

Markets and More Portfolio Optimization

BUSI 721: Data-Driven Finance I

Kerry Back, Rice University



Outline

1. How markets work (and why your broker doesn't need to charge commissions)
2. Stocks, bonds, and gold over a longer horizon
3. Optimal portfolios without short sales



1. Markets



Limit orders versus market orders

- Market order (usual order) is an order to trade at the market price. It will always execute.
- A limit order is an order to trade at a specified (limit) price or better.
 - E.g., buy at \$50 or less
 - E.g., sell at \$50 or more
- A marketable limit order is a limit order that can be executed immediately, because its limit price is available in the market.
- In general, limit orders may or may not execute.



Limit order books

- Each exchange keeps a book of limit orders
- Orders to buy are called bids
- Orders to sell are called offers
- Incoming market orders are executed against the best available limit order
 - A market buy order executes against the lowest priced offer
 - A market sell order executes against the highest priced bid
- The lowest price offer and highest price bid are called the best bid and offer or the inside quotes.



Bid-ask spread

- Offer prices are also called ask prices.
- The inside quotes can be called the best bid and ask.
- The difference between the best ask and the best bid is called the bid-ask spread.
- Some traders post bids and offers to earn the spread rather than to trade.
 - They try to make round trips to keep inventories low.
 - Called market makers or dealer.
 - Nowadays high frequency traders (fast machines and connections and trade via algorithms).



Nasdaq best bid and offer

 CVX

NMS (National Market System)

- Reg NMS requires your broker to execute your order at the exchange (or non-exchange venue) that provides the best price.
- The national best bid and offer are called the NBBO.
- Reg NMS requires execution at the NBBO.



U.S. stock exchanges

- NYSE
- NYSE Mkt
- NYSE Arca
- Nasdaq
- Nasdaq Boston
- Nasdaq Philadelphia
- BATS (owned by Chicago Board Options Exchange=CBOE)
- IEX



Non-exchange trading venues

- Trades can be executed outside of exchanges provided the execution is at the NBBO or better.
- Institutions like Citadel fill orders to earn the spread.
- To get orders, they kick back part of the spread to brokers (payment for order flow).



Make or take fees

- Exchanges have make or take fees
 - Limit order = make liquidity
 - Market order = take liquidity
- Some exchanges pay limit orders and charge market orders
- Other exchanges pay market orders and charge limit orders
- In general, a means of attracting order flow.
- Fees are limited by the SEC to no more than 3/10 of a penny per share.



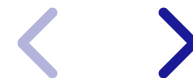
Broker order routing

- [Schwab](#){target="_blank"}
- [e-Trade](#){target="_blank"}
- [Interactive Brokers](#){target="_blank"}



Chairman of the SEC on order routing

[Gary Gensler on YouTube](#)



2. Stocks, bonds, and gold



- IEF, SPY, and GLD history is not long enough, especially for estimating expected returns
 - IEF returns as illustration
- Can use stock and bond indices over longer time period
 - Data from Aswath Damodaran (NYU)
- Stock and bond correlation was > 0 in 20th century, < 0 in 21st century
 - What does the future hold?

IEF returns


```
In [41]: import yfinance as yf
import seaborn as sns
import matplotlib.pyplot as plt
sns.set_style("whitegrid")

price = yf.download("IEF", start=1990)["Adj Close"]
price.plot()
plt.ylabel("IEF")
plt.show()
```

[*****100%*****] 1 of 1 completed

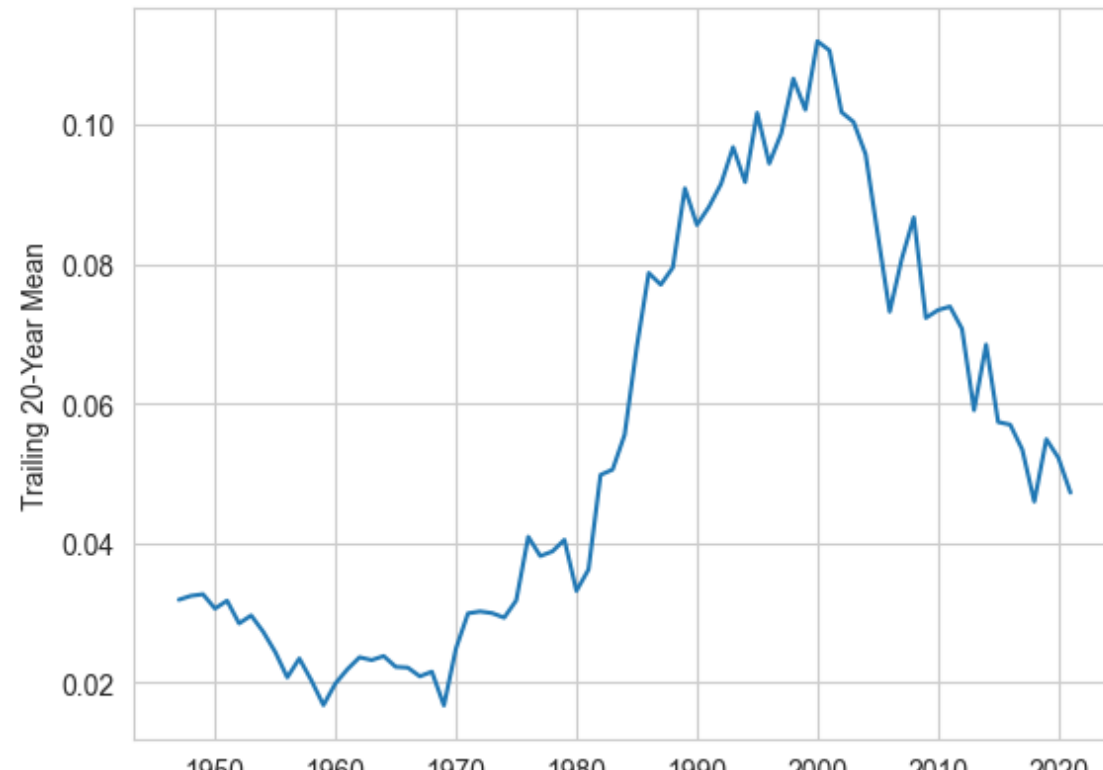


20-year Treasury means from Damodoran's data



```
In [42]: import pandas as pd
df = pd.read_csv(
    'https://www.dropbox.com/s/hgwte6swx57jqcv/nominal_sbb.csv?dl=1',
    index_col="Year"
)

means = df.Treasuries.rolling(20).mean()
means.plot()
plt.ylabel("Trailing 20-Year Mean")
plt.show()
```



In [43]: `df.head()`

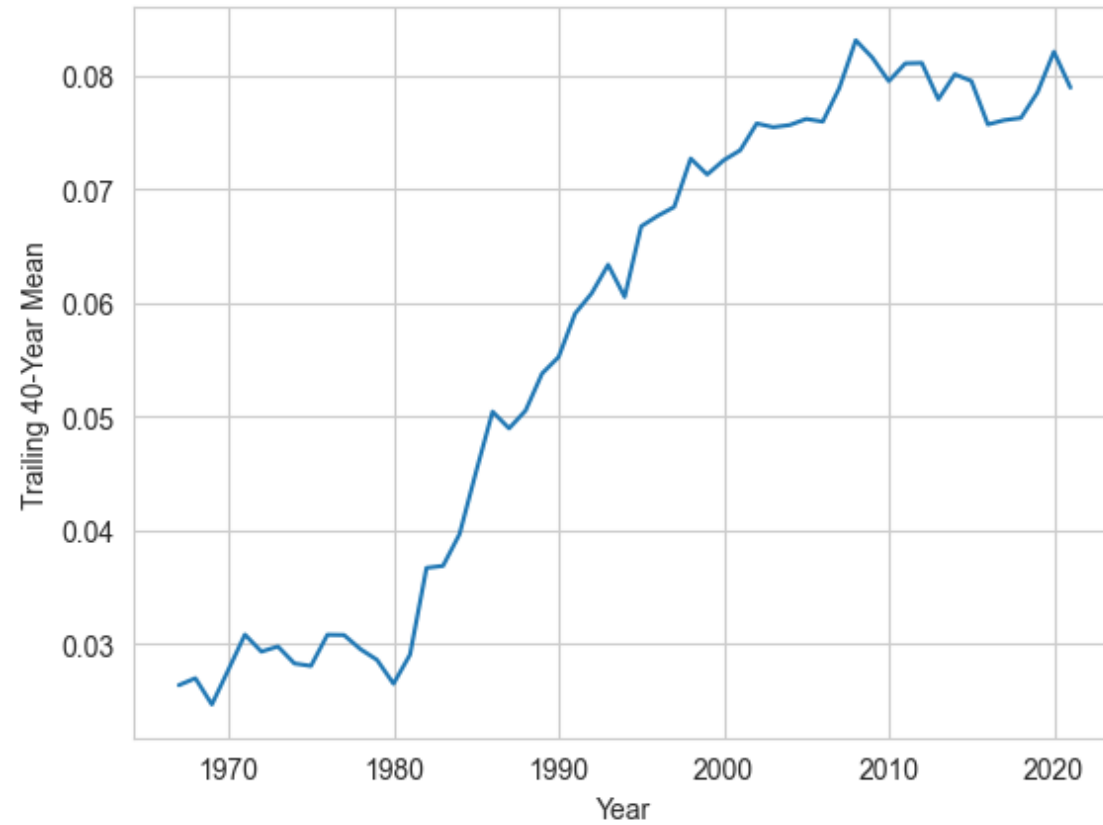
Out[43]:

	S&P 500	TBills	Treasuries	Corporates
Year				
1928	0.438112	0.0308	0.008355	0.032196
1929	-0.082979	0.0316	0.042038	0.030179
1930	-0.251236	0.0455	0.045409	0.005398
1931	-0.438375	0.0231	-0.025589	-0.156808
1932	-0.086424	0.0107	0.087903	0.235896

40-year means



```
In [44]: means = df.Treasuries.rolling(40).mean()  
means.plot()  
plt.ylabel("Trailing 40-Year Mean")  
plt.show()
```



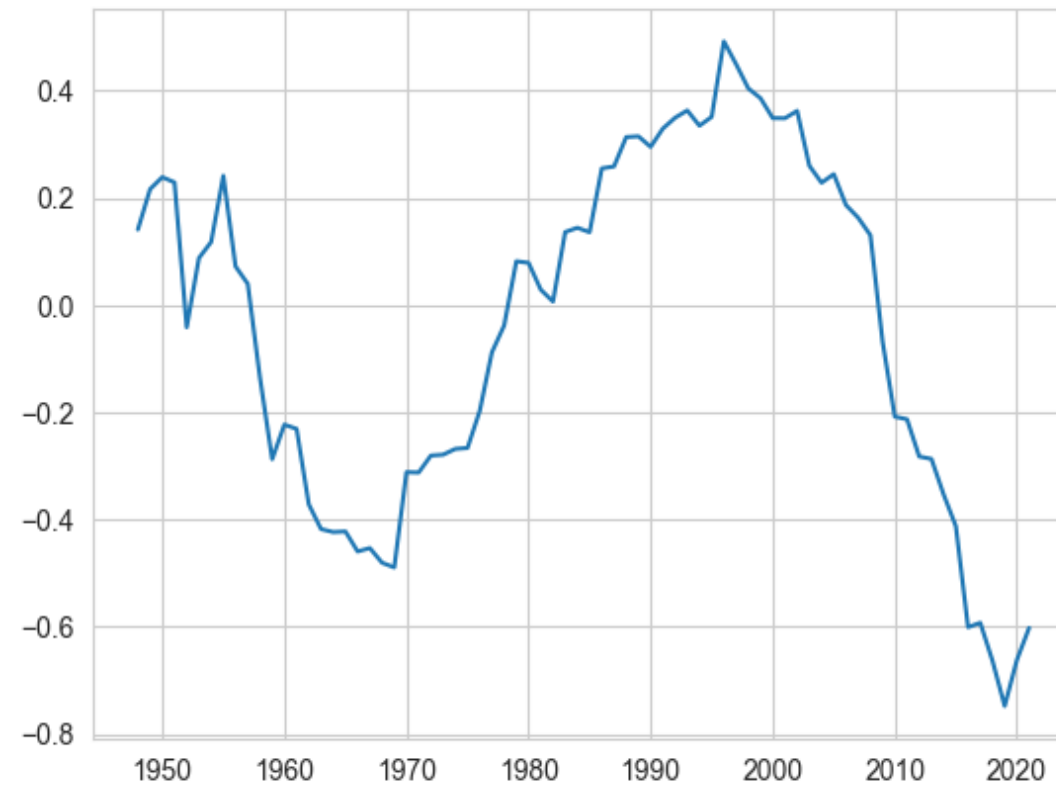
20-Year Stock and Bond Correlations



```
In [45]: corrs = []
for i in range(20, len(df.index)):
    corr = df.iloc[(i-20):i]["S&P 500"].corr(df.Treasuries)
    corrs.append(corr)

plt.plot(df.index[20:], corrs)
```

Out[45]: [



3. Optimal portfolios without short sales

Example



```
In [46]: import numpy as np

rf = 0.03
mu = [0.04, 0.10, 0.10]
stdevs = [0.2, 0.2, 0.2]
corrs = [
    [1., 0., 0.8],
    [0., 1., 0.3],
    [0.8, 0.3, 1.]
]
Sigma = np.diag(stdevs) @ corrs @ np.diag(stdevs)
```

Define arrays



```
In [47]: # example target expected return
r = 0.08

P = Sigma
q = np.zeros(3).reshape(3, 1)
A = (mu - rf*np.ones(3)).reshape(1, 3)
b = np.array([r-rf]).reshape(1, 1)
```

Compute the efficient portfolio (with short sales)



```
In [48]: from cvxopt import matrix
from cvxopt.solvers import qp

sol = qp(
    P=matrix(P),
    q=matrix(q),
    A=matrix(A),
    b=matrix(b)
)
pd.Series(sol["x"], index=range(1, 4)).round(3)
```

```
Out[48]: 1    -0.497
2     0.109
3     0.676
dtype: float64
```

Compute the efficient portfolio (without short sales)




```
In [49]: G = -np.identity(3)
h = np.zeros((3, 1))

sol = qp(
    P=matrix(P),
    q=matrix(q),
    G=matrix(G),
    h=matrix(h),
    A=matrix(A),
    b=matrix(b)
)
pd.Series(sol["x"], index=range(1, 4)).round(3)
```

	pcost	dcost	gap	pres	dres
0:	7.0157e-03	-7.5505e-01	8e-01	0e+00	2e+00
1:	7.0089e-03	-1.4634e-03	8e-03	8e-17	3e-02
2:	6.7723e-03	6.5362e-03	2e-04	1e-17	3e-04
3:	6.6347e-03	6.6316e-03	3e-06	8e-17	4e-06
4:	6.6327e-03	6.6326e-03	3e-08	8e-17	4e-08

Optimal solution found.

```
Out[49]: 1    0.000
         2    0.357
         3    0.357
         dtype: float64
```

