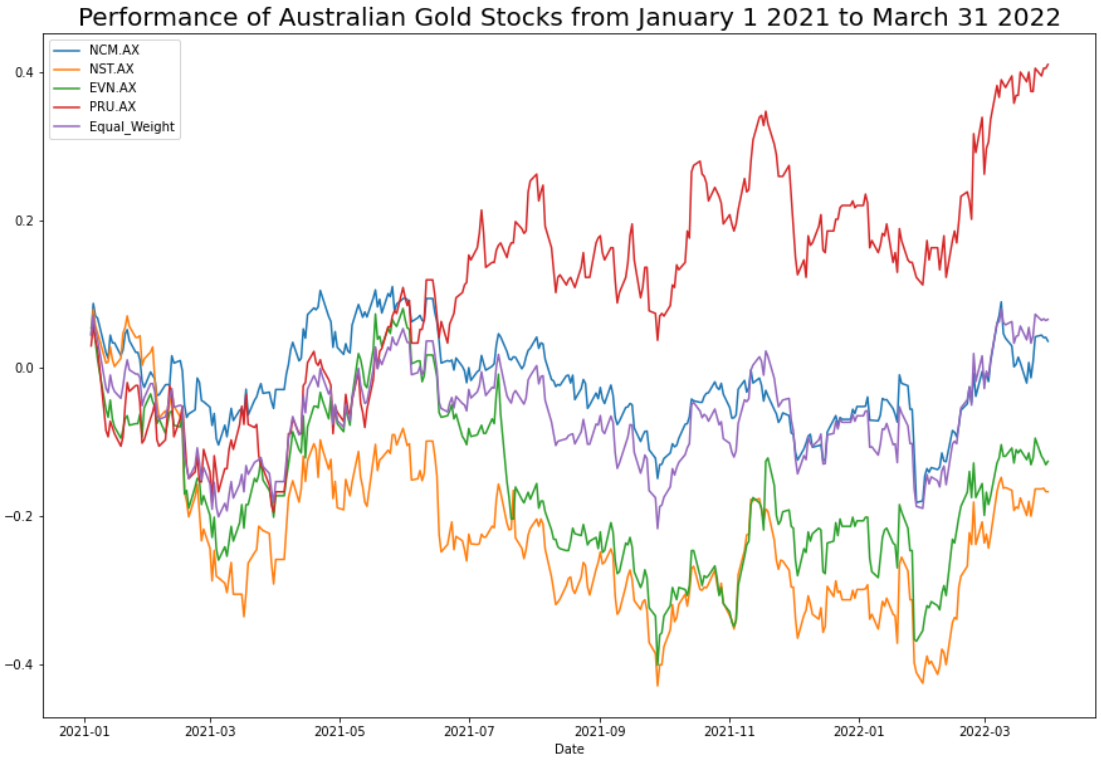
Hedging an Equity Portfolio with Futures

Assume AUD500,000 is to be invested in an equal-weighted portfolio on April 1, 2022, for 3 months. The portfolio will comprise four Australian stocks: NCM, NST, EVN and PRU all of which are from the gold exploration and production sector. This report documents the process of identifying market risks to be hedged with an appropriate futures contract.

Company Analysis

The market risks that each company is exposed to can be determined by analysing recent financial reports. In March 2022, Newcrest Mining's (NCM) gold production costs dropped by 10% caused by higher sales of gold and copper, higher copper prices, and fewer fixed investments. Revenue for Northern Star Resources (NST) increased by 40% due to an increase in gold prices of 3%. Evolution Mining (EVN) saw a 9% decline in income due to decreased gold production and lowered average gold prices. For Perseus Mining (PRU), gold, copper, and silver brought in $753.9 million, $135.1 million, and $9.7 million respectively.



State of the Gold Market

An information timeline leading up to 1 April 2022 can reveal macroeconomic factors that may impact gold prices over the next 3 months.

March 16, 2022 (Schneider and Saphir, 2022)

The Federal Reserve increased interest rates and a hawkish strategy was made public, shifting focus from the COVID-19 pandemic to the fight against high inflation.

March 22, 2022 (Patel, 2022)

After Jerome Powell suggested tougher monetary policy to combat inflation, treasury yields increased, and gold prices dropped more than 1% to a week low. Despite gold being regarded as a hedge against inflation, storing non-yielding gold has a higher opportunity cost when US interest rates rise.

March 28, 2022 (Reuters, 2022)

10-year bond yields reached their highest level since April 2019, helped by predictions that the Federal Reserve would raise interest rates aggressively to combat skyrocketing inflation.

March 31, 2022 (Reuters, 2022)

Gold prices decreased on Friday, widening its weekly losses as a stronger dollar outweighed safe-haven demand fuelled by the failure of the Russia-Ukraine peace talks. Investors were waiting for the March jobs report, which was scheduled for release later in the day, for clues on wage inflation and the Federal Reserve's future stance on monetary policy. The FOMC members will vote on where to set the rate on May 5 and June 16, 2022

Major Risk in the portfolio

Based on the timeline of gold market and U.S. jobs report, the Fed may decide to act more aggressively by raising interest rates to combat inflation. Even though gold is regarded as a hedge against inflation, rising U.S. interest rates raise the opportunity cost of owning non-yielding bullion and could cause a decline in gold prices. This fall in gold prices is a major risk that can be hedge by shorting gold futures.

Choice of futures contract

Contract	Contract Months	Last trading day
YAP: ASX SPI 200 Index Futures	MAR/JUN/SEP/DEC up to 6 quarter months ahead along with 2 nearest serial months	3rd Thursday of the settlement month
GC: CME Gold Futures	Conducted for delivery during the current calendar month	3rd to last business day of the maturing delivery month

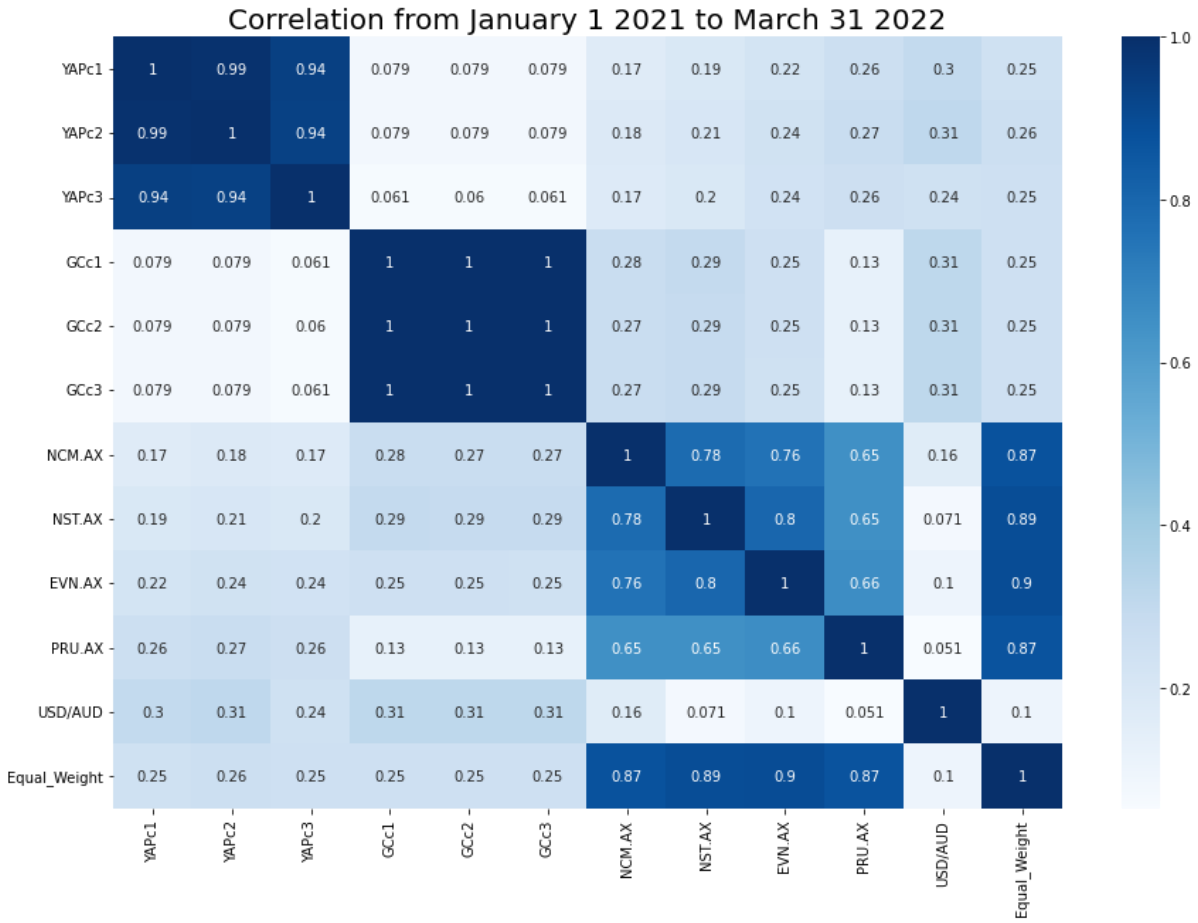
- YAPc1: 16 June 22
- YAPc2: 15 Sep 22
- YAPc3: 15 Dec 22
- GCc1: 27 April 22
- GCc2: 27 May 22
- GCc3: 28 June 22

Source: Refinitiv Data

The risk of a futures contract's value deviating from the underlying asset is known as basis risk. The potential of a perfect hedge is eliminated due to this basis fluctuation. The decision made on the futures contract to be used for hedging is a significant factor that affects basis risk (Hull, 2018). There are two options here:

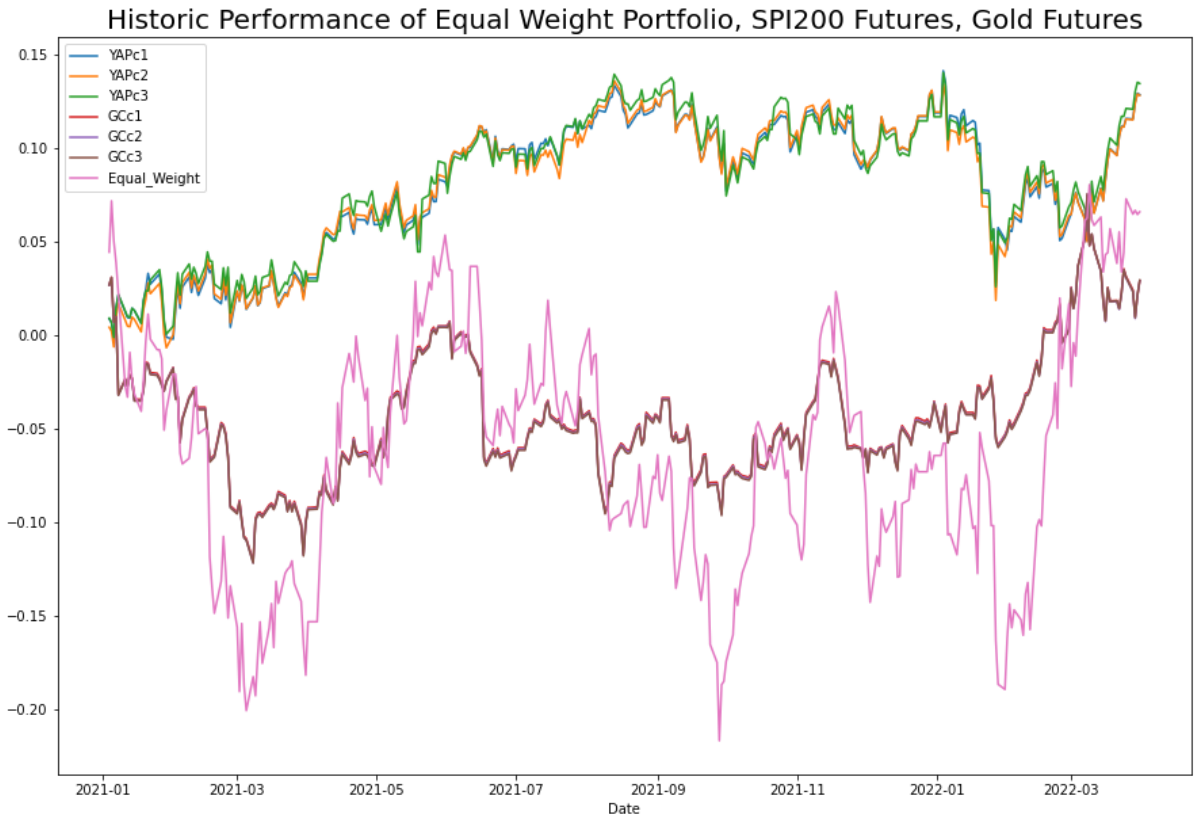
1. The choice of the asset underlying the futures contract
2. The choice of the delivery month

Cross-hedging is when there must be sufficient correlation for the hedge to be effective when the futures and portfolio are not fully identical. From January 1, 2021, through March 31, 2022, a simulation of an equal-weight portfolio was created. The equal-weight portfolio during this time had the highest correlation with YAPc2.



	r	p-value
Equal_Weight	1.000000	0.000000
YAPc2	0.260953	0.000002
GCc1	0.251309	0.000005
GCc3	0.250326	0.000005
GCc2	0.250100	0.000005
YAPc3	0.248982	0.000006
YAPc1	0.245097	0.000008

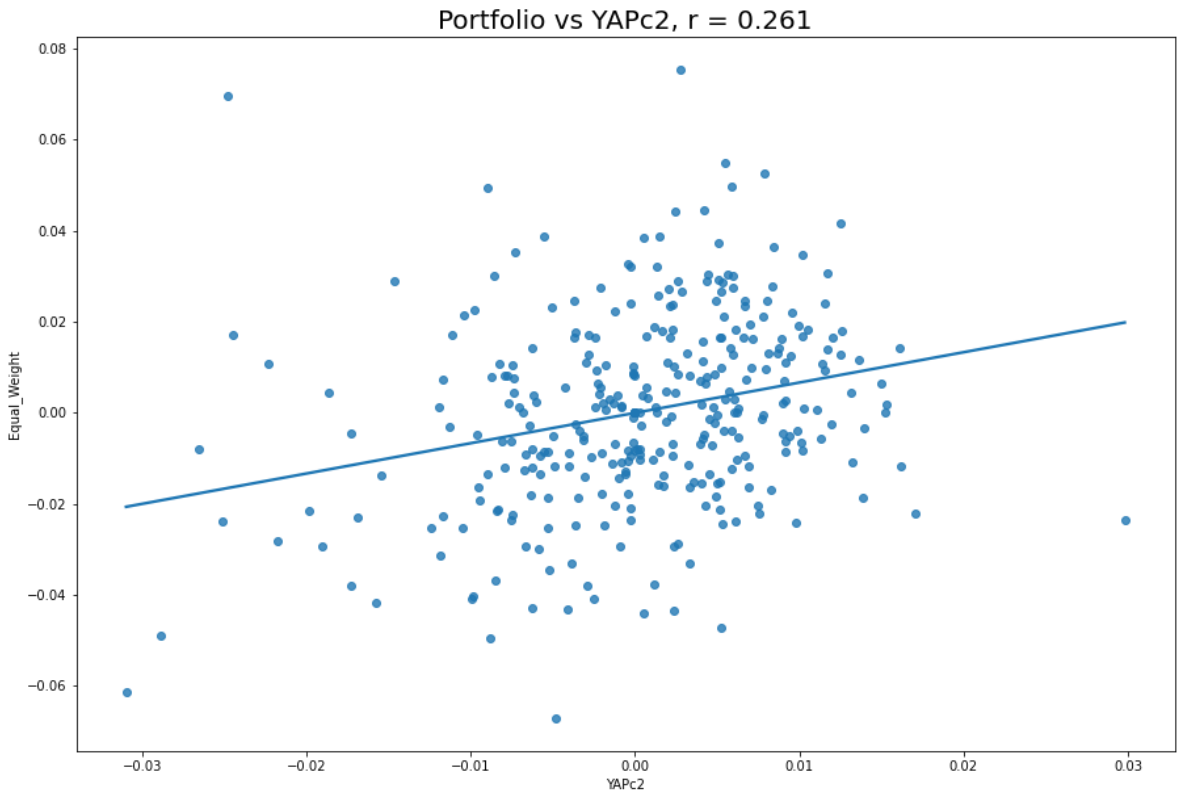
As with the delivery month, basis risk increases as the time difference between the hedge expiration and the delivery month increases. Choosing a delivery month that is as close as possible to the hedge's expiration date but later than that date is a good general rule of thumb (Hull, 2018). Despite the YAPc2 contract having a higher correlation, the GCc3 contract, which expires on June 28—the day that is closest to the hedging period—is the ideal futures contract to use as a hedge. Given that gold futures are fundamentally more linked to individual equities, it is logical to assume that this correlation will endure throughout the upcoming three months.



Implementation of hedge

Hedging the portfolio beta is necessary to provide short-term protection from the identified monetary policy risks.

NCM, NST, and EVN are more correlated to gold futures than SPI 200 Futures. PRU has twice the correlation to YAPc2 than the gold futures. As a result, the equal-weight portfolio was more correlated to YAPc2. It also has an expiration date of September 15, which is later than the hedging period but closest to it. Therefore, the hedge will be implemented using the YAPc2 contract.



Calculation of the hedge ratio

Defining:

- VA: Current value of the portfolio
- Vf: Current value of one futures contract

The number of futures contracts used to hedge is:

$$N_f = -\beta * \frac{V_A}{V_f}$$

This formula assumes the futures contract's maturity is close to the maturity of the hedge (Hull, 2018).

Stock	Beta
NCM.AX	0.5445
NST.AX	0.7554
EVN.AX	0.1287
PRU.AX	0.7517

The equal-weight portfolio beta is the sum of beta weighted by 25%, giving 0.545.

<u>On 1 April 2022:</u>

- YAPc2 Index Futures: 7469
- Multiplier: $25
- Value of futures = 25 * 7469 = 186,725

$$N_f = -0.545 * \frac{500{,}000}{186{,}725} = -1.46$$

The optimal number of futures contracts to short is 1. Using the fees from Interactive Brokers, this would incur a cost of $18,679.65 (initial margin of $18,675 + cost of $4.65). This leaves $481,320.35 to invest in the equal-weight portfolio, which would incur a transaction fee of $385.1.

Transaction costs from Interactive Brokers

Stocks **0.08% of trade value**	481,320.35 Trade Value = AUD 385.1
Futures **AUD 3.55/contract**	1 SPI Futures Contract = IBKR Execution Fee AUD 3.55 + Exchange Fee AUD 1.10 + Regulatory Fee AUD 0.00 = AUD 4.65
Overnight Initial for SPI	18,675 per contract
Overnight Maintenance for SPI	14,940 per contract

Source: Interactive Brokers

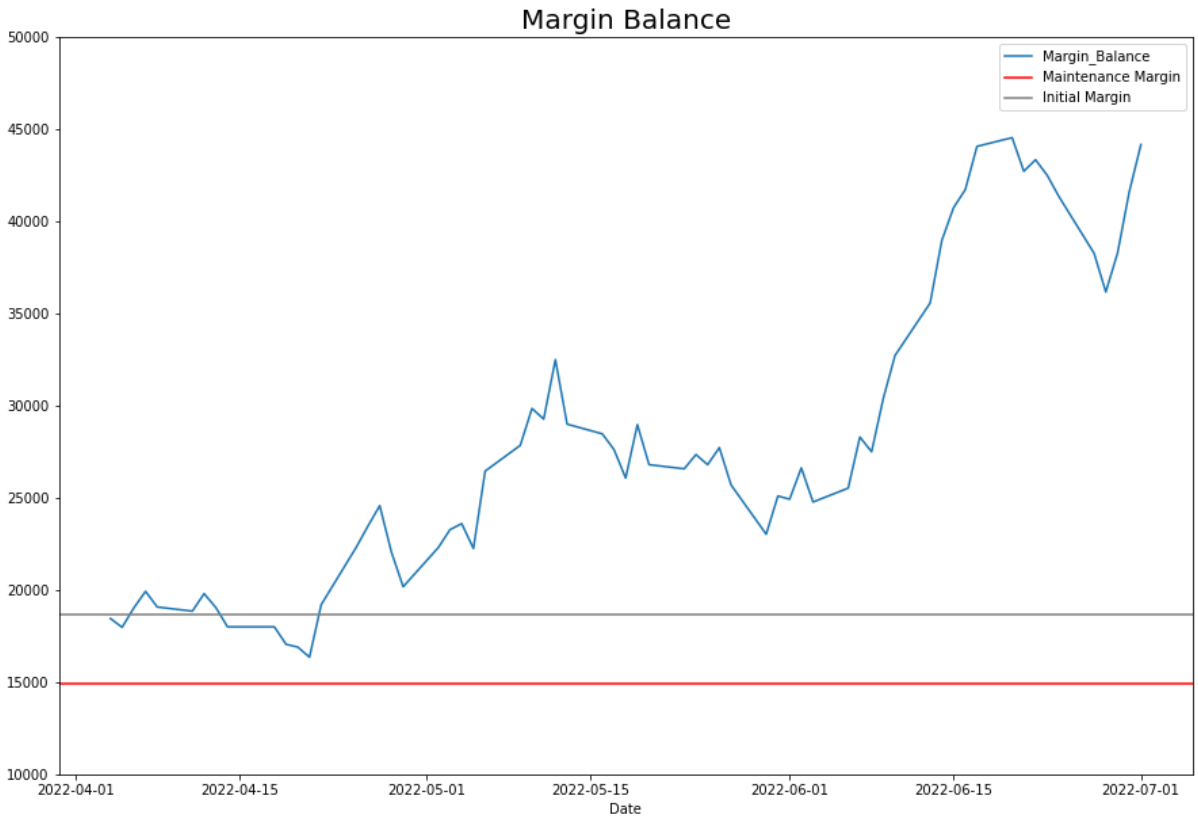
	Stock	Beta	Price	Shares	Value	Weight	Weighted_Beta
0	NCM.AX	0.5445	26.930	4464.0	120215.52	0.249978	0.136113
1	NST.AX	0.7554	10.500	11450.0	120225.00	0.249997	0.188848
2	EVN.AX	0.1287	4.330	27767.0	120231.11	0.250010	0.032176
3	PRU.AX	0.7517	1.855	64816.0	120233.68	0.250015	0.187936

- Beta of portfolio: 0.545 (sum of Weighted Beta)
- Value of portfolio: $480,905.31 (sum of Value)

Futures transaction details

Date	Trade_Price	Settlement_Price	Futures_Value	Daily_Gain	Cumulative_Gain	Margin_Balance	Margin_Call
2022-04-01	7469		186725	0.0	0.0	0.0	18675.0
2022-04-04		7478	186950	-225.0	-225.0	18450.0	0.0
2022-04-05		7497	187425	-475.0	-700.0	17975.0	0.0
2022-04-06		7455	186375	1050.0	350.0	19025.0	0.0
2022-04-07		7419	185475	900.0	1250.0	19925.0	0.0
...	...	...	...	...	...	...	...
2022-06-27		6685	167125	-3075.0	19600.0	38275.0	0.0
2022-06-28		6769	169225	-2100.0	17500.0	36175.0	0.0
2022-06-29		6685	167125	2100.0	19600.0	38275.0	0.0
2022-06-30		6552	163800	3325.0	22925.0	41600.0	0.0
2022-07-01	6449		161225	2575.0	25500.0	44175.0	0.0

Initial margin is the amount deposited to enter the contract. Marking to market, is the process of adjusting the margin account to reflect the trader's profit or loss at the close of each trading day (Hull, 2018). If the balance falls below the maintenance margin of $14,940, a margin call is received. The margin account needs to be topped up to the initial margin level of $18,675 or else the broker closes out the position. This is one of the key roles of the exchange so that futures contract defaults are avoided.



Over the 3 months, the margin balance stayed above the maintenance margin of $14,940 so there was no margin call.

Equity transaction details

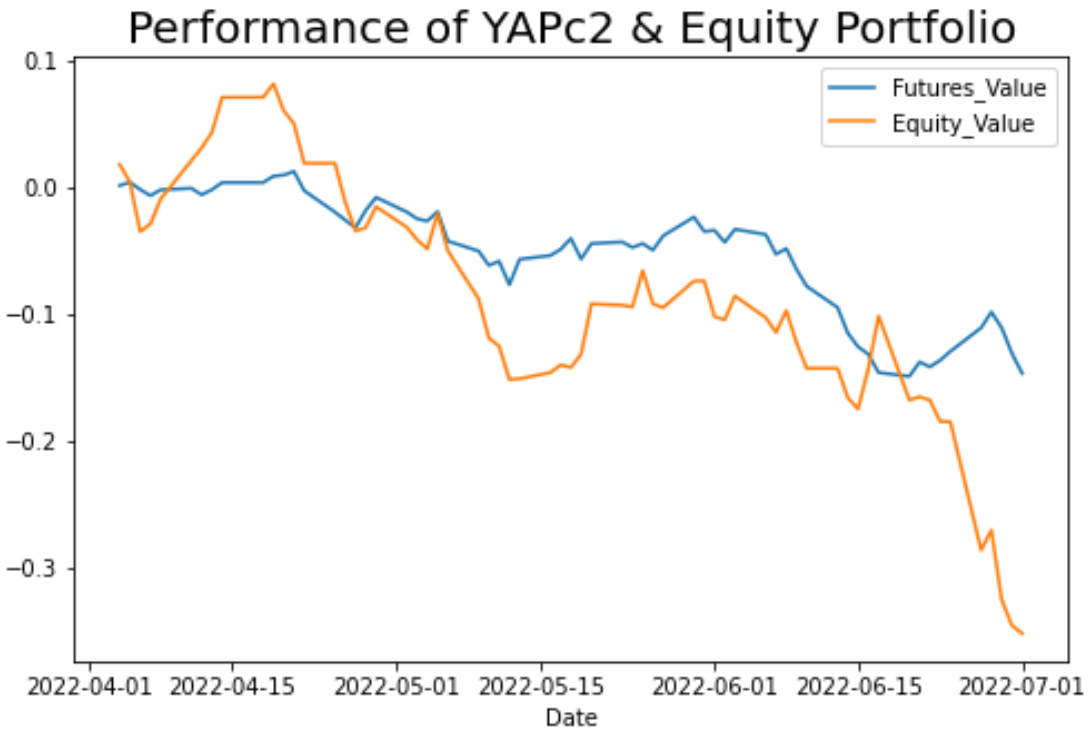
Date	Transaction_Fee	Equity_Value	Equity_Daily_Gain	Equity_Cumulative_Gain	Total_Position_Value
2022-04-01	-389.70628	480905.31	-389.70628	-389.70628	480905.31
2022-04-04	0.00000	489587.34	8682.03000	8292.32372	489362.34
2022-04-05	0.00000	482859.88	-6727.46000	1564.86372	482159.88
2022-04-06	0.00000	464337.69	-18522.19000	-16957.32628	464687.69
2022-04-07	0.00000	467103.83	2766.14000	-14191.18628	468353.83
...	...	...	...	...	...
2022-06-27	0.00000	361242.52	-38429.52000	-120052.49628	380842.52
2022-06-28	0.00000	366988.24	5745.72000	-114306.77628	384488.24
2022-06-29	0.00000	347419.42	-19568.82000	-133875.59628	367019.42
2022-06-30	0.00000	340389.78	-7029.64000	-140905.23628	363314.78
2022-07-01	-275.25000	338250.84	-2414.19000	-143319.42628	363750.84

Analysis

- Transaction fee incurred to execute the hedge on 1 April 2022 was $389.71
- Closing the position on 1 July 2022 incurred transaction fee of $275.25.
- The market value of stocks declined by $480,905.31 - $338,250.84 = $142,654.5 a loss of 29.66% (excluding transaction fee)
- The future profit was
    - 1 * ($186,725) --- Sale price of futures
    - -1 * ($161,225) --- Purchase price of futures
    - $25,500 --- Profit on futures
- Thus, the overall loss on the stocks was effectively reduced to $142,654.5 - $25,500 = $122,692.1, a loss of 24.56%

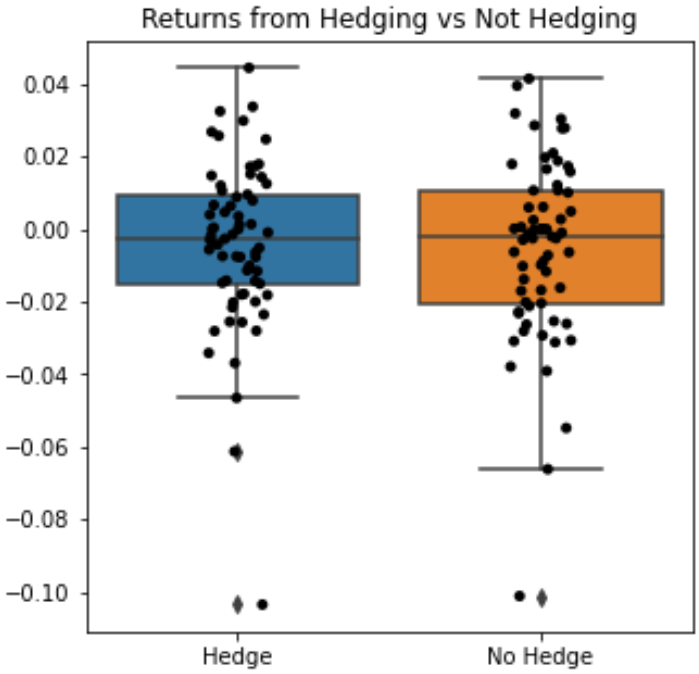
Effectiveness of the hedge

When a futures contract expires, if the underlying asset and the asset to be hedged are the same, the basis should be zero and there will be no basis risk exposure. Since the hedging period ends on 1 July 2022 and YAPc2 expires on 15 September 2022, there is a maturity mismatch and basis risk exposure. This exposure to basis risk when employing the YAPc2 contract can lead to an ineffective hedge. Additionally, using an index future, which represents a diversified portfolio, to hedge a portfolio of four gold stocks, which reflects a non-diversified portfolio, would not be the best course of action. As seen below, the low correlation led to prices not moving proportionally and in opposite directions, so the short futures position did not completely offset the losses on the equity position.



By using an index future to hedge the portfolio, it was the systematic risks that was reduced. There was still individual stock risk or alpha no hedged. It was also assuming the beta of 0.545 will stay constant over the next 3 months, but beta changes over time.

The objective of the hedge is to minimize the variance of profits and it decreased volatility from 2.49% to 2.33%



	Hedge	No Hedge
Volatility	0.023256	0.024874

Hedge effectiveness can be defined as the proportion of the variance that is eliminated by hedging and this is the r-square from running a regression of the changes in futures against changes in portfolio. In hindsight, the effectiveness of the hedge was only 7%.

	coef	std err	t	P>|t|	[0.025	0.975]
const	-0.0040	0.003	-1.301	0.198	-0.010	0.002
YAPc2	0.6298	0.288	2.183	0.033	0.053	1.206

R-squared:	0.070
Adj. R-squared:	0.056
F-statistic:	4.766
Prob (F-statistic):	0.0328
Log-Likelihood:	150.75
AIC:	-297.5
BIC:	-293.1

How the hedge can be improved?

The hedge can be improved by selecting a hedging instrument that is more identical to the portfolio. Alternatively, the portfolio can be more diversified to be more identical to the index futures. Using the index futures also leaves the portfolio exposed to individual stock risks. As discussed earlier, the major risks were the monetary policy impact on gold prices so the hedging can be improved if gold futures were used to hedge the gold stocks risk. Beta also changes over time and if gold price is expected to be volatile based on upcoming monetary policy changes, it would be optimal to use a beta higher than the portfolio beta of 0.545, hence increase the number of contracts to short. The maturity of the contract also led to an imperfect hedge. YAPc2 expires on 15 Sep 2022, which is about 2 months after the 1 July 2022 hedging period. This leaves the portfolio exposed to basis risk so the hedge can be improved by selecting a hedging instrument that has an earlier expiration than YAPc2 but still later than July.

Assessing the market risk using the gold term structure

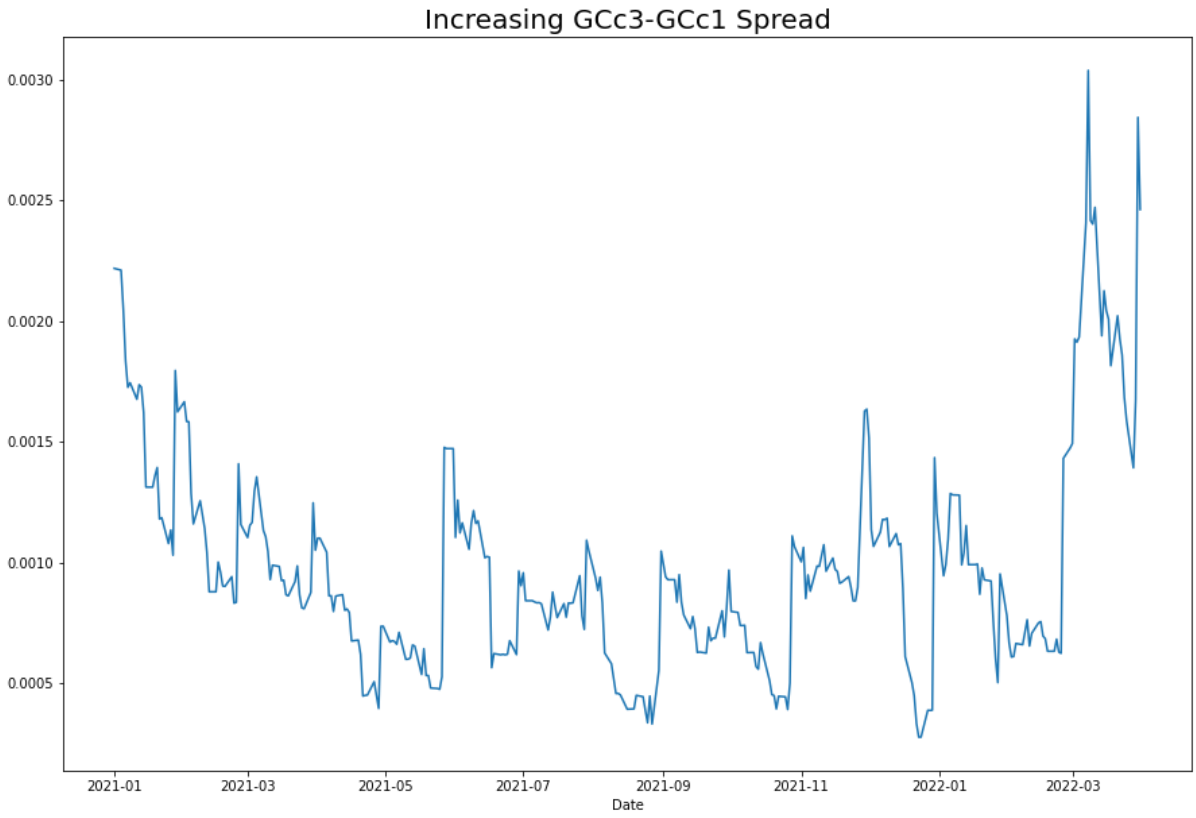
An important concept that arises from the term structure of futures contracts is the spread. This is the price difference between futures contracts with different maturities. If the price of gold futures contracts is spot price plus cost of carry:

- $f_0(1) = S_0 + \theta_1$
- $f_0(2) = S_0 + \theta_2$

The spread will be the difference between carry cost:

- $f_0(2) - f_0(1) = \theta_2 - \theta_1$

This difference between futures prices also refers to the basis. As seen below, the GCc3-GCc1 spread shows the basis of gold increasing significantly since March 2022, indicating more basis risk. When hedging with futures, the objective is to manage basis and this strengthening of the basis aligns with the objective of hedging over the next 3 months.



When lending gold, gold owners like central banks levy interest in the form of what is referred to as the gold lease rate. The convenience yield reflects a market situation where gold investors may gain more from possessing actual gold right now than they would from holding a right to purchase it in the future. They have storage expenses, much like other commodities, and these can be viewed as a loss (Hull, 2018).

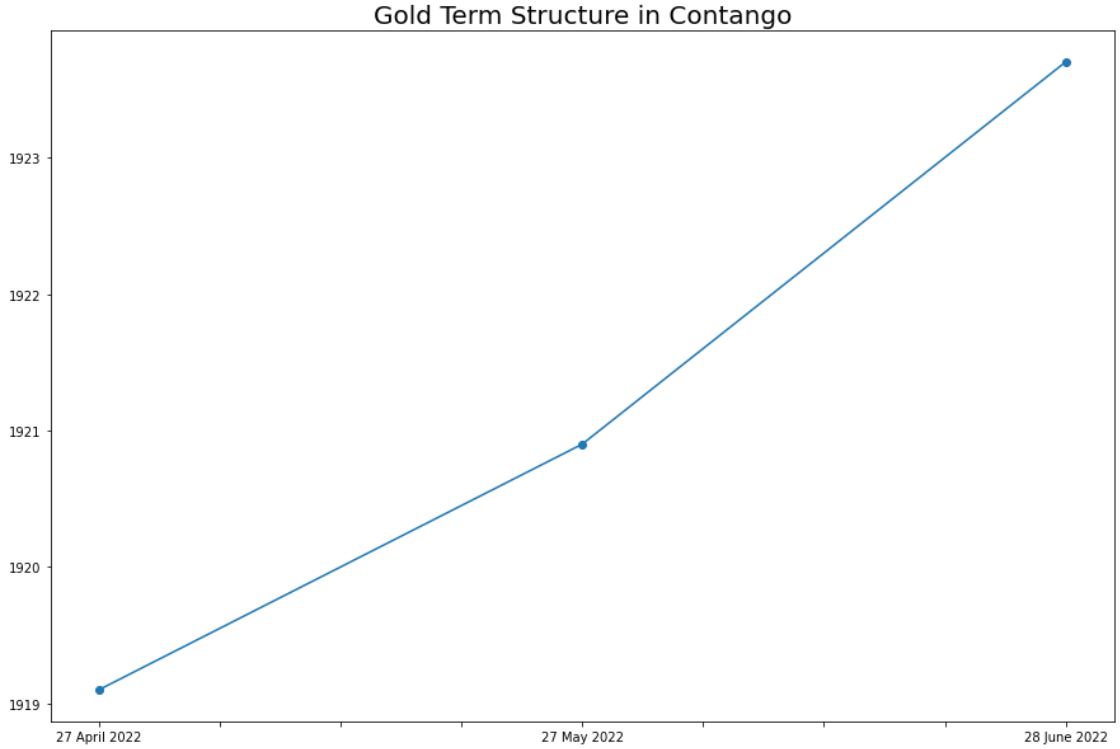
At the basic level:

Futures price = spot + cost of carry - convenience yield.

If the fraction of the spot price that the storage cost per unit represent is constant, u, then convenience yield, y, is defined such that

$$F_0 = S_0 e^{(r+u-y)T}$$

There is very little possibility of shortages occurring soon if users of gold have large inventories, and the convenience yield is often modest. Shortages are more common when inventories are low, and the convenience yield is typically larger. As a result, the convenience yield lowers the price of futures and has a negative impact on spot prices (Hull, 2018). A contango term structure is when the futures price fall below those further out in the future. This upward sloping curve is typical for gold since they will inevitably trade at a higher price in the future as their carrying costs rise. However, a tightening monetary policy would be costly to hold gold. As of 1 April 2022, the below term structure and the GCc3-GCc2 spread shows a steepening contango, which may reflect the lower convenience yield and high inventory, pressure on the front months due to oversupply, lack of demand or some combination of them.



Date	GCc1	GCc2	GCc3
2022-04-01	1919.1	1920.9	1923.7

Investors will be watching for job statistics in the coming month, as well as the FOMC members' votes on interest rate setting on May 5 and June 16. The analysis of the gold term structure and the increasing GCc3-GCc1 spread are all in line with this risk of tighter monetary policy and is consistent with the purpose of beta hedging over the next 3 months.

Increasing the hedge ratio

It is reasonable to anticipate more volatility in the portfolio than the market after observing a growing spread of basis in the gold futures, which aligns with the risk of tighter monetary policy. Using the beta of the SPI futures contract is one technique to achieve a target beta for the hedging ratio in this case. This can help determine whether the initial portfolio beta of 0.545 is too high or too low. A regression of an equal-weight portfolio and the YAPc2 futures contract from 4 January 2021 to 31 March 2022 is run. The minimum variance hedge ratio, coefficient, is 0.667 which is greater than the portfolio beta of 0.545. The effectiveness of using YAPc2 to hedge is 6.8%.

Date	YAPc2	Equal_Weight
2021-01-04	0.004243	0.044465
2021-01-05	-0.002119	0.027378
2021-01-06	-0.008370	-0.021401
2021-01-07	0.016219	-0.011700
2021-01-08	0.006892	-0.016301
...	...	...
2022-03-25	0.004338	0.028871
2022-03-28	-0.000406	-0.008192
2022-03-29	0.009027	0.002031
2022-03-30	0.004817	-0.002239
2022-03-31	-0.000801	0.001469

R-squared:	0.068
Adj. R-squared:	0.065
F-statistic:	23.53
Prob (F-statistic):	1.92e-06
Log-Likelihood:	800.84
AIC:	-1598.
BIC:	-1590.

	coef	std err	t	P>|t|	[0.025	0.975]
const	-6.003e-05	0.001	-0.053	0.958	-0.002	0.002
YAPc2	0.6666	0.137	4.851	0.000	0.396	0.937

Implementation of hedge with higher beta

On 1 April 2022:

- YAPc2 Index Futures: 7469
- Multiplier: $25
- Value of futures = 25 * 7469 = 186,725

$$N_f = -0.667 * \frac{500{,}000}{186{,}725} = -1.786$$

The optimal number of futures contracts to short is 2. Using the fees from Interactive Brokers, this would incur a cost of $37,359.3 (initial margin $37,350 + cost of $9.3). This leaves $462,640.7 to invest in an equal-weight portfolio, which would incur a transaction fee of $370.113.

Transaction Costs from Interactive Brokers

Stocks **0.08% of trade value**	462,640.7 Trade Value = AUD 370.11
Futures **AUD 3.55/contract**	2 SPI Futures Contract = IBKR Execution Fee AUD 3.55 + Exchange Fee AUD 1.10 + Regulatory Fee AUD 0.00 = AUD 9.3
Overnight Initial for SPI	18,675 per contract
Overnight Maintenance for SPI	14,940 per contract

Source: Interactive Brokers

	Stock	Price	Shares	Value	Weight
0	NCM.AX	26.930	4291.0	115556.63	0.249988
1	NST.AX	10.500	11006.0	115563.00	0.250001
2	EVN.AX	4.330	26689.0	115563.37	0.250002
3	PRU.AX	1.855	62300.0	115566.50	0.250009

- Value of portfolio: $462,249.5 (sum of Value)

Futures transaction table

Date	Trade_Price	Settlement_Price	Futures_Value	Daily_Gain	Cumulative_Gain	Margin_Balance	Margin_Call
2022-04-01	7469		186725	0.0	0.0	0.0	37350.0
2022-04-04		7478	186950	-450.0	-450.0	36900.0	0.0
2022-04-05		7497	187425	-950.0	-1400.0	35950.0	0.0
2022-04-06		7455	186375	2100.0	700.0	38050.0	0.0
2022-04-07		7419	185475	1800.0	2500.0	39850.0	0.0
...	...	...	...	...	...	...	...
2022-06-27		6685	167125	-6150.0	39200.0	76550.0	0.0
2022-06-28		6769	169225	-4200.0	35000.0	72350.0	0.0
2022-06-29		6685	167125	4200.0	39200.0	76550.0	0.0
2022-06-30		6552	163800	6650.0	45850.0	83200.0	0.0
2022-07-01	6449		161225	5150.0	51000.0	88350.0	0.0

Equity transaction table

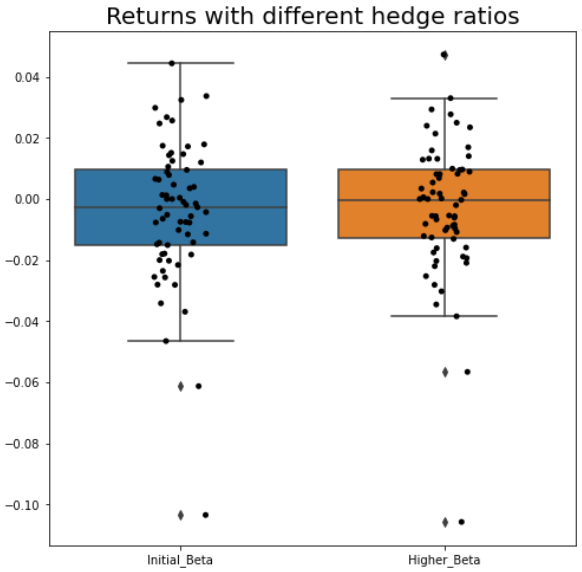
Date	Transaction_Fee	Equity_Value	Equity_Daily_Gain	Equity_Cumulative_Gain	Total_Position_Value
2022-04-01	-379.41256	462249.50	-379.41256	-379.41256	462249.50
2022-04-04	0.00000	470594.67	8345.17000	7965.75744	470144.67
2022-04-05	0.00000	464128.31	-6466.36000	1499.39744	462728.31
2022-04-06	0.00000	446324.76	-17803.55000	-16304.15256	447024.76
2022-04-07	0.00000	448983.58	2658.82000	-13645.33256	451483.58
...	...	...	...	...	...
2022-06-27	0.00000	347228.92	-36938.48000	-115399.99256	386428.92
2022-06-28	0.00000	352751.99	5523.07000	-109876.92256	387751.99
2022-06-29	0.00000	333942.37	-18809.62000	-128686.54256	373142.37
2022-06-30	0.00000	327185.35	-6757.02000	-135443.56256	373035.35
2022-07-01	-269.40000	325129.25	-2325.50000	-137769.06256	376129.25

Analysis

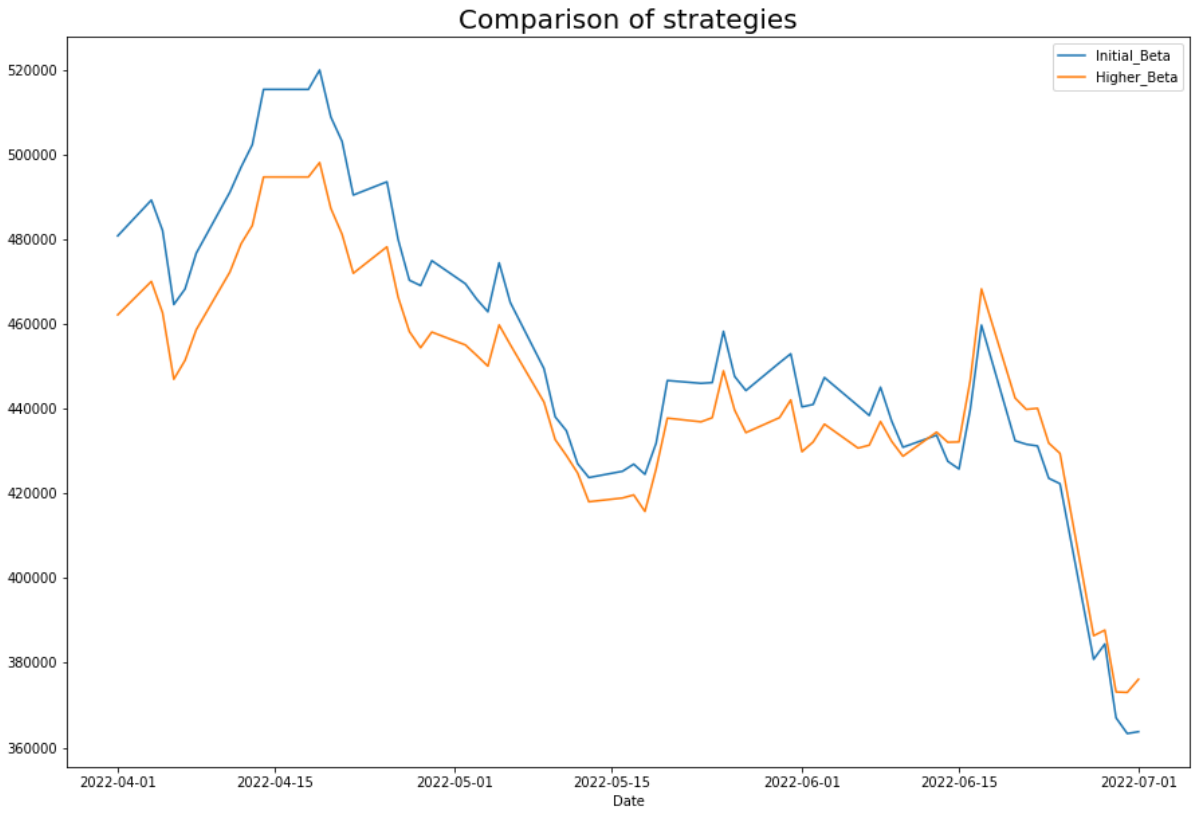
- Transaction fee incurred to enter on 1 April 2022 was $379.41
- Transaction fee to close the position on 1 July 2022 was $269.4.
- The market value of stocks declined by $462,249.5 - $325,129.25 = $137,120.25 a loss of 29.66% (excluding transaction fee)
- The future profit was
    - 2 * ($186,725) --- Sale price of futures
    - -2 * ($161,225) --- Purchase price of futures
    - $51,000 --- Profit on futures
- Thus, the overall loss on the stocks was effectively reduced to $137,120.25 - $51,000 = $86,120.25 a loss of 18.63%

Evaluation of the new strategy in comparison to the old strategy

The new strategy had a loss of 18.63%. The strategy using the portfolio beta had a loss of 24.56%. The higher hedge ratio of 0.667 aligned with the expectation of higher portfolio movement relative to the market over the next 3 months based on the monetary policy risks and increasing basis of GCc3-GCc1 so this higher hedge ratio strategy was better than the initial strategy.



	Initial_Beta	Higher_Beta
Volatility (%)	2.33	2.24



This higher hedge ratio led to shorting 2 contracts which increased profits from the futures position, hence offsetting some losses from equities to decrease volatility of the overall position. However, this outcome could be anyone's guess because the correlation between the portfolio and the YAPc2 contract is very low, and they are not identical. Prices could have moved in opposite directions when correlation is low, leading to a completely different outcome. In hindsight, the higher hedge ratio led to a better outcome, but it cannot be said that this is a more superior strategy. The problem is less with the hedging ratio, but more with the choice of futures contract. A strong hedge is one in which the overall predicted value of the hedger's position over the next three months is essentially independent of the index's value. Additionally, both strategies need to be compared to a relative benchmark using the CAPM model. If both strategies underperformed the benchmark, then neither is good. If one strategy outperforms the benchmark, then that strategy is superior to the other.

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