## Forward

* Long forward A = Long Spot A + Long A Bond + Short B Bond = Short forward B
* e.g. Buy forward USD(w/JPY) = Buy Spot USD(w/JPY) + Buy US Bond(Lend out) + Sell JP Bond(Borrow From)
* lower bound when cost exist = replicating short = sell at forward bid
* upper bound when cost exist = replicating long = buy at forward ask
* For Asset pay discrete yield(e.g. dividends) D:

## Future

* Cash Settlement future/ non-deliverable forwards/ non-physical underlyings
* f = F when: (1) carry cost random **and** (2) carry cost highly correlated with underlying. $ F > f; iff; (S\_t, (r\_t-d\_t)) <0$
* extra case: spot increase then r decrease: reinvestment of future cashflow is hurted
* Hedge future and Forwards given carry cost: Suppose f(T-1)>F(T-1) or Suppose f(T-1)F(T-2). Use So f(T-1)=F(T-1) to show that too lets you construct an arbitrage. Then so on T-3, T-4...
* , (Long)

## Swap

* deliver A and receiving B cannot be different than long a series of forward B (Quoted in A) and financed with lending
  + e.g. deliver gold and receiving cash:
  + e.g. deliver JPY and receiving USD (Change of home country):
* When Losing, "hedged" swap position have no change in expiring payoff during counter party default/ bankruptcy
* Transaction cost: , change side and reverse get bid
* Value of old swap in new price: (floating receiver for a IRS)
* Rate Market:
  + Gov Debt, T-Bill/T-note(10yr-,0-coupon); T-Bond(10yr+, w/ coupon) and it's STRIP
  + Repo: Lend you money, taking bonds as collateral, you pay rate (typically 3m TB)
  + EuroDollar/ LIBOR
* IRS: Fixed side value , Floating side value ,
* IRS from total bond review: Value of IRS must be the difference between two assets
* forward rate
* OIS: fixed receiver pay compound all O/N interest rate, fixed receivor gets
* Swap Spread = swap - rf ytm, e.g.
* Asset Swap: swap payout and pricipal difference at expiring
* Total-return Swap(TRS): periodically exchange realized return, then rebalancing to unit value
* Credit Default Swap(CDS):
  + you pay me cf from long X coupon bond at T; I pay you cf from long rf bond at T; both at par; exchange difference at maturity; if defaults, terminal payoff is: face value of riskless bond - recovery value of defaulted bond
  + fee should be the same as credit spread.

## Options

* Basic Arbitrage: (1) option value > 0 (2) (3) (4) (5) (6) (7) (8) (9) (10) optimal exercising: right before ex-date (11) not optimal exercising before ex-date
* Put-Call Parity:
  + or
  + or
* Butterfly and Risk Neutral: share of butterfly price , is the risk-neutral prob q times
* Breeden and Litzenberger Theorem: one can identifying RN prob by watching curvature.
* Binomial when we have div or foreign: conventional
* Black PDE General setting:
  + Geometric Brownian: or in general a: drift, b: diffusion, a/S: expected, b/S volatility(std dev)
  + Ito and Delta hedge:
  + Based on Black Schole formula: => is the precentage of PV of K we need to borrow to replicate portfolio
* Black Schole's "additional" assumption: (1) continue transaction is possible (2) no price jump (3) r constant (4) d = 0
* Black Schole Greek

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Greeks | Call | Put | Call Sign | Put Sign |
|  |  |  | l+ s- | l- s+ |
|  |  | Same | l+ s- | l+ s- |
|  |  | Same | l+ s- | l+ s- |
|  |  |  | l- s+ | l- s+ |
|  |  |  | l+ s- | l- s+ |

* Lira-Peso Case Margarbe's Formula: , where , and is the volatility of the ratio
* Lira-Peso Case II Future Option: , where , for future, for Forward.
* Merton's Forward volatility:

## From Midterm

* 2017Q3 OIS: => , one year simple rate(EAR).
* 2017Q4 Bound: find best and worst scenario
* 2016Q2 and . Treat as a func of S, find
* 2016Q4 Through Black Schole PDE back into ito's result

## Volatility

* short-dated options Deeo OTM, not sensitive to volatility
* Heston Model:
* When is high and s is low, mean reverting faster and behave like constant vol.
* VS GARCH: GARCH is 1. discrete in time, 2. when take time to limit become non-stochastic
* Multi dimensional Ito: add , $\frac{\partial C}{\Partial Y}dY$, and a to all other risk factors.
* Idea of hedging non-tradable risk factor(e.g. Heston): Creating a all-else neutral (e.g. BS delta-neutral) portfolio and, create another such portfolio , long 1 and short ratio (e.g. )
* Doing hedge above, get (not RN) market price of risk factor , a kind of sharpe ratio (use sharpe ratio approach to estimate from hist data).
* Feymann-Kac: 1. risk-neutralize (traded asset drift to , non-traded asset drift to ) in PDE 2. calculate value w.r.t that drift 3. disc at 4. take
* Observation from Heston Model: 1. fatter tail of return dist 2. leptokurtic 3. Deep OTM option more valuable, Near-the-money option less valuable
* positive: 1.less likely to go down after go down, higher likely to go up after go up 2.left low right high 3. OTM call more/ put less likely to payoff ITM 4. Smile skewed ll to ur 5. vice versa for negative
* Problem with Multi-dimension: (Econometrics)1. stochastic model of each 2. parameters (Market Completeness)3. two securities you can use to hedge (risk X only, long and short) 4. Jumps negligible (Risk preference)5.
* Given GBM and using Feymann-Kac:
* Vasicek: (RN, change to if physical), , CIR: change b to
* Vasicek way to calculate Term Strucuture:
* Error of MC: 1. Discretization () 2. Not enough paths ($\epsilon ~ \mathcal{O}(M^{-\frac{1}{2})$)
* Short Log forward get , where
* Butterfly approach toward VIX: =>

## Credit

* Merton's Model: Equity is a long european Call with K = Debt FV => CFO increase volatility of stock to max shareholders benefit (hurting Bond holders), assuming 1. 2. no taxes and reorganization cost 3. won't do unanticipated financing 4. enforcable
* Modigliani-Miller Theorem: market value of firm is independent of its capital structure and only cash flows instaed.
* assuming earning ~ GBM, constant rate, and perpetual, => . Then F, a claim on V, follow BS PDE with and add a coupon rate and has soluntion , yield spread =
* Equity Model: assume S ~ CEV then F follow BS PDE with => S in second derivative term, add a coupon rate and change r to (r-div)
* Convertible Bond: Change BC on Stock to where , Manager convert whenever Bond Value is greater than that.
* Better model = 1. Jump 2. Future Financing 3. Restructring 4. Constraint
* CDS: long credit spread = protection buyer = pay fee to protection seller = short credit spread = pay (1-R) to buyer when credit events happen.
* CLN: Z =pricinpal=> Y, won't payback pricipal if X default still need to pay high coupon rate.
* Assuming no recovery, risky Bond , => cdf of dying before T, h => pdf, f = => conditional probability (if constant = , or credit spread)
* CDS , MtM value
* fetching RN probablity of default: , then recursively solve all others.
* Credit Value Adjustment = Expected Discounted Unrecoverable Mark-to-Market Profit =
* If CVA is a loss on one leg, then Debit Value Adjustment is the same idae on the other leg. Generally: adj. value to protection leg = protection Leg value - fee leg value - CVA + DVA
* ABS, CDO and unhedgeable Repayment Risk(Timing risk): transfer! long tranch in CDO = long rf + short CDS on those tranch(or short CDX NA IG)