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The Impact of Russia-Ukraine War on Global Commodity Prices

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Title

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Executive Summary

The Russian-Ukrainian war had significant impact on the economy, particularly on goods sold worldwide. This research paper is designed to provide a comprehensive analysis of the factors responsible for global commodity price inflation. Additionally, It also explores the impact of the Russia-Ukraine War, options for Russia and European countries, and the potential impact of the war on small and large businesses. It also explores the role that India, China and the BRICS countries can play in the global economy. The document also compares grain prices for 2021 and 2023, examines the potential assistance the BRICS could provide, evaluates Ukraine's Plan B, and presents a timeline for restoring supply shortages. Finally, current shortages and strategies to manage them are identified, and alternative export sources are explored to compensate for wheat shortages. In addition to wars, geographical disasters, natural disasters such as floods and droughts, ongoing economic pressures and frequent supply-demand conflicts cause prices to increase. Some recommendations have also been provided to the key stakeholders and policy makers based on this research. Commodity prices data from real-time worldbank dataset provides future guidance to a lot of stake holders worldwide including those from emerging and developing economies (EDME's). World grain prices soared to record highs before the Russia-Ukraine war broke out on February 24, 2022, but Wheat price is still above historic levels, after the Russian war broke out and continued. The war in Ukraine has already lasted more than a year and a half. This study attempts to use machine learning and forecasting techniques such as ARIMA for forecasting. Although, Regression Models, Futures, Artificial Intelligence and Machine Learning have been used for several decades in forecasting the commodity pricing data, but this research has used a time series dataset from the

worldbank site for doing this analysis. The research focuses on augmented forecasting techniques on commodity pricing time series data, for addition to this field of research.[30]. Machine Learning methods such as Lasso, KNN, Support Vector Regressor, MLP Regressor (Neural Network), Gradient Boosting Classifier, Random Forest Regressor, Adaboost Regressor, Decision Tree Regressor have been used on commodity pricing time series wheat grain data.. The analysis in this study is to discover the root cause of the increase in the market price of wheat and the lack of supply. The most widely used forecasting method, even if it is not fair (no release or forecast), is the futures price, which has made huge predicition errors [30]. Due to food security and war in the world, this research has been done on wheat data. The same method can be used to predict and be useful for all items in this dataset. Additionally, Baumeister and Kilian (2015) found that mixed forecasting combining forecasts from different models, including futures prices, resulted in more accurate reporting of the model as is found useful for the fuel price forecast. Similarly, Manescu and Van Robays (2017) found that forecast combination approaches improved directional accuracy and unbiasedness over futures prices. Studies have shown that combining more data in different models can improve performance. For example, accounting for global economic conditions, petroleum inventories, world output gap, the U.S. dollar exchange rate, and the possibility of speculation has been shown to improve oil price forecasts (Baumeister, Korobilis, and Lee 2022; Kaufmann et al. 2008; Lalonde, Zhu, and Demers 2003). Similarly, accounting for relevant external regressors, such as industrial production, exchange rate dynamics, commodity currencies, and international metal stock indexes, has improved forecast performance of some metal prices (Gong and Lin 2018; Issler, Rodrigues, and Burjack 2014; Pincheira-Brown and Hardy 2019). Multivariate time series models also have the advantage of capturing the interactions and relationships between variables. They can account for the dynamics and dependencies among different variables, allowing for a more comprehensive understanding of the underlying factors driving commodity prices.

Keywords:

Russian-Ukraine Conflict, Food Prices, Food Crisis, Grain Exports, Time Series Analysis, Wheat Circulars, Univariate Models, Multivariate Models, Machine Learning, Random Forest, Extra Tree Classifier, Decision Trees, Futures Prices, Commodity Prices, ARIMA, MLP Regressor (Neural Networks), Global Trade, Inflation, Diplomatic Negotiations, Supply Chain Disruptions.

Introduction

The war that started in Ukraine in 2022 has significantly affected the global food supply, especially the grain market. Ukraine is one of the world's largest grain exporters, and its agricultural production has been severely affected by the conflict. This research paper aims to identify the factors responsible for the increase in world grain, Crude Oil, Precious Metals and Minerals and Natural Gas prices and also aims to understand the impact of the Russia-Ukraine war

on these commodities, analyze the options available for Russia and European nations. Additionally, the research paper delves into the implications of these changes on small and large businesses, as well as the role that India and China can play in the global economy dynamics. Furthermore, a comparison of wheat prices in 2021 and 2023 has been done. Also, the role of BRICS in providing relief during the crisis could be an option, while exploring Ukraine's plan B. The paper also investigates the timeline for restoring supply shortages and analyzes how current supply shortages are being handled in different regions. Finally an assessment, whether an increase in other commodity exports can counterbalance the shortage of wheat. Thus. the objective of this research is to pinpoint the exact reasons for sustained increased food prices above the historical level and provide recommendations based on results from machine learning algorithms for future recommendations, thereby causing enhanced food security and optimal capacity building measures after the war.

RESPONSIBILITY FOR INCREASE IN PRICES:

The rise in prices of wheat grain, petroleum, precious metals and minerals and natural gas worldwide can be attributed to several factors. Supply chain disruptions caused by the war in Ukraine have had a significant impact on world wheat prices. Ukraine, one of the largest exporters of wheat, has struggled to maintain pre-war export levels (1). Interventions caused by the war affected the global supply of wheat, causing prices to rise worldwide (2). In addition, the war caused massive damage to infrastructure and transportation, exacerbating supply shortages that drove up prices (3). Although the supply of wheat remains low, wheat prices have fallen from their highest level since the war. The war in Ukraine has hit developing economies the hardest, as imports of food and oil depend on the Russia/Ukraine region. Ukraine remains one of the largest producers of sunflower oil in the world, and Russia and Ukraine together produce about 50 percent of the world's sunflower oil. More than a third or the 36 percent of the world's wheat is exported from the region. Indonesia, the Philippines and Morocco are the largest exporters of Ukrainian wheat. Turkey, Vietnam and Indonesia import a significant part of Russian wheat. Inflation in Lebanon (396 percent), Zimbabwe (75 percent) and Turkey (70 percent) was the highest since the war. However, sub-Saharan Africa experienced its worst inflation on record, leading to rising food prices and renewed concerns about food security.

Sanctions against Russian companies and the proposed ban on energy exports also led to an increase in oil prices in the EU. The European Union is the largest collective buyer of Russian oil. In 2021, the EU bought 42 percent of Russian oil production.

A large dam collapsed in Ukraine, further undermining Ukraine's ability to export food to Africa, the Middle East and parts of Asia. According to Glauder, amidst the ongoing war with Russia, Ukraine can export 40 percent less grain than before the war. The threat of reduced production, disruptions at Ukrainian ports and sanctions against Russian fertilizers (urea) have led to food shortages, supply chain disruptions and unprecedented increases in logistics costs.

All this has put increased inflationary pressures on the economy and has also raised food security concerns. Researchers in the interconnected and highly

complex global economy predict a labor shortage and compressed growing season, thus forcing Ukrainians to lower yield of grains. Even if the war ends today or in the near future, the grain production capacity of Ukraine's damaged infrastructure would be reduced, raising long-term concerns about rising commodity prices around the world. 95 percent of Ukraine's grain is sent through Odessa, Mariupol and Kherson, all these cities have been under significant Russian attacks. The effects of the war, combined with bad weather, caused global food shortages, droughts, floods and, in some cases, excessive rainfall, resulting in supply shortages and volatile market price fluctuations that raised concerns about the future.

Literature Review

Review relevant literature, including academic articles, reports and news articles from reliable sources as cited in References. Based on the literature review of the World Bank's Commodity Data Analysis, it is evident that the review did not identify specific forecasting methods for the industrial commodity pricing in the volume of studies that have been conducted so far. However, much effort is being made to improve the accuracy of the forecast. The review also emphasizes the use of model-based approaches and additional information can improve forecast accuracy compared to using futures prices as a predictor of future spot prices. Overall, the literature review highlights the importance of combining multiple models and incorporating more data to improve commodity forecasting. These approaches have been shown to provide more accurate and reliable forecasts compared to individual models and futures prices. Future research can build on these findings and further explore novel methods of forecasting industrial commodity prices.

Adding more information to models involves incorporating additional data on the behavior of economic agents and relevant economic variables. For example, accounting for global economic conditions, petroleum inventories, world output gap, and the U.S. dollar real effective exchange rate has been shown to improve oil price forecasts. Similarly, including relevant external regressors, such as industrial production, exchange rate dynamics, commodity currencies, and international metal stock indexes, has improved forecast performance for some metal prices.

In summary, although futures prices are often used to forecast industrial commodity prices, several studies have shown that model-based approaches such as multivariate time series models and composite forecasting methods generally outperform futures prices. Machine learning on time series data is a promising approach, but requires careful consideration of data quality, model selection, and validation. Adding additional information to models, such as the inclusion of related economic variables, has been shown to improve forecast performance.

Standalone machine learning algorithms can also be effective in forecasting prices of industrial commodities such as Wheat HRW. However, their performance should be compared with other forecasting methods, and the addition of

additional data may further improve their accuracy.

Research Methodology

Identify relevant data sources, such as World Bank data, public reports, news articles, and academic journals. Download the pricing data-set from world bank data. Perform data preprocessing to convert the data into a suitable format for machine learning algorithms, such as time series analysis or regression analysis. Machine learning analysis follows CRISP-DM process methodology for consistency, repeatability, transparency on algorithms and clarity. Perform Heatmap and correlation studies on independent variable for dependable feature engineering, which is a very important excercise for machine learning. Use python inbuilt libraries as pandas, numpy matplotlib, scikitlearn etc for machine learning analysis. Test various M/L algorithms for finding the best features and best algorithms based on accuracy, rmse etc. For building various M/L Scenarios on our dataset, we use 80 percent training and 20 percent test data. For Machine Learning, We have used lasso, ridge, KNN, Support Vector, decision tree, random forest, extra tree classifier, gradient boost, ada boost regressor, MLP (neural network). Visualize the results and insights derived from the analysis using suitable data visualization techniques, such as charts, graphs. Present the results and report to relevant stakeholders, such as policymakers, researchers, and market participants, to support decision-making and planning. Submit the research for publications and dissemination.

Research Questions

Impact of the Russia-Ukraine War

1. The Russia-Ukraine war has had significant impacts on various countries and sectors. The European nations, particularly those heavily reliant on Ukrainian wheat and Russian gas, faced disruptions in their supply chains and increased energy costs (8). These disruptions not only affected businesses but also had implications for the general population, leading to higher food prices and energy bills (9).

Disrupted Supply Chains

2. The war has severely disrupted supply chains, particularly for wheat grain. Ukraine is one of the largest wheat exporters globally, and the conflict has directly affected its ability to export grains. The disruption in supply chains has led to higher prices and shortages in the global wheat market. The research suggests that this has contributed significantly to the global food crisis (8).

Production Delays

3. The ongoing conflict has hindered agricultural production in Ukraine. Farmers have been unable to access their fields due to security concerns, resulting in delays in planting and harvesting crops. This has further exacerbated the supply shortage and contributed to the increase in wheat grain prices (9).

Market Uncertainty

4. The Russia-Ukraine war has created market uncertainty, particularly in the energy sector. Natural gas prices have risen due to concerns about supply disruptions. Additionally, the war has led to geopolitical tensions, which have further increased market uncertainties and contributed to price volatility (9).

Options for Russia and European Nations:

5. Both Russia and European nations have several options to mitigate the economic impact of the war and stabilize commodity prices. These options include diplomatic negotiations, diversification of energy sources, investment in renewable energy, and regional cooperation.

Diplomatic Negotiations:

6. Diplomatic negotiations between Russia and European nations can play a crucial role in resolving the conflict and stabilizing commodity prices. By engaging in dialogue and finding peaceful solutions, the parties involved can create a more stable economic environment.

Diversification of Energy Sources

7. European nations heavily rely on Russian natural gas supplies. Diversifying energy sources, such as investing in renewable energy and exploring alternative suppliers, can reduce dependence on Russian gas. This diversification can help mitigate price shocks and enhance energy security.

Investment in Renewable Energy

8. Investing in renewable energy sources, such as wind and solar power, can reduce the dependence on fossil fuels and stabilize energy prices. The transition to renewable energy can create a more sustainable and resilient energy market.

Regional Cooperation

9. Regional cooperation among European nations can enhance economic stability and provide collective bargaining power. By working together, countries can develop joint strategies to address the economic challenges caused by the war and the increase in commodity prices.

Impact on Small businesses:

10. Impact on Small businesses The impact of the war on small businesses was particularly severe, as they often rely on stable and affordable inputs to run their operations. The increase in prices for essential commodities and raw materials made it challenging for small businesses to maintain profitability and compete in the market (10). Many small businesses had to adapt by finding alternative suppliers or altering their production methods, which could have further implications for costs and efficiency (11).

Impact on Large businesses:

11. Large businesses also faced challenges due to the increase in prices and supply disruptions. Industries such as agriculture, manufacturing, and energy intensive sectors, which heavily rely on wheat, metals, and energy resources, were significantly affected (12). Large businesses had to renegotiate contracts, find alternative suppliers, or pass on the increased costs to consumers, which could impact their competitiveness and profitability (13).

Role of India and China in the global dynamics:

12. India and China play crucial roles in the global economy dynamics and have unique positions regarding the Russia-Ukraine war. India is one of the largest importers of commodities such as wheat and crude oil. The increase in global wheat prices due to the conflict impacted India's food security and forced the government to explore alternative sources or limit exports to stabilize domestic prices (14). The Government of India responded to this food security issue by putting a temporary ban of Rice Produce. This move of India was not welcomed by many countries across the globe. India and China account for more than 52 percent of total Rice Produce across the world. Similarly, the increase in crude oil prices affected India's petroleum sector, leading to higher costs and potential inflationary pressures (15). India can take this as an opportunity to increase it's agricultural productivity to counter the uncertainties caused in the global food market due to Ukraine's incapacity to meet the previous year supply targets post war with Russia.

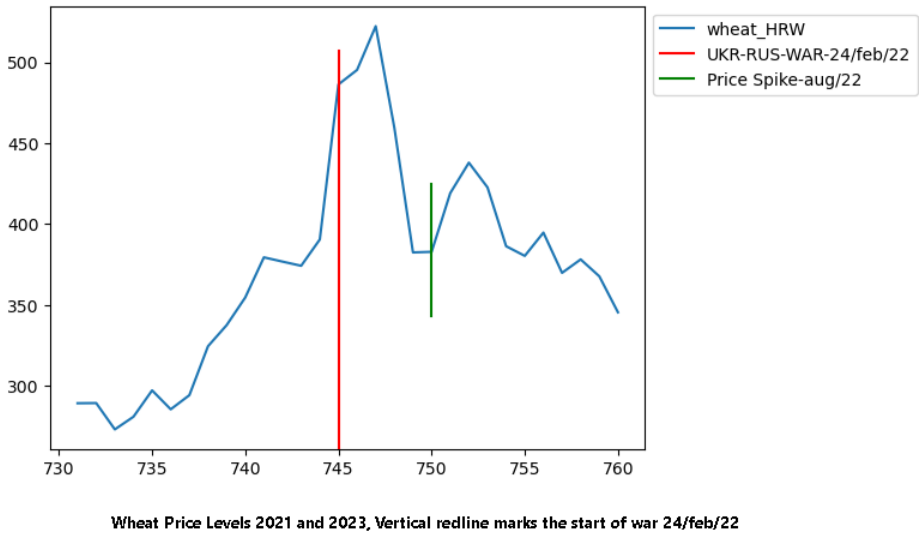


Figure 1: Wheat Price Comparison 2021 and 2023

China, being a major consumer and producer of commodities, also faces challenges due to the increase in global prices. The country's heavy reliance on imported commodities, including wheat and crude oil, makes it vulnerable to supply disruptions and price volatility (16). China has taken measures to strengthen its food security and diversify its suppliers to mitigate the impact of the conflict (17). China is hoarding food on a massive scale. Now, China has 60 percent of the world's maize reserves, 60 percent of the global rice reserves, 51 percent of the world's wheat reserves, this food storage strategy has been done to counter the instability in food imports , due to China's reliance on food imports. This has been done to reduce China's over reliance on the imports.

Comparison of Wheat Prices in 2021 and 2023:

13. The prices of wheat witnessed significant changes from 2021 to 2023 due to the Russia-Ukraine war. In 2021, wheat prices were relatively stable, with global supply and demand in balance (18). However, the outbreak of the war in 2022 disrupted the wheat market, leading to supply shortages and price surges (19). The market reacted to the reduced exports from Ukraine and the concerns about future supplies, resulting in sharp increases in wheat prices (20), although there has been a steady decline in the past months compared to the the highest level before the outbreak of the war, still there has been almost 20 percent increase in the wheat price levels in 2023 compared to 2021, based on the data points used for this analysis.

For a staple commodity such as wheat, 20 percent price increase can bring a lot of pressure on such households, who tend to spend almost 75-80 percent of their monthly income on daily diet.

In 2023, the situation further escalated with the signing of the black sea grain deal between Russia and Ukraine. This deal aimed to ensure the strategic stability of the grain market and stabilize prices (21). While it provided some relief, the global wheat prices remained elevated due to ongoing tensions and uncertainties (22). The fluctuations in wheat prices during this period reflect the volatility and vulnerability of the market under geopolitical disruptions and supply chain challenges.

Role of BRICS for Relief in the Crisis

14. BRICS, a group of emerging economies comprising Brazil, Russia, India, China, and South Africa, can play a significant role in providing relief in the crisis caused by the Russia-Ukraine war. As major players in the global economy, these countries have the potential to coordinate efforts and mitigate the impact of the conflict on food prices and supply chains.

    Cooperation among BRICS nations can involve measures such as increasing production and exports of wheat to stabilize the market, providing financial assistance to affected countries to ensure food security, and facilitating trade agreements to diversify sources of commodities (23). Additionally, collaborative efforts in research and development for sustainable agriculture practices and innovations can contribute to long-term resilience and stability in the food market (24).

Analyzing Market Risks

15. The Russia-Ukraine war has exposed market risks associated with geopolitical conflicts and supply disruptions. The increased volatility and uncertainty in commodity markets make it challenging for businesses and investors to make informed decisions and manage risks effectively. Price fluctuations, supply chain disruptions, and changing regulations pose significant risks to businesses operating in affected industries.

    To manage market risks, businesses need to develop robust risk management strategies that involve diversifying suppliers, building buffer stocks, hedging against price fluctuations, and actively monitoring geopolitical developments (25). Governments and international organizations can also play a crucial role in implementing policies and frameworks that promote stability, transparency, and resilience in commodity markets (26).

Ukraine's Plan B

16. In response to the supply disruptions caused by the war, Ukraine has developed a plan B to mitigate the impact on its agriculture sector. This plan involves diversifying export destinations, expanding domestic storage capacities, and investing in infrastructure to enhance logistical capabilities (27). The aim is to reduce reliance on traditional export routes and establish alternative channels to ensure uninterrupted supply and minimize price volatility.

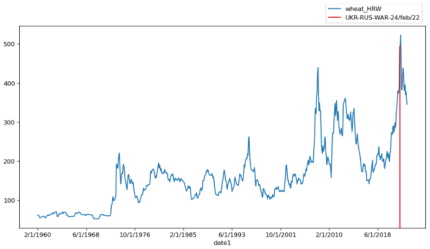
Timeline for Restoring Supply Shortages

17. The timeline for restoring supply shortages depends on several factors, including the resolution of the conflict and the recovery of affected infrastructure and transportation networks. Restoring supply shortages will require efforts from both Ukraine and its trading partners to rebuild trust, reestablish trade relationships, and adopt measures to enhance the resilience of supply chains (28). The timeline is uncertain, even if the war stopped today, The war in Ukraine has directly impacted the country's agricultural sector, leading to a decline in wheat production and disruptions in the agricultural supply chain. The destruction of infrastructure, farmland, and storage facilities, together with the displacement of farmers, has severely hampered agriculture in Ukraine. As a result, Ukraine's wheat exports have decreased, leading to a global wheat shortage and a subsequent surge in prices. The increase in global wheat prices has triggered market reactions and policy responses. Market participants, including traders, farmers, and consumers, have adjusted their strategies and consumption patterns in response to the rising prices. The irreversible closure of several small and family businesses has caused long term problems to the existing Ukraine's Agriculture Sector, termed as "breadbasket of Europe". Furthermore, governments and international organizations have implemented various measures to address the food crisis, such as export restrictions, import diversification, and humanitarian aid programs.

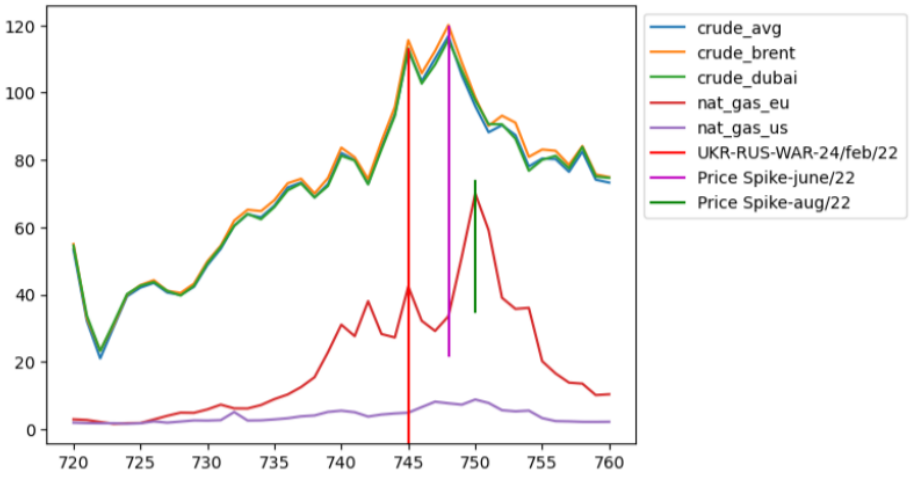
Data visualization for Global Commodity Pricing: Agriculture, Energy, and Precious Metals

It is clearly evident that wheat prices had already reached an all time high, before the outbreak of war. The vertical red-line is the offset of war on February 24 2022.

Similarly, there is a downward trend in the price of both crude oil and gas after the start of the war, the increase in the price of natural gas in the EU



Timeseries Monthly Wheat Pricing Data, Data Range - 1960 - 2023,



Price / Date , Date Range 2020-2023 - Energy Commodities consolidated.

Figure 2: Wheat and Energy Pricing, vertical line - Onset of War

is due to the record number of sanctions imposed on Russia by EU countries. Russia had also decided to block energy supplies to several European countries, therefore the increase in the gas price is due to the mismatch between demand and supply. The rise in oil prices is due to geopolitical tensions between Russia and Ukraine. Russia is one of the largest producers of oil in the world, and disruptions in its production or supply can significantly affect oil prices [4]. The war and subsequent sanctions against Russia raised concerns about supply disruptions and instability in the oil market, leading to higher prices [5].

Agriculture Produce, wheat prices are also showing a downward trend from the peak , along with maize and other food commodities. Similarly, the war also affected the prices of metals and minerals, especially those sourced from Ukraine and Russia. The conflict disrupted mining operations and transportation, leading to supply shortages and higher prices globally (6) as is evident from the consolidated table of precious metals.

ARIMA Model for Wheat Prices forecast generation-Fig 8

Correlation Matrix - Figure 9

Feature Engineering, Model Selection, Model Training and Validation, Analysis

Scenario 1 - Depicted in Figure 10

Forecast Accuracy is 97.13 percent while using Random forest algorithm for Machine Learning and While performing Feature Engineering on Wheat output, Wheat Price has more than 80 percent dependency on Maize Pricing. Since, maize and wheat are staple food, China has stock piled inventory of maize and wheat reserves , which are 60 percent and 51 percent of total cereal reserves of the maize and wheat grain world reserve stock respectively. hence, In the same economic environment, both are subjected to similar market movements and that's causing a similar price movement, leading to the most important feature for future price prediction of Wheat. This is one of the main reasons of sustained higher prices than the historical averages of these commodity food produce. Based on accuracy and feature engineering, random forest is recommended for analysis.

Scenario 2 - Depicted in Figure 11

Forecast Accuracy of 98.07 percent, extra tree for machine learning and feature engineering on wheat output . Since, maize and wheat are staple food, China has stock piled inventory of maize and wheat reserves , which are 60 percent and 51 percent of total cereal reserves of the maize and wheat grain world reserve stock respectively, hence, In the same economic environment, both are subjected to

similar market movements and that's causing a similar price movement, leading to the most important feature for future price prediction of Wheat. This is one of the main reasons of sustained higher prices than the historical averages of these commodity food produce. Urea is imported from Russia and is subjected to sanctions, hence, a shortage of fertiliser can cause a lower yield and increase in prices. 2020 was the year of drought and hence a recovery in production yield happened in 2021 for both maize and wheat. Also, due to food supply disruptions in the middle east, it led to the increase in food prices and thereby an increase in the prices of crude oil. food as a commodity has far reaching affects on the other commodity prices including oil and gas. A war after a record breaking production of maize in 2021, can surely cause increase in food prices and lower production including lower exports as well as internal food security issues in Ukraine. The increase in food prices can cause the prices of other commodities to rise, as a measure of inflationary pressure as well as a negative sentiment to the overall economy. Extra Tree classifier is recommended for analysis.

Scenario 3 - Depicted in Figure 12

Forecast Accuracy - 92.06 percent using Machine Learning and Feature Engineering for Wheat Output. Wheat Price has 80 percent or higher + dependency on Maize Pricing. Since, maize and wheat are staple food, China has stock piled inventory of maize and wheat reserves , which are 60 percent and 51 percent of total cereal reserves of the maize and wheat grain world reserve stock respectively, hence, In the same economic environment, both are subjected to similar market movements and that's causing a similar price movement, leading to the most important feature for future price prediction of Wheat. This is one of the main reasons of sustained higher prices than the historical averages of these commodity food produce.

Scenario 4 - Depicted in Figure 13

Forecast Accuracy - 92.6 percent using Machine Learning and Adaboost and Feature Engineering for Wheat Output. Maize, Soybean-meal, palm-oil, copper, urea are top 5 features for this machine learning model. From all these machine learning models, it is clearly evident that price of wheat is single most heavily dependent on the price of maize, the underlining reason of dependency has been provided in the detailed feature engineering analysis for the different machine learning algorithms.

RESULTS

Top Machine Learning Algorithms for Wheat Forecasting based on Accuracy and RMSE - Figure 14, Figure 15

Machine Learning Models - Accuracy and RMSE

1. Extra Tree Algorithm Accuracy - 97.966 Percent, RMSE - 12.965
2. Random Classifier Algorithm Accuracy - 97.238 Percent, RMSE - 15.112
3. Gradient Boost Accuracy - 97.103 Percent, RMSE - 15.477
4. MLP Regressor (Neural Network) Accuracy - 92.22 Percent, RMSE - 25.35
5. KNearestNeighbor Accuracy - 93.62 Percent, RMSE - 22.975
6. Ridge Accuracy - 94.41 Percent, RMSE - 21.488
7. Lasso Accuracy - 94.37 Percent, RMSE - 21.58

Conclusion and Recommendations

The war in Ukraine has had a profound impact on the global food supply chain, particularly on the wheat market. The disruption in Ukraine's agricultural sector has led to a significant increase in wheat prices, affecting food security and stability worldwide. As it is evident from the research, standalone machine learning algorithms can be useful for forecasting these commodities. However, adding more information as well as overlapping several forecasting methods such as stacked classifier as depicted in Heart Disease Prediction Using Machine Learning and Neural Nets [57, Pal, H].

Recommendations

1. Governments and International Organizations: - Provide financial and humanitarian aid to Ukraine to help alleviate the impact of the war on food security and stabilize grain prices. - Support measures to increase grain production in other countries to offset the decrease in Ukrainian exports. - Coordinate efforts to ensure fair and transparent grain trade policies and minimize hoarding or market manipulation. - Strengthen regulations and monitoring mechanisms to prevent speculative trading and price volatility in the global grain market. - Promote sustainable agricultural practices and investments in research and development to enhance global food security.

2. Consumers: - Practice responsible consumption by reducing food waste and supporting local and sustainable food sources. - Promote awareness and understanding of the impact of global events, such as wars and conflicts, on food prices and availability. - Support initiatives and organizations that work

towards achieving food security and mitigating the effects of price spikes on vulnerable populations.

3. Farmers and Agricultural Industry: - Diversify crop production and explore alternative markets to reduce dependence on Ukrainian grain. - Collaborate with research institutions and adopt innovative farming techniques to increase productivity and resilience to climate change. - Engage in sustainable farming practices to conserve water, reduce pesticide use, and protect soil health. - Advocate for supportive policies and subsidies that incentivize agricultural production and help alleviate financial burdens.

4. Financial Institutions and Investors: - Conduct responsible and ethical investment practices that consider the potential social and environmental impacts of commodity trading. - Promote transparency and responsible lending practices in grain markets to avoid speculative bubbles and price manipulation. - Invest in research and development of innovative agricultural technologies and practices that enhance productivity and sustainability.

5. Research Institutions and Academia: - Conduct studies and analysis to understand the impacts of the war in Ukraine on global food security and grain prices. - Collaborate with policymakers and industry stakeholders to develop strategies and policies that address the challenges posed by the conflict. - Provide evidence-based recommendations on crop diversification, sustainable farming practices, and trade policies that promote global food security. - Disseminate research findings to raise public awareness and facilitate informed decision-making.

6. Media and Journalists: - Report accurately and comprehensively on the causes and consequences of the war in Ukraine on global food prices and grain markets. - Promote understanding of complex economic and geopolitical issues surrounding food security and global agricultural trade. - Highlight the experiences of farmers, consumers, and other stakeholders affected by the crisis to raise awareness and advocate for necessary actions.

The findings and recommendations presented in this research paper provide valuable insights for policymakers, international organizations, and market participants to address the challenges and mitigate the risks associated with the current food crisis. It is essential to prioritize coordinated efforts and proactive measures to ensure food availability and affordability for all.

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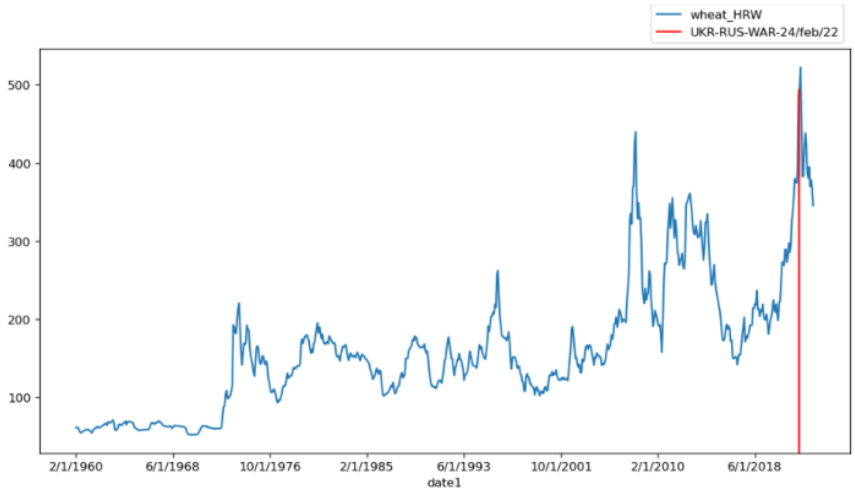
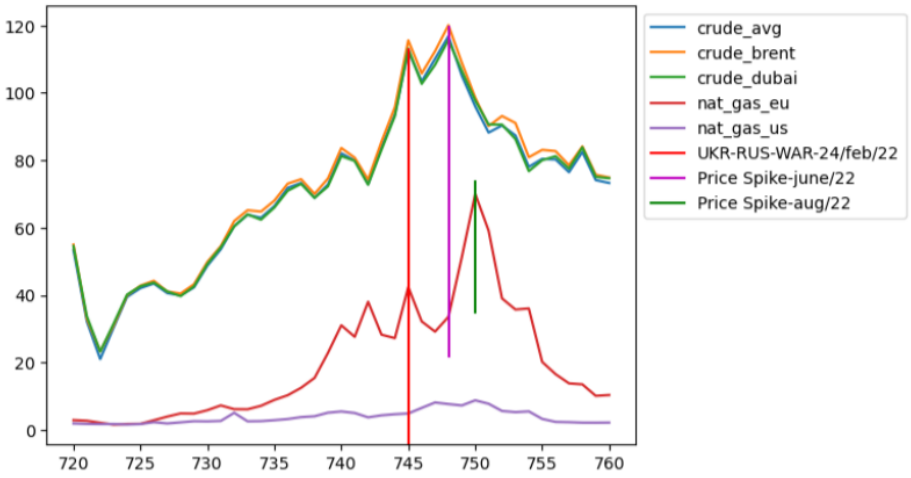


Timeseries Monthly Wheat Pricing Data, Data Range - 1960 - 2023,



Price / Date , Date Range 2020-2023 - Energy Commodities consolidated.

Figure 3: Global Commodity Pricing

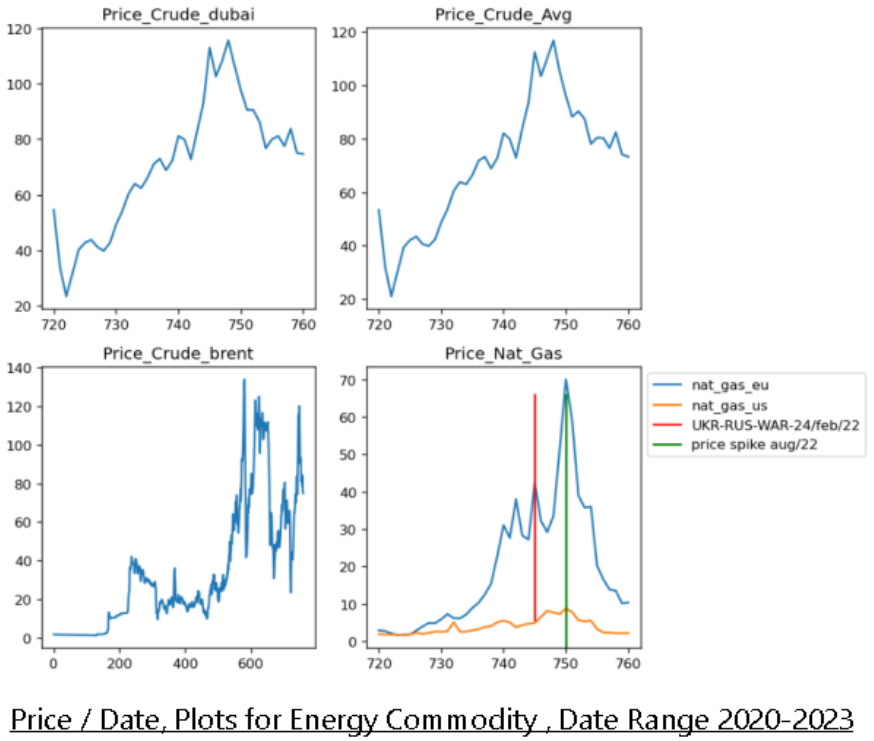
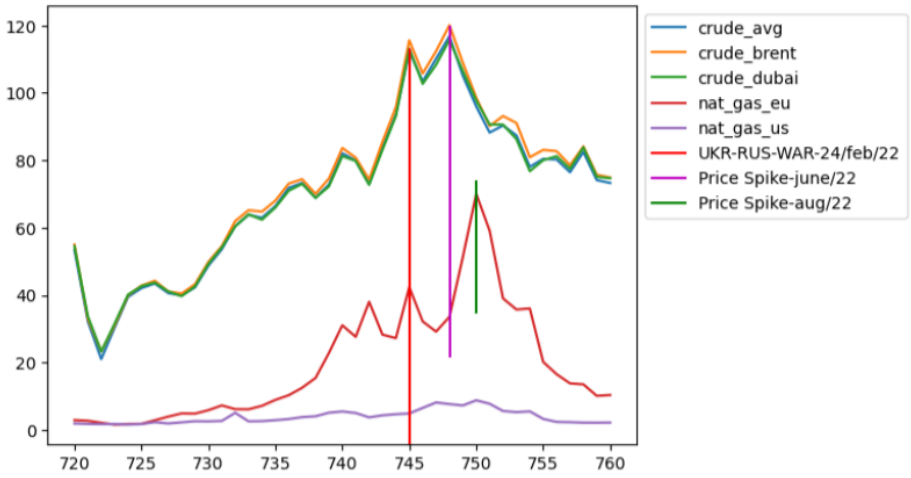
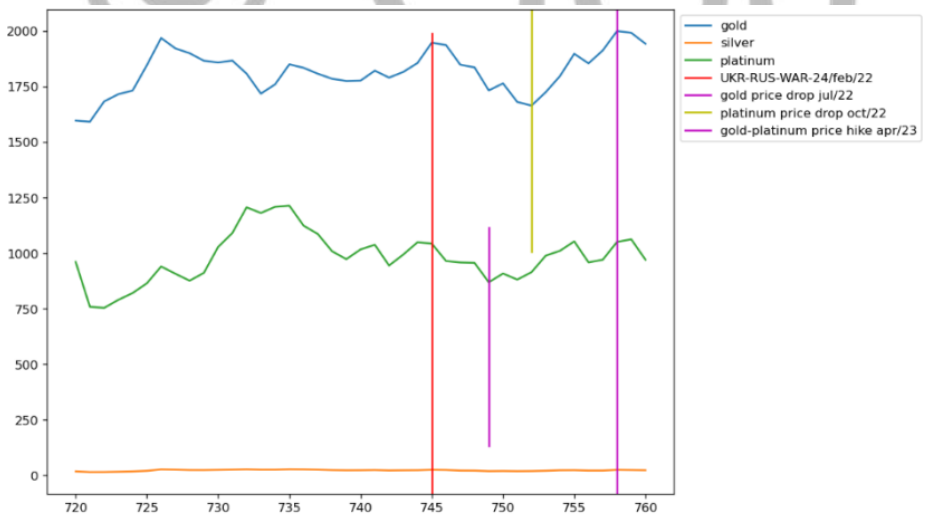


Figure 4: Global Energy Commodity Pricing



Price / Date , Date Range 2020-2023 - Energy Commodities consolidated.

Figure 5: Global Energy Pricing

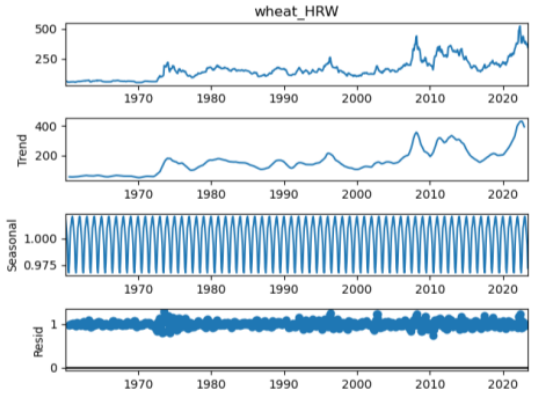


Price / Date , Date Range 2020-2023 - Precious Metals consolidated data.

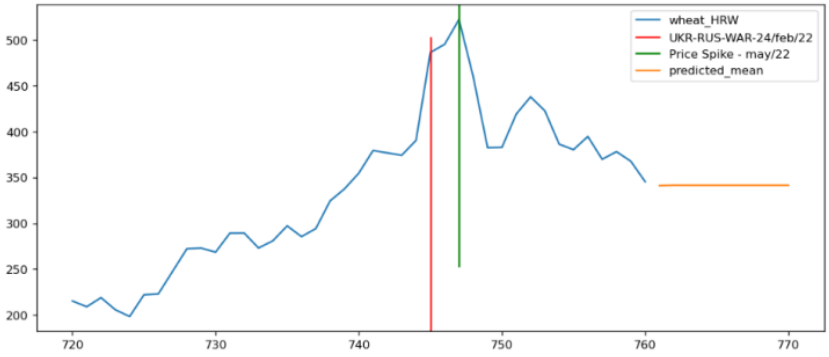
Figure 6: Global Precious Metals Pricing

Price / Date , Date Range 2020-2023 - Agriculture consolidated data,

Figure 7: Agriculture Food Produce Pricing



Seasonal decomposition of Error, Trend , Seasonality and Residual components of Times Series Data using ARIMA Modeling.



ARIMA Model for Wheat forecast based on historical time series data. vertical redline depicts the onset of war on 24/feb/22

Figure 8: ARIMA Model for Wheat Prices forecast

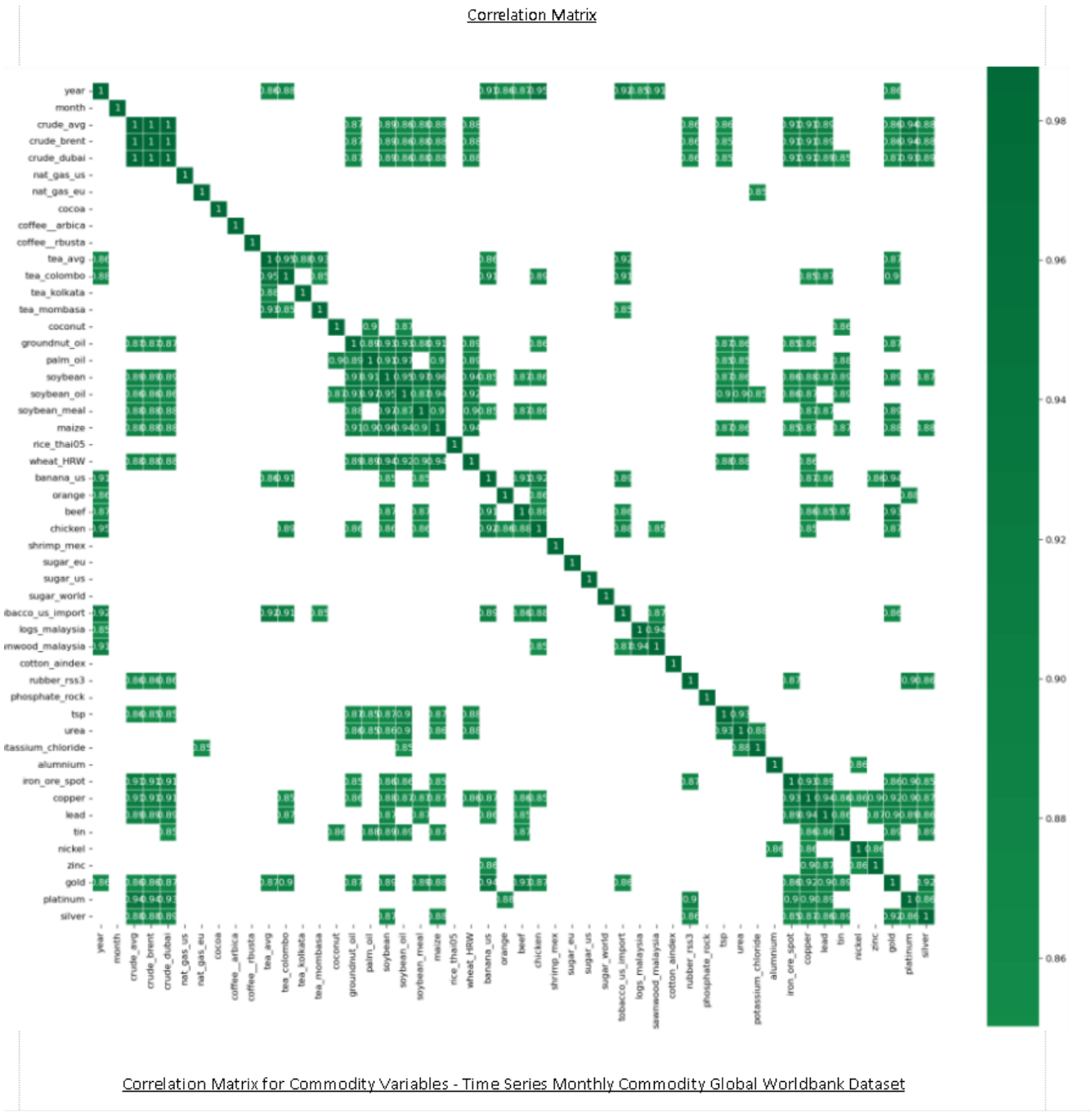


Figure 9: Correlation Matrix

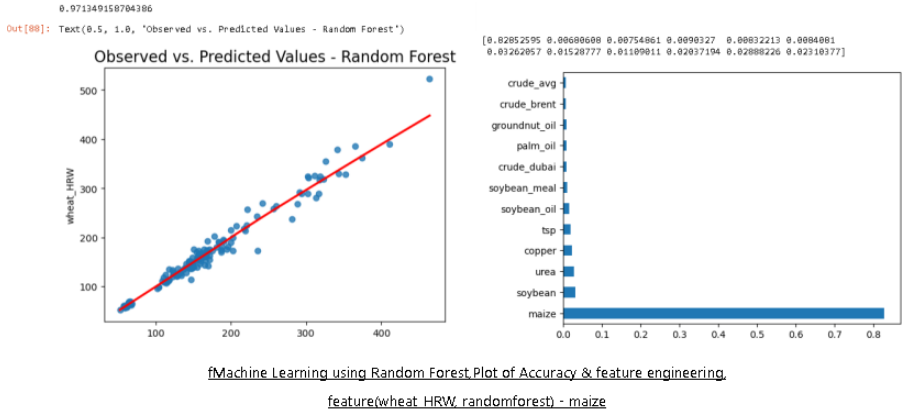


Figure 10: Machine Learning using Random Forest, Plot of Accuracy and feature engineering, feature(wheat, randomforest) , maize

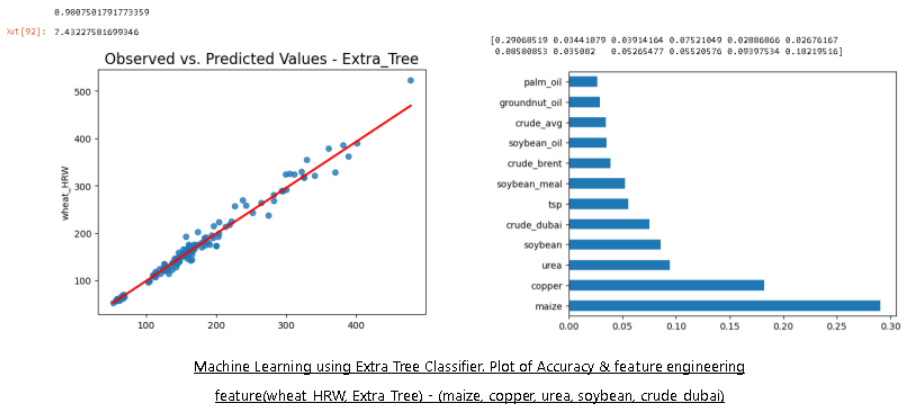
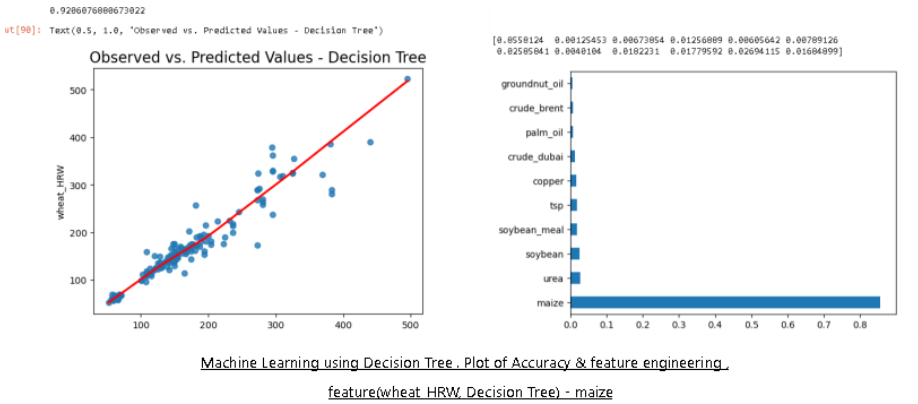


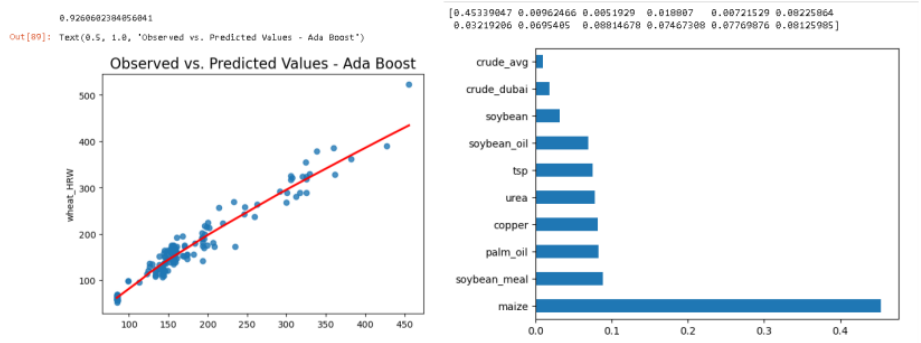
Figure 11: Machine Learning using Extra Tree Classifier. Plot of Accuracy and feature engineering feature(wheat, $\text{Extra}_{T}ree$) – $(maize, copper, urea, soybean, crude_{d}ubai)$



Machine Learning using Decision Tree . Plot of Accuracy & feature engineering .

feature(wheat_HRW, Decision Tree) - maize

Figure 12: Machine Learning using Decision Tree . Plot of Accuracy and feature engineering , feature(wheat, Decision Tree) - maize



Machine Learning using Adaboost Regressor. Plot of Accuracy & feature engineering

feature(wheat_HRW, Adaboost) - (maize, soybean_meal,palm_oil,copper, urea)

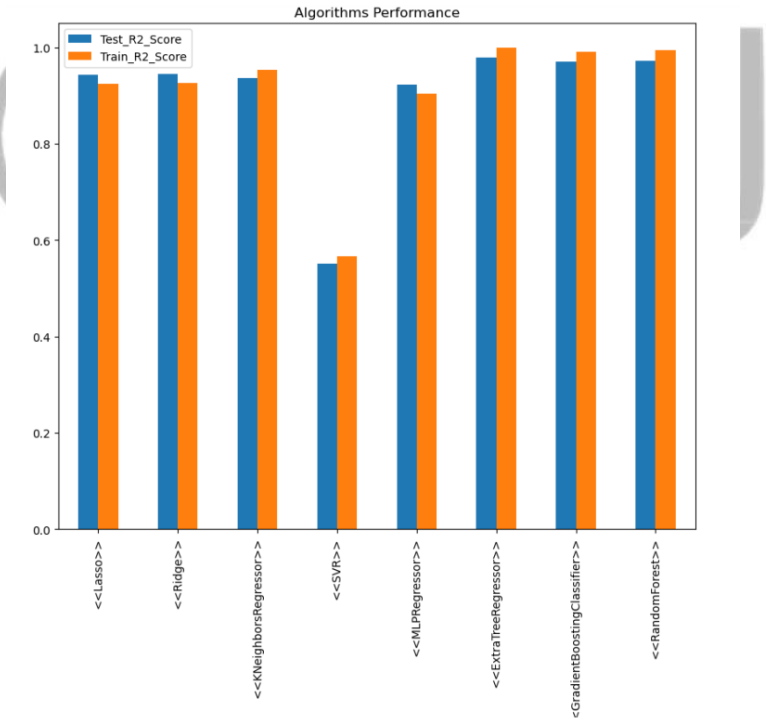
Figure 13: Machine Learning using Adaboost . Plot of Accuracy and feature engineering , feature(wheat, Adaboost) - maize soybeanmeal palmoil copper urea

Out[116]:

	Name	Train_Time	Train_R2_Score	Test_R2_Score	Test_RMSE_Score
0	<<Lasso>>	0.021941	0.925021	0.943693	21.575953
1	<<Ridge>>	0.008974	0.926392	0.944153	21.487577
2	<<KNeighborsRegressor>>	0.000000	0.953201	0.936152	22.975373
3	<<SVR>>	0.039690	0.566594	0.550992	60.927878
4	<<MLPRegressor>>	0.184884	0.904479	0.922247	25.354002
5	<<ExtraTreeRegressor>>	0.488189	1.000000	0.979668	12.965286
6	<<GradientBoostingClassifier>>	0.625715	0.990284	0.971026	15.477167
7	<<RandomForest>>	1.310515	0.993889	0.972377	15.112079

Summary of different Machine Learning Algorithms.

Figure 14: Summary - Accuracy and RMSE of M/L Models



Graphical Comparison of Machine Learning Algorithms Performance

Figure 15: Plot of Algorithms Performance