Markets and More Portfolio Optimization

BUSI 721: Data-Driven Finance I

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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.

SPDR S&P 500 ETF TR TR UNIT

Orders Accepted	Total Volume
1,153,586	7,689,062

	TOP OF BOOK		LAST 10 TRADES		
	SHARES	PRICE	TIME	PRICE	SHARES
ASKS ↑	11,000	180.07	14:42:13	180.03	100
	12,500	180.06	14:42:11	180.02	100
	12,900	180.05	14:42:11	180.01	100
	9,700	180.04	14:42:09	180.01	100
	1,100	**180.03**	14:42:09	180.01	200
BIDS ↓	6,400	**180.02**	14:42:08	180.01	100
	9,700	180.01	14:42:06	180.01	100
	9,600	180.00	14:42:06	180.01	100
	14,700	179.99	14:42:06	180.01	100
	11,500	179.98	14:42:06	180.01	100

The best bid is $180.02 and the best offer is 180.03$.

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 bid and offer

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 Damodoran (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()
```

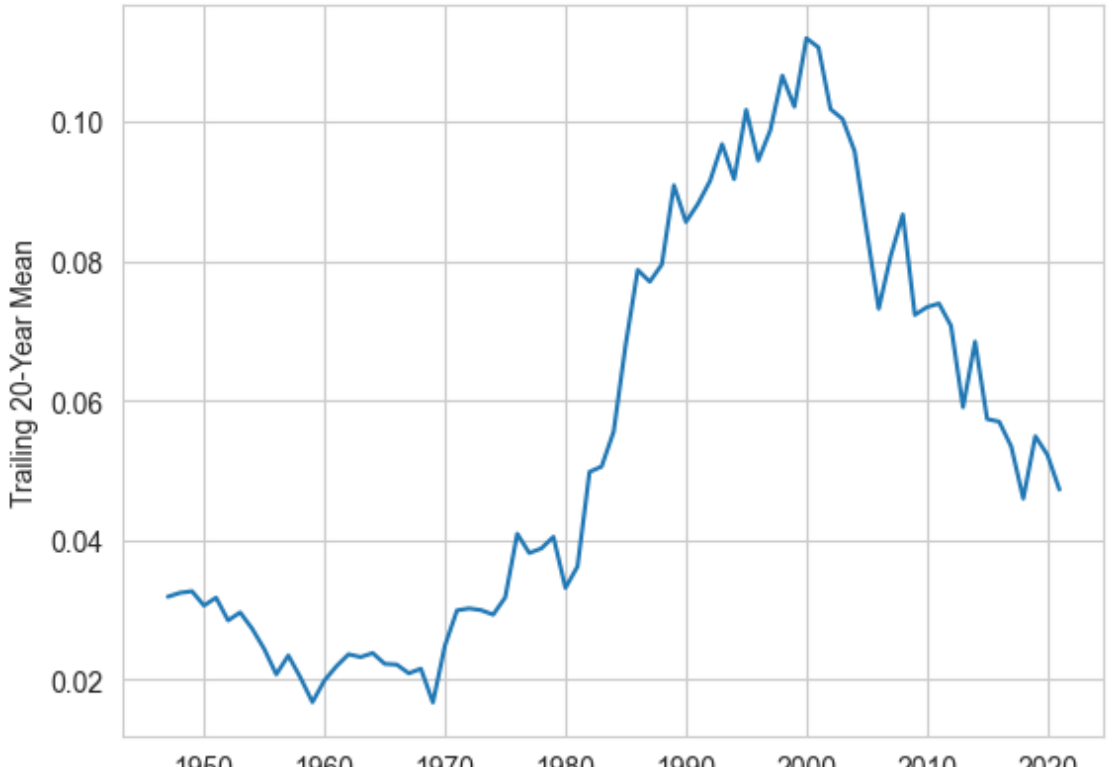
```
[**********100%%**********]  1 of 1 completed
```

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()
```

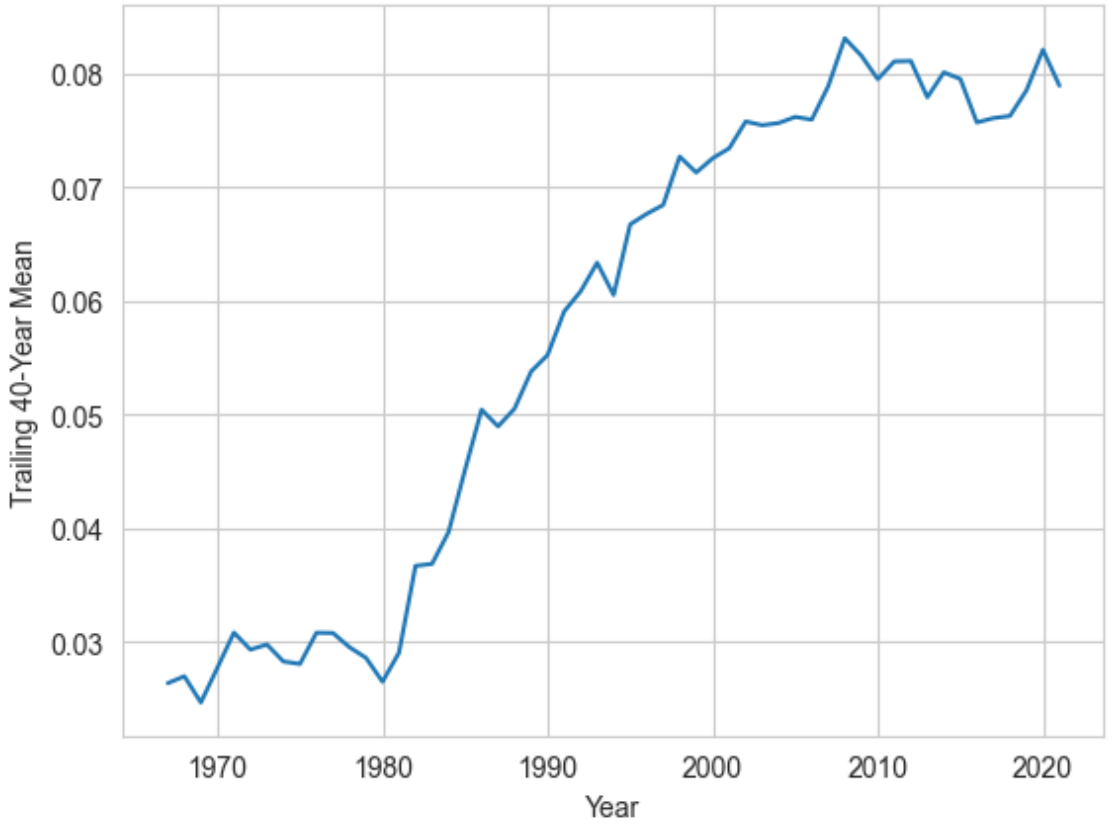
Out[43]:

Year	S&P 500	TBills	Treasuries	Corporates
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()
```

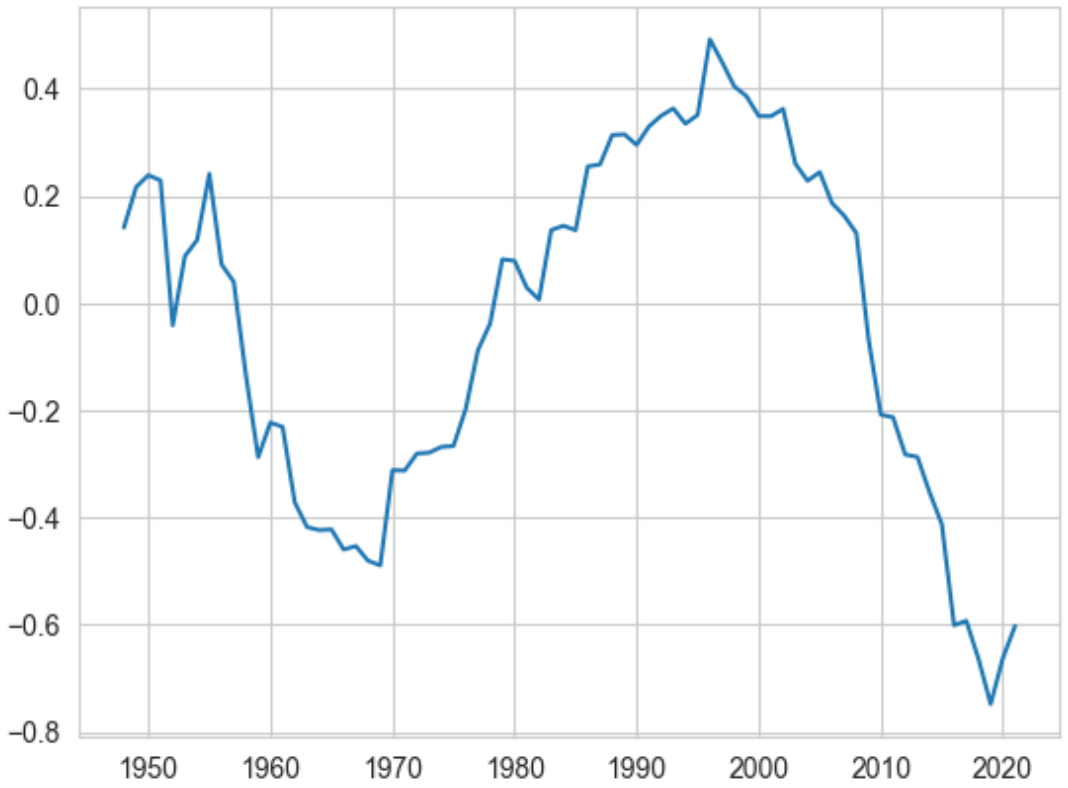


20-Year Stock and Bond Correlations

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]:
```
[<matplotlib.lines.Line2D at 0x1fdf64aa290>]
```



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
```