



QTM 385 Quantitative Finance

Lecture 4: Stock market indices and derivatives

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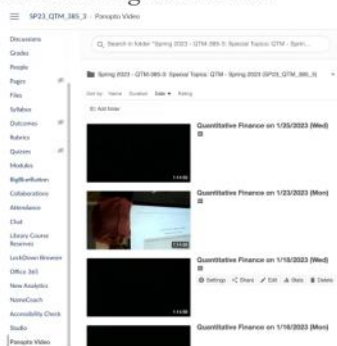
Suggested reading: Investments Ch 2



Question from Google form

- Where can we find the recordings of lectures?

Answer:



Question from Google form

- Callable bonds:** The firm has the option to repurchase the bond from the holder at a **defined call price before maturity**
- Example:** A 20-year maturity 9% coupon bond with par value \$1,000 paying coupons semiannually is callable in five years at a call price of \$1,050
- For the callable bonds slide example, does that mean that the firm gets to borrow \$1050 at a lower rate, and the bond holder also gets more money back since the call price is usually higher than par value?
- Answer: The firm borrows \$1,000, but usually at a higher rate since the firm has the option to call back. The firm needs to pay a "premium" for the option. The bond holder receives a higher coupon rate to compensate for the risk of early redemption*

So the firm borrows 1000. This is equal to the par value
So where does the 1050 come from? This comes from the call price, which is the price that the firm needs to pay in order to repurchase the bond.

In order for the bond to be appealing to investor, they need to be compensated for a higher rate of return
So usually the callable bond comes with a higher coupon rate/interest rate in order for the holder to be willing to hold such a bond
Usually the bond holder will get more money before the firm calls back the bond



Question from Google form

- What is the benefit in investing in callable bonds?
- *Answer: With a callable bond, investors have the benefit of a higher coupon than they would have had with a non-callable bond*
- Are callable bonds related to stock options?
- *Answer: Conceptually, bond issuer is similar to the holder of call options. If the bond value exceeds the call price, the issuer buys back the bond at the call price. If the stock price exceeds the exercise price, the call option holder exercises the option and buys the stock at the exercise price.*

Higher coupon rate

So in the first example, call price is 1050, and if the bond value is indeed above 1050 (has remaining coupon payments), the firm needs to pay more than 1050 to pay off the remaining coupon payments and par value.
A better strategy for the firm is to take the call price and repurchase the bond so that they can waive the remaining coupon payments

For stock options specifically call options, if the stock price exceeds the exercise price, the holder can exercise the option and buy the stock at the exercise price



Question from Google form

- What are some of the common strategic reasons why companies might choose to issue callable bonds as opposed to corporate bonds?
- *Answer: Consider a firm borrows money now (the prevailing interest rate is high). If they issue callable bonds, they can payoff their debt early, and issue new bonds at a lower coupon rate when interest rate drops, reducing their overall interest expenses.*



Question from Google form

- Would you say that tech companies with higher than average P/E ratio (18 or even higher) tend to be riskier because investors rely on companies' future R&D potential to realize that growth? Or would you say investors are optimistic about these companies and thus they are a profitable investment opportunity?
- *Answer: Sometimes stocks with high P/E ratio can be overpriced. Other times, companies with high P/E ratio can be expected to grow revenues and earnings (e.g., by R&D) much more quickly than those with low P/E ratio. P/E ratios tend to vary from industry to industry (utility vs tech), so it is important to compare companies from the same industry and with similar characteristics*



Stock market indexes

- Well known stock market indexes include
 - Dow Jones Industrial Average**: 30 large, “blue-chip” corporations
 - Standard & Poor’s Composite 500 (**S&P 500**): about 500 firms
 - NASDAQ**: more than 3,000 firms traded on the NASDAQ market
 - NASDAQ 100** is a subset of the larger firms in NASDAQ
 - ...
- Stock weights in the index
 - Price-weighted** average
 - Market-value-weighted** average
 - Equally weighted** average

Dow Jones is calculated from price weighted average
Originated in 1896
Used to be the average price of the stocks in the index

Price weighted is just the simple average



Price-weighted average

- Example**: Dow Jones Industrial Average
- Originally, back in 1896, the Dow was the **average price** of stocks in the index
- Consider the **two-stock** version of the Dow
 - Stock ABC starts at \$25 a share and increases to \$30
 - Stock XYZ starts at \$100, but falls to \$90
 - Initial index value = $(25 + 100)/2 = 62.5$
 - Final index value = $(30 + 90)/2 = 60$
 - Percentage change in index = $-2.5/62.5 = -.04 = -4\%$

So this is price weighted average

Stock	Initial Price	Final Price	Shares (million)	Initial Value of Outstanding Stock (\$ million)	Final Value of Outstanding Stock (\$ million)
ABC	\$ 25	\$30	20	\$500	\$600
XYZ	100	90	1	100	90
Total				\$600	\$690



The Dow now

- The Dow **no longer equals** the average price of the 30 stocks because the averaging procedure is adjusted for **two events**
 - a **stock splits** or **pays a stock dividend** of more than 10%
 - one company** in the group of 30 industrial firms is **replaced by another**
- To leave the **indexed unaffected** by two events, the **divisor** to compute the “average price” is adjusted
 - By 2019, the divisor for the Dow had fallen to a value of about .1475.



Divisor adjustment in stock splits

- Suppose XYZ splits two for one so that its share price falls to \$50
- The index value before the stock split: $(25 + 100)/2 = 62.5$
- We find a new divisor, d , that leaves the index unchanged. We solve d in the following equation

$$\frac{\text{Price of ABC} + \text{Price of XYZ}}{d} = \frac{25 + 50}{d} = 62.5$$

$$\bullet d = \frac{25+50}{62.5} = 1.2$$

Original: $d = 2$

After: $d = 1.2$

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Rate of return after the splits

- The split changes the price of XYZ and the relative weights of the two stocks in the price-weighted average. Therefore, the **return** of the index is also **affected**
- Initial index value before the split = $(25 + 100)/2 = 62.5$
- Final index value after the split and price change = $(30 + 45)/1.2 = 62.5$
- Percentage change in index = 0

$d=1.2$ which comes from the stock split

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Rate of return should not be affected by whether the stock splits or not which is why we consider market value weighted average



Companies included in the Dow: 1928 and 2019

Dow Industrials in 1928	Current Dow Companies	Ticker Symbol	Industry	Year Added to Index
Wright Aeronautical	3M	MMM	Diversified industrials	1976
Allied Chemical	American Express	AXP	Consumer finance	1982
North American	Apple	AAPL	Electronic equipment	2015
Victor Talking Machine	Boeing	BA	Aerospace and defense	1987
International Harvester	Caterpillar	CAT	Construction	1981
Westinghouse	Chevron	CVX	Oil and gas	2008
Texas Gulf Sulphur	Cisco Systems	CSCO	Computer equipment	2009
Texas Corp	Coca-Cola	KO	Beverages	1987
Standard Oil (NJ)	DowDuPont	DWDP	Broadcasting and entertainment	1991
General Electric	DowDuPont	DWDP	Chemicals	1935
American Tobacco	ExxonMobil	XOM	Oil and gas	1928
Seers Rubber	Goldman Sachs	GS	Investment banking	2013
General Motors	Home Depot	HD	Home improvement retailers	1999
Chrysler	Intel	INTC	Semiconductors	1999
Atlantic Refining	IBM	IBM	Computer services	1979
Raymour Fulk	Johnson & Johnson	JNJ	Pharmaceuticals	1997
Bethlehem Steel	JPMorgan Chase	JPM	Banking	1991
General Railway Signal	McDonald's	MCD	Restaurants	1985
Rock Trucks	Merck	MRK	Pharmaceuticals	1979
Union Carbide	Microsoft	MSFT	Software	1999
American Smelting	Nike	NKE	Apparel	2013
American Can	Pfizer	PFE	Pharmaceuticals	2004
Postum Inc.	Procter & Gamble	PG	Household products	1932
Nash Motors	Travelers	TRV	Insurance	2009
American Sugar	UnitedHealth Group	UNH	Health insurance	2012
Goodyear	United Technologies	UTX	Aerospace	1939
Radio Corp	Verizon	VZ	Telecommunications	2004
Woolworth	Visa	V	Electronic payments	2013
U.S. Steel	Walgreens Boots	WBA	Pharmaceuticals	2018
	Walmart	WMT	Retailers	1997

Table 2.4

Companies included in the Dow Jones Industrial Average, 1928 and 2019



Market-value-weighted average

- **Example:** S&P 500, NASDAQ, NASDAQ100
- The initial value was **\$600M**, and the final value is **\$690M**
- Suppose the initial index value is set as **100** (can also set as other value)
- Final index value = $100 \times (690/600) = 115$
- Percentage change in index = $115/100 - 1 = 0.15 = 15\%$
- Percentage change not affected by stock splits

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Overall value

Index value is just how much \$ you have in the stock,
You can set it to be any value you want, it won't affect rate of return

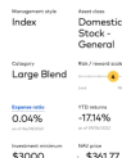
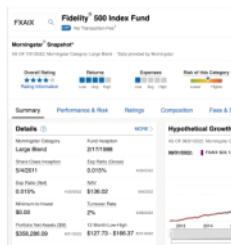
Equally weighted average

- **Equally weighted average** of the returns of each stock in an index
- Equivalent to a portfolio strategy that invests equal dollar values in each stock
- Initial index value = 2 (\$1 in ABC and \$1 in XYZ)
- Final index value = $\frac{30}{25} \times 1 + \frac{45}{50} \times 1 = 1.2 + 0.9 = 2.1$
- Percentage change in index = $\frac{2.1}{2} - 1 = 5\%$
 - Average of 20% of ABC and -10% of XYZ

Stock	Initial Price	Final Price	Shares (million)	Initial Value of Outstanding Stock (\$ million)	Final Value of Outstanding Stock (\$ million)
ABC	\$25	\$30	20	\$500	\$600
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Invest in market indexes

- One way is to purchase **index funds** (shares in **mutual funds** that hold shares in proportion to their representation in the S&P 500 or another index)
 - Purchase directly from the fund or through brokers or financial advisers



Fidelity, Vanguard, and Black Rock
Offer index funds that track stock market indexes

Expense ratio: this is a management fee you need to pay for the mutual funds
When things happen like a stock has a larger share or a stock is included in s&p500, they need to balance their index fund, so they need to charge a fee and market. You want to look for a low expense ratio

Index funds and ETFs are both investment products that track a basket of securities, such as stocks or bonds, to match the performance of a financial market index, such as the S&P 500. The main difference between them is in their structure and the way they are traded:

Index Funds: Are traditional mutual funds that are bought and sold at the end of the trading day at the net asset value (NAV) price. They typically have lower operating expenses and minimum investment requirements.
So for example apple is 13% of the S&P500, so vanguard or fidelity will invest 13% into apple, or something like that. The goal is to mimic the S&P500

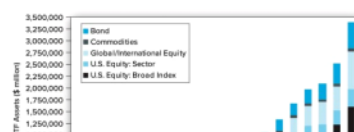
ETFs: Are similar to index funds, but they are traded like stocks on an exchange and their price changes throughout the day based on supply and demand. ETFs generally have lower operating expenses than mutual funds and offer more flexibility in terms of trading and taxation.

Both index funds and ETFs offer low-cost and diversified investment options, but the choice between them depends on the individual investor's goals and preferences.

Index funds are not "actively managed" compared to active managed ones like hedge funds
90% of hedge fund managers cannot outperform the S&P500 because of the high management fee
Why are there still so many hedge funds that charge high fees then? Because 1. clients increase pension funds (require that when the markets are down, the rate of return cannot be too low because of pension funds) meaning lower volatility which still meets the needs of some clients.

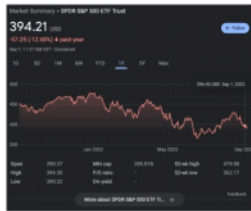
Management fees are even lower than mutual funds for ETFs

MUTUAL FUNDS OFFER BOTH ETFs AND INDEX FUNDS



Invest in market indexes

- Another approach is to purchase an *exchange-traded fund*, or ETF, which is a portfolio of shares that can be bought or sold as a unit, just as one can buy or sell a single share of stock
 - Trade index portfolios as stocks
 - Lower management cost



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Management fees are even lower than mutual funds for ETFs

MUTUAL FUNDS OFFER BOTH ETFs AND INDEX FUNDS

Mutual funds and index funds are both investment products that pool together funds from multiple investors to purchase a diversified portfolio of securities. The main difference between the two lies in their investment approach:

Mutual Funds: Are actively managed by a fund manager who makes investment decisions on behalf of the fund. The fund manager selects and trades the underlying securities in an effort to generate returns for the fund's investors.

Index Funds: Are passively managed, meaning they aim to track the performance of a particular market index, such as the S&P 500, rather than actively seeking to outperform it. Index funds are constructed to match the components and weightings of the underlying index as closely as possible.

The management approach is one of the main differences between mutual funds and index funds, with mutual funds relying on active management and index funds relying on passive management. This difference can affect the investment outcomes and the expenses associated with the products. Index funds generally have lower expenses than mutual funds and are often considered a low-cost investment option.

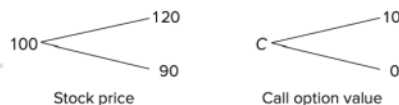
Derivatives

- Derivative contracts**, e.g., *futures and options*, provide payoffs that **depend on the values of other variables** such as commodity prices, bond and stock prices, interest rates, or market index values
- Their values *derive from* the values of other assets
- Also called **contingent claims** because their payoffs are contingent on the value of other values

Call options

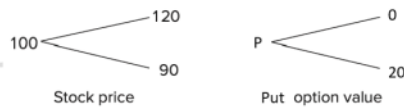
- A **call option** gives its holder the right to *purchase* an asset for a specified price, called the **exercise** or **strike price**, on or before a specified expiration date
 - The holder of the call **only exercises** the option when the **market value** of the asset **exceeds** the **exercise price**
- Example:** a February expiration call option on Microsoft stock with an exercise (or strike) price of **\$110**
 - The current stock price is **\$100**
 - If the stock price rises to **\$120**, the holder exercises and earns **\$10**
 - If the stock price falls to **\$90**, the call is left unexercised

So if the stock prices rises to \$110, they neither make nor lose money



Put options

- A **put option** gives its holder the right to *sell* an asset for a specified **exercise price** on or before a specified expiration date
 - The holder of the put **only exercises** the option when the **market value** of the asset **falls below** the **exercise price**
- Example:** a February expiration put option on Microsoft stock with an exercise (or strike) price of **\$110**
 - The current stock price is **\$100**
 - If the stock price rises to **\$120**, the put is left unexercised
 - If the stock price falls to **\$90**, the holder exercises and earns **\$20**



Question

- What would be the profit or loss to an investor who bought the January 2019 expiration Apple call option with exercise price **\$105** if the stock price at the expiration date is **\$109**?
- What about a purchaser of the put option with the same exercise price and expiration?

Valuation of options

- The **payoff** of the options is always **non-negative**, so there is a **cost** or **premium** to own the options
- We will learn option pricing at the end of this semester
- For both call and put options, each option contract is for the purchase of **100** shares. However, quotations are made on a per-share basis

Table 2.6
Prices of stock options on Microsoft, January 2, 2019

Expiration	Strike	Call	Put
18-Jan-2019	95	7.65	0.98
18-Jan-2019	100	3.81	2.20
18-Jan-2019	105	1.45	4.79
8-Feb-2019	95	9.50	2.86
8-Feb-2019	100	5.60	3.92
8-Feb-2019	105	3.08	6.35

Note: Microsoft stock on this day was \$101.51.
Source: Compiled from data downloaded from Yahoo! Finance.

Futures

- A **futures contract** calls for delivery of an asset at a **specified maturity date** for an **agreed-upon price**, called the **futures price**, to be paid at contract maturity
- Two parties:
 - **Long position** commits to **purchasing the asset** on the delivery date
 - **Short position** commits to **delivering the asset** at contract maturity



Example

- A future contract calls for delivery of 5,000 bushels of corn in March 2019 at the price \$3.8025 per bushel
- Suppose at contract maturity, corn is selling for \$3.8225 per bushel
- The **profit** to the long position: $5,000 \times (\$3.8225 - \$3.8025) = \$100$
- What is the **loss** to the short position?



Options vs futures

- The long position of a **futures** contract: *obliges* to purchase the asset at the futures price
- The long position (owner) of a **call** option: *conveys the right* to purchase the asset at the exercise price
- With the same futures price and option's exercise price, the **call holder** has a **better position**
 - Call options must be purchased
 - Futures contracts can be entered into without cost

