Apply Arbitraging in the market

5010 Project Report

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I. Introduction

When we talk about arbitrage, we can't help to mention Warren Buffett, one of the most successful investors in the world. He saw profit-generating opportunities in arbitrage at the age of six. He would buy 6 cans of Coca-Cola for 25 cents and sell them nearby for 5 cents, making a profit of 5 cents per can. He found that he could profit from the difference between the price of a six-pack of beer and what people were willing to pay for a bottle of beer. This is a typical example of arbitrage. Actually, arbitrage includes many types and methods, but its essence is to use information differences to make profits. There are several common kinds of arbitrage in the market, including time arbitrage, index arbitrage, spatial arbitrage, and inward arbitrage.

Time arbitrage is an opportunity created when a stock misses its mark and is sold based on a short-term outlook with little change in the long-term prospects of the company. It may occur when there are rumors spreading or news headlines propagating that affect the price immediately. Investors like Warren Buffett and Peter Lynch have used time arbitrage to increase their chances of outperforming the market. The index arbitrage makes profits when there are differences in the index between two markets. Where the price difference originates, the index arbitrage occurs. It can keep markets' prices synchronized in all the trading sessions. The spatial arbitrage happens when there is a price difference between two places. The arbitrageur can buy an asset from an area and sell it at a different place at a higher price. The inward arbitrage occurs when there is a difference in interest rate between two banks or financial institutions. One can borrow money from the interbank market and then deposit it somewhere at a higher interest rate.

In this project, we will further explore arbitrage opportunities in real estate, forex, sports betting, cryptocurrency, and the stock market.

II. Real Estate Arbitrage

The process of buying at a price lower than the market price and selling at or higher than the market price is known as real estate arbitrage. A real estate investor's profit is the difference between a purchase and a sale (Khoury, 2022). The arbitrage strategy can be used on any sort of real estate, including commercial land, rental, and sale of residential areas, and so on(Osterhout,n.d.). According to Khoury(2022), "Wholesaling real estate, flipping houses, and master leasing are three common types of real estate arbitrage."

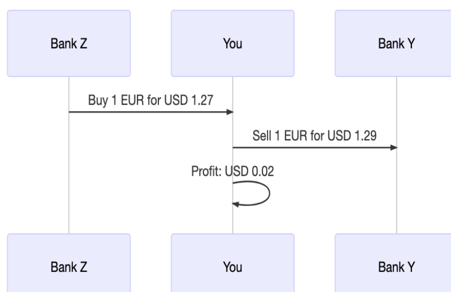
One of the most traditional methods of real estate arbitrage is wholesaling. This strategy needs the investor's networking and communication abilities to discover the appropriate seller and buyer in a short period. It also enables the investor to make up the difference in a short time without having to take possession of the property or invest a myriad of money. There are two acronyms that investors should be aware of and know how to calculate when it comes to wholesaling. The first is ARV (after repair value), while the second is MAO (maximum allowable offer). Following that, I will give a simple example. Assume the house sells for $200,000. The townhouse requires $20,000 in repairs. MAO = (ARV*80%) - Repair Costs = $160,000 - $20,000 = $140,000. In the above equation, the investor pays no more than 80% of the home's value. We can compute the possible profit as $140,000 * 20% = $28,000. However, the investor doesn't really receive the entirety of the profit. The wholesaler, as well as the buyer and seller, must work out a distribution plan of profit(Rohde, 2021).

At the same time, we must evaluate the risks associated with wholesale. One of the most potential risks is the wholesaler's failure to find an appropriate customer within a certain period, resulting in the listing and deposit being lost. Another potential threat is a high maintenance fee, which could lead to significant lost profits and extend the maintenance period.

III. Forex Arbitrage

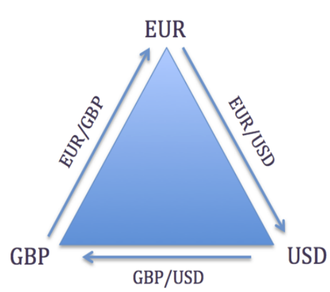
Forex arbitrage, usually known as currency arbitrage, is a trading strategy of taking advantage of price disparity in the currency markets. Specifically, a currency trader takes advantage of different spreads offered by brokers for a particular currency pair by making trades.

3.1 Locational Arbitrage



Forex arbitrage can be locational. Different spreads for a currency pair imply disparities between the bid and ask prices. The arbitrage involves buying and selling currency pairs from different brokers to take advantage of the mispriced rates. For example, when banks have different bid and ask rates: bank Y quotes USD 1.29/1.31 for Euro, and Bank Z quotes USD 1.25/1.27 for Euro. In order to take riskless profit, we can buy 1 euro from bank Z for 1.27 USD and then sell 1 euro to bank Y for 1.29 USD. In this way, we end up making 0.02 USD without any risk. However, if Bank Z quotes USD 1.30/1.35 for Euro, then there is no arbitrage opportunity. It is due to the fact that the ask rate of one bank is higher than the bid rate from the other bank.

3.2 Triangular Arbitrage



The forex arbitrage can also be triangular. Here we have three currencies and three rates: USD: 1.2/EUR, USD: 1.5/GBP, and EUR 1.3/GBP. Now the strategy is that we can get a cross rate of the first two by trading through the USD/EUR and USD/GBP.
$\frac{1.5\,USD}{GBP} \div \frac{1.2\,USD}{EUR} = 1.25\,EUR/GBP$. Then we buy the cross rate at EUR 1.25/GBP and sell GBP for the quoted rate of EUR 1.3/GBP. Because of the price disparity, we end up earning EUR 0.05.

IV. Sports Betting

In sports betting, arbitrage occurs when a bettor places multiple bets on the same sporting event in order to assure a profit regardless of the outcome. When two different sportsbooks offer different moneyline pricing at the same time, investors can bet on both sides to ensure a profit.

To further develop this strategy, we created a formula that could be used to calculate the weight of betting. We should first find two sportsbooks that offer different prices from different teams. Suppose Sportsbook A has higher odds on Team 1 than Sportsbook B, which is $odd\,1 > odd\,3$, while Sportsbook B has higher odds on Team 2, $odd\,4 > odd\,2$.

	% of money	Team 1	Team 2
Sportsbook A	x (%)	odd 1	odd 2
Sportsbook B	y (%)	odd 3	odd 4

In that case, we assume that we place the x% bet of our money for team 1 to Sportsbook A and y% for team 2 to B, so $x + y = 1$. While the return of our arbitrage will either be $odd\,1 * x$ if Team 1 wins, or $odd\,4 * y$ if Team 2 wins.
The betting weight formula becomes:

$$odd\,1 * x > x + y = 1 \qquad\qquad odd\,4 * y > x + y = 1$$
$$\Rightarrow x > \frac{1}{odd\,1} \qquad\qquad \Rightarrow y > \frac{1}{odd\,4}$$

Weighting our bet in that proportion, we always have a chance to win some money without risk. That is how arbitrage works in sports betting.

However, sometimes arbitrage is not able to be achieved. While the odds are pretty small, we will get a large number for x and y, that $\frac{1}{odd\,1} + \frac{1}{odd\,4} > 1$. The amount of betting could not exceed the maximum amount of 100%. In that case, arbitrage does not exist.

V. Cryptocurrency Arbitrage

The logic of cryptocurrency arbitrage is the same as that of the fiat currency market, where assets are bought and sold simultaneously in order to profit from the difference in price between the two markets. Cryptocurrency is an immature market with relatively few trading bots compared to traditional markets. (NextAdvisor, 2022)

The percentage of high-frequency trading is small compared to the fiat currency market, where there are currently very few investors. Therefore, there are more opportunities for arbitrage even in the same exchange market. Also, in addition to buying cryptocurrencies on an exchange, you can also buy digital currencies with other individual investors.

There are two main methods of arbitrage in the digital currency market. The first arbitrage method is arbitrage in different exchanges. Unlike traditional markets, where there are many participants, whenever there is a price difference, it quickly becomes even due to the quick reaction of market participants, in the cryptocurrency market, the arbitrage method can be used because of the small number of participants. For example, on Exchange A, one bitcoin is trading at $7,500 each, while on Exchange B the price of a bitcoin is $8,100. A trader buys 1 BTC on Exchange A, transfers it to Exchange B, and sells it there. As a result, he or she can make a profit of $600.

Another arbitrage opportunity is triangle arbitrage, which aims to profit from two or more currencies. For example, you can buy Bitcoin in US dollars and a corresponding amount of Ether with the Bitcoin you just exchanged. Compare the number of dollars exchanged from Ether with the original amount of dollars you invested, and if it is greater than the original amount, you have the opportunity to do arbitrage. (Ajay, 2022)

VI. Stock Market Arbitrage

The stock market has a lot of arbitrage opportunities. A straightforward case is that we can make profits from buying the stock on the New York Stock Exchange and immediately selling the same shares on the London Stock Exchange, earning a profit from their price difference.

6.1 Futures Arbitrage

We can make arbitrage using futures contracts by Cash-and-carry Arbitrage and Reverse Cash-and-carry Arbitrage. Cash-and-carry Arbitrage is used when the futures contract is expected to be more expensive than the underlying asset. Assume a stock asset is $100, and the one-month futures contract is $104. The monthly carrying cost is $2. We can combine the purchase of a long position in a stock and a short position in a futures contract on that same asset, hold the asset until the expiration date and deliver the asset. Then, we can ensure an arbitrage of $104-$100-$2=$2.

Now, assume an asset is $104, one-month futures contract is priced at $100, with $2 monthly carrying costs. When the futures price is cheaper than the stock price, the reverse cash-and-carry arbitrage can be used by combining a short position in the stock and a long future position in that same asset. Then, deliver the asset at the expiration and cover the short position in the asset. Finally, we can get a risk-free profit of $104-$100-$2=$2.

6.2 Options Arbitrage

We can make arbitrage opportunities from options including synthetic position, the conversion, and the reversal. The call option gives you the right to buy, and the put option gives you the right to sell. The classical put-call parity is a no-arbitrage relationship between stock, European call and put options, and a forward contract. The equation is shown as follows, where S=stock, P=put price, C=call price, E=strike price at expiration, r=interest rate, T=expiration date, and t=current date.

$$S + P_E(S,t) = C_E(S,t) + Ee^{-r(T-t)}$$

Once the put-call parity is violated, arbitrage opportunities exist.

$$S + P_E(S,t) > C_E(S,t) + Ee^{-r(T-t)}$$

When the above inequality holds, we can sell the put and sell short the stock, buy the call and deposit the money $Ee^{-r(T-t)}$ at interest rate r and end up with a risk-free profit at maturity.

$$S + P_E(S,t) < C_E(S,t) + Ee^{-r(T-t)}$$

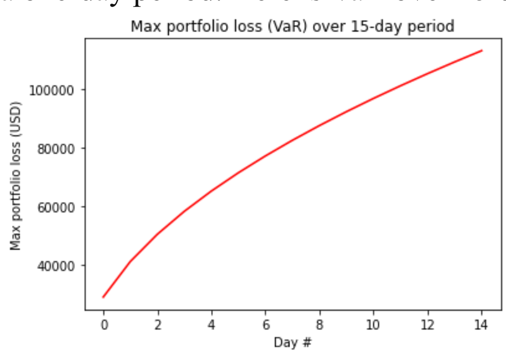
When the second situation occurs, we can buy the put and the stock, sell the call and borrow money $Ee^{-r(T-t)}$ from the bank to make a positive arbitrage opportunity.

6.3 VaR

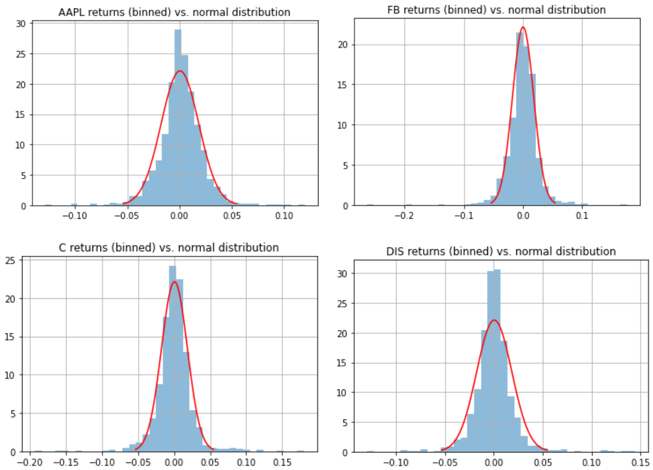
Value at Risk (VaR) is used to try and quantify the level of financial risk within a firm or portfolio over a specified time frame. VaR provides an estimate of the maximum loss from a given position or portfolio over a period of time and can be calculated across various confidence levels. In this project, we will use the variance-covariance method. Suppose an initial $1,000,000 investment portfolio of 0.25 Apple, 0.3 Facebook, 0.15 Citigroup, and 0.3 Disney stocks from January 1, 2018 to April 30, 2022. We calculate the covariance matrix based on returns.

	AAPL	C	DIS	FB
AAPL	0.000426	0.000236	0.000182	0.000300
C	0.000236	0.000611	0.000300	0.000219
DIS	0.000182	0.000300	0.000396	0.000193
FB	0.000300	0.000219	0.000193	0.000629

Then we calculate the VaR that our portfolio of 1 million USD will not exceed losses greater than $29174.79 over a one-day period. Here is VaR over 15 days:



We can also check how the historical returns have been distributed to help us assess whether VaR is suitable to use for our portfolio.



From the histogram above, we can see the returns have all been fairly normally distributed for our chosen stocks since 2018.

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In [4]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn
import matplotlib.mlab as mlab
from scipy.stats import norm
import yfinance as yf
from tabulate import tabulate
```

In [14]:
```
tickers = ['AAPL','FB', 'C', 'DIS']
weights = np.array([.25, .3, .15, .3])
initial_investment = 1000000

df=yf.download(tickers=tickers,start="2018-01-01",end="2022-04-30")
df=df[['Close']]
returns=df.Close.pct_change()
returns.tail()
```

```
[*********************100%***********************]  4 of 4 completed
```

Out[14]:

Date	AAPL	C	DIS	FB
2022-04-25	0.006737	-0.001952	0.014205	0.015643
2022-04-26	-0.037328	-0.017602	-0.034848	-0.032301
2022-04-27	-0.001467	-0.012542	-0.004837	-0.033158
2022-04-28	0.045155	0.008468	0.000694	0.175936
2022-04-29	-0.036605	-0.036186	-0.031746	-0.025567

In [16]:
```
cov_matrix = returns.cov()
cov_matrix
```

Out[16]:

	AAPL	C	DIS	FB
AAPL	0.000426	0.000236	0.000182	0.000300
C	0.000236	0.000611	0.000300	0.000219
DIS	0.000182	0.000300	0.000396	0.000193
FB	0.000300	0.000219	0.000193	0.000629

In [17]:
```
avg_rets = returns.mean()
port_mean = avg_rets.dot(weights)
port_stdev = np.sqrt(weights.T.dot(cov_matrix).dot(weights))
mean_investment = (1+port_mean) * initial_investment
stdev_investment = initial_investment * port_stdev
conf_level1 = 0.05
cutoff1 = norm.ppf(conf_level1, mean_investment, stdev_investment)
var_1d1 = initial_investment - cutoff1
var_1d1
```

Out[17]: 29174.79404621618

In [18]:

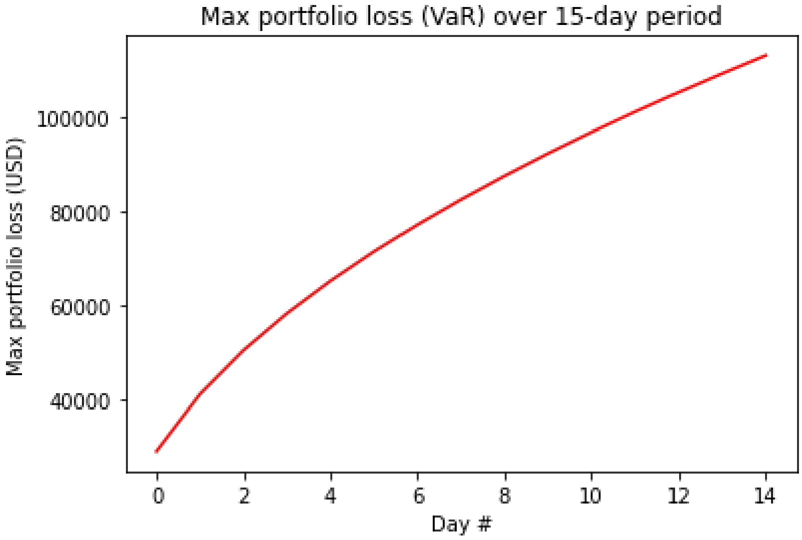
```
var_array = []
num_days = int(15)
for x in range(1, num_days+1):
    var_array.append(np.round(var_1d1 * np.sqrt(x),2))
    print(str(x) + " day VaR @ 95% confidence: " + str(np.round(var_1d1 * np.sqrt(x),

# Build plot
plt.xlabel("Day #")
plt.ylabel("Max portfolio loss (USD)")
plt.title("Max portfolio loss (VaR) over 15-day period")
plt.plot(var_array, "r")
```

```
1 day VaR @ 95% confidence: 29174.79
2 day VaR @ 95% confidence: 41259.39
3 day VaR @ 95% confidence: 50532.23
4 day VaR @ 95% confidence: 58349.59
5 day VaR @ 95% confidence: 65236.82
6 day VaR @ 95% confidence: 71463.36
7 day VaR @ 95% confidence: 77189.25
8 day VaR @ 95% confidence: 82518.78
9 day VaR @ 95% confidence: 87524.38
10 day VaR @ 95% confidence: 92258.8
11 day VaR @ 95% confidence: 96761.85
12 day VaR @ 95% confidence: 101064.45
13 day VaR @ 95% confidence: 105191.22
14 day VaR @ 95% confidence: 109162.08
15 day VaR @ 95% confidence: 112993.49
```

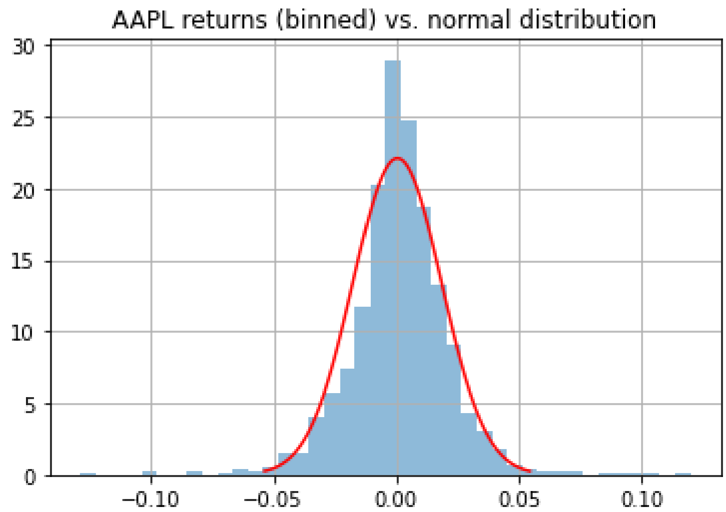
Out[18]:

```
[<matplotlib.lines.Line2D at 0x7f5bc186ea50>]
```

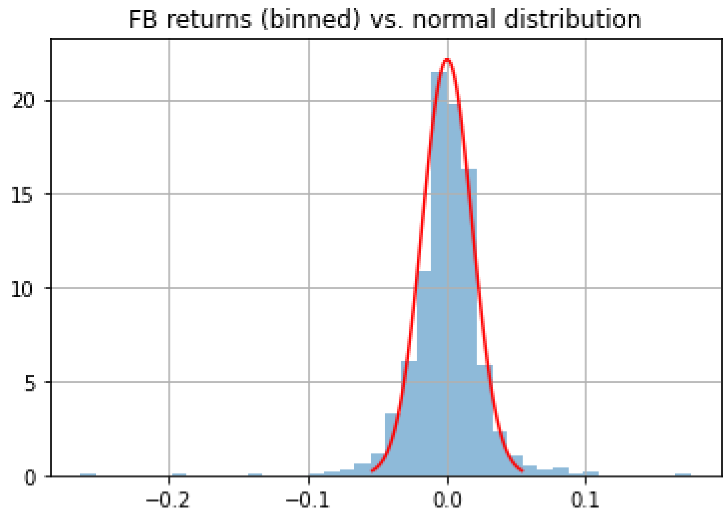


In [21]:

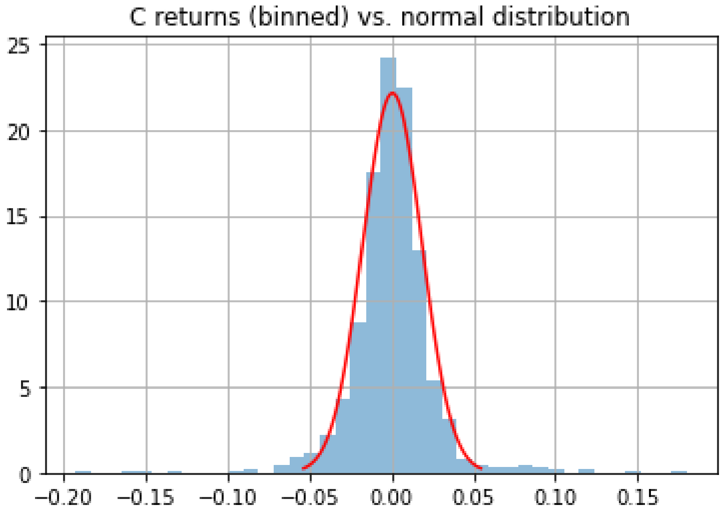
```
returns['AAPL'].hist(bins=40, density=True,histtype="stepfilled",alpha=0.5)
x = np.linspace(port_mean - 3*port_stdev, port_mean+3*port_stdev,100)
plt.plot(x, norm.pdf(x, port_mean, port_stdev), "r")
plt.title("AAPL returns (binned) vs. normal distribution")
plt.show()
```



In [22]:
```
returns['FB'].hist(bins=40, density=True,histtype="stepfilled",alpha=0.5)
x = np.linspace(port_mean - 3*port_stdev, port_mean+3*port_stdev,100)
plt.plot(x, norm.pdf(x, port_mean, port_stdev), "r")
plt.title("FB returns (binned) vs. normal distribution")
plt.show()
```



In [23]:
```
returns['C'].hist(bins=40, density=True,histtype="stepfilled",alpha=0.5)
x = np.linspace(port_mean - 3*port_stdev, port_mean+3*port_stdev,100)
plt.plot(x, norm.pdf(x, port_mean, port_stdev), "r")
plt.title("C returns (binned) vs. normal distribution")
plt.show()
```



In [24]:

```
returns['DIS'].hist(bins=40, density=True,histtype="stepfilled",alpha=0.5)
x = np.linspace(port_mean - 3*port_stdev, port_mean+3*port_stdev,100)
plt.plot(x, norm.pdf(x, port_mean, port_stdev), "r")
plt.title("DIS returns (binned) vs. normal distribution")
plt.show()
```