Bonds

BUSI 721: Data-Driven Finance I

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Coupons and Face Value

- Pay a specified coupon at regular intervals (usually semi-annually).
- And pay face value (= par value) at maturity. Last payment is coupon plus face.
- Usually in \$1,000 denominations.
- Example: a 6% bond with $1,000 face value pays 3$1,000 = \$30 every six months.

Coupon rates

- The coupon on a bond is usually set so that it can be issued at or near face value.
- This requires setting the coupon at the market interest (for a bond of its maturity and credit quality).
- Investment banks assist companies and municipalities in setting coupons and issuing bonds.
- The U.S. Treasury runs auctions - buyers bid in rates and low bidders win. The coupon is set at the marginal rate.
- Upcoming Auctions

The bond market

- Many, many different bonds outstanding. Most do not trade in any given period.
- Trade via dealers - contact a dealer to get a quote - rather than on exchanges.
- Mostly an institutional market.
- Better to buy bonds through ETFs than buy them directly, except maybe Treasury bonds through Treasury Direct.

	Weighted Average Interest Rate (%)[1]	Range of Interest Rates (%)[2]	2022 Principal	2021 Principal
Notes due 2023	1.282	0.426 - 7.250	$ **1,800**	$ 4,800
Floating rate notes due 2023	3.384	3.121 - 3.821	**800**	800
Notes due 2024	3.291	2.895 - 3.900	**1,650**	1,650
Notes due 2025	1.724	0.687 - 3.326	**4,000**	4,000
Notes due 2026		2.954	**2,250**	2,250
Notes due 2027	2.379	1.018 - 8.000	**2,000**	2,000
Notes due 2028		3.850	**600**	600
Notes due 2029		3.250	**500**	500
Notes due 2030		2.236	**1,500**	1,500
Debentures due 2031		8.625	**102**	102
Debentures due 2032	8.416	8.000 - 8.625	**183**	183
Notes due 2040		2.978	**293**	293
Notes due 2041		6.000	**397**	397
Notes due 2043		5.250	**330**	330
Notes due 2044		5.050	**222**	222
Notes due 2047		4.950	**187**	187
Notes due 2049		4.200	**237**	237
Notes due 2050	2.763	2.343 - 3.078	**1,750**	1,750
Debentures due 2097		7.250	**60**	60
Bank loans due 2023	5.206	4.928 - 5.342	**91**	100
3.400% loan			**—**	211
Medium-term notes, maturing from 2023 to 2038	6.306	4.283 - 7.900	**23**	23
Notes due 2022			**—**	4,946

Coupons vs Yields

- The coupon rate of a bond is set at the time of its issue.
- However, what one anticipates earning on a bond varies with the market price.
    - Price $<$ par $\Rightarrow$ coupon + capital gain
    - Price $>$ par $\Rightarrow$ coupon - capital loss
- What one would earn per year on a bond if held to maturity (assuming no default) is called the bond yield.

Yield calculation example

- Bond trading at 90% of par
- Paying 5% coupon
- Next coupon in six months, matures in 2 years
- Do semi-annual discounting at the annual rate / 2
- Yield is $y = 2r$ where

$$0 = -90 + \frac{2.50}{1+r} + \frac{2.50}{(1+r)^2} + \frac{2.50}{(1+r)^3} + \frac{102.50}{(1+r)^4}$$

- In other words, r is the IRR of the cash flows from buying the bond at 90 and holding until maturity.

```
In [18]: import numpy_financial as npf

cash_flows = [-90, 2.5, 2.5, 2.5, 102.5]
r = npf.irr(cash_flows)
y = 2*r
print(f"The bond yield is {y:.2%}")
```

```
The bond yield is 10.69%
```

In this example, you are getting, roughly,

- 5% per year from the coupons
- a 10% capital gain in 2 years $\sim$ 5% per year
- so approximately 10% per year

Bond price is the PV of the cash flows

- A bond price is the PV of its cash flows when discounted at the yield.

$$\text{Price} = \frac{\text{coup}}{1+y/2} + \frac{\text{coup}}{(1+y/2)^2} + \cdots + \frac{\text{coup}+\text{face}}{(1+y/2)^{2n}}$$

where $y =$ yield and $n =$ number of years to maturity.

Example

- 5-year bond with 6% coupon rate and 8% yield
- $1,000 face value
- calculate price

In [20]:
```
years = 5
coupon = 1000 * 0.06 / 2
yld = 0.08

pv_factors = (1+yld/2)**np.arange(-1, -2*years-1, -1)
cash_flows = (coupon) * np.ones(2*years)
cash_flows[-1] += 1000
price = np.sum(PV_factors * cash_flows)

print(f"price is ${price:.2f}")
```

```
price is $918.89
```

In [21]:

```python
# check yield

cash_flows = np.concatenate(([-price], cash_flows))
r = npf.irr(cash_flows)
print(f"yield is {2*r:.2%}")
```

```
yield is 8.00%
```

Long-term bonds are riskier than short-term bonds

- Let y = bond yield.
- Consider a cash flow C that is n years away. Its PV is

$$\mathrm{PV} = \frac{C}{(1+y/2)^{2n}} = C(1+y/2)^{-2n}$$

- How does this change when the yield changes?

$$\frac{d}{dy}C(1+y/2)^{-2n} = -nC(1+y/2)^{-2n-1} = -n \times \frac{PV}{(1+y/2)}$$

- So the percent change in the value is

$$-n(1+y/2)$$

Term structure of interest rates

- Term structure = how Treasury yields depend on maturity of bond
- Usually longer-term yields are higher
- But it varies a lot over time
- Learn Investments

Fed funds rate

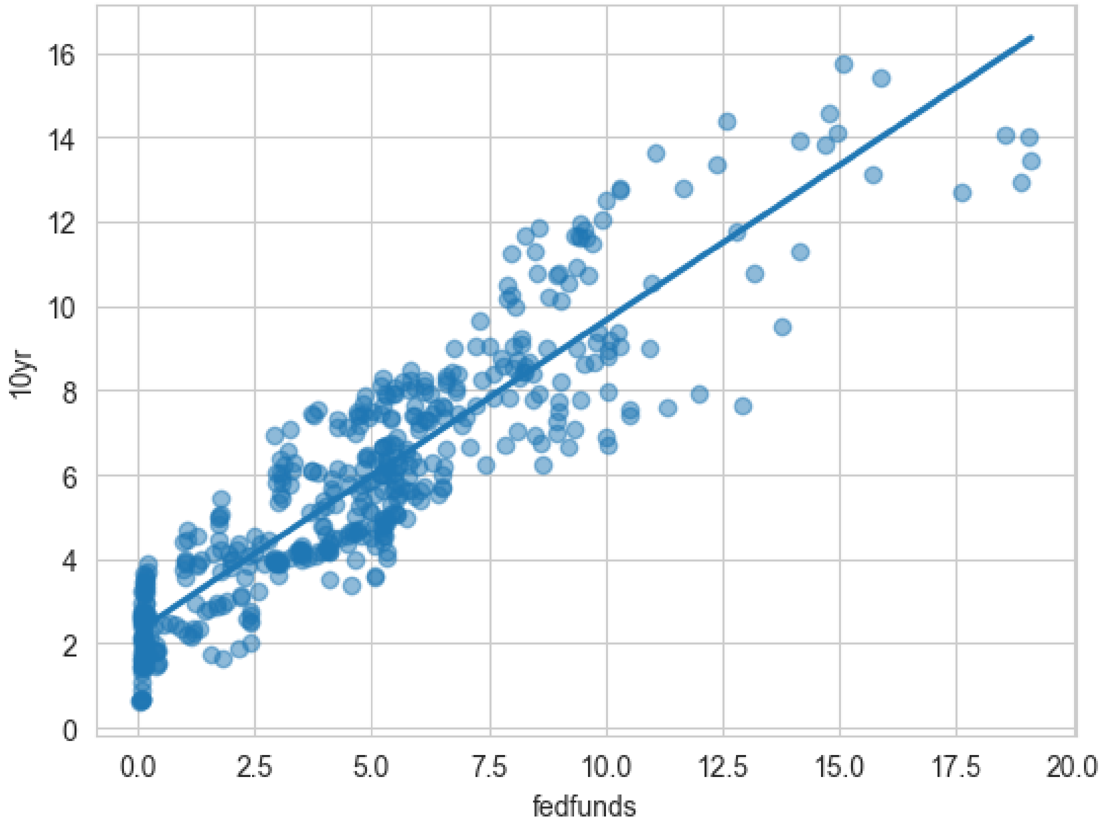
- The Federal funds rate is an overnight rate that is targeted by the Federal Reserve
- The Fed borrows or lends in the market to push the equilibrium rate to the rate they want
- Long-term rates tend to move up and down with the Fed funds rate

In [23]:

```python
from pandas_datareader import DataReader as pdr
rates = pdr(["FEDFUNDS", "DGS10"], "fred", start=1900).dropna()
rates.columns = ["fedfunds", "10yr"]
sns.regplot(x="fedfunds", y="10yr", data=rates, ci=None, scatter_kws={"alpha"
```

Out[23]:

```
<AxesSubplot: xlabel='fedfunds', ylabel='10yr'>
```



TIPS (Treasury Inflation Protected Securities)

- The Treasury issues bonds with payments indexed to inflation.
- 4% inflation $\Rightarrow$ all future coupons and the face value go up by 4%.
- This is cumulative. So each coupon and the face value are adjusted for all past inflation.
- Example: a $1,000 denomnation 2$10 in today's dollars each 6 months and pay $1,000 in today's dollars at maturity.

Treasury yields and TIPS yields

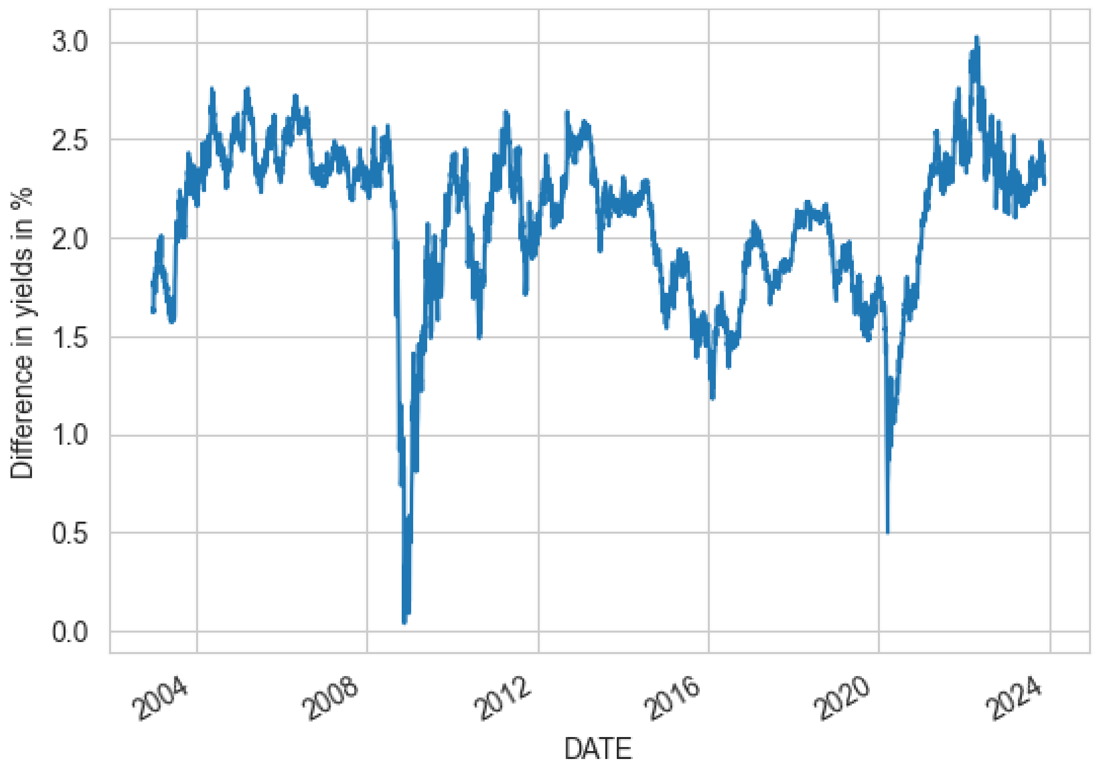
- Get 10 year Treasury yields and TIPS yields from FRED (Federal Reserve Economic Data)
- Calculate the difference in yields
- Difference depends on inflation expectations

In [24]:

```
yields = pdr(["DGS10", "DFII10"], "fred", start=1900).dropna()
yields.columns = ["Treasuries", "TIPS"]
yields.plot()
plt.ylabel("Yield in %")
plt.show()
```

In [25]:

```
(yields.Treasuries - yields.TIPS).plot()
plt.ylabel("Difference in yields in %")
plt.show()
```



Fixed income universe

- Treasuries
- corporates
- municipals
- asset backed securities
    - mortgage backed securities
    - credit-card receivables, other receivables
    - collateralized debt obligations
- Asset backed securities enable the spreading of risks among more investors. For example, pension funds hold mortgages. Also instrumental in financial crisis.

Municipal bonds

- Municipal bonds in the U.S. are exempt from federal income tax.
- Municipal bonds are also exempt from state income taxes in the state of issue.
- So, NY investors want to hold NY municipals, California investors want to hold California municipals.
- Municipals are issued by states, cities, counties, school boards, fire districts, ...
- Tax increment financing allows limited use of municipal bonds to back private investments: sports stadiums, etc.