Project 3 Milestone 3

Forecasting Natural Gas Prices

Final White Paper

Michelle Helfman

Bellevue University

DSC680 -T302 Applied Data Science (2247-1)

Professor Amirfarrokh Iranitalab

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Business Problem:

Natural gas for future use is purchased for speculation and hedging. Speculative commodity purchasing is for making a profit; hedging mitigates risk. Prices are affected by the amount of available natural gas, economic growth, seasonality, weather, geopolitical instability, and the availability and price of other fuels. No matter why it is necessary to forecast future prices, the information generated by the forecasting models is the same.

Using prior natural gas trading to forecast future prices for mitigating risk is a starting point. End-of-day closing prices by month, season, and extended periods can be used to analyze various historical trends and create statistical models to predict future trends.

Background/History:

Natural gas is a vital part of our daily lives. It is primarily used to generate electricity and provide heat. In residential settings, natural gas fuels cooking appliances, clothes dryers, and water heaters. This connection to our everyday routines makes it a commodity of interest, traded through the New York Mercantile Exchange (NYMEX) for near-term consumption or stored for future use when demand increases.

Natural gas is a fossil fuel, like coal and oil, derived from plants, animals, and microorganisms that lived millions of years ago. Over millions of years, organic matter breaks down, creating pockets of natural gas deep underground. In 500 B.C., the Chinese began using natural gas to remove salt from water, making it safe to drink. It was not until 1785 that the British commercialized the use of natural gas created from burning coal, and in 1816, the United

States began to use coal-based natural gas. It was not until the 1920s that natural gas was pumped directly for heating homes and later for cooking and creating electricity.

Data Explanation:

The dataset contains ten years of information about natural gas traded by the New York Mercantile Exchange (NYMEX) through the National Association of Securities Dealers (NASDAQ/NASD). It includes the trade date, opening and closing prices, and the volume traded for each date. Since the stock exchanges do not trade on the weekends, there are no Saturday and Sunday natural gas prices. A cross-reference dataset will create a winter season from December, January, and February data that begins in one year and concludes in another. (see Appendix A and Appendix B)

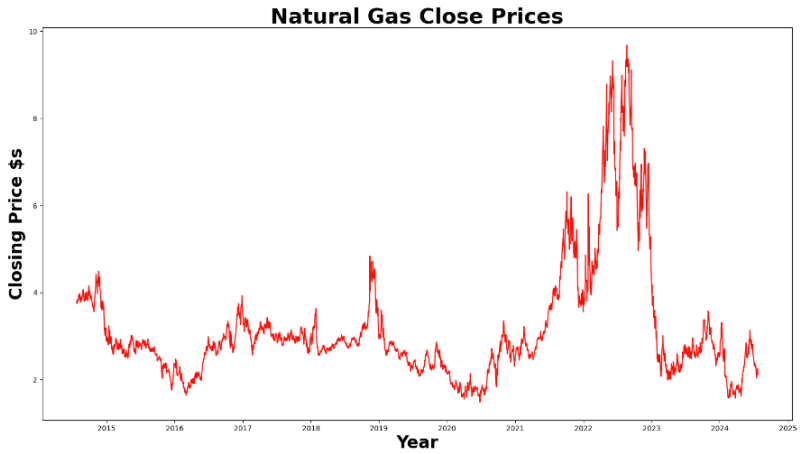
Methodology:

I will perform Exploratory Data Analysis (EDA) to visualize the different pricing and volume trends: monthly, seasonal, and over an extended period. I will then visually compare the annual results between the first four years and the second five years, looking for how things have changed.

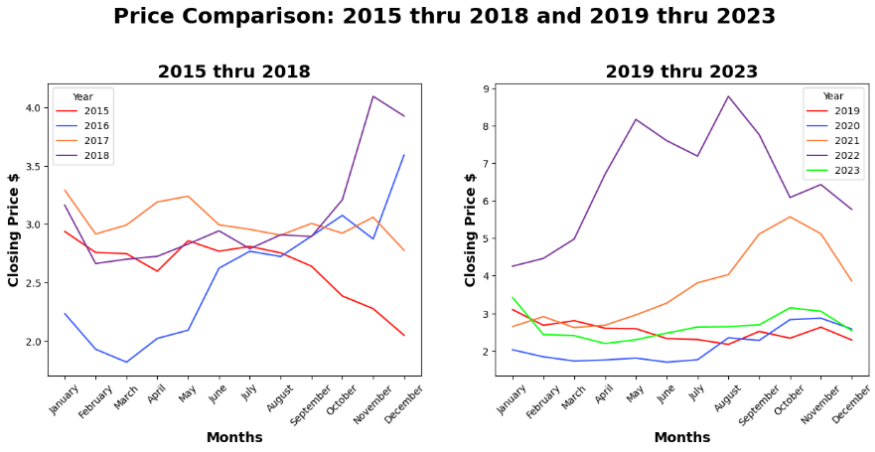
After the initial evaluation, I found no NULLs or zeros; all columns contained meaningful information. I will examine the correlation between the daily closing prices and the volume traded that day. Finally, I will plot the results by forecasting the natural gas prices using Autoregressive Integrated Moving Average (Arima) and Prophet.

Analysis:

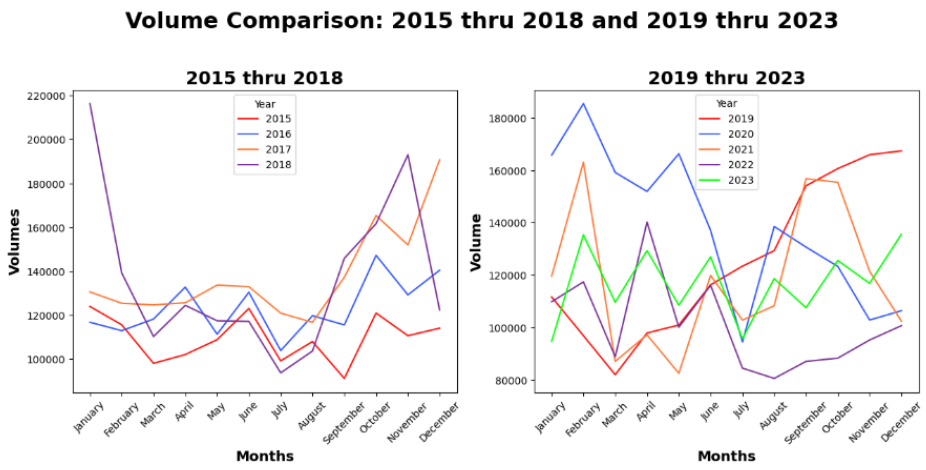
Whether for mitigating risk or speculation, understanding future natural gas pricing trends is essential to the overall goal of a company



While traditionally, the lowest natural gas prices occur during the summer month when usage should be at the lowest level, the Summer of 2022 was a major exception. This price spike was due to a perma-heat wave and lower inventory levels. Some of the lowest prices were during the pandemic in the Summer of 2020 when the United States economy was shut down. A smaller spike occurred during November 2018 because of fears of a colder-than-expected winter. In the Summer of 2024, it is again experiencing some of the lowest prices per MMBtu due to a milder winter and plentiful inventory.

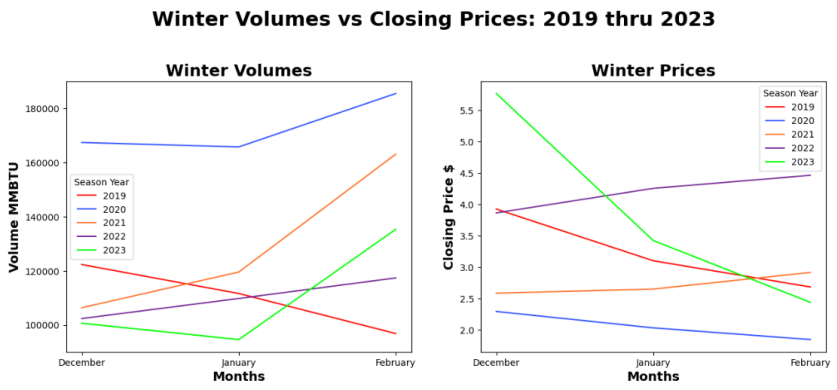


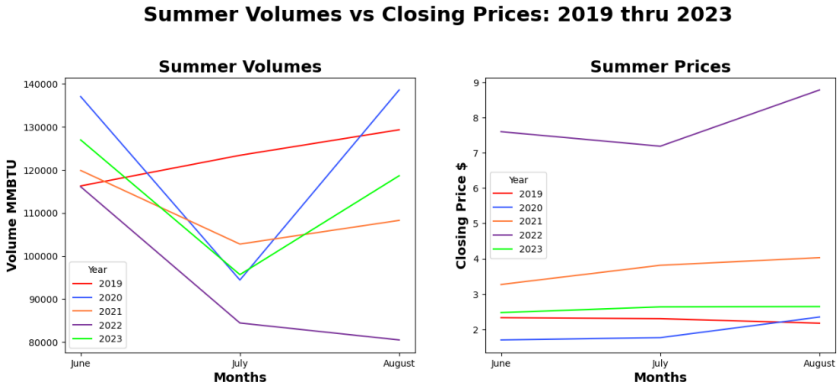
Comparing the first four and the last five full years of data, we can see the pricing spikes in November 2018 and the Summer of 2022 and the lowest sustained prices during the pandemic in 2020. Overall, prices stay between $2.5 and $3.5 per MMBtu.



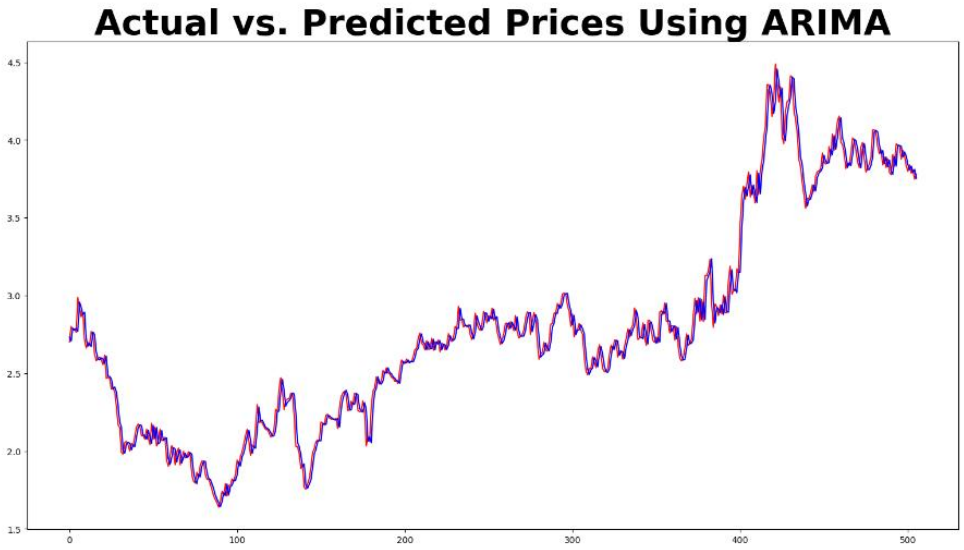
There are no discernable patterns in volumes over the past ten years, but the supply shortage in the Summer of 2022 is noticeable. The shortage of natural gas led to the highest prices during the ten-year data period.

So far in 2024, the prices are below the seasonal averages, but according to the U.S. Energy Information Administration (EIA), inventories are 19% above the five-year average. The EIA expects production to be curtailed and prices to rise in the coming months. Looking at June, that is the case. Comparing the prior volume versus price visualizations, it is unusual that volume and price resemble each other so closely.

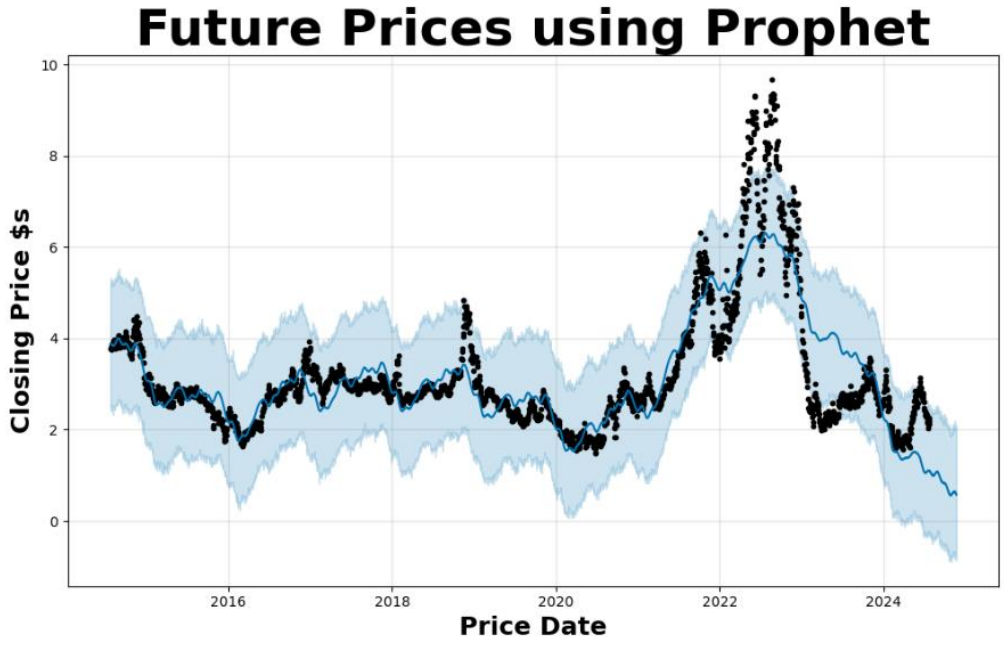




Natural gas prices were the lowest in years during the winter of 2019 - 2020, but demand was the highest even though this was milder than a typical winter. This winter was pre-COVID-19, so demand was not based on just heating homes. The prior fall was colder and snowier than usual; thus, there was a need to tap into natural gas stores earlier than expected, and the reserves were replenished during the following season. In general, excluding the Summer of 2022, prices tend to be more stable during the summer and a regular volume dip in July. Overall, the summer months may still be a good time to purchase some natural gas for the winter to offset an unforeseen increase in price and demand.



The actual values (red) and the predicted values (blue) are in sync, one on the other. The accuracy of the ARIMA model has a Mean Absolute Percentage Error of 2.2%, meaning the accuracy is very high at 97%.



Prophet uses prior information to predict future values for 120 days. The actual values are the dots, and the predicted range is light blue. The predicted values are the blue line going forward 120 days. This model has a wide area of uncertainty, even at the earliest days of forecasting.

Conclusion:

The accuracy is around 97%, showing that the ARIMA model is accurate using prior pricing data. When reviewing pricing and volumes over time, the spikes in prices and the availability of natural gas can be attributed to various weather events. However, predicting the weather accurately four to six months in advance is not realistically possible. Pricing patterns, especially in the past five years, have not conformed to traditional norms of lower prices in the summer and higher prices in the winter. Unless there is a sharp rise or fall in prices, there is very little difference in the overall average. When using Facebook's Prophet, the wide area of uncertainty means the predicted prices could be off as much as a dollar higher or lower.

Assumptions:

We have to assume that prices accurately reflect the state of the natural gas market on that given day. At that moment, inventory supply, weather, current regulations, and geopolitical statuses are taken into account by those purchasing natural gas.

Limitations:

The inability to forecast natural gas prices accurately is primarily driven by unforeseen and unpredictable events that shift expectations for natural gas supply and demand. No matter how accurate the model is today, the farther from the forecast date, the less accurate it becomes, even with an accuracy of 97%.

Challenges:

The natural gas pricing information from the National Association of Securities Dealers (NASDAQ/NASD) represents only Monday through Friday, suitable for training but not for corporate decision-making. After successfully training the initial time series models, index data that reflects all 365 days per year can retrain the model, providing a more complete picture.

While the ARIMA model is good for short-term forecasting, anything over six months is unreliable. Prophet works well for long-term predictions but is complex to tune because of all the options. Forecasting models do not consider outside forces, such as a freak snowstorm in Texas or geopolitical unrest disrupting the supply chain.

Future Uses/Additional Applications:

This model was initially trained using Nasdaq information, reflecting overall natural gas prices. Most trading companies use prices at the pipeline price point, but the information is the same. Since natural gas pricing services have the same form of price data, these models can easily be converted to use any of them. No changes would be needed for visualizations because the data is just trade date, price, and volume.

Recommendations:

No matter how accurately a model can forecast natural gas prices, it cannot be considered independent of other factors. Forecasting models should be part of an ensemble that includes weather, inventory, government regulations, the strength of the United States and global economies, and the general political state of the world. Forecasted natural gas prices cannot be considered on their own.

Implementation:

The data exploratory visualizations and forecasting results can be part of a website with dashboards that can drill down into the natural gas pricing and volume details, facilitating trend analysis of pricing and volumes over time. Taking into account forecasting, analyzing future weather patterns, and considering

events that could disrupt the supply of Liquefied Natural Gas and how all these combined would affect the market when making future purchasing decisions.

Ethical Assessment:

Climate change, with warmer summers and colder winters, contributes to an ever-growing demand for energy; the United States' economic growth and industry knowledge should be included along with the forecasted information when considering whether to hedge on future natural gas prices. A hedging misstep will have consequences for both the company and the customer. The company loses money when the future natural gas price is below the hedged price because the company overpaid for the product and cannot pass on the difference to fixed-rate customers. Consumers, whose costs are based on market rates, will bear the brunt of hedging miscues.

The forecasted prices should be just one piece of the hedging decision. All pieces should be evaluated separately, and how they interact with each other when deciding whether to purchase future natural gas or wait to purchase closer to the time of use.

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Appendix A

Natural Gas Pricing Data File Description

Natural Gas Pricing Data (2529 rows, 6 columns)

- Date – Trading Date from July 25, 2014, through July 24, 2024 (Monday through Friday)
- Close/Last – Price at the end of the trading day
- Volume – Number of MMBtu (1 Million British Thermal Units) units traded per day
- Open – Price at the start of the trading day
- High – Highest traded price during the day
- Low – Lowest traded price during the day

Appendix B

Winter Cross-Reference Data File Description

Winter Dates Data (15 rows, 4 columns)

- Month Name – Calendar month name (December, January, or February)
- Year – Actual calendar year (2018 through 2023)
- Season Year – Year of the winter season (2019 through 2023)
- sort_order – the order the months will appear on the graph.