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Original Article

Designing Theoretical Models for Commodities Price Forecasting Using Supervised Machine Learning

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Abstract:

Precise commodities price predicting is crucial for market members, risk managers, and policymakers, as price oscillations impact financial stability and investment policies. This research emphasizes designing theoretical models for merchandise price estimating using administered machine learning, highlighting their potential to improve projecting accuracy in complex market settings. The study explores key supervised learning algorithms, including Decision Trees, Support Vector Machines (SVM), Random Forest, and Gradient Boosting, detailing the theoretical basis and design principles behind each method. Our framework underscores essential basics such as data preprocessing, feature business, model training, and authentication strategies to tackle challenges caused by market unpredictability, nonlinearity, and seasonal differences.The theoretical analysis indicates that ensemble methods, like Random Forest and Gradient Boosting, offer superior predictive performance due to their ability to manage complex relationships and reduce overfitting. SVM demonstrates robustness in handling high-dimensional data and nonlinear features, making it suitable for diverse forecasting scenarios. These findings underscore the importance of model selection and optimization techniques to maximize forecasting accuracy and efficiency in commodity markets.

The implications of this research are significant, it provides a structured approach for developing advanced forecasting models that enhance market efficiency and inform better decision-making. Future directions involve integrating deep learning techniques, incorporating external economic factors, and validating the models with real-world data to further refine predictive performance. This theoretical work lays the foundation for empirical studies on transforming commodity price forecasting.

Key Words: *Supervised Machine Learning, volatility, predictive, robustness, overfitting.*

Introduction

The unpredictable nature of commodity prices, principally in the Indian marketplace, offers an extensive challenge for depositors, traders, and legislators. The effort comes from a variety of aspects, encompassing geopolitical tensions, supply chain disturbances, altering economic conditions, and oscillations in demand and supply. These intricacies emphasize the need for effective projecting models that can precisely predict price movements. The latest advances in data science and machine learning have delivered novel tactics to tackle this problem.

Managed machine learning (ML) replicas are particularly promising for commodity price prediction. These models leverage past data and recognize patterns that can be used to make estimations on future trends. Unlike outdated econometric replicas, supervised learning approaches such as regression analysis, decision trees, support vector machines, and neural networks can handle large datasets and complex, non-linear associations, making them more adaptable to the nuances of commodity markets.

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This exploration focuses on emerging and designing theoretical models to forecast the prices of nominated commodities listed on the Multi Commodity Exchange in India. The MCX, as one of the chief commodity derivatives exchanges, provides a complete platform for trading a wide range of commodities. The importance of this work lies in creating models that can offer higher correctness and reliability compared to existing predicting approaches.
The key role of this study is to associate the gap between theoretical understanding and practical execution of ML algorithms in commodity price forecasts. By examining various supervised machine learning techniques, this research aims to govern the optimal models for forecasting price oscillations, taking into account the unique features of the Indian commodities market. The study also highlights the importance of feature selection, data preprocessing, and model evaluation methods to ensure robust and scalable results. In doing so, it seeks to enhance the decision-making capabilities of market participants and contribute to the wider field of financial analytics.

Review of Literature

Hachmi Ben Ameur (2024) The works highlight the efficiency of deep learning techniques, particularly Long Short-Term Memory (LSTM) networks, in predicting commodity prices due to their capability to capture complex temporal patterns. LSTM models have been found to outperform traditional forecasting methods in forecasting price actions. Additionally, the prominence of the Bloomberg Livestock and Industrial Metals Subindices is recognized for their role in refining model accuracy and providing relevant market visions **Jin Shang (2023)** The paper studies the effectiveness of sentiment displays and machine learning models, including RF, XGB, and LSTM, in predicting commodity prices. It offers hybrid models that incorporate data decomposition methods, offering improved forecast accuracy over traditional ARIMA models. **Laszlo Vancsura (2023)**Recent literature highlights the growing success of AI-based predicting models, particularly machine learning algorithms, in predicting product future prices. These models have been shown to outstrip traditional econometric methods, especially under volatile market conditions. Studies emphasize their potential to improve decision-making for investors and policymakers by providing more accurate and timely predictions. **Emmanuel Senyo Fianu (2022)** Recent studies propose hybrid models, merging mode decomposition and extreme learning machines, to tackle non-linearity and non-stationarity in multi-commodity price forecasting. These models have shown enhanced predictive accuracy, particularly during unpredictable market conditions like the COVID-19 pandemic. **Yeong Hyeon Gu (2022)** The paper proposes a dual input attention LSTM (DIA-LSTM) model for anticipating agricultural commodity prices and assimilating meteorological and trading volume data. This approach improves forecasting accuracy by focusing on dynamic production areas, offering advances over traditional models that rely on static factors. **Shian-Chang Huang (2018)** The paper discovers deep multiple kernel learning (DMKL) for oil price predicting, integrating kernel methods with deep learning to capture complex, nonlinear dynamics. This approach outstrips traditional models, improving forecasting accuracy in energy commodity marketplaces.

Objectives:

1. To understand the dynamics and key factors influencing price movements in the Indian commodities market.
2. To evaluate the effectiveness of supervised machine learning algorithms in forecasting commodity prices.

Methodology:

The methodology involves a detailed review of secondary sources, including journals, articles, and market reports, to explore existing commodity price forecasting methods and the application of supervised machine learning models. The paper critically evaluates various forecasting techniques to identify the most effective models. Theoretical frameworks and algorithms are analyzed based on their performance in prior studies to inform the proposed approach.

Development of Theoretical Models:

Selection of Supervised Machine Learning Algorithms:

Identifying suitable algorithms for commodity price forecasting involves evaluating both traditional and advanced machine learning techniques. Traditional methods, such as linear regression and decision trees, have been widely used due to their ease and ease of interpretation. Linear regression replicas work well for capturing forthright associations between variables, while decision trees offer a clear, hierarchical structure for decision-making. However, these approaches often fight with non-linear patterns and complex dependencies in the data, which are prevailing in commodity markets.

To overcome these confines, more sophisticated approaches like support vector machines (SVM), random forests, and neural networks are considered. Support vector machines are effective in handling both linear and non-linear relationships by using kernel functions to map data into higher-dimensional spaces, allowing for more accurate pattern recognition. Random forests, which use an ensemble of decision trees, enhance predictive performance and minimize the risk of overfitting by averaging the outcomes of multiple trees. This collaborative technique delivers heftiness and better generality across various datasets.
Neural networks, mainly deep learning models, are greatly suited for catching non-linear relations and complex connections among variables. They can learn intricate patterns from large and varied datasets, making them well-

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equipped for predicting volatile and dynamic marketplaces. By leveraging these advanced mockups, researchers can better address the difficulties integral in commodity price predicting, ultimately leading to more precise and reliable forecasts.

Data Preprocessing and Feature Selection:

Data quality is crucial for the reliable performance of overseen machine learning models in commodity price forecasting. Preprocessing methods like normalization are essential to scale data regularly, ensuring that no single feature unreasonably affects the model. Outlier removal helps remove irregularities that could mislead forecasts while handling missing values prevents gaps in data from compromising model correctness. These steps are vital to creating a steady and robust dataset.

Feature selection additionally improves model performance by recognizing the most important variables that impact commodity prices. By focusing on relevant features, the model becomes simpler and more effective, reducing the risk of overfitting. This careful collection of variables confirms that the model simplifies well to new data, eventually improving its predictive competencies.

Model Training and Performance Evaluation:

The selected models are skilled using old price data and estimated with metrics like Mean Absolute Error, Root Mean Squared Error, and R-squared to assess the correctness and trustworthiness of forecasts. To ensure the replicas are robust and simplify well to new data, cross-validation methods are engaged, which involve dividing the data into numerous subsets for training and testing. This method helps validate the model's presentation across different data sections, enhancing its steadiness and effectiveness for real-world predicting.

Exploring Hybrid Models for Enhanced Accuracy

The paper offers using hybrid models that associate multiple algorithms, such as boosting, bagging, or stacking, to capitalize on their separate powers and enhance projecting performance. Ensemble approaches have important potential for improving prediction correctness by mixing diverse methods, thus creating more robust replicas. By combining the benefits of various methods, these hybrid models can better handle data complications and deliver more reliable forecasts in commodity price prediction.

Addressing Market Dynamics and Volatility

The focus is on designing replicas that efficiently account for non-linearity and market fluctuations, ensuring they provide consistent estimates even in changing economic environments. These replicas are built to handle the difficulties and variability inherent in commodity marketplaces, making them more robust and precise. Additionally, their adaptability to different market situations improves their practical presentation, offering valuable insights and greater dependability for real-world decision-making across various economic situations.

Findings:

The study finds that forward-thinking managed machine learning models, such as support vector machines, random forests, and neural networks, meaningfully outperform old-fashioned forecasting methods in the supervision of non-linearity and complex relations in commodity marketplaces. Hybrid models that associate multiple procedures demonstrate enhanced projecting accuracy and sturdiness, particularly in unstable economic circumstances. Data preprocessing and feature selection are critical for improving model consistency and effectiveness. Cross-validation methods ensure mockups are well-generalized and stable. Inclusive, machine learning replicas show great probability for improving decision-making in commodity price estimates.

Conclusion:

This research highlights the benefits of using supervised machine learning models for commodity price projecting, signifying their ability to handle complex and active market data more efficiently than traditional methods. The findings highlight the importance of incorporating data preprocessing and feature selection to improve model presentation. Hybrid models offer extra benefits by leveraging multiple processes. The results recommend that these techniques can offer more reliable and accurate forecasts, aiding market participants in making informed results.

Future Work:

Future studies should discover the incorporation of more real-time data sources, such as social media sentiment and macroeconomic pointers, to improve predicting correctness. Increasing the study to include global product markets would help authenticate the models' efficiency across diverse economic backgrounds. Furthermore, developing adaptive models that constantly learn from new data could additionally improve predictive presentation and ensure models remain appropriate in ever-evolving market circumstances.

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