publications. In the ever-evolving landscape of financial technology, cryptocurrency has emerged as a revolutionary yet volatile asset, capturing the attention of investors, economists, and technologists alike. The unpredictable nature of cryptocurrency prices, driven by myriad factors ranging from market sentiment to regulatory changes, presents a unique challenge: the need for precise forecasting tools. This paper describes some principles of System Analysis and Machine Learning (ML) Tools, exploring their potential to enhance the accuracy of cryptocurrency price forecasting.

Some authors collectively explore the efficacy of various analytical methods in understanding financial markets, focusing on cryptocurrency price forecasting. Baranovskyi et al. (2019) discuss econometric models related to monetary policy in Ukraine, potentially laying the groundwork for analytical techniques useful in cryptocurrency markets [1]. The same group (2021) later examines correlations between cryptocurrency market trends and economic indicators, suggesting a regression analysis approach for price predictions [2]. Derbentsev et al. (2020) investigate machine learning ensemble methods for forecasting prices, demonstrating their effectiveness in a conference setting [3]. Finally, Derbentsev and colleagues (2021) compare different machine learning algorithms for the same purpose, validating their application for short-term cryptocurrency price forecasting [4].

System analysis principles and models as tools are the backbone of this study, providing a vital framework to navigate the complexities of the cryptocurrency market. This methodology underpins the selection and application of various machine learning tools and ensures that the forecasting models account for the intricate web of factors that influence market dynamics. Therefore, the paper systemizes top machine learning (ML) tools for cryptocurrency price forecasting, leveraging Python programming tools. It encompasses models such as ARIMA and Prophet for time series forecasting and utilizes deep learning frameworks, including Keras with TensorFlow and PyTorch. The study also overviews advanced neural network architectures like

the LSTM (Long Short-Term Memory) networks, the Transformer and Temporal Fusion Transformer, and LSTNet versions.

Results and discussion. ARIMA via statsmodels. The ARIMA model, implemented through Python's statsmodels library, demonstrated proficiency in capturing linear relationships in the time series data for cryptocurrency prices. It excelled in short-term forecasting, benefiting from its simplicity and ease of use, allowing quick model fitting and interpretation. However, its efficiency was limited by non-stationarity and volatility in the data—a common trait in cryptocurrency markets. The model's reliance on past values and differences means it often failed to capture sudden, non-linear shifts in market sentiment [5].

Facebook Prophet. Facebook's Prophet tool offered flexibility in handling daily seasonality and trend changes in cryptocurrency data, making it robust against irregular patterns. It was particularly useful for datasets with strong seasonal effects and long-term trends. Its intuitive parameters allowed for fine-tuning to improve model accuracy. Nevertheless, Prophet's performance was less impressive when dealing with very noisy data or outliers, which are frequent in cryptocurrency markets. Its assumption of regular seasonal and holiday effects only sometimes aligns with the unpredictable nature of these markets [6].

Keras & TensorFlow. Deep learning models built with Keras and TensorFlow brought significant advancements in price prediction tasks. Their capacity to learn non-linear relationships and intricate patterns in high-dimensional data allowed for capturing complex market dynamics. Models such as LSTMs and GRUs were particularly adept at understanding temporal dependencies. The main drawback was the need for extensive computational resources and large datasets to train these models effectively. Additionally, the complexity of these networks sometimes led to overfitting, requiring careful regularization and hyperparameter tuning to generalize well to unseen data [7; 8].

Model Variants. Variants of models like Transformer, Temporal Fusion Transformer, LSTNet, and multivariate LSTM architectures each brought their strengths to the table. The Transformer's self-attention mechanism provided a nuanced understanding of time series relationships, while the TemporalFusionTransformer's ability to integrate static and time-varying data proved advantageous for complex datasets. LSTNet's hybrid approach addressed spatial and temporal patterns, but its application required domain expertise to structure the data appropriately. Multivariate LSTMs extended the single-variable analysis to capture interactions between different market indicators, though at the cost of increased model complexity and potential overfitting [9].

The testing of the specified models on cryptocurrency market data demonstrated the high efficiency of the Prophet-based models, which provided the broadest forecasting range. The most accurate predictions were achieved using Temporal Fusion Transformer models, although they require a significantly longer training period. To assess the accuracy of these models, metrics such as Mean Absolute Percentage Error (MAPE) and Mean Absolute Error (MAE) were utilized.

Conclusions. The investigation presented in this paper reveals that while traditional models like ARIMA are beneficial for their simplicity and interpretability, they are often outperformed by more sophisticated ML tools that can grapple with the non-linear and complex patterns of cryptocurrency data. Tools like Facebook Prophet and advanced neural network architectures, including LSTM, Transformer, and Temporal Fusion Transformer, represent a significant leap forward in forecasting capabilities. These models accommodate the erratic nature of cryptocurrency prices, with the Temporal Fusion Transformer standing out for its exceptional accuracy despite its intensive training requirements.

The research describes a composite approach that marries the predictive prowess of ML models with system analysis techniques. Such a holistic strategy could substantially refine forecasting accuracy. Moving forward, there is a promising avenue in preliminary data

clustering by time periods and asset types to further enhance model performance. Additionally, integrating these predictive insights with established financial models could pave the way for a new frontier in economic forecasting and asset management. Embracing these directions for future research could unlock unprecedented levels of foresight in the volatile domain of cryptocurrency markets.

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