Executive summary

This report investigates effective hedging strategies to manage risks associated with fluctuations in Jet Fuel spot prices. Due to the limited availability of Jet Fuel futures contracts, we are exploring using futures contracts on Heating Oil and Crude Oil (assets correlated with Jet Fuel prices) as a proxy for cross-hedging. We analyze three hedge strategies: using Heating Oil futures, Crude Oil futures, and a combination of both. Our analysis employs various methods to find the optimal number of futures contracts needed to achieve minimum variance in each strategy across different time periods. Variance here is a measure of risk of our position. Our results show that Heating Oil futures consistently deliver the best proxy for jet fuel futures. This was due to the high correlation between heating oil futures and spot jet fuel prices for our assessment period. Correlation is a way of measuring how much is the strength of a relationship between two metrics, in our case the prices in futures and spot markets. Our devised strategy was successful in reducing exposure to price movements in the spot market by up to 55% in best case scenarios and significantly reducing the cost of this exposure.

The report emphasizes the importance of considering market conditions when choosing a hedging strategy. The analysis explores two contrasting real-world scenarios: the extreme volatility and negative oil prices of April 2020 (super contango), and the high price backwardation environment of March 2022. We highlight how hedging strategies need to adapt to these varying market conditions to achieve optimal risk management. We will also discuss the challenges faced and considerations made for our analysis in detail. The report is not exhaustive and there are several other strategies and techniques that could be adopted to hedge against the risk of jet fuel prices which haven't been discussed.

Approach

In this analysis, different hedging instruments have been analyzed across different time periods to determine the best cross-hedging strategy that could minimize risk against fluctuating jet fuel spot prices. Cross-hedging is a risk management strategy in which the underlying asset in a futures contract differs from the asset being hedged against. This strategy has been used for jet fuel due to insufficient futures on jet fuel. It involves using futures contracts for a different asset such as heating oil that is strongly correlated with the underlying asset that we want to hedge. The aim is to offset the price movements of our target asset with the price movements of the hedged asset.

The analysis examines three cross-hedging strategies that include hedging with heating oil futures only (Case A), hedge with crude oil futures only (Case B) and hedging with both heating oil and crude oil futures (Case C). The price fluctuations of these assets correlate with those of Jet fuel spot prices, making them suitable choices for this analysis (Turner & Lim, 2015). Considering the underlying asset in the futures contracts differ from the asset being hedged, the purpose of this analysis is to deduce the optimal number of contracts that would reduce risk exposure for each strategy and further assess which strategy produces the best results.

To arrive at the optimal number of contracts, we compute the minimum variance hedge ratio using different estimation methods including a simple approach, Simple and Multiple Linear Regression and Solver on MS excel. We know that the hedge ratio is defined as “the ratio of the size of the position taken in futures contracts to the size of the exposure” (John Hull, 2021). We, therefore, calculated the minimum variance hedge ratio for each strategy and each time period so as to arrive at a hedge ratio which showed the lowest variance in the hedged position and determine the optimal number of future contracts for that hedged position.

In the assessment of which strategy worked best, both, in sample analysis and out of sample forecasting were carried out. For this purpose, the hedge ratio computed from in sample analysis was applied to out of sample datasets to gauge the performance of the proposed hedges. The differences in variances between hedged and unhedged positions and also the hedge effectiveness were parameters looked at to compare which strategy outperformed across different time periods.

Our Results

When considering the choice of futures contracts for the hedge, it is imperative that the correlation between the asset to be hedged and the underlying asset in the futures contract is high. A strong positive correlation indicates that the movement in prices between the two assets occurs in a similar manner and direction. From our analysis, we noted a strong position correlation between Jet Fuel spot prices and Heating oil futures prices across all sample periods. In contrast, crude oil futures had a very low correlation with spot prices of jet fuel with a negative correlation in Sample 2. From these results, we can infer that crude oil would not provide a material hedge against market risk.

Correlation	In sample 1	In sample 2	In sample 3
	Jet fuel spot prices		
Heating oil	0.89	0.85	0.82
Crude oil	0.11	-0.09	0.13

Based on the calculations, we computed the following minimum variance hedge ratios and optimal number of contracts across different sample periods. These are summarized in the table below:

Scenario Analysis: Optimal Hedge ratios & no. of contracts	In Sample 1		In Sample 2		In Sample 3	
	MHR	Contracts	MHR	Contracts	MHR	Contracts
Hedging with heating Oil futures only	0.9154	436	0.8727	416	1.0772	513
Hedging with crude Oil Futures only	0.0007	0	-0.0041	-2	0.0077	4
Hedging with Heating Oil futures * Crude Oil Futures						
Heating oil futures	0.9133	435	0.8767	417	1.0768	513
Crude oil futures	0.0001	0	-0.0054	-3	0.0001	0

A notable observation to make here is that, across all time periods, the minimum hedge ratio and the optimal number of contracts for crude oil have been consistently very low across all in-sample periods. Infact in in-sample 2, these values also come out to be negative. To determine the best strategy for hedging, we assessed the reduction in risk or Standard Deviation between hedged and unhedged positions, which as we know would be the lowest for the optimal number of contracts. To evaluate the effectiveness of the hedge for forecasting purposes, we applied the optimal number of contracts to out-of-sample datasets. Each in-sample data had a separate out-of-sample dataset. We also looked at hedge effectiveness which indicated the percentage of variance removed by hedging. The tables below summarize the results.

Scenario Analysis: reduction in risk (in %)	Sample 1		Sample 2		Sample 3	
	In Sample results	Out of sample forecast	In Sample results	Out of sample forecast	In Sample results	Out of sample forecast
Hedging with Heating Oil futures only	55.04%	52.41%	47.3%	41.28%	43.4%	47.74%
Hedging with crude Oil Futures only	0.58%	-0.08%	0.4%	-1.08%	0.8%	0.07%
Hedging with Heating Oil futures * Crude Oil Futures	55.09%	51.97%	48.7%	40.33%	43.4%	47.76%

Scenario Analysis: Hedge Effectiveness	Sample 1	Sample 2	Sample 3
	In Sample results	In Sample results	In Sample results
Hedging with heating Oil futures only	79.78%	72.27%	67.98%
Hedging with crude Oil Futures only	1.16%	0.82%	1.62%
Hedging with Heating Oil futures * Crude Oil Futures	79.83%	73.67%	67.98%

The following are some key findings from this analysis:

- Hedging with a combination of Heating Oil and crude futures delivered the best in-sample and out of sample performance across all three time periods. This combination produced the highest risk reduction consistently across all time periods. However, this was only marginally better than the risk reduction achieved by hedging with Heating Oil futures only, which also performed well across all time periods and for both in-sample and out-of-sample data sets.
- The best hedge was achieved from the minimum hedge ratio estimated for In-Sample 1 dataset with the highest risk reduction of 55.09% for hedging with a combination of Heating Oil and crude futures. This was closely followed by 55.04% risk reduction through hedging with Heating Oil futures only.
- The hedge effectiveness which we retrieved from MLR, was the highest for in-sample 1, indicating that the combination of Heating Oil and crude futures reduced the most variation followed by hedging with Heating Oil futures only.

In determining which hedge is the best, we would consider hedging with Heating oil futures only. Apart from considering the key findings above, we also considered the correlation between Jet Fuel spot price and Heating oil futures. We believe that hedging with heating oil futures only would be the best strategy and the minimum variance hedge ratio and optimal number of contracts for adopting the best hedged position would be 0.9154 and 436 contracts, respectively.

Challenges & Recommendations

One of the most pressing challenges we recognized while undertaking our analysis was that we made use of historical data. In a backward-looking analysis, forecasts of what the future market conditions will be are lacking. In practice, hedgers often “hedge-and-forget”. This means that they fail to account for daily changes in the parameters estimated to create the best possible hedge after locking in their futures position at the start of the hedge. As the parameters mentioned above, which include volatility of changes in Jet fuel spot prices and future prices of different hedging instruments and the correlation between the two, changes, so does the hedge ratio. Therefore, this analysis and the results computed above will not remain constant as new market information comes into light. Consequentially, any dramatic fluctuations in prices can lead to significant hedging losses if the timing or the type of hedging strategy is not aligned perfectly with market movements.

As a solution to the issue described above, we recommend that the hedger takes a dynamic position to hedging or employs flexible hedging strategies. A dynamic position in hedging would involve constant monitoring and re-adjustments of future position in response to newly presented market information. Alternatively, the hedger could also leverage flexible hedging strategies, which entail employing more flexible instruments such as options. To elaborate further on this, options are a type of contract that gives the buyer of an option the right to exercise a contract to hedge

unfavorable market movements. Take, for instance, a call option which offers the buyer the right to sell a commodity later as a pre-agreed or strike price. This sort of safety net is especially valuable if the spot price falls below the strike price. In such a case, the owner of the call option can execute the option and cushion any losses incurred if the hedged future position fails to reduce risk.

Analysis of Market Condition

Negative oil prices and super contango in Apr 2020

Super-contango is when the spot price for a commodity is trading dramatically below the futures price.

The May 2020 futures contract for West Texas Intermediate (WTI) crude oil, a benchmark for US oil prices, fell to an unprecedented negative value of $37.63 per barrel on April 20, 2020. The oil futures contract has traded at a negative price for the first time in history.

The primary factors that led to this dramatic collapse in oil prices were:

1. Unprecedented demand destruction: The COVID-19 pandemic caused a massive drop in global oil consumption, leading governments to impose lockdowns and travel restrictions that resulted in an impoverishment of fuel consumption.

2. Oversupply and lack of storage: With demand plummeting, oil producers were left with a glut of crude oil that they struggled to store, leading to a supply-demand imbalance. As a result, some producers were forced to pay the buyers to take the oil off their hands.

However, not all oil prices went negative. The international benchmark, Brent crude, settled at $25.57 per barrel on April 20, down 8.9% but still in positive territory. In contrast to the landlocked WTI that trades at Cushing, Oklahoma's storage hub, Brent crude is a seagoing commodity with more flexibility in terms of storage and transportation.

Futures contracts are agreements to buy or sell oil at a predetermined price on a specific date in the future. Owning oil on delivery day became a burden rather than an asset when storage tanks are approaching capacity.

Additionally, the May 2020 WTI contract was set to expire the following day, and traders holding long positions in that contract were desperate to avoid taking physical delivery of the oil, as storage capacity was rapidly filling up, traders holding expiring WTI May 2020 contracts resorted to selling them at a loss, even if it meant negative prices (U.S. Energy Information Administration. This created a unique situation where the imminent expiration of the May contract, combined with the lack of storage, led to unprecedented negative pricing.

In contrast, the June 2020 WTI contract, which was more actively traded, fell about 18% to settle at $20.43 per barrel, while the July contract was approximately 11%

lower at $26.18 per barrel. This shows a major divergence in the lead months contract with subsequent monthly contracts, which have not been as severely affected by storage restrictions.

The complex interplay between supply, demand and storage capacity on the oil market has been highlighted by events of April 20, 2020. While a unique set of circumstances led to the never-before-seen negative WTI prices, it serves as a stark reminder of the oil industry's vulnerability to external shocks of the oil futures market and the need for better coordination between producers, regulators, and market participants to prevent such extreme price volatility in the future.

Backwardation in March 2022

Backwardation is when the current price of an underlying asset is higher than prices trading in the futures market.

On April 20, 2020, the oil futures market experienced an unprecedented event when the price of West Texas Intermediate (WTI) crude oil plummeted into negative territory for the first time in history. This was primarily due to a combination of oversupply and lack of storage capacity amidst the COVID-19 pandemic-induced demand slump. Traders holding May contracts found themselves in a desperate situation as they faced the prospect of taking physical delivery of oil without adequate storage facilities, leading to panic selling and pushing prices into negative territory.

On April 21, 2020, the oil futures markets continued to exhibit extreme volatility as traders grappled with the fallout from the previous day's historic plunge. The futures curve on this day likely reflected the heightened uncertainty and turmoil in the market. In a typical futures market, prices for contracts further out in the future are higher than those for immediate delivery, reflecting storage costs, time value of money, and other factors. However, during periods of extreme stress like what occurred in April 2020, this relationship can become distorted, leading to what is known as a "super contango."

The June 2020 WTI contract settled at $20.43 per barrel, while the July contract was approximately 11% higher at $26.18 per barrel. This significant disconnect between the front-month contract and the later-dated contracts demonstrated the market's expectation of a continued supply-demand imbalance and the need for storage capacity.

The super contango in the oil futures market on April 21, 2020 reflected the market's assessment that the oversupply and lack of storage would persist in the near term, even as producers and policymakers worked to address the crisis. The steep backwardation in the futures curve indicated that market participants anticipated a gradual recovery in demand and rebalancing of the market over the coming months and years.

Implications

Market Conditions on April 20, 2020:

- Extreme Volatility: The data shows extraordinarily low prices, with the May 2020 contract closing at $4.55 and a significant price drop during the session (opening at $14.00).
- Contango: The futures prices were in super contango, evidenced by higher prices in future months (e.g., June 2020 at $20.47). This indicates that the market expected future prices to be higher, mainly due to current oversupply and anticipated recovery in demand.

Market Conditions on March 29, 2022:

- Higher and More Stable Prices: Prices were substantially higher across all futures contracts, with the May 2022 contract at $105.21 and the subsequent months showing relatively stable prices (June 2022 at $102.86).
- Backwardation: Unlike in 2020, the futures curve in 2022 shows prices decreasing in future months (e.g., May 2022 at $105.21 and March 2023 at $85.54), indicating a backwardation market structure. This suggests that the market expected the current high prices to decline over time, possibly due to forecasted decreases in demand or increases in supply.

Implications on Risk Management Practices:

- Volatility Management:

2020: Risk management needed to focus heavily on managing extreme volatility and negative price risks, particularly around physical delivery and storage logistics.

2022: Strategies should still account for high prices and volatility but could also leverage standard hedging tools more effectively, as the risk of negative prices was not present.

- Liquidity Concerns:

2020: Ensuring liquidity was critical, especially when closing or rolling over positions in a highly volatile market. Companies needed robust liquidity plans to manage these risks.

2022: Although prices were high, the market structure was more stable, likely offering better liquidity and fewer surprises during rollovers.

- Strategic Adjustments:

2020: Companies had to be agile, revising their long-term contracts and storage strategies drastically. There was a need for innovative thinking to manage or mitigate unprecedented risks such as negative prices.

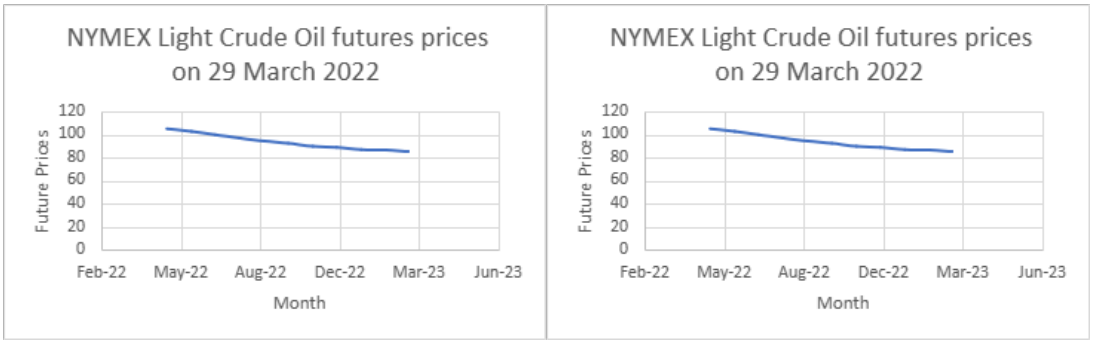
2022: With a more predictable albeit high-price environment, companies could return to more traditional risk management practices but remain vigilant about potential downturns in prices as indicated by the backwardation.

- Hedging Strategies:

2020: Diverse and flexible hedging strategies were necessary to cope with the extreme market conditions. Options and swaps could have been more effective than futures alone.

2022: More straightforward hedging strategies could be used to lock in profits or protect against declines in prices, with a focus on optimizing the timing and selection of instruments due to backwardation.

Overall, the transition from extreme contango and negative prices in 2020 to a more traditional but high-priced backwardation market in 2022 shows how dynamic the oil market can be. Risk management practices must be equally dynamic, adapting to the changing market conditions to protect against losses and capitalize on opportunities.



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