Derivatives
--2017
Instructor: Feng

Brief Introduction

Topic weight:

SS1	Ethics & Professional Standards	15%
SS2 - SS3	Quantitative Methods	12%
SS4 - SS5	Economics	10%
SS6 - SS9	Financial Reporting and Analysis	20%
SS10 - SS11	Corporate Finance	7%
SS12	Portfolio Management	7%
SS13 - SS14	Equity Investment	10%
SS15 - SS16	Fixed Income	10%
SS17	**Derivatives**	**5%**
SS18	Alternative Investments	4%
	Weights:	100%

Brief Introduction

Content:

- **Study session 17: Derivatives**
  - Reading 57: Derivative Markets and Instruments
  - Reading 58: Basics of Derivative Pricing and Valuation
  - Reading 59: Risk Management Applications of Option Strategies

Brief Introduction

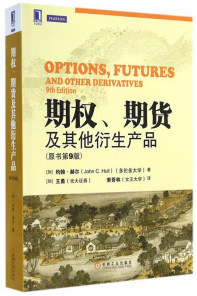
考纲对比:

- 与2016年相比，2017年的考纲没有变化。

Brief Introduction

推荐阅读:

- 期权、期货及其它衍生产品
  - John C.Hull 著
  - ISBN: 978-7-1114-8437-0
  - 机械工业出版社



Brief Introduction

学习建议:

- 本门课程难度较高，着重理解，加强总结；
- 如遇到一遍没听懂的，建议重听一到两遍；
- 听课与做题相结合，但并不建议“刷题”；
- 最重要的，认真、仔细的听课。

早上，叫我们起床的，不是闹钟，而是梦想！

Overview of derivative instrument & market

Tasks:

- Define derivatives;
- Distinguish between exchange-traded and over-the-counter derivatives;
- Contrast forward commitments with contingent claims.

Definition of Derivative

Definition of derivative

- A derivative is a financial instrument that derives its performance from the performance of an underlying asset.
  - Financial asset: equity, fixed-income security, currency;
  - Physical asset: commodity;
  - Other: interest rate, credit, other derivatives, etc.
- Derivative usually transform (not simply pass through) the performance of the underlying asset before paying it out in the derivatives transaction.

Definition of Derivative

Definition of derivative (Cont.)

- Derivatives are created in the form of legal contracts.
  - The long: buyer, holder
  - The short: seller, writer

Types of Derivatives

Forward commitment

- Contracts entered into at one point in time that require both parties to engage in a transaction at a later point in time (the expiration) on terms agreed upon at the start.
  - Forward, future, and swap

Contingent claim

- Derivatives in which the outcome or payoff is dependent on the outcome or payoff of an underlying asset.
  - Option

Structure of Derivative Markets

Exchange-traded markets

- Standardized
- No default risk – guaranteed by clearinghouse
- Regulated
- Transparent

Over-the-counter (OTC) markets

- Customized
- Default risk/counterparty risk
- Unregulated
- Less transparent

Structure of Derivative Markets

Exchange-traded markets

- Future
- Some options

Over-the-counter (OTC) markets

- Forward
- Swap
- Some options

Summary

- **Importance:** ☆☆
- **Content:**
  - Derivatives: forward, future, swap, option;
  - Exchange-traded Vs. Over-the-counter;
  - Forward commitment Vs. Contingent claim.
- **Exam tips:**
  - 常考点：Exchange-traded和OTC market的特征对比。

Forward, future and swap

Tasks:

- Define forward contracts, futures contracts, swaps, and compare their basic characteristics.

Types of Derivatives

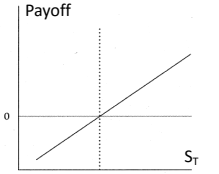
Forward

- An over-the-counter derivative contract in which two parties agree that one party, the buyer, will purchase an underlying asset from the other party, the seller, at a later date at a fixed price they agree on when the contract is signed.
- In addition to the (forward) price, the two parties also agree on several other matters, such as the identity and the quantity of the underlying.

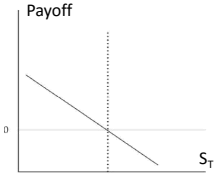
Types of Derivatives

Forward (Cont.)

- The long hopes the price of the underlying will rise above the forward price, $F_0(T)$, whereas the short hopes the price will fall below the forward price.



Payoff of the long = $S_T - F_0(T)$



Payoff of the short = $F_0(T) - S_T$

Types of Derivatives

Forward (Cont.)

- Forward contracts can be settled in two ways:
  - Delivery of the underlying asset;
  - Exchange of cash: non-deliverable forwards (NDFs), cash-settled forwards, or contracts for differences.
- Forward contracts can be structured to create a perfect hedge, providing an assurance that the underlying asset can be bought or sold at a price known when the contract is initiated.

Types of Derivatives

Future

- Future contracts are specialized forward contracts that have been standardized and trade on a future exchange.
  - Future contracts have specific underlying assets, times to expiration, delivery and settlement conditions, and quantities.
  - The exchange offers a facility in the form of a physical location and/or an electronic system as well as liquidity provided by authorized market makers.

Types of Derivatives

Future (Cont.)

- **Future price**: the agree-upon price, like forward price.
- **Price limit**: a provision limiting price changes, establish a band relative to the previous day's settlement price, within which all trades must occur.
  - **Limit up/limit down**: trading stops if trading price is above/below the upper/lower band.
  - **Locked limit**: when market hits limits and trading stops.

Types of Derivatives

Future (Cont.)

- **Mark-to-market**: daily settlement of gains and losses to margin account according to the settlement price.
  - **Settlement price**: an average of the final futures trades of the day.

Types of Derivatives

Future (Cont.)

- **Initial margin**: both parties deposit a required minimum sum of money when the contract is initiated.
- **Maintenance margin**: the amount of money that must maintain in the margin account after the trade is initiated.
  - Always significantly lower than the initial margin.
- **Margin call:** a request to deposit enough funds to bring the margin account balance up to the initial margin when it is below the maintenance margin.

Types of Derivatives

Future (Cont.)

- There are significant differences between futures margin accounts and equity margin accounts:
  - A futures margin is simply an amount of money put into an account that covers possible future losses, and there is no formal loan created as in equity markets.
  - For equity margin account, an investor deposits part of the cost of the stock and borrows the remainder at a rate of interest.

Types of Derivatives

Future (Cont.)

- **Offset/close-out:** a party re-enters the market at a later date but before expiration and engages in the opposite transaction.
- **Open interest**: the number of outstanding contracts at any given time.
  - Each contract counted in the open interest has a long and a corresponding short.

Types of Derivatives

Forward vs. Future

- Forward contracts realize the full gain or loss at expiration, whereas futures contracts realize the gain or loss in parts on a day-to-day basis.
  - The time value of money makes these not equivalent, but the differences tend to be small.
  - In forward contract, with the entire payoff made at expiration, a loss by one party can be large enough to trigger a default.

Types of Derivatives

Swap

- An over-the-counter derivative contract in which two parties agree to exchange a series of cash flows whereby one party pays a variable series that will be determined by an underlying asset or rate and the other party pays either (1) a variable series determined by a different underlying asset or rate or (2) a fixed series.
  - A swap is a series of (off-market) forwards.

Types of Derivatives

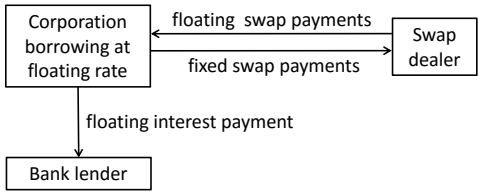
Swap (Cont.)

- Interest rate swap
  - Fixed for floating (plain vanilla)
  - Floating for floating
- Equity swap
- Currency swap

Types of Derivatives

Swap (Cont.)

- **Example**: using an interest swap to convert a floating rate loan to a fixed rate loan:



Summary

- **Importance:** ☆☆
- **Content:**
  - **Forward**: payoff, delivery;
  - **Future**: standardized forward, daily settlement, margin;
  - **Swap**: a series of forward, interest rate swap.
- **Exam tips:**
  - 常考点1：forward payoff的计算；
  - 常考点2：future跟forward的对比；future的特征，包括daily settlement和margin。

Options and credit derivatives

Tasks:

- Define option contracts and credit derivatives, and compare their basic characteristics.

Types of Derivatives

Option

- A derivative contract in which one party, the buyer, pays a sum of money to the other party, the seller or writer, and receives the right to either buy or sell an underlying asset at a fixed price either on a specific expiration date or at any time prior to the expiration date.
  - An option is a right, but not an obligation.
  - Default in options is possible only from the short to the long.

Types of Derivatives

Option (Cont.)

- **Option premium** (c_0, p_0): payment to seller from buyer.
- **Call option**: right to buy;
- **Put option**: right to sell.
- **Exercise price/strike price** (X): the fixed price at which the underlying asset can be purchased.
- **American option**: exercisable at or prior to expiration;
- **European option**: exercisable only at expiration.

Types of Derivatives

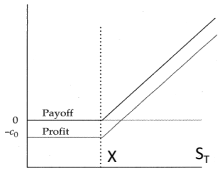
Option (Cont.)

- **Moneyness** (X: exercise price; S_T: spot price at time T)
  - In the money
    - ✓ Call: $S_T > X$
    - ✓ Put: $X > S_T$
  - At the money
    - ✓ $S_T = X$
  - Out of the money
    - ✓ Call: $S_T < X$
    - ✓ Put: $X < S_T$

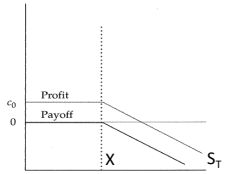
Types of Derivatives

Option (Cont.)

- Payoff (c_T)and profit (∏)from a call option:
  - From buying: $c_T = Max(0, S_T - X)$; $\prod = Max(0, S_T - X) - c_0$
  - From selling: $-c_T = -Max(0, S_T - X)$; $\prod = -Max(0, S_T - X) + c_0$



Payoff/Profit from buying

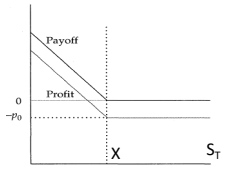


Payoff/Profit from selling

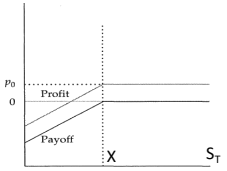
Types of Derivatives

Option (Cont.)

- Payoff (p_T)and profit (∏)from a put option
  - From buying: $p_T = Max(0, X - S_T)$; $\prod = Max(0, X - S_T) - p_0$
  - From selling: $-p_T = -Max(0, X - S_T)$; $\prod = -Max(0, X - S_T) + p_0$



Payoff/Profit from buying



Payoff/Profit from selling

Types of Derivatives

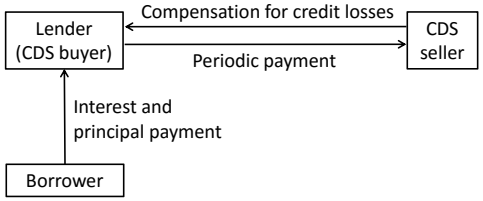
Credit derivatives

- Derivative contracts between two parties, a credit protection buyer and a credit protection seller, in which the latter provides protection to the former against a specific credit loss.
  - Credit default swap (CDS): the buyer makes a series of cash payments to the seller and receives a promise of compensation for credit losses resulting from the default of a third party.
  - CDS is essentially an insurance contract against default.

Types of Derivatives

Credit derivatives

- **Example**: using an CDS to hedge the credit risk of a loan:



Purposes of Derivatives

Purposes of derivatives

- Risk allocation, transfer, and management
- Information discovery
  - Price discovery
  - implied volatility
- Operational advantages
  - Lower transaction cost
  - Greater liquidity
  - Easy to go short
- Better market efficiency

Controversies Related to Derivative

Controversies Related to Derivative

- Speculation and gambling
- Destabilization and systemic risk
- Complexity
- High leverage - too risky

Summary

- **Importance:** ☆☆
- **Content:**
  - **Option:** call & put, American & European option, moneyness, payoff & profit;
  - **CDS:** essentially an assurance contract against default;
  - Purposes & controversies of derivative.
- **Exam tips:**
  - Option的分类和特征是需要重点了解的知识点。

Pricing derivatives

Tasks:

- Explain how the concepts of arbitrage, replication, and risk neutrality are used in pricing derivatives.

Pricing the Underlying

Present value of discounted cash flow (DCF)

- The value of the financial asset is the expected future price plus any interim payments, such as dividends or coupon interest, discounted at a rate appropriate for the risk assumed.
- $S_0 = E(S_T)/(1+r+\lambda)^T - \Theta + \gamma$
  - S_0: spot price; $E(S_T)$: expected spot price at time T;
  - r: risk free rate; λ: risk premium;
  - Θ: the present value of the cost of holding an asset;
  - γ: the present value of the benefit of holding an asset.

Pricing the Derivatives

Arbitrage

- Arbitrage is a type of transaction undertaken when two assets or portfolios produce identical results but sell for different prices.
- Law of one price:
  - Assets that produce identical future cash flows regardless of future events should have the same price.
  - Trader will exploit the arbitrage opportunity quickly (buy low and sell high), then make the prices converge.

Pricing the Derivatives

Arbitrage

- If a return greater than risk-free rate can be earned by holding a risk-free portfolio, then an arbitrage opportunity exists.

Pricing the Derivatives

Replication

- Creation of an asset or portfolio from another asset, portfolio, and/or derivative.
- An asset and a hedging position of derivative on the asset can be combined to produce a position equivalent to a risk-free asset.
  - Asset + Derivative = Risk-free asset
  - Asset - Risk-free asset = -Derivative
  - Derivative - Risk-free asset = - Asset
    - ✓ A "-" indicates a short position, or borrowing at R_f.

Pricing the Derivatives

No arbitrage pricing

- Determine the price of a derivative by assuming that there are no arbitrage opportunities (no arbitrage pricing).
- The derivative price can then be inferred from the characteristics of the underlying and the derivative, and the risk-free rate.

Pricing the Derivatives

Risk-neutral pricing

- The investor can be assumed to be risk neutral, because the investor's risk aversion is not a factor in determining the derivative price.
- Virtually all derivative pricing models ultimate take this form: discounting the expected payoff of the derivative at the risk-free rate.

Summary

- **Importance:** ☆☆
- **Content:**
  - Arbitrage & replication;
  - No-arbitrage pricing and risk-neutral pricing.
- **Exam tips:**
  - 是derivative定价的基础；
  - 主要掌握概念。

Pricing & valuation of forward

Tasks:

- Distinguish between value and price;
- Explain the pricing and valuation of forward contract.

Price vs. Value

Price of forward, future, and swap

- The fixed price or rate at which the underlying will be purchased at a later date.
  - Generally may not change as the (expected) price of the underlying asset changes.

Value of forward, future, and swap

- The difference of "with the position" from "without the position".
  - May increase or decrease as the (expected) price of the underlying asset changes.

Pricing and Valuation of Forward

At initiation

- The forward contract at initiation has zero value.
  - Neither party to a forward transaction pays to enter the contract at initiation.
    $V_0(T) = 0$
- Forward price must be set so its value at initiation is zero.
  $F_0(T) = (S_0 - \gamma + \theta)(1+r)^T$
  - $\gamma - \theta$: net cost of carry, γ and θ are in PV form.
  - If net cost of carry is zero:
    $F_0(T) = S_0(1+r)^T$

Pricing and Valuation of Forward

During its life

- In the financial world, we generally define value as the value to the long position.
- At time t < T, the value of a forward contract is the spot price of the asset minus the present value of the forward price, and minus the net cost of carry.
  $V_t(T) = S_t - (\gamma - \theta)(1+r)^t - F_0(T)(1+r)^{-(T-t)}$
  - If net cost of carry is zero:
    $V_t(T) = S_t - F_0(T)(1+r)^{-(T-t)}$

Pricing and Valuation of Forward

At expiration

- The value of a forward contract is the spot price of the underlying minus the forward price.

$V_T(T) = S_T - F_0(T)$

Pricing and Valuation of Forward

Benefits and costs of holding the underlying

- Benefits will decrease forward price at initiation, and decrease the value of forward contract during its life.
  - Including dividend, interest, **convenience yield**, etc.
    - ✓ **Convenience yield**: nonmonetary advantage of holding the asset.
- Costs will increase forward price at initiation, and increase the value of forward contract during its life.
  - Including storage cost, maintenance cost, etc.

Forward Rate Agreement

Definition

- Forward contracts with the underlying of an interest rate (e.g. Libor) are called forward rate agreements (**FRAs**).

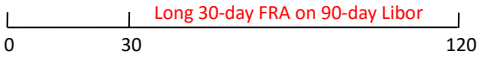
The uses of FRAs

- Lock the interest rate or hedge the risk of borrowing or lending at some future date.
  - One party will pay the other party the difference (based on notional value) between the interest rate specified in the FRA and the market interest rate at contract settlement.

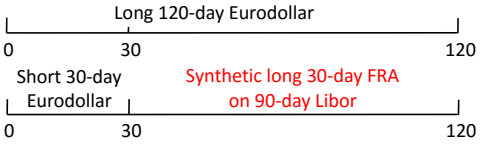
Forward Rate Agreement

Example: 30-day FRA on 90-day Libor

- **Real FRA**



- **Synthetic FRA**



Summary

- **Importance:** ☆☆☆
- **Content:**
  - Forward price and value: at initiation, during the life, and at expiration;
  - FRA and synthetic FRA.
- **Exam tips:**
  - 常考点：forward的定价，以及forward在initiation和expiration时的value.

Pricing & valuation of future, and swap

Tasks:

- Explain why forward and futures prices differ;
- Explain similarities and differences between forward and swap contracts.

Pricing and Valuation of Future

Future vs. Forward

- Future contracts are standardized, exchange-traded;
- Future contracts realize the gain or loss in parts on a day-to-day basis because of daily settlement (mark-to-market), while forward contracts realize the full gain or loss at expiration.
  - The time value of money makes these not equivalent.

Pricing and Valuation of Future

Future vs. Forward

- Future price will be higher than forward price when interest rate and future price are positively correlated, and will be lower when they are negatively correlated.
  - A positive correlation between interest rate and future price means that (for a long position) daily settlement provides funds (excess margin) when rates are high and they can earn more interest.

Pricing and Valuation of Swap

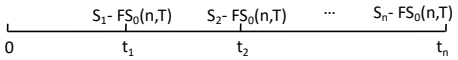
Pricing and valuation of swap

- As with forward contract, the price of a swap is the fixed price specified in the swap contract (the contract price) and the value depends on how expected future price change over time;
  - At initiation, a swap has zero value;
  - An increase in expected future price will produce a positive value for the fixed-price payer, and a decrease in expected future price will produce a negative value.

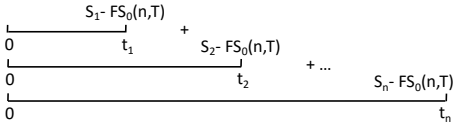
Pricing and Valuation of Swap

Swap vs. Forward: similarity

- A swap is a series of forwards, each created at swap price.
  - **A swap**: make n payments of $FS_0(n,T)$ at time $t_1, t_2, \ldots, t_n$, and receive $S_1, S_2, \ldots, S_n$.



  - **A series of forwards**:



Pricing and Valuation of Swap

Swap vs. Forward: difference

- At initiation, the value of each one of the series forwards is not zero.
  - Off-market forward: forward contract created with a contract price that gives it a non-zero value at initiation.
  - A swap consist of some off-market forwards with positive PVs and some off-market forwards with negative PVs, so that the sum of their PVs equals zero.

Interest Rate Swap

Interest rate swap

- In a simple (plain vanilla) interest rate swap, one party pays a floating rate and the other pays a fixed rate on a notional principal amount.
  - An increase in expected future rate will increase the value for the fixed-rate payer, and vise versa.
- At each payment date, a net payment is made from one party to the other.
- Equivalent to a series of (off-market) FRAs, each with a forward rate equal to the swap fixed rate.

Summary

- **Importance:** ☆☆
- **Content:**
  - Forward Vs. future, forward Vs. swap;
  - Interest rate swap.
- **Exam tips:**
  - 主要是概念题；
  - 常考点：forward和future定价的差异。

Valuation of options

Tasks:

- Explain how the value of a European option is determined at expiration;
- Identify the factors that determine the value of an option, and explain how each factor affects the value of an option.

Valuation of Option

Moneyness

- Moneyness refers to whether an option is in the money or out of the money:
  - If immediate exercise would generate a positive payoff, the option is in the money.
  - If immediate exercise would result in a loss (negative payoff), the option is out of the money.
  - If immediate exercise will generate neither a gain nor loss, the option is at the money.

Valuation of Option

Moneyness (X: exercise price, S: spot price)

- Call option
  - In the money: S > X;
  - Out of the money: S < X;
  - At the Money: S = X.
- Put option
  - In the money: S < X;
  - Out of the money: S > X;
  - At the money: S = X.

Valuation of Option

Exercise value (intrinsic value)

- The maximum of zero and the amount that the option is in the money.
  - Call option: Max(0, S-X);
  - Put option: Max(0, X-S).

Time value (speculative value)

- The amount by which the option premium (price) exceeds the intrinsic value.

  Option premium = Intrinsic value + Time value

Option Value at Expiration

Option value at expiration

- The time value is zero, and the option value is its intrinsic value:
  - For in-the-money call option: $S_T - X$;
  - For in-the money put option: $X - S_T$;
  - For at-the-money or out-of-the-money option (both call and put): Zero.

Factors that Determine Option Value

Price of the underlying asset (S_t)

- For call option, a higher S_t will increase its value;
- For put option, a higher S_t will decrease its value.

The exercise price (X)

- For call option, a higher X will decrease its value;
- For put option, a higher X will increase its value.

Factors that Determine Option Value

The risk-free rate of interest (R_f)

- For call option, a higher R_f will increase its value;
- For put option, a higher R_f will decrease its value.

Volatility of the underlying price (δ)

- A higher δ will increase the value of both call and put options.

Factors that Determine Option Value

Time to expiration (T-t)

- For call option and most put option, a longer (T-t) will increase the time value and then increase its value;
- For some European put options, a longer (T-t) are more likely to decrease its value when:
  - The deeper a put option is in the money;
  - The higher the risk-free rate;
  - The longer the current time to expiration.

Factors that Determine Option Value

Costs (θ) and benefits (γ) of holding the asset

- For call option, a higher cost (θ) will increase its value and a higher benefit (γ) will decrease its value;
- For put option, a higher cost (θ) will decrease its value and a higher benefit (γ) will increase its value.
  - **Reason**: cost will generally increase the price of the underlying asset, and benefit will generally decrease the price of the underlying asset.

Factors that Determine Option Value

Summary of factors determining option value

	Call option	Put option
S	↑	↓
X	↓	↑
R_f	↑	↓
δ	↑	↑
T-t	↑	↑ (with exception)
θ	↑	↓
γ	↓	↑

Note: ↑ means positively related, and ↓ means negatively related.

Summary

- **Importance:** ☆☆☆
- **Content:**
  - Option moneyness and option value at expiration;
  - Option value: intrinsic value + time value;
  - Factors on option value: S, X, R_f, δ, T-t, θ, γ.
- **Exam tips:**
  - 常考点1：影响option value的factors，及影响方式；
  - 常考点2：option value的components及其含义。

Put-call parity & binomial model

Tasks:

- Explain put-call (forward) parity for European options;
- Explain how the value of an option is determined using a one-period binomial model;
- Explain under which circumstances the values of European and American options differ.

Put-Call Parity for European Option

Fiduciary call ($c + X/(1+R_f)^T$)

- Combination of a European call option with exercise price of X and a pure-discount, riskless bond with face value of X.

Protective put (S + p)

- A share of stock together with a put option on the stock with exercise price of X.

Note: the call and put must be European-style (c, p) with same exercise price (X) and time to expiration (T). Also, the maturity of the bond should be the same (T).

Put-Call Parity for European Option

Payoff at expiration:

	Fiduciary call ($c + X/(1+R_f)^T$)	Protective put (S + p)
If $S \le X$	$0 + X = X$	$S + (X - S) = X$
If $S \ge X$	$(S - X) + X = S$	$S + 0 = S$

- In either case, the payoff on a fiduciary call is the same as the payoff on a protective put, so:

Put-call parity: $c + X/(1+R_f)^T = S + p$

Put-Call Parity for European Option

Synthetic equivalencies

- The put-call parity can be rearranged to create synthetic equivalencies.
  - Synthetic call: $c = S + p - X/(1+R_f)^T$
  - Synthetic put: $p = c + X/(1+R_f)^T - S$
  - Synthetic stock: $S = c + X/(1+R_f)^T - p$
  - Synthetic bond: $X/(1+R_f)^T = S + p - c$

Note: the term "+" means long and "-" means short.

Put-Call Forward Parity

Put-call forward parity

- Put-call-forward parity is derived with a forward contract (forward price: $F_0(T)$) rather than the underlying asset itself.
  - Substituting $F_0(T)/(1 + R_f)^T$ for S_0 in put-call parity gives us the put-call-forward parity:

    $F_0(T)/(1 + R_f)^T + p = c + X/(1+R_f)^T$

    Or:

    $p - c = [X - F_0(T)]/(1+R_f)^T$

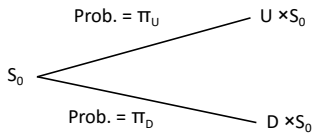
Valuation of Option

One-period binomial model

- Binomial model is based on the idea that, over the next period, some value will change to one of two possible values.
- To construct a binomial model, we need to know the beginning asset value (S_0), the size of the two possible changes(U, D), and the probabilities of each of these changes occurring (π_U, π_D).

Valuation of Option

One-period binomial model (Cont.)



- $D = 1/U$;
- $\pi_U = (1 + R_f - D)/(U - D)$, risk-neutral probability of an up-move;
- $\pi_D = 1 - \pi_U$, risk-neutral probability of an down-move.

Valuation of Option

One-period binomial model (Cont.)

- With one-period binomial model, the value of an option on stock can be calculated as:
  - **Step 1**: Calculate the payoff of the option at maturity in both the up-move and down-move states;
  - **Step 2**: Calculate the expected value of the option in one period as the probability-weighted average of the payoffs in each state;
  - **Steps 3**: Discount this expected value back to today at the risk-free rate.

American Option vs. European Option

Call option

- Identical American and European call options on assets with no cash flows (dividend, interest, etc.) during the life will have the same value.
  - There is no advantage to early exercise, because the market value of a call option will be greater than its exercise value (worth more alive than dead).

American Option vs. European Option

Call option (Cont.)

- Identical American and European call options on assets with cash flow during the life, the price of American call option will be greater than the price of identical European call option.
  - Early exercise may be valuable.

American Option vs. European Option

Put option

- Prior to expiration, American put prices can differ from (greater than) identical European put prices (when the underlying price is below a critical value).
  - The right to exercise early always has value for a put, which is because of a lower limit (zero) on the value of the underlying.

Summary

- **Importance:** ☆☆☆
- **Content:**
  - Put-call parity & Synthetic equivalencies;
  - One-period binomial model;
  - American Option vs. European Option.
- **Exam tips:**
  - 常考点1：利用put-call parity计算价格；构建Synthetic equivalencies的方法；
  - 常考点2：One-period binomial model中的概念。

Applications of Option Strategies

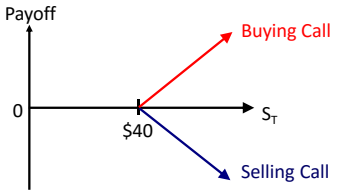
Tasks:

- Determine the potential outcomes of buying and selling calls and puts;
- Explain the risk management application of covered call strategy and protective put strategy.

Value at Expiration

Call option

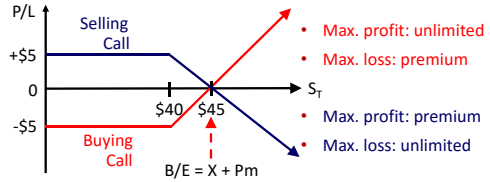
- Payoff of buying = intrinsic value at expiration
- Payoff of selling = - (payoff of buying)
- Example: call option with X = $40



Profit and Loss at Expiration

Call option

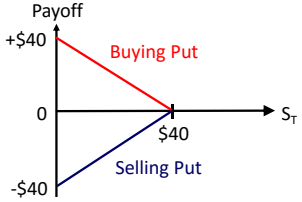
- Profit of buying = intrinsic value at expiration - premium
- Profit of selling = - (profit of buying)
- Breakeven underlying price = X + premium
- Example: call option with X = $40 and premium = $5



Value at Expiration

Put option

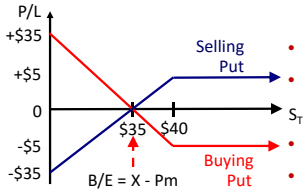
- Payoff of buying = intrinsic value at expiration
- Payoff of selling = - (payoff of buying)
- Example: put option with X = $40



Profit and Loss at Expiration

Put option

- Profit of buying = intrinsic value at expiration - premium
- Payoff of selling = - (profit of buying)
- Breakeven underlying price = X - premium
- Example: put option with X = $40 and premium = $5



- Max. profit: premium
- Max. loss: X – premium
- Max. profit: X - premium
- Max. loss: premium

Summary

Payoff and profit/loss, Max. profit/loss, and breakeven:

	Long call	Short call	Long put	Short put
Payoff at T	Max(S_T - X,0)	-Max(S_T - X,0)	Max(X - S_T,0)	-Max(X -S_T,0)
P/L at T	Max(S_T - X,0) - Pm	-Max(S_T-X,0) + Pm	Max(X-S_T,0) - Pm	-Max(X - S_T,0) + Pm
Max. profit	Unlimited	Pm	X - Pm	Pm
Max. loss	Pm	Unlimited	Pm	X - Pm
Breakeven	X + Pm	X + Pm	X - Pm	X - Pm

Example

- Consider a call option with exercise of $50 which is purchased at $4.
  - What is the maximum profit?
  - What is the maximum loss?
  - What is the breakeven underlying price?
  - What is the option value, and gain or loss if stock price is $60.00 at expiration?

Example:

- **Answer:**
  - Maximum profit: unlimited;
  - Maximum loss: $4;
  - Breakeven underlying price at expiration = $54;
  - Option value at expiration: $10;
  - Gain or loss: $6 ($10 - $4 = $6).

Risk Management Strategy

Covered call (S - c)

- Write (sell) a call when owning the underlying stock.
  - Any loss will be reduced by premium received.
  - Call writer trades the stock's upside potential for the call premium.

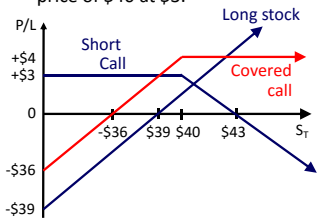
Protective put (S + p)

- Long a put and long the underlying stock.
  - Any gain from the stock will be reduced by put premium.
  - Long the put for protection against stock price falling below the strike price.

Covered call

Covered call

- Example: buy stock at $39, sell call option with strike price of $40 at $3.



- $V_T = S_T - Max(0, S_T - X)$
- Profit: $V_T - S_0 + c_0$
- Max. profit: $X - S_0 + c_0$
- Max. loss: $S_0 - c_0$
- Breakeven: $S_0 - c_0$

Example

- Consider a bond selling for $98 per $100 face value. A call option selling for $8 has an exercise price of $105. Answer the following questions about a covered call.
  - Determine the value of the position at expiration and the profit when the price of the bond at expiration is $110.
  - Determine the maximum profit and maximum loss.
  - Determine the breakeven bond price at expiration.

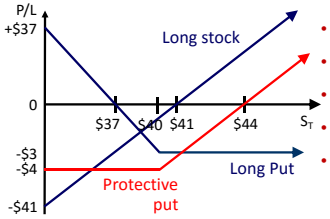
Example

- **Answer:**
  - The value of the position at expiration: 110 - 5 = 105;
  - The profit of the position at expiration: 105 - (98 - 8) = 15;
  - The maximum profit: 15;
  - The maximum loss: 90;
  - The breakeven bond price at expiration: 98 - 8 = 90.

Protective put

Profit and loss of protective put

- Example: buy stock at $41, buy put option with strike price of $40 at $3.



- $V_T = S_T + Max(0, X - S_T)$
- Profit: $V_T - S_0 - p_0$
- Max. profit: unlimited
- Max. loss: $S_0 + p_0 - X$
- Breakeven: $S_0 + p_0$

Example

- Consider a currency selling for $0.875. A put option selling for $0.075 has an exercise price of $0.9. Answer the following questions about a protective put.
  - Determine the value of the position at expiration and the profit when the price of the currency at expiration is $0.96.
  - Determine the maximum profit and maximum loss.
  - Determine the breakeven price of currency at expiration.

Example

- **Answer:**
  - The value of the position at expiration: 0.96;
  - The profit of the position at expiration: 0.96 - (0.875 + 0.075) = 0.01;
  - The maximum profit: unlimited;
  - The maximum loss: 0.875 + 0.075 - 0.9 = 0.05;
  - The breakeven bond price at expiration: 0.875 + 0.075 = 0.95.

Summary

- **Importance:** ☆☆
- **Content:**
  - **Call & put:** value at expiration, the profit, maximum profit, maximum loss, breakeven, and payoff graph;
  - **Covered call & protective put:** value at expiration, profit, maximum profit, maximum loss, breakeven, and payoff graph.
- **Exam tips:**
  - 主要考covered call和protective put，常考计算题。